Built by Fire:

Wildfire Management and Policy in Canada

by

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ABSTRACT

Wildfire is an inescapable feature of Canadian landscapes, burning an average of over two million hectares annually and causing significant repercussions for communities, infrastructure, and resources. Because fire is managed provincially, each jurisdiction has developed a distinctive approach to preparing for, responding to, and recovering from fire on its landscapes. Using a comparative study between seven provinces and four national agencies, this dissertation examines differences in institutional design and policy with respect to the knowledge management systems required to respond to wildfire: How do policies and procedures vary between jurisdictions, how do they affect the practices of each fire management agency, and how can they be improved through a critical analysis of the knowledge management systems in use? And, what is the role of and limits on expertise within these fire management institutions that manage high-risk, highly uncertain socio-environmental challenges?

I begin by introducing the 2016 Fort McMurray/Horse River fire as a lens for exploring these questions. I then use the past one hundred years of fire history in Canada to illustrate the continual presence of fire, its human and social dimensions, and the evolution of differing fire management regimes. Drawing on extended ethnographic observation and interviewing of fire managers across Canada, I examine the varied provincial systems of response through following an active fire day in Alberta. I analyze the decision support and geospatial information systems used to guide fire agency decision-making, as well as the factors that limit their effectiveness in both response and hazard reduction modes. I begin Part Two with a discussion of mutual aid arrangements between the provinces, and critically

examine the core strategy – interagency fungibility – used to allow this exchange. I analyze forecasting and predictive models used in firefighting, with an emphasis on comparing advantages and disadvantages of attempts at predicting future firefighter capacity requirements. I review organizational learning approaches, considering both fire research strategies and after action reviews. Finally, I consider the implication of changes in climates, politics, and public behaviours and their impacts on fire management.

ACKNOWLEDGEMENTS

A project of this size wouldn't be possible without the support of a large community of people. Numerous colleagues, professionals, family, and friends have listened to a never-ending stream of thoughts about fire, hosted me as I traveled across the country, opened up their offices and experiences to learn from, and allowed a fire novice to learn a great deal about the subject. I'm grateful and fortunate beyond measure.

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trails to hike (perhaps the most fruitful location to process ideas, ask questions, and jot notes about the book), for home cooked meals, or for brief distractions from the world of wildfire.

I cannot find adequate words to thank the fire management community across Canada (and in Western Australia and Victoria) for their contributions to this project. While I will keep their names anonymous at this moment, this project is dedicated to them. Across the country, fire program managers welcomed me in with surprising warmth and openness, always eager to share and help however they could. They laid the groundwork for future meetings, introducing me to counterparts and opening up conversations as I traveled. They tolerated a 'fly-on-the-wall' during busy and quiet times alike, and they were always available for answering questions. Their kindness also showed in a much more profound way too: in the kinds of organizations they fostered, where each and every person I talked to, from aviation coordinators to regional warehouse staff, exemplified the exact same warmth an openness. Any insights from this project belong to them, and any errors are mine alone.

Throughout the project, I benefited from an excellent supervisory committee. They allowed me the room to explore this area on my own, but were always available and willing to be a touchstone when I needed to return for reflection, guidance, and ideas. Dr. Clark Miller not only served as a steadfast friend and supporter – always there if needed. His hand is woven through the book not only in the returning theme of knowledge systems, an idea which has profoundly shaped my professional identity as a scholar, but also in the broader ways I've learned to think, reflect, and write through his mentorship. The impact Dr. Stephen Pyne would have on me, personally and professionally, was orders of magnitude larger than I estimated when he accepted my invitation to join the committee. He has been a

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Prologue: First Sparks

1. Introduction: When Fire Came to Fort McMurray

"People had been saying it was bound to happen. This is fire country." [1]

Forty-six hours before the Horse River wildfire began leaping into Fort McMurray's Beacon Hill neighbourhood – well before the smoke had reached the city, and before families began their hurried evacuations north and south along Highway 63 – a helicopter flew over Alberta's boreal forest. The helicopter contained five people: a veteran helicopter pilot named Dave Mulock, and four young crewmembers. These four firefighters were members of Alberta Agriculture and Forestry's wildfire management program, a group of highly skilled seasonal workers who are often the first to attack forest fires across the province.

As they flew over forests and grasses above Northern Alberta, Mulock and the crew would have scanned for wisps of smoke and signs of human use: utility corridors, roads, industrial sites, and ATV trails.[2] While lightning plays its role in starting about half of Canada's wildfires, and an even larger proportion in Canada's expansive and remote

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[1] KPMG, "Lesser Slave Lake Regional Urban Interface Wildfire – Lessons Learned," 29. Quotation from a

[2] As I discuss in Appendix A, with respect to the accounts of the Horse River fire, the 2017 British Columbia season, and the Waterton National Park fire, for this dissertation I draw exclusively on publicly available reporting via print news, after action reports, and other published sources.

northern forests, humans play a significant role in causing ignitions as well.[3] Many of these fires are the result of negligence or misfortune – a hot piece of metal thrown from machinery, a scalding ATV or car tailpipe that makes contact with dry grass, or a power line blown down in the wind – while others are much more intentional and nefarious. The general kinds of sources are predictable, but their precise occurrence – the where and the when – is not.

It was in one of these utility corridors, approximately seven kilometers southwest of Fort McMurray's urban core, that the crew aboard the helicopter spotted a wildfire. The fire was burning in the grass, already dry from a winter with below average snowfall and higher than average temperatures. It was just after four o'clock in the afternoon, May 1st.

Detecting a fire seems like a trivially straightforward question. For those of us who live in an urban environment, fires are remarkably rare events. When they do happen, they're obvious: a car aflame after an accident, a pan of oil in the kitchen as cooking goes wrong, or the framing of a building burning brightly on a construction site. In an urban setting, people are almost always nearby, and – despite the human inclination to freeze as a bystander (in a famous experiment from the 1960s, only ten percent of individuals and thirty-eight percent of trios reported when the examination room began filling with smoke[4]) – the alarm for emergency services is quickly raised.

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[3] Stocks et al., "Large forest fires in Canada, 1959–1997," FFR 5-1–FFR 5-12. Across the country overall, there's roughly a 50/50 split between lightning and human fires. However, lightning fires account for far more area burnt: they generally occur further from humans, meaning that detection and response are slower and fires may not be attacked as aggressively as if they occurred near people.

[4] Bibb and Darley, "Bystander 'Apathy'".

When the fire starts away from the bustle of crowds, however, finding them is a much more complicated question. Sheer scale creates a challenge: although human-caused fires usually start in regularly visited areas, lightning fires can occur thousands of kilometres away from major population centres. Most provinces and territories use a combination of several strategies. People do play a large role by calling in reports of smoke via government hotlines like the "310-FIRE" number available in Alberta. In other parts of the province, a smoke report might come from one of 132 fire towers spaced across the vast landscape. In Saskatchewan, the towers have entered the digital age, with human lookouts replaced with cameras monitored from the basement of a command centre in Prince Albert. In many provinces, like Nova Scotia and Manitoba, small detection planes are sent out along fixed paths to cover large distances looking for signs of new fires. In the case of the Horse River fire, it was a "loaded patrol" – a helicopter sent on a lookout route, already loaded with a small group of firefighters able to perform Initial Attack when they find the flames. Helicopters are slower than planes, reducing the ground covered on patrol, but this strategy means that boots can be on the ground within minutes after the fire is first detected.

With the firefighters and their boots riding along on patrol, Dave Mulock guided the helicopter in circles around the fire burning below. Just as they were trained, they each gazed out to "size up" the scene below. They estimated the size of the fire (a little less than two hectares in size, or about the size of ten Olympic hockey rinks) and the temperament of the flames around its edges (already spreading at about 10 metres per minute into the surrounding bush). Trained into them in firefighting boot camp, they began to think about their LACES: how to keep reliable lookout over the fire and their operations; anchor points that they could use in the fire fight; communications within their team and with Mulock, who would soon be overhead again; escape routes to be maintained and available throughout the fight; and safety zones in which they could take refuge if they were under threat. Yet, as Mulock and the crew prepared to begin the firefight, a much bigger machine was just beginning to spin into action.

When Canadians across the country turned on the news two days later, as the fire entered Fort McMurray, eyes focused on the heroic parts of firefighting: the young men and women working on the fire line; the crews rappelling out of helicopters; Royal Canadian Mounted Police officers guiding the evacuation as they were showered by embers; and the aircraft flying overhead dropping retardant and water to slow the flames. Missed was the much simpler moment that happened forty-six hours earlier, when Dave Mulock and the crew aboard that helicopter called back to their base and reported the new fire, and everything that stemmed from that decision. It was the moment when the fire transformed from an unknown pall of smoke on the landscape to a codename, MWF-009. It was the moment when a massive system came into play – an apparatus as big as Canada itself. It was the moment everyone involved began to learn just what 'The Beast' was, how it could be beat, and what they would have to do to fight it.

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Firefighting, it turns out, is pretty straightforward. Fires, whether big or small, are controlled by the three elements: fuel, heat, and oxygen. These make up the fire triangle (see
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Figure 1). Remove one of them and you extinguish the fire. With everything from shovels to bulldozers, wildland fire crews cut fuel breaks to prevent fire spread by removing the substances that can burn. A network of pumps and hoses deliver water to the fire to quench the heat. And, retardant and foamed water can be dropped from aircraft to simultaneously cool the combustion process and create a barrier between fuels, flames, and oxygen.

Firefighters and fire managers continually return to these simplified, representative triangles. Wildland fire has its own version of a fire triangle that captures what drives fire behaviour in these much larger settings. Fuel remains. Different kinds of trees, shrubs, grasses, and debris burn with different intensities, each of which firefighters must know intimately to understand how a fire will behave when they're fighting it. Topography is the second element: the arrangement of physical features on the landscape. Fires burn quicker, for instance, when progressing uphill: hot air rises, preheating the fuel above and creating air movement that draws the flames upwards at a quicker rate. The third crucial element is weather. Among other factors, wind, humidity, temperature, and past precipitation are powerful determinants of how aggressively a fire will behave. Each of these three factors have been responsible for countless fatalities around the globe, from 'flashy' fuels that kill victims in quick burning grasses before they can get away, to the infamous Mann Gulch incident where thirteen firefighters died as they tried to outrun a fire uphill, to the flames pushed by the Santa Ana winds through California in December, 2017.

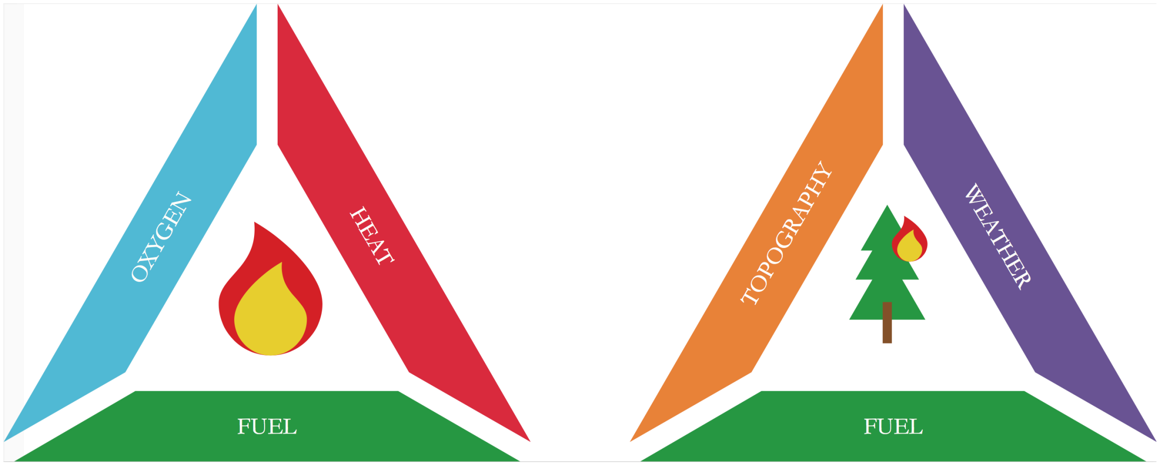

Figure 1
Fire and wildfire triangles.

These two triangles – fuel, heat, and oxygen; fuel, topography, and weather – are known commodities that govern fire behaviour. The actual labour of fighting a fire is exceptionally taxing, with hours of slogging equipment through the bush and hunting down stubborn embers. The principles of how to put out fires, however, are simple. Walk the hallways of any Canadian wildfire agency during fire season, and before the day is done you'll hear someone offer up the mantra of firefighting: "put the wet stuff on the hot stuff."

It's more difficulty to organize the firefight. Fires in the western urban environment are characterized by neatly bounded scope. They're remarkably rare, and when they do occur, they're quickly detected and reported. They generally involve only a single building, which usually has a straightforward address (or, in the case of a car accident, a cross street or some other landmark). And, in most cases, the firefighters are easily able to extinguish the fire by the end of their shift, returning the equipment to the station for the next crew to take over any new emergencies. By contrast, wildland fire is much less defined: they can be slow to detect, take place in an unbounded and poorly constrained landscape (in the Canadian

Boreal, often with almost unlimited potential for spread), and they can span weeks, months, or, in the case of the Horse River fire, more than a year.

These factors mean that putting out a wildfire is as much about being well organized, maintaining organizational effort over long periods of time, and making good decisions in the face of uncertainty as the frontline firefighting itself. These decisions are incredibly high stakes: Which fires are the most important? Where should the firefighters and tankers be sent, and what should they be tasked to do? What happens when an agency runs out of resources? What needs to be protected? What fires can be expected over the next days, weeks, and months? What science, technology, and knowledge would help to battle these flames? And, how will fire change in the future, and how should we prepare for it?

Understanding how agencies across Canada address these questions is no small task. Finding these answers has taken me across the country and back again, from tiny towns like Weyakwin, Saskatchewan and St. Peter's, Prince Edward Island to urban hubs like Edmonton, Alberta and Winnipeg, Manitoba. I have hiked trails in flammable places like Waterton Lakes National Park on the Alberta-Montana border, and walked the fire line in Nipigon, Ontario. I've observed meetings of fire managers in Halifax, Nova Scotia and Kelowna, British Columbia; spent hundreds of hours sitting with Duty Officers as they dispatch firefighters to the front lines; interviewed over two hundred wildfire managers across the country and met with eleven different management agencies; and spent more nights than I can count camped in a tent somewhere along the Trans Canada Highway.[5]

This experience has offered a firsthand window into the multitude of kinds of management that are needed to respond to wildfire across Canada. Like all things in government, there is a policy and legal landscape that dictates who is responsible for fire, how they can be fought, who gets the bill for the costs involved in firefighting, and even what cities and towns require of homeowners in terms of being prepared for fire. These policies and laws shape – and are shaped by – the organizational level of fire management, like the structure of the agencies themselves and the procedures that they create for their firefighters and managers.[6] There's an operational dimension of firefighting: how these procedures are actually translated into practice in offices and on fire lines across the country. And, underpinning all of these functions are knowledge dimensions. Many different forms of knowledge – techno-scientific, experiential, and local, among others – must be created and mobilized to enable these other layers. When a fire is burning, it's often the firefighting that captures the public's attention – but, it's actually the mostly invisible layers of policy, law, organizational, operational, and knowledge management lying in the shadows that really determine whether the fire can be controlled or not.

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[5] Further details about the methodologies involved in this project, as well as detailed analysis of the interviews and observational data, is being published in a variety of reports and peer reviewed articles. Additional deails can also be found in Appendix A: Essay on Sources. As these materials are published or made public, they will be found at ericbkennedy.ca/wildfire.

[6] In this dissertation, I use the term "manager" to as an intentionally generic reference to the whole class of non-firefighting decision-making roles in wildfire management agencies, ranging from duty officers and analysts to the highest level of the executive. This is intentional, often to provide confidentiality to particular respondents who would be easily identifiable by their specific roles within small agencies.

This multidimensionality is one of the factors that make wildfire a fundamentally 'socio-environmental' problem. Fire is the most natural phenomenon in the world. Forests burned long before humans were present on earth, and almost all landscapes in Canada south of the tundra look the way they do because of the role of fire in their history and ecology. Yet, our relationship with fire is anything but natural. Fire is often described as a 'natural hazard,' but it's the decisions that we make as humans, such as the ways we chose to manage forests or to build communities or how we choose to respond to fire outbreaks, that ultimately shape our interactions with wildfires. From the way that the earliest human communities used fire to clear landscapes for hunting and agriculture, to the ways we banish fire from suburban landscapes in forested hills, to the fire-starting rail lines and hydro wires that we string across the landscape, it's humans who wield the torch and shape modern flames.

This book offers two key lessons about fire. The first is that wildfire reveals a great deal about who we are as Canadians and the struggles that we face in managing all sorts of complex problems. How we manage fire reflects our regional and national identities, and, in turn, who we are is profoundly shaped by fire itself. By pulling apart these moments of action – from the 2016 Horse River Fire in Fort McMurray and the 2017 fires in British Columbia and Waterton Lakes National Park – we can understand what works and what doesn't about how we react.

The second lesson is that we need to stop seeing destructive wildfires – like those that happened in Kelowna, Slave Lake, and Fort McMurray – as isolated or new events that can be solved by simply throwing more people, money, or technology at the flames. Instead, we need to have more thoughtful, reflective conversations as a country about how we should prepare for a reality of continual fire. This can't be just any kind of conversation, however. As I illustrate through the book, one of the worst options is increasingly heated public debates about the "would haves, should haves, and could haves" of particular responses. Firefighting – and even more so, managing the firefighting – requires deep expertise, and the debates about how to best defend properties and lives should be focused and ongoing within these expert communities, not litigated on the pages of newspaper op-eds, Facebook groups, and talk radio.

At the same time, however, there are massive and difficult questions about values that need to be worked through in the public and political world. To what degree should homeowners be required to prepare for wildfire, and how should this preparedness be supported and enforced? How should the risk of having people living in vulnerable places be accounted for in insurance? How much should provinces spend to protect industrial assets like timber and oil, and who should bear these costs? And how should the country adjust its responses to these questions as the risks of fire evolve in response to global processes of climate change? Politicians and the public alike need to grapple with these questions of community preparedness, the expectations of total protection from fire in neighbourhoods and towns surrounded by trees, and the emphasis on funding response rather than pre-fire risk reduction – rather than focusing on cheap sound-bites in the immediate aftermath of significant fires.

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Shortly after four o'clock in the afternoon on May 1st, Mulock's helicopter was near the Horse River fire, about seven kilometers west of the town of Fort McMurray. At roughly the same time, in a non-descript office building in downtown Edmonton, over 400 kilometers south, a dot and label appeared on the overhead screens in the operations room. Within a few moments, that label – MWF-009 – begun to pulse gently, and a ping sounded to draw the attention of the Duty Officer and the Provincial Aviation Coordinator. This signal for attention has a particular meaning: a request from the Fort McMurray region for a provincial air tanker to drop water or retardant to help the efforts of crews on the ground. This created a series of crucial questions for the team in Edmonton, who were facing several such dots and labels on the screen that day – questions that guide the chapters ahead.

The label of MWF-009 wasn't the only indicator that had appeared on the screen near the city of Fort McMurray. Nearly simultaneously, MMD-004 had also been reported and was kicking up smoke near the city.[7] In fact, according to the assessment of the managers involved, MMD-004 was already within the boundary of Fort McMurray and posed a greater immediate risk to nearby structures.[8] As a result, decision makers in both Fort McMurray and Edmonton had to make a set of choices – which fire was most important and to which of these fires should inbound resources like the requested air tankers

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[7] In all accounts of the timeline, MWF-009 was discovered at 4:03pm. In the KPMG report to the Regional Municipality of Wood Buffalo, MMD-004 (the Taiganova Fire) is spotted at 4:50pm; in the KPMG report to the province, MMD-004 was also spotted at 4:03pm. In any event, the discovery was nearly simultaneous and resulted in an air tanker diversion at 5:02pm from MWF-009 to MMD-004, which was closer to the city.

[8] MNP, "A Review of the 2016 Horse River Wildfire," 29.

and additional crews be sent? Chapter Two is about the question raised by this dilemma: what makes a fire important, both in the heat of an emergency and looking back over Canadian fire history? It's easy to assume that the biggest fires are the most important fires (and vice versa), but in Canada this is rarely the case. Moreover, not every fire is an emergency – fire plays a vital and natural role on Canadian landscapes, and often the best course of action is to allow fire to fulfill its ecological and fuel-reduction functions.

Figure 2 illustrates this dilemma perfectly. Taken from northwest of the city at 6:35pm on May 1st, approximately two and a half hours after Dave Mulock and the crew spotted the fire in the grass below, the photograph illustrates the difference of size in the plumes of smoke from MWF-009 (the Horse River Wildfire) on the right and MMD-004 on the left. It also indicates the proximity of MMD-004 to structures in Fort McMurray, visible as the lighter grey immediately surrounding the smaller fire.

Figure 2
MMD-004 and MWF-009 at 18:35 on May 1st.[9]

Air tankers rarely travel alone. In most cases in Canada, they work in at least pairs – and sometimes even groups of four, five, or six – to ensure more rapid delivery of water or retardant to keep fire behaviour in check. Just as importantly, they also travel with a smaller aircraft known as a 'bird dog,' which typically contains a pilot and an Air Attack Officer. This officer – called an "AAO" among fire types – is a fire expert who has likely progressed through time working on fire on the ground, in addition to formal training and, ideally, apprenticeship in their airborne role. The bird dog will establish a circling pattern above the fire, neatly nestled into a giant, invisible layered cake where five hundred or one thousand feet separate these tanker, helicopter, and bird dog circles to prevent conflict between the aircraft. The AAO onboard is tasked with seeing the big picture and developing strategy for

[9] MNP, "A Review of the 2016 Horse River Wildfire," 29. Photo by Alberta Wildfire, with permission for educational and non-commercial use per terms of website.

where the tankers should drop, coordinating action with crews on the ground, and maintaining a safe airspace as the five thousand feet above the forest become busier than a major airport.

The AAO also needs to consider tactical choices, like whether to send the tankers to MMD-004 or MWF-009. That afternoon, the AAO made a decisive call based on their experience: the tankers were to support operations on MMD-004 not only because of its proximity to structures at risk, but also because the Horse River fire was behaving far too aggressively to be slowed by air drops. As such, the AAO directed the tankers to MMD-004. That was where he judged they could be most successful in short order. The AAO was right.[10]

As I traveled the country a year after the Fort McMurray fire talking to fire managers, duty officers, and firefighters, they often expressed a hint of surprise about the number of jurisdictions I was visiting. "It's basically the same across Canada," many would remark. "We all put the wet stuff on the hot stuff." Although the sentiment is largely true – there's a remarkable degree of similarity in the missions of fire agencies across the country – the details about how a response takes place actually vary in crucially important, if subtle, ways. In Alberta, there's a standard operating procedure that dictates how many crews and tankers must be immediately dispatched to a fire detection based on the current weather and fire location. In Saskatchewan or Manitoba, a fire at the same latitude as the Fort McMurray ignition might not even be visited that day, and perhaps only observed by periodic visits from an aircraft passing overhead. And, in Prince Edward Island, the local volunteer fire

[10] MNP, "A Review of the 2016 Horse River Wildfire," 29.

departments might well have a wildfire nearly under control before the first government responder arrives on scene. The training, experience, and role of this AAO would vary too – and some AAOs might even have to simultaneously pilot their own aircraft.

Chapter Three explores this variation in greater detail. Following the events of a heated 2017 afternoon in Alberta, I discuss the phases of responding to a fire and the differences in these operational procedures across the country. In the United States, the primacy of federal agencies in fighting fire across the country (like the United States Forest Service, the Bureau of Land Management, and the National Parks Service) results in much more commonality throughout the system. By contrast, in Canada the key actors are provinces that ideally pursue the solutions that are best for their context (or, less preferably, stick to the historical momentum of how things have previously been done), resulting in a somewhat patchwork and varied approach to fire.

One of the primary goals of this chapter is to tease apart the ways that knowledge, science (including natural and social science alike), and technology factor are used within wildland fire management. These tools – like massive databases of properties, models of how fire will spread, or air tankers – have become such a de facto part of wildfire fighting that they often seem like the only possible solution. Yet, they've emerged as a result of very particular histories, and even small tweaks in their design, assumptions, and understandings can result in large differences in how they're used in the field. Chapter Three begins to illustrate some of these key elements, which are explored in more detail throughout the subsequent chapters.

Chapter Three also aims to illustrate the massive institutional networks that are involved in managing fire. While each province and territory has an agency that is responsible for responding to wildfire, this organization represents only a fraction of the machine that is activated when a fire occurs. When fires occur near a city or town, municipal fire departments, police services, and hospitals are rapidly enlisted into the response. Even if the fire doesn't directly affect a major population centre, other agencies are engaged as well: hydro utilities, for instance, often have generation and transmission infrastructure that is at risk, and water utilities need to take precautionary action should ash be washed into reservoirs, remote pumps be taken offline, or large volumes of water become needed for firefighting.[11] At a provincial level, the emergency management office may be activated to provide coordination for the different agencies involved in any evacuations. This can occur federally as well for large fires, through the activation of the "Government Operations Centre" in Ottawa or offering airlift or military assets to assist. And, national coordination needs to be ramped up, allowing for mutual aid (like sharing pumps and hoses) between provinces and even countries.

There are also non-governmental agencies involved. Most of the helicopters – and many of the air tankers – used to fight fire in Canada, for instance, are owned by private companies. Some of these are contracted per season, while others (especially the helicopters) are hired on an as-needed basis. These aircraft, alongside contracted crew and equipment, flock to the fires to participate in the firefight. Industries in the path of the fire also have to

[11] Per Canadian terminology, I refer to electrical power interchangeably with both "hydro" and "electricity." Hydro as both a colloquial and formal term for electrical power arises from the large portion of electricity generated from hydro-electric dams across the country.

respond, whether it's shutting down oil production facilities or attempting to protect timber stands that might be threatened. Wildfire summons these many different players, some of whom work in close concert, and others who might have competing priorities or equipment demands. And, the knowledge systems functions remain essential: each of these agencies is, in effect, attempting to process what's happening in the world around them and to respond accordingly. Together, these different players and their institutional apparatuses represent a massive 'fire machine' that responds to these conflagrations, whether in small, select ways for easily managed fires, or in sustained, massive ways for infernos as large as the Horse River fire.

The next four chapters follow this track in unpacking the mechanisms and arrangements used by government agencies in an attempt to create order, predictability, and effectiveness in their programs. Firefighting seems like it should be entirely straightforward task: put out the flames as quickly as possible. Yet, unlike the first few days of the Horse River fire, where the priority of protecting the nearby city of Fort McMurray was the obvious objective, most fires in Canada are characterized by significantly less certainty in the aim at hand. Although life and property are heralded as goods to be protected, just how much is reasonable to spend protecting an isolated cabin or timber that is unlikely to actually be harvested? And, why is it so difficult for wildfire agencies to confidently know where these cabins are or which timber is actually valuable? Thing become even more complicated when different social benefits or priorities come into conflict, such as the objective of restoring fire to the landscape to improve ecological systems versus the desire to exclude fire from landscapes to protect the established habitat of a species at risk. As argued in Chapter

Four, these are vital, value based questions for firefighting, and increased wildfire science and suppression technology can do little to solve these tensions on its own.

Another challenge with differing provincial approaches to firefighting is that it creates inherent inconsistencies when resources need to be shared across the country. Over the span of the Horse River fire, firefighters, incident commanders, and resources would come to Alberta to assist from every Canadian province and territory (excluding, of course, Nunavut, which doesn't have a wildfire program). These personnel have to work together seamlessly to ensure that operations to prevent the spread of fire are efficient, effective, and safe for everyone involved. The Canadian system – through an organization called the Canadian Interagency Forest Fire Centre, or CIFFC for short – adopts a very specific approach to solving this problem: creating interoperability, or a system wherein units are made "interchangeable" or "fungible," much like currency. Chapter Five investigates the tension between provincial independence and the need for interoperability, and the intricate systems that governments and para-governmental organizations create to attempt to instil interoperability over the personnel and resources they interact with.

A place where wildfire agencies claim that science could make a significant difference is in predicting fire behaviour, fire occurrence, and resource availability. By its end over sixteen months later, the Horse River fire had spread over more than one and a half million hectares (over twice the size of the entire Greater Toronto Area). Knowing how many firefighters were needed to battle a blaze of this scale – let alone how many additional resources needed to be kept available for other fires that would happen in the country simultaneously – is a remarkably difficult problem to solve. Moreover, the system of sharing resources described in Chapter Four depends entirely on agencies being able to make these predictions accurately throughout the system in order to be comfortable sharing their own resources (in other words, having confidence that they will not need the firefighters or equipment within their own province during the period that they are loaning it elsewhere). Chapter Six considers the different approaches that are used to forecast fire occurrence and resource availability, the limits of modeling and prediction, and possible paths forward for a system so dependent on this kind of forecasting.

In Fort McMurray and elsewhere, the only guarantee is that fire management and response will never be perfect. Instead of expecting failure-free operations, it is essential that wildfire management agencies effectively learn lessons from what went well and what could be improved during past operations, as well as effectively integrate scientific research into their decision-making. Creating an institutional knowledge system that is capable of change and improvement, however, is no small task. In the Canadian context, fire agencies largely attempt to learn lessons through three different paths, which I discuss in Chapter Seven. The first option is 'After Action Reviews' or AARs. These are comprehensive analyses produced either internally or externally that review some element of a fire response. In the case of large fires like Horse River there may be several such reviews, both commissioned from arms-length agencies and conducted within the response organization itself. Fortunately, as identified in Chapter Seven, these reviews do tend to feed effectively back into agency practice within Canada. The two problems, however, are that the lessons do not tend to be shared as effectively as they could be across the country and that rarely do those outside of wildfire management agencies (like provincial and federal politicians, local governments, and community members) learn these lessons, let alone change their actions as a result.

There are two other paths for learning lessons about how to better manage fire: fire research and knowledge exchange through the Canadian Interagency Forest Fire Centre. Canada has a storied history of research in fire behaviour, fire ecology, and fire weather. Problematically, however, this research has declined significantly since the 1990s, and what little was left shifted from field-validated research to computer modeling. Chapter Seven explores a confluence of factors – including perpetual fears about scientific prescribed burns and inadequately short research horizons – that led to these changes, which have potentially slowed important learning and undermine the reliability of data for firefighting operations across the country. Moreover, there has been a particularly notable gap of systematic work on the human, social, and political dimensions of wildfire to the substantial detriment of Canadian safety. A subset of these important but ignored issues have been seen as sufficiently 'operational' to warrant inter-agency knowledge through CIFFC, but this overall gap results in inadequate attention to and learning about human factors in fire management. At best, these choices relinquish Canada's global reputation in wildfire research; at worst, they jeopardize public and firefighter safety behind a façade of sound bites about renewed commitments to wildfire research.

The final chapter – Chapter Eight – concludes the volume with a forward-looking view of wildfire in Canada. In the wake of Fort McMurray, the incredible fire season in British Columbia the following year, and the December 2017 firestorm that swept through southern California, pundits have been quick to blame climate change as the source of increased fire risk. Climate – as well as impacts through drought, disease, and pests – are certainly a portion of the increasing risk of wildfire in Canada. Yet, just as large are drivers like the conscious choices that we make as people and communities: where to settle and build, what kinds of aesthetic and resilient landscape we want around these homes, and how much we are willing to either tolerate fire on the landscape or invest in expensive alternatives to manage fuel loads. Wildfire may well be affected by climate change – even if early signals are complicated to examine – but an overemphasis on blaming fire on climate can blind us to more straightforward, if taxing, responsibilities and actions we must take to protect our communities from fire.

This is a book about wildfire. It is meant as an accessible introduction to the state of wildfire management in Canada, the pressures and stresses that managers face, and what could tangibly be done to improve the system. To this end, the Appendix contains a summary for policy makers and fire managers of the key recommendations from each chapter. The chapters contain the qualitative stories and quantitative data about why they are important, described in a way that makes sense for those readers who may have never thought about fire in Canada. This is a book for both: the veteran fire manager and the new-to-fire reader who wants a primer on the issues that matter.

Yet, this book ultimately is about something bigger than – and revealed by – Canadian fire. It's about how the systems we have built to control fire reveal something about who Canadians are, how we think governments ought to run, what the role of science and technology is in improving fire response in the future, and what the example of wildfire teaches us about how institutions know, learn, and act on high-stakes challenges. It's an exploration of how agencies try to make sense of the world around them, and how they grasp for forecasts and predictions and knowledge and certainty in a world that offers very little. And, it's an investigation into how we ought to divide up those things that are best managed by experts, those things where experts can never manage effectively because of divergent public values, and those challenges that lay somewhere in between. It's a set of stories of fire about who we are, how we wish we could control the world, and how, ultimately, we will never be able to totally control fire.

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Just before the sun set on May 1st over Fort McMurray, Dave Mulock, the crew aboard his helicopter, the tankers overhead, and the other firefighters who had been working MMD-004 and MWF-009 would have prepared to return to their bases. They had activated a massive apparatus of wildfire management that would bring together a country – and international allies – in an attempt to control the fire. They knew the process was just beginning.

Heather Pelly piloted another helicopter flying back from the Horse River fire that evening. Recounting the day to author Edward Struzik later on, she remembered the flight back vividly. "Usually," she said, "at the end of the day, the helitack crew is pumped and talking about what happened on the ground. But all I saw and heard was the four of them looking back at the fire in silence. It was spooky."
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Part I: Fires Past

2. One Hundred Years of Canadian Fire

"Boreal forest without fire is like a rainforest without rain."

"We've got a bit of a problem," Darby Allen said over the phone to Dale Bendfeld.[12] "Would you come in and give me a hand?"

Over the course the Horse River fire, Darby Allen became something of a Canadian folk hero. As the Fire Chief in the Regional Municipality of Wood Buffalo, which contains Fort McMurray and the surrounding area, Allen was one of the most visible faces of the fire response through his daily media briefings. Late afternoon on Sunday, May 1st, however, Allen was at home alone when he received a call from Alberta Forestry alerting him to the fires on the doorstep of Fort McMurray.[13] He headed to the Regional Emergency Operations Centre, located in the south end of Fort McMurray, and began to call colleagues like Dale Bendfeld, the Executive Director of Community and Policing Services for Fort McMurray.

Within the next few hours, a total of four helicopters and fifteen firefighters from Alberta Forestry were working the Horse River fire. As these crews began to work MWF-009, air tankers and additional resources – including municipal fire crews from the city, as

12 Warnica, "Battling the Beast: The Untold Story of the Fight to Save Fort McMurray." Phone conversation and context as recounted by Darby Allen to CBC news.

13 The timings attributed to this phone call from the CBC account (namely midday and lunch) conflict with the reported actual detection of the fire at 4:03pm in the provincial after-action reviews.

the fire fell within their boundary – were diverted to MMD-004, the closer fire posing a larger immediate threat to Fort McMurray. While this hard and fast strike was, as predicted, effective in subduing the smaller MMD-004, the Horse River fire was hardly cooperative. From under two-hectares when it was discovered at 4:03pm, it had grown to sixty hectares by six o'clock, and 120 hectares only an hour later.[14]

Like most fires in the vast boreal region that spans across Canada, weather and fuel were the two key elements of the wildfire triangle (topography, by contrast, plays a slightly more minor role in these large and relatively flat forests). Winds from the west blew at roughly 10-20 kilometers per hour as crews first arrived on scene, and the temperature between 11:00am and 6:00pm ranged from 21-25 Celsius. This created a condition fire managers refer to as 'crossover,' where the relative humidity level (just over 20% on May 1st) is lower than the air temperature. Crossover conditions supercharge fires, with the higher temperature and lower humidity helping to create dry air to feed the flames. As Darby Allen recounted later, "I realized, based on the weather, based on the conditions, that it was going to be coming this way".[15]

Fires in Canada are described according to a set of six-level ranking systems known as intensity classes or ranks, built on decades of research by fire scientists like Kelvin Hirsch, Marty Alexander, and many others at the Canadian Forest Service. When Mulock and the helitack crew began working the Horse River fire, it was ranked as 'Intensity Class 4' – a fire

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[14] MNP, "A Review of the 2016 Horse River Wildfire," 56-85. Times and values in this section are drawn from the account in the MNP Horse River Wildfire Report, as well as the KPMG reviews for Alberta and the Regional Municipality of Wood Buffalo.

[15] Warnica, "Battling the Beast: The Untold Story of the Fight to Save Fort McMurray."

that was mostly on the surface (e.g., the grasses and ground debris) but with an organized and moving flame front. Less than an hour and a half later, when the wildfire jumped its namesake Horse River at 5:26pm, the fire behaviour had increased to Intensity Class 5. This jump is significant: in Intensity Class 5, the fire has progressed from the ground to burning in the 'crowns' of the trees (the upper foliage), a major increase in its heat, intensity, and behaviour. Moreover, at this stage a fire begins to 'spot' by throwing embers and pieces of burning debris up into the air, which get carried by the wind ahead of the fire front itself and ignite new flames. At this stage, the Horse River fire was throwing these firebrands tens to hundreds of meters ahead – several days later, it would be spotting fires five to ten kilometers ahead of the core conflagration.

These weather conditions put the Horse River fire on the move. Over its afternoon and evening run, its average rate of spread reached 29 metres per minute. Even as the evening and night brought lower winds, lower temperatures, and higher humidity (eliminating the crossover conditions), the fire continued to burn.

The fire's rapid growth and movement towards the city resulted in a number of responses from local government, in addition to the firefighting being conducted by Alberta Forestry. Fort McMurray is located within a larger municipality, the Regional Municipality of Wood Buffalo (RMWB). The Regional Municipality provides significant services to both the city and surrounding areas. The Fort McMurray Fire Department (a full time department with five stations), for instance, falls under the RMWB, as do five other rural, paid-on-call departments in Fort Chipewyan and Fort Mackay north of the city, and Saprae Creek, Anzac, and Conklin to the south.[16] The RMWB also provides an emergency management branch responsible for all hazards (including wildfire), which can activate a Regional Emergency Operations Center.

By suppertime on Sunday, Darby Allen, Dale Bendfeld, and about twenty other municipal personnel had gathered in this Regional Emergency Operations Centre (known as the REOC in the language of firefighters). The threat escalated rapidly. Just after seven o'clock, Mayor Melissa Blake issued an Evacuation Warning for the neighbourhood of Gregoire (in essence, a directive to be prepared for a possible evacuation). By the time the sun had set – a late 9:09pm on May 1st – the fire was less than two kilometers from the McKenzie Industrial Park, and the city had formally activated the REOC for decision-making. At 9:57pm, Mayor Blake declared a State of Local Emergency for the Regional Municipality, which meant that Darby Allen (Fire Chief and Director of Emergency Management) became the highest-ranking decision maker in Fort McMurray, Dale Bendfeld became the deputy, and senior firefighter Jody Butz became the director of city firefighting operations.

Although the sunset meant that helicopters and air tankers could no longer operate on the fires – and, as a result, fire crews couldn't work on the ground without overhead supervision and evacuation options – there was much remaining to be done as the late hours of May 1st bled into early morning on Monday, May 2nd. At 10:33pm, an Evacuation Order was issued for Centennial Park, Prairie Creek, and Gregoire, and by midnight the fire had

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[16] KPMG, "May 2016 Wood Buffalo Wildfire Post-Incident Assessment Report," 23. A sixth volunteer department in Janvier was revived on November 3, 2017. The five departments at the time of the Horse River fire constituted approximately 90 firefighters.

reached approximately one kilometer from the only highway into and out of town. At the same time, Bendfeld coordinated a series of logistics – calling in transit drivers to move garbage trucks from a dump that was threatened, booking helicopters for air observation in the morning, and preparing for the possibility of losing power lines. While the cooler temperatures, lower winds, and higher humidities overnight brought some relief – and a downgrading of the evacuation orders into 'shelter in place' orders – the relief was temporary rather than permanent.

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Pelly, Mulock, and their respective crews were hardly the only firefighters active in the province of Alberta as the Horse River fire began to grow earlier that day. At ten o'clock on the morning of Sunday, May 1st – before Darby Allen received that phone call, before Mulock spotted the smoke, and before MWF-009 had even started – there were already twenty-six other fires burning in Alberta. Two were out of control, and Alberta Wildfire was actively managing another ten.[17] An additional 255 fires had already been extinguished between January 1st and the beginning of that burning period.

These 281 total fires were mostly human caused, which is typical for spring fires in Alberta. Spring is a particularly volatile time in the province, as it marks a period between the protective cover of snow on the ground and a point when trees and grasses have become green, taking on enough moisture to easy the initial spread of fire. This 'pre-green-up' season

[17] MNP, "A Review of the 2016 Horse River Wildfire," 25.
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is also a time of active winds and periodic warm weather. There is one redeeming feature of human-caused fires. Because they come about from human activities, they also tend to be observed, reported, and 'actioned' (in the colloquial language of wildfire responders) in a much more timely manner. As a result, these 281 fires had only burnt approximately 834 hectares across the province – far less than later season fires typically burn.

Averages are incredibly misleading in trying to understand wildfire in Canada. As illustrated in Figure 3, there is radical variation in fire activity in each province from year to year.[18] Using the total hectares burnt in each province as reported to the Canadian Interagency Forest Fire Centre on the final day of the fire season, the chart plots area burnt logarithmically. In Newfoundland, for instance, the twenty-five year average of area burnt (1992-2017) is 13,686 hectares. Yet, while the province was close to that value in 2014 and 2013 (9,129 and 10,235 hectares respectively), they had almost 30,000 hectares burnt in 2013, and fewer than 700 hectares burnt in 2015 and 2017. Similarly, in British Columbia – with a 25-year average of 31,753 hectares – the past five seasons range from fewer than 90,000 hectares burnt in 2014 to over 1.2 million hectares in 2017.

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[18] Harrington, *A statistical study of area burned by wildfire in Canada 1953-1980*. In general, the variation is spread relatively evenly across the country because of the way seasonal weather load tends to be distributed, with some provinces experiencing high loads while other experience lower loads. Per the Harrington results, for instance, between 1953 and 1980 only a total of six months of the 28-year period saw more than two provinces affected by "extreme fire months" simultaneously.

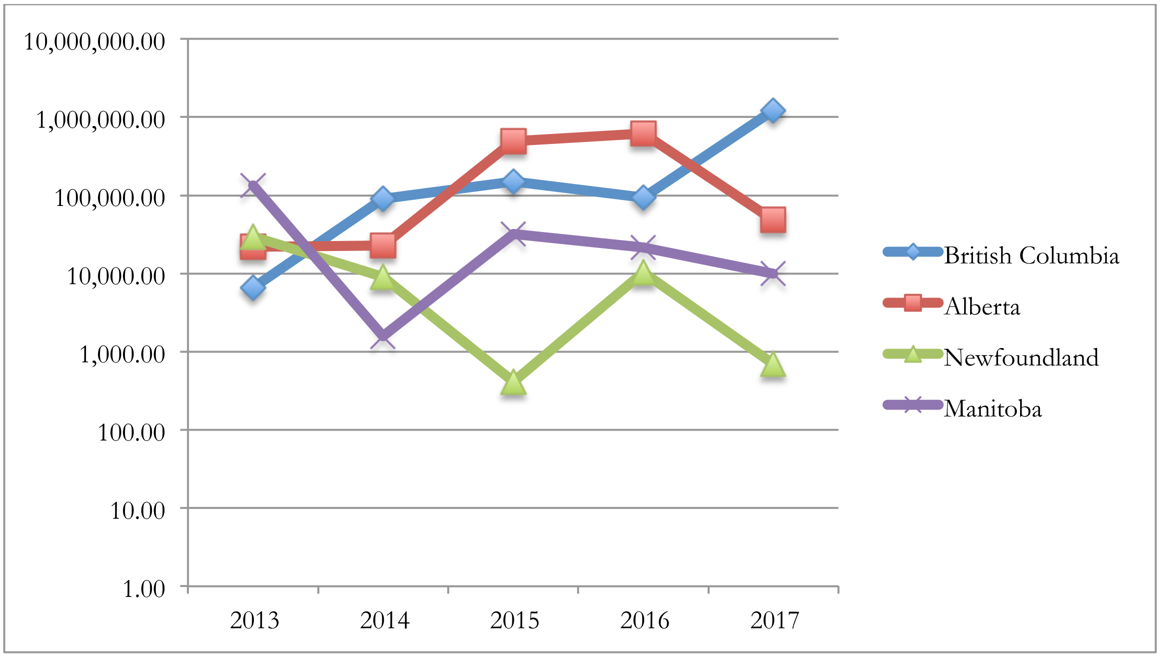

Figure 3
Hectares burnt per season, presented logarithmically, as reported by the Canadian Interagency Forest Fire Centre in their final situation report each year.

They are just as misguiding when you consider national level data. Take, for example, the range of timespans you could use in calculating average fire seasons up to 2017. The national twenty-year average (from 1997 to 2017) of hectares burnt in Canada is 1,034,831 hectares. Yet, the ten-year average (from 2007-2017) is only 169,846 hectares – only a sixth of the result if you look at a period twice as long.

Part of this variation comes simply from having busy and quiet seasons. Some seasons simply have fewer fires that all stay relatively small. Others are referred to as 'one hit wonder' seasons, where a single major fire massively inflates the provincial tally (take, for instance, the Horse River fire in Alberta in 2016 – a single fire responsible for 589,552 hectares burnt, or almost seven times the 25-year average total Albertan season in a single fire). By contrast, the 2015 season in Alberta saw approximately 1,700 fires total in the province, compared to a 25-year average of 562 fires in a season. Both 2015 and 2016 look like vastly above average fire seasons in Alberta, but for completely different reasons.

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Just as averages can be misleading, so too can focusing on the exceptions. All too often, the story of wildfire in Canada is told through giant fires alone – the 1825 fire in Miramichi, killing hundreds; the 1950 Chinchaga River fire that was the largest in North American history; or the 2016 Horse River fire and its $9.9 billion direct and indirect costs. To understand these massive fires and how Canada has been shaped by fire, however, requires examining a larger set of important fires and the way they shaped how Canadians encounter, make sense of, and respond to wildfire across the country. These fires aren't always the largest, the most intense, or those generating the most fatalities. Instead, they shaped institutions, caused managers to question previously shared norms, or revealed something new about wildfire in Canada and the evolution in the relationship between people and fire.

One hundred years before Dave Mulock arrived on the scene of the first smoke, and before Darby Allen received the phone call and began his drive to the REOC, another wisp of smoke began to waft above the trees of the boreal forest. July 29th, 1916 in Cochrane, Ontario was, in many respects, much like May 1st, 2016 in Fort McMurray, Alberta. As was common at the time, settlers cleared land via slash and burn methods, igniting piles of flammable debris to rid themselves of the waste. Much like in Fort McMurray, there had
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been little rain over the preceding months, and the arrival of a gale winds (in this case from the southwest) drove the fire towards the town.[19] And, in parallel form, the Cochrane fire brigade was unable to extinguish the blaze, which ran through the centre of the town itself. In Cochrane, the fire wasn't a single cohesive blaze, but a "matrix of burns" that advanced across the town taking advantage of intermingled settlements and broken forest. The biggest difference from Fort McMurray, perhaps, were the fatalities – in one case, ten people died as they tried to make their way to safety in a lake.

This burn wasn't unsurprising. In August of 1910, only 6 years prior, Cochrane had also been burnt to the ground, only to be quickly rebuilt. Again, a year later in 1911, gale-driven fires "virtually razed… a tangle of tiny towns, hastily erected along recent railways that linked mines with metropolises," including Timmins, Porquis Junction, and Cochrane.[20] These fires and their context in a region so rapidly opening to mining and other resource exploration led to a host of remarkable stories, including a boxcar chock full of 350 cases and 50 kegs of dynamite that blew a seven hundred square foot hole, only "to have arise from the cavity a spring that would supply water for the survivors."

It wasn't Cochrane, however, but the fire the same day in Matheson – some eighty kilometers to the southeast – that defined the 1916 fire season in Ontario. Even more than in Cochrane, the 'fire' wasn't so much a single blaze as a multitude of fires that burnt together and flared "at almost every point of the compass." To this day, the cause of these fires isn't clear. Depending on the theory, many sources of ignition were possible

[19] Pyne, *Awful Splendor: A Fire History of Canada*, 423.

[20] Pyne, *Awful Splendor: A Fire History of Canada,* 420.

contenders: further burning of slash by settlers; sparks or embers from the Ontario Northland Railway; or even the use of dynamite to clear land for the railway.[21]

Much like their land clearing methods, the railways had an explosive influence on Canadian forests. In Cochrane, the railway was a relatively new feature, having been surveyed only in 1900 and reaching the town in 1908. They brought economic activity, connecting mining and forestry resources to southern metropolises. They also brought fire: sparks from their locomotives, embers from their coal fired engines, and human causes to previously inaccessible areas. Their combustion-driven engines claimed to control fire for productive human use – powering machinery and transportation across great distances – but ultimately brought and amplified humans themselves, the ultimate uncontrolled source of fire.

Whatever the cause, the fire starting in Matheson was even more significant than the Cochrane fire. Villages built of wood were consumed in minutes and forests were completely levelled. "It came," recounted a prospector from the area, "sped by a howling tornado, a living wave of flame, traveling at 60 miles an hour, and nothing lived in its wake".[22] The official death toll read 244, but local estimates suggested closer to 500 killed. The community of Nushka, population 300, had only eight people accounted for after the fire. Matheson and Iroquois Falls were destroyed.

While the Miramichi fire of 1825 officially killed more (between three and five hundred), the Matheson fire remains the most deadly fire since Canadian Confederation in

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[21] Commito, "The Deadliest Fire in Canada's History was in Northern Ontario."

[22] Commito, "The Deadliest Fire in Canada's History was in Northern Ontario."

1867. The significance of Matheson, however, comes less from the fatalities associated and area burnt – almost two hundred thousand hectares – and more from the impact that came in the years that followed over how fires were fought in Canada. The government reaction was underwhelming in the immediate aftermath: a commitment to coordinating the relief operation (though, largely assumed by the Northern Ontario Fire Relief Committee, which drew on funds raised following the earlier Porcupine fire), a reminder that it had helped the Northern Development Branch battle the fire. Even worse, the department argued that the area said to have burned was "much exaggerated" and aside from a "tremendous loss of life" could not compare with larger fires of the previous fifty years.[23]

Yet, in the years that followed, significant changes arose. Ontario began to build the apparatus of a modern fire state, initially through the 1917 Forest Fires and Prevention Act. This Act created the position of a provincial forester and E. J. Zavitz, the first person to assume that role, created "protection districts" across the province (analogous to the modern 'Fort McMurray District' responsible for responding to the Horse River fire, and foundational to current arrangements, as will be discussed in Chapter Three). The province began building fire towers across its forests, which provincial staff would use to detect fire for decades to come. These advances ultimately wouldn't tame fire in the province, or across Canada, but they represented early efforts towards building massive systems of government in an attempt to control the flames.

[23] Pyne, *Awful Splendor: A Fire History of Canada,* 424. Pyne's account emphasizes the lip service of the Ontario government response, and its 1920 "confession" of its inability to control fire.

This era – the era of the combustion engine – represented a broader turning point in the relationship with nature as well. Fires like 1825 in Miramichi and 1916 in Cochrane and Matheson were largely fled on foot, with limited assistance during and after the fire by rail. One hundred years later, automobiles and aircraft defined the evacuation from Fort McMurray, as trucks, helicopters, and air tankers were enlisted to fight the flames. The fire was consumed across the country in social media video clips and instant news headlines, with a particularly technical lens as scientists and computer modellers offered predictions about where and how the fire might grow.

The fires one hundred years ago that set us on a course towards today's massive government responses and all consuming, heat-of-the-moment news attention were defined by the same triangles: fuel, heat, and oxygen; fuel, topography, and weather. They were massive conflagrations, with death tolls far higher than Fort McMurray or other contemporary Canadian fires. Yet, it wasn't their size that made them important, but the ways in which they interacted with society and the changes they spurred on in institutional and governmental arrangements as a result.

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As Eastern Canada faced massive flames between 1911 and 1922, the western portion of the country (with Saskatchewan and Alberta recently partitioned from the Northwest Territories into their own provinces in 1905) faced fewer "truly villainous" fires.[24]

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[24] Pyne, *Awful Splendor: A Fire History of Canada,* 177.
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Like in the east, fire followed the railways, although technical solutions including improved fuels, spark arrestors, debris clearing, and regular patrols helped began to keep the problem in check. More futilely, the Forestry Branch of the Government of Canada's Department of the Interior operated a series of fire rangers who patrolled over 150 million acres of forest reserves and 'ranging districts' for incipient flames. Patrolling in canoes and boats, these federal rangers exerted little ability to control fire outside of unattended campfires on common trade routes. Like it had been for thousands of years, these rangers largely relied on Aboriginal communities to manage fire in the vast Canadian west.

This federal control over western forests (it had earlier been ceded to Ontario and other Eastern provinces) did not remain the case for much longer. Three years after the Cochrane and Matheson fires that shaped Ontario's approach to managing the hazard, the same province-reshaping flames came to the west in a massive firestorm that ultimately burned almost four times the land that the Horse River fire would 97 years later. Again, the ingredients were virtually identical to the cocktail present in Fort McMurray in 2016.[25]

The town of Lac La Biche, Alberta, home to a community of approximately 300 settlers, was a frontier town like Fort McMurray. The winter of 1918-1919 had offered little snowfall in Alberta and Saskatchewan. The drought continued through an early spring, again creating conditions where grasses and trees were dried out and 'pre-green-up.' All that was needed was a source of ignition – "rampant incendiarism as settlers and ranchers seized on the dry conditions to catch up on years of poor burning" – and the arrival of hot, dry winds

[25] Murphy, Tymstra, and Massie, "The Great Fire of 1919: People and a Shared Firestorm in Alberta and Saskatchewan, Canada." In this section, I draw heavily on the excellent narrative and analysis of the 1919 fire by Peter J. Murphy, Cordy Tymstra, and Merle Massie.

on May 19th.[26] Word of the fire passing through Lac La Biche finally reached Edmonton on May 20th, delayed in large part because of the fact that the fire had burnt the telegraph lines. The report from the Edmonton Journal on May 21st was grim, and could easily be mistaken for a report from a century later:

> "Swept away in the maelstrom of a raging forest fire which descended upon the place like a furnace blast on Monday afternoon, the little village of Lac La Biche is today a mere smouldering mass of ruin and desolation… From noon, the men of the village were out trying to hold the fire on the south side of the track. It is thick brush all through there and the roar of the fire as it swept through the great Spruce, and the green Poplars was terrific. The bush comes right to the town, and with the gale that was blowing, the fire carried for miles. When the fire was still a mile and a half away, the flames carried over and set the town afire".[27]

Lac La Biche was far from the only town affected. All across mid Alberta and Saskatchewan, a massive patchwork of fires burned intensely for nine days, until heavy early June rains extinguished the blaze. Matters were made worse by the massive general strike in Winnipeg (which made it hard to find firefighters who, at the time, were often recruited from bars and hired on for the fire); the Spanish Influenza outbreak over the preceding winter (which killed somewhere between thirty and fifty thousand Canadians); and significant pent-up woody debris that hadn't been cleared around communities because of the sheer number of Canadians fighting in the Great War. The devastation was widespread, reshaping communities and landscapes from Lac La Biche in Alberta almost as far as Prince Albert in Saskatchewan.

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[26] Pyne, *Awful Splendor: A Fire History of Canada,* 179.

[27] Edmonton Bulletin, "Lac La Biche Village in Ashes; Entire District Is Homeless; Condition of People Perilous."

Perhaps the biggest change to arise from the firestorm was a shift in responsibility for forests and, in turn, fire. As Alberta and Saskatchewan became provinces in 1905, they experienced the great Canadian exercise of 'devolution'. On issues like health, education, and resource management, the federal government transfers control – and with it, responsibility – downwards to the provinces. Yet, much like in the history of the modern territories, the Government of Canada was hesitant to transfer ownership over valuable natural resources like oil, coal, and timber. As such, it was the Dominion Forestry Branch who maintained responsibility for creating parks and reserves, overseeing lumber activity, and, indeed, fighting fire.

This federal control translated into limited on-the-ground presence. The fire rangers mentioned earlier, for instance, were each responsible for patrolling approximately 10,000 square kilometers in Northern Alberta and Saskatchewan. The Edmonton Fire Ranging District, created in 1912 on recommendation of a timber inspector, was responsible for the area from the Red Deer River to "as far north as it is practicable".[28] And, the chief fire ranger in Edmonton, who was the only person responsible for managing this district, served in the Great War until only weeks before the 1919 fire.

As with most elements of devolution, power is often given up only when it's too costly for the owner to bear. Although the forests offered lucrative timber for the Department of the Interior, rapidly escalating firefighting costs led Prime Minister Mackenzie King to begin considering transferring forestry and resource responsibility to

[28] Murphy, Tymstra, and Massie, "The Great Fire of 1919: People and a Shared Firestorm in Alberta and Saskatchewan, Canada," 25.

Alberta and Saskatchewan in 1921. These agreements were signed by 1929, driven largely by a federal estimation that the Government of Canada could save at least one million dollars a year by passing the responsibility to the provinces.

Other changes arose from the 1919 fires as well. One of the final acts of the Dominion Forestry Board, before losing responsibility over Saskatchewan and Alberta a decade later, was to initiate aircraft patrols for fire. These flights continue to this day, serving as predecessors to both the fixed-wing detection programs across Canada, and the loaded-patrols in helicopters like Mulock was piloting when they detected the Horse River fire. Fire Rangers were also given increased enforcement power over the use of fire to clear land: a precursor of the emphasis on arson investigation and prosecution that would emerge decades later. And, in an ironic turn of events, the fire also led to the establishment of Prince Albert National Park, less than a decade later, because its burned timber was significantly less valuable to keep open to logging operations.

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The final defining fire of the 1910s and 1920s returned the focus to Ontario. In 1922, the all-too-familiar ingredients came together again to produce a tragic burn. The town of Haileybury had been incorporated in 1904, only to burn in 1906 and 1911. It was rebuilt each occasion, growing to a population of 5,000 residents by the time the fire struck in 1922. The town, located 150 kilometers northeast of Sudbury, was a self-pronounced 'millionaire town' with amenities like three cinemas and an elevator-equipped hospital.
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As in 1916 and 1919, hot and dry conditions were the prelude to fire. The summer had been particularly parched and weary fire rangers asked to extend their season. The request was denied, however, and on October 4th, burning permits were no longer required for settlers who wished to dispose of slash or clear the land.[29] These small burns came in massive numbers that morning, and town residents were hardly concerned by the smoke (some, even, saw it as a sign of progress, much like the smokestacks found in communities further south).[30] Yet, with so many fires on the landscape – and poorly contained – it was only a matter of time and wind before they became a blaze. The winds remained calm that morning, but by afternoon they shifted from the south to west. Around 5pm, a cold front arrived bringing gale force winds to the region. The winds kicked up smaller fires into larger blazes and, just as dangerously, created blizzards of embers capable of crossing rivers, fields, and roads.

This ember storm is a regular feature of wildfire. Heat, wind, and dry materials regularly conspire to launch firebrands well in advance of the fire itself. This small burning matter can travel several kilometers, lighting spot fires in the bush and nesting into the roofs, eves, and decks of homes to kindle fires. In Fort McMurray, embers and firebrands caused the majority of home losses. According to a post fire assessment by the Institute for Catastrophic Loss Reduction, most homes were not lost because of the fire itself, but rather

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[29] Galloway, "The Great Fire of 1922 (The Haileybury Fire)."

[30] Pyne, *Awful Splendor: A Fire History of Canada,* 426.

“millions of raisin-sized firebrands searching for places to carry on with combustion, and succeeding all too often”.[31]

In Haileybury in 1922, these embers also led to massive destruction. Within the course of a single afternoon, eighteen townships had been burnt, almost 6,000 people were left homeless, and forty-three people had been killed. Citizens of the town panicked, heading for the lake where they covered themselves with blankets in an attempt to ward off the embers. By midnight, all but one building in the town was razed to the ground.

The fire in Haileybury was illustrative of a pattern to come in wildfire across Canada. While Cochrane, Matheson, and Lac La Biche all suffered from massive losses of towns and residential areas, the land in Haileybury had a different character. Some ninety percent of it had been made private by the government, turning the town from a remote mining outpost into ‘agricultural countryside.’ Yet, the change from forest to urban environment wasn’t uniform or complete: pockets of forest, slashing, grass, and other flammable materials were mixed all throughout the town. When the fire came knocking, these partly cultivated, partly urbanized landscapes proved remarkably flammable, contributing to the ember storms that burnt the city to the ground. Haileybury was a reminder that not only are fires an inevitable reality of the Canadian boreal, but that towns mixed into the bush burn just as readily as the trees themselves. The fire proved that the era of combustion engines would not eliminate uncontrolled combustion, as appealing as helicopters, air tankers, and fire engines would prove in 2016 in Fort McMurray.

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31 Cotter, “Blizzard of Embers Sparked Fires that Burned Fort McMurray Homes Last Year.”

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As dawn broke on Monday, May 2nd, there was a calm in Fort McMurray. Jody Butz, who had become the director of firefighting operations within the city, took a helicopter flight around the fire as soon as there was enough light to fly (and before Alberta Forestry closed the airspace above the fire so that it could be used safely by air tankers and firefighting helicopters). The Horse River fire had indeed gotten close to the city – about a kilometer and a half from the edge of the town – but Butz imagined the fire would look worse than it actually did. It appeared to have a narrow leading edge that could be managed, and the Alberta Forestry plan to use bulldozers to construct firebreaks seemed viable. "We've got a little bit of a head start here," thought Butz. "There's no surprises".[32] Improving the situation further, the Fort McMurray crews had mostly finished the mop-up of MMD-004, and extra crewmembers were being used to get gear back into order at the stations.

Alberta Forestry continued to maintain responsibility for fighting MWF-009, using both bulldozers and tankers to work the fire. As the day progressed, smoke began to thicken – leading to difficulties accurately pinpointing the edge of the fire relative to the city and creating a light snow of white ash over the neighbourhood of Gregoire. Yet, these changes were expected throughout the day as temperatures rose and the humidity fell. As such, many responders and managers still had a great deal of confidence about the likelihood of

[32] Warnica, "Battling the Beast: The Untold Story of the Fight to Save Fort McMurray." Subsequent quotations from Butz and Allen are drawn from this account.
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containing the blaze. "There wasn't a lot of uncertainty there," said Butz. "The wind was blowing away from town. We're two days into this and the edge of the fire closest to town was getting cold".

Around 1:30 in the afternoon, Damian Asher, the captain of Fort McMurray Fire Station Five, made his way up to the REOC on the second floor.[33] As he walked into the room, he was greeted with roughly two-dozen coloured vests draped over chairs. The vests each represented a different incident command function: orange for operations, red for logistics, and blue for planning. Darby Allen was wearing a green vest as the commander, and a variety of other folks were busy writing notes on the whiteboards that surrounded the windowless room.

Jody Butz called over to Asher.

"Where's forestry with it?" asked Asher.

"Spread to eighteen hundred acres but they can contain it," replied Butz. "Dozers are working around the fire's edge, making a break. They've got a good head start… it's still west of the Athabasca. Long as that river stays put, I think we're fine."

In Asher's view, this made sense. The fire was still west of the Athabasca River, which was a kilometer wide. While firebrands could easily jump that gap, as long as ground crews were ready to snuff them out, it should be easy to keep the fire under control.

"We'll be ready," replied Asher.

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[33] Asher and Mouallem, *Inside the Inferno: A Firefighter's Story of the Brotherhood that Saved Fort* McMurray, 35-37. This account is the source of Asher's perspective of his time in the REOC and his conversation with Butz.

Despite the confident pronouncement, the reality was that as the fire burned outside of city limits, it was the responsibility of Alberta Forestry. "We're the Fort McMurray Fire Department," Asher reminded his firefighters that afternoon, many of whom were concerned by the images they were seeing on social media. "When there's a fire in Fort McMurray, we're the first to know."

Darby Allen and Dale Bendfeld, however, didn't feel this calm. In 2003, while still with the Canadian Forces, Bendfeld had led a team involved in responding to the wildfire that burned through parts of Kelowna, British Columbia. He was particularly nervous of the impending "witching hour," the overnight period when it was easy to underestimate a wildfire and think it was 'asleep.'

Allen, too, was kept up by those concerns: "Monday then, maybe things had calmed down. But, in my mind, it hadn't calmed down because I knew it was going to go this way [toward Fort McMurray]. Whether the wind was going to help it or not, it was going to go this way."

Just before the end of the shift, however, Asher still wanted to ensure that his firefighters projected a message of calm to their families and friends. He took several of his firefighters up to the top of the hall's hose tower to get a better glimpse of the fire. "Looks fierce, doesn't it," he said. "But, look. See where it's headed? South. That's good… I know it looks big and scary, but they've got everything on it. Tonight, the temperature will cool and squeeze it down. Forestry will go for the kill in the morning."

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The massive number of institutions and managers involved in responding to the Horse River fire were the result of an increasingly sophisticated approach to wildfire response born out of the decades prior. While the fires of the 1910s and 1920s in Canada set the stage for a more aggressive response to conflagrations, it was through the 1930s and 1940s that the apparatuses of wildfire response became increasingly large and sophisticated. These decades were marked by an era of massive attempts at suppressing fires, and rapidly diminishing public and government acceptance of large losses from blazes – whether of timber or lives. With this came increased risk to the safety of firefighters, who found themselves placed in more aggressive roles in an attempt to stop the flame. And, concurrently, it began a pattern of escalating costs and resources invested in fighting fire across the country, tying the knot even more tightly between the worlds of logging and firefighting.

In 1930, the responsibility for forestry activities was devolved to the Province of Alberta from the Federal Government. There was initially apprehension among rangers about this change, but according to the first Director of Forestry, T. F. Blefgen, "employees were transferred so smoothly from one government to the other that most didn't notice any difference".[34] With this change, the Alberta Forest Service, located within the Department of Lands and Mines, assumed responsibility for protecting and administering over five million

[34] Murphy, *History of Forest and Prairie Fire Control Policy in Alberta*, 227. This section draws heavily on Murphy's detailed and thorough history.

hectares of forest reserves, as well as fire protection for thirty seven million hectares located within the "Edmonton Fire Ranging District."

During the first year of this provincial management, several changes occurred to both fire protection tactics and land administration, including constructing roads and fire breaks throughout the reserve and ranging district; disposing of slash piles from previous logging efforts; replanting some burn sites; and cutting boundaries around the forest reserve to reduce the potential of spread outside the parameter. Significant effort was also invested into developing a training program, which consisted of 18 camps, almost 800 rangers-in-training, and another 100 supervisors.

These advances were a far cry from previous approaches to managing fire in the province. Without government firefighters to depend on, preventing catastrophic losses required all residents to take care to prevent fires in the first place and to band together to respond when they did occur. As Blefgen summarized in his first report as the Director of Forestry,

> "One thing we had down there [in the mountain and foothill regions] which we liked very much was that every rancher surrounding those hills was very careful with fire and knew exactly what he was up against if there was a fire because he lost grazing for his cattle… Any time we got a fire in that particular area the ranchers would come from every direction and bring their own tools, ploughs, [and] everything else, and they would dig in and work to beat the band and you never had to pay them. They just flatly refused to take any payment. They said 'We're saving our own bacon, why should you pay us for it.' And this went on for years. Later on of course they demanded pay but the original was a co-operative deal. 'Let's get in and get the darn job done and get out'."[35]

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[35] Murphy, *History of Forest and Prairie Fire Control Policy in Alberta,* 228-229.

The techniques used for firefighting by these ranchers were quite rudimentary. A common approach to dealing with grass fires was to take one or more logging chains and attach the ends to two different saddle horses. "Racing along the fireline," with one horse ahead of the fire and one on the already burnt side, they would drag the chain along the grass and fire to extinguish it. In one particularly graphic case, related a rancher, they didn't have a chain:

> "…one guy said, 'Oh, that's all right.' So he butchered a steer – split him down the middle and hooked a [rope] on one front leg and one on the back leg and put the bloody side down and tore across the fire and it worked better than the chain."[36]

Chains – and butchered steers – were soon to be replaced by an increasingly large and formalized firefighting role by the Forest Service.[37] The Prairie Fires Act offered more responsibility and workload for fires, effectively putting all of Alberta within the fire district and allowing fires only under permit and when safeguards and weather were appropriate. In 1932, responsibility for timber operations was also transferred to the Forest Service (from the Lands Division), continuing to reinforce the linkages between silviculture and fire management. Fires continued to be a problem through the early 1930s, however, including those started by unemployed job seekers looking to be hired on as firefighters.

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[36] Murphy, *History of Forest and Prairie Fire Control Policy in Alberta,* 229. This practice was actually fairly widespread in the United States under the moniker of the "beef drag."

[37] This increasing formalization took significant time. Through the 1970s, for instance, Manitoba was still periodically recruiting firefighters at moments of crisis from local bars.

The fire season in 1936 was particularly severe. Blefgen noted an "appalling carelessness" in how people cared about fire and the losses it created. He also laid the blame at understaffing, and particularly the emphasis on hiring workers seasonally (rather than full time, year round) and often only for the shortest season possible – a pattern that has continued and re-emerged in recent years across the country.

Two 1936 fires also illustrated that fire management could not be a provincial problem alone. Although the size of the provinces in Canada generally meant a degree of isolation, two different infernos that summer burnt from British Columbia into Alberta. The Pass Creek fire (some 18,500 hectares) burned from British Columbia's Flathead River Valley into Alberta's Castle River Valley. And, the Highwood Fire (larger yet, at 24,500 hectares) burnt from BC's Elk River Valley into Alberta's Highwood Pass. In both cases, the Alberta Forest Service had positioned crews in the passes in an attempt to hold the fires before they could gain a foothold in the province. Yet, these crews became a liability when they each encountered "problems of access, mobility, and manpower compounded by fast-spreading fires burning under severe weather conditions". [38] In the Pass Creek fire, the crew was feared lost as the fire grew, and they were only saved by escaping down a rockslide as a fire burnt overhead. In the Highwood Pass, crews "had to retreat… to avoid getting trapped by new fires along the Highwood River which had spotted over them". These near-fatalities each received substantial post-fire discussions, which were a factor in the inter-provincial agreements that would emerge in coming decades.

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[38] Murphy, *History of Forest and Prairie Fire Control Policy in Alberta*, 239; *Awful Splendor: A Fire History of Canada,* 305.

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Not only did significant fires blow out of British Columbia during the 1930s, but they were also fought within the province in ways that represented the increasingly mechanised and institutional approach to fire management that was becoming common. Although BC had escaped significant fires during the first half of the decade, that good fortune changed dramatically in 1938. June of that year was particular hot and dry throughout the whole of the North American west, and particularly so on Vancouver Island, with only 2% of the normal rainfall in Victoria, British Columbia. Fires were plentiful, as was smoke: most flights in Alberta and Saskatchewan were cancelled, and by late June in British Columbia, the provincial Forest Branch was no longer even able to fly its detection flights.

The Bloedel Fire (also known as the Campbell River fire) was detected by a logging company fire patrol late in the afternoon of July 5th.[39] The lumberyard, belonging to Bloedel, Steward, and Welch Logging Company, had a series of train tracks running through it, and the fire started about 300 feet away. Jock McLeod and David Crawley, the two men on patrol, ran for two miles to the nearest telephone to sound the alarm. One hundred and eighty-five lumbermen were dispatched from a nearby camp, and firefighting began around two hours later. The fire was two hectares in size, or about the same size of the Horse River

[39] Parminter, "Darkness at Noon – The Bloedel Fire of 1938." John Parminter of the BC Forest Service has written an excellent, narrative style of the account, which I draw on heavily in this section.
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fire when it was first spotted. By sundown, winds from the northwest blew embers across the eight-hundred-meter-wide Gosling Lake.

Beginning the second day of the fire, logging crews attempted to use a combination of bulldozed firebreaks and train-mounted water tanks and pumps to hold the fire. All appeared to be going well until day ten of the fire, when the resurgence of wind from the northwest pushed the relatively small (sub 300 hectare) fire out of control again and forced the evacuation of forty guests from the Forbes Landing Hotel ("despite the desire of many guests to remain and watch the advancing fire").[40]

As much as the threat to hotels and small agrarian communities was real (the fire eventually blocked all highways out of Forbes Landing, forcing 25 firefighters to prepare a motorboat for possible evacuation), it was the impact on logging companies that drove the fight. It burnt almost exclusively land that was owned or used by logging companies (over 30,000 hectares in total), affected mostly communities that were home to loggers, and destroyed significant logging equipment. The fight, too, was handled by the logging companies. Although the Forestry Branch was left "nominally in charge as a matter of public order," it was the private companies who offered forest workers, provided equipment, and leased outside resources like aircraft and buses.[41]

This build-up of manpower was hard to overstate, and remarkable in Canadian history. By day twelve, after the blow-up (then over 3,000 hectares), approximately 800 firefighters were employed. By day sixteen, this was 1,200 men; day seventeen, 1,700 men;

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[40] Parminter, "Darkness at Noon – The Bloedel Fire of 1938," 4.

[41] Pyne, *Awful Splendor: A Fire History of* Canada, 428.

day twenty-two, 2,500 men. Two weeks into the fire, the minister of lands closed two-thirds of Vancouver Island to logging and open fire. On the request of the Forest Branch, the Canadian Navy sent two destroyers to "assist with fire suppression and emergency evacuation of residents and firefighters" and to lay hoses ashore to protect the town of Campbell River.[42]

The Bloedel fire was defined by its deep connections to the logging industry, who had caused the blaze, fought it at great cost (over $210,000 in suppression costs, in 1938 dollars), and ultimately suffered from a massive loss of timber resources. But, it was also a fire of contradictory lessons. The silviculture industry couldn't be satisfied: they had been hurt tremendously by lost productivity, and yet there was little interest in outlawing the logging practices that contributed to the fire's volatility because of its perceived impact on profit and employment in an industry that had been so devastated. Similarly, as much as the logging companies were eager to tout their eventual success in bringing the blaze under control through their men and machines, the fire stood as a reminder for those willing to listen that:

> "…the larger forces behind the burn were too vast. Pumps could not counter droughts, dozers could not overcome slash, railways could not resist wind. As [British Columbia's Chief Forester] himself confessed near the midpoint, "the only things that will help us now are rain and a favourable wind.""[43]

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[42] Parminter, "Darkness at Noon – The Bloedel Fire of 1938," 11.

[43] Pyne, *Awful Splendor: A Fire History of Canada,* 429.
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The presence of fire – and the valiant, if futile attempts to fight it with machinery – continued across the country. Later the same year, there was another destructive fire on the border between Minnesota and Northeastern Ontario. September 1938 brought little rain and many fires on both sides of the border, with crews battling hundreds of fires across the region. The heat, drought, and unstoppable series of small fires set by residents lead a newspaper in Littlefork, Minnesota to warn that "Lest we forget – it was a day just like this…An Indian summer day it was, and a light haze of smoke…" when the Cloquet fire of 1918 killed 453 and displaced 52,000.[44] Personnel in both Canada and the United States chased a relentless stream of fires – started by careless smokers, an seemingly unending desires by residents to burn slash and trash, and the occasional property owner who started their own back burning fires to create fire breaks capable of protecting homes and fields – with Forestry and Highway departments enlisted to haul water to flames.

By October 10th – Thanksgiving Day in Canada – the powers that be had largely imagined that the fire season was coming to an end. Fire crews in Fort Frances had been reduced down to only thirteen members, and the Forestry Branch had declared that "The situation at this time was considered to be well in hand and no apprehension was felt".[45] That morning, the thirteen crewmembers were tending to a handful of fires smouldering

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[44] Dalstrom and Dalstrom, *"We Were Not Worried at Dinner Time": The October 1938 Forest Fires and the Last Frontier in the Rainy River-Lake of the Woods Borderland*, 18-19. This anecdote (p.18-19), and much of this account, is drawn from the remarkably detailed synthesis by Dalstrom & Dalstrom.

[45] Dalstrom and Dalstrom, *"We Were Not Worried at Dinner Time": The October 1938 Forest Fires and the Last Frontier in the Rainy River-Lake of the Woods Borderland*, 25.

around the Dance Township. By one-thirty in the afternoon, the wind had picked up to between fifty and sixty-five kilometers per hour, and the temperature to an unseasonably warm twenty-six Celsius.

The townspeople leapt into action, trying to defend homes and property. One man, Don Patterson, recounted shortly after the fire how quickly it had all happened. It had started as a "beautiful afternoon," only to soon hear the sound of "a dozen freight trains going over trestles in the distance".[46] He and a group gathered a team of horses, a wagon, and their neighbours, only to run into flames blocking the road "in a blanket of fire." They broke for the nearest house with a large clearing around it…

> "…and we thought that, being trapped on all sides, we might be able to fight off the fire and save ourselves in this clearing… We fought there desperately, pouring water on the buildings, but when the outer buildings started going, it looked hopeless. Then when the house caught fire the disaster struck… It was so terrifying that there is no possible way of describing it. I was up on the roof pouring water, helping try to save the house, when one of those heat waves hit me. It took me right off the roof, into the air like a feather, and when I hit the ground in a heap I figured I was done for."[47]

Although Patterson survived, seventeen were killed in the blaze.

Much like in the case of the Bloedel fire, the Fort Frances fire demonstrated an increasing attempt at technological solutions to the problem of wildfire. Caterpillar tractors and heavy ploughs, for instance, were used to cut firebreaks and access swampy terrain. At

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[46] Dalstrom and Dalstrom, *"We Were Not Worried at Dinner Time": The October 1938 Forest Fires and the Last Frontier in the Rainy River-Lake of the Woods Borderland*, 29.

[47] Fort Frances Times and Rainy Lake Herald, "Patterson Relates Story of Tragedy that Took Twelve of Labelle Family."

the same time, hints of the limitations of technology were clear. Radio communication was rudimentary, and more indicative of future use than of viability at the time.[48] And, while aerial observation was employed to track fire growth, the thickness of the smoke hanging in the air prevented any ability to track the fire's behaviour during the first forty-eight hours.[49]

These technological limitations, however, did not reduce the overarching desire to fight fire with more men and more machines. Perhaps the greatest illustration of this desire took place a decade later in the Mississagi Provincial Forest in Ontario. A fire started by a negligent poacher on May 25th quickly took off given the pre-green-up conditions and high winds.[50] First spotted by an aircraft at one o'clock in the afternoon, by a third aerial observation at four it had already reached forty hectares.[51] By the third day, the fire was burning almost 12,000. Making matters worse, a second fire (which escaped from road construction crews burning a pile of slash) began near Chapleau, while third and forth fires started thanks to lightning strikes.

The reaction was predictable. Men and pumps were thrown at the fire: first 137 firefighters, then doubled, then doubled again. Crews were repeatedly split into teams and sent chasing after the four fires on the landscape. Aircraft, heavy equipment, and some twenty miles of hose were accumulated in the fight. They were forced to pull out from

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[48] Dalstrom and Dalstrom, *"We Were Not Worried at Dinner Time": The October 1938 Forest Fires and the Last Frontier in the Rainy River-Lake of the Woods Borderland*, 87.

[49] Dalstrom and Dalstrom, *"We Were Not Worried at Dinner Time": The October 1938 Forest Fires and the Last Frontier in the Rainy River-Lake of the Woods Borderland*, 43.

[50] Commito, "The Biggest, Blackest Graveyard," 11.

[51] Pyne, *Awful Splendor: A Fire History of Canada,* 430.

between the burns, allowing the fires to merge on June 12th. The total area burnt totalled over 300,000 hectares by the time the fire was under control in July. More striking than its size, however, was the "campaign fire" approach to suppression – the seemingly endless people, pumps, and planes that were directed to fight the fire.

Yet, it wasn't the "dogged firefighting" that tamed the fire, but rather rain on June 21st that ultimately slowed its spread. In the excited pursuit towards technological solutions to the management of fire, though, even rain was seen as something to be controlled. Starting on June 10th, the Department of Lands and Forests (DLF) and the Dominion Meteorological Service teamed up to begin a series of cloud seeding experiments in hopes of producing rain that could halt the fire. Pilot K. E. Pettit flew up to some 15,000 feet and dropped dry ice in hopes of inducing rain to fall below.[52] Although it had little effect, it was actually a much more reasonable strategy than that tried almost four decades earlier by American firefighters in Yellowstone National Park, who attempted to create rain with a sixty-hour barrage of dynamite and cannon fire into the clouds.[53] In the end, however, yet another attempt at technological control turned out to be more performance than results:

> "While the DLF argued that the artificial rainmaking was yielding some moderate success, the actual success was that the Department was able to focus attention on its daring technological feats while diverting it away from the fact that the fire was still raging out of control. By the end of the campaign, the DLF had definitively ended any further experiments with artificial rainmaking."[54]

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[52] Commito, "The Biggest, Blackest Graveyard," 12.

[53] Egan, *The Big Burn: Teddy Roosevelt and the Fire that Saved America,* 145.

[54] Commito, "The Biggest, Blackest Graveyard," 12.

In many ways, the 1930s and 1940s foreshadowed the core lessons of wildfire in Canada. Fires could not be eliminated from the landscape. Governments could choose to pour resources – particularly people and machines – into the fight. Yet, the results were destined to remain mixed: some properties and lives could perhaps be saved, but firefighters could be killed in the battle (like almost happened in 1936), and extinguishing fires in the Canadian boreal was ultimately an act of weather, not people. As long as forests were loaded with fuels, periodic draughts and hot spells occurred, and multiple concurrent fire starts tested responders, there were limits to the ability to control fire.[55]

These realities were equally true in the passes between British Columbia and Alberta, in the Blodel Fire, and across Dance Township and Fort Frances. They were similarly striking in northern Ontario, leading fire historian Stephen Pyne to argue that

> "The most remarkable fact may be that Ontario even fought the fire at all or that, once having attacked and failed, it continued to pour men and machines into the fight. These were fires far removed from settlements, remote from the centres of commercial timber harvest, a region stricken with massive bug kill and blowdown, well beyond the field of vision of Toronto politicians."[56]

Just as importantly, the same lessons were repeated over and over again, but never learned. In a scathing article in the Winnipeg Tribune on October 12th, 1938, as the fire burned near Fort Frances, the editors called these lessons out:

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[55] Alexander, "'Lest We Forget': Canada's Major Wildland Fire Disasters of the Past, 1825-1938." This volume is particularly useful for a examining the common features of several Canadian wildland fire incidents.

[56] Pyne, *Awful Splendor: A Fire History of Canada*, 431.

> "The fate of several families… is a tragic object-lesson in what may well be called Canada's national attitude toward fire hazard.
>
> "Warned and urged by fire rangers to abandon their homes when the fire was five miles away and trucks at hand to take them away, they refused to go. This refusal is an illustration of the familiarity-bred contempt for forest-fire danger which is all to common in this nation…"
>
> "We are altogether too familiar with fire in Canada, altogether too confident, individually and collectively, that if a fire does start we can put it out before it does any serious damage…"[57]

The question that all too few considered over the coming decades: Could Canadians understand that fire was always going to be part of their landscape, and that some proportion were destined to be uncontrollable even with massive investments of technology and labour?

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Unfortunately, the answer was a simple 'no': fire would continue to seemingly surprise the nation, and a relentless desire to control the flames would continue to grab hold over decision makers and the public alike. Although the Fort Frances fire represented the last mass fatality fire in Canadian history (at least through the 2017 season), both large and population-proximate fires continued to burn across the country.

Perhaps the only notable exception was the Chinchaga River Fire of 1950. Among the largest documented fires in North American history, it burnt an astounding 1.4 million

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[57] Winnipeg Tribune, "Forest Fires," 13.
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hectares (almost two and a half times the size of the Horse River fire). Because of its location far from most settlements in northern British Columbia and Alberta – not to mention an obvious inability to control it, plus an Alberta government policy against taking suppression action of fires more than ten miles from highways, settlements, or primary rivers – it was largely allowed to burn on its own.[58] It took advantage of human ignition on June 1st to have an entire season to "ramble" across the boreal forest, taking alternating major runs and periods of rest as the forest dried.[59]

While the fire was remarkably large, its impact was twofold. Its proximate affect was to generate – along with a series of other fires across Canada – a smoke plume so thick that it turned daylight into darkness; made some in New York believe the sun was burning out; convinced others that military cloud seeding or nuclear tests had gone awry; created sporadic blackouts as electricity usage soared to power mid-day lighting; caused roosters in the Northeastern United States to crow at four o'clock in the afternoon when the smoke had lifted; and turned the moon blue in the British Isles.[60] It's longer term impact (which is still felt today, and can be seen in the massive and rapid response to both of the fires near Fort McMurray) was to convince the Albertan government that fires could not be fought when they were large, and rather needed to be struck aggressively when they were small. A report by the Eastern Rockies Conservation Area's chief forester argued that what was needed was

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58 Tymstra, *The Chinchaga Firestorm: When the Moon and Sun Turned Blue.* This volume provides an effective and comprehensive account of the fire, with an emphasis on the smoke impacts that were felt far beyond the burn itself.

59 Pyne, *Awful Splendor: A Fire History of Canada,* 61-62.

60 Tymstra, *The Chinchaga Firestorm: When the Moon and Sun Turned Blue,* 43-51.

complete coordination between a dense network of roads and trails across the province; effective detection and communication systems; and a series of elite, highly-trained firefighters – the precursors of the helitack crews that feature so prominently today.[61]

In the 1970s, the flames turned towards the north. In the Northwest Territories, expansive fires had always been the norm rather than the exception. But, in 1971, a season of 322 fires burned over a million hectares with dramatic effect: cutting off the road to the capital, Yellowknife, killing six firefighters, leading to the crashes of three firefighting aircraft, and ballooning to over five million dollars in suppression costs.[62] This, predictably, led to increased and costly firefighting efforts (particular in air tanker use), as well as perpetual calls for increased fire research (a seemingly easy solution to a vexing problem). Two years later and another 163 fires added to the financial cost and acreage lost. Policy flipped repeatedly, from prioritizing certain fires (see Chapter Four for a more detailed discussion of this quest), to minimizing the numbers of fires fought, to increasing the size of the response organization through aircraft and firefighters. 1979 brought 380 fires and two million hectares burnt; 1980 another 1.2 million hectares; 1981 another million. Political reorganization was plentiful, and fire research continued to enjoy support, yet the fires continued.

The 1979 and 1980 seasons were also difficult in Ontario. The first year, a group of student interns were conducting a prescribed burn of slash near Geraldton. Ironically, the regional program was an example of proactively clearing these fuels through the use of

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[61] Tymstra, *The Chinchaga Firestorm: When the Moon and Sun Turned Blue,* 12.

[62] Pyne, *Awful Splendor: A Fire History of Canada,* 385-386.

prescribed fire. But, a burn went bad, and seven 17-year olds were killed (the last Canadian mass fatality of fire-related personnel, at least through 2017). And, the next year, with half a million hectares burning, Ontario dedicated seventy-five airplanes, ninety-three helicopters, and almost sixty million dollars to the firefight.[63] Despite water bombers and backfires, one fire cut off access to the town of Red Lake (not to mention hydro and telephone lines), leading the Canadian Forces to requisition nine aircraft to evacuate residents from that town and Fort Hope.[64] The fires would lead to reviews and a proposal by Ontario to establish increased exchange across the country (see Chapter Five).

Yet, the same lessons were clear from those years and the others. While the province of Ontario, like every other region in Canada, had worked towards the ability to control fire on its own terms, there seemed to be absolute limits. Whether lighting fires (like in Geraldton) or attempting to extinguish them (like in Red Lake), sometimes fire simply couldn't be controlled. As summarized by Stephen Pyne,

> "In 1922, there was still ample room to expand the domain of fire control; in 1980, in Ontario, and in time the other provinces, recognized that it had 'come close to total commitment in fighting fires,' not to mention its 'heavy reliance' on crews and equipment from outside its own caches and the worrisome suggestion that the organization might have discovered that its 'tremendous resources are being committed to hopeless causes.' The future required something different."[65]

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[63] Pyne, *Awful Splendor: A Fire History of Canada,* 259-260.

[64] Pyne, *Awful Splendor: A Fire History of Canada,* 431.

[65] Pyne, *Awful Splendor: A Fire History of Canada,* 433.

The difference was the degree to which Canadians continued to build increasingly large and valuable properties in forested areas. Whereas fires in the twentieth century were quickly overwritten through the rebuilding of wood-framed houses, the fires that came in 2003 in Kelowna and 2011 in Slave Lake snaked through wildland-urban interfaces and intermixed regions full of pricy homes, expensive cars, and heightened expectations placed on fire crews to keep the flames away. Big fires still burn across the Canadian landscape with little notice (like the Horse River fire did in the months following its high-profile pass through Fort McMurray), but when geography and sparks line up, the consequences continue to be poignant. As one fire manager told me in the wake of the 2016 season, "If the Horse River fire had started five kilometers east [on the other side of the city], it would have been the biggest fire you never heard of."

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All of the ingredients from these historical fires were in place on Tuesday, May 3rd, as the city of Fort McMurray woke to a beautiful, sunny, and warm day. A temperature inversion had drawn the smoke down towards the ground, making it difficult to spot where the fire's edge was during the first helicopter flight at 6:15am. The wind was expected to blow strongly to the north/northeast – directly from the fire to the city. The drought had persisted, with no sign of rain in the forecast. The fuel was ready: much of the area hadn't burned since 1931, meaning that there had been plenty of time (accelerated by the pest, Spruce Budworm) for flammable materials to accumulate. For Darby Allen and Bernie
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Schmitte (the forestry manager for the Fort McMurray district), there was ample cause for concern.

As I talked to fire managers across the country, many drew a distinction between the approaches of junior and senior decision makers. Junior managers have a "classic misunderstanding," several said, and 'throw resources and risk' at fires when the flames should be guided to burn out at a firebreak or cool overnight. But, you simply can't afford to have an "ego" about holding the fire line. "The philosophy," one long-time firefighter told me, "is managing fire and bringing it to the right place at the right time of day." "It's a mother nature thing," said another. "You have to try to have a relationship with fire that's symbiotic; living with fire."

The problem facing Allen and Schmitte was that there was simply no space left to dance with the flames. The fire had doubled to 2,600 hectares in size, according to the morning briefing in the REOC, and was only a kilometer from the edge of town. Crews had managed to construct a limited firebreak in the northeast corner, but the forecasted winds – a 'low level jet' – would make short work of such a gap. Another ninety provincial firefighters were also en route to the city, and the Regional Municipality had reached out to Slave Lake and other jurisdictions to borrow sprinkler kits to protect buildings.[66] Yet, Schmitte and others seemed to believe that the Athabasca River would provide a much

[66] Struzik, *Firestorm: How Wildfire Will Shape Our Future,* 38-40. Struzik's account has a candid telling of the exchange between the two cities as Slave Lake personnel attempted to convince local Fort McMurray managers of the need to prepare more proactively for the battle ahead.

larger firebreak and that the fire was unlikely to reach the city that day. "There is fuel for the fire," said Schmitte that morning to the CBC, "but it's a distance away".[67]

At 10:30, however, Darby Allen received a call. The Horse River fire had jumped the Athabasca River. At the 11:00am news conference, however, there was no expanded evacuation order. Hoping to avoid panic, Allen instead warned residents to "Start thinking that if you had to leave sometime in the next couple of days, what would you bring with you?" The fire would enter Fort McMurray in three and a half hours.[68]

Damian Asher was watching the news conference as well. He had been on a night shift the evening before and was spending the day at home working on landscaping after seeing his wife and children off. That afternoon, he was just dragging a hose out back when ash began to land on him, and when he realized how hot and windy it was outside. He called the battalion chief to ask to come on shift and, after some debate, headed for Fire Station 5 to grab his gear. When he arrived, the truck bay contained only three remaining fire trucks and not a person to be seen.

There was, however, a flurry of action upstairs in the REOC. Earlier in the afternoon, Jody Butz had been giving a tour of the REOC to a set of new recruits for the Fort McMurray Fire Department. Now, early afternoon, was glued to social media, where people were reporting flames entering the city. Officials had little sense of where the fire

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[67] Warnica, "Battling the Beast: The Untold Story of the Fight to Save Fort McMurray."

[68] Note that there are major disparities in the timings reported by media reporting (e.g., CBC long form), firsthand accounts (e.g., Struzik and Asher), and the timings reported in the after action reviews commissioned by the province and RMWB. Where conflict cannot be easily resolved, I defer to the timings established in the official reviews (although, even the two reports by KPMG vary on key details, like the timing of detection of MMD-004).

perimeter was, so Butz sent a firefighter to check reports of flames entering the neighbourhood of Beacon Hill.

In Alberta, where an inordinate effort is given to quickly responding to every smoke report, rarely do fires become big. Over ninety percent are controlled before ten o'clock the next morning. Only three percent become large fires. The Horse River fire was about to become one of those fires, and the most readily available fuel was the intermix of trees, debris, and buildings that were intermixed in and around the community of Fort McMurray.

As Damien Asher drove to Fire Station 5, the Municipality announced a voluntary evacuation notice for the neighbourhoods of Abasand, Beacon Hill, and Thickwood warning residents to be ready to leave their homes within thirty minutes. Ten minutes later, at 2:05pm, the warning became a 'Mandatory Evacuation Notice.' Thirty-six minutes after the first evacuation warning, falling firebrands lit the first spot fires in the neighbourhood of Beacon Hill.

As Asher changed into his turnout gear, he ran into another firefighter who had been tasked with driving a remaining tanker to the golf course. "Should I get in with – ," he asked, only to be interrupted. "No. We just got a report that the fire has crested into Beacon Hill," replied the firefighter. "I'm on my way there now. Not sure what you're doing, but there's a pump here ready to go." Asher hopped into the pumper and headed for the neighbourhood of Beacon Hill.[69]

The group of recruits that Jody Butz was touring earlier had already been loaded onto trucks and sent into Beacon Hill, along with a veteran firefighter from the Slave Lake Fire Department who had brought equipment to Fort McMurray. Asher met up with some of these recruits, as well as two paramedics who were still in the midst of their firefighting training. One picked up a ground monitor "for the first time in his life," while other firefighters arriving in coveralls and street clothes hopped in to run pumps and hoses. They could do little except point hoses at burning homes and evacuate residents, while a

[69] Asher and Mouallem, *Inside the Inferno: A Firefighter's Story of the Brotherhood that Saved Fort* McMurray, 48.

cacophony of exploding propane tanks and ammunition made the streets sound like a war zone.

The information getting to Butz back at the REOC was partial at best. The Fire Department was operating on a different radio frequency than Alberta Wildfire, and the unified command post was slow in being set up. It meant that, among other things, the firefighters in the city were "unable to ask for and direct air tanker support," limiting them to overstressed fire hydrants.[70] Butz had little clarity about where the fire was, but knew that it would be moving into Abasand. He sent "about a half dozen firefighters – all he could spare."[71]

Darby Allen recalled Butz telling him that the Department was losing Abasand. "He was almost crying. And I said, 'It's OK. Let's just get on with the rest of it.'"

> "The radio squawked with more reports of areas under attack: 'We're in Waterways, houses on fire!' 'Tanker to Abasand!' 'We've lost water supply!' 'We can't find our way out.' It all blended together, a melody of turmoil and adrenaline, until I head the call, 'Emergency traffic, emergency traffic, emergency traffic! Abandon Beacon Hill. The fire is over our heads. Drop your lines and leave the area.' I punched the ceiling. I still had people in houses."[72]

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[70] Struzik, *Firestorm: How Wildfire Will Shape Our Future,* 43.

[71] Warnica, "Battling the Beast: The Untold Story of the Fight to Save Fort McMurray."

[72] Asher and Mouallem, *Inside the Inferno: A Firefighter's Story of the Brotherhood that Saved Fort* McMurray, 76.
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It can be hard to comprehend the scale of forested land in Canada. The Canadian boreal zone is over 550,000,000 hectares in total – larger than half of the entire United States of America – and represents more than a quarter of the total global boreal forest. About 300,000,000 hectares (just over half) of this is forested, with another 50,000,000 hectares of non-boreal forest in the southern portion of the country. Federal, provincial, or territorial governments own some 90% of this forested landscape. An additional 4% belongs to specific government departments, like the National Parks and the Department of National Defence. Only 6% is privately held, although that number varies from province to province.

Most of the boreal forest is remote and inaccessible, with no more than a handful of highways and virtually no cellular coverage. The distances are vast as well: in Ontario, Manitoba, Quebec, and the Northwest Territories, for instance, the provincial wildfire headquarters are located more than a thousand kilometers from portions of the forest for which they are responsible. This distance, combined with weather and competing fire loads, can mean that it can, at times, be days before a fire in a remote area can be observed in person.

The scale of Canada has many impacts on how fire is managed. Canada's population is incredibly concentrated in the southern, non-boreal portions of the country, with ninety percent of its people living within 160 kilometers of the US border. As a result, hauling and stationing people and equipment closer to where fires do occur is an expensive and logistically complicated undertaking. It's difficult to find fire personnel (particularly student firefighters) who are willing to move to and live in many of these remote regions, and massively complicated to attempt to detect and monitor fires that are spread hundreds of kilometers apart.

There is also a difficult, unresolved tension in how we understand the character of these northern reaches. On one hand, these are places with remarkably low population densities. Southern Ontario, for instance, has just over ninety people per square kilometer, mostly concentrated in cities like Hamilton, Toronto, and Ottawa. Northern Ontario, by contrast, has a population density of less than 1% of that figure: a mere 0.9 people per square kilometer. By and large, in places like Northern Ontario or Wood Buffalo National Park (Northern Alberta), there is simply much more space to have a philosophy that allows fire to roam the landscape.

On the other hand, it is a classic and problematic misunderstanding to think of non-urban spaces in Canada as empty. Aboriginal communities are woven throughout the country, and with many in alignment with forested and flammable landscapes. These communities deal with a disproportionate burden of both smoke and evacuation impacts from wildfires. The landscape is also used and stewarded by a number of other groups, including industry (for timber and other resource production), vacationers (with cottages, cabins, and camps), and hunters and outdoors enthusiasts, each of whom are affected in different ways by fire. As I explore in Chapter Five, the conflicts are plentiful between these groups and the roles they envision for fire.

Although the impacts of fire are often felt most prominently at the individual and community level, it's the thirteen provinces and territories that are generally responsible for managing wildland fire in Canada. This arises for two reasons. First, the responsibility for preventing and responding to fire is coupled with the responsibility for managing forest and natural resources. Second, in most parts of Canada there is simply no one else to whom the provinces can pass the buck: they're responsible because they're the most local form of government in much of the country.

Legally, the 1930 Natural Resources Act gives provinces control over and responsibility for their natural resources (the territories received these powers later). With respect to forests, for instance, provinces and territories are able to choose how to develop their commercial timber. They also receive a variety of financial benefits from the sale of lumber (some provinces cut the lumber themselves and sell it to companies for milling, while others effectively rent the land to timber companies who take care of the seeding, harvesting, transport, and processing of wood themselves). As such, the provinces and territories have both a legal and practical responsibility for managing fire: they're the government responsible for overseeing forests, and they stand to profit when the timber is available for harvesting rather than burnt.

The provinces and territories are also responsible for wildland fire because of a general pattern towards devolving expensive operations to the lowest form of government possible. Cities and municipalities, for instance, are responsible for managing fire and emergency services (like house fires, car accidents, and medical emergencies) within their boundaries. But, municipalities only make up a tiny piece of Canadian lands – and an even smaller fraction of forested land in Canada. Roughly eighty-nine percent of the country is 'crown land' – land that is held by either federal or provincial governments on behalf of the monarch.

Within the ten Canadian provinces, the biggest landowner is always the province itself, thanks to its crown land holdings. The percentage of the provinces that remains crown land varies significantly from province to province. Some are almost entirely crown land, like Newfoundland and Labrador (95% crown land) and British Columbia (94% crown land), while in others it is simply a sizeable portion (e.g., 60% of the land in Alberta, and 48% of the land in New Brunswick). Moreover, over 90% of the boreal forest in Canada falls on provincial crown land.[73] The result is that provinces end up being responsible for their forests and the fires within them.

This is remarkably different than the United States, where federal agencies play a major role in fire management. In the US, for instance, the Forest Service administers 139 million acres of land across the country that is set-aside as national forests and national grasslands. The Canadian Forest Service, by contrast, administers only a handful of office buildings and research plots amounting to only a handful of acres across the country. And, there is no Canadian equivalent of the United States Bureau of Land Management, which oversees over 247 million acres – approximately an eighth of the total country – and also plays a major role in fire management. These two agencies shape the American fire agenda from coast to coast, a remarkably different approach to the province-centric nature of the fire program in Canada.

By contrast, the federal portion of land is almost exclusively located in the Northwest Territories, Nunavut, and the Yukon. Only a tiny corner of Southwest Nunavut is forested, making the territory the only jurisdiction in Canada to not have a wildfire

[73] Natural Resources Canada, "The State of Canada's Forests 2004-2005: The Boreal Forest," 49.

management agency.[74] In the Northwest Territories and Yukon, management of natural resources – including the responsibility for managing fire – was devolved to the territorial governments much more recently.

The federal government holds a small percentage – about four percent – of land in the provinces as well. This land is mostly constituted of Indigenous reservations, National Parks, and Canadian Forces bases that are spread across the country. Each of these three also present interesting exceptions to the province-centric approach to wildfire.

On Indigenous reservations, provinces still maintain responsibility for wildfire response just like they would on crown land. Often, the Aboriginal communities play an active role in fuel and risk reduction programs in these areas, including through organizations like the First Nations Emergency Services Society in British Columbia. In addition, several provinces – particularly in the West – maintain significant Indigenous participation as firefighters, which can be coordinated on a reservation or community level. One notable difference, however, is that while evacuations are normally conducted by the provincial emergency management organization, the evacuation of Indigenous communities is coordinated through Indigenous Affairs and Northern Development Canada.

Within the National Parks, Parks Canada is the federal agency responsible for wildfire management. Their program is not only in charge of responding to fire and maintaining guest safety across a diverse set of parks in Canada, but also for working with the individual parks to restore fire to its natural role in several of the landscapes. This is a

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[74] If needed, the Northwest Territories, Saskatchewan, and Manitoba are able to provide support – particularly air tankers – in this area.

significant task, as National Parks in Canada represent roughly three percent of the entire country's landmass, or about 53 times the size of the smallest Canadian province. They respond to wildfire across the country with staff of only sixty firefighters, grouped into teams of four. The teams are pre-stationed in parks across Canada and dispatched as needed to work together on larger fires as they occur.

The other federal agency that plays a fire management role is the Department of National Defence. The Canadian Forces own or lease slightly under three percent of Canadian land, much of which is actively used for training activities and military exercises. One base in particular – CFB Gagetown, outside of Fredericton, New Brunswick – contains a large amount of forested land. As a result, there is a full forestry and wildfire management program on base that is responsible for responding to wildfires within base limits. This wildfire program has the distinction of hosting the only fire teams in Canada that include an explosive disposal specialist on each shift. On other bases, the base fire department (which normally deals with structural firefighting) is responsible for fighting fires that get into grassland or trees.

The net result is that with the exception of cities and municipalities, National Parks, and Canadian Forces Bases, each province is responsible for managing wildfire within its boundaries. From British Columbia to Quebec, this largely means that provinces are responsible for the northern reaches of their provinces – known as 'forest protection areas' – while the southern areas fall to cities, parks, and bases. A large swath of southern Alberta, Saskatchewan, and Manitoba, for instance, is excluded from the forest protection area as agricultural land and falls under the responsibility of rural volunteer fire departments (the fires in this area tend to be mostly in grasses and crops). In the Maritimes, the arrangements are slightly more patchwork, as cities, parks, and bases are scattered throughout the smaller provinces more evenly.

The bottom line is that provincial wildfire management programs manage most wildland fire in Canada. These programs are usually located within a Department of Natural Resources, Forestry, or the Environment, although exceptions exist. In the Yukon, for instance, wildfire management is housed within the Department of Community Services reflecting a shift towards seeing fire protection as a community function rather than timber protection. Outside of city limits and within their forest management areas – which can be a challenging distinction when dealing with intermix fires like the Horse River fire as it rolled into Fort McMurray – these programs are responsible for managing fires, whether through observation or attack.

Most wildfire programs are said to be 'streamed,' which means that they are established as a distinct structure from other resource or forestry functions. The wildfire program in Saskatchewan, for instance, was streamed from a general Forest Protection Branch to a Wildfire Program about a decade ago. Other jurisdictions remain 'unstreamed,' and have relatively few (e.g., Manitoba) if any (e.g., Prince Edward Island) full-time, dedicated fire staff.

Unstreamed wildfire programs can face a series of challenges around staffing, funding, and priorities. In Manitoba, for instance, there are only about twenty full-time wildfire staff across the province, including experts at both the headquarters in Winnipeg and in more remote regions. While the program does hire a large number of seasonal firefighters, many of the intermediate roles are either filled by Conservation Officers who have part-time fire responsibilities or by seasonal hires. This can lead to a series of problems. Acquiring staff time for fire projects, training, and meetings can be difficult, because it relies on the good graces of supervisors on the conservation side of the operation. Fire risks being seen as 'second fiddle' to other operations and can fall into being a large source of funding yet have its projects deprioritized. Moreover, it can lead to cultural and experience challenges, where Conservations Officers have little real-world fire experience – or even interest – yet are tasked with important functions in fire operations. In Prince Edward Island, the situation is even more striking: there are no full-time fire positions, and even the high-ranking staff in the fire program have fire assigned as one of many natural resource responsibilities. In these smaller fire management agencies, it can be especially difficult to fulfill all the task needs. "My next desk needs to have more corners," a manager from one agency told me, reflecting on the number of important fire tasks that jostled for space on his agenda.

Another challenge with unstreamed programs is developing and retaining a cadre of fire experts beyond the seasonal summer positions. All jurisdictions – streamed or unstreamed – face a common challenge in high workforce turnover. Most wildfire programs in Canada populate their firefighting programs mostly with seasonally hired college and university students.[75] Turnover can approach 30-40% annually – and often worse after quiet years, when firefighters have had neither the excitement nor the overtime pay of more active

[75] Two exceptions to this are Parks Canada, which attracts more senior firefighters with previous provincial experience, and Prince Edward Island, where community fire departments conduct the majority of firefighting operations, and natural resources staff are cross-trained as firefighters

seasons – which requires intensive training programs and season-long mentorship. Yet, it's difficult to make a career out of seasonal firefighting. Compounding matters, high-level leadership like managers and directors tend to turn over quite infrequently, making full-time positions hard to come by. This is particularly pronounced in unstreamed programs, where it is more difficult to allocate full-time, year-round staff lines at these middle positions necessary to retain expertise, groom future leaders, and have consistent hiring to prevent mass cohort retirements.

Against these disadvantages, there are two broad kinds of arguments in favour of unstreamed programs. One is something of a post hoc justification: unstreamed programs are seen by some as more economically viable to maintain because they spread administrative duties, regional workload, and uneven time requirements across a larger pool of employees. The other is a stronger positive vision: in their ideal state, unstreamed programs allow for more integrated approaches to environment management. Generalized staff are responsible for managing an environment as a whole, with fire sitting in a more integrated approach alongside hunting, silviculture, waterways, and a variety of other natural resources.

While I heard differing views within these each of these programs about whether they should be streamed, it's important to realize that an unstreamed program is not a lesser agency. Both Manitoba and Prince Edward Island are active fire programs in their respective contexts, and regularly contribute both firefighters and overhead personnel to national exchanges in support of campaign fires like Horse River. Their size and structure may be different, but it fosters different approaches to innovation: innovation spurred on by their context and constraints, rather than massive sets of resources like might be seen in Alberta or British Columbia.

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Just over a year after the Horse River fire rolled into Fort McMurray, I joined one of Alberta's duty officers in their Provincial Forest Fire Centre. The command centre is located on an upper floor of a non-descript office building in downtown Edmonton. The operations room itself is relatively large and filled with half-height cubicles. Two cubicles sit near the centre: one for whoever is acting as the Provincial Duty Officer, and one for the Provincial Aircraft Coordinator. Above them, a series of screens show map after map of the province: one with active fires, another with helicopters and aircraft, another with animated weather forecasts, and so on. Around them, more cubicles with support staff for various parts of the operation. Most were empty on June 1st, 2017, with the staff that could fill them during a busy 'fire flap' working at their regular desks elsewhere in the building.

The sun was rising on a beautiful day across the province, with clear skies and moderately warm temperatures. In fact, most of that month was beautiful, both from regular and fire weather standpoints. During the month I spent with Alberta Wildfire, the pattern was consistent: several days of pleasant weather would encompass most of the province, with periodic rain passing through just often enough to keep the various fuels wet enough to prevent burning. It was quiet enough on the fire front to be annoying as a researcher trying to learn how wildfire response worked, but the agency staff largely appreciated the pace.
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Aside from occasional concerns about young firefighters getting bored and restless, the quieter season provided an opportunity to catch up on the projects and institutional work that busy 2015 and 2016 seasons had prevented completing. By the time the fire season ends and post-season paperwork is done, hiring and preparations for the following season are already underway. There's no such thing as an 'off-season' for year-round fire managers, just busy seasons and busier summers, when long-term projects are pushed off the desk because of immediate flames.

As the morning began, we gathered for the daily briefing to recap what had happened in over the day before and to plan for the burning period ahead. Around the table sat the Duty Officer for the week, Morgan Kehr (a veteran of Alberta Wildfire serving as its Wildfire Operations Director), the Provincial Aircraft Coordinator for the week, a Public Information Officer, and a Fire Prevention Offier. Two fires were burning as the morning started, both roughly 600km northeast of the Edmonton office. They were sizable – about four hundred hectares – but had seen a good overnight 'recovery' in the humidity (which rose into the 80% range), which helped to slow their growth. And, although there had been a few days of dry weather, the same pattern was about to unfold: a cold front was expected to push through the next day, bringing rain with it. There was confidence that ground crews could manage these fires easily. The last 24 hours had been similarly quiet for the management team. The only aircraft movements the previous day had been because of a false alarm (smoke from a farmer burning their own field) and hail: tankers were moved to a different base to avoid possible damage, and a crew was taken off a fire to avoid golf-ball sized chunks of ice.

The key morning debate was about setting 'preparedness levels.' Firefighters and fire managers alike have something of an obsession with anything that can be classified into levels: fire danger levels, fire intensity levels, aircraft alert levels, fire ban levels, and preparedness levels, among others. Today's preparedness level had already been set: a three, on a scale from one to five. In this case, the preparedness level was more symbolic: each different resource (like aircraft or firefighters) would receive its own directions about what to do and when to be ready. Instead, the preparedness level was more about getting "more situational awareness to more people," said the duty officer, so that firefighters and decision makers alike were geared up for the rough level of risk they would face throughout the day. In the morning, a preparedness level was proposed for the following day; by the afternoon, it would be confirmed based on any major changes to fire behaviour throughout the day.

There wasn't much uncertainty in the room as I looked around. The duty officer weighed in that crew levels were a little lower than ideal because many of the firefighters had been assigned their mandatory days off. He wasn't particularly concerned – the cold front and its rain would keep things manageable – but didn't think it was appropriate to drop to a level two until more crews were back on duty. With Morgan in agreement, the provisional level was set: three for tomorrow, with a possibility of dropping to a two the following weekend.

Sitting beside the duty officer in the Fire Centre, you could be forgiven for confusing the duty officer with a telephone operator. Outside of the briefings – like a twice-daily weather briefing, to keep up an awareness of how the weather is changing across the province – most of the Duty Officer's day is spent liaising with area Duty Officers (like

Bernie Schmitte from Fort McMurray). Alberta is broken up into ten different Wildfire Management Areas, each of which is something of a miniature version of the Provincial Forest Fire Centre in Edmonton. Each area has its own Duty Officer, who performs roughly the same tasks as the Provincial Duty Officer: tracking new fires, dispatching crews, and managing operations proactively with an eye towards weather, future need, and competing fires.

It's a fractal pattern: fires in Canada are managed at a regional level (by provinces and territories), and those jurisdictions are divided into even smaller areas or districts that manage fires locally. Some jurisdictions, like Ontario, have an intermediate "regional" layer (Eastern and Western regions, managed out of Sudbury and Dryden respectively) falling between the district (such as the headquarters in Kenora) and provincial levels (the headquarters in Sault Ste. Marie). Others, like Manitoba, cluster areas into larger regions to achieve efficiencies in staffing (both the North and Northwestern districts are managed by the regional headquarters in The Pas).

More often than not, regional lines are a product of historical accident rather than careful planning. Sometimes the borders were drawn because of different natural resources (one district was a timber producer, while another was mostly an area for hunting), different geographic features (like following a river or highway), or proximity to a central office. Fire was an afterthought. Districts were appropriated as a matter of bureaucratic convenience rather than a reflection of any division in how fire behaves. "It's one of those things that if you could go back and redo it," one Duty Officer told me, "we'd have a much better system."

Just how much power and responsibility is given to these regions varies province by province as well. Air tankers are usually the top of the food chain: because of how expensive, effective, and long-range they are, they are 'provincial' resources that are generally available at the discretion of the Provincial Duty Officer. By contrast, firefighters are most often regional resources and, in some cases, may not even belong to the fire program at all (they might be employed and supervised, for instance, by the district office). In many regions, districts were historically a source of competition, eager to stockpile people and equipment to protect their own areas rather than seeing the provincial picture. In the 1930s, for instance, Albertan forest superintendents "were gods" over their own kingdoms. Even today, Provincial Duty Officers must be careful to garner the trust of their regional counterparts in order to be able to request the inter-district movement they require, and deal with differing views from their colleagues about how and how much resources ought to move in practice.

In more recent decades, however, there has been a trend towards better coordination between districts. This is partially thanks to an increased realization in provincial headquarters that local knowledge from districts can be more timely, accurate, and contextualized than top-down decisions. "You can't sit in the rain in Edmonton and really know the conditions in Fort McMurray," one duty officer told me. It's also because of districts coming to understand that provincial consistency and resources can improve their operations. Centralization in Manitoba, for instance, arose after devastating fires in 1989 (burning over three million hectares and costing over 68 million) indicated that "they could have seen it coming if they had been doing a regular weather briefing" and planning with their provincial counterparts. This coordination, in turn, requires increased standardization in the form of Standard Operating Procedures, uniform provincial training, and interoperability among crews and resources.

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Just after lunch, an air tanker request appeared as a black dot and a label (fire MWF-013) on the screen above the provincial aircraft coordinator. Looing at the digital map on the screen in front of him, he performed a quick measurement from the fire to the two closest airbases to confirm which air tanker group was closer. Zooming in on the fire, he also checked the distance between the reported smoke and the nearest lake that an amphibious skimmer could land on. At over twenty-five kilometers, a skimmer wasn't a workable option: reloading at the lake would take too long, and so it was better to send a tanker carrying retardant. A quick call was placed to the tanker base in High Level, Alberta, where three airplanes – two tankers and a bird dog – began performing the last checks before take-off.

The whole process went remarkably quickly. In most cases – like with this fire – the duty officer and provincial aircraft coordinator in Edmonton already know that an air tanker request is likely, whether from a warning phone call from the Regional Duty Officer shortly after the report of smoke, or from their intuition about how the fires might behave given the day's weather. And, in Alberta, there's little question about what to do when a smoke is reported – the potential judgement about response is baked into a provincial operating philosophy of aggressive fire attack. The "standard operating procedure is to hit everything
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as hard and fast as we can,' one program staff member said a few months earlier. "We operate the most aggressive initial attack on the globe… because every stick of wood that's merchantable is committed already." This philosophy has translated into an Albertan approach to fire management that leans on heavy equipment (like bulldozers and air tankers) and moves firefighters around rapidly via helicopter.

Move a couple of provinces away and the philosophy changes entirely. In Manitoba, for instance, a symbolic line is drawn across the province where anticipated timber use ends. North of that line, fires are generally only 'actioned' when they threaten a community. In the south, where cottagers are more plentiful, a similar 'hit fires hard and fast' mentality prevails. The space between is negotiated and renegotiated as the lumber industry rises and falls in the provinces. In Prince Edward Island, smaller woodlots are interwoven throughout agrarian and rural landscapes, meaning that local volunteer departments are usually the first to arrive on scene, with a comparatively small provincial wildfire program providing training, operational support, and resources as needed to extinguish fires that have moved into wooded areas.

A province's views on how aggressively and vigorously to fight its wildfires shapes the kind of management agencies that it creates. Simultaneously, the structure of these agencies shapes the province's philosophies as to how fire ought to be managed. In the case of Alberta, for instance, this no-holds-bared approach to fire management creates a feedback loop that, in turn, can have an impact what is seen as a viable response or agency evolution. As I spent time with Alberta Wildfire staff, it was clear that almost all of them deeply believed that – outside of the National Parks – that there was no space to let fire run on the landscape. Every tree was valuable and, in turn, needed to be protected for timber production, because it surrounded an oil site, or because it backed into a residential neighbourhood. As such, the whole enterprise was dedicated to providing this quick strike intervention: nine helicopter rappel crews with advanced training that could drop into inaccessible areas to fight fire; over 270 firefighters arranged into four- and eight-person helitack (short for 'helicopter attack') crews that could be set down on the smallest of landing pads; another 350 firefighters arranged into twenty-person crews to perform sustained firefighting on large fires; and some 1,500 additional call-as-needed firefighters available for hire during peak times. These crews form a veritable army of firefighters, each of whom is put through rigorous training each season to prepare them for the tasks of firefighting. From these ranks rise the future leaders of the organization: the new crew bosses, the next duty officers, and a new generation of program managers to staff the Edmonton office. They are steeped in the mechanics of firefighting, groomed through a system that prepares them suppress fire, and – for those among them called to a career in fire management – ready to continue the program's reputation as the "most aggressive initial attack in the world."

By contrast, fire in a province like Prince Edward Island is defined by its deeply co-mingled relationship with agriculture and local communities. The size of the island – at approximately 5,600 square kilometers, smaller than the Horse River fire alone – and its dense population means that all fires are so-called 'interface fires.' It also means that a local volunteer fire department almost always arrives on scene within a matter of minutes. As always, this corresponds to land management: only 12% of the Island remains crown land.

While the vision of total suppression prevails – there's no room for, nor ecological history of fire – the provincial fire management program usually serves in a supporting capacity. As such, fire makes up only part of the responsibility of the staff affiliated with their fire program: they also maintain parks, conduct environmental assessments, and work on silvicultural projects. It creates a program that emphasizes multi-disciplinarity and approaches fire management with an emphasis on how principles and methods can be taught to volunteer departments rather than standardized within an exclusive program.

Different too is the Parks Canada program, who benefit from a larger degree of control within the forty-five parks that they operate across the country (thanks, in no small part, to limited private timber holdings). With a core mission to "protect… Canada's natural and cultural heritage," fire is seen as an entirely different beast. Instead of something to be excluded, it is largely understood as something that cannot be removed from ecosystems without fundamentally altering their character. As such, the Parks must balance two conflicting tasks: to protect visitor safety and cultural resources, while simultaneously protecting the role of fire. The result is that sixteen parks have targets set for how much of their land should be burned each year based on historical and ecological studies. For most parks, the goal is to burn at roughly 20% of the 'natural fire regime'; for the mountain parks like Jasper and Banff, the goals is 60%. The goal is to use fire, natural features, and strategic fuel reduction to steer the fire in a way of managing fires that doesn't require as many people and that manages risks for communities within the park without suppressing fire on the landscape.

Because of this different approach to fire, Parks Canada staff are hired and cultured in a different way than many provincial programs. Many of the staff, for instance, have post-graduate training in ecology and environmental management, are older and more experienced than the typical provincial student firefighter (and usually with several years experience fighting fires at the provincial level), and see fire as a natural rather than threatening phenomenon. These staff are trained and groomed in an organization where starting fires, allowing them to burn, and learning to 'breathe with fire' is the norm. With fifteen four-person crews based in parks across Canada, firefighters move from park to park responding to fire, with a common understanding of how fire ought to be managed that transcends mountains, boreal forests, and grasslands alike. In turn, the organization is shaped to hire staff with backgrounds in the sciences, to incentivize management plans that include regular fire, and to develop a culture among fire technicians that embraces a very different mix of firefighting tools (such as lighting fires by helicopter, a tactic only used regularly by a handful of Canadian jurisdictions).

A degree of commonality is achieved across the country through dividing firefighters up according to certain standards. Broadly speaking, there are Type One (T1) and Type Two (T2) firefighters, with the occasional jurisdiction that uses intermediate clusters or Type Threes. Type One firefighters are fairly consistent: they are trained and capable of being the first firefighters on scene and conducting 'Initial Attack' operations on a fire. Type Two firefighters vary much more from region to region. In some provinces, they receive less training or are tasked with sustained firefighting and mop-up operations rather than initial attack. In others, they receive all the same training and experience as T1 firefighters but aren't expected to perform as high level a fitness test as their T1 counterparts (see Chapter Five). To make matters more confusing, most jurisdictions have additional firefighter groups with yet another set of training and experience requirements, such as programs that contract 'emergency firefighters' (usually referred to as EFFs, and often hired from Aboriginal communities for operations within the same region) on an as-needed basis.

These are sweeping generalizations, of course. Symbolic events and personnel dynamics are idiosyncratic and unpredictable, and each organization must confront and re-confront questions of balance between different objectives (see Chapters 5-7 for a detailed analysis of some of these processes). But, the core point remains: alike begets alike, and each agency develops a culture of policy and practice that is reinforcing. It's also the reason why inter-jurisdictional exchanges (see Chapter Four) are so crucial.

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Over the next hour, the Forest Fire Centre became an increasingly busy hub of activity. The High Level tanker group was off tending a fire. Another new ignition near Grand Prairie resulted in a tanker request, but the nearest available "tanker package" – a set of Canadair 415 skimmers – wouldn't be able to work effectively given the long distance to the nearest skimmer-sized lake, so the tankers from Edson were sent northwest instead. I asked the provincial aircraft coordinator how he figured out that the lakes near the fire weren't long or deep enough for the 415s. "You just know which lakes are skimable and which aren't," he said. "It's just local knowledge." When I asked 415 pilots similar questions,
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the answer featured the same reliance on experiential, tacit forms of knowledge: spend enough time flying at a few hundred feet over the landscape and you learn which lakes you can use pretty quickly.

Wherever you are in Canada, the fire reports arrive in largely the same way. Where provinces used to maintain massive networks of fire towers, humans now serve as the primary reporters. Whether through a phone hotline (like the 310-FIRE number in Alberta), reports from commercial and recreational pilots, or calls routed through local 911 dispatch, the majority of fires are reported through these human pathways. Although preferable to not being alerted, the reality is often many successive callers report smoke in the same general area, leading to a significant challenge during the crucial first moments in determining how many distinct fires are being reported.

The occasional jurisdiction still maintains fire towers, staffed with rangers who look out for and report signs of smoke. Alberta still maintains an array of these towers, as does the one Canadian Forces base that deals with significant fire – CFB Gagetown – which positions a staff member on top of a water tower to report fires started by military training exercises. In Saskatchewan, cameras have replaced these towers, with feeds monitored from a basement room in Prince Albert. Whether staffed by rangers or monitored remotely, the task is the same: use multiple viewpoints to triangulate the location and report it back for investigation. Most jurisdictions, however, have switched from a tower-based setup to detection flights that, while expensive, can cover more ground and be adapted on a daily basis in accordance with the weather conditions.

Once the detection has been received, some basic information is uploaded into a piece of software. In a fit of surprising duplication driven in equal part by overzealous provincial IT departments and by a path dependency that favours maintaining existing solutions, most jurisdictions maintain their own unique geographical information systems (GIS) for cataloguing this data. These GIS feed the monitors sitting over the duty officer and the provincial aircraft coordinator, displaying weather, aircraft tracking, and current fires.

Figure 4
A provincial aircraft coordinator and the GIS displays above him.

Once a fire is reported, it is up to the district to send the initial attack crew. Because crews are local resources, they're dispatched by the Regional Duty Officers. Usually this is a matter of judgement on behalf of the duty officer, considering the weather, fire potential, and possible risks to determine how many firefighters should be sent. In Alberta, it's driven by a mathematical calculation based on the 'Head Fire Intensity' (a measure that combines the rate of spread and fuel consumption): at a certain level, one helitack crew and one tanker are to be sent to any smoke detection; above that, two helitack crews and two tankers are dispatched. Further tanker requests come from the incident command, routed through the Regional Duty Officer.

The challenges largely arise because of limited information as these dispatches happen. Sitting with the duty officer and provincial aircraft coordinator, the phones began to ring off the hook. "It's like playing a game of chess where you can never win," one announced. Murphy's Law was a regular visitor at the office: as soon as you dispatched a tanker to the east, invariably a fire would start to the west of the base that could have been handled more quickly if you had sent the first aircraft that direction instead.

Another few minutes pass, and then another dispatch. This time it was for a fire near the town of Fort Chipewyan in Northeastern Alberta, north of Fort McMurray and just outside of Wood Buffalo National Park. Every staff member has a phone off the hook, as the provincial duty officer called to alert a town near the fire in the Northwest, the aircraft coordinator called his counterpart in the Northwest Territories to ask about a tanker 'quick strike,' and another staff member fielded a call from the Fort McMurray Regional Duty Officer alerting the Provincial Centre to the fact that a tanker request for the fire near Fort Chipewyan was on the way. Telephone tag was common as one duty officer tried to reach another only to discover they were busy on the phone, and for the situation to be reversed when the call back occurred a few moments later.

Quick strikes are not uncommon in the Canadian context. Because of the position of tanker bases around each province, there are many places where the nearest available air tankers are those of another province. The fire near Fort Chipewyan was one such example: the Northwest Territories base at Fort Smith was much closer to the fire than the nearest Alberta tankers to the south. With agreements already in place between neighbours for how much Alberta would pay for such a strike (to cover fuel, retardant, and pilot costs), as well as regular communication between the Duty Officer counterparts, a quick phone call was all that was needed to send tankers south, drop a load of retardant on the fire, and return to their base in the NWT.

Such agreements are one of four levels of partnerships between fire agencies in Canada. For physical neighbours, border zone agreements offer the most proximate collaboration. Under these agreements, provinces are allowed to fight fires within a certain distance into the neighbouring province (including on their own initiative) – even without formally obtaining permission from the jurisdiction on a fire-by-fire basis – and to receive a pre-determined reimbursement for the process. Border zone agreements exist both within Canada and between Canadian provinces and their neighbouring American states. At a slightly larger level, regional compacts offer clusters of states and provinces that facilitate resource exchange and collaboration. Nationally, the Canadian Interagency Forest Fire Centre (or CIFFC, the subject of Chapter 4) provides a framework for pan-Canadian resource exchanges. Finally, bi-lateral agreements between nations (such as with America, Australia, and Mexico) allow for more distant exchanges during the most active fire seasons. In this case, the closest neighbours were key: the aim was a quick retardant strike that would allow a helitack crew to gain the upper hand over the fire.

For a moment, a phone call settles down the situation. The duty officer and aircraft coordinator reach the Duty Officer in Fort McMurray and are able to establish a plan that simplifies the tanker and skimmer dispatches. Armed with clarity about what resources were needed, and with the repositioning of a few aircraft groups to achieve a more balanced coverage, things calmed down.

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The best way to ensure that a response to fire is calm, coordinated, and effective is to prevent the fire from happening in the first place and to take steps to reduce possible harms if a fire does start. Some ignitions simply can't be prevented: lightning strikes are a reality across most of the country, and while lightning strike data can help guide where detection aircraft should fly over the coming days, little can be done to prevent them from igniting fires. Lightning is a timeless part of boreal ecosystems, and these ignitions are a key factor in shaping how species of trees, other plants, and animals have evolved around fire. Many of these species now depend on these fires to propagate and to protect them from pests (some pine trees, for instance, have seed cones whose wax must be melted by heat to allow the seeds to be released).
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Human ignitions, by contrast, can at least in theory be reduced. Sparks, dumped coals, and floating embers from train operations, for instance, were a leading cause of fires as the railway expanded west across the country. Through a combination of regulations and industry practice (shaped in no small part by the fact that railway companies are usually forced to pay for the suppression costs of fires that they start), these sources of ignition have been massively reduced. Careless humans, however, are a constant source of fires. Common causes include hot exhaust pipes on vehicles parked in tall grasses; campfires and garbage burns that escape; a seemingly endless stream of hot metal shards dropped by ATVs; and, unfortunately, occasionally intentional arson (whether children or teenagers attracted by the curiosity or thrill, in a quest to conceal evidence of another infraction, or by someone looking for employment as a firefighter once the response begins).[76]

The other important component of prevention is to ensure that properties are prepared for fire well before the actual ignition happens. In Canada, these practices are largely encouraged through a program called "FireSmart," the equivalent of the American FireWise initiative. 'Fire smarting' a property or community includes a series of simple and well-known steps that reduce the likelihood of fire spreading: removing piles of wood and shrubs from around houses, ensuring that embers cannot fall into air vents, and creating a sufficient gap between trees and homes to establish a 'defensible space.' These simple changes can make a significant difference. In Fort McMurray, for instance, 81% of

[76] While provincial agencies were understandably hesitant to discuss the frequency of arson by children, teenagers, and prospective firefighters, they do occur across the country each year. They are more than matched, however, by those who are generally much more economically privileged but behave carelessly with ATVs, cigarettes, and escaped fires.

properties that survived had been fire smarted, and every single surviving home had fully 'treated' the vegetation located within the zone most proximate to their house.[77] The vast majority of homes that are burnt in wildfires ignite not because of the initial wall of fire, but because of a prolonged attack from embers and places where even a single ember can incubate into a much larger fire (a wooden deck, flammable shingles, open vents, or wood products near the home, among others). Similar techniques can be applied on a community level (like ensuring that there are sufficient gaps between wooded areas and homes or evacuation routes) and a landscape level (such as creating fire breaks, thinning fuels, and creating a forest 'mosaic' that breaks up homogenous fire spread).

Unfortunately, persuading homeowners and communities to take responsibility for these tasks is remarkably difficult. Some individual homeowners face conflicting pressures, such as homeowner associations that push for plants near houses and wooden cladding or shingles. More pressing, however, is a surprisingly common belief the wildfire risk they face is "low to moderate" despite living in wildland-urban interface communities. This is then coupled with constraints like the financial cost, physical ability required, lack of information, and beliefs that the risk reduction behaviours would render the property less attractive.[78] Compounding individual problems, the central organization tasked with promoting these behaviours – FireSmart Canada – is underfunded and understaffed. Moreover, it struggles

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[77] Westhaver, "Why Some Homes Survived."

[78] McFarlane et al., "Human Dimensions of Fire Management in the Wildland-Urban Interface: A Literature Review," 27. (2006). This source provides a summary of two Canadian funded projects on this issue. Note, however, that this and other studies focus disproportionately on self-reported mitigation practices and do an insufficient job at identifying both how high over-reporting is and why a failure to conduct mitigation activities occurs.

with jurisdictional tensions as well: members reported, for instance, more effective engagement with industry partners while it was an Alberta-focused organization, although the need is pressing across the country.

At a provincial level, another systematic problem is the way that budgets are operated. Generally speaking, provinces tend to have two fire-related budgets: one fixed and one variable. The fixed budget provides for a variety of different predictable expenses, like the base salary of firefighters, overhead staff, and equipment purchasing and maintenance.[79] The variable budget is a suppression-focused pot of money, which can be tapped to pay overtime and as-needed hiring for firefighters, expenses like fuel and retardant, additional aircraft contracts, and the importing of personnel from other jurisdictions. Usually, this budget has a set amount assigned at the beginning of the year (either a fixed placeholder or an estimate based on average costs over a historical period). During a busy fire season, management agencies return to the provincial government – often several times – to request additional funds for fire suppression. Because putting out fires, protecting properties, and saving lives is generally seen as a political good, politicians tend to readily oblige refilling these accounts.

The problem is that most preventative activities – like the costs involved with running FireSmart programs – are counted in provincial base operating expenses. These base budgets rarely keep pace with rising costs as programs hire more firefighters, invest in new technologies, and keep up with changing regulatory landscapes. Although preventative work

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[79] Sometimes purchases can be amortized over multiple years, or separated out into a third capital expenditure category.

through programs like FireSmart can have a tremendous return on investment, there is effectively endless money for firefighting and almost none for prevention.[80]

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After the afternoon weather briefing, the duty officer and I returned to the operations room. Almost immediately, there was significant confusion: according to the mapped location, the fire near Fort Chipewyan was on the east side of the river, meaning that it fell inside the National Park and was therefore the responsibility of Parks Canada. But, the fire was assigned an Alberta regional fire number, suggesting that it was actually located on the west side of the river and belonged to Alberta Wildfire. Adding to the mix, the Parks Canada crews were already occupied: at the same time as this confusion about sides of the river, several fires within the park were 'blowing up' with increasingly aggressive fire behaviour. In any event, because of the border zone agreements, either Alberta Wildfire or Parks Canada could action the fire. The needed action was clear: the fire had to be put out, quickly. Although spread to Fort Chipewyan was unlikely because of the lakes, rivers, and swamps between the fire and the town, the smoke blowing that direction was a major nuisance.

Not every fire in Canada is attacked aggressively, however. At a broad level, there are three different ways to handle a fire. One is "full suppression": throwing enough resources at

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[80] In Australia, only three percent of wildfire-related spending goes to mitigation activities, despite these projects having documented cost/benefit ratio ranging from 1.4:1 to 8:1 (3:72).
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the fire to contain it and eventually extinguish it. This is the initial aim with almost all fires managed by Alberta Wildfire: if possible, control and eliminate the fire before it can cause damage to communities, resources, or infrastructure, or become larger than can be managed.

The second is "observation," where the fire is largely left to its own devices and monitored to ensure that it doesn't begin to pose a threat. Many fires in Northern Manitoba and Ontario, for instance, can be relegated to this status. If they're not near a community and if they're burning timber that would never be harvested anyways, they may as well be left to burn. This is effectively an economic calculus: the further from a firebase, the more expensive it is to fight the fire – and, in all likelihood, the less valuable it is to extinguish the fire at all. Observation also has the advantage of allowing fire to play a more 'natural' role on the landscape.[81] Because most fires that are observed are far from human settlement, they're almost all started by lightning. Observing a fire is observing a natural ecological process in actions.

The third option is "modified response." Instead of choosing from a binary of observing or suppressing, often the best answer is a mix of both. A fire could be allowed to safely grow to the north and west – restoring fire to the landscape and reducing fuel loads for future fires – while the southwestern flank might require more complete suppression to protect other 'values' (the industry shorthand for things that need protecting, like homes or

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[81] Gamborg and Larsen,"'Back to nature'—a sustainable future for forestry?" 559-571. Just what counts as 'natural' is, of course, contested. As is discussed later, the 'natural' has changed significantly over time thanks to shifting climates, different degrees of human influence (e.g., burning by indigenous communities), and competing definitions of what nature is (e.g., dense forest versus open grassland versus a managed landscape). This particular source delves into some of these tensions within forestry management in particular, as well as the tendency to romanticize 'the natural' in various contemporary management approaches.

timber) at risk.[82] Or, a fire in a more remote region might be allowed to burn almost entirely freely, while specific values – like buildings, hydro lines, or other infrastructure – are protected from the incoming fire with sprinklers, back fires, and fuel breaks. Like observation, a modified response requires trading one kind of risk for another: instead of the direct risk of immediate action with fire crews, it is instead a risk that the fire could become a threat to something else down the road, well after it has become too large to control.

By and large, observation is a long-standing strategy used by fire managers in two situations. Fires can sometimes be temporarily observed when there are too many to action simultaneously, allowing managers to deprioritize lower priority fires to, instead, respond to those that immediately threaten lives or property.[83] Observation is also a longstanding technique for fires that are distant from even the most remote communities, allowing space to stand in for expensive firefighting operations. The big question in fire management is the degree to which modified responses can become an acceptable and frequent part of the response toolkit, and the degree to which they can be deployed even within private timber holdings. There are some early signs of success – such as projects by Ontario to collaborate with lumber companies who want dead trees that cannot be harvested cleared from their

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[82] Because wildland fire managers generally use the term 'values' rather than 'assets' in referring to things that are valued by people, in the remainder of the book I refer to two different kinds of 'values' using the same name but in different contexts. Sometimes this is in reference to values that are held by people (e.g., beliefs, priorities, and stances); in other cases, these are values that people create (i.e., assets). A 'values protection approach to firefighting' refers simply to an asset-centric model (wherein fires are managed with respect to minimizing this asset loss, rather than for total suppression) and doesn't involve actually attributing a given dollar value to each individual asset.

[83] In most Canadian jurisdictions, in fact, the option of allowing the fire to burn for ecological reasons is *only* considered if it cannot be contained during the initial burning period. With a few exceptions (namely within Parks Canada where fire is managed for ecological purposes in all cases, as well as a handful of other management areas where pre-established plans allow for fire), alternatives other than suppression are only put

land – but these programs take significant up-front investments of time, resources, and planning to be possible.

Of course, the provincial nature of fire in Canada means that each jurisdiction has a different way of labeling and tracking these fire statuses. Consider four neighbouring provinces. In Alberta, for instance, fires are classified by whether they are Out of Control, Being Held, Under Control, or Turned Over.[84] In Saskatchewan, fires can be Contained, Not Contained, Ongoing Assessment, or Protecting Property.[85] In Manitoba, the labels Out of Control, Being Held, and Under Control seem to parallel Alberta, until the addition of observational categories Being Watched and No Action.[86] And, in Ontario, there are Not Under Control, Being Held, Under Control, and Being Observed.

Making matters even more challenging, seemingly similar categories aren't always interchangeable. A fire receiving values-based modified response (with firefighters attacking the fire in some areas to protect values at risk, but allowing it to grow on its own pace elsewhere), for instance, might be classified under Protecting Property in Saskatchewan, but either be Out Of Control or Being Held in Alberta. A remote, non-threatening fire would likely be classified as Being Observed in Ontario, while it could be fit into either Being Watched or No Action in Manitoba, depending on the particulars. This creates incommensurability between provincial data in Canada: it's impossible to translate fire data coded in provincial classificatory schemes into a standardized format without knowing

84 Alberta Wildfire, "Provincial Active Fires Report."

85 Government of Saskatchewan, "Status of Active Wildfires."

86 Government of Manitoba, "FireView."

specific context about at least some of the fires. A time-demanding approach, used by the Canadian Interagency Forest Fire Centre, is to simplify the categories down (into three: Full Suppression, Under Control; Full Suppression, Out of Control; and Modified Response, Active) and require each province to reclassify their own fires into these master categories. But, this approach loses nuance and detail, and highlights a second fundamental problem: the categories are 'double-barrelled,' meaning that they conflate two separate dimensions into a single measure.[87]

There are two different ways of counting fires. One, described above, is through clustering according to the plan of action for the fire: to suppress it entirely, to conduct a modified response like partial suppression or values protection, or to observe the fire without taking action at that given time. Another, embedded in the taxonomies created by each province, is to sort by fire behaviour and the status of attaining 'control' over the fire: whether the fire is out of control, being held (usually defined as expected not to grow beyond the current lines of defence established by firefighters), or under control. The problem is that one taxonomy has little bearing on the other. An out of control fire might be progressing as planned (if observation is the goal), an entirely acceptable status in general (if the specific values at risk are being adequately protected, like with sprinklers on cabins), or catastrophic (if the goal is to extinguish the fire as quickly as possible).

When a measurement or data collection system conflates these two categories – by using a system that consists partially of status categories (like out of control) and partially of

[87] I owe a great deal of thanks to Den Boychuk of the Ontario Ministry of Natural Resources for pointing me towards this problem through discussions of how Ontario was revamping its approach to fire classification.

objective categories (like being watched or property protection) – overlap and ambiguity is generated. This can usually be managed just fine by the people directly responding to the fire (a local duty officer, for instance, will have no trouble disentangling the status of a fire and the management objectives on a case-by-case basis). But, it can generate confusion when data is being passed to a central office. It also means it's impossible to look back on historical fire data and know why a certain status was assigned to a fire (for instance, was that fire considered out of control because it was being observed rather than actioned, or was it out of control because firefighters were attempting and failing at suppressing it?). Fire management and research alike would be improved if Canadian jurisdictions moved to a standardized and shared two-fold classificatory scheme, in the vein of the system Ontario has moved towards for this very reason (classifying a fire both by its status and the action being taken).[88]

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As the afternoon progresses, the duty officer and aircraft coordinator continue the Sisyphean task of a Duty Officer: trying to understand the conditions in the field from their location hundreds of kilometers away. As soon as they get a handle on one situation, something has changed somewhere else. As they hear about the fires 'blowing up' in Wood Buffalo National Park via an email to the agency director, they also learn from a regional

[88] The new Ontario classificatory scheme uses status categories of "Not Under Control, Being Held, Under Control, Out, and Being Observed" and objective categories of "Full Suppression, Modified Response, Values Protection, and Monitoring."
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duty officer that firefighters have been pulled off of a different provincial fire because of aggressive burning behaviour there. An information officer wanders through the operations room, and the duty officer briefs her on the latest information about each fire in case of media questions.

Immediately thereafter, a specialist in fire behaviour arrives to update the team on simulations of fire spread for the blaze near Fort Chipewyan that he has been running in his office. The models seem to line up with the fire size and spread that's being reported from the field, but they can't answer the key question – which side of the river the fire is on in the first place – because they are working from the same assumptions as everyone else in the office (the geo-tagged location of the fire, which is the very thing being questioned). The duty officer pours over photos of the fire that have been emailed from the crews on scene, but they're unclear at best.

This informational uncertainty, unfortunately, characterizes most fires. In hindsight, at least three factors are routinely present: (1) the fact that fire, weather, and human conditions are always changing, (2) the distributed character of the geographical and jurisdictional spread (there are a huge number of people involved in producing knowledge, who are separated by physical distances and use a variety of information sharing systems), and (3) a lack of clarity about which data is up-to-date (because parts of the necessary information are often being produced rapidly and in parallel between different offices, it's difficult to know who produced what, which is the most up-to-date version, and who has the most reliable source knowledge to begin with. All three of these factors can be seen in an after-action review from the Horse River fire:

> "On May 3, [Alberta Forestry] wildfire managers were attempting to confirm wildfire escape predictions at the same time things were quickly changing in the field. Although there was information available in the system (e.g., observations from wildfires, discussions among [Fire Behaviour Analysts], model projections, etc.), that information was not completely available to all decision-makers. In some cases, people at a distance (in Edmonton, for example), were asked to confirm a wildfire growth projection, but those staff struggled to obtain the latest information adjustments that were being made elsewhere such as the wildfire perimeter, fuel type and condition, and other data. In some cases, maps and updates flowed through email or telephone conversations to senior managers, and the staff working on forecasts did not have the latest situation update. Although a strategic planning unit was ultimately created, it took valuable time to establish the situational context and information flow throughout the organization."[89]

Suddenly, there's more confusion. A report comes in to the duty officer and aircraft coordinator that the air tankers performing a 'quick strike' from the Northwest Territories have dropped their payloads on the fire without checking in first with the crews on scene. The report turns out to be a miscommunication from the field – all went according to procedure and was simply garbled in a game of telephone – but it raises huge red flags. Across Canada, firefighter safety is paramount. While information can often be incomplete by the time it's translated back to headquarters, there's little tolerance for on-the-ground firefighter risk.

One commonality with each of the provinces I visited was their views on what constituted acceptable risk. Firefighting is an inherently dangerous profession. From 1941 to

[89] MNP, "A Review of the 2016 Horse River Wildfire," 21.

1990 in Canada, 132 fatalities occurred in wildfire suppression roles.[90] Another 33 were killed between 1991 and 2010, which represents a slight downward trend (from a previous average of 2.6 per year to 1.7 per year). The fire itself does pose a direct hazard, of course, but rarely is the fire the greatest source of risk when firefighting. In both Canada and America, wildland firefighters are most likely to be killed in aircraft accidents, followed by vehicle accidents (such as failing to wear seat belts or driving while fatigued). Other causes, like heart attacks and falling trees, rolling rocks, and downed power lines make up significant causes as well.[91]

Like many parts of Canadian identity, this risk tolerance was often framed in contrast with America. On average, 1.65 suppression related fatalities in Canada occurred each year between 1991-2010, in contrast to 17.35 per year in America.[92] These numbers, of course, are difficult to compare head to head: normalizing by raw population, for instance, doesn't account for differences in patterns of where communities settle, nor which fires are fought and which are left to burn. What fire managers regularly cited, however, was a difference in

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[90] Alexander and Buxton-Carr, "Wildland Fire Suppression Related Fatalities in Canada, 1941-2010: A Preliminary Report." Note that, especially pre-1980, there is high variability year-to-year (from 0-16 suppression related fatalities).

[91] Mangan, "Wildland Firefighter Fatalities in the United States: 1990-2006."

[92] National Interagency Fire Center, "Wildland Fire Fatalities by Year."

techniques and risk tolerance.[93] Many American firefighters, for instance, carry with them blankets that serve as emergency fire shelters. In 2013, nineteen firefighters from the Granite Mountain Hotshots deployed their fire shelters just before being overrun by fire near Yarnell Hill. All nineteen were killed. They were venerated as heroes killed in battle, a narrative that is not uncommon throughout the mythology surrounding American wildland firefighting: the young men of fire; their courageous battles to save buildings from flames; and a culture that risks encouraging heroic efforts.

Canadian firefighters, by contrast, don't carry these emergency fire shelters. Managers across the country, without fail, cited what they articulate as a different approach to risk: if you were close enough to an aggressive fire to consider deploying the blankets, terrible mistakes had been made far earlier. Crews simply weren't to be put in vulnerable places as fires advanced. In remote boreal forest, of course, there are times when fire simply cannot be fought, and crews need to be reposition to manage the parts that can be safely guided. But, even in cities like Fort McMurray, realize managers, there are times when evacuation is the only option: boreal fires can sometimes simply be unstoppable.

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[93] The question of normalization is also complicated by the fact that tactical differences and risk tolerances are inseparable, not to mention muddled with other factors like availability of water and the flashiness of fuels. Each context requires a different approach to firefighting. This manifests, however, as larger numbers of firefighters on the ground – cutting fire lines and manually fighting the fire – in the United States than in Canada, where crews tend to be deployed in smaller numbers and more mobile configurations (helicopter access rather than ground access). Ultimately, this is something of a chicken and egg problem that warrants further research: are these tactical differences a result of the conditions on the ground, which translate into different risk profiles? Or, are these tactical differences in part a manifestation of different risk tolerances, views about the role of labor and technology in firefighting, and philosophies about employment (e.g., seeing firefighting as an opportunity to make jobs versus firefighting jobs as a high-cost part of the business).
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Fortunately for the Alberta Wildfire team, the fire near Fort Chipewyan wasn't unstoppable. As dinner approached (the staff work until late evening during fire season, as fires remain active after business hours), some clarity emerged. What had been lost in translation between the local knowledge of Fort McMurray's district and the Provincial office in Edmonton was the nuance of the on-the-ground geography. The fire was indeed to the east of a river – but that was a secondary channel of the main river in the area. As such, the fire was indeed west of the river and within the jurisdiction of Wood Buffalo National Park.

With calming winds and this mess of waterways, marshy areas, and firebreaks between the fire and Fort Chipewyan, things became much more manageable. As I left the office, the flurry of phone calls was slowing down and the crews on the ground were making progress. The provincial aircraft coordinator had positioned a few extra water bombers in Fort McMurray to be able to take care of flare-ups more quickly the next morning, but things were largely under control. It was entirely different than the Regional Emergency Operations Centre in Fort McMurray on the afternoon as the Horse River Fire rolled into the neighbourhoods of Abasand, Beacon Hill, and Waterways.

> "The captains tried the radio, but their call was breaking up. The fire had reached the tower, compromising communications. Captain Collins went after it in a squad truck, and the next time the radio worked it was his voice: 'Emergency traffic, emergency traffic, emergency traffic – we're abandoning Abasand'." [94]

As the Fort McMurray Fire Department worked from neighbourhood to neighbourhood – protecting homes and evacuating people where they could and retreating where the fire had gained too much of a foothold to safely fight – other agencies across the city were thrown into similarly pitched, high-paced battles. Many, including emergency managers at the REOC, hospital planners, and police brass, had little idea that the fire would come as fast and furious as it did. Lorna Dicks, the acting superintendent of the Royal Canadian Mounted Police (RCMP) detachment, had spent the past days planning for possible scenarios.[95] She only found out that the fire had entered the town when she received – during the middle of a planning conference call – a "text message from her sister-in-law, along with a photo of a big fire burning behind a row of houses" that was taken from the front steps of her sister-in-law's house.[96]

Looking out the window, Dicks saw normally quiet streets filling up with cars breaking for the single highway running south out of the town. "Clearly something was

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[94] Asher and Mouallem, *Inside the Inferno: A Firefighter's Story of the Brotherhood that Saved Fort* McMurray, 77. The subsequent narrative presented also draws on this source.

[95] Outside of Calgary, Edmonton, five other towns, and three First Nations police services, the RCMP provide community-level policing in Alberta. As such, the Wood Buffalo detachment of the RCMP is, in effect, the city police department in Fort McMurray.

[96] Struzik, *Firestorm: How Wildfire Will Shape Our Future,* 41.

happening, and it was happening fast. From that point on we went into full-court press. It was chaotic. We went from going zero miles per hour to one million miles per hour." Some RCMP officers were dispatched in their own cars, as the detachment didn't have enough cruisers. The bus bringing additional officers into town had broken down, rendering them even shorter staffed. Not all officers had respiratory masks to protect them from the smoke.

One officer, Constable Andrew Brock, was sent to the intersection between the highway, Gregoire, and Beacon Hill. He described the most difficult task as convincing parents not to drive further into the city towards the school. Children were being loaded on buses, he told them, and they needed to keep the roads clear for fire trucks. The threat was greater than just the school, he later told Struzik:

> "I watched as the Super 8 hotel over there burned to the ground in 45 minutes. I was concerned this gas station on the corner here was going to blow up. Then the fire jumped the four-lane highway right before my eyes. It lit up the grass and the fence over there. There was a heavy loader parked nearby. I figured those buildings were going to burn next. Then some guy comes along, gets out of his truck, starts up the heavy loader, and knocks down the burning fence to save the buildings. He came out of nowhere and disappeared just as quickly."[97]

After-action reports from the fire capture the all-consuming nature of this effort. Alberta Emergency Management set up a mobile command post. RCMP called in all members to help with the evacuation. Alberta Health Services evacuated the hospital, with a combination of self-evacuation, ambulances, and helicopters. When school buses couldn't reach some schools because of traffic congestion, teachers evacuated students in their own

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[97] Struzik, *Firestorm: How Wildfire Will Shape Our Future,* 43.

vehicles.[98] The fire threatened every part of the community, from gas stations and hotels, to hospitals and schools, to water treatment plants and bridges, to homes and the fire halls themselves.

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In and of itself, fire is neither good nor bad – it simply is. The fires that members of the public tend to care about, whether in urban or rural landscapes, are important because of the things they cause directly and indirectly. The 2017 Grenfell Tower fire in London was devastating because of the 71 deaths that it caused. The December 2017 Thomas Fire in California were notable for the twenty people killed in mudslides resulting from the fire weeks later. And, the Horse River fire was significant because of the 88,000 people that it forced as it burnt through Fort McMurray, not to mention the almost ten billion dollars in losses that resulted. In each of these cases – and in every fire – the flames matter because of human-defined impacts of the heat they produce, the fuel they consume, and the landscapes they move through.[99] These can be bad (burning people or equipment; feeding on houses and possessions; entering an home-filled environment) or good (the warmth of a campfire;

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[98] KPMG, "May 2016 Wood Buffalo Wildfire Post-Incident Assessment Report," 26.

[99] It is true, of course, that fires have large impacts on biotic and abiotic components of ecosystems as well. Without humans, though, the *valuation* here becomes much fuzzier: even in the 'natural' world, it's only through a socially constructed lens that we ascribe value to certain configurations of species and ecosystems. A fire that affected a hypothetical non-human ecosystem, for instance, couldn't be called 'devastating' without humans giving value to whether the original or transformed landscape was to be more greatly valued.
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the unwanted debris burned to ash; the ecosystems they reinvigorate), but their valence is determined by their perceived impact on people rather than some immutable property.

This has always been true. Since the earliest indigenous communities, humans have used fire to shape landscapes to make them more readily accessible for prey and agriculture.[100] Fire was also used on smaller scale applications, including for domestic heating and for burning small gardens prior to planting to improve the ease of planting.[101] These uses continued as settlers spread across Canadian landscapes, as evidenced by the number of fires started by land clearing and scrub burning in Chapter Two. As humans spread, so too did fire – both from their attempts to use it in controlled ways and their inability to prevent regular escapes.

Growing populations spread across flammable landscapes created not just the fire itself, but also the things threatened by the flames. Thanks to humans, homes and factories were built; trees were declared 'valuable' and 'merchantable'; roads and railways and pipelines were linked; and certain lands were designated for hunting or trapping. Ever-larger populations created more and more dense arrangements of these features on the landscape. In the first two-thirds of the twentieth century, this was largely the expansion of the timber industry across the boreal. It resulted in the approach described earlier: a concurrent

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100 Regan, "Austrian Ecology: Reconciling Dynamic Economics and Ecology." This source is particularly effective for its recounting of Yosemite National Park and fire regimes within. For a longer example, a comprehensive encapsulation of this phenomenon in Australia can be found in *The Greatest Estate on Earth*.

101 Berkes and Davidson-Hunt, "Biodiversity, Traditional Management Systems, and Cultural Landscapes: Examples from the Boreal Forest of Canada," 35-47.

expansion of firefighting capacity, pouring more resources into fire suppression through aircraft, firefighters, and ever-larger provincial fire management agencies.

Over the past decade, however, two things have changed. First, the cost of this endless expansion of fire-fighting capacity has become increasingly apparent. In 2015, for instance, the United States Forest Service spent more than 50% of its budget on wildfire-related preparedness and suppression – a far cry from the 16% of Forest Service budget fire represented in 1995.[102] While this figure is often leveraged to illustrate the potential impact of climate change increasing fires, there are a number of other factors that more thoroughly explain why the number keeps rising (see Chapter Eight for a discussion of these influences). One part of the explanation, though, is how labour-centric fire suppression is in the United States. Because crews are such a massive part of the operation – cutting fire breaks, using hoses, and running fire engines – firefighting remains an expensive task. Technologies like improved helicopters or models can help to position these crews more effectively, but they don't fundamentally increase the productivity per dollar spent on employing people.[103]

In the Canadian context, the financial cost of wildfire management has also increased. The average budget spent nation-wide on fire suppression between 1980-2011 was

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[102] USDA, "The Rising Cost of Wildfire Operations: Effects on the Forest Service Non-Fire Work," 2.

[103] This evokes the idea of Baumol's law, wherein rising salaries can affect occupations where labor productivity is not increasing. The contrasting case would be one where labor is becoming more efficient: twenty firefighters, for instance, are replaced by an air tanker. This is not clear in the fire case, however, where it seems as though the prevailing management strategy is to use both rather than to supplant manual labor with technology, and where each serves a different role. As such, one would not expect technological innovation to reduce the cost of firefighting, but rather to increase it.

$537 million.[104] This number has risen by approximately $120 million each decade since 1970, as evidenced in Figure 5.[105]

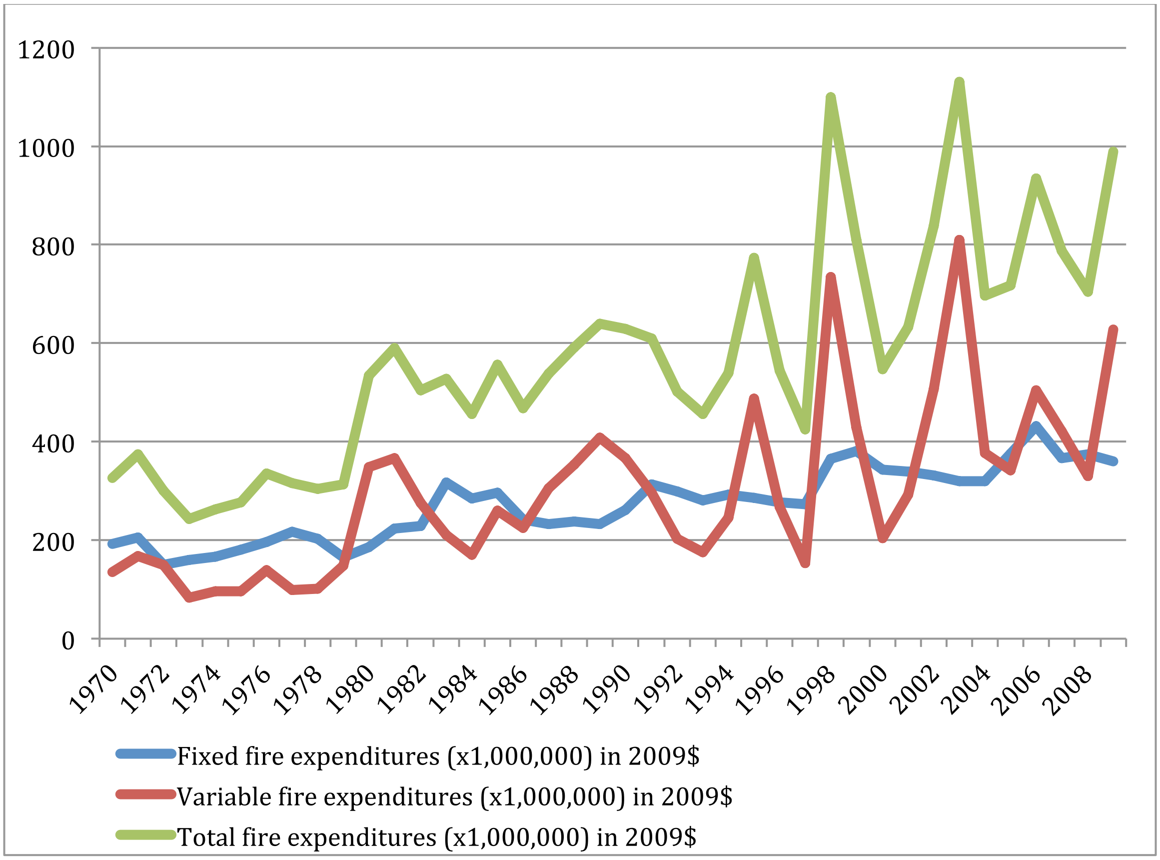

Figure 5
Fire expenditures in Canada in 2009 dollars.[106]

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104 Hope et al., "Wildfire Suppression Costs for Canada Under a Changing Climate."

105 Natural Resources Canada, "Cost of Fire Protection." Data drawn from this source, graph produced by author.

106 Natural Resources Canada, "Cost of Fire Protection."

These rising costs are broadly viewed as being "unsustainable" by fire management agencies. A report by the US Forest Service, for instance, argued that their ability to fulfil their other forest management roles was "threatened" by the "debilitating impact" of the ever-growing fire suppression budget.[107] Yet, the increasing fire suppression costs also reflect the ever-higher expectations placed on fire management agencies to protect more people, with more numerous and expensive properties, and under increasingly high pressures to deliver on perfect protection. At the same time, however, fire managers face significant pressures to reduce costs and maintain budgets: how can fires be suppressed in a way that doesn't become prohibitively expensive?

The second change is more directly human induced and ultimately explains a large portion of the rising costs. One fire manager I interviewed offered a succinct summary: "It was easy when it was just trees." Nowadays, wildland fire managers often find themselves in increasingly urban-seeming roles: fighting fires that involve buildings and infrastructure strewn throughout. In Alberta, this is often industry expansion; in Manitoba, it's a growing number of cottages in forested lands. Across the country, it's often economically well-off individuals looking to live on picturesque, forested properties outside of the suburban sprawl. Indeed, over twenty percent of Canada's wildland fuel is located within 2.4 kilometers of communities, homes, or industrial development.[108]

At the same time, public expectations are also rising about what fire suppression ought to be able to protect. The homeowners and cottagers that move to flammable

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107 USDA, "The Rising Cost of Wildfire Operations: Effects on the Forest Service Non-Fire Work," 2.

108 Johnston and Flannigan, "Mapping Canadian Wildland Fire Interface Areas."

landscapes bring with them expectations of the same 4-minute response times they expected from city fire departments and the guarantee of properties protected from the prospect of flames. Smoke is also frowned upon, both from prescribed and unplanned fires. And, governments are eager to avoid headlines about fires going uncontrolled, especially if they damage property or cost lives.

Put together, these factors – increasing costs, rapid growth in what must be protected, and heightened expectations about the quality of this response – are forcing a change in how fire is managed in Canada and elsewhere.[109] The old model was one of 'total suppression;' the new is a model of 'values protection.' In a values protection regime, the aim is no longer extinguishing every fire, but rather managing the portions of a fire that are responsible for its negative effects.

For an oversimplified example, consider a fire burning through a remote area of forest late in the season. The 'values' present on this landscape may be relatively sparse: only a few cabins and docks. Instead of pouring resources – firefighters, hoses, pumps, and aircraft – into fighting the fire, an agency using a values-protection model might elect to use a much smaller response. A few firefighters would be sent by helicopter to set up pumps, hoses, and sprinkler kits to protect each of the cabins and docks, and to remove other possible causes of ignition (e.g., fire wood piled against the home, or cutting down trees to provide a larger barrier). These pumps would be turned on in advance of the fire, and the helicopter and crews could provide support as needed to ensure that the cabins went

[109] Literature on values-based approaches to wildfire management began to appear in academic venues in the 2000s and proliferated post 2010.

unharmed as the fire passed through. Otherwise, the late-season fire would be allowed to burn as the weather, fuel, and terrain dictated, until rain or snow extinguished the fire. The values would be protected; fire would be allowed to play a more natural role on the landscape to ecological benefit; and the agency would have spent significantly less money on the operation.

Of course, even in this simplified example, many questions remain. Just how valuable would the cabins be to their owners, for instance, if the forest around them was largely burnt? Do all of the landowners and users – including Indigenous communities, trapping companies, and ecologists, among others – agree that the only values are the cabins and docks, or are there other values threatened by the fire? How often does such a simple situation present itself, when cabins, dams, hydroelectric lines, trapping grounds, indigenous land, industrial infrastructure, and remote communities are scattered across the landscape? And, how confident can you be in upcoming precipitation and fire behaviour to know how far the fire will travel before it is extinguished?

The model, though, is admirable. Using a values protection approach to fire management shifts the equation from excluding fire from landscapes to recognizing its ever-present role. In turn, humans are asked a different question: how can we live with fire, rather than deluding ourselves about the possibility of living without any risk.

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For Damian Asher and the other firefighters battling the Horse River blaze as it rolled through Fort McMurray, the fire was surrounding and engulfing. "The heat intensified," Asher recalled, "but finally, the smoked cleared and we got a glimpse of our surroundings. We saw fire tornados in the trees on either side of the road. Dressed in a reddish-black aura, they whirled fifty metres into the sky."[110]

If you could have peeled back the smoke for a moment to get a closer glimpse of the buildings, however, you would have seen three different phenomena underway. Houses don't just spontaneously combust, even in the path of the most aggressive forest fires; they require a source of ignition. One possible source – convection – occurs when the flames are able to make prolonged contact with the building itself. If trees or shrubs are close enough to the house, flames can transfer directly. Another cause is radiation, where the intense heat itself can light the fire. In both of these cases, however, the distances must be quite short: allowing twenty to thirty metres between the forest and a home is not only enough to prevent wooden walls from igniting, but even to prevent much residual scorching.[111]

The majority of building ignitions, therefore, come not from direct convection or radiation, but a third source: embers and firebrands. These embers usually rain down most intensely about 100 metres ahead of the fire itself, but can arrive as early as an hour before

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110 Asher and Mouallem, *Inside the Inferno: A Firefighter's Story of the Brotherhood that Saved Fort* McMurray, 126.

111 Cohen, "Relating Flame Radiation to Home Ignition Using Modeling and Experimental Crown Fires," 1616-1626.

the fire itself (five to nine kilometers in advance, depending on the fire).[112] In two particularly thoroughly researched fires near San Diego (the Witch and Guejito fires), embers were responsible for between 66-100% of the 1,125 homes lost.[113] Making matters even worse, structures already on fire can also create embers, resulting in new building fires hours – and even days – after the original forest fire passed through.

This was true in Fort McMurray as well. In most locations, homes were separated from the forest by total breaks (like roads) or low-fuel zones (like mowed lawns) by thirty-five metres or more, meaning that direct ignition from the fire itself was rarely the cause of the threat to homes.[114] Rather, most were ignited either directly by embers or because of the presence of an ember-friendly "Achilles' heel" like ornamental shrubs against the home, easily ignited materials (like garden sheds, gasoline, firewood, or construction timber) within five meters of the home, decks or fences (which serve as 'wicks' connecting the forest to homes), or wooden mulch.

As such, a values protection approach to fire management begins with the values themselves. Communities can be made increasingly fire resilient through FireSmart or FireWise treatments at the individual building level (like removing wicks, eliminating ember-catching fuels within the parameter, and screening vents in a way that prevents firebrands from entering). And, these effects can be multiplied over the community level when such

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112 Marenghides and Mell, "A Case Study of a Community Affected by the Witch and Guejito Fires (TN 1635)."

113 Institute for Business & Home Safety "Mega Fires: The Case for Mitigation, the Witch Creek Wildfire," 416-417.

114 Westhaver, "Why Some Homes Survived."

threat-reduction strategies are performed with shared buildings (including critical infrastructure like hospitals and water treatment plants, as well as important service providers like grocery stores and gas stations).

Another key is creating sufficient distance between the forest and flammable buildings and evacuation routes. This can be done through manual thinning, such as mowing a wide band beside roadways and hydro wires to slow or prevent fire spread. It can also be done through targeted fuel reductions, like thinning forests on the outskirts of human dwellings through mulching programs (which are time consuming and expensive but can be done where prescribed fire is too risky or aesthetically undesirable). And, prescribed fire can be used to reduce built-up fuel load. Almost all jurisdictions in Canada have small 'hazard reduction burn' programs that target roadsides or slash piles; very few conduct larger-scale burns to create mosaic landscapes that slow fire spread (Parks Canada being the obvious exception, given its mandate of restoring fire to the landscape).

Of course, this approach – coupled with the very limited funds for risk reduction because of the budget structures and political priorities described earlier – naturally leads to a demand for quantification and prioritization. Which values are at the greatest risk and where should such risk-reduction efforts be conducted given constrained resources? The answer across Canada, unfortunately, often has to do more with jurisdiction (which agency and level of government has the funds available vs. which owns the land?) and idiosyncratic reasons (which area has obtained sufficient local buy-in, planning, and permissions – which, like funding, are quite limited given a lack of staff capacity dedicated to prevention and environmental planning efforts). Risk reduction is done where the stars align and in whatever small cases it actually can be accomplished. This isn't, however, the only option.

Before the fire season began in Canada, I visited Victoria, Australia to learn about a new approach to choosing where to target risk reduction: Phoenix. All across Canada – and the globe – different models are used to predict fire behaviour, which are discussed in more detail in Chapter Six. In Tasmania, New South Wales, and Victoria, the model of choice is 'Phoenix,' which was developed in collaboration with the University of Melbourne.[115]

Each model has specific parameters and assumptions, some of which are advantageous and others limiting.[116] Phoenix, for instance, only uses a smaller and older set of grass and forest models for computing fire spread, rather than more advanced recent approaches. It is run deterministically, meaning that the model outcome is predictable given the weather and starting parameters used; inserting randomness or conducting multiple different runs is seen as being too computationally intensive. The model itself simulates fire behaviour based on 120x120 metre grid squares, but the fuel type data it uses is rendered at 30x30 metre grids – so it is averaged for the purposes of simulation. And, it requires a large number of other data sources as inputs (including roads, rivers, past fires, and meteorological data like wind speed and direction, humidity, temperature, cloud cover, draught factors, and fuel drying). Each of these data sources have their own challenges, such as the use of 2015

[115] Just which model is used is quite contingent. The rest of Australia, for instance, uses the nationally funded Aurora model. Phoenix, however, had been funded by the state governments in question, hence they have opted to use it despite its relatively older fire spread computations. Aurora currently has richer historical data and hotspot information, but simulates at a larger scale (200x200 meters as of early 2017), with an aim of reaching 50x50 meter simulation.

[116] I'm grateful to a series of personnel who remain unnamed with various agencies in Victoria for explaining and demonstrating this model to me.

postal addresses to place properties – a decision that performs well in urban areas, but leads to increasingly inaccurate information in more rural locales.

Such models can be used for a wide variety of applications. Perhaps the most frequent use today is for fire operations themselves. Predicting how a fire will spread is crucial for not only responding to a fire on the landscape – knowing where to evacuate, how to position crews, and when the fire might no longer be safe to fight directly – but also for knowing when it is appropriate to ignite a prescribed fire. Phoenix is used for both: it feeds into an emergency mapping product for Victoria and can be used to simulate prescribed fires before the ignition is made.

In talking with fire managers, there was broad agreement – even from those who were critical – that the model represents fire reasonably well. The problem, though, is just what 'reasonably' means. As one manager summarized to me, "at the end of the day, [a fire behaviour model] can't give a terribly accurate prediction anyways. If you get to sixty percent, you've done a really good job." Making matters worse, there's little consensus on just how much weight should be given to these models. "Some duty officers are really keen to see [the model outputs] as predictions," another manager said, while "others don't really care." No standard operating procedure or established doctrine exists for when the models (and other knowledge generated by fire behaviour analysts) should be used in decision-making, nor how their limitations ought to be considered and accounted for.[117] This is

[117] Neale and May, "Bushfire simulators and analysis in Australia: insights into an emerging sociotechnical practice." This article provides more detail on bushfire simulators and the "fire behaviour analyst" role in particular, which is known as the "FBAN." Fire behaviour analysis generally combine fire experience with formal training in fire behaviour, and are called upon to make predictions about how fires will behave and grow.

particularly challenging when the models feed directly into operational decisions, like establishing fire danger levels or triggering school closures.

Perhaps the most unique application of Phoenix, however, is related to determining how fire risk should be reduced through prescribed burns. Because the model is deterministic – that is, will output the same fire behaviour given the same initial inputs – it can be used to compare different landscape arrangements. The model can be run, for instance, to simulate the current fuel load around a community. The fuel data can then be changed through the addition of a road or a hypothetical prescribed burn, and the model can be re-run given these new conditions. The results can be compared: the number of houses burned under current versus modified conditions, for example. This produces a quantitative measure of the impact of a given treatment and, in turn, a numeric scheme to prioritize different risk reduction methods. A hypothetical prescribed burn in one location might save 20 houses, for instance, while a different burn would protect fifty (again, given the single deterministic scenario the model was using). Thus, a rationale for prioritization is provided: burn here and you protect more houses than if you burn there.

In Victoria, this approach is extended to include certain targets about risk reduction. By running these comparative Phoenix models – first as is, and then with a treatment – you can quantify the 'amount of risk reduced' in a given area. Set a goal (say, 'reduce risk by 20%'), simulate a bunch of possible projects, and optimize the most efficient way to achieve that goal. Wash, rinse, and repeat: fire management can be turned into a quantifiable science with a model that determines the best way of reducing risk for a landscape.

In talking with fire agency decision makers, there was understandable scepticism about this approach. Several expressed a concern that Phoenix had largely been developed as a research tool but was now being inserted into operational roles with real consequences. "We've pushed it beyond what it really is," said one manager. Talking with more rural forest managers, there was another concern. A number – especially one produced by a model – is embedded with objectivity, with certainty. In turn, it led to gaming the system. Some projects were relatively easy and scored well under the pre/post Phoenix comparison, such as a prescribed fire that protected a large number of houses if a fire was ignited in a certain location. But, other projects required more work (such as working with landowners to gain trust and permission to burn or executing a more complex prescribed burn that required very specific weather conditions to be done safely) and didn't score nearly as highly on the system (they might be important ecologically, or protect a piece of critical infrastructure, but not offer insurance for sheer numbers of buildings). Gaming the system meant picking off the low-hanging fruit and shelving more complex, costly, or unimportant-to-the-model-score burns.

Such a pre/post comparison also created challenges for integrating local knowledge. Rural fire managers often have a good sense about areas that are particularly prone to human ignitions, for instance. The same swatch of roadside might be prone to the same children playing with matches, or a particular agricultural area might routinely see annual escape fires because of land-clearing burns by property owners. But, the model doesn't consider the likelihood of a fire actually occurring there – just sheer 'risk' reduced. As such, it would be easy to gain support for a treatment that might be much less likely to be important (like a fire start in an area that could be easily controlled before posing a risk to a community) while making it difficult to argue for smaller, more costly, but more rewarding work in a fire-prone locale.

The question of where fuel reduction treatments should be prioritized is hardly unique in experiencing this tension between tacit expertise and quantification. As was evidenced throughout the previous chapter, a vast majority of decisions in wildfire management – from which crews will be dispatched to a certain fire to what tactics should be used – are based almost entirely on the experience-based judgement of fire managers. Because fire managers have generally worked up through the ranks within their programs, they've accumulated significant lived experience. This translates into an ability to make judgements, some of which can be easily and explicitly articulated ("this pile of wood beside the house is a fire risk that we should keep our eye on"), while others exist in a tacit realm that is hard to explain, even if asked for a rationale (such as "the conditions here just feel risky and we need to be careful").[118] While this kind of judgement allows for a much more comprehensive set of knowledge to be included in the decision-making (such as information shared with colleagues, experiences on-the-ground in different locations, and even gut feelings based on past experience), it also makes it very difficult to accurately explain why a

[118] Collins and Evans, *Rethinking expertise*. This volume provides an extended discussion of these forms of expertise, as well as the debates around "embodied" practice (e.g., could you learn to become an adequate firefighter just via formal courses and training from experts, or do you need to actually work the hose line to really understand it?). There is significant opportunity for exploring the expert practice of both firefighters and fire managers, how much of it operates within tacit vs. explicit realms, and how training and experiences are transformed into lessons learned and expert judgement.

certain decision was made the way that it was.[119] The factors are variable and context dependent, and the judgement tacit rather than formal and explicit.[120]

The alternative, as illustrated by the use of Phoenix to evaluate risk reduction strategies, is to pursue more formalized models. An approach like Phoenix requires focusing on a far smaller number of variables and modeling in a structured and regimented way. The fuel types on the ground, for instance, aren't represented in a real-life level of detail, but are rather simplified into much coarser grids that purport to represent these real-world conditions while making the models something a computer can actually run in a timely manner. This strategy offer several benefits, however. One is readily appealing: the promise of neat numbers that can inform decisions, even if they are based on artificial and simplified calculations. Another is the shift of liability from individuals making high-stakes judgement calls to a "scientific" model. Still another is the opportunity to be able to unpack and analyze the algorithms being used, which is simply impossible when humans are making one-off judgements.

As appealing as it is, however, quantification can lead to problematic outcomes in emergency management and high-risk environments. As discussed in more detail in Chapter Six, focusing on quantification can conceal outliers and specific impacts, such as obscuring

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119 Sanders, "Have you been identified? Hidden boundary work in emergency services classifications." 714-736. This piece offers a particularly interesting analysis from the emergency services context of how tacit and experiential expertise can be leveraged to navigate and take advantage of more formalized systems.

120 Kennedy, "How Many Firefighters Can We Send: Mutual Aid and Availability Forecasting in Canadian Wildfire Management." In this paper, I offer a more in-depth discussion about tacit versus formalized knowledge and the tradeoffs that are made between the two modes of expert judgment. I also highlight the many roles that expert judgment and tacit knowledge still play in formalized systems, which generally (though often unintentionally) are based on assumptions and heuristics used by the people who create them.

the ways that individual properties might be affected by a fire that is deprioritized relative to another that is judged by an algorithm to be more vital. It can also lead to the exclusion of knowledge that doesn't conform to the definitions of what counts as valid or allowable data. Quantification can also, however, lead to much more catastrophic outcomes. As an illustration, consider the Space Shuttle Challenger, which met a catastrophic end during its launch in January 1986. In retrospect, the failure was a vexing mystery: personnel within NASA had warned of the exact possible cause of the failure in advance of the launch, and yet the decision was made to proceed anyways. This was caused in no small part by an institutionalized over-reliance on certain quantified metrics while neglecting other decision-making inputs, such as "excluding historical analysis of quantitative data relevant to safety".[121]

Even with all of these challenges of quantification in general, though, the Phoenix model offers an interesting attempt at a values protection approach to fire management. The reality is that attempting to fully suppress all fires faces tremendous stresses. Hence, difficult decisions need to be made about what to protect, how to protect it, and how to prioritize competing values when resources are inadequate. Approached properly, using models offers an opportunity to open up reflection and discussion of the values and assumptions they are built on, rather than simply applying them as a black box that forces managers to 'game the system' to show outcomes.

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[121] Feldman, "The culture of objectivity: Quantification, uncertainty, and the evaluation of risk at NASA," 714.
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Not only did Asher, Allen, and the rest of the emergency responders face a challenge in protecting the homes in Fort McMurray, but they also needed to defend other critical infrastructure from the flames. Over May 3rd and 4th, firefighters gave their all protecting Gregoire, Timberlea, Beacon Hill, and other neighbourhoods from the flames, only to be sent to the hospital, airport, or garbage dump to protect critical infrastructure for the city. Although the flames were still active, these structures would be among the most crucial in returning people to Fort McMurray in the weeks ahead.

Others were essential even during the firefight. The water treatment plant, for instance, was threatened by flames on more than one occasion. Guy Jette, the manager in charge, had to contend with smoke and failing sensors while attempting to provide adequate water for the fire hydrants scattered throughout the city. Despite being evacuated, the city was drawing three times its normal water volume: sprinklers and hoses for the firefighters, as well as damaged pipes and fittings leaking water as hundreds of homes burned to their foundations. Ninety million litres of water flowed through the plant, prompting Jette to enlist Syncrude, one of the major oil companies present in Fort McMurray, in hooking up a backup pump to the river that could be activated in the worst-case scenario (even though the decision would mean contaminating the entire drinking water system).[122]

Ember attacks and structure-to-structure transmission also threatened buildings for several days after the fire went through. Speaking at a media briefing, Allen described the challenge: "This is a nasty, dirty fire. There are certainly areas within the city that have not

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[122] Asher and Mouallem, *Inside the Inferno: A Firefighter's Story of the Brotherhood that Saved Fort* McMurray, 122.

been burned, but this fire will look for them, and it will find them, and it will want to take them".[123]

As such, before outside assistance arrived from fire departments like Calgary, Edmonton, and Slave Lake, weighty decisions had to be made about how to use the 152 municipal firefighters within Fort McMurray.[124] Darby Allen and Dale Bendfeld were at the centre of many of these decisions. As a former soldier, Bendfeld saw these decisions in military terms. "I positioned the city like a battle field," he recalled. "I started sectioning parts of the city of just as I would overseas. What did we have? What was the threat? What could I put towards it?"

Bendfeld laid out three priorities for the firefighting effort. Protecting the lives of residents and responders, of course, was first. The second priority was defending what he called 'vital ground' for the evacuation effort, like the bridge and highway running through town. Third was critical infrastructure like the water treatment plant. Empty homes and businesses fell after that. Darby Allen summarized the sentiment in unequivocal terms: "We don't give a shit right now about anything else. We need to save the people. Preservation of life, critical infrastructure, the rest of the infrastructure: That's what we did for days and days and days."[125]

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123 Pruden, "A Week in Hell: How Fort McMurray Burned."

124 Warnica, "Battling the Beast: The Untold Story of the Fight to Save Fort McMurray." I draw the number of firefighters and subsequent Bendfeld quotations and prioritization from this source.

125 Warnica, "Battling the Beast: The Untold Story of the Fight to Save Fort McMurray."

This prioritization seems relatively straightforward in a case like Fort McMurray. Focus on evacuating and securing the most critical transportation corridors and infrastructure. Yet, even here there were questions: firefighters and RCMP officers had to be sent door to door in some neighborhoods to determine whether residents had actually evacuated. Making matters more challenging was incomplete information: much like during the initial moments of fighting the fire in Beacon Hill, when Butz had to physically send a firefighter to the neighborhood to determine whether the fire had already arrived.

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In the simplest possible terms, fire management agencies need to transform confused and muddled information – like reports of smoke or fire from the public – into decisive, actionable information. It's an exercise in taking action despite uncertainty on three different fronts. First, agencies need to decide which fires to respond to and how to allocate their limited firefighting resources to each. Second, similar decisions need to be made within the fire itself: which front to attack and which values to defend. Finally, agencies have to make weighty choices about how to resolve competing values, such as ecological priorities that are in tension.

These competing priorities aren't always straightforward. There's a temptation to think about exaggerated examples in a trolley-problem like way – how do you choose between saving a full office building or an assisted living facility? – but the actual tradeoffs encountered in the field are much more nuanced. There are unlikely enemies, such as those
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who support caribou and those who support moose. Moose, treasured by both hunters and outdoors enthusiasts, are hardy species that are happy to move into landscapes relatively shortly after fires. Caribou, by contrast, are designated as a species at risk and are much more dependent on both old-growth forest and lichen that is threatened by fire.[126] Compounded by the fact that their habitat has been broken up in a way that threatens their range, caribou are much more sensitive to even small amounts of wildfire. Worse, these values aren't even always consistent within a single stakeholder: outfitters who prefer more fire in general on the landscape for its creation of moose habitat are also none too pleased about specific fires, which generally occur at the same time they hope to be guiding and hunting on the land.

This tension – plus the Species at Risk Act (SARA) designation afforded to caribou – troubles the notion that restoring fire is 'good for ecology'. Rather, restoring fire to a heavily modified landscape is good for certain kinds and certain formulations of ecology, such as plentiful moose habitat versus, for instance, caribou herds that cannot be hunted. In many jurisdictions, these tensions can make it increasingly difficult to support fledgling prescribed fire programs. In others, like Parks Canada, where there is a firm commitment to fire for its ecologically beneficial effects, it creates an evermore complex environment for prescribed fire where burns have been canceled over SARA regulation wording or biologist concerns. These concerns have generally been navigated with nuance and care but are yet another indication of the ways in which fire management is no longer as easy as "when it was just trees."

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[126] Whitman et al, "A Framework for Modeling Habitat Quality in Disturbance-Prone Areas Demonstrated with Woodland Caribou and Wildfire"; Courtois et al. "Effects of Forest Disturbance on Density, Space Use, and Mortality of Woodland Caribou."

When it comes to the actual decision-making on active fires, because of the fractal arrangement of fire programs described earlier (with the country divided into provinces, provinces divided into regions, and regions divided into areas), many of these decisions are devolved to the regional level. Fire crews are generally a regional resource, so regional duty officers make initial decisions about where they are dispatched. It's their job, then, to make decisions about competing priorities, such ranking life and property protection ahead of forestry resources. Provincial duty officers make these decisions on shared resources, like air tankers, weighing competing requests as needed and optimizing which tankers should be used where.

This reliance on duty officer discretion poses obvious problems. One is a fundamental debate about how to achieve the best outcomes. For many of the duty officers I spoke to across the country, discretion is paramount. In their eyes – as well as the eyes of many higher managers – duty officers are mythologized as keepers of local knowledge, intimately familiar with the landscape around them. "I can look at a fire on the map and tell you in five seconds whether we need to fight it or not," one duty officer told me. They know what values are located where, as well as the subtle nuances of how their crews and equipment can be most useful given the current mix of fire risks. It's an argument that essentially appeals to tacit and experiential knowledge: by virtue of their working up through the fire service, as well as living and working within their regions, they've gained firsthand knowledge that doesn't transmit up to the provincial level. Duty officers, in this telling, are imbued with an experiential wisdom that leads to the most effective decision-making.[127]

On the other side of the debate is a push to shift decision-making away from individual decision makers and towards either algorithms or predetermined plans. In the algorithmic arrangement, agencies like Alberta use a calculation that factors in head fire intensity (effectively, a measure of how the fire will behave) to determine how quickly it will spread to a certain size. Based on this spread potential, a fixed arrangement of crews is 'auto-dispatched' to new fire: a helitack team and air tanker at a certain level and increased responses given higher risk. The algorithm, albeit rudimentary, serves to increase the efficiency and speed of dispatching while also providing protection for the individual duty officer: as long as they follow the plan, they've done their job appropriately.

Alternatively, individualized response plans can be created for regions that weigh these competing values ahead of time. Such plans are time- and resource-intensive to create – at the time of writing, for instance, Alberta had only completed one area plan, for the Lac La Biche region – but provide a more ideal opportunity to weigh these values and determine agreeable ways to respond to them outside of the rush of an emergency. A year after the Lac La Biche plan was signed in 2014, Alberta faced a year with a higher fire load than Fort McMurray. According to personnel involved, it was 'tempting' to fall back into normal

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[127] One result of this appeal to this experiential expertise is a cohort effect. Because of a period of little hiring during the 1980s, there's a perceived 'cohort' that has emerged who progressed through the system together and, in turn, will retire together. In a system that hinges on experiential expertise, a concurrently retiring cohort poses a major loss of expertise. The accuracy of whether this cohort exists depends on who is being asked, and would be an interesting subject for further research. A cursory examination with provincial agencies suggested that lack of opportunities for progression (i.e., insufficient roles to begin with) was more of a problem than a cohort effect.

approaches of management. But, under guidance from the provincial office, regional duty officers used the plan to brief imported resources and prioritize fires that lined up with designated high-risk areas. When they had to deprioritize a fire that overlapped with a forest management area, resulting in pushback from a timber company, the plan made it easier to explain the decisions that were being made. And, much of the plan reinforced local knowledge of the fire staff, while helping to identify occasional values that were unknown by even the local duty officers (such as a high-risk power line). Planning in advance, therefore, served to both document experiential knowledge and to provide a line of defence ahead of depending on individual judgement.[128]

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The impact of the Horse River fire on industry was also tremendous. The oil industry, the backbone of the Fort McMurray region, lost almost seventeen million barrels of oil production during the shutdown.[129] Over six hundred work camp units were lost to the fire. The Albertan GDP dropped by 0.33% during the conflagration, netting a loss of almost a billion dollars. The fire was also deeply personal: almost half of the Fort McMurray

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128 Clarke, *Mission improbable: Using fantasy documents to tame disaster*. The alternative extreme is to see these plans and procedures as "fantasy documents" that mostly exist to project confidence, gain social license, and assuage public concerns rather than present a viable response. Based on my experience with agency decision-makers, the big difference between these two was the question of geographical specificity. Plans that existed only at an abstract provincial level were indeed often more symbolic than actionable. Those that were focused on specific, geographically-bounded cases, with decisions already made in them (in consultation with stakeholders) about how particular situations should be managed provided a much more actionable kind of guidance.

129 Accenture, "Horse River Wildfire Industry Lessons Learned."
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community members affected had a tie to the oil and gas industry in the region. With this strong connection between the industry and the community, almost immediately after the fire entered the city, oil companies deployed their industrial and airport firefighting apparatus to protect houses in Fort McMurray.

Because of the amount of oil infrastructure throughout the region, the prospect of damage was even higher. Deciding to evacuate the residents was difficult enough. "Making that declaration the city is going to be overrun by fire is gut-wrenching; it's visceral," one manager with Alberta Wildfire recalled. Dealing with the industry was even more complex. Because bitumen pipelines require heating to keep their contents liquid for transport, for instance, they faced the prospect of a potential $23 billion dollar loss if pipelines were forced to shutdown too quickly.

Yet, even with these high stakes, little information was available to effectively manage the risk faced by industry. According to an after action report,

> "A single source map of critical assets and camps was not initially available, which required reactive action to pull together the information from several stakeholders during the response. In the future, there is an opportunity for government to leverage industry's deep knowledge of potential risk impact to their critical infrastructure during an emergency (i.e. awareness of facility scales and full GIS datasets), to ensure all critical assets are clearly outlined in the response plans."[130]

Part of this lack of sharing was because of the delay in establishing a regional incident command structure to integrate the individual industry management operations underway. Another crucial portion, however, was attributable to trade secrets. Industrial

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[130] Accenture, "Horse River Wildfire Industry Lessons Learned," 7.

operators are not typically eager to share the locations of sensitive operations, not to mention detailed GIS information, making it difficult for wildfire managers to know where values are in the first place.

This surprising lack of knowledge about values on the landscape, however, is remarkably common across Canada and is far broader than simply an industrial reality. For a long period of time – before the strong push towards a values protection approach to firefighting – these assets were documented through two different methods: the tacit knowledge of local duty officers and a coarse system of 'zonation'. In a zone system, certain regions of the province, territory, or park are designated into low, medium, and high priority areas – each with their own response protocols and requirements. This is symbolically depicted in a map published by the Manitoba wildfire program. The province is divided into three different zones: an Agricultural Zone in the south, where wildfire is the responsibility rural and municipal fire departments; a Primary Protection Zone in the midsection of the province (as well as two isolated provincial parks located in the otherwise agricultural zone); and an Observation Zone in the northernmost reaches. In the Primary Protection Zone, fires are fought aggressively because of the dense land use by homeowners, timber companies, and cottagers. In the Observation Zone, fires are largely allowed to wander the landscape as the weather dictates, with occasional monitoring by the provincial fire program.

Prior to the emergence of these zonation maps, other rules prevailed that put value on tangible assets. Until September 16, 1952 in Alberta, for instance, the "Ten Mile Fire-Fighting Limit" dictated firefighting. The rule declared that fires could only be fought if they were within ten miles of a navigable river, road, or settlement – and never further north than

20 miles beyond Slave Lake. Not only was the rule firm, but it was also enforced by the lack of technology and resources to chase fires over massive landscapes, as one fire manager remarked: "If it was within 10 miles of the river you were allowed to go and fight it, but we didn't have much to fight it with so nothing was done. We lost huge areas of that north country simply because they wouldn't let us touch it".[131]

The zonation maps of today are also artefacts influenced by a history that represents the desire of those governing to quantify massive landscapes and render them legible in a simple system of priorities.[132] In 1967, for instance, the Northwest Territories adopted the already common zonation practice, through a process where

> "…the agency, or its Ottawa minders, tried to rank landscapes by their values, both the potential revenues they might yield to the Treasury Board and the likely costs they would impose. Not everything could be protected; not everything warranted protection; and, since the dominion was paying, it would decide which lands were worth protecting at what price. Life and property ranked highest, followed by those 'natural resources' useful to an industrial society, namely those traditionally assessed by foresters, who not coincidentally oversaw the fire program."[133]

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131 Murphy, *History of Forest and Prairie Fire Control Policy in Alberta*, 256.

132 Scott, *Seeing Like a State: How Certain Schemes to Improve the Human Condition Have Failed.* This case of governments imposing order to create legibility among their landscapes and constituents is, of course, not unique to fire, but rather part of a much larger pattern of these kinds of acts of ordering and demarcation. What is illustrative from the fire case is not just the ease to which it happened as a result of a need to prioritize fires (and via the post hoc justification of reduced suppression in more remote areas), but also the tenacity with which it has persisted. For a system that is simultaneously so simplified and yet so pivotal for actual decisions – which fires to respond to and which not to – it continues to be the defining criteria for management in several provinces in Canada. While there is a slow shift away from these approaches, the enculturation and tacit expertise emphasis of fire management presents a roadblock: most senior managers and their non-fire bosses are so comfortable operating within this system, having done so for decades, that changes are slow and painstaking.

133 Pyne, *Awful Splendor: A Fire History of Canada,* 385.

After a particularly busy 1971 fire season, the NWT zones were reorganized into a fourfold scheme: Zone 1 and 2 for towns, villages, highways, mines, and tourist sites; Zone 3 for priority wildlife and trapping zones; Zone 4 for the remaining areas. While the zones have changed since, the policy for dealing with these layered priority areas has largely remained the same across the country to this day. Zone 1 implied immediate and full suppression, but the ideal of extinguishing all fires extended to Zones 2 and 3 as well. It was – and largely still is, outside of Parks Canada – only when resources are stretched that fire is allowed to roam. By contrast, both then and now, Zone 4 embodies deep cultural assumptions about empty barrens and largely valueless land: fires that are of interest only if they start to threaten a higher ranked zone.

In their current form, the zonation systems are slightly more granular. Manitoba's current internal system includes more stratification between high, medium, and low zones. Red circles with a radius of twenty kilometers surround northern communities, indicating high priority zones embedded within the Observation Zone. The parameters are in constant flux, as land use by timber companies ebbs and flows with economic conditions, resulting in continually shifting priority areas (the northern line bounding the observation zone is mostly defined by the anticipate future boundary of forestry, and has shrunk over time as timber activity has dropped off within the province).

Yet, this fluctuation makes it difficult to maintain accuracy: not only does the integration of company and land use data introduce lag, but as I traveled the province, I saw at least three versions of the map concurrently posted in different facilities. "Priority zones," one manager confessed, "are based on old forest values that aren't really there anymore."

Areas free of timber activity could be logged tomorrow if economic conditions changed. And, non-economic values – like caribou habitat – aren't incorporated into the maps in a systematized way. These coupled sources of lag are revealing: although the maps purport to offer a policy about how to respond (akin to fire plans), because of near universal agreement among managers and responders that they are dated, insufficiently detailed, and without key context, the maps offer little more than a poor representation of duty officer knowledge and never actually contests that expertise.

The red marks encircling northern communities, for instance, claim that fires should be treated as highest priority whenever they are within twenty kilometers of a community. But, duty officers consider these communities with respect to new fire starts independent of the map's urging and, in fact, explicitly disregard the formal perimeter. Duty officers know that these perimeters need to be treated as fluid and that fires upwind of communities should often be treated as high priority fires much further out than 20 kilometers, while downwind fires that are relatively close to communities but be low priority even if they're only a few kilometers away. Tacit knowledge almost always prevails, and the maps printed so massively on the walls become used mostly to track helicopters and tankers via aircraft-shaped magnets. Zones represent this tacit knowledge to a degree, but only as thoroughly mixed with residual beliefs that most fire should be suppressed and that remote areas are largely empty of values needing protection.

Fortunately, most fire managers are increasingly aware that wildfires must be dealt with on a far more case-by-case basis than zonation maps suggest, as well as the benefits to firefighter safety from using full suppression less frequently. This is reflected in a shift in official policy as well. Through the 2000s, Ontario used a system of geographical zones: monitor, generally suppress, mostly suppress, and almost always suppress. In 2015, however, the organization shifted away from zones to a system of "managing threats to values" through a "total cost plus net loss" approach.[134]

Shifting from a zonation-based approach to a values-based approach fundamentally changes the kind of knowledge and management practices required of fire management agencies. In a zonation approach, as illustrated by the first Manitoba map and the Northwest Territories example, the landscape is made legible by, effectively, decision maker decree: land is symbolically divided on maps in ways that may or may not have any correspondence to reality. The net results are convenient, clean demarcations that theoretically ease decision-making but in practice are not terribly useful because manager tacit knowledge is more effective regardless. As the zonation approach evolved, maps became more nuanced and multi-faceted, reflecting these evolving conditions and more granular realities. Yet, the maps could never keep up, meaning that duty officer decision making still ruled. The natural shift, then, was to an even more granular system of fire-by-fire specific decision-making. Conveniently, this values-based model also spoke to other imperatives: increasing pressures to protect assets on the landscape, as well as a general societal push towards more detailed quantification (usually based in economics and assessing values down to the level of individual assets, rather than in broad zones).

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[134] This particular approach is still in development. An emphasis on economic modeling also has the potential of creating difficult questions about whether this is a slippery slope towards calculating economically worthwhile firefighting (e.g., not pursue some fires because protecting values would be too expensive).

Yet, it demands a much more detailed and robust set of knowledge. Each individual asset on the landscape must be known, documented, and incorporated into decision-making: Every home, every trapping cabin, every power line, every mine, and every piece of equipment. This is a remarkably difficult task. Alberta, for instance, has attempted and disbanded efforts to collect this data, largely because much of the data belongs to other government agencies that lack the capacity and buy-in to share this data in a timely and complete fashion. Other times the data doesn't exist at all: in some jurisdictions, Indigenous residents are not required to register particular kinds of dwellings with the government, meaning that there simply is no knowledge of where some of these properties are located. In other cases, duty officers told me of times where industry had expensive assets on the landscape that would never be tracked by a forestry program: a pair of million dollar bulldozers, on one occasion, that had been left for the season on a forested shore after the ice road meant to remove them had melted and had to be protected as a fire approached months later. Sometimes managers are informed – as a fire burns – about values that don't even require direct fire contact to threaten them (a water filtration plant, for instance, that was shut down because of smoke from a distant fire). Another duty officer recounted a time when a crew and helicopter had been tasked with setting up pumps and sprinklers to protect a remote cabin, only to discover after several hours of searching for the registered property that the cabin had been removed by the owner, leaving only its foundation behind.

In the views of most duty officers I spoke with, the completeness of this knowledge decreases exponentially as you move further north and more remote.[135] Documentation may exist down to the cottage, dock, and even shed level in more heavily trafficked regions. As you progress into more remote areas, however, duty officers varied widely in their confidence about their knowledge. The most confident duty officer I spoke with thought that 95% of the assets actually on the landscape in their region were documented and mapped within their resources; the least confident duty officer reported that only about 50% of the assets within their region were documented on the maps in the office. It explains why a first priority on new fires is to physically patrol the surrounding area by helicopter to determine if any values are immediately at risk, but it also creates significant difficulty in being able to confidently triage fires prior to a first observation (which is crucial when fires are being triaged because of a lack of resources to respond to each).

Making matters even more complicated, even if complete information was obtained and incorporated into maps or geospatial databases, decision-making would still be complicated because of a lack of agreement about how to prioritize values. This can exist at both detailed levels (e.g., relative priority of caribou versus moose habitat) and high, political-priority levels (e.g., how timber management should be balanced between provincial

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[135] Chambers and Gillespie,"Locality in the history of science: Colonial science, technoscience, and indigenous knowledge." This central/periphery dynamic is, of course, unsurprising considering the long history of knowledge from the 'margins' being deemphasized (see the article cited). Part of this has to do simply with distances and experiences – although many of the contemporary fire management community have indeed worked up through rural postings, even these rural postings were relatively central compared to much of the remote province (e.g., The Pas and Thompson in Manitoba, the locations of the two most 'remote' fire regional headquarters, are major regional centers). Moreover, there is also a long, colonial-influenced Canadian history of disparaging and disregarding traditional and Indigenous forms of knowledge, which can reduce the effective integration of a wide variety of important inputs (e.g., traditional ecological knowledge, historically significant sites, and even homes and cabins that are kept intentionally private).

and private actors). "Good risk management is dependent on the highest level of organizational agreement about what dictates high risk," one provincial fire manager described to me. "We don't have that. Every election results in another reorganization. With each new ministry [the fire program is placed within], we try to connect with other risk managers. But, as soon as we get to know the other risk managers, everything changes again."

All of this analysis underscores the importance of developing area fire plans in advance of a wildfire occurring. While the management challenge described above is one of uncertainty, of conflicting values, and of questionably effective decision support tools, the conclusion should not be that effective decision-making is impossible. Rather, it needs to be temporally shifted: taken out of the moments of emergency and given time for focused attention, deliberation, and analysis during periods of relative calm. These processes are resource and personnel intensive – which is challenging, given strained base budgets – but should be given the highest priority. It's a counter-intuitive solution that doesn't call for more equipment or technology, but rather more agency managers with a skill for developing management plans, integrating and managing knowledge within existing geospatial frameworks, and conducting engagement activities with the necessary stakeholders.

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The Horse River fire embodied a multitude of threats to many different values. Fort McMurray presented an incredibly dense clustering of these assets, which made its
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destructive capacity readily apparent. But, over the months that followed, the fire would continue to burn across Northern Alberta, threating a much wider range of industrial, civic, and environmental resources. As May 3rd came to an end, Darby Allen was frank in his fears:

> "I really believed at the end of Tuesday, if we wake up at first light and we've got 50 per cent of our homes left, and we've only killed a few thousand people, we'd have done well. That's how bad I felt. You're basically running on adrenaline. You just can't let your emotions get the better of you. What you really want to do is sit down in a chair and hug your mom or your wife and say, 'Make this better for me, please.' But nobody can make it better for you."[136]

As he expressed these fears, however, the nation was rallying together to respond. When fire overwhelms local capacity, resources from other communities are essential to sustaining the battle. Help was needed, and quickly, not only in firefighters from Calgary, Slave Lake, and Syncrude responding to blazes within the city itself, but from wildfire programs across the country and around the world.

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136 Warnica, "Battling the Beast: The Untold Story of the Fight to Save Fort McMurray."

Part II: Fires Present

5. Creating Fungibility: Mutual Aid and the Canadian Interagency Forest Fire Centre

As traffic streamed out of Fort McMurray on Highway 63, heading both south towards Edmonton and north towards the oil camps, help began to stream in to the city. Veteran firefighter Jamie Coutts had arrived from Slave Lake, Alberta, with a trailer of sprinklers earlier on May 3rd, at the request of the Fort McMurray fire department.[137] The stakes of the fire were not lost on Coutts, having fought another May inferno in 2011 that burnt through the town of Slave Lake, destroyed over 400 buildings, and resulted in a fatal crash of a helicopter engaged in the firefighting effort.

Initially, three kinds of help were crucial. As early as the day before, Alberta Wildfire began to reposition wildland firefighting crews to augment those based in the Fort McMurray district. Because the wildfire had become an urban conflagration, there was also a desperate need for urban firefighters who could immediately begin protecting homes and buildings. Coutts and his 'values protection' trailer were among the first to arrive, alongside industrial firefighters from the oil companies to the north. As soon as the magnitude of the disaster became apparent, though, other cities raced to contribute their own equipment. A convoy of fire trucks left Edmonton at 9:00pm on May 3rd for the four-and-a-half hour drive north. From Calgary, Olds, Strathcona, and countless other cities, crews raced towards Fort McMurray. Joining them was a third kind of assistance; Canada Task Force One, an urban

[137] Staples, "Firestorm Part Three: 'You're Out of Time.' Fort McMurray Flees."

search and rescue and disaster response team based in Calgary, capable of providing logistical support, technical rescue, and incident command capacity.

These firefighters from Fort McMurray and elsewhere did a remarkable job under adverse conditions. Yet, the defining feature of the first few days of the emergency response was a lack of unified command. In such a chaotic environment – with a fire that was initially under the jurisdiction of Alberta Wildfire, but with very clear risk for the urban firefighters and need for municipal firefighters – it was crucial to have clear communication and decision-making between all agencies. This is achieved through 'unified command,' where all agencies involved are coordinated through a single command post with individuals designated as responsible for specific roles. Yet, despite Alberta Wildfire offering several times between May 1 and May 5 to establish a unified command post with the Wood Buffalo REOC – not to mention experienced leadership on scene from Slave Lake's Wildland-Urban Interface Team – no integration occurred until May 5th.[138]

Yet, once command was eventually unified, and as the firefighters began to gain a foothold within the city of Fort McMurray itself, the Horse River fire was still growing at a rapid pace beyond city limits. The disaster was not constrained to Fort McMurray; it then

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[138] The after action review is particularly damning on this subject. According to KPMG Alberta review, p. 87, for instance: "Unified command should have been a key enabler for the response but was not successfully achieved during the first few days of the event... While the wildland and structural firefighters organized to respond to the Wildfire within their jurisdictions, there were challenges establishing unified command between the two groups. As an example, Alberta Agriculture and Forestry offered several times, between May 1 and 5, to provide resources to the REOC to form a unified command, however these resources were not integrated until May 5. In addition, the Slave Lake Wildland-Urban Interface Team, which had the necessary training and specialized equipment, had arrived in the Region to assist, but was not appropriately leveraged and integrated into operations in a timely manner."

progressed towards the town of Anzac (where many refugees of the fire had fled), towards oil fields to the north, and, eventually, towards the Saskatchewan border. As those in Fort McMurray began to think about how to restore services and begin to readmit residents, Alberta Wildfire was settling in for a firefight that would last for months.

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A wildfire doesn't need to be anywhere as big as Fort McMurray to overwhelm local resources. Firefighting in any context is labour intensive. Working in the field involves cutting down trees, clearing pathways for people and vehicles, dragging hose and pumps across marshes, and digging up hotspots to make sure the fire is truly out. Working in incident command is exhausting as well, with endless decisions about where to deploy firefighters and how to coordinate meals and travel and equipment and personnel problems. This may be manageable when it comes to a small fire – something less than a few hectares under manageable weather conditions – that can be extinguished in an afternoon. But, anything larger can easily take days to 'mop up'.

As a result, it is essential for wildfire agencies to be able to seek aid from each other during times of need. During the Horse River wildfire, for instance, Alberta received resources like firefighters, hoses, pumps, and aircraft from every jurisdiction in Canada to assist in the firefight. Yet, although the question seems simple at first blush – how do you integrate firefighters from Prince Edward Island, Quebec, and the Yukon seamlessly into
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fighting a fire in the Albertan Boreal? – the mechanics of this kind of exchange are remarkably complicated.

What's more, the decentralized system that Canada uses to manage fire makes this challenge endlessly complex. Provinces are notoriously fickle beasts, each with a long history of attempting to preserve independence and autonomy. They're divided by language (Quebec, for instance, is a unilingual Francophone province, while fewer than a quarter of a percent of Newfoundlanders speak French at home), by industrial background, by economics, and by identities. Moreover, as has been illustrated in the first four chapters, each province has evolved very different fire management organizations and structures, in part because of historical contingency, in part because of adherence to tradition and previous ways of managing, and in part because of the varied geographies across the country. Each province, as discussed in Chapter Four, attempts to make their landscapes legible and uniform – but, in doing so in their own unique ways, ends up creating a patchwork of institutions, policies, procedures, and practices across the country.[139]

This isn't the case everywhere. In the United States, for instance, the major players in managing wildland fire are national: the United States Forest Service, the Bureau of Land Management, and the National Parks Service. While American managers must contend with the same geographical variation across the country, these nation-spanning agencies provide a

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[139] This is hardly a unique challenge to fire. Education and health care, for instance, are also contentious issues in Canada where management has been devolved to the provinces resulting in uneven and patchwork implementations across the country. On those issues, however, the federal government has a large 'carrot': the huge sums of money that they invest into education and healthcare, to be administered by the provinces. By contrast, in wildfire, the federal government transfers almost no money to the provinces for management or response. This creates another layer of the challenge, wherein something else needs to motivate standardization.

part of the solution in ensuring standardization from coast to coast. In Canada, by contrast, there's no standardization – each province builds its institutions and response mechanisms as it sees fit. These are the conditions of the core struggle: how can we integrate crews on the same fire when they come from such differing operational homes?

The Canadian way is to walk a tightrope, aiming to achieve interchangeability rather than standardization. It requires negotiation and renegotiation on every new issue, from what kinds of boots and hoses should be used, to what the proper procedure is to exit a helicopter. Ultimately, however, it reflects not only a perennial Canadian question (how do we balance integration with diversity and independence?), but a remarkable institutional problem: how to impose enough order to function without losing the buy-in from all parties involved in this voluntary association, and how to build a trust that leads participants to share their resources with those in need even when it comes at a risk to protecting their own home.

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Provincial agencies can very quickly find themselves managing a large amount of fire on the landscape. Although fires are treated as a freak, unpredictable phenomenon by the media, their causes are simple. Aggressive fires need heat, fuel, and a breeze to fan the flames. All too often, if these three elements are present to start one fire, they're also available to kindle other sources of ignition as well. As recently as the 1970s, agencies would
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literally handle this load through hiring makeshift firefighters from nearby bars and other gathering places.

Today, firefighters are much more expensive and time-intensive. New and returning firefighters require training, mentorship, and equipment, and cannot simply be inexperienced civilians transported from a bar to the fireline. Yet, fires within a given province vary a great deal. Sometimes the province is hot and dry for a prolonged period (2017 in British Columbia, when over 1,200,000 hectares burnt), while in other years the province is wet and cool (2013 in British Columbia, with only 6,5000 hectares burnt). While seasonal forecasts can offer something of a reasoned guess at what the conditions might look like in the next one to four months, firefighters must be hired throughout the winter before. This creates an unresolvable tension known as the "peak load problem" among fire managers. A provincial fire agency needs to be prepared to respond to manage their worst-case scenario, while all-too-often being judged for overstaffing based on the economics of hindsight when the summer turns out wet.

In Canada, this problem is resolved through exchange. As described earlier, many agencies effectively function with small regional fiefdoms within the province itself. During a time with a normal amount of fire on the landscape – that is, no excessively large campaign fires, and not an overwhelming number of fires – these regional centres can handle fire management with their own crews and resources. These crews are often referred to as 'regional resources,' and the decisions about which resources go to which fires are made by the regional duty officer. The central agency might keep tabs on the resources to varying degrees (for instance, Saskatchewan uses software that tracks a wide variety of features on a map, including vehicles and individual firefighters). But, ultimately the responsibility rests with the regions to deploy their resources as needed. When the fire load increases, however, the provincial level operations centre may begin to step in to a larger degree. The ultimate patterns of control vary here – some provinces ultimately have the ability to 'pull' resources from the region and redeploy them elsewhere, while other provinces must first get permission from the home region before moving them – but many times during a typical season, resources will move around the province.

Sometimes – like 2015 or 2016 in Alberta, or 2017 in British Columbia – the fire load becomes too big to handle even as a whole province. Even if there's a critical incident, not every resource can be thrown at the fire – some firefighters must be left stationed across the province to be able to respond quickly to new fire starts. And, firefighters have restrictions on how many days they can work before they need to be given days off for rest, recovery, and ultimately safety. As such, just like provinces depend on pooling between their own regions to provide mutual aid, they also pool their resources collectively. When Alberta is on fire, it can request aid from the rest of the provinces in Canada, which in turn can each provide whatever resources they are able to.

There is one fortunate reality. Because of Canada's size, prevailing weather tends to vary significantly across the country. During the moment when some jurisdictions are experiencing extreme fire behaviour thanks to drought, heat, and high winds, others are comparatively suppressed with cool, wet weather.[140] Between 1953 and 1980, for instance,

140 Magnussen and Taylor, "Inter-and intra-annual profiles of fire regimes in the managed forests of Canada and implications for resource sharing."

only a total of six months of the 28-year period saw more than two provinces affected by "extreme fire months" simultaneously.[141]

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In late June of 2017, just over a year after the Horse River fire had begun burning, I arrived in Winnipeg, Manitoba to reconnect with the team at the Canadian Interagency Forest Fire Centre – known as CIFFC in the fire world. The appearance of the Centre belies its importance to the wildfire community across the country. It's tucked away in a non-descript strip mall near the Winnipeg International Airport; a parking lot decorated with a construction dumpster, a closed down neighbouring bar, and a busy arterial street. This understated appearance, though, is in some ways representative: it's not the office itself that makes CIFFC crucial to managing wildfire in Canada, but rather the symbolism, procedures, and willingness to collaborate that has been cultured by the people within.

While the weather was warmer than during my first visit to CIFFC months earlier in March – at a chilly -24 degrees Celsius – it was hardly a hot beginning of the summer. Temperatures were sitting in the high teens and low twenties, and they reflected a broader pattern across the country. The biggest weather event of 2017 to that point had been major May flooding in Quebec, with prolonged rain characterizing much of the spring from coast to coast. Coming on the heels of Horse River in 2016, the start of the year couldn't have been more different or quieter from a national perspective. Spending time with the CIFFC

[141] Harrington, "A statistical study of area burned by wildfire in Canada 1953-1980."
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team, you very quickly adapt to thinking at this broader and longer-term level. The roles of the Executive Director and the Strategic Planning Manager in particular could be summarized as stretching time: its their job to stay out of any given single emergency and to keep their focus on medium- and long-term issues, such as what the weather will look like in several days, when crews will time out for their mandated rest, and, longest term, relationship and trust building efforts that span years.

A quiet May and June, therefore, presented an unexpected reprieve. Early in my study of fire management, I had asked one of these managers a terribly naïve question: 'what to you do during the off season, when you're not fighting fires?" It was clearly a question he was asked regularly, because the answer was direct: there's no such thing as an off-season, he replied. There are busy times (the winter) when everyone is scrambling to get caught up from the past season and prepared for the next – not to mention trying to invest time in long-term projects – and even busier times, when staff are seconded into their fire roles on incident management teams and agency operations. His corrective guided me well throughout my agency visits: although the actual firefighting may be mostly seasonal, most of the crucial management like procedure development, incident reviews, and procurement ideally occur when fire isn't on the landscape. A quiet spring meant time for actual, non-firefighting work to get done… until July arrived with a bang.

While fires had occurred through May and June (180 by June 25th in BC), they had accounted for relatively few hectares burnt (only 1,119 – about 6 hectares per fire, or the size of forty hockey rinks). Each day, the team at CIFFC would collect and tabulate these numbers from across the country, creating a daily "situation report" of the status of wildfire in Canada. For the first several days of this visit to CIFFC, the reports were quiet. As the month came to a close, though, we began to hear a changing story in the descriptions being submitted by the province of British Columbia:

June 26th: "Fire activity has increased with continued drying expected in the next 96 hours and 40% chance of dry lightning."[142]

June 27th: "Southern BC continuing to build significant fire indices."

June 30th: "Building indices and temperatures for the long weekend," always a source of fear for fire managers because long-weekend vacationers bring with them ATVs, fireworks, and campfires – all prone to causing accidental wildfire ignitions.

Then, on July 3rd, the heat and low humidity had finally had enough time to dry out the fuels. 8 fires were reported.

July 4th came, with 16 new fires: "Building indices throughout the province, record breaking BUIs and high temperatures. Forecast ridging over the province for the next week has the potential to create significant fire danger."

July 5th, and another 10 new starts: "BC is in a warming trend with increased fire activity and therefore will not be offering any resources to CIFFC at this time."

Then, July 6th arrived, with 12 new fires: "Record breaking temperatures expected in many locations today giving BC extreme fire danger in many areas." In many accounts looking back, July 6th marked the beginning of BC's summer ablaze. Early afternoon, a fire –

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142 Canadian Interagency Forest Fire Centre, "Wildland Fire Situation Report."

two hectares, just like Horse River – broke out west of a town called 100 Mile House.[143] Firefighters worked against hot, dry conditions, holding the Gustafsen fire to only eight hectares by the next day. It would grow to 5,700 hectares before being contained on July 26th.[144]

The situation continued to deteriorate. The evening of July 7th, a provincial state of emergency was declared, citing 56 new wildfires that started that day, as well as an "expected increase in wildfire activity" thanks to a combination of hot and dry weather with mostly dry thundershowers.[145] July 8th brought even more aggressive behaviour, with a remarkable 183 new fires from a combination of lightning and human activity.[146] The report from the British Columbia Wildfire Service to CIFFC on July 10th captured the stark reality: "Over 300 starts in the last 96 hours. Lots of aggressive fire behaviour showing. Detection is becoming a challenge due to heavy smoke. Some fires being detected at 500+ hectares."[147] The unparalleled number of fires those four days highlighted the impossibility of being staffed and resourced for such a situation, even in the words of the Service itself:

> "Under normal circumstances, the BC Wildfire Service has sufficient staff, aircraft and equipment available to tackle almost any situation that may arise during the fire

143 Culbert et al., "B.C.'s Wildfires Began With a Lightning Strike on July 6, Sparking Fear and Uncertainty for Thousands."

144 McCullough, "Gustafsen Fire Updates."

145 Government of British Columbia, "Provincial State of Emergency Declared."

146 Canadian Press, "'Extraordinary' Fire Situation with Over 170 New Fires Started in B.C.: Official."

147 Canadian Interagency Forest Fire Centre, "National Wildland Fire Situation Report July 10, 2017."

> season. More than 1,600 B.C. firefighters and support staff are in place for the 2017 fire season, and the government can also call on about 2,500 private contractors to pitch in when necessary. However, the extraordinarily high number of wildfires that were sparked from July 7-8 (over 223 new fires over just two days), their extremely volatile behaviour and their rapid spread prompted the BC Wildfire Service to bring in some much-needed help this week."[148]

'Bringing in help' is a phrase that seems simple in theory, but turns out to be remarkably difficult in practice. Moving firefighters from one part of the country to another, tasking them to fight a wildfire in a different kind of geography, resourcing their needs, and getting them home safely is a massively complicated challenge. It's a simultaneous exercise in cutting through existing red tape and bureaucracy that can block these exchanges, while establishing a new institutional scheme that systematizes each part of the challenge. To boil its role down to a single task, though, CIFFC ultimately is about creating fungibility: making it so that any given firefighting element – hoses, pumps, and people – become replaceable and interchangeable. Understanding this function, and the profound impact it has on firefighting in Canada, requires understanding where CIFFC came from and how it operates.

Through the 1960s and 1970s, sharing was much more geographically localized. Neighbouring provinces, through the use of the border zone agreements previously discussed, would be able to exchange the occasional firefighters and respond to conflagrations that occurred on their borders. It was the 1979, 1980, and 1981 seasons, however, that pushed the system to its limit. These three massive fire seasons compelled the creation of a task team on interagency exchange.

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148 Government of British Columbia, "Firefighting Help Arrives in B.C., More on the Way."

There were also important institutional precursors to CIFFC. Approximately 50 years before the emergence of the Interagency Forest Fire Centre, the National Research Council of Canada created an Associate Committee that had a subcommittee responsible for forest fire protection. In many ways, this organization played a precursor role in facilitating discussion between fire managers, developing trusted relationships, and laying the groundwork through basic but essential data and information exchange, like fire statistics. Through many name changes, this organization – eventually known as the Canadian Committee on Forest Fire Management – would overlap with about a decade of CIFFC's history, before passing off its responsibilities on issues like technical committees, national meetings, and country-wide standards.

Yet, these influences weren't strong enough on their own to compel a national framework for exchange. Canada had seen major fire seasons before, not to mention an endless historical stream of committees and councils on forest and fire management. One major difference, however, was the increased role of aircraft in firefighting. As aircraft became available in the wake of World War Two, they rapidly found uptake within forest protection. The particulars of their use varied a great deal from province to province, but they provided a way of tackling the Canadian problem of scale – albeit at a significant financial cost to provincial and federal governments alike. By the 1960s, the emergence of purpose built firefighting aircraft began to require new institutional arrangements. The Canadair CL-215, which saw a relatively high degree of success in Europe as early as the 1960s, was viewed as prohibitively expensive until almost two decades later in Canada. Over a decade of debate about the feasibility of a national fleet would eventually lead to an inter-provincial effort to acquire air tankers, which spurred the broader national coordination effort.

The other factor was the American influence. South of the border, the Boise Interagency Fire Center (the predecessor to today's National Interagency Fire Center) was created in 1965 with an ambitious aim of collaboration: to consolidate efforts of the Forest Service, Bureau of Land Management, and National Weather Service in planning and responding to wildfire. In short, suggests historian of fire Stephen Pyne, a fear emerged that in the absence of a Canadian equivalent, Canadian resources might end up being coordinated through an American organization. This concern over domestic exchange being coordinated by an American agency provided part of the impetuous for finally achieving agreement among Canadian agencies to create a national equivalent.

The initial goals of CIFFC in June of 1982 were lofty. Initial projections, for instance, envisioned fifteen to twenty full time staff, while today the organization has only about six. Yet, its function in coordinating exchange and sharing has been crucial. In its first year as an organization, CIFFC received only 10 requests for resources from the provinces involved, which moved a grand total 9 overhead personnel, 100 pumps, and two air tankers. Because of their ease in movement, aviation assets comprised a majority of initial exchanges during the first decade. By 1987, a series of standards and requirements had evolved to shift the project from a 'whatever you have; beggars can't be choosers' model of exchange to a much more systematized, request-based framework. Personnel movement increased in the mid 1990s, and a shift in 2014 to a Board of Directors comprised of the Assistant Deputy Ministers from each agency created stronger lines of accountability and trust. All twelve provincial and territorial fire programs, as well as Parks Canada, are members of the agency, and consideration is being given to the addition of the Department of National Defence in order to be able to share resources to and from Canadian Forces Base Gagetown in New Brunswick. By the most recent decade, from 2006 to 2015, CIFFC averaged 126 resource requests per year, with an average of over 1800 personnel movements, almost 600 pumps, 14,600 lengths of hose, and 41 aircraft.

While it's the resource exchange function that usually garners the attention during the fire season, CIFFC also plays a role in coordinating knowledge transfer. A series of working groups – including aviation, training, and meteorology, among others – provide a venue through which provincial working group members can share knowledge and best practices. As will be discussed in greater detail in Chapter 8, CIFFC plays an important role in this space – although it also represents a somewhat odd division of labour, given what ought to be a tight link between research and operational needs. The organization also serves as a clearinghouse of information, publishing a daily situation report on nation-wide fires and resources moved, as well as convening a series of conference calls between provincial duty managers.

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As the morning began on July 10th – with over 220 fires active in British Columbia, and even more new starts hidden shrouded in the thick smoke, yet to be detected – I joined the staff in the CIFFC operations room (Figure 6). The pace was markedly different than the
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previous week, before the uptick in BC fires on July 6th, when the operations room largely sat empty as I interviewed CIFFC members in their offices. In the past 72 hours, 41 resource requests had been made, all related to the fires ranging within British Columbia. The first resources had already arrived: three air tankers from Saskatchewan and Alberta on July 8th and a fire investigator on July 9th. Much more was about to occur.

Figure 6
Staff in the operations room at the Canadian Interagency Forest Fire Centre.

The Centre's position in Winnipeg helps to ease the timing challenges endemic to national coordination in Canada: with six different time zones spread across the country, coordinating fire is a daily struggle of being behind the east coast and needing to stay late to support the West. CIFFC's position in Central Time provides as much balance as is possible. It's also exceptionally convenient for CIFFC duty officers when major fires occur in the west. Because British Columbia is a full four and a half hours behind Newfoundland, much of the country has already had a full business day of planning before noon ushers in more aggressive fire behaviour on the west coast. As such, the aim of the duty officer was to get ahead of the ball by strategizing for the day, getting solid information from their provincial counterparts in the east, and beginning the movement of personnel and resources to take advantage of the extra hours while heading west.

To provide additional capacity for the small organization, CIFFC brings on duty officers from provincial agencies during peak national times. As such, the current duty officer was on exchange from New Brunswick to Winnipeg for a seven day, Wednesday to Wednesday stint as the national duty officer, before rotation into the Government Operations Centre in Ottawa for an additional week as a CIFFC representative there.[149] This additional capacity allowed other staff to take on a much more strategic role, focusing on big-picture coordination rather than the minutiae of carrying out the exchanges.

The task of the duty officer was straightforward but relentless. Serving as the intersection of communication between duty officers from each separate jurisdiction, his job was to manage a seemingly endless stream of spreadsheets, slips of paper, and logistical arrangements – the core ingredients of exchange requests. The process was simple enough:

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[149] This role was a relatively new one, being used to improve communication between federal emergency operations and the resource exchange that CIFFC provides (which, on non-fire emergencies, would normally be handled by Public Safety Canada).

When a jurisdiction (which becomes known as the 'receiving agency') decides that they need outside resources to assist with the firefight, they submit a standardized Microsoft Excel document known as a 'Resource Request Form' detailing the resources requested, dates needed, and intended destination (not always straightforward – by the heat of the crisis, British Columbia operated a series of staging areas before crews were dispatched to different fires across the regions). The CIFC duty officer then effectively 'shops' the request around, gathering details about what resources are available from different provincial agencies. This is hardly a simple process, as will be discussed more in Chapter Six, in part because of the number of overloaded provincial and territorial duty officers that need to be wrangled to reply. Once there's a sense of the resources available, a decision is made about how to optimize which resource is sent (including factors like balancing provincial contributions, maintaining adequate long-term capacity across the country, and deploying the most suitable and economical resources).

From there, most of the process is guided by the details within CIFFC's core document, the Mutual Aid Resources Sharing Agreement (more commonly known as the "MARS"). The MARS governs the particulars of resource sharing between Canadian agencies and is periodically renewed (which, in and of itself, can create interesting challenges – two jurisdictions, for instance, had not signed onto the renewed MARS as the fire flap in British Columbia began, resulting in significant pressure on their political leaders to quickly finish its approval). The document is mostly used for "Schedule A," or its "Implementation Guidelines" that lay out, in painstaking detail, the rules of engagement for everything from requesting resource to recuperating costs. Their scope grows annually based on experiences from the field: regulations for how to deal with invasive species, or how to recover costs if a vehicular accident occurs during firefighting (even something as seemingly non-fire related as hitting a deer).

According to these rules, for moves involving people the lending agency then provides a "Personnel Information Exchange document" ('PIE sheets' for short) detailing everything from the names and roles to the actual weights of those traveling. These documents exemplify the question of salience in facilitating this kind of exchange. Throughout my time at CIFFC, for instance, it was almost a daily occurrence to hear frustration about some agency failing to fill out the PIE sheet in a timely manner or using estimated average weights rather than the actual weights of each firefighter and their pack ("PIE sheets! Unbelievable. They're simple, simple stuff. Every year!"). For the provincial agencies, these sheets represent yet another layer of bureaucratic paperwork to be done in the midst of what they actually care about: deploying their firefighters. Yet, for CIFFC, these numbers are essential: aircraft were loaded, routed, and rerouted based on the firefighter weights provided.

Once all this paperwork is in order, crews and resources could finally be moved. They'd be dispatched from their home locations, be sent to participate in the firefighting, and eventually be demobilized through another standardized form. And move they did: these efforts amounted to a total of 115 personnel, 3,000 lengths of hose, and five aircraft, all processed by three o'clock pm on July 10th and prepared for imminent departure.

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While the resource sharing agreements, PIE sheets, demobilization forms, and host of other paperwork seems superficially simple – of course organizations create extensive amounts of policy and procedure – they represent a phenomenon that lies at the core of the Canadian approach to mutual aid in managing fire: interchangeability. Anywhere you are on the globe, mutual aid depends on the notion of making things fungible. Firefighters from Prince Edward Island and incident command personnel from Australia must be swapped into roles previously served by local personnel. As such, the requesting agency needs to know what they're getting: knowing that the firefighters arriving can safely work in the fire environment; knowing that pumps will turn on and hoses will interconnect; and knowing that overhead personnel will be able to work with remarkably diverse teams.

In the United States, because wildfire is largely a federal endeavour (primarily run by the Forest Service, Bureau of Land Management, and Parks Service), interchangeability can be imposed through standardization. An agency, for instance, can roll out a set course on firefighting or incident management across all personnel, thereby standardizing the training and performance metrics for a given role. Regional variation certainly exists among the actual culture, performance, and practices of fire crews, but an expectation of standards can be laid down from these central agencies.

By contrast, the province-centric nature of fire management in Canada means that CIFFC has no such luxury. Like on many other political issues in Canada, the provinces and territories were weary of giving up control over provincial jurisdiction, resulting in the long process that was required to even establish CIFFC in the first place. As such, CIFFC has to walk a tightrope between two different forms of standards: a standard that allows exchange and interoperability, and a standard that dictates that jurisdictions – particularly the small ones – must change to conform to others. In the world of wildfire in Canada, the first is essential, while the latter is untenable.

This challenge manifests itself in a wide variety of issues, from negotiating interoperability on hoses and boots to how personal are trained to run chainsaws and exit from how high they can exit hovering helicopters. Over the span of years, CIFFC must navigate a process that allows agencies to be comfortable that they're going to receive useful resources, while not overburdening agencies – particularly the smaller ones – with training and expenses that aren't relevant to their local operations. CIFFC largely frames this through saying that they pursue 'training standards' rather than 'standard training.' For CIFFC personnel, this draws a distinction between forcing all jurisdictions to conform to a particular, centrally established training program, and an approach that comes to consensus on important shared competencies but allows each jurisdiction to achieve them in a way that's appropriate to their needs, resources, and experience.

Often this process results in sort of semi-stable situation where 80% agreement is achieved and the remaining 20% difference is understood to the point where it can be managed. Workplace safety in Quebec, for instance, requires that firefighters wear steel-toed boots in their wildland operations. The mountainous territory in British Columbia, however, means that anything other than hiking boots take a drastic toll on foot health. If Quebec were to import firefighters from British Columbia, then, they would either pay for new boots or need to negotiate a formal exemption from the requirements. In the other direction, British Columbia has much larger trees than are found elsewhere in the country, and has thus evolved a much more stringent set of requirements around training and practice on chainsaw use. If you're a firefighter arriving in BC from out of province, one manager told me, "you know that you might as well just wave to the trees and say: 'can't cut you!'" Thus, another set of particular exchange rules emerges: on export to BC, you need to pass a competency check in chainsaw use upon arrival and can only cut trees up to six inches in diameter. It also means that the training working group is tasked with developing a set of training standards around chainsaw use to begin to close this gap.

Ironically, however, on some issues CIFFC has been able to achieve more standardization than in the United States with this approach. In most of the firefighting world, for instance, hoses are notoriously fickle. Even today, California alone uses several different styles of fittings on their wildland fire hoses. The urban setting is similar. In Lac-Mégantic, Quebec, for example, when a massive fire broke out following a petrochemical train derailment, fire departments responding from neighbouring jurisdictions couldn't connect their differently fitted hoses. In 1994, however, most wildfire agencies across Canada moved to a single fitting – the Quarter Turn Quick Connect hose, standardized by Underwriters Canada. The move wasn't without protest. Manitoba hired a handful of firefighters to work through the winter to change all their hoses over. Ontario held out from completing the change, but only until they realized they could no longer access exchanged resources like hoses, pumps, and maintenance.

Perhaps the most interesting example of this quest for fungibility is the emergence of the WFX-FIT standard. An abbreviation of the "Canadian Wildland Fire Fighter Exchange

Fitness Test for Initial Attack," the test was implemented in 2012 as standardized approach to measuring personal fitness for Type 1 firefighters. Because firefighting is a strenuous occupation, it is vital to the safety of both the individual and their team that any given member is in good physical health and able to perform tasks to a high standard. This becomes all the more crucial when firefighters are exported to other jurisdictions, where questions of liability and safety become even more pronounced if a firefighter is unable to perform adequately. In view of the creators of the WFX-FIT test, firefighters from "jurisdictions that do not have mountains or muskeg are often unable to meet the demands of fighting wildland fires if they are exchanged to provinces or territories that have these arduous terrains."[150]

Prior to having a nation-wide standardized test, each province used its own method of assessing fitness, such as a timed one-mile hike with a weighted pack or test-formatted combinations of other job related tasks. In 1999, however, the Supreme Court of Canada heard the case of Tawney Meiorin, a wildland firefighter in British Columbia with three seasons of experience and positive performance evaluations. When returning for her fourth season, she was subjected to a fitness test (developed by Dr. Brian Sharkey of the University of Victoria) that required 24 push-ups in 60 seconds, 24 sit-ups in 60 seconds, 7 pull ups in 60 seconds, and a 2.5 kilometer run in 11:49.[151] Meiorin failed the fourth of the requirements, the running test measuring aerobic fitness, and was denied her job. Meiorin

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150 Gumieniak, "Establishing a Legally Defensible Physical Employment Standard for Canadian Wildland Fire Fighters," 38.

151 Gumieniak, "Establishing a Legally Defensible Physical Employment Standard for Canadian Wildland Fire Fighters," 10.

sued on the grounds that "aerobic standard discriminated against women in contravention of the British Columbia Human Rights Code, as women generally have lower aerobic capacity, and she had sufficiently demonstrated she could perform the duties of her job safely and effectively".[152] In its ruling against the Government of British Columbia, the Supreme Court established a new series of tests for "*bona fide* operational requirements," largely centred on preventing discrimination on protected categories and a high burden of proof connecting the physical tests with "legitimate work-related purposes" and job performance. It argued, in short, that the BC government had failed to show that the standard was "reasonably necessary" and strongly enough connected to actual work requirements.

Given this history, establishing a fitness standard became not only a task of creating fungibility and homogeneity, but also creating legal defensibility for that standardization. This rhetoric of objectivity and legal suitability is woven throughout the WFX-FIT promotional material, which emphasizes that "WFX-FIT is a valid job-related physical performance standard" and offers an authoritatively abstract (although citation free) assurance that "it was confirmed that performing the WFX-FIT test protocol involves the same physical demands as performing the related on-the-job tasks".[153] Even more striking is the answer to a frequently asked question about whether alternative assessments can be substituted to demonstrate physical fitness: "No. There is not an alternate test. The test is based on the most highly important, frequently occurring and physically demanding

[152] Canadian Human Rights Commission, "Bona Fide Occupational Requirements and Bona Fide Justifications under the Canadian Human Rights Act - The Implications of Meiorin and Grismer."

[153] Canadian Interagency Forest Fire Centre, "Canadian Physical Performance Exchange Standard For Type 1 Wildland Fire Fighters."

firefighting tasks. *The test is the job and the job is the test - if you can do the job, you can do the test and if you can do the test, you can do the job"* (emphasis original).[154]

A team of researchers at York University developed the new WFX-FIT test, a process that was largely documented through the dissertation of then PhD-candidate Robert Gumieniak. In consultation with agency fire managers and union representatives, as well as a survey of current firefighters, a series of core firefighting tasks were identified and then converted into gym-friendly "task simulations" "embodying the same weights and applied forces".[155] These were assessed using measurements from a dynamometer for weights, coupled with heart rate monitors and oxygen utilization measurements for energy expenditure. A key hypothesis then came into play: that "the unique and sometimes arduous terrain differences in Canada" would result in different firefighting requirements for each jurisdiction, and that British Columbia (thanks to its mountains) would prove to be the most 'challenging' to cardiovascular fitness.[156] Once the test was developed, a series of experienced firefighters from each member agency were sent during the summer of 2011 to complete the test "using a self-selected safe, effective, and efficient emergency pace" which was validated by observing subject matter experts.

This approach to adapting the test to each jurisdiction led to very different approaches. According to key informants in a variety of provinces, because managers knew

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[154] Canadian Interagency Forest Fire Centre, "Frequently Asked Questions."

[155] Gumieniak, "Establishing a Legally Defensible Physical Employment Standard for Canadian Wildland Fire Fighters," 3. See p. 46-49 for more detailed account of the ranking and statistical analysis performed.

[156] Gumieniak, "Establishing a Legally Defensible Physical Employment Standard for Canadian Wildland Fire Fighters," 23.

that the results would be used to determine the within-province fitness requirements for each jurisdiction, agencies used very different strategies in choosing which of their members should complete the "derivation of performance standards" portion. Some jurisdictions that rely heavily on student firefighters, like British Columbia, selected remarkably young candidates: an average age of only 24. Others, like the maritime provinces, sent much older members: an average age of 36 in Newfoundland, 39 in New Brunswick, and 48 years old in Newfoundland.[157] The end result was a remarkably uneven playing field that represents who was sent for testing by each province, rather than necessarily the fitness required in each province. In British Columbia, firefighters must now complete the test within 14:30. In New Brunswick and Prince Edward Island, 17:45. In Newfoundland, firefighters have a full 20:15 to complete the same test to meet the provincial standard.

This shouldn't downplay the consideration given to establishing representativeness and validity in the WFX-FIT methodology. Care was given, for instance, to ensuring that a "representative cohort of individuals" on the basis of sex, age, experience, and Aboriginal status completed the initial simulation of critical tasks.[158] The selection of the cut-off times

157 Of course, as has been discussed earlier, each province has very different demographics involved in its fire crews, which would have factored into who could be sent. This created a feedback loop, however: according to informants, jurisdictions reliant on older members needed to ensure that these members could continue to qualify as workers, while jurisdictions primarily reliant on younger students could use aggressive results to create a desirable higher bar of entry into their fire programs.

158 Gumieniak, "Establishing a Legally Defensible Physical Employment Standard for Canadian Wildland Fire Fighters," 83.

also involved using paces that were "safe and efficient" and achieved a pass rate of at least 83.3% of participating female firefighters.[159]

Yet, considering these issues in the methodological and legal construction of the test doesn't preclude the emergence of unintended impacts in its deployment. As I traveled across the country as the fires continued to burn in BC, for instance, I met with Aboriginal firefighters who were frustrated that they were not able to be exported, in equal parts because of the desire to contribute, the eagerness to actually be fighting fires, and the prospect of overtime pay. Fire agencies across Canada offer multiple opportunities for firefighters to take the fitness test at the beginning of the season. In some provinces, for instance, the jurisdictional cut-score – or the maximum time allowed to successfully qualify as a Type 1 firefighters – is 17:15. But, because the national export standard is set at 14:30 (the lowest time of all jurisdictions, belonging to Alberta, British Columbia, and Parks Canada), candidate firefighters need to hit that 2:45 quicker pace in order to be considered for export assignments to any jurisdiction (regardless of their local cut-score). There's little incentive at the time of early-season testing to achieve these quicker times – the prospect of export is often a far-off idea, and many firefighters have been much less physically active throughout the winter months – but it doesn't reduce the frustration in not being able to be exported later in the season.

Because CIFFC depends so strongly on this fungibility, deviations can be frustrating from a management perspective. One source of this challenge is trainees. Because junior

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[159] Gumieniak, "Establishing a Legally Defensible Physical Employment Standard for Canadian Wildland Fire Fighters," 84-85.

firefighters and incident command personnel require significant fire experience to progress beyond their classroom training, agencies – particularly those with quiet fire seasons – are eager to send their trainees to the action to put in hours on real fires. Yet, this comes at a difficult time for the receiving agencies (British Columbia, for instance, was at a stage where all personnel, including senior incident managers, needed to bring their own tents on exchange because there were no longer enough places to board these staff). It also makes things very difficult for CIFFC. A trainee who is about to be qualified as a fire behaviour analyst, for instance, might well be able to function in that role under mentorship in the field. On the other hand, the trainee might well be just out of the course with little experience with fires in mountainous terrain or real life at all. The difference between these two trainees has huge implications for their suitability for deployment – and yet is a level of nuance that is antithetical to a system built around creating interchangeable staff.

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With the amount of activity taking place, was easy for days to blur together during a fire flap at CIFFC. A mid-day conference call on the 10th began with a cross-country check-in, featuring a personable duty officer in BC greeting the group with "oh, nothing much going on here in BC." The actual situation, of course, was far more fluid, he reported: "we're very much still in a stage of triage, trying to get our heads around where we're at" with rapid fire growth, like one that had gone from 500 hectares on July 9th to 2000 a day later. Both the symbolic and tangible functions of CIFFC were on display in the call. The duty officers from
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each province expressed a willingness to support with whatever they could as soon as they could, even if they were managing fires on their own landscape. Yet, it was sometimes challenging to achieve effective information flow: what the CIFFC staff needed were specifics about what resources were available so that they could optimize the deployment, and sentiments that a province would "entertain any requests you might have" were logistically useless.

As fire activity picks up across the country, the 'National Preparedness Level' rises as well. Much like provinces have their own preparedness levels that dictate how resources are made available, CIFFC members come together to assign a subjective number between one and five (parallel to the American system). Unlike the provincial equivalents, however, this 'NPL' is less about sheer fire load and more about the matching of capacity and availability across the country. An NPL of 1 or 2 represents relatively few resource orders that can be easily filled by agencies across the country. An NPL of 3, the level on July 10th, is described as follows:

> "Some Agencies have Moderate to High wildland fire hazard and load with a high potential for increased fire load. Two or more Agencies are experiencing wildland fire activities requiring the increase in the mobilization of interagency resources through CIFFC. Incident Management Teams and Type 1 initial attack crews have been mobilized and committed. National resource levels remain generally adequate to meet occurring and anticipated wildland fire activity".[160]

An NPL of 3 is seen as a big trigger within CIFFC. Resource requests are generally plentiful at NPL3, but they can also be readily filled by the other agencies across the country. The problem, however, is that NPL4 or 5 rarely require more resource requests – rather,

160 Canadian Interagency Forest Fire Centre, "National Wildland Fire Situation Report July 10, 2017."

they come about because of a lack of resources available to fill the orders (see Chapter Six for a more detailed discussion about these kinds of predictions). As such, at NPL3, a number of functions – including a management committee that takes decision-making authority off the duty officer and a strategic planning unit – are activated to better managing the filling of requests in a sustainable way. In addition, more formal briefings begin to lay the groundwork in case resources need to be imported. Because CIFFC works to stay abreast of its counterparts' activities throughout the fire season, sometimes these calls end up being an acknowledgement of mutual stress rather than negotiations about exchanges (one staff member made a call to keep his American counterpart in the loop, for instance, full well knowing that the United States were also stressed with a high fire load and thus unable to send firefighting resources – it was a "no-shit, Sherlock" call, he later joked).

On the conference calls throughout these days, the CIFFC staff checked back regularly about the current NPL. We're "…likely to go to a four this weekend, given the anticipated BC orders. We're in this for the long haul," one staff member told the duty officers on the 10th, reflecting the way that available resources could become constrained. By the 12th, the constraints were beginning to be felt: "We've been sitting at a 3.7 for a while here, but we're going up to a four," he announced. The reference to a 3.7 was an internal joke of sorts. Because the preparedness levels had real world implications, like activating the CMAC at NPL3 and bringing in Interagency Representatives from international partners like Australia and Mexico at NPL4, the CIFFC team strategically stretches the numbers: joking about a decimal value as a way of reflecting an upgraded or downgraded actual state, while holding onto a different NPL value on the basis of anticipated trends.

As much planning as was done on conference calls, with the strategic planning unit, and through the masses of paperwork, real world events could very quickly change the conditions on the ground. Using data from the PIE sheets, the CIFFC staff had established a series of carefully weighed airlifts on July 11th to get crews from Ontario and Saskatchewan into their respective mustering points in British Columbia. Using two chartered aircraft based in Edmonton, three stops to pick up firefighters (Sudbury, ON, Dryden, ON, and Prince Albert, SK), and two technical stops for fuel and crews (Winnipeg, MB and Saskatoon, SK), firefighters would be delivered to both Kamloops and Prince George, British Columbia (Figure 7).

Figure 7
Planned flying for July 11th.[161]

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161 Author's own visualization of planned flight routes, created using the interface at gcmap.com.

These plans very quickly fell apart, however, with a phone call to the CIFFC office at 11:32am. The plane flying to pick up Ontario firefighters in Dryden had suffered an engine shutdown on its approach to the airport, and although it had landed safely, it was grounded for the day for inspections and repairs. The next available plane wasn't able to depart Calgary until 2:00pm, which meant far too late an arrival into BC. A few more calculations, though, and a solution opened up: if the firefighters in Prince Albert could be bussed the ninety minutes to Saskatoon, reducing a stop for the aircraft, the timings could work. With that, another flurry of telephone calls were made to update the plan, request the new aircraft, and inform British Columbian counterparts about the new arrival time.

The situation illustrated the degree to which CIFFC is built on the good graces, trust, and relationships that span the country. One example is its para-governmental position as a private not-for-profit, but with a clear public service mandate and close partnerships with provincial and territorial governments. While CIFFC staff often spoke about the challenges that arose by virtue of being non-governmental – past hesitation and misunderstanding, for instance, by the federal government about why a private organization was coordinating emergency response and previous difficulty getting in touch with federal agencies – its independence is advantageous.[162] By being unaffiliated with either the federal or a particular provincial government, it carries increased legitimacy and perceived neutrality in serving a facilitative role in planning and response.

[162] The new liaison role at the Government Operations Centre that the rotating staff member filled the subsequent week was one attempt to improve these relationships and to provide a local representative who could field questions about the organization, its procedures, and its role.

Another example is the need to carefully manage the asymmetry of firefighting in Canada. Some provinces – like British Columbia and Alberta – are colloquially referred to as 'fire powers,' with thousands of staff, massive investment in their fire programs, and huge institutional apparatuses dedicated to managing fire. Others are smaller, whether because of budgets or physical size. It creates something of an elephant in the room, wherein fire-prone provinces – particularly those who choose to chase every fire aggressively, like British Columbia – can rapidly suck up every single available resource in the country, while other provinces can provide very little into the system. On July 10th, for instance, BC had deployed six incident management teams (usually consisting of 12-20 senior staff who are tasked with supervising a large fire), had assignments waiting for the next four being assembled, and were preparing to request another four for rapid deployment. Prince Edward Island, by contrast, doesn't have a single team at all, let alone any available for export.

These latent asymmetries risk giving rise to imbalances. Some provinces are net importers, while others are net exporters. Others are constrained in how much they can contribute at all given the size of their fire programs or how the staffing is set up (such as needing to get permission from a conservation program to export staff for fire duties, for instance). And, it would be easy to imagine gaming the system: choosing to staff your own fire program to a lower level, relying increasingly instead on a sort of mercenary model of firefighting where you hire out-of-province imports without having to pay their training or standby costs.

These problems require systemic fixes. The asymmetry challenge (particularly with respect to the smaller Maritime programs) has been largely abated for the moment because the Executive Director, Kim Connors, hails from New Brunswick. This has provided a local credibility for CIFFC, as well as offered an administrator who is willing to invest time and enthusiasm in developing capacity (such as facilitating joint Incident Management Teams or firefighting crews), which can be fully staffed with the support of several agencies.

The potential for over-reliance on imported firefighters is more challenging to solve, mostly because of its perverse incentives. One problem is that negative feedback – such as understaffing a program, only to find that the resources that needed to be imported were not available – would come much too late, with the potential of deadly consequences, and likely only after significant frustration had built up between provincial managers about not every jurisdiction taking its fair share. Another problem is much simpler to remedy: When firefighters are exported, the lending agency is paid for the travel and staff costs incurred. This provides an incentive for maintaining fully staffed fire programs. In quiet years, your staff can be exported for firefighting elsewhere, with their salaries on export being reimbursed by the receiving agency, helping to reduce the costs your program faces for training and maintaining these staff. Problematically, however, in most provinces this income is not returned to the fire program, but rather deposited into general government coffers. Instead of providing a positive incentive to maintain large fire programs – as well as a small source of revenue to offset other programs – it creates an even more challenging fiscal situation where fire programs are not credited for their positive value.

Fortunately, however, the broad consensus is that each Canadian jurisdiction pulls its fair weight. Even in the midst of particularly busy periods, CIFFC is able to operate on a consensus model. During the active 2015 fire season, for instance, even when the

Management Committee needed to make hard decisions about which provinces would and wouldn't get requested resources, it "was probably the best… picture of how collaboration could work," recounted one CIFFC staff member. "Everyone wanted to collaborate and cooperate." Although political leaders would periodically inject pressure about not letting resources leave, the fire program managers were able to cut through and offer up resources and personnel to those in need. Most strikingly, when available resources were particularly tight, agency directors would deprioritize their own requests, suggesting that other provinces or territories likely needed the help more.

The trust that is required to facilitate this exchange is remarkable. In essence, each province is put in a situation of impossible conflicting incentives. On one hand, it is in both the collective and individual interest to contribute as much as possible to national exchange. Not only does this assist those provinces that are in desperate need, but it's also a selfish move: it is important to contribute to the system during your times of availability so that other provinces contribute during your times of need. Yet, for an individual province, any given deployment is a high-risk event. There's significant potential that the fire load at home could change: a week of hot, dry weather could be enough to turn a wet landscape back into a readily flammable forest. This makes contributing to the system high risk, as sending your own resources away puts your home jurisdiction at a greater degree of vulnerability and puts your own assets at risk by putting them in harms way. In essence, it's a situation where practicing trust is crucial: by demonstrating a continued willingness to invest and contribute, even when there's fire load at home, each province is in essence reaffirming the importance and the value of the system for when their time of need arrives. This tension – the need to contribute meaningfully, while putting yourself at risk by doing so – fuels a quest to predict future conditions at home to 'de-risk' the question of how many firefighters could be safely deployed away from home (a challenge I explore in the next chapter).

Fortunately, the trust in the "Spirit of the MARS" was alive and well in 2017 thanks to agencies digging deep to support the needs in BC, and the system of interchangeability was working effectively on the ground out west. On the last conference call I sat in on in Winnipeg, just as the agenda was wrapping up, the duty officer from British Columbia cut in. "I just want to thank everyone for coming to bat for us," he said.

6. How Many Firefighters Are Needed? The Quest for Prediction

'Forecasting is a shell game.'

The report from British Columbia to CIFFC on July 10th was remarkable: "Over 300 starts in the last 96 hours. Lots of aggressive fire behaviour showing. Detection is becoming a challenge due to heavy smoke. Some fires being detected at 500+ hectares." So, too, were their requests for aid. The CIFFC staff functioned as the conductors of the train, matching dozens of requests with what provinces, territories, and the Parks could offer up. The staff at CIFFC, by contrast, served as the network engineers, with their eyes focused "seven, fourteen, and thirty days out" as one staff member often described his role.

While these descriptions might sound like mere platitudes of organizational planning, at their core, firefighters and wildfire managers seek more than anything else to predict, forecast, and, in essence, see the future. Fires are fickle beasts, kicked up in a moment's notice with an uptick in wind; tamed just as quickly with the arrival of cool rains. This is the paradoxical nature of fire itself. The mechanisms that cause it to burn in general – heat, oxygen, fuel; fuel, weather, and topography – are well understood, as are the features that cause it to be damaging to humans, like non-FireSmarted homes nestled into forested landscapes. Yet, when managing a particular fire, these generalities offer little guidance for the purposes that institutions need. What fire managers crave are specifics: How will this fire behave? How will it grow and which buildings in specific will be threatened? How long will it last? How many firefighters are needed to put it out?

Take, for instance, the city of Slave Lake, Alberta in early May. Located just over 250 kilometers southwest of Fort McMurray, Slave Lake is also defined by its boreal forest. The spring weather conditions can look similar as well, with prolonged dry conditions augmented by pre-green-up high winds, low humidities, and relatively low snowfall the previous winter. Indeed, the conditions looked much like this forty-three years apart, in mid-May of 1968, 2001, and 2011 alike.

In all three cases, the spark likely came from humans. May of 1968 was defined by the prevalent phenomenon of the time: settler fires set to clear land and burn debris to prepare the fields for agricultural use.[163] These fires "presented no special suppression problems for the Alberta Forest Service" until the weather conditions shifted quickly on May 18th. The winds averaged above 25 kilometers per hour, gusting at times beyond 65. Not only did these winds feed the fires' spread, but they carried firebrands miles in advance of the fires themselves. Investigations on the ground after the fact confirmed that not only had the winds pushed the fires in rapid 'runs' of thousands of feet, but they had also created fire whirls "where thousands of trees had been felled by the force of wind generated by the fire or scattered in a circular pattern up to several hundred feet in diameter."[164] On May 23rd, the fire burnt roughly 150,000 hectares in one day alone, traveling a distance of 60 kilometers from the Athabasca River to just south of Slave Lake.[165] That day, it traveled over six

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[163] Kiil and Grigel, "The May 1968 Forest Conflagrations in Central Alberta." Fire is referred to as both the "Vega Fire" and the "Lower Slave Lake Fire" in different historical accounts.

[164] Kiil and Grigel, "The May 1968 Forest Conflagrations in Central Alberta," 29.

[165] Murphy, introduction to *The Sky was On Fire.*

kilometers per hour forward over a 15-25 wide kilometer front, accounting for almost half of its total size (330,000 hectares) in a single twenty-four hour period.

Much like in British Columbia in 2017, not only were single fires concerning for locals, but the overall 1968 fire load was also overwhelming. The Government fought the over 250 fires burning with forces of "100 aircraft, retardant planes and helicopters, 580 bulldozers, and an army of about 5,000 firefighters." As federal researchers summarized a year later – evocative of proclamations that would be made again in 2015, 2016, and 2017 – "Alberta Forest Service fire-fighting personnel and facilities were taxed in that period to an extent never before experienced."[166] Yet, for the town of Lower Slave Lake, relief arrived just in time. Cooler, wetter weather stopped the fire "at the last minute" before it could burn into town.[167] While mop-up continued for weeks, the town site was spared.

In 2001, thirty-three years to the day after the Vega fire run, fire took aim at Slave Lake again. The Chisholm fire, like the fires before and after it, was human-caused, this time by Canadian National rail operations along their corridor.[168] The fire was detected just before ten o'clock at night, and an eight-person crew was immediately dispatched. Some ten hectares when it was detected, it spanned over 3,000 hectares by the following morning. By the day after its detection, almost 150 firefighters, 32 bulldozers, and three groups of air tankers were engaged. The number of firefighters continued to grow, including management personnel imported from Ontario through CIFFC. The towns of Hondo, Smith, and

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166 Kiil and Grigel, "The May 1968 Forest Conflagrations in Central Alberta," 1, 8.

167 Struzik, *Firestorm: How Wildfire Will Shape Our Future,* 37.

168 Chisholm Fire Review Committee, "Final Report."

Chisholm were evacuated, and by May 28th, the town of Slave Lake was put on evacuation alert. Again, however, the arrival of rain and favourable weather slowed down the fire before it could enter Slave Lake proper.

Another ten years, another dry May, another human spark, another fire. On May 14th, Alberta Wildfire was managing yet another cluster of fires on the landscape, several of which "seemed a greater threat than any of the wildfires in the Lesser Slave Lake region."[169] The fire itself started about fifteen kilometers outside of town. Through the 14th and early on the 15th, those involved "were cautiously optimistic" about the likelihood that the town would be spared by the fire.[170]

Unlike 1968 and 2001, however, the shift in the weather brought devastation rather than relief. The arrival of gusty winds – in some cases over 100 kilometers per hour – not only drove the fire towards the town, but simultaneously grounded air tankers. "The timing, it just occurred so fast," recalled the Mayor, Karina Pillay-Kinnee. "It just happened so quickly."

The parallels to the last minute and incomplete knowledge transmission in Fort McMurray and the Horse River fire were remarkable. "With tremendous speed," the fire review by KPMG stated, "the wildfires reached the Town, at which point many residents were still unaware of the imminent threat."[171] No warnings or evacuation instructions were issued, and most sources of public information suggested instead remaining calm:

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169 KPMG, "Lesser Slave Lake Regional Urban Interface Wildfire – Lessons Learned," 29.

170 Wingrove, "Change in Winds Caused Chaos for Fire Devastated Slave Lake, Alta."

171 KPMG, "Lesser Slave Lake Regional Urban Interface Wildfire – Lessons Learned," 30.

> "In particular, many people recall that the radio told them that there was no need to evacuate – ironically, this same message continued to broadcast on a loop after the radio station itself was evacuated, meaning that people were being advised there was no need to leave even as others were already in flight. Similarly, several people recalled phoning the RCMP and being told that everything was fine, and that the fires would miss the Town. Not only did many residents experience little or no warning of the need to evacuate, but many also did not receive any formal evacuation order at any point. Instead, a great many people simply self-evacuated, whether because their own house was on fire, a neighbour's house caught fire, or because they were aware of others evacuating."[172]

Limited evacuation routes – in some cases impeded by roadblocks attempting to prevent unsafe driving through smoke – also evoked the Fort McMurray experience on Highway 63. Common, too, were infrastructural challenges: limited gas available, which often couldn't be pumped at all because of electrical failures; water pressures that dwindled when they were needed most; and failing telephone services that made basic communication complicated. Similar as well was the outpouring of support from across the province, with thirty-eight separate fire departments involved in battling the flames throughout the city. Over four hundred buildings – approximately one third of the town – were destroyed, leaving over 700 homeless.

These three cases – 1968, 2001, and 2011 – all shared a common stage. All three had human caused fires kindled under the high winds and dry conditions of May. The only true difference was the weather: in the first two, the weather brought relief just before the town itself was threatened. In 2001, however, the weather brought the fire into Slave Lake. It's indicative of why firefighters and fire managers are so desperate to know the future. The

[172] KPMG, "Lesser Slave Lake Regional Urban Interface Wildfire – Lessons Learned," 30-31.

difference between losing a town and being criticized for spending too many resources on a 'nothing' fire can be as simple as a change in wind direction.

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In many ways, managing fire is essentially managing knowledge. These provincial and territorial agencies are responsible for managing knowledge systems that serve to generate, validate, circulate, and apply knowledge to a very tangible practice: suppressing fires. This drives a demand for both real-time and prospective knowledge production. Real-time knowledge – like the information, procedures, and inputs described in the first five chapters – drives the response enterprise, enabling fire management agencies to distribute their resources across a landscape far larger than can be physically observed from a single headquarters. It also, however, requires prospective decision-making (as was introduced in Chapter Five), wherein agencies need to make decisions not only about real-time conditions and how to respond, but how to be prepared for future conditions and demands (things like the placement of firefighters, the allocation of budget to firefighting, and the sharing of equipment and personnel between provinces). This prospective decision-making – and the question to predict future conditions – is what I explore in this chapter.

Considering these prospective knowledge management dimensions gives rise to two different core issues to investigate and question. First, it draws out the distinction that we have already begun to grapple with between tacit or experiential knowledge and explicit or formalized knowledge. And, in particular, it requires us to examine the ways in which these
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different forms of knowledge are manifest at not only the individual level (like was discussed with respect to deploying firefighters or forecasting availability) but also embedded into the collective, institutional level. The second issue arises with respect to generalized versus particular knowledge. When responding to real-time challenges, knowledge is very particular: where are the firefighters currently deployed, which houses are threatened at this moment, and where is the fire most intense? When we examine knowledge production about the prospective or future, however, determining the particular becomes much more difficult. Weather forecasts might provide a general forecast about what conditions might exist in the province, but it's the particulars that fire managers want to know – exactly where, for instance, will this particular fire be driven by the wind, fuel, and topography, and when will that happen?

In many ways, investigating prediction is also about questioning a fundamental assumption. As will be illustrated through the chapter ahead, the fire management industry is relentlessly enthusiastic about new models and forecasts that can predict future conditions and determine their precise impact on fires. Improved prediction, in this model, leads to improved outcomes. Yet, this is not always – and perhaps not even often – the case.[173] Fire management depends on extensive systems of informed risk management that build in uncertainties and unpredictability, and the quest to know exactly what will happen can push back against a management strategy grounded in adaptability and caution. Moreover, there

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173 Sarewitz, Pielke, and Byerly, *Prediction: Science, Decision Making, and the Future of Nature*. See, in particular, the discussion around p. 363.

are significant positive features that arise out of embracing uncertainty, like the commitment to supporting neighbours despite imperfect knowledge that underpins the system of mutual aid discussed in Chapter Five. The promise of forecasting can be seductive, but it should not be seen as an unbridled good.

There are three broad kinds of models and predictions that fire managers crave. The first is weather forecasting, and particularly fire weather forecasting. The second is fire behaviour modeling, which combines weather forecasting with fuel and topographical data to translate high-level weather patterns into actual fire behaviours. For the purpose of discussion here, fire behaviour modeling also includes three related forms of modeling: smoke modeling (which combines fire data with winds at multiple altitudes to determine where smoke will be blown and at what densities), fire occurrence modeling (which combines fuel and weather data with attempts to predict where and when lighting- and human-caused fires will occur), and models that attempt to predict fire spread, behaviour, and growth, like the Phoenix system described in Chapter Four and the boreal forest burn models that will be explored in Chapter Seven. Finally, the third kind of modeling is the newest and most relatively under-developed form of prediction in fire management: resource demand modeling. This final forecasting focuses on translating fire behaviour models into a determination of how many firefighters and firefighting resources are needed and, ideally, where.

In spending time with both those who develop and use these models, consistent terminology is notoriously difficult to nail down. These kinds of systems – systems that take in data like meteorological conditions, lightning strikes, geospatial data on fuel types, or topological data, among others – and create some sort of prediction about what may happen are referred to with terms like "models," "forecasts," and "decision-support systems" relatively interchangeably depending on the proclivities of the person spoken with. Some of these uses invoke objective prediction, others suggest simply one perspective into possible futures, and others still emphasize the link with translating outputs into actual decisions. These understandings are crucial to how the models are used in firefighting decision-making, yet rarely seemed to be deployed with consistency.

Fire weather forecasting is crucial because it forms the foundation upon which all other kinds of fire forecasting are built. The daily fire briefings also often serve as a core ritual for fire managers; the one occasion each day in which many of the agency personnel can actually be found in the same room simultaneously. In Alberta, a team of five meteorologists deliver the fire weather briefings twice daily in a room adorned with a pseudo-wallpapered border of a chart plotting above and below normal temperatures and rainfall, as well as countless maps, graphs, and model outputs (Figure 8). The morning briefing covers weather predictions for that and the next day, while the afternoon briefing considers 3-5 days out for planning purposes. Regional duty officers call in via a conferencing line and watch the series of slides and annotations being performed in real time, adding questions as necessary about their specific regions.

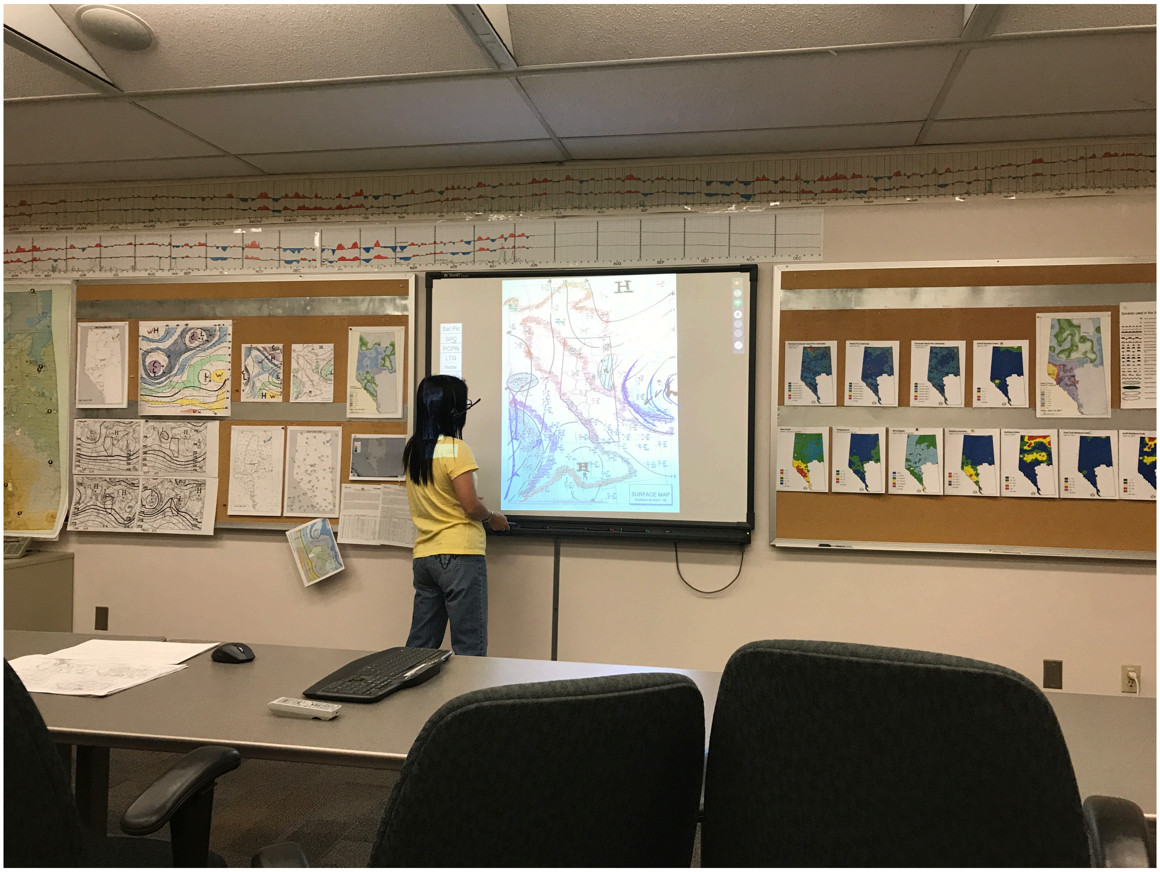

Figure 8
A typical fire weather briefing in Edmonton, Alberta.

Often, these questions from regional duty officers are remarkably focused: "What time will the wind shift from West to North?" "How much precipitation are we expecting to fall over this particular fire?" "How much will the humidity recover overnight?" During my months observing agencies across Canada, the meteorologists fielded these questions as best they were able, although were often stuck between the duty officer's desires for an exact prediction and the range- and probability-based nature of meteorology. At the same time, however, as appealing as exact predictions were, duty officers understood that they were an impossibility. By and large, an emphasis on high margins of safety forces a different management approach regardless: in the view of management personnel, if firefighter safety in a particular situation depends on a forecast being exactly as predicted, the situation was far too dangerous to directly insert firefighters in the first place.

In both the fire briefings and the preparatory work in advance, it was obvious that a combination of expertise and art were required to link broader forecasts with their fire implications. In another jurisdiction, I sat with a meteorologist as they walked me through their process of preparing forecasts for the briefing. Their first focus was on the Fire Weather Index, or the FWI. The FWI was created by the Canadian Forest Service and serves as a "numeric rating of fire intensity" and is "suitable as a general index of fire danger" in forested areas.[174] The index itself is mathematically calculated by combining two other weather products, the "Initial Spread Index" (or ISI, which represents how quickly a fire is expected to spread) and the "Buildup Index" (or BUI, which creates a quantitative rating for how much fuel is available for a fire to burn). In turn, the ISI and the BUI are also calculated on the basis of other products. The ISI brings together the wind and the "Fine Fuel Moisture Content" (the FFMC, roughly speaking, the top layer of fuel on the forest floor, like leaves and twigs), while the BUI combines the "Duff Moisture Code" (DMC) and the Drought Code (DC) which assess the dryness of the next two larger sizes of fuel, like packed debris (known as 'duff') and logs. In essence, the FWI represents the synthesized peak of a large pyramid of other indices, each of which is built on a variety of weather parameters like temperature, relative humidity, wind, and rain.

[174] Government of Canada, "Canadian Wildland Fire Information System."

Ostensibly, the production of the Fire Weather Index was automated for this meteorologist. Every morning a piece of software would automatically run the calculations for the almost one hundred weather stations spread across the province, computing a FWI value for each individual station. These numbers were then shared with regional and provincial duty officers, who could use the values to adjust positions of aircraft or firefighters, set shorter or longer maximum response times, or even (in the case of Alberta) use particular values like the ISI in algorithms that determined how many resources would be sent to each particular fire. This automatic calculation could easily give the impression that the FWI value was an observable measurement, just like the temperature or wind speed. The reality, however, was that because the FWI sits on top of this pyramid of nested calculations, it's profoundly shaped by the values that are fed into the calculation. For present values, this isn't a particularly big problem: a given weather station would report the wind speed, precipitation, temperature, and humidity, which could then be converted into an FWI value (albeit one based on the assumptions present in the formulas).

More problematic, however, were forecasted values for later in the day or week. The 'actuals,' as he referred to them, do eventually get posted – well after the fact. The challenge instead, as the meteorologist explained, was that you have to pick one weather model to use for the calculation of this forecasted five-day FWI. Some 'products' (the common parlance for forecasts of the weather or fire values like the FWI) would perform better for certain parts of the province than others, or for particular weather phenomenon like cold fronts or low-level jets. Some models seemed to provide more accurate calculations but suffered from fewer data points or inability to deal with prevalent features like topography. In this case, the meteorologist tended to use a certain model for the first two days, and then switch the data source to a model that he thought more accurately tended to represent days three through five of a typical forecast. "You get burned really fast," he explained, when you try to go through each individual station and determine the best possible model. Keeping the workload viable means focusing on making adjustments only when you see big discrepancies.

Generally all the models get something vaguely close to reality, he suggested, but they can miss particularly on the timing or placement of precipitation – unfortunately one of the features duty officers seemed to care the most about in briefings. To illustrate the differences, he pulled up two different models forecasting the precipitation in the province twenty-four hours ahead of as we were speaking. While they both suggested that the southern half of the province would see some precipitation while the northern half would remain quite dry, there were notable differences in where the precipitation would be occurring and at what time. In one model, the far south-eastern corner was the epicentre of rain, while in the other the precipitation sat several hundred kilometers further north in the province. Had there been an active fire in either one of those areas, the difference in the forecast could dramatically change fire behaviour and the volume of resources that needed to be dedicated to suppression, both in real time and over the coming days.

As a result, working the models is something of an art. "For every system that passes through," he explained, "the favourite model is different." Often regional models performed more strongly for the province, but for the system that was passing through as we spoke, an

American model seemed to be more accurate in comparing its prediction to actual values. Some provinces can also benefit from their location: Manitoba and Western Ontario, for instance, have a relatively longer time to predict some of the large systems that pass out of Alberta and Saskatchewan, as opposed to heat-fuelled convective thunderstorms in Alberta. Meteorologists also have to account for the time that it takes errors to work out of the system. Certain products require a 'hot start,' or in other words, being fed several days (often five to six) worth of data before they can provide forecasts about upcoming weather. If they have inaccurate predicted data in the system, therefore, they propagate that into several days worth of weather calculations.

Weather forecasting, therefore, becomes a test of deep expertise. It was important to see the big picture of weather across not only the province, but much of the continent, to understand how a particular system would develop. Part of this required a reliance on not forgetting the basic lessons in meteorology – the atmospheric features that dictate how weather behaves. More crucially, he explained, is building a conceptual model and "paying attention to what the model is saying." It was an appeal to tacit expertise, a kind of understanding of the weather that was more than the sum of its basic mechanics and formal model outputs. "Observations first, models after," he explained.

As a result, the weather briefings themselves were remarkably important as a venue for contextualizing simplistic numbers and visual representations, and for translating expert knowledge into usable commentary. Because the models themselves have, in essence, personalities that are more or less suitable for particular systems, they need interpretation and contextualization to understand what is likely to be accurate and what may just be a feature of the data the model is running on or particular tendencies to over or under predict certain features. The links between general forecasts and fire weather implications also need to be drawn out, helping fire managers understand how the bigger picture might relate to their particular situation. "With the precipitation," one meteorologist commented in a daily briefing in a different province, for instance, "this is going to be the battle of which model is right." Interestingly, however, as I crossed the country, there was a strong divide: meteorologists were trained on the meteorological side; fire mangers raised through the fire program. Rarely did meteorologists employed by the fire program have any formal experience in wildfire, rather, they were left to draw the connections between their training and the fire implications on the basis of what they perceived from duty officer questions and in-office guidance.

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Not only did the fires come fast and furious during the early days of July in British Columbia, but they extended through the season. By mid-August, nineteen separate fires had merged into what was dubbed the Plateau Complex. The complex eventually covered some 545,151 hectares, roughly the size of the entire province of Prince Edward Island. The provincial state of emergency, launched on July 7th, continued for seventy days until September 15th.

The fires in British Columbia were split between lightning and human causes. The weather played a significant role. The story of the spring had been pronounced flooding
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across the province, with hundreds of firefighters and incident managers brought in from BC Wildfire to provide support with the rising waters. This 'all-hazards' crossover is becoming increasingly common. Fire agencies are appealing for emergency management in general for two reasons. First, they offer a large set of willing and fit staff – the firefighters – who are capable of working well under orders and in a safe manner, capable of operating tools like chainsaws, and able to be easily logistically supported (like accommodations, meals, and supplies). Second, the overhead personnel – the incident management teams that normally manage major fires – can be easily appropriated to manage other emergencies and are sometimes seen as available staff to requisition into these roles.[175]

As the spring faded into the summer, the weather instability continued, albeit in different forms. A series of unstable air masses progressing through the southern portion of the province brought storm system after storm system through July, August, and September. Lightning – often accompanied by little to no precipitation – provided a ready source of ignitions for fires. While fire starts declined somewhat after the early July peak, hot and dry conditions sustained the fire activity well into August when another series of storms provided resurging kindling.

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[175] Whether this 'all-hazards' approach is safe, effective, or appropriate is a different matter entirely. There are two arguments about expertise in play here. The first suggests that emergency management and response is an emergency-agnostic form of expertise, wherein the expertise and experience is in managing *emergencies* rather than a specific form of hazard. This view emphasizes common elements (e.g., incident command, assessing scene safety, formulating action plans, communicating effectively) of all emergencies as the core skills required. The alternative view is that expertise is actually domain specific: while communication skills and working under incident command are important, just as – if not more – essential are specific forms of experience about the hazard itself. Knowing how to stay safe around fires and fire equipment, for instance, is entirely different than knowing how to operate safely in and around floodwaters. The first view would reply that these disciplinary skills can be easily trained; the second would dispute that and suggest that it leads to significant and unnecessary risk. Ultimately, neither position is well supported through empirical research, and the question needs to be the subject of further investigation.

Because of this important role of lightning in starting fires, fire meteorologists have to pay close attention to the location of lightning strikes throughout their provinces as well. Although lightning is remarkably rare and accounts for almost no fires in some eastern provinces like Nova Scotia and Prince Edward Island, in the west, it is a crucial ignition source. Alberta, for instance, can easily see seventy to one hundred thousand lightning strikes in a season. Agencies rely on a series of sensors to detect these strikes, either through a national system (the Canadian Lightning Detection Network) or subscriptions to private services. The end goal is the production of yet another form of geospatial data: maps that are displayed on screens around the operations centres, showing in near-real time the location of each new lightning strike and its positive or negative charge (positively charged lightning is hotter and therefore more likely to start a fire).

Lightning strikes rarely manifest immediately in fires, however. Because electrical storms are often accompanied by at least a little rain, the lightning instead kindles a smouldering start in the flammable debris like peat that make up the forest floor. As conditions improve – as the fine fuels dry out, as a little bit of warm wind is introduced – these kindling embers can then emerge as small surface fires. This can happen in a matter of hours or the next day. Duty officers I spoke with, however, discussed cases where these 'holdover fires' could take up to twenty-eight days to emerge. The maps of lightning strikes, therefore, are less about immediate knowledge (except for protecting fire crews from the strikes and associated possible hail) and more about long-term decision-making. Duty officers, for instance, plan where to send 'detection flights' (the small aircraft tasked with looking for smoke from newly started fires) based on the location of past lightning strikes (see Figure 9).

Figure 9
A duty officer plots out the daily detection flights and loaded helicopter patrol routes.[176]

Predicting which of these lightning strikes will actually result in a wildfire is a difficult challenge and is the subject of much research.[177] At the moment, these predictions are largely made based on the tacit and experiential knowledge of the duty officer. Duty officers use

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[176] Note the sidearm pictured. This photo was taken in Manitoba where Conservation Officers staff much of the fire program, some of whom are armed for duties in enforcement, public safety, and wildlife management.

[177] There is also a question here about what, exactly, prediction is expected to do. Lightning strikes *can* be predicted at a generalized level, such as for a region of a province, which allows for some management decisions to be made (e.g., removing crews from the field for their safety, or anticipating a higher fire load in the weeks that follow). Yet, there's also a pressure for prediction to be more than just this generalized information: can it provide the practical details about where exactly these fires will start for the purpose of forecasting exactly how many firefighters are needed, for instance.

their memory of previous lightning strike locations, combined with the new daily trends of drying fuels and changing weather, to estimate what areas are likely to see emerging fires. Sufficient rain with the lightning or in the following days is likely to drown out the starts, whereas dry lightning and drying trends increase the likelihood. It represents yet another area where there is a deep craving for precise weather data: the precise placement of precipitation can make all the difference between lightning that has no impact and lightning that starts a series of new fires. In this case, duty officers and meteorologists can largely depend on actual values rather than forecasted values (looking back at more precise data about what actually happened in retrospect) – but in many ways this simply shifts the challenge from the imprecision of forecasts to the imprecision of limited weather stations.[178]

Compared to human fire starts, however, lightning fires seem almost simple to predict because of the ability to forecast storm systems and track the actual locations of lightning strikes. Humans, by contrast, are fickle and unpredictable: no weather system or atmospheric principles govern when a child will decide to play with matches in a field, when an ATV will throw off a hot metal shard, or when a campfire will escape. The causes of human fires are diverse – escaped fires from clearing land for agriculture, intentional or negligent arson, and recreational and industrial fire starts – which also adds to the difficulty in predicting their occurrence. Location is slightly easier to anticipate than timing (people

[178] One attempt to solve the gaps in weather stations in through the use of portable equipment. At many large fires, for instance, fire agencies will deploy small, stand-mounted weather instruments. This provides much more localized weather than relying on the nearest airport, yet can still be subject to significant variation (e.g., winds behaving quite differently because of local topography, or heat disparities because of the aspect of the slopes). Another challenge is the problem of multiple station types and elevations (e.g., a small portable weather station located close to the ground versus a tower-mountain system at an airport). Saskatchewan Wildfire Management, for instance, has set up an entire field of weather stations for testing behind their office to examine relative precision and strengths and weaknesses of each.

don't tend to stray far from conduits like trails and roads when starting fires, whether intentionally or accidentally), but the prevalence of these features makes that observation far less useful in actual planning.

In fact, the difficulty in predicting human starts is so pronounced that duty officers across the country report using only one real heuristic in staffing and preparedness decisions: long weekends. When more people are out on the landscape starting campfires, using ATVs, and docking their boats on the sides of lakes to cook lunch, the incidence of human-started fires goes up. The saving grace, however, is that because human fires don't tend to be started far from people themselves, they are also typically detected much more quickly by other people in the area.

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The inherent tension in these quests for models and prediction is that being able to predict the future simultaneously does and doesn't matter. On one hand, duty officers, incident commanders, and agency managers across Canada are able to use a series of principles that hold true without any model inputs or fancy forecasts. One such principle would be to position resources in a way that maximizes later flexibility: air tankers and helicopters can be 'day-based' out of a different airport than their home location to more evenly stratify them across regions facing high risk weather. Excess provincial resources (like hose and pumps) in Newfoundland can even be temporarily based on the mainland, in Nova Scotia, to dramatically reduce ferry-induced transportation time if they are exported to
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another province, while keeping them within a short return period should they be needed to supplement at home. Another principle would be to emphasize the use of helicopter-based firefighting units (as opposed to smoke jumpers or ground-based crews) that can be inserted and extracted more rapidly to prevent exposure to high-risk fire behaviour, and whose dedicated air support can be used to augment capacity through bucket water bombing. Still another is to establish an organizational culture with a low tolerance for risk, avoiding the question of whether firefighters ought to have fire shelters by denying the premise entirely: firefighters should never be close enough to a fire front to risk being burnt over if there is even a low chance of aggressive fire behaviour developing. Such principles effectively mitigate risk without relying on forecasts. And, in turn, they avoid not only a bad outcome – being paralyzed from action because of the absence of a forecast – but also reduce the likelihood of a much worse possible outcome: dealing with tragic consequences because of a high-stakes decision that depends tightly on the accuracy of a model.

The risk, then, is that these crucial management philosophies could get lost in the pursuit of fantastical models that purport to offer perfect future knowledge. No-regret management approaches require heavy, iterative work to make incremental improvements in efficiency and outcomes, while models promise quick payoff in results. They also risk deemphasizing the comprehensiveness of the knowledge inputs that are integrated through these expert-based management strategies, simplifying instead into a set number of parameters that disregard qualitative inputs.

On the other hand, forecasting and prediction offers a convenient solution to the fundamental tension of Canadian firefighting: the vast size of the landscape relative to the limited resources, both human and financial. The promise of prediction is to allow a smaller pool of people and resources to be responsible for a larger area of forest – a 'force multiplier,' in both military and firefighting parlance. Without clarity about where fires will occur and how they will grow, agencies have to provide a relatively high degree of coverage in all fire-prone areas. But, the prediction – whether through fire behaviour or meteorological models – transforms size from a constraining feature into a multiplicative: because the hazard is rarely high across an entire province, or, at the very least, across an entire country, firefighting resources can be shifted from place to place. For maximum impact, this shifting needs to occur in an anticipatory rather than reactive way – offering time to get crews positioned to intervene early on new fire starts, rather than chasing fire across the landscape with a travel-induced lag.

Throughout the British Columbia fires, for instance, over 1,200 firefighters and incident managers were brought in from outside the province and country (including the United States, Mexico, Australia, and New Zealand). As described earlier, the mechanism for facilitating this resource exchange is CIFFC, the Canadian Interagency Forest Fire Centre. Although this logistics of facilitating this exchange are complicated – as discussed in Chapter Five – there are two more existential questions that underlie their work. These were the currency of the daily CIFFC conference calls with the duty officers across the country; a struggle to get information that, in many cases, the duty officers didn't even know themselves. First, how many firefighters and other resources were needed by the importing agencies? Second, and much more challenging, how many resources could be offered by each agency in the rest of the country?

The conflicting imperatives about sending resources are relatively simple. Fire agencies, both through their legal mandates and public perception, have a primary responsibility for fighting fires within their home jurisdictions. Yet, there are also incentives to share resources, ranging from an altruistic desire to help to the political photo-ops of sending flag-carrying firefighters to a jurisdiction in need. And, there's also a longer-term motivation: while several seasons may see an agency export resources to others in need, eventually the fire load at home may exceed local capacity and require the same help from others.

Agencies, therefore, need a way to optimize their approaches to determining how many resources can be sent while withholding enough at home to attend to the current fires they are managing as well as prospective fires that could emerge. This requires more than just knowing the weather for the next day or two, as exported crews are typically unavailable for up to two weeks (travel to the scene, briefings and preparation, the actual shift, travel back home, and then mandated rest days before they can resume their normal roles). Making matters more complicated, provincial economic imperatives mean that agencies rarely have a large number of excess firefighters. Therefore, the margins are narrow: It might be tempting to hold an extra three twenty-one person crews in reserve, but you may only have three or four total that aren't actively engaged on fires. A conservative rounding could be the difference between sending a crew and not sending anything to a jurisdiction in need.

As with most consequential decisions in the fire world, this discretion is currently left largely to the duty officers and program managers in each province or territory. Throughout my visits, I witnessed several of these conversations between duty officers and program managers, either during daily briefings or as side conversations in the operations centres, where the staff would attempt to determine just how many crews could be safely spared. They largely consisted of attempts to make tacit expertise explicit: to give words to their experience-based beliefs about what the weather would do, how fires would behave, whether more new starts were coming, and even about whether crews were sufficiently rested or in need of action. While generally grounded in vast experience, the subjectivity of these decisions frustrated managers – a common desire was to have a better prediction system that could accurately identify how many resources could safely be loaned.

The alternative option, then, is to create systems that codify this tacit knowledge into a more formalized predictive framework. This requires creating some sort of predictive equation that considers three key elements over the span of at least two weeks: how many fires will start, how aggressively those fires will grow, and how many firefighters will be assigned to each. Fire starts are relatively straightforward to quantify, if underdeveloped in their prediction: figure out how many lightning strikes will actually start fires and combine that with the number of human started fires.

Fire growth and firefighter demand, however, are difficult to conceptualize and quantify at all, let alone to predict accurately. The relevant fire behaviour spans many attributes: the total size of the fire, the actual area burning (excluding, for instance, 'islands' of forest that remain unburned), and the intensity with which it burns, among others. This must then be translated into a smaller-scale, per-fire version of the very question these models try to solve: how many firefighters and other resources will be assigned to each fire? But, again, this depends a great deal on the context of each individual fire. A remote fire, for instance, might be assigned very few – if any – personnel, while a small fire close to a community might require a massive influx of firefighters. And, staffing can vary for all kinds of intangible reasons: duty officers might staff certain fires at higher or lower levels based on what staff are occupied with other fires, what staff are eager or in need of more time on the fireline, or even highly subjective comfort factors (duty officers, for instance, often talked about being 'comfortable' or 'uncomfortable' with levels of staffing on particular fires, often in relation to speculation about future weather or the arrival of fall and winter).

Despite all of these complexities, a handful of agencies have attempted to quantify their future firefighter needs. One jurisdiction, for instance, uses a relatively straightforward Microsoft Excel spreadsheet. Their duty officers categorize fires into general brackets according to their overall size, each type of which is defined to last for a certain number of days. A "sector type one" fire, for instance, always lasts for seven days. Each of these days has a set number of firefighters required, following a growing than shrinking arc as the fire comes under control (see Figure 10). By making a subjective estimation – informed by the weather briefings (both for the presence of lightning and the overall weather conditions), whether or not a long weekend is arriving (that might increase human starts) – duty officers can make a rough-and-ready guess about how many of each type of fire will be sparked over the predication period.

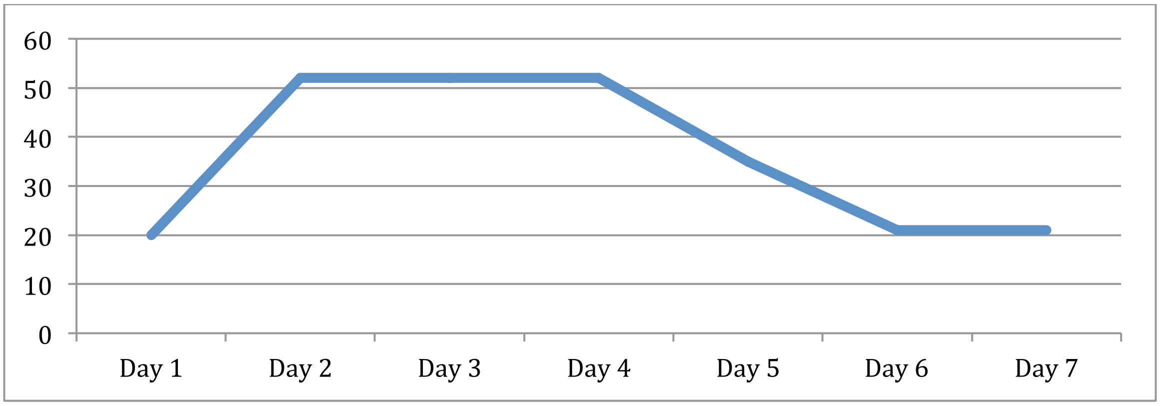

Figure 10
Sector Type One Fire Firefighter Requirements.

Broader inter-agency collaboration has also led to the development of a federal equivalent of these efforts at prediction, known as the Canadian Fire Resource Demand System or CFRDS.[179] The 'conceptual model' behind the CFRDS follows largely the same logic, using the following recipe:

(1) First, forecast the weather by combining statistical models with expert judgements. This allows a determination of the number of 'anticipated fires' for the days ahead.
(2) Second, rank all current fires into their 'stage.' Add the anticipated fires for each day, and subtract the extinguished fires for each day (predicted by the 'stage'). This creates a total number of fires for each day.

[179] Taylor et al., " Projecting National Fire Management Resource Demand to Support Resource Sharing."

(3) Finally, multiple each fire by the number of firefighters assigned to it each day. This produces a 'Total Resource Needs' for each day.[180]

These systems are crude and simplistic. Fires within the same category are treated as identical, and the software doesn't allow you to forecast whether the fire will grow or shrink from its current state. There is a multiplier effect that allows adjusting the prediction by 25-200% of the value suggested, which allows for a degree of tuning based on its current actual resourcing. But, the values of resources required are dated, and haven't been adjusted to account for either efficiencies in how firefighting occurs or increases in per-fire staffing. Yet, according to staff that I spoke with within the provincial organization using the spreadsheet model, the model has "transformed [their] function" as an operations center: even this basic level of foreword thinking about upcoming resource needs was seen as revelatory.

Firefighters aren't, however, the only forecasting requirement for agencies. Budgets can also be difficult to project, yet are particularly important for agencies where there is pressure to estimate as accurately as possible to reduce the number of times the wildfire agency has to return to the treasury board to ask for funds. Additional firefighting funding needs to be requested from government coffers in advance of actually needing it. This creates a de facto requirement to begin asking for funds about a month in advance of the time that it is actually needed. The more accurately you can forecast your needs, therefore,

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180 Taylor and McAlpine, "Canadian Fire Resource Demand System," (PowerPoint presentation, Canadian Wildland Fire Conference, Kitchener, ON, October 10, 2010.)

the more accurately you can know when to begin the process and how much money to ask for.

In this situation, effective prediction is important for garnering credibility with the broader government leaders.[181] Credibility can be lost quite quickly if, for instance, a fire agency requests to be allocated additional funding towards their Emergency Firefighting Budget (or equivalent), and then doesn't end up actually spending it. This can happen in short order: if a province gets hit with an exceptionally dry week, causing a fire flap, they may need to move for additional funds quickly. But, if a hefty amount of rain settles into the province a couple of weeks later, those fires may be rapidly extinguished at a fraction of the cost expected. A good outcome for all involved, certainly – but it creates a loss of face with political leaders who have an expectation that fire agencies can predict fire load more accurately.[182]

While most jurisdictions again rely on tacit expertise among managers and duty officers, others look towards quantification and prediction. In Ontario, for instance, managers use a tool called, tongue-in-cheek, "The Prognosticator" to estimate seasonal fire expenditures. The tool begins by taking in a base value calculated for each day of the season,

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[181] Credibility here has many components. Part of this is an explicit shifting of liability from individuals to approvable protocols. Part is a 'scientizing' wherein expert judgment is moved into formalized frameworks that carry weight because of their quantitative and mathematical nature. And, part is an explicit appeal for credibility – a model that can be pointed to as evidence of having thought through an issue and being trust worthy.

[182] A very reasonable question, of course, is to ask whether this expectation is at all reasonable. In any event, however, program managers in multiple jurisdictions spoke frequently about the credibility that can be lost if these 'over requests' happen to often. They can also in other situations: One jurisdiction in the 2017 season, for instance, was spending far less than anticipated and made a request to move funds from their firefighting budget into fire prevention and prescribed fire activities. Only a matter of days after that was approved, Murphy's Law kicked in: the first of several above-average costly fires occurred, in what would become a very expensive season.

which provides a vaguely accurate (within roughly plus or minus ten percent) approximation of season-to-date expenditures. Instead of trying to forecast future fires on an individual basis, however, the prognosticator uses a more historically grounded approach. Using these expenditures and details about weather and area burnt, the prognosticator then searches historical fire data to seek out the closest comparable years. These provide a set of possibilities that represent how the remainder of the year may progress, which can then be translated into projected costs based on a multiplier of how much additional fire could be found on the landscape.

This approach to using history to forecast future behaviours can be applied to non-financial issues as well. An experimental approach to predicting weather and its influence on fire in Ontario is a program called Weather Shield. In this version of weather prediction, weather is divided into three different timescales: the next five days, next fifteen days, and next months. The five-day forecast is drawn from the work of meteorologists, using their interpretations of the competing models discussed earlier to provide a human-generated forecast. The fifteen-day forecast, by contrast, is based on a series of models combined into an 'ensemble' forecast. These forecasts are presented with 66% and 90% confidence intervals, providing a degree of visualization of the range of weather that is possible in the next two weeks. Finally, the next months of forecast is provided by a comparison to historical years. All the years with historical data are divided into months, each of which has values about different ocean patterns that influence weather (like El Niño and La Niña systems). The degree of match to these past months is quantified on a -3 to +3 score asking, effectively, "what historical August looks like this August?"

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These cases of prediction indicate the centrality of knowledge in the fire management enterprise. Managers depend on knowledge of the future, but are perpetually interested in shifting that from informal, tacit, and experiential sources to something more certain, more guaranteed. There is also a relentless craving for the specific: general predications can be somewhat useful, but it's the precision and the specificity that really is desired for driving changes in management approaches.

In all of the forms of modeling discussed above, there's a tension. On one hand is expert judgement: grounded in experience earned on previous fires and rooted in gut judgements and practiced interpretation. Yet, this form of knowledge is often limited in its precision. It's also inherently constrained in its transparency and reliability. Because it depends on these experienced, lived, and gut-based judgements, any explanation of the judgement becomes a partial, post-hoc justification of what was decided.

On the other hand, modeling offers the promise of a precise and dependable crystal ball into the future. It presents an attractive option: resolving uncertainty that must otherwise be accommodated. Sometimes this is more of a craving of managers than an operational necessity. In other cases, however – like predicting how many firefighters you have available to loan to other jurisdictions – it has incredibly real need, like being able to support your neighbours in need. Multiple approaches to modeling will continue to advance its practice, whether through using predictive forecasts, simulations that sketch out a range
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of possible futures, or historical-matching systems. The next chapter discusses the research that is needed to underpin the future development of models and management strategies more generally.

Yet, it's also crucial not to see models as a panacea – particularly under the changing climates discussed in Chapter Eight. Fire management will always need to rely on conservative estimations and a safety-first attitude that embraces the inherent uncertainty of flames. Even the dream scenario – perfectly forecasting models – has its drawbacks. If a jurisdiction could accurately predict how many firefighters it needed several weeks out, it wouldn't be long before that ability stopped empowering increased exchange between provinces and was instead used by politicians to reduce the number of firefighters staffed within the jurisdiction in the first place… the ultimate cost savings.

7. Institutional Knowledge Production and Learning How to Fight Fires

Dave Mulock wasn't the only pilot involved in battling the Fort McMurray Wildfire. At its peak, over 140 aircraft – helicopters, air tankers, and bird dogs – were tasked to the firefight. Ever since Mulock and his helitack crew had detected the fire, other pilots were pulled in from across the province and country to assist.

Heather Pelley, another helicopter pilot, was responsible for Bell 407 helicopter on seasonal contract to Alberta Wildfire. "It was hot, so hot, that day. I remember I was sitting on the patio not far from the [helicopter] playing my guitar."[183] Because of the preparedness level set by the duty officer in Edmonton, she and her crew were on an alert that required them to be able to have their skids off the ground within ten minutes of a call. As she lifted off, the radio buzzed with the coordinates of the fire. But, "as I cleared the trees," she later recalled, "it was very apparent that we didn't need them" because of the visible smoke plume.

Once she, like Mulock, had dropped her crews off to work the fire from the ground, her role evolved. With firefighters in action, a helicopter pilot has two crucial tasks: to assist with maintaining situational awareness from their higher vantage, and to deploy the bucket carried onboard to begin scooping water onto the fire to aid the crews below. Mulock and Pelley had to begin an intricate dance. First they flew, with the bucket slung below the helicopter, to the nearest water source that was deep enough to scoop from (in this case, the Horse Creek Canyon). They filled the buckets, returned to the fire, and immediately had to

[183] Gordon, "Special Report: Fire in Fort Mac."

size up how the fire and crew positions had evolved since they left. They then chose a target that would help to protect the crews and aid in their fight, and dropped the water, dodging power lines and each other in the process.

Scoop from the river or lake, reassess the scene, dump the water, repeat. The cycle was fast, essential, and endless, continuing daily throughout the weeks that followed. Pilot Ken Saumure was tasked with defending the airport later that week. Scooping up 600 litres of water per bucket, he'd guide his helicopter back from the pond to the airport itself, where flames burned only 200 feet from his company's hanger, its fuel tanks, and the crews preparing for their shifts.[184] The entire turnaround took less than 120 seconds, from the scoop through the drop and back to the pond again. "We have to defend this place with all we have," he said.

Bucketing helicopters weren't the only aircraft in the rotation. During a fire situation, airspace is chunked into horizontal layers, like those of a cake, only a few hundred feet apart. Keeping this separation is crucial, with helitack crews and bucketing helicopters sharing a busy airspace with air tankers and command and control aircraft. It's up to the 'air attack officer,' orbiting overhead in one of the birddog aircraft or helicopters, to choose how to most efficiently use the aircraft to support the crews on the ground and defend the homes, infrastructure, and other values at risk.

One crucial question is how quickly aircraft can be back on scene with a fresh payload to drop on the fire. With respect to firefighting, Canada is blessed with a large number of rivers, ponds, and lakes available for pumping, bucketing, and skimming water.

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[184] Tait and Giovannetti, "Inside Fort McMurray: Helicopter Crews Battle Wildfires from the Sky."

For Saumure, the timing was ideal – only about two minutes between drops, making his efforts far more effective at suppressing the fire below. The time requirements increase, however, with larger aircraft that demand huge lakes to skim water from or airports where they can be refilled with retardants. The "Fire Boss," a small, single-engine aircraft on pontoons, uses a fraction of the lake length required by larger twin-engine aircraft, like the iconic CL-415 (pictured in Figure 11). Yet, even the shortest aircraft can be constrained by environmental factors. "Due to drought conditions," one Fire Boss pilot recalled during the firefight, "the lakes we have used before have dried up to the point where they are too shallow to land on now."[185] The chemical payload of retardant tankers helps to stop the spread of fire for much longer than the water carried by skimmers – and means they're not constrained by drought-stricken conditions – yet the need to return to the airport to refill after each drop can make their effectiveness just as challenging. It's part of the reason why the massive aircraft that hold media appeal in the United States – like the converted 747 or DC-10 air tankers – see little utility in places like Canada and Australia. Not only are the airstrips with sufficiently long runways to handle these aircraft for refilling so few and far between in the remote, forested regions, but the aircraft also deliver such a massive payload in one drop that ground crews need to be pulled away from the fire for safety.[186] With the Fort McMurray fire, the incredible work of ground crews – and the proximity of both the

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185 Torstar News Service, "Aerial Firefighter Talks About Fighting Fire from the Sky."

186 Cart and Boxall, "Air Tanker Drops in Wildfire Are Often Just for Show." This questioning of the utility of extra-large air tankers also occurs in Australia. I had extended conversations with Australian fire managers about the use of these so-called "Very Large Air Tankers," colloquially referred to as VLATs (rhyming with 'splats'). By and large, the reaction was that the role they best served was one of staged photographs: to reassure the public that something was being done about the fires, and then to use the far more nimble, quick, and suitable smaller aircraft to deliver more payload more quickly and more accurately.

Fort McMurray International Airport and several oilfield airstrips – allowed the turnaround times to be kept remarkably low, sometimes down to twelve minutes to land, refill, and return the aircraft to the scene.[187]

Figure 11
A Canadair CL-415 taxies between two of its parked sister aircraft in Dryden, en route to a smoke report in Northern Ontario.

Yet, proximity to the refilling location isn't the only consideration for selecting firefighting aircraft. There are a huge number of other attributes that fire managers need to take into account when choosing which machines to assign to a fire. Some machines, like the Fire Boss and helicopters, offer an ability to work within more rugged terrain. Others, like

[187] Gordon, "Special Report: Fire in Fort Mac."

the CL-415, not only deliver a much larger amount of water, but can use a variety of drop patterns to string out the delivery or drop it in one punch, and to combine those choices with different foam mixtures to increase effectiveness. Retardant tankers not only provide a longer-standing coverage against fire spread with their chemical mixtures, but offer a particularly important feature for Canadian fire seasons that are lengthening: the ability to fight fires before the ice on lakes has thawed enough for skimmer access.

Like so many of the issues discussed in the book so far – crew deployment, knowing which values to protect, or anticipating future fire loads – these decisions largely depend on the discretion of duty officers and managers. In many cases, decision-making could be supported through a variety of scientific inputs, like evaluations of the effectiveness of firefighting technologies, research into the behaviour of fire, or analysis about the impact of particular strategies or choices in past fires. Taken together, these different methods of learning and knowing – including lab-based science, field trials, and social science – create a rich epistemic landscape that has the potential to underpin real-world decision-making for fire managers in Canada and beyond. Yet, as I will explore in this chapter, there are also many disconnects between these research efforts and end-user practice, which is often shaped by the emergence of new technologies, experiments with new approaches, and a multiplicity of different actors involved with their own aims, priorities, and histories. Questions that seem simple at first glance turn out to be very difficult to research in systematized and rigorous ways. And, significant work remains to be done in evaluating whether these lessons are actually learned and used to improve practice on the ground.

Take, for instance, one seemingly straightforward question: when dropped, how much water actually makes it from the aircraft to where it's needed on the fireline? This was the exact question being examined during my time visiting one of the Ontario Wildfire program's Fire Management Centres in Dryden. There, a large team of researchers were collaborating to test the potential effectiveness of different aircraft, payloads, and drop styles for slowing the advance of a fire.

Imagine taking a large bottle of water and emptying it onto the ground below. The result would be pretty straightforward: almost all of the water (less the tiny residual amount being held to the inside of the bottle by surface tension) would end up in a puddle on the floor, radiating outwards from directly below where it was dropped. Now, make this a little more like the actual fire situation. Instead of dropping the water from a stationary position, dump it instead while walking forwards, adding the momentum that would be in play from a tanker in flight. Then, add wind to the equation, blowing the water as it falls – and multiply that effect over several hundred feet. Next, try the experiment over different kinds of trees, some of which have heavy leaves closely packed and prevent the water from "punching through" to the ground below, while others have only small needles and spindly branches that offer little resistance. Finally, begin to vary the 'what' and 'how' of the drop: change the speed at which the water bottle is poured (simulating how many of the four drop doors are opened on a CL-415 simultaneously), or mix in a little soap to the water to simulate the foam that can be added at several different concentrations onboard the aircraft.

Each of these different choices varies the result tremendously. Air attack officers and pilots alike must decide which aircraft is most suited to the task and how it ought to be implemented. Yet, conducting research to validate and support these choices is a highly complex endeavour. Aircraft and their pilots must be wrangled from their bases, the costs of their flying time accounted for, the staff on the ground dedicated to the task, and elaborate experiments designed and set up. In this case, three different jurisdictions were involved: Ontario as the host and provider of several aircraft types; Manitoba to provide CL-215s (which Ontario no longer owns); and the Canadian Forest Service to support the project through research staff. "What we're trying to do," Josh Johnston, one of these Canadian Forest Service researchers, explained to the local newspaper, "is get a better understanding of the different ways that different types of water-bombers drop. How is the water hitting the ground? What pattern is it forming and how much water is in each part of it? We're also looking at how long it takes for that water to evaporate. The idea is to get an understanding of the best way to use each individual water bomber to get cost effectiveness out of drops."

The test, of course, was much more complicated than dropping water from a bottle onto the floor. In conjunction with a private firm, FP Innovations, Alberta and British Columbia had previously done some observational work with drop analysis, but those projects didn't provide the kind of standardized, quantified detail needed to compare different air tankers and drop settings in a controlled manner. In the Ontario version of the test, several kinds of quantified data were collected. First was the conventional approach: a grid was placed across the field with upright cups anchored at fixed spacing. The amount of water in each cup had to be painstakingly noted and emptied, providing a granular representation of where the water was dropped. This was combined with two other methods, humidity sensors and moisture analysis of the moss, to offer comparisons with the cup data. Finally, a more technologically advanced method was also used – an infrared camera, capable of measuring temperatures to a thousandth of a degree Celsius, was mounted at the top of a tower to determine how much cooling effect the water created. Then, after completing the test over a field, the entire procedure was repeated in a forest, testing just how much the tree canopy affected the results.

Making matters even more challenging, the test was difficult to keep stable. Perhaps the biggest source of variance was from the pilots themselves. Each aircraft had to be flown at a consistent height and speed, while being kept perfectly in line with the test zone amid the buffeting low-level winds. And, the release – which is manually controlled – had to be timed at the exact right moment to drop the payload from the same position in each test. There was also an unknown variable: there wasn't a clear sense of whether earlier drops would damage the leaves and branches in the tree canopy, making it easier for the water in subsequent tests to make it to the ground.

This kind of muddled, complex, and logistically difficult work is emblematic of the long history of fire research in Canada. In its strongest form, wildfire research aims to inform management decisions: to provide guidance to agencies on how to prepare and respond; to evaluate practices used in the field to improve their execution; and to offer a hope of grappling with the intractable questions surrounding fire (like how to allow fire to exist for ecological benefits with deleterious effects to human communities, or how to forecast an unpredictable future to allow for 'ideal' management). Yet, these grand ambitions mean that fire research also exemplifies some of the most challenging problems in linking research with decision-making: gaps between user needs and researcher interests, a shift towards more feasible projects, and a techno-centric and model-centric approach.

To this point in the book, I've explored the ways in which fire management agencies know: how they know about the fires they face, how they translate those observations into response, and how they endeavour to predict the future. These knowledge systems translate real-time knowledge into action through procedures and practices, learning about conditions on the ground and attempting to act as a result. Yet, there's another, more abstract kind of learning involved: producing new insights, methods, procedures, and evaluations to underpin that response, like data about the effectiveness of different air tankers in different settings. This research takes on many forms, each attempting to grapple (to various degrees) with the challenge of producing knowledge that actually helps solve an incredibly complex problem. Each form has its own strengths, limitations, and heritage, with tensions between the perceived legitimacy of different research methods and data sources.

Broadly speaking, fire research breaks down into five categories. The first is research on historical fires and baselines, which is largely conducted through sampling of tree ring data (dendrochronology) and various kinds of core data (like carbon and ash that has settled). This work aims to identify when historical fires occurred and how large and intense they were. The second kind of research lays at the intersection of ecology and fire regimes, exploring the relationship between different species of plants and animals, ecosystems, and fire. Like the historical research, this work also requires being out in the field to observe animals and ecosystems, as well as pre- and post-fire changes. Both can be used towards management ends – such as establishing historical baselines upon which to base 'natural fire regimes' as fire is restored to the landscape, or to establish the kinds of fires that can be used to support certain ecological ends (like helping to protect a particular kind of animal or plant).

The final three other kinds of research, however, are of particular interest for their more direct influences on fire management. The third – human factors research – is largely notable for its absence, at least in Canada. In the case of many other kinds of emergency-based or high-risk tasks (such as physicians or nurses in hospitals, pilots in commercial or military aircraft, or operators of power or industrial plants), significant effort has been dedicated to understanding human factors in causing or preventing accidents. However, with the exception of a significant body of work by Dr. David Martell under the umbrella of Operational Research, and periodic efforts to examine whether citizens comply with fire bans, fire warnings, and FireSmart programs (largely conducted by a team at the University of Saskatchewan), there has been remarkably little work done in this space. Two other kinds of research remain: research about fire behaviour, including fire weather and smoke spread, as well as research about the actual decisions made and practices during fire responses.

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Despite sharing a border, Canadians and Americans have taken very distinct approaches to modeling fire behaviour and fire weather. The American experience was built on a resurgent view of what science could achieve, born of the Second World War and the atomic bomb. This fever for fundamental data drove "American fire science," in the view of
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Stephen Pyne, "…to erect itself on the first-principle hard pilings of physics, chemistry, and math," buoyed by military and civil defence interest and money.[188] American fire scientists, for instance, broke fuel types up into convenient logarithmic categories – fuels that could dry in one hour, ten hours, one hundred hours, and one thousand hours – allowing laboratory-style science to guide the research enterprise.

By contrast, the Canadian blessing and curse was the scale of the boreal. The forested tracts of land were massive, as were the fires. The Canadian Forest Service had been endowed with portions of this land, such as the Petawawa Research Experimentation Station in Ontario – land upon which they could conduct research and, in particular, light up experimental fires. With a research program beginning in the 1920s, by 1956 the Department of Forestry (which would later become the Canadian Forest Service) had already conducted some 14,000 test fires. These tests – largely at the impetus of Jim Wright and Herb Beall – laid the groundwork for a particular kind of scientific approach to wildfire. Before their work, "the cold fact was that forestry had repeatedly failed to render fire into a robust science."[189] Given his disciplinary training, Wright brought:

> "the imagination of an engineer, the mind of someone who could identify the critical quantitative features, who could devise instruments to measure those components, who could factor those data into a mathematical model, who could approach the question of what kind of conditions yielded what kind of fire as he would the question of erecting a bridge or digging a canal. The need was to define fire as a

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188 Pyne, *Awful Spleandor: A Fire History of Canada*, p. 339.

189 Pyne, *Awful Splendor: A Fire History of Canada*, 269.

> phenomenological puzzle to be solved, not an enemy to be fought, an engineering problem to be broken down into researchable units."[190]

The work of Wright and Beall had the effect of transforming the problem of understanding fire behaviour from something random and unpredictable into a quantifiable science. In this paradigm, fire occurrence wasn't to be seen as a spontaneous outbreak, but rather dictated by environmental properties:

> "the moisture content of a fuel determines its behaviour in the presence of a potential source of ignition, and if the weather factors which influence this moisture content can be isolated and measured, it should be possible to determine the inflammability of the fuel under given weather conditions; in other words, to build up a chart from day to day showing the cumulative effect of the weather upon the fire hazard."[191]

The end goal in this system was to translate these field-driven, experimental measurements into practical handbooks that documented fire behaviour. But, the commitment was firm: in Wright and Beall's perspectives, in the investment in Petawawa and other research stations, and in the attitudes of successors in the field, this data needed to come from real-world experiments rather than modeling laboratory results. One such successor, Charlie van Wagner, went so far as to pronounce that "the answers to predicting fuel moisture and fire behaviour would never be found in expensive laboratories or through

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[190] Pyne, *Awful Splendor: A Fire History of Canada*, 269.

[191] Wright, Frost, and Kilpatrick, "Influence of Weather," 40.

sophisticated complex maths and physics."[192] A momentum emerged: fundamental research was done through field trials, grounded in actual test conditions and real fire in real forest.

There are two ways of understanding this institution- and nation-wide commitment to field trials. One is to see it as an extension of Canadian identity, as argued by Stephen Pyne. "The issue was not simply the lab versus the field, or physical models versus empirical ones; it had to do with differing cultural contexts," Pyne argues.[193] In his view, Canadian literature reveals a national psyche of survival, endurance, and nature as powerful and threatening.[194] Fire and weather, then, can be measured and understood, but fundamentally remain forces beyond human control. Fire agencies evolved not to "alter [these] fundamental conditions," but rather to "resist or rebound from the forecasted blows." The land allowed space to execute these burns, but was also home to the forces that were larger than human control. This stood in contrast to a highly interventionist American ideal, believing in its core in an ability to influence outside forces like the weather. In other words,

> "The best Canadians could do was to predict events over which they had scant control; Americans assumed they could influence those outside forces. The world existed to be shaped. The two solitudes of fire science, as encoded into national fire-danger rating systems, thus conveyed not only two distinctive national traditions of

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[192] Van Wagner, "Forest Fire Research in the Canadian Forestry Service," 17.

[193] Pyne, *Awful Splendor: A Fire History of Canada*, 342.

[194] Pyne's language is a little more pointed, with Canadians as metaphorical "frightened creatures" versus "nature the monster." The point holds, however, without needing to appeal to this interpretation: in consistent words of duty officers and fire managers across the country, it was much more of a "humility," "respect," and "appreciation" for the power of fire and its inability to be controlled. See, again, language around 'bringing the fire to the right place at the right time rather than fighting it,' for instance.

research but also two very different national understandings of how cultures and their intellectuals related to their surroundings."[195]

The other view is a more epistemic claim: that data from real-world trials is simply more accurate than extrapolating from laboratory experiments. It's a perspective shared by many of the older guard of the fire research community in Canada, who collectively established a strong disciplinary culture of experiment-centric approaches to research. At the very least, for instance, extrapolations should be validated in real-world experimental burns to determine whether they validly represent actual fire behaviour. It isn't enough to simply burn sample materials in a lab and to assume that they will behave the same in a forest, this view suggests. The Canadian commitment, then, is a marriage of an epistemic commitment to certain kinds of data, a landscape that has offered the space to actually conduct these trials, and a Canadian Forest Service that, until somewhere between the 1980s and 2001, had an appetite, the skill, and the resources to carry out these real experiments.

These kinds of field burns are hardly a simple task, however. Much like the air tanker trials at Dryden, there are a number of variables that need to be managed. The fundamental task is to test how different kinds of fuels burn: a particular species of pine tree (say jack pine), for instance. The burns must also be conducted across several different weather conditions (humidity, wind speed, and temperature as the key factors), in each case testing to see how quickly and intensely the fire spreads. This means creating a number of plots of the same kind of fuel type and then undertaking an immense waiting game: waiting for each combination of weather factors to occur and burning one plot under each condition. Burn a

[195] Pyne, *Awful Splendor: A Fire History of Canada*, 342.

plot at twenty degrees Celsius and twenty percent humidity, then wait – for days, weeks, or even years - until twenty degrees Celsius and ten percent humidity arrives. But, jack pine burns differently when it's one year old than at five, ten, twenty, or fifty years old, so more trials are needed. And, it burns differently when it's been toppled en masse by a downdraft, or when a pest or disease has killed it off. Hence the need for large numbers of experiments – each case must be validated in the real world, with all of the logistical complexity that ensues.[196]

The last major experimental burn in collaboration with the Canadian Forest Service, however, took place almost two decades ago. Called the International Crown Fire Modeling Experiment, this field trial ran from 1995 to 2001 in the Northwest Territories. The project was originally convened to test and validate a model of crown fire behaviour, but rapidly expanded to include a host of other research ambitions. American researchers, for instance, used it as an opportunity to test firefighter shelters under actual crown fire conditions.[197]

The Crown Fire Modeling Experiment illustrates the sheer magnitude of logistical challenges involved in this kind of research. The site to be used for the experiment was selected in 1994, with 1995 and 1996 dedicated to setting up the plots and conducting pre-fire sampling. Even setting up the plots is a difficult task: control lines must be established to reliably stop the fire at the edge of the plot, as well as to gain access for instrumentation and

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[196] As much as the field trials offered a step towards a more direct representation of nature, they too were bounded by the same kind of modeling limitations discussed in Chapter Six. Testing fire in the field also requires a reductionist model, wherein only so many variables can be examined. These trials remained a simplification, wherein certain attributes needed to be prioritized for testing while others (like slope or age of stand, for instance) were left for managers to integrate on their own.

[197] Putnam and Butler, "Evaluating Fire Shelter Performance in Experimental Crown Fires," 1600-1615.

observation. In 1997, burning began with three fires in June and July. The next year saw only two fires, with another six in 1999 and seven in 2000, for a total of 18 experimental burns. Carrying out these burns required over 100 participants representing 30 different agencies, with collaborators from a total of 14 different countries.[198] All told, at least twenty different scientific publications resulted from data from the fire, and the observations were used to calibrate fire behaviour models for crown fire behaviour in Canada and beyond.

The cost and logistical difficulties of these kinds of burns, however, are not the only challenge associated with experimental fires. Much like with prescribed burning, the potential for escape fires is an ever-present possibility. These escapes have been exceptionally rare but are often poignant touchstones that disproportionately affect agency appetite for conducting this kind of research. One particularly notable escape occurred in 1982 in the Northwest Territories. In this case, the Canadian Forest Service and then Indian and Northern Affairs Canada were collaborating on burns to test fire spread in black spruce. From June 27 to July 7, nine burns were conducted without any problems. The final burn, however, escaped its plot under intense wind conditions, with spotting 100 meters in advance of the fire and eventually spreading to 1430 hectares before it was extinguished 19 days later.[199]

Inherent to conducting these burns, as one of the lead researchers from both the Crown Fire Modeling Experiment and the Porter Lake fire explained to me thirty-five years later, are three trade-offs. First, experimental burns have "little value" if they are conducted

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198 Alexander and Stocks, "The International Crown Fire Modelling Experiment."

199 Flannigan and Harrington, "Synoptic Weather Conditions During the Porter Lake Experimental Fire Project."

only at the absolutely safe ranges of weather conditions. Their entire purpose is to document fire behaviour under a range of conditions – especially those that cause aggressive fire behaviour – to allow for better fire prediction and, therefore, community and firefighter safety. A conservative burning regime, therefore, misses the key data: experimental fires must be conducted under extreme ranges. Second, the weather conditions that are amenable to testing this part of the range mean that fires are likely occurring elsewhere in the province. In essence, experimenting on the upper end of fire behaviour means that the experiments must be done while there is fire already on the landscape – raising significant questions from the public and politicians about why additional fires are being started when resources are already in demand. Finally, while it would be appealing to use naturally occurring fires as an opportunity to collect the data without having to light new ones, the volume of baseline data and instrumentation required means that the data off unintended fires is nowhere near as rich as the data collected during an experimental setup.

In sum, Canadian fire behaviour modeling is grounded in this real world experimental data. In turn, this has informed many generations of tools that are used in every fire operation to keep firefighters and the public safe, including the Canadian Forest Fire Danger Rating System and the Fire Weather Index. This data needs to be renewed to keep up with new fuel types (such as blowdown and pest damage) and to examine whether FireSmart-like treatments have any significant effect. But, the very nature of experimental fire makes it remarkably difficult to sell politically.

This combination of factors has largely led to the Canadian Forest Service ceasing to conduct this kind of research. The Petawawa Research Centre no longer exists, nor is there much appetite for this kind of expensive, risky work. This is partially driven by an increasing focus on computational modeling of fire based on existing data. It's also, however, driven by the reality of timelines in an increasingly high-paced government landscape. The current research review being conducted at the Canadian Forest Service, for instance, uses five years as its longest-term time horizon for research projects. A suite of experimental burns are remarkable if they only take five years to complete, let alone an additional several years to plan and analyze. This timescale problem presents a fundamental incommensurability: government pressures make it difficult for the Forest Service to organize research on the kinds of timescales necessary to conceptualize this kind of work, let alone carry it out.

There are, to be fair, a few glimmers of hope for future experimental research. In the summer of 2017, for instance, the province of Nova Scotia and Parks Canada collaborated to conduct a series of test burns in the Cape Breton Highlands. Even a small-scale project like this (focused on relatively small plots of a mid-size shrub landscape that is not currently included in the Red Book) required significant investment from both agencies in terms of firefighters, research staff, and even a helicopter to keep possible escape fires in check. But, it offers a hint of possibility that trusted relationships can be built to support this kind of work going forward.[200]

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[200] Taylor, Pike, and Alexander, *Field Guide to the Canadian Forest Fire Behaviour Prediction System*. This is colloquially known as the "Red Book" by fire managers, which contains tables about how fire is predicted to behave in different field situations. It serves as a bible of sorts for these managers, often being used as a quick reference in fire operations.

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Even experimental burns, however, exist in something of a vacuum; a research exercise that is divorced from real-world firefighting by time and space. As much as research can help provide a stronger theoretical basis for firefighting, it's the implementation that really matters. Do these forms of scientific knowledge actually influence decision-making on the ground? Were reasonable decisions made, and what were their outcomes? How could the situation be handled more effectively if it were to occur again? This requires a particular kind of reconstructive or forensic research. The aim is for an agency to, in essence, reflect upon what worked well and what needs improvement.

These questions represent a fundamentally different kind of research than the experimental burns we've discussed to this point. Although experimental burns are not purely "basic research" (they have applied dimensions given their direct link to informing operational decision-making via handbooks and models), they hold a place within a scientific enterprise that is divorced from management. The work is conducted by scientists and then ported into management through artefacts like the Red Book. It is, in essence, a loading-dock form of science – the research enterprise generates the numbers, drops them off for managers to use as they fit, and then largely disconnect.[201] Sometimes this research is implemented in a way that changes practices, sometimes it cannot compete with established heuristics, and sometimes it is simply never noticed, picked up, or connected.

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201 Sarewitz and Pielke Jr., "The Neglected Heart of Science Policy: Reconciling Supply of and Demand For Science," 6.
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The second set of questions here – about management practices, outcomes, and adaptation – represents a different flavour of epistemic inquiry. These questions attempt to learn by doing, rather than learning through formalized experiments. It introduces challenges – variables cannot be isolated in the same way, single examples cannot be taken as representative of broader patterns, interpretation changes dramatically in hindsight, and multiple interpretations regularly exist and compete. And, it's no more guaranteed to actually affect practice than the previous form of inquiry – these lessons can just as easily go ignored and unlearned.

There are two broad approaches to conducting this kind of institutional learning. One is to have real-time observation of agency and decision-making processes, including both forensic documentation of key materials (such as transcriptions of phone calls and meetings, or records of email chains) and observation by arms-length analysts. Their role is to observe, document, question, and assess the ways that the agency produces knowledge, validates what they believe is true, act upon this information, and respond to changing conditions and lessons learned. While this style of evaluation provides a more thorough access to the actual decisions made and rationales for each, it is rarely, if ever, practiced in wildfire management in Canada.[202]

The more common approach is through the use of post-incident reviews. These so-called 'After Action Reviews' or 'After Action Reports' (more commonly referred to as

[202] The one exception to this might be the occasional participation of academics, like David Martell, on Incident Management Teams. Serving a formal role within the ICS structure provides a high degree of access to real-time decision-making, although the participant-observer role removes some of the arms-length independence. It also reduces the ability to be focused on documentation, review, and analysis, given the full-time responsibilities of serving on the team itself.

AARs among fire managers) provide a formal process through which the response to and management of fires can be assessed once the emergency has been completed. They can have several different focuses, from broad evaluations of the entire incident management by all agencies involved, to an issue as focused as reconstructing the exact weather conditions during a fire blow up. The term is also used to refer to a wide range of activities, from some agencies that use them to describe short and informal reviews after all fires of note, to other organizations that reserve the term for only large reviews after abnormally significant fires.

The idea of an 'After Action Review' is surprisingly recent. The term itself first saw use in the United States Armed Forces in the mid-1970s, when the Army Research Institute began to use AARs in the context of training programs. Prior to that point, reflection on incidents had largely occurred through either "interviews after combat" or performance critiques. Interviews after combat were pioneered during the Second World War by S. L. A. Marshall, a journalist turned military historian who was frustrated by difficulties in reconstructing battles from limited official reports.[203] In the context of training, debriefing was generally done through a form of "Performance Critique" that saw a senior military leader in the role of an 'umpire,' offering a seemingly-objective verdict on what would have happened in the exercise and often admonishing failures in what had been done by the soldiers. The shift to AARs in the 1970s, therefore, was largely to create a format of review that was more scalable than Marshall's interviews, but that avoided the traps of the performance critiques. Performance critiques were largely performative, lecturing to soldiers who were expected to passively listen and accept admonishment about shortcomings.

[203] Morrison and Meliza, "Foundations of the After Action Review Process."

Instead, AARs were meant to rely on participation from all involved to create an accurate sequence of events and to open discussion about possible improvements. Through the 1970s and 1980s, these reviews became part of other high-risk industries, as well as incident management and disaster response, often being linked to their roles in establishing a 'safety culture' within the larger organization.[204]

This explicit emphasis on constructing a narrative of events is interesting. It differentiates the AAR from other kinds of reviews, placing it much more strongly in the tradition of the Marshall interviews that sought to establish the facts about what happened during an operation, rather than taking a single reported narrative as gospel. Although modern AARs benefit from a much more detailed set of evidence available about how events unfolded – including radio and telephone recordings, time stamped entries by dispatchers, and a massive amount of photographic and video evidence from responders and citizens alike – it highlights the degree to which an AAR is a curatorial exercise of establishing an accepted narrative about how things happened.[205] It's an inherent tension of the format: as much as an AAR is meant to be a blame-free, learning-oriented exercise, there are also very real dimensions of institutional risk involved with admitting errors or fault. There are distinct trade-offs between both the need for and the public right to transparency (in terms of sharing between agencies and the responsibility of government services to be

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[204] Allen, Baran, and Scott, "After-action Reviews: A Venue for the Promotion of Safety Climate."

[205] This can result in conflicts, for instance, between different constructions. Between the after action reviews of the Horse River Fires, there are conflicting accounts of when exactly the two fires described in Chapter One began.

examinable by the public, respectively) versus the caution of exercising control over what is presented and how.[206]

In Canadian wildfire, the emergence of AARs came through a relatively smooth evolution. Although the term itself was an artefact of 1970s America, since early in the twentieth century, fire agencies had been producing annual reports each fire season. These reports documented fire sizes and behaviours, as well as the response decisions that were made. By midway through the century, the Canadian Forest Service was producing post-fire incident reports on fire behaviour and fire weather. As such, the shift to conducting after action reviews was a gradual evolution from more top-down reporting to the bottom-up, engagement-styled AAR approach.

To understand the role of After Action Reviews, it's helpful to focus on one province. Prior to the Horse River Fire, Alberta had conducted several major wildfire AARs, each of which followed particularly notable fire years (see Table 1). Some of these reports were produced by an external auditing agency (the 2015 and 2016 reviews were both conducted by the company MNP), while others were produced by a committee of fire experts from both within and beyond the agency in question.

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[206] Agencies also differ substantially in how much they release these reports. Alberta Wildfire, for instance, makes their major reviews publicly available post fire, while other jurisdictions are remise to even share them with researchers.

Table 1
Significant wildfire reviews since 1998 in Alberta.

Year	Fire	Consequence	Reviews
1998	Entire Season	>700,000 hectares burnt; 86% above average number of fires	Program Review[207]
2001	Chisholm	>115,000 hectare fire; ~1/3 seasonal suppression budget spent on single fire	Chisholm Fire Review[208]
2011	Flat Top Complex	189 fires in several days; 500 structures lost in Slave Lake, Alberta	Overall Review[209]; Operations Review[210]; Fire Science Review[211]
2015	Entire Season	>490,000 hectares burnt; 1,786 fires	Summary[212]; Detailed[213]
2016	Horse River	>88,000 evacuated; ~590,000 hectares burnt; >2,400 structures lost	Fire Review[214] and provincial reviews.

[207] Nash et al., "Alberta Fire Review '98."

[208] Chisholm Fire Review Committee, "Final Report."

[209] Flat Top Complex Wildfire Review Committee, "Final Report."

[210] Wildfire Operations Documentation Group, "Flat Top Complex Final Report."

[211] Wildfire Operations Science Group, "Flat Top Complex Final Report."

[212] MNP, "2015 Fire Season Summary."

[213] MNP, "2015 Fire Season Detailed Report."

[214] MNP, "A Review of the 2016 Horse River Wildfire."

Unlike many jurisdictions, Alberta is quite unique in how open they are about sharing the reviews of major fires publically. Large fires in the past twenty years have generated nine different reviews, each of which are available for public review. Of course, a much larger number of reviews are produced in a multitude of other situations – after smaller fires, following particular incidents in the field, or to examine a specific aspect of the program (like aviation operations or communications) – that are not published externally. But, the commitment to transparency and knowledge sharing is admirable, and close examination – like what follows – should be understood with that in mind.

Reviews tend to follow something of a similar pattern. After an executive summary, they establish the seasonal context that led up to the fires, discuss the particular sequence of events that took place, and then focus on different aspects of the response and operations. Yet, the particular sections vary a great deal. Some reviews emphasize the weather and fire behaviour, while others provide more detail on the community, industrial, and responder dimensions of the fire. Although this variation sometimes reflects the addition of new areas of research or advances in science, the disparity in formats can reduce the comparability of the reports.

The bread and butter of AARs, however, is more than just the documentation that they provide. A key feature is the providing of specific recommendations about what can be changed in wildfire preparedness, response, and management for future events. These recommendations, however, vary even more than the format of the reports overall. The 1998 fire report, for instance, includes fifty-four recommendations about changes that should be made to the program. The next review in 2001, by contrast, offers only five. And, in 2015, advice is split into two separate categories of recommendations (largely framed as deficiencies that need correction) and opportunities for improvement (which are articulated as places where there isn't an existing problem, but performance could be increased).

These vastly different styles of comparison highlight a link between quality and quantity. Instead of being a trade-off between the two, however, there is a positive correlation. In general, in reports where more recommendations are made, the recommendations are more focused, specific, and actionable than where only a few recommendations are offered that are highly generalized. A recommendation from the 1998 report, for instance, speaks to the problem of early season fires by advocating that the province "schedule completion of all fire line courses before April 15 each year." By contrast, in 2001, much more general advice is offered as one of the five recommendations: "During existing and anticipated extreme fire behaviour conditions, SRD should use other strategies in addition to resource build-up to reduce the occurrence, or impact of large fires." While more context is provided in the report to support this recommendation and potentially identify specific themes, it is not represented in the high-level recommendations made.

This variation makes it difficult to determine whether new lessons are being learned, or whether the same lessons are being repeated. There are, for instance, consistent themes that emerge in the reviews. In all but the 2016 review, multiple recommendations focused on the theme of communications. In 1998, in addition to a five-recommendation section explicitly on communication practices, three other recommendations addressed inter-jurisdictional and inter-cultural communication with Aboriginal communities. Yet, because the recommendations vary significantly between the general and the specific, it's hard to compare like with like.

One way to more effectively examine whether recommendations are being implemented is to consider whether a more standardized format of after action reviews could be developed. Something as simple as a common ordering of reviews could help to make it easier to compare fire situations, and to track whether lessons learned from previous reviews have actually changed practices.[215] A similar format could also be applied to recommendations, with a set of themes providing guidance to help order a larger number of more specific, more actionable lessons. Even with these challenges, however, after action reviews are already an important part of institutional learning in wildfire management.

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Each of these forms of institutional learning offers opportunities to improve fire management across Canada. Research into fire behaviour in particular has been a remarkable strength for the country, feeding modeling products and on-the-ground advising that allows for the safer and more informed management of fire. The work done by the Canadian Forest Service, in collaboration with provincial, territorial, and international counterparts is world-class and must continue to be supported. In particular, this involves a federal government that is willing to see research on a longer timescale than a political term of four

[215] One approach, for instance, could be mandating either an annual evaluation of whether lessons learned have been implemented, or requiring subsequent reviews of major incidents to evaluate whether previous lessons were adequately implemented.
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or five years. Experimental fire projects need to be conceived on a roughly decadal timescale, and need to be part of strategic research plans (such as updating the Fire Danger or Fire Weather indices) that span several decades.

Another major problem is the abdication of social science research on fire. While the Canadian government, particularly through the Canadian Forest Service, has done a strong job of funding natural science and engineering research on fire science, commensurate investments on the social sciences (including human dimensions, policy, and sociological research) have not been made. Even more troubling is the lack of personnel and projects within the CFS dedicated to this kind of work. The federal government must do more to support it, while social scientists share the burden of demonstrating how their research can contribute positively to improved management outcomes.

One confusing part of this problem is that in the void of CFS leadership on social science, policy, and operational research, CIFFC has largely become the venue for exchange. Because of its working group structure, agencies have taken to sharing their practices through the appropriately themed committee. Yet, CIFFC is explicitly not a research organization: it does not have the mandate, the staffing, or the experience to identify research gaps, pursue their exploration, or even to help catalyze research driven by other partners. It plays a vital role in sharing results that are developed by member agencies, but cannot guide this research itself. This is a major gap that needs addressing, either through a substantive increase in CFS research on social and behavioural dimensions, or through the establishment of an academic research institute dedicated to that work.[216]

This problem is ever more crucial to address given a perpetually changing fire landscape. As we are about to explore, humans are changing a multitude of different aspects of the world. The largest system, of course, is that of the climate, but it also exists alongside other cultural, political, economic, and attitudinal changes. Without a strong social and behavioural research agenda on wildfire, communities will be even more vulnerable to these massive changes.

[216] The Western Fire Science Partnership could serve as a model for this. Based largely on the University of Alberta's strong work in fire science, it has established a major research enterprise on fire ecology and fire behavior. An equivalent centre on the social and behavioral aspects of wildfire would go a great distance to filling this gap, so long as it was supported through a variety of funding sources.

8. Climate Change(s)

Although the massive simultaneous fire starts of 2017 rolled through British Columbia in early July, the landscape was still covered in fire by late August. Resources from across Canada – firefighters, hose, aircraft, and equipment – were continuing to be used in the suppression effort, as were international allies from Australia, New Zealand, Mexico, and America. On August 30th, crews were still dealing with 142 fires on the landscape, including eight different fires of note. Six of these fires each had over two hundred firefighters assigned, and another which had blown in from across the border with Montana. Three of the fires each spanned more than 200,000 hectares. Yet, it was a new fire – one of nine started that day – that defined the end of the 2017 season.

That fire began near the Canadian-American border in the southwest of the province. Akamina-Kishnina Provincial Park is located at the corner of three jurisdictions: Montana, British Columbia, and Alberta. On August 30th, a previous lightning strike emerged as a fire, which totalled roughly five hectares when it was spotted.[217] For the next three days, it burned within the park, creeping east with the prevailing winds. Snaking through mountain valleys and around peaks, on September 3rd it reached the western edge of Waterton National Park in Alberta, burning actively in the Sage and South Kootenay Passes.

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[217] Parks Canada, "Kenow Fire Informational Updates." Chronology in this chapter developed from these informational updates, as well as a variety of local media reports.

Waterton National Park is one of the jewels of the Canadian national park system. Located four hours south of Banff and two-and-a-half south of Calgary, the park is something of a refuge from the tourist meccas of Jasper, Lake Louise, and Banff National Parks. Waterton is defined by its sharp Rocky Mountain peaks and long finger lake (see Figure 12), as well as by a town site located within the park and home to approximately 100 year-round residents. The town is accessed by a single highway that runs to the northeast through a relatively narrow gap between the summits, spilling out into agricultural plains (Figure 14) with plentiful ranches and farms. It's also a personally significant park: several portions of this book were conceived while hiking its trails and dodging wildlife ranging from ticks to mountain goats, and I had visited the park in June of 2017 just prior to setting out for CIFFC in Manitoba.

Figure 12
Looking south from Mount Crandell in Waterton National Park on June 3rd, 2017, with the town site peeking through between rocks in the foreground.

By its arrival at the park's westernmost passes several days after it started, the fire had grown to roughly 4,000 hectares. Because of the incredible strain on firefighting resources in British Columbia, Parks Canada had begun to prepare to manage the fire even in advance of its arrival in the park. Just as provinces have border zone agreements, Parks also maintains such arrangements with the jurisdictions outside of its holdings. Even before the fire had hit this official border zone line, Parks Canada had staffed an Incident Management Team for the fire and was in close communication with counterparts in British Columbia.

By September 4th, Parks Canada had deployed three of its initial attack crews and five helicopters to the fire. The fire had spread half a hectare into the park, which crews held effectively through a combination of work on the ground and helicopter bucketing from above. Several closures throughout the park were put into effect, reducing front and backcountry tourist traffic on the trails and roadways closest to the fire's potential path. The next day, an evacuation alert was issued to increase awareness and preparedness among possible visitors and town residents.

The resource build-up within the Parks Canada operation was impressive – especially for a fire that only totalled half a hectare within its jurisdiction. Not only had Parks Canada brought in several initial attack crews and helicopters to deal with the fire itself, but staff had also been tasked with preparing the town site for a possible fire to move through. Five different urban fire departments, including a ladder truck and over 50 firefighters from the City of Calgary, were brought into the Park to provide structural protection. Particularly treasured was the Prince of Wales hotel, a historic building from the 1920s perched overlooking the main lake. Parks staff also conducted a massive exercise of setting up sprinkler and pump infrastructure, both to protect individual buildings (see Figure 13), but also to create a thoroughly soaked barrier around the town site. Also notable was the decision to move into a unified incident command structure with Alberta Wildfire in advance of any major run into the park or province. Yet, for almost a week, this massive build up was all because of a fire that had, in all that time, still burnt only half a hectare in the park.

Figure 13
A Parks Canada fire crew testing the sprinkler system at Crandell Theatre, in advance of the arrival of the Kenow Fire.[218]

The 2017 fire season had been remarkable, but by September, snow and rain tend to bring relief to the mountains. This year was no exception, with a devilish forecast for the days ahead. A cold front was set to pass, bringing high winds through the mountain passes of a park that is infamous for its regular gusts. Yet, only a few days out was the promise of rain and snow that would quench the fire for good. There had been days of build up and

218 Parks Canada, "Kenow Fire: Photo Gallery." This photo is used for educational purposes under the terms laid out by Parks Canada, and is a reproduction of an image available on their website.

preparation, and the Parks crews had been able hold the fire at several different mountain passes. As one of the incident management team members later recounted, however, 'we were just buying time; the rain was coming just a couple of days later.'

An evacuation for non-essential personnel was ordered at 1:15pm the afternoon of September 8th, and was completed within six hours. This helped to keep the population safe and reduce unnecessary traffic within the park. It also, however, made the firefight a little more complicated. With only incident personnel left, it complicated things in terms of managing the incident, because the hotel, restaurant, and shop owners that had been supporting the fire crews were required to leave as well. On September 10th, the fire took a run into the park of about 5 kilometers through the Akamina Valley, with several spot fires started ahead.

Then, on the night of September 11th to September 12th, it made a run. With so much smoke in the valley, it was difficult to know exactly where the fire was. A 'trigger point' had been identified west of the site for the evacuation of all but essential fire staff from the town, but the fire spotted past that line by late evening, resulting in an expedient evacuation. Normally fires die down overnight, calmed by the increase in humidity, falling temperatures, and gentler winds. In Waterton, however, a calm night was not in the cards. Winds gusted up to 100 kilometers per hour.

Between sunset and sunrise, the fire took a fifteen-kilometer run, passing straight through the park and roughly eight kilometers into the municipal district on the other side (pictured in Figure 14). At 10:15pm, an evacuation alert was issued in the Municipal District of Pincher Creek. It took only twelve minutes to be converted into an evacuation order.[219] (The alert notifications, by contrast, took up to seventeen minutes to reach some phones.) By sunrise, five homes outside the park were lost. "The next day," recalled one person involved in the response, "the rain came. They were short less than 24 hours."

Figure 14
Looking east from Mount Crandell, towards the agricultural plains just beyond the park.

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219 Wilson, "Questions Linger in the Aftermath of Kenow Wildfire."

A few months later, I had a chance to speak with a Parks Canada staff member about his experience during the fire. Although he was stationed outside of the park at a headquarters, the fire was a visceral experience:

"I was up all night. I was on the phone non-stop… Part of the time I was just worried about our fire personnel, to be honest, including the ones that I knew had to stay in the town site to protect the town site… The last time I talked to the [incident command] at three-something am, they had full-on ember showers in the town… Part of it was wondering if the whole town site was going to burn or whether they were going to be able to be effective. That was the night."

Those planning also had to think about the next morning. "We knew," he recalled, "that our fire personnel were going to be up all night. So, tomorrow morning, people managing this crazy thing are going to be burned out." The Parks team tracked down a cadre of incident managers from other Parks and fires who had been properly rested, and flew them to the incident command post for Waterton at first light the next morning.

What was remarkable as the sun rose, however, was how much of the Waterton town site had survived. Some of the park's buildings – including the entry station on the main highway and the maintenance compound at the base of Mount Crandell – had been lost to the fire. But, not a single home or business in the town had been lost to the fire. Even the Prince of Wales hotel, with the dry grass burnt on the hill surrounding it, had been saved by the intense efforts of firefighters to soak it over the several days leading up to the fire's arrival (Figure 15).

Figure 15
The Prince of Wales Hotel at approximately 5:45am on September 12th, with fire in the forest behind and in the grass in front.[220]

The incredible success in defending the town in Waterton, however, wasn't an accident or a stroke of good fortune. Three factors were the essential ingredients to the success. First, the decision to staff up, in advance and in great numbers, had provided enough capacity to establish strong defensive sprinkler lines around the town and to protect

[220] Parks Canada, "Kenow Fire: A Forecast for Extreme Fire Behaviour."

individual buildings, as well as to do last minute strategic fuel reductions and other preparations. Second, Waterton had become "almost a poster child for preparedness," investing an incredible amount of effort over several proceeding years into protecting the town site. At both a community and individual level, significant work had been poured into establishing fuel breaks, developing FireSmart features, and doing the leg work required to be fire ready.

Most poetically, however, had been a decision by the superintendent of the park the winter before. The superintendent had requested the fire division of Parks Canada to assist with a tabletop exercise simulating a wildfire that forced the evacuation of the town site. That winter, the exercise had been sprung on the local fire department and parks staff to test their preparedness and served as a learning opportunity several months before the actual fire entered the park.

The town of Waterton survived a powerful and fast-moving fire – running fifteen kilometers overnight, while fires are supposed to be asleep – not because of luck. Instead, Parks Canada and the community had taken time to prepare. Their preparedness was thanks to the fire risk reduction work that had been done around and throughout the community, as well as because of the managerial simulation that had taken place in advance of the actual fire. And, they were ready in the short term because they had almost a week and a half to prepare for the fire's arrival, and actually invested that time in taking the steps necessary to fortify the community. Can we – and will we – do the same for the fires of the future?

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Read an article about the future of wildfire and it's likely to be dominated by a common theme: climate change. Climate change is a profound and global force that is anticipated to play a powerful role in shaping all kinds of futures, from the location of arable lands to the rise of sea levels, and from the spread of pests to the prevalence of extreme weather. But, the literal climate isn't the only long-term change that might impact the fire of the future. There are other climates as well – the social climate, the economic climate, the political climate – that have already begun to radically change the impacts on the fire landscape.

The potential disruption, of course, that gets the most attention within casual observers of the wildfire community – and even among some within – is climate change itself. The link between a changing climate and increasing wildfires is a common refrain among many different observers. Journalists, like Ed Stuzik, the author of *Firestorm*, have argued that "As we get warmer and the forests get drier, and as we get more lightning strikes and more people in these forested landscapes, we're going to get more of these fires."[221] Activists like the Sierra Club echoed the same in their press release on the wildfires in California: "…a changing climate is likely to increase unnaturally large and more dangerous fires across the country."[222] Indeed, even some conservative politicians in Canada have acknowledged the link, including the leader of Alberta's Wildrose party, Brian Jean, in the wake of the Fort McMurray fire. "Some of the evidence," he remarked, "does suggest that

[221] Hahn, "California's Wildfires Point to a New Normal."

[222] Cramer, "Sierra Club Statement on California Wildfire."

we're moving into changing times and we are to expect more fires and more weather that is frankly unpredictable."[223] So too have academics and public servants in the research enterprise underscored the links between climate change and wildfires in tweets and statements.[224]

There are several possible pathways linking climate change and wildfires, which affect two of the components of the wildfire triangle: fuel and weather. On the fuel side, the major variables are increasing droughts, which dry out fuels making them easier to burn, and increasing pest populations (like bark beetles[225]), which kill trees, possibly rendering them more flammable than when alive and more moist. With respect to the weather, three changes are important. First, broad changes in temperature and precipitation could extend the wildfire season (such as warmer temperatures earlier in the spring and later in the fall) or result in less rain (which is crucial to extinguishing large fires and reducing the start and spread of fires through higher moisture contents). Second, an increase in lightning strikes could result in a corresponding growth in the number of fires started. Finally, increasingly unstable weather could bring with it more wind (such as dry fronts, which bring wind without much precipitation), contributing to fire spread. Making matters even more

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223 Thomson, "Alberta's Wildfire Seasons to Get Worse Thanks to Climate Change."

224 Norton, "Good Article," Twitter post; Schmidt 2018, "Forest Fire Surge May be Blamed More by Human Touch Than Changing Climates."

225 Bentz et al., "Climate Change and Bark Beetles of the Western United States and Canada: Direct and Indirect Effects."

challenging, there's a potential for feedback loops – smoke from wildfires, for instance, could increase lightning activity[226] or reduce precipitation.[227]

This creates a pair of significant questions. Just how much will wildfire increase across the country as a result of a changing climate? And, in turn, can the signature of climate change be teased apart from all of the other factors that also push towards increased and more costly fires? These are questions with policy implications, as growing numbers or sizes of fires could necessitate different management strategies, ranging from an increase in the number of firefighters to a shift towards less labour intense technologies like water bombers. It's also a question that's predicated on a commonly held assumption within the climate change debate – that documenting or 'proving' the negative consequences of climate change will help to convince people to accept climate change as real and, in turn, persuade them to take action.[228] With respect to the academic study of the relationship between climate change and wildfire in Canada, this particular framing (the forward-looking question of 'what will happen?') drives the research enterprise. A vast majority of publications on wildfire and climate change interactions in Canada are predictive, forecasting the effect that

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226 Lyons et al., "Enhanced Positive Cloud-to-Ground Lightning in Thunderstorms Ingesting Smoke from Fires."

227 Rosenfeld, "TRMM Observed First Direct Evidence of Smoke from Forest Fires Inhibiting Rainfall."

228 Hoffarth and Hodson, "Green on the Outside, Red on the Inside: Perceived Environmentalist Threat as a Factor Explaining Political Polarization of Climate Change." This belief – that if only we could get agreement on the causes, importance, or negative impacts of climate change, then people would *of course* take action on it – is a poor heuristic and predicated on a "deficit model" understanding of how scientific communication and broader societal change work. In the case of views on climate change and necessary societal action, a series of far more complicated drivers shape whether or not people believe it's important to take action.

climate change could play over the future, rather than examining whether any changes have yet happened.

Among peer-reviewed publications – many of whom share three key players in the Canadian wildfire research enterprise as authors, Mike Flannigan, Brian Wotton, and David Martell – there is almost unanimous agreement that climate change, including an increase in global mean temperatures, will result in more active fire seasons across Canada and around the world. Beginning in roughly the 1990s, these and other researchers began to use global climate models to explore the relationship between wildfire and climate. In general, these studies use some sort of correlation between weather and fire (for instance, the Fire Weather Index) to translate meteorological predictions from established climate models into impacts on fire behaviour. Of course, there's significant difference in how each of these studies quantify an 'active' fire season (such as number of fires, size of fires, or severity of fire danger), as well as variability in the kinds of data used within climate models.

Some authors for instance, focus on the meteorological components that feed into the Fire Weather Index (temperature, wind speed, precipitation, and humidity), using global climate models to predict an increase in the area under extreme fire danger.[229] Others use similar climate models, but focus on assessing the 'seasonal severity rating' as a different proxy for fire behaviour, projecting an increase of 46% in seasonal severity ratings under a doubling of carbon dioxide.[230] Yet another approach is to examine the area burnt, at scales

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[229] Stocks et al., "Climate Change and Forest Fire Potential in Russian and Canadian Boreal Forests." The increase mostly comes from areas under moderate fire danger moving into the high and extreme ranges.

[230] Flannigan and Van Wagner "Climate Change and Wildfire in Canada."

ranging from relatively small pixels up to entire ecozones.[231] More recent work has developed models predicting an actual number of fires under different climate scenarios, again showing an increase in both human- and lightning-cased fires by both 2030 and 2090.[232] Other studies have focused on geographically specific areas, like probable increases in fire load in the Yukon.[233] Taken together, these studies offer a unanimous consensus: climate change is likely to increase fire severity, occurrence, and size in Canada, supporting the arguments that appear so often.

Yet, other examples of research suggest that the relationship between climate and wildfire isn't quite as generalizable as these studies suggest. As early as 1995, for instance, some research using global climate models highlighted "the importance of large regional variability" in the impact of climate, and called "into question previous generalizations suggesting universal increases in the rate of disturbance with climate warming," such as the effect of climate change in the southeastern boreal forest because of the possibility of increased regional precipitation.[234] Other research, drawing on ensemble models, suggests that while an increase in burn rate is to be expected under increased carbon dioxide levels, because the year-to-year fire burning varies so tremendously already, "the future burn rate is

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231 Flannigan et al., "Future Area Burned in Canada."

232 Wotton, Martell, and Logan, "Climate Change and People-Caused Forest Fire Occurrence in Ontario"; Wotton, Nock, and Flannigan, "Forest Fire Occurrence and Climate Change in Canada."

233 McCoy and Burn, "Potential Alteration by Climate Change of the Forest-Fire Regime in the Boreal Forest of Central Yukon Territory."

234 Bergeron and Flannigan, "Predicting the Effects of Climate Change on Fire Frequency in the Southeastern Canadian Boreal Forest."

predicted to remain within the natural range of variability for this region of the boreal forest."[235] Research that focuses in on a particular geographical area can often discover regional abnormalities. In British Columbia, for instance, warmer temperatures are largely expected to result in wetter summers, which leads in turn to an "observed decrease in wildfire activity."[236]

One of the things all of these examples of research have in common, however, is their focus on predicting future wildfire behaviour under climate change. They all take some form of existing weather data that is correlated to fires, such as the relationship between meteorological parameters and the Fire Weather Index, and then use predicted changes in weather under different global climate models to anticipate what might happen to these fire parameters over time. Their common conclusion – that fire activity, measured in a variety of ways, is likely to increase given higher levels of carbon dioxide – through different models, assumptions, and approaches offers a confidence born of convergence. Question an assumption or replace a model, and the result is still the same: climate change is likely to increase fire activity on average across Canada, although the specific impacts for any given location are much less clear.[237]

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[235] Bergeron et al., "Will Climate Change Drive 21st Century Burn Rates in Canadian Boreal Forest Outside of its Natural Variability: Collating Global Climate Model Experiments with Sedimentary Charcoal Data."

[236] Meyn et al., "Spatial Variation of Trends in Wildfire and Summer Drought in British Columbia, Canada, 1920-2000."

[237] This relates back, of course, to the discussion of modeling in both Chapters Six and Seven. While fire managers clamor for specific models indicating exactly how their jurisdictions will be affected and when, climatological models struggle to offer this granular level of detail. Moreover, the is temporal ambiguity – multi-decadal changes in climate patterns offer very little indication of how any given fire season will play out, as indicated by the peak load prediction problem discussed in Chapter Six.

The other commonality is a focus on climate as the defining driver of changing fire regimes in Canada. While weather conditions – and therefore the prevailing climate – does have a significant impact on fire, the wildfire triangle introduced at the beginning of the book calls attention to two other key drivers: fuel and topography. Although literal changes in topography are relatively rare, changes in the topographies inhabited by humans are increasingly common as communities expand into desirable canyons, hills, and forested landscapes. More significant are the dramatic changes in fuels. The introduction of new species, ranging from the introduction of eucalyptus in California in the mid nineteenth century to the importing of new decorative species for landscaping, increases the flammability of both wildland and intermix environments. The long history of suppressing fires from forested lands builds up volatile volumes of fuel. The development of a new type of highly flammable fuels – homes, vehicles, and other infrastructure – fundamentally changes the fire environment. And, ever-changing human practices (such as the exclusion of indigenous communities, many of whom historically were very active in using fire and allowing it to spread throughout the landscape) transform core determinants of fire behaviour.

As such, it's important to reflect on the primacy that is given to climate change in considering the changing face of fire. While it is a crucial factor, it is hardly the only factor among changing fuels, landscapes, and management patterns. Moreover, it's unlikely to be as independent a variable as indicated by these researchers. It's the interactions between changes in the climate, changes in management practices, changes in settlement patterns, and changes in social priorities that will drive future fires. To consider these interactions requires exploring more about past changes in fire regimes and overall fire load, their contributing factors, and the ways in which other changing drivers could compound climate.

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The research I've introduced thus far focuses on the question of predicting how the climate will change in the future. A very different issue, however, is whether it's possible to determine whether there has already been an impact from climate change on the fire load in Canada. The question has three parts. First, is the fire load in Canada yet increasing, as would be expected under climate change? Second, what other factors contribute to these increases. Third is the question of 'attribution,' which is a comparatively contentious element of climate science. In short, it's the same question that gets asked when a particular flood, drought, heat wave, or hurricane occurs – to what extent was this particular event or particular increase caused by climate change?

As is hinted at by the variety of approaches to predicting the influence of climate change, there are also several different ways of measuring a current fire load. The two most straightforward are through total area burned and the total number of fires. There are also other options, including the economic cost of fires and firefighting, the number of lives or buildings lost, or measures of potential fire severity like danger ratings or the Fire Weather Index.

Some of these measures are very unappealing from a methodological perspective, even if they're problematically common in public discussions about climate change (among
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both media outlets[238] and peer reviewed publications[239]). The economic cost of fire, for instance, is almost entirely a measurement of two factors: increasing human exposure to fire risk and the choices we make about how much to invest in fire suppression. The total economic impact of fire (the almost nine billion dollar figure quoted for the Horse River fire, for instance) measures very little about the fire itself, and instead tells us much more about the value of the buildings, infrastructures, and human systems that we've built in flammable landscapes. The cost of firefighting is similar, measuring almost entirely a human decision about how much money we should pour into responding to fires.[240] These costs are, of course, related, as Canadian fire management agencies typically invest significantly more money into fighting those fires that threaten economically valuable assets.

Although total area burned is a tempting measure – it seems to reflect the real 'impact' of fire on the country, at least in terms of the actual scar of the fires, and provides a way of assessing the impact of weather and fuel dryness in terms of fire spread – it is highly problematic in terms of accurately representing fire. As has been discussed thus far, not all fires are managed the same. Some are further from values at risk, or take place within an area where there are pre-existing plans that seek to allow fires on the landscape, meaning that they are allowed – on the basis of a policy of management decision – to grow much larger

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238 Bello, "Climate Change Is Increasing Forest Fires, and the Cost Will Be Huge."

239 Hope et al., "Wildfire Suppression Costs for Canada Under a Changing Climate."

240 This decision is, of course, hardly a coherent and singular one (we certainly, for instance, don't sit down and have a single conversation about how much Canada should spend in a given year on fire suppression). Rather, it's an artifact of multitude of smaller decisions: decisions of individual fire managers about the fire they're working, of provincial management offices and their approaches to fire, and of perceived pressure about how much should be invested into fire protection in general.

than if they were located right beside a community. Others are allowed to grow because of a lack of capacity. Both the Horse River Fire and the 2017 British Columbia fires, for instance, were allowed to grow much larger than the same fires would have been under ideal circumstances (in the case of Horse River because disproportionate attention had to be given to protecting the city and other human values, and in the case of 2017 in British Columbia because there simply weren't enough firefighters to respond to all fires quickly). And other fires become large as a result of management tactics or decisions that, in hindsight, proved ineffective. As such, using total area burned as a measure of fire load is inaccurate: it doesn't reflect just the possible impact of changing weather, but rather the choices that management agencies both intentionally and unintentionally make about how to respond to fires. Making matters worse, the quality of this data varies in a consistently changing way: prior to the 1970s and 1980s, fire area data was based largely on estimations rather than exact mapping, leading to significant variance in the quality, accuracy, and style of notation (for instance, should an isolated, unburned patch within the burnt area be included or excluded from the area burnt).

The raw number of fire starts provides something of a simpler measure of wildfires themselves. Again, it has the problem of convoluting the measurement of human factors as well – ideally, for instance, effective education and outreach campaigns would reduce the number of human-started fires – it is slightly more focused on the fires themselves. Moreover, it is also a measure of technological change. Improvements among railroad operators, for instance, have dramatically reduced the number of fire starts since the early twentieth century – the result not of climate change, but rather train changes like improved breaks, spark arrestors, and a shift away from coal as a fuel source.

Unfortunately, there has been surprisingly little study of whether wildfire activity in Canada has demonstrated any correlation with climate-expected increases, let alone attempts at attributing possible trends to climate change causes. In 1982, the Canadian Forest Service's James Harrington used national data of area burnt from 1953-1980 (27 years) to examine trends in fire impact.[241] Citing "concern recently about the increase in area burned during the decade including the late seventies and early eighties," Harrington emphasizes the regional variability in the data finding "there is no consistent continent-wide pattern." Different provinces experience different peaks in fire behavior: British Columbia in the 1950s and 1960s; Manitoba in the 1960s; Ontario, Quebec, and Eastern Canada in the 1970s; and Alberta and Saskatchewan with periodic peaks but no overall trends.

A more recent (2008) foray by Martin Girardin and Mike Wotton of the Canadian Forest Service examined data from 1901 to 2002. The study focused on the relationship between periods of drought or wetness and fire behavior, finding a strong fit between the two. But, the driest periods in the nation occurred between the 1920s and 1960s, with wetter periods between the 1960s and 1980s. And, again, regional context and high degrees of baseline variability are the defining features, with the northern territories seeing the most sustained drying pattern over the century, and British Columbia and eastern regions seeing increasingly wet weather. These results were supported by another study led by the same author in 2009, which "did not reveal widespread patterns of linear increases in dryness

[241] Harrington, "A statistical study of area burned by wildfire in Canada 1953-1980."

through time as a response to rising Northern Hemisphere land temperatures," which was "coherent with widely reported decreases in area burned since about 1850."[242]

Resources made public by the Canadian Forest Service tell a similarly complicated story that challenges the notion of a uniform increase in fires. Such charts serve mostly to show the high degree of variability in any given year, rather than to illustrate a strong trend. Data sets can also differ in their conclusions, with two national databases (the Canadian National Fire Database and the National Forestry Database) showing opposing trends between 1980 and 2014 in terms of number of fires nationally.[243] The research discussed earlier, however, suggests that it's quite problematic to look at fires on such as short timescale (even just, for instance, 1980-2014). Because the 1960s-1980s were a period of relative wetness across the country, one would expect a return to more average dryness levels to bring a corresponding increase in fire. As such, it's difficult to determine whether an increase since the 1980s is related to climate, to a return to average moisture levels, or to other changes (like changes in forest management, human activities on the landscape, or even firefighting tactics and technologies).

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242 Girardin et al., "Heterogeneous Response of Circumboreal Wildfire Risk to Climate Change Since the Early 1900s."

243 To compare these two specific databases, the National Forestry Database (NFD) is comprised of the annual aggregate statistics reported by each provincial and territorial fire agency. By contrast, the Canadian National Fire Database (CNFD) uses spatial fire point and polygon data from fires reported individually by agencies. The CNFD data has become significantly more reliable over time, as the quality and completeness of this individual fire data gathering has improved (such as using handheld GPS devices to physically walk the fire parameters to map burnt areas, or increased use of satellite and airborne imagery to assess unburned patches). For analysis, the official advice is to conduct fire-by-fire comparisons of the two databases to isolate exactly where data variation might be located.

It was also interesting to note the reactions of fire managers when asked about the impact of climate change on their encounters with wildfire. Instead of identifying an increasing trend in the number or size of wildfires, however, the managers with whom I had extended conversations about the impacts of climate change suggested reframing the question in two ways. First, instead of seeing patterns of an overall increase of fire load because of climate change, almost all suggested, the real issue they observed was distribution: how fires are distributed throughout the season, how they are distributed across the landscape, and how extreme behaviours are distributed throughout any given fire. Second, managers uniformly identified other factors that they saw as much more influential in changing the fire regimes within their local contexts: land use, human activities, and forest management practices, among others.

To give a specific example, while questioning whether there was any change in overall fire load, they were nearly unanimous in pointing out the fact that fires were starting earlier and running longer throughout the season, generally ascribing this to climate change. For Albertan fire managers, the Horse River fire is the symbolic touchstone of this challenge: a massive fire beginning on May 1st, taking advantage of the dry 'pre-green-up' conditions to explode into a massive conflagration. This isn't a new shift – indeed, the need for increased over-winter condition monitoring, earlier preparedness planning, and the completion of almost all training courses by April 15th was recommended in the 1998 program review. It does, however, raise a particular challenge for many provincial agencies. Because university and college students play such a foundational role in fire response, expanding fire seasons push against the beginning and end of classes, making it harder to staff and train for these roles in time for longer seasons.[244]

Changes in fire distribution aren't just temporal; they're also occurring spatially. Climate change-induced variation in precipitation and temperature can shift the 'climate gradients' that span hundreds of kilometers, bringing with them changes in vegetation type and spacing.[245] A changing climate also has impact on pest populations, including the pine beetle that is notorious for its impact on boreal forests. As temperatures rise, the range of the pine beetle can expand, resulting in damaged forest that can be more susceptible to wildfire.[246] These drivers, however, are not simply determined by changes in climate: they're also substantially shaped by forestry policy (like the tools used or rejected for fighting particular pests) and fire policy (like the exclusion of fires that would play a role in reducing the range of these beetles). They also aren't the kinds of spatial variation that wildfire managers are most concerned with. Rather, it's the ways that human are shifting – where they choose to settle, work, and play – that are the crux of the fire managers' problems.

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244 MNP, "A Review of the 2016 Horse River Wildfire," 16.

245 Hogg and Hurdle, "The Aspen Parkland in Western Canada: A Dry-Climate Analogue for the Future of Boreal Forest?"

246 Taylor et al., "Forest, Climate, and Mountain Pine Beetle Outbreak Dynamics in Western Canada," *The Mountain Pine Beetle: A Synthesis of Biology, Management, and Impacts on Lodgepole Pine*. Interestingly, the question of how pine beetle affects forest flammability is more contentious than is sometimes presented. In particular, forest flammability may increase and decrease throughout pine beetle impacts, including high points when trees are damaged but still have dry needles in the canopy and lower points once these needles have dropped.
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Perhaps the most striking feature of the Horse River fire was the remarkably quick drop-off in public attention once the fire moved beyond Fort McMurray. The dramatic stakes – the crisis – of the fire arose from the threat it posed to people and to a community. "If the Horse River fire had started five kilometers east", one manager remarked, placing a hypothetical fire on the downwind side of the city, "it would have been the biggest fire you never heard of." People cared about the Horse River fire because of its human stories, largely not because of the fire in the trees.

Although the fire moved into the town in early May, it was the town that had much earlier moved into the path of the fire. Long home to the Cree and other Indigenous communities, Northern Alberta wasn't the subject of European attention until the late 18th century. Much like what motivated so many to live in Fort McMurray in 2016, the Europeans were attracted on the basis of the natural resources that could be extracted – initially fur. The Hudson Bay Company established Fort McMurray as a trading post in 1870, and the decades that followed brought increased connectivity by rail to the south. In 1930, the company of Abasands Oil began to extract from the oil sands, although production remained low for the years that followed. It wasn't until the 1970s – and the global oil crises – that Fort McMurray began to grow. From roughly 7,000 residents in the early 1970s, the city grew an order of magnitude by the time that the fire struck in 2016.

With them, these residents brought sparks, kindling, and values. Sparks were plentiful: hot exhaust pipes, carelessly tossed cigarettes, and scalding shards from ATVs, among others. Kindling was provided, too, in the form of flammable homes with nearby sheds, woodpiles, flammable shingles, and wooden and plastic siding. The homes – filled with mementos and imbued with symbolism and meaning – created a community worthy of protection; a community built in part through physical artefacts; a community that could be threatened by advancing flames. This expansion of the urban into the forested transformed a piece of the boreal from endless forest into a Fort that needed to be defended.

This meeting of the urban and the natural has long been labeled the "Wildland-Urban Interface." The proliferation of the term represents an advance in fire management, wherein the human and community dimensions are more explicitly considered, and where added attention and emphasis is placed on the importance of managing this high-stakes zone. Yet, it's also something of a misnomer. Humans – including in Fort McMurray – do not interact with wildlands through a singular interface, but rather a blurry and amorphous intermix that defies neat characterization. It's a repetitive pattern across scales. Cities and towns spring up well beyond the defined 'frontiers' to access natural resources, joining Indigenous communities that buck the southern-leaning settlement patterns of the country. Within those municipalities, neighbourhoods and individual homes branch out into forested hills and valleys rather than being separated by linear breaks. And even on individual properties, the patterns repeat: sheds and decks create branches that reach out towards property edges and can guide fire in, while junk and wooded debris thrown into the forest around change the fuel types and increase flammability.

The Horse River fire Fort McMurray wove its way into and through an urban setting that was intermixed with the boreal forest. In Canmore, Banff, Jasper, Kelowna, and beyond, this kind of development is increasingly expanding and repeating across the country (to the tune of a 69% increase in the populations living in "urban fringe" areas between 1986 and

2001).[247] A second kind of settlement pattern is also present, however: a migration of urbanites into cottages and rural homes. Although the rural population of Canada is growing at a much slower rate than urban centres (in fact, has largely held steady since the 1930s), this stability belies a crucial underlying shift. Where rural residents used to be almost exclusively farm-dwellers, the past eighty years have brought a massive shift from farm residents to non-farm residents among this stable population. In short, while the farming population declines, urban dwellers are taking up properties in largely more forested locations. Added to this are longstanding Indigenous and remote communities, a third pattern within an intermixed landscape.

The implication of these increases – particularly among those in the urban fringe and in recreational and rural forested properties – is a change in the landscape for fire managers. While the twentieth century was characterized by the protection of timber from fire, the twenty-first century reality in Canada is one of increasing human and community exposure to fire risks. Recreational use adds further challenges, creating a seasonal surge in the residence patterns that largely aligns with the warmest and driest portions of the year and exacerbates exposure during times of high risk. In turn, this "increases the potential number of fires that need aggressive and costly control efforts" – not to mention the potential impact of fires that elude this control.[248]

This is a fundamental change facing fire managers in Canada, the United States, and around the world. It's the coupling of two factors – the stakes and the tactics – that makes

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247 Peter et al., "Fire Risk and Population Trends in Canada's Wildland-Urban Interface."

248 Peter et al., "Fire Risk and Population Trends in Canada's Wildland-Urban Interface," 46.

this change particularly difficult to manage. As has been illustrated throughout this volume, fire management agencies as institutions are fundamentally developed to deal with wildfire as a forestry problem. Across Canada, they're based within natural resource management departments as opposed to integrated with municipal and city fire services (illustrated in Chapter 2 and 3). Their knowledge disproportionately comes from silvicultural inputs (like timber companies declaring which stands are being harvested and need protection), while individual cabins, homes, and trapping grounds can be much more difficult to document and protect, not to mention prioritize when many are under simultaneous threat (Chapter 4). Increasing human exposure results in higher stakes – lives and property to protected – which in turn demands more regular and larger exchange between jurisdictions to staff these massive fires rather than simply allow them to burn through uninterrupted tracts of boreal forest (Chapter 5). It also results in a shift in firefighting tactics: no longer is aggressive attack enough, rather fire management agencies must be ready to fight fires that are intermixed into urban environments.

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No organization in the world is more emblematic of these changes than 'Cal Fire' in the United States. An abbreviation of the California Department of Forestry and Fire Protection, Cal Fire shares a heritage of timber protection across the state lands of California beginning with a law that enabled the appointment of fire wardens by the State Forester in
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1905.[249] The build out in the decades that followed – of watchtowers, fire stations, and depression-era work camps – paralleled the evolution of many other organizations across the continent. More so than in the Canadian context, however, expansion continued to be driven by the Second World War and surrounding fears of the threat wildland fire could bring (from, nuclear bombs and incendiary devices, among other things) to the United States. The 1940 "Clar Plan" formed under these fears resulted in a recommendation that California "assume statewide fire dispatching and standby fire protection on the periphery of cities and vital industries" – explicitly linking the wildland, WUI, and urban values.

The organization that resulted was massive, and responds to not only the over 6,000 average annual fires on state land in California, but to an additional 300,000 other annual 911 calls including motor vehicle accidents, hazardous material spills, and search and rescue emergencies. With a budget of over two billion dollars annually, over a thousand engines and squad trucks (including 28 aerial ladder trucks operated on contract), and three times as many fire stations as the New York City fire department, the organization represents a hybridization of wildland and urban firefighting.[250] In the Oakland Hills, Ventura County, and across the rest of the state, the residential and wildland in California has become so tightly intermixed that 'wildland fire' is often a misrepresentative term for landscapes that blend natural and anthropogenic flammability. And, this zone is not only continually

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249 Thornton, "Cal Fire General History." The actual question of exactly when Cal Fire was founded is slightly more complicated, as following this 1905 Act, the State of California was still devolving the costs of forest protection to municipalities. It wasn't until 1919 that the State final began to fund a centralized effort towards fire protection. For additional details, see http://calfire.ca.gov/about/about_calfire_history.

250 CAL FIRE, "CAL FIRE at a Glance."

growing, but is the key driver when it comes to determining the social and economic destructiveness of wildfire in the region.[251]

In Canada, by contrast, the destructive potential of massive boreal forests has always been accompanied by the other side of the coin: the blessing of space. Many fires can be managed around their periphery without hundreds or thousands of residents mixed into the landscape under threat. Although the occasional fire, from Cochrane in 1916 to Fort McMurray in 2016, pushes back against that and reminds us of the potential impact on humans that exists, the challenge has generally been conceptualized in different terms: protecting a community here or there from the threat of fire, rather than dealing day-in and day-out with an intermixed landscape.

The British Columbia fires of 2017, however, offer a stark counterpoint. Through migration, through seasonal residences, and through industrial expansion, we are weaving our way in increasing numbers – and with increasingly expensive buildings and infrastructural investments – into these landscapes. British Columbia leads the pack in this respect, and the 2017 fire season is indicative. “BC can be something of a black hole,” one manager remarked, “sucking up every available firefighter across the country” in the scramble to fight back against higher and higher stakes fires. This has tactical implications for how fires are fought, for the training and tools required, and for the importance of enlisting homeowners into the preparations – but it also necessitates care in a nation so reliant on goodwill and equitable contributions into a countrywide system of mutual aid.

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[251] Keeley, Fotheringham, and Morais,. "Reexamining Fire Suppression Impacts on Brushland Fire Regimes.”

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Changes to the climate and to settlement patterns have the potential to reshape fire management in Canada at municipal, provincial, and national levels alike, yet they are far from the only changes and drivers with influence. Not only does the increasing numbers of properties, residents, and visitors raise the stakes of fire protection in these intermix settings, but these urban migrants also bring with them different – and largely higher – expectations of what level of protection they ought to experience from wildfire. Although research on these exact attitudes is thin to absent in the Canadian context, fire managers largely attribute it to bringing expectations of urban levels of fire protection to a rural environment. In the American context, this can be connected to the affluent nature of many of these migrants, expecting a combination of insurance and urban-quality fire response to protect expensive properties being developed in flammable landscapes.[252] Moreover, this level of protection is seen as important no matter the cost, as illustrated by firefighting cost being among the lowest priorities expressed by rural residents with respect to wildfire management.[253] This illustrates several coupled factors, including the price inelasticity of demand for fire protection, but also the ways in which the burden of costs is distributed across a much larger community than those directly benefiting from it.

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[252] Collins and Bolin, "Situating Hazard Vulnerability: People's Negotiations with Wildfire Environments in the U.S. Southwest."

[253] McCaffrey and Olsen, Research Perspectives on the Public and Fire Management: A Synthesis of Current Social Science on Eight Essential Questions."
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These expectations – and the provisioning of services – are not always equally distributed either. While many of these so-called "amenity migrants" (the urbanites who elect to live in beautiful, though high risk, forested landscapes) benefit from being able to afford significant insurance to protect their investments, as well as primary homes in the city where they can shelter if forced out by fire. In the American context, this privilege is further reinforced through stronger fire services in more affluent areas thanks to local taxes and community investment.[254] As economic inequality grows, so too do the ways in which those of lower socioeconomic status are put at increased risk and exposure because of immigration status, renting rather than owning properties, and not having access to comparable insurance coverage.[255]

These changes in risk exposure, distribution, and perception are also not unique to wildfire. The increasing costs of hurricanes, for instance, are largely explained by human choices – building more expensive homes and businesses into increasingly more vulnerable locations – rather than a net change in the hurricane frequencies themselves.[256] So-called "risk-transference" is also a common factor with other disasters. In flooding, for instance, a focus on reducing more frequent risks (such as establishing building codes for those located within an area that floods regularly) can do little to mitigate risk when larger events strike

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[254] Collins, "The Political Ecology of Hazard Vulnerability: Marginalization, Facilitation and the Production of Differential Risk to Urban Wildfires in Arizona's White Mountains."

[255] The justice dimensions of wildfire are an important area for increased investigation, including the disproportionate impacts on indigenous communities, the distribution of risk among different socioeconomic and demographic communities, and distributional impacts of high demands for service by amenity migrants (e.g., potentially either increasing protection for a community which was underserved, or drawing resources away from a different region).

[256] Pielke Jr., *The Rightful Place of Science: Disasters and Climate Change.*

(such as a flood that reaches further into areas not subject to this regulation and preparedness, creating catastrophic outcomes), or can even create new risks, such as the hardening of certain areas through levees and dams forcing water levels to rise higher in other locals.[257]

One other human choice in this system is crucial: how much fuels are allowed to accumulate around human values. Because the wildfire triangle depends so strongly on access to readily flammable fuels to sustain a conflagration, fuel breaks provide an opportunity to cut this chain of transfer and prevent community ignitions. At all scales, this is well evidenced. Individual property owners can take specific steps to reduce the likelihood of ignition and the continuity of fuels that could ignite their homes. These basic steps were a key determinate of which homes survived in Fort McMurray.[258] Fire managers also regularly use larger versions of these breaks, including roads and rivers as well as previously burnt areas, to guide and slow large-scale fires. Yet, as much as a long history of suppression intuitively leads to a landscape with more pent up fuel (as opposed to a mosaicked landscape providing large scale firebreaks for future conflagrations), this truism among observers of fire management ought not be taken as gospel. Fire finds a way: large, stand-replacing fires have always and will always be a part of the Canadian landscape, and it doesn't take long after a fire for new landscapes to become flammable again.[259]

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257 Etkin, "Risk Transference and Related Trends: Driving Forces Towards More Mega-Disasters."

258 Westhaver, "Why Some Homes Survived."

259 Johnson, Miyanishi, and Bridge. "Wildfire Regime in the Boreal Forest and the Idea of Suppression and Fuel Buildup."

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It is easy when talking about wildfire is often to frame impending change as a phenomenon outside of direct control. Climate-centric narratives in particular creates a narrative wherein humans are passive victims of changing fire behaviour created by a much larger, global system – and where the reduction of carbon emissions is framed as the appropriate response strategy. Perhaps humans can influence the course of climate change – or perhaps much damage is already done – but in this narrative, the future of fire necessarily follows from these changes. Fire is an all-powerful, natural force beyond human control. The future is a future of more fire, where humans are left scrambling to respond appropriately.

The core message of this chapter and of this book is, however, different. From the moment that humans began domesticating fire – even the earliest fire sticks that humans used to preserve, carry, and transport flames that were started by lightning fires – fire was no longer a strictly natural phenomenon. Rather, it weaves together the human, the political, the technical, and the social with a biophysical process (burning itself) in inseparable ways. Humans have shaped fire, harnessing it for their own use to clear agricultural land, to hunt, and, eventually, to run the combustion-based engines that would spark flames and eventually be used in the bulldozers, fire trucks, and air tankers that fight back. In turn, fire shaped humans, from the ways we feed ourselves and digest food, through to the massive
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institutional arrangements that we build to manage fire on our landscapes – and that is the main subject of this book.

The future of fire, therefore, is not one defined by climate change alone. Although climate change has largely been cast as the main causal villain in a future of firestorms, it is one of many influences – and an influence for which it is difficult to ascribe an exact relative importance. Rather, the future of fire is a future defined by a multitude of choices – how we build, how we prepare, how much we choose to invest into firefighting, and how we deploy those resources – that are fundamentally social, political, and human. We make these choices at an individual level, as this chapter has showed, in the places we choose to live and the attitudes that we have about what kind of response and protect we expect. And, we make these choices collectively, as we choose which kind of research to fund on ecosystems and fire management; in how to structure fire management organizations and policies; and in how much we accept fire and smoke as part of the reality of living in a forested country, rather than something to be suppressed and eliminated. These choices are, in turn, filtered through the institutions and policies and knowledge system that have evolved in Canada over the past century.

The first lesson is one of the ever-presence of fire in Canada. As easy as it is to look at Fort McMurray, British Columbia, and Waterton National Park and see something entirely new or unprecedented, it's simply not the case. Fires – massive fires, stand clearing fires, and tragically devastating fires – have always been part of our history. The first step to managing fire is to understand this long history and context. It also requires understanding the debates that have animated these century-long struggles: Where is the balance to be found between protecting timber and homes as opposed to allowing fire to play a natural role? What are the limits of technology and management in controlling significant fires? And, who is responsible for what, and how can the varied parties be made to work together rather than at odds? These questions will not have a convenient, settled, or singular answer, but will be continually debated and renegotiated. It is important, therefore, to engage them explicitly and with historical context, and to not treat the answers as givens.

The second lesson is about the importance of expertise and institutions. In Canada, debates on wildfire suffer from periodic but short-lived public and government engagement during the heat of a crisis. Yet, the most important parts of fire decision-making in Canada are not these big political moments, but rather the complex, interconnected, and, at times, odd and unpredictable institutions that we build to manage the flames. And, contrary to the refrain I often heard from fire managers who were surprised at how many different jurisdictions I was visiting over the course of this project ("they do it all pretty much the same as us!"), there are a multitude of variations between jurisdictions across the country. They can be big (agencies that employ hundreds of firefighters versus agencies that rely entirely on local volunteer departments) and small (such as what software and procedures they use to map out where values are located on their landscapes), but all of these decisions have profound effects during moments of emergency. These varied institutions are simultaneously a great strength and a great liability to the Canadian fire management system. Their diversity – coupled with frequent exchange between jurisdictions – offers opportunities for learning and growth, while their occasional inclinations to maintain local solutions over alternatives developed by neighbours, the sometimes limited sharing of knowledge, and the logistics of coordinating more than a dozen different agencies can make Canadian fire management particularly challenging.

The third issue is that even seemingly simple tasks can become – or be revealed to have always been – complicated in the arena of wildfire management. Firefighters are tasked with protecting things from fire, but just what things need to be protected and which are the most important are contentious and complicated questions. These experts and institutions are fundamentally tasked with fulfilling knowledge functions: producing reliable knowledge (such as where homes, cottages, and important timber stands are), circulating that knowledge effectively (especially in the transfer from regional levels to provincial levels and back again), and actually applying it to real-world management problems (making decisions, for instance, about which fire to fight first). These knowledge processing functions become all the more complicated when the underlying values are in dispute, such as which kind of ecological benefit ought to be pursued. In addition, the interplay between political disputes, contested identities, and these unsettled values has a profound impact on both how the institutions are perceived by those outside and how they are run within.

The fourth observation is that we take distinctively Canadian approaches to solving these problems. Our system, for instance, is built on mutual aid and assistance. Yet, this mutual aid takes on a distinctly different flavour than these kinds of arrangements elsewhere, relying on fungibility rather than uniformity to allow for integration. Like with so many other parts of the system, this flavour of mutual aid is the product not of a clean-slate design, but rather of political and relational negotiations under pre-existing constraints (the independent spirit of provinces, for instance). It's a product of particular historical contingency, and is an arrangement that must be continually renegotiated under changing conditions and demands.

The fifth lesson is one of the limits of prediction and the interplay between different forms of expertise. Forecasting and modeling hold an unending appeal for managers, with the promise of being able to predict the future and thereby eliminate uncertainty and risk. Yet, real-world models never achieve this: they still rely on expert input, they offer only simplistic representations of the conditions in the field, and they demand just as much discernment, judgement, and navigating of uncertainty as expert-driven alternatives. Moreover, they are never as simple as they appear on the outside. These models don't offer a single objective answer that directly tells managers what to do. Rather, competing models and interpretations can be leveraged to support a wide range of different possible management choices, often driven by the existing discretion and judgements of experts with very long histories in the fire services. While models can indeed, with slow, painstaking development, serve in a decision-support role that can help integrate more knowledge sources in a more transparent way, this kind of configuration does not arise by accident. Rather, we have to think consciously and carefully about what kinds of models we want, what uncertainties we're really trying to eliminate, and how they can be integrated in a robust and meaningful way into decision-making.

The sixth challenge, then, is to step back and see fire management not as just "putting the wet stuff on the hot stuff," but instead as a process of institutions muddling through the production, circulation, and application of knowledge. These functions are often treated in a facile way, being seen as "just" the research or "just" the after action reviews.

But, they're the core task of fire management: knowing the natural and human world around us, making judgements about values and priorities, and pursuing particular technical solutions in a way that allows us to get closer to those kinds of technical outcomes. We leave a real, problematic gap, then, when these research and learning functions become so focused on techno-scientific solutions rather than integrating social, political, and human dimensions.

These six issues, therefore, leave us with a future characterized not just by important natural change, but ultimately shaped by massive human changes. The story of the future of fire isn't one defined by mega-fires or firestorms, but rather defined by the need to grapple with the inseparable connections between people and fire. It's a story of the importance of expertise among managers; a story of the need to see social science research as just as critical as natural science; a story of reflecting as individual and communities about how we related to flammable landscapes; and a story of conflicting values and priorities that need to be solved through thoughtful conversations among experts and the public alike, rather than polarized debates during the heat of the moment. In essence, it's a story of an issue that becomes a microcosm for so many other questions: how we relate as individuals and provinces in Canada, how we value and shape our natural and built environments, and how we respond collectively in moments of crisis.

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On August 2nd, 2017, one hundred and thirty-five fires were burning in British Columbia, with seventy-four of them out of control. It would be another month before the
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Kenow Fire would burn through Waterton National Park. The Canadian Interagency Forest Fire Centre was sitting at a National Preparedness Level of five, its highest possible level, and the update that morning from BC had been direct: "Still extremely high levels of activity in the southern half. High pressure building which will continue to produce high temperatures spreading to the northern half of the province."

August 2nd also marked roughly six months from Darby Allen's retirement in Fort McMurray. Even on his retirement day, he was plagued by a sense of guilt for not being able to do more. "Nobody feels guiltier than me and those firefighters that we couldn't have saved every property," Allen said in the news conference. "With that type of fire in those early days we didn't have the resources to do everything."[260] Thirteen of his staff were on leaves of absence, mostly, he suggested, stemming from the mental toll of the fire that had rolled through the city nine months earlier.

In Edmonton and across Alberta, the staff of Alberta Wildfire were in the midst of managing their wildfire season. British Columbia was bearing the brunt of the fires at that point, with only 10 fires active and under control in Alberta on August 2nd. One hundred and eighty-one of their firefighters and forty-seven of their staff were on loan to British Columbia through CIFFC, along with over five thousand lengths of hose, and a hundred and fifty pumps. I was a province east, in Prince Albert, Saskatchewan, standing in a field outside their office being briefed on different portable weather stations that could be deployed with firefighters and managers at the fire itself to increase the resolution of weather data for prediction and modeling efforts.

[260] Thurton, "Retiring Fort McMurray Fire Chief Still Plagued by Guilt."

In Fort McMurray, August 2nd was dry and sunny. The temperature reached twenty-six Celsius – about the same as the day the Horse River Fire started. While not all the homes had been rebuilt – almost 15,000 people had not returned by a year after the fire – construction was well under way. The human-fire connection remained unbroken: contractors hauled softwood lumber – much like the pines surrounding town – and other supplies into town, building out homes on the edges of neighbourhoods around Fort McMurray. Workers had long returned to the oil sands projects surrounding the city, continuing the extraction of hydrocarbons to fuel a combustion-dependent world.

August 2nd arrived not with fanfare, like the fire had done four hundred and fifty six days earlier. It arrived, instead, with an announcement: the Horse River Fire was officially extinguished.

Fires in Canada can over-winter. Dropping low enough into flammable peat and debris below the surface, they can simmer below the frost line and until the ground thaws again. In the case of a conflagration as massive as the Horse River Fire, it can require a vast amount of effort with infrared cameras, satellite imagery, detection flights, and human patrols to identify and respond to any rekindled blazes once the fuel on the surface has dried enough to sustain combustion. It's emblematic of fire in Canada in general: never further than a snow melt away, and eager to spring into a country so blessed with flammable resources.

That fire was extinguished, but British Columbia was ablaze, and Waterton National Park was about to burn. Fire managers marked the occasion with little more than a fleeting glance, if that, as their eyes remained focused on the West and the ever-present Canadian flames.

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APPENDIX A

ESSAY ON SOURCES

Attempting to understand the history, design, function, and idiosyncrasies of fire management institutions across Canada necessitated working with a wide variety of sources. The project required using, of course, a large volume of published, unpublished, and archival sources, gathered as part of agency visits conducted from coast to coast across Canada. The notes throughout the volume directly cite many of these sources, as well as provide some crucial context about their limitations, insights, and origins. Yet, the utility of these material resources would never have been obvious or appropriately contextualized without the human intelligence involved: the conversations, interviews, and observations in which I had the pleasure of participating with agencies across the country.

Part of the challenge of this project – and, in turn, an important rationale for the work – was the lack of established, comprehensive secondary sources describing and analyzing the overall system of wildfire management in Canada. The most thorough volume on the matter is, unsurprisingly, written by the preeminent historian of fire Stephen Pyne and is entitled *Awful Splendour: A Fire History of Canada*. It provides a remarkably detailed encapsulation of the evolution of attempts to manage fire across the country until roughly the 1980s, largely organized through a set of regional lenses on the system. Several other sources by Pyne (including *World Fire: The Culture of Fire on Earth*, *Burning Bush: A Fire History of Australia*, and *Between Two Fires: A Fire History of Contemporary America*) helped to provide comparative lenses through which to understand the Canadian story and experiences. Pyne's productivity, attention to detail, and ability to weave together comprehensive histories of complex fire management systems is true of his oeuvre as a whole – some thirty odd books at the time of my working with him. He was also, without a doubt, the most crucial source of human intelligence for me, and his supervision and mentorship as a member of my committee provided a continual source of insight, interpretation, and analysis for making sense of the phenomenon I was witnessing across the country.

His *Burning Bush* was also crucial preparation for the first foray into gathering empirical data: a pilot study in the states of Western Australia and Victoria. This three-week visit provided opportunity to test and refine a series of questions for the semi-structured interviews I would conduct in Canada. It also provided a rich understanding of the influence of inter-state relationships on fire management within a Commonwealth country. The State Library of Western Australia was particularly helpful in providing access to a number of both government publications and technical reports on fire management. Internal reports from the Australasian Fire and Emergency Service Authorities Council, the National Aerial Firefighting Centre, and the departments of both conservation and emergency management in Western Australia and Victoria alike were particularly helpful. The Bushfire and Natural Hazards Cooperative Research Centre was a similarly rich source of primary and secondary documents, as well as for inviting me to participate in an informative research workshop in Perth during my visit.

Two Canadian sources were especially helpful for project-shaping research materials and incredibly insightful conversations early on in the research. Prior to the Australian pilot, I attended the 2016 Wildland Fire Canada conference in Kelowna, British Columbia, which proved invaluable in both formative conversations and laying foundations for informants I would interview throughout the following two years. I also made two visits – one during the winter of 2017 for several days, and then for approximately a month in May 2018 – to the

Northern Forestry Centre of the Canadian Forest Service in Edmonton Alberta. The team of wildfire researchers there proved insightful and helpful in shaping the project. Moreover, the Centre represented a treasure-trove of scientific reports, annual statistics, and archival sources from meetings and experiments, both in their formal archival collections, through a massive database of electronic scans of international resources, and the assorted collections left behind by former researchers and directors in offices throughout the building. I was grateful their office-quality scanner was able to furnish digital copies, as creating paper copies of these resources would have consumed more timber than a small fire.

The bulk of the project consisted of a trip across Canada, visiting and learning from fire management agencies in seven provinces (Alberta, Saskatchewan, Manitoba, Ontario, New Brunswick, Nova Scotia, and Prince Edward Island), the two federal agencies with fire management responsibilities (Parks Canada and the Department of National Defence, at both Canadian Forces Bases Shilo and Gagetown), and the Canadian Forest Service and Canadian Interagency Forest Fire Centre. Spanning from March 2017 to November 2018, plus pilot and follow-up visits before and after, I conducted roughly twenty-eight weeks of observation in Canada and a total of 203 interviews (including both the Australian pilot and Canadian interviews). During this time, I also collected a substantial set of published, unpublished, and archival resources. Even though I attempted, whenever possible, to collect digital versions of these documents (or produce my own through scans at agency offices), this still amounted to over forty pounds of documents in paper form – notable in an already packed car during a 21,000 kilometer drive across the country.

These interviews and observations form the backbone of my project. Because my project concentrated on understanding the institutions as 'knowledge systems,' the perspectives of those inside the system were crucial to understanding the differences between theoretical and actual management strategies. While the archival sources, internal reports, and published documents were often used to provide formal citations for the ideas, it was the insights of the fire managers themselves that really helped to unpack the way the system worked on a day-to-day basis. Agency directors were remarkably welcoming, hospitable, and willing to share across the country, not only providing me with a huge degree of access within their own organizations, but also providing the introductions and contacts for neighbouring counterparts to continue my study.

Within each agency, I began with semi-structured interviews with the program manager and duty officers. These personnel tended to have the best grasp on some of the basics of the organization (including points of comparison about personnel, tactics, and organizational structure that were important to establish early on). They were also key informants, crucial to introducing me to other colleagues, providing credibility as I conducted these subsequent interviews, and providing follow-up conversations to help me contextualize what I was learning and answer questions that arose throughout the project. Developing these relationships with duty officers also helped to provide a place to 'hang out,' allowing me to establish myself in a corner of the operations room, have ongoing conversations during the emergency response throughout the day, and providing a home base between interviews where I could continue my observations.

Access was, of course, a crucial part of this project. With each of my interviewees, I laid out a set of terms about how I would use the data: that they would be kept anonymous, that their comments would be used to steer the project and inform my interpretation rather than for 'gotcha' writing, and that prior to the final deliverables (including a book and various journal articles) I would circle back to them to share the ways I was using their materials. As such, in the dissertation I draw heavily on published sources in lieu of specific quotations and anonymize quotations where they are absolutely needed. This dissertation represents the first step in that process of refining, re-engaging stakeholders, and working towards the more final, more public book project. This quantity of interviews, observational notes, and documents also created an enviable, if unfortunate, limitation of this study. The sheer volume of raw data I collected was far more than could be integrated into a single dissertation, particularly over the span of the abridged writing process of a doctoral degree. As such, this dissertation represents a stepping-stone rather than a final product in the process of understanding, documenting, and analyzing Canadian fire management institutions as knowledge systems.

The process of transforming this volume of data into a readable manuscript was substantially assisted by a series of secondary sources on wildfire management. Ed Struzik's *Firestorm: How Wildfire Will Shape Our Future* served as both a model and a source of valuable information on the Horse River fire – especially after having the chance to meet and talk with him about our respective projects at the Wildfire Canada meeting in Kelowna in 2016. The three after action reviews commissioned in the province of Alberta following the Horse River fire were also invaluable to developing that narrative, which served as a backbone for the book as a whole. The collection of *Muscle and Heart: Fort McMurray Fire Stories* (by Dee Bentley and others) and Damian Asher's *Inside the Inferno: A Firefighter's Story of the Brotherhood that Saved Fort McMurray*, not to mention a massive volume of excellent local and national reporting by print media from across Canada, provided inside glimpses that fed this narrative as well.

A series of other books (including Cordy Tymstra's *The Chinchanga Firestorm*, Danielle Clode's *A Future in Flames*, Adrian Hyland's *Kinglake-350*, Roger Franklin's *Inferno: The Day Victoria Burned,* and Keith Keller's *Wildfire Wars: Frontline Stories of BC's Worse Forest Fires*) also served in this dual role of exemplars of the genre and rich sources of information. David Carle's *Burning Questions: America's Fight with Nature's Fire*, David Gantenbein's *A Season of Fire: Four Months on the Firelines of America's Forests*, and Erich Krauss' *Wall of Flame: The Heroic Battle to Save Southern California* served in a similar function, providing especially valuable contrasts from outside of the Canadian and Australian contexts. While many of these volumes were not directly cited in the text, their literary and thematic roles in the development of my project were crucial.

Finally, it's hard to overstate how crucial experiential and embodied knowledge is in producing a project like this. Given that my personal background with crisis and response is on the emergency medical services side, several agencies were remarkable in helping me to understand – firsthand – the geographies, scales, and forces involved. From driving across northern Saskatchewan with the program director from Prince Albert; to getting hands on with equipment in the workshop in The Pas, Manitoba; to participant observation of a training day held in Shilo, Manitoba; to hiking trails (both guided and on my own) throughout National and Provincial parks shaped by fire across the country; to Ontario Wildfire's insistence on flying me out to a fire being mopped up and taking me on a guided walk of its parameter near Nipigon, Ontario – each of these experiences was crucial to developing my understandings. Although these experiences weren't citable artefacts in the same way as the reports and interviews I took home from each of those locations, they were among the richest sources I had the pleasure of working with.

APPENDIX B

ETHICS APPROVAL

EXEMPTION GRANTED

Daniel Sarewitz
Future of Innovation in Society, School for the
202/446-0386
Daniel.Sarewitz@asu.edu

Dear Daniel Sarewitz:

On 7/13/2017 the ASU IRB reviewed the following protocol:

Type of Review:	Initial Study
Title:	National Review of Wildfire Policy in Canada
Investigator:	Daniel Sarewitz
IRB ID:	STUDY00006522
Funding:	Name: Arizona State University (ASU)
Grant Title:	
Grant ID:	
Documents Reviewed:	• KennedyWildfireIRB_2017-07-12.docx, Category: IRB Protocol; • Question bank for semi-structured interviews, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • Template - Initial Org Contact.pdf, Category: Recruitment Materials; • Template - Individual Consent.pdf, Category: Consent Form;

The IRB determined that the protocol is considered exempt pursuant to Federal Regulations 45CFR46 (2) Tests, surveys, interviews, or observation on 7/13/2017.

In conducting this protocol you are required to follow the requirements listed in the INVESTIGATOR MANUAL (HRP-103).

Sincerely,

IRB Administrator

cc: Eric Kennedy
Eric Kennedy