

**FIRE IN A DYNAMIC SOCIAL-ECOLOGICAL SYSTEM:
LEGACIES AND FUTURE OF FIRE IN BRITISH COLUMBIA, CANADA**

by

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Abstract

Fire, people, and landscapes have dynamically coexisted through time in fire-dependent social-ecological systems, supported by diverse Indigenous stewardship. Today, however, fire is increasingly threatening peoples' lives and livelihoods. This growing threat is partly attributed to an inadequate fire governance model that prioritizes fire control and fails to recognize the complexity of fire-dependent social-ecological systems across scales. In this dissertation, I take a collaborative and case study approach to explore these complex relationships in British Columbia (BC), Canada, at provincial and local scales over the last five centuries. By combining multiple methodologies, including historical document analysis, semi-structured expert interviews, place-based group interviews (forest walks), and tree-ring records, my dissertation demonstrates that the dominant fire governance model has cascading consequences for social and ecological systems through time. At the provincial scale, Indigenous stewardship was replaced by command-and-control fire governance in the late 19th and early 20th centuries, which was enforced by centralized government actors who continue to retain decision-making power over fire in BC. At the local scale, in a dry, Douglas-fir (*Pseudotsuga menzeisii*) dominated forest in the central interior of BC, the disruption of Indigenous stewardship in the 1870s altered the historical mixed-severity fire regime by eliminating highly frequent fire and landscape-level pyrodiversity. As a result, the dry forest today is more dense and likely to burn at uncharacteristic high severity, threatening enduring Indigenous values and livelihoods of adjacent communities. The 2017 fire season in BC was one such uncharacteristic season, which broke records for area burned (1.2 million hectares), number of people evacuated (~65,000), and fire suppression costs (~CAD\$600 million) and prompted calls for a new paradigm of fire governance that includes Indigenous (and local) communities. To do so, however, this research demonstrates that Indigenous knowledge is uniquely situated within a place-based context, and it is imperative that decision-making power is redistributed to Indigenous peoples to ensure that context is respected. Ultimately, transformative change is needed to shift to a more equitable fire governance model that prioritizes proactive, Indigenous stewardship and ensures that resilience in a fire-dependent social-ecological system is defined and led by Indigenous peoples.

Lay Summary

Fire has long been an important natural and cultural process but today is increasingly threatening peoples' lives and livelihoods. Many people recognize that our current approach to fire – attempting to control it after it has already started – is an outdated and at times ineffective approach that must change if we are to coexist with fire in the future. In my dissertation, I demonstrate that our approach to fire in British Columbia, Canada marginalizes Indigenous peoples. Over the last 150 years, this marginalization interrupted place-based land and fire stewardship by Indigenous peoples. In the dry forests of the central interior of British Columbia, the absence of Indigenous stewardship removed fire and resulted in landscapes that are more likely to burn in ways that threaten peoples' livelihoods. Coexisting with fire will require restoring decision-making power to Indigenous peoples to ensure a more equitable fire governance in the future.

Preface

This collated dissertation is my original work. The overall research program was developed by me and my two co-supervisors, Dr. Lori Daniels and Dr. Shannon Hagerman. The research presented in Chapters 2 and 3 was approved by the University of British Columbia Behavioral Research Ethics Board (Certificate H18-00779). The research presented in Chapters 3 and 4 is the result of a collaboration with the Williams Lake First Nation and the Williams Lake Community Forest following our signed Memorandum of Understanding (dated May 1, 2018). Feedback on the chapters in this dissertation were provided by Dr. Daniels, Dr. Hagerman, Dr. Jeanine Rhemtulla, and Ken Day.

Chapter 2 was designed by me and Dr. Hagerman, with strategic input from Dr. Daniels. Together we identified the research questions and developed the methodologies. I undertook data collection, analysis and writing with feedback from Dr. Hagerman at each stage. A version of Chapter 2 has been accepted and is currently in revision for *Regional Environmental Change* with me as lead author and Dr. Hagerman and Dr. Daniels as co-authors.

Chapter 3 was designed by me, Dr. Daniels, and Dr. Hagerman, with strategic input from our collaborators at the Williams Lake First Nation and Williams Lake Community Forest. Dr. Daniels and Ken Day initiated the collaboration and Dr. Hagerman provided oversight on the research questions and methods. I collected data with help from Spencer Bronson, analyzed results and authored the chapter. A version of Chapter 3 has been published with the citation: Copes-Gerbitz, K., S. M. Hagerman, and L. D. Daniels. Situating Indigenous resilience in a fire-dependent social-ecological system. *Ecology and Society* 26(4):25. As per the Memorandum of Understanding, the rights to the data collected for this chapter is retained by the Williams Lake First Nation.

Chapter 4 was designed by me and Dr. Daniels, with strategic input from our collaborators at the Williams Lake First Nation and Williams Lake Community Forest. Dr. Daniels initiated the collaboration and helped develop the research questions. I collected data with help from Greg Greene, Owen Raybould, Ian Mott, Skye Forcier, Carleigh Walters, Liz Shebib, Spencer Bronson, Bryn Gerson, Marcos Kavlin, and James Bergal. I prepared samples with help from Spencer Bronson, David Pashinsky, Devan Stewart, Dexter Everett, Ian Mott, Nikki Saadat, and Wei Shuo. I conducted analyses with help from David

Pashinsky; both sample preparation and analyses were undertaken in Dr. Daniels' UBC Tree-Ring Lab. Dr. Daniels provided input at each stage of the research. A version of Chapter 4 will be submitted for publication in a journal with me as lead author and Dr. Daniels as co-author.

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List of Abbreviations

BC – British Columbia

BCWS – BC Wildfire Service

DBH – Diameter at breast height

FNESS – First Nations' Emergency Services Society

FRPA – Forest and Range Practices Act

MFLNRORD – Ministry of Forests, Lands, Natural Resource Operations and
Rural Development (Ministry of Forests)

MSFR – Mixed-severity fire regimes

NGO – Non-governmental organization

SES – Social-ecological systems

USA – United States of America

WLCF – Williams Lake Community Forest

WLFN – Williams Lake First Nation

WUI – Wildland-urban interface

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Dedication



Inheritance by Lauren Sansregret (by permission)

*This dissertation is dedicated to the people and places that made this work possible –
thank you, mahalo, kukwstsétsemc.*

To Garth who showed me that there is more than one truth.

And for you, Dad, always my biggest fan – Aloha nui loa.

Chapter 1: Introduction

1.1 The modern fire challenge

The modern fire challenge continues to threaten peoples' lives and livelihoods globally (Bowman et al. 2013, Stephens et al. 2014). Historically, however, people dynamically coexisted with fire in a way that actively supported their livelihoods, driven by diverse and intentional Indigenous fire and landscape stewardship (Bowman et al. 2011, Huffman 2013, Roos et al. 2014, Biggs et al. 2016, Lake and Christianson 2019). Across North America, Indigenous stewardship was disrupted by Western colonial systems of land governance that perceived fire as disastrous and destructive (Wiebe 2008, Pyne 2016, Nikolakis and Roberts 2020). The disruption of Indigenous stewardship (Lake and Christianson 2019), shifting land use (Bowman et al. 2011), and accelerating climate-change impacts (Krawchuk et al. 2009, Jolly et al. 2015) are converging into the modern fire challenge, in which fire control rather than coexistence is prioritized. Increasingly, policymakers, scientists, practitioners and communities recognize that a business-as-usual, 'command-and-control' (Holling and Meffe 1996) approach to fire is inadequately addressing current challenges, and instead propose a future guided by coexisting with fire (Stephens et al. 2013, Moritz et al. 2014, Schoennagel et al. 2017, Higuera et al. 2019, McWethy et al. 2019, Tedim et al. 2019).

"Coexisting with fire" is a term increasingly used to encapsulate the preferred future approach to fire, but it remains an amorphous concept. In this dissertation, borrowing from the wide literature that applies the concept in the fire context (Moritz et al. 2014, Roos et al. 2016, Schoennagel et al. 2017, McWethy et al. 2019, Tedim et al. 2019), I use "coexisting with fire" as a way to describe a future in which negative impacts from fire on lives and livelihoods are minimized through proactive fire management and shared decision-making among diverse peoples. Ultimately, though, who defines what coexisting with fire looks like? How does the past influence our ability to coexist with fire in the future? What types of interventions are needed to coexist with fire? These questions are central to addressing the modern fire challenge and yet answering them is itself a challenge because of the complex social (including cultural and political) and ecological dimensions of fire. Increasingly, scholars addressing these questions through the lenses of social-ecological systems (Carmenta et al. 2011, Moritz et al. 2014, Spies et al. 2014, Fischer et al. 2016, Smith et al.

2016, Long and Lake 2018) and resilience (Higuera et al. 2019, McWethy et al. 2019) because they seek to embrace, rather than filter out, complexity. An emerging recommendation from these scholars is the need to move away from a one-size-fits all approach towards context-specific solutions that reflect unique social and ecological circumstances (Stephens et al. 2013, Moritz et al. 2014, Spies et al. 2014, Fischer et al. 2016, Paveglio et al. 2016). Investigating these unique contexts and dynamics requires interdisciplinary approaches that attempt to overcome the intellectual dichotomies (e.g., natural vs. social science, Indigenous vs. western science, science vs. practice) that undermine efforts to capture complexity and constrain our ability to coexist with fire in the future (Carmenta et al. 2011, Roos et al. 2016, Smith et al. 2016).

Below, I first introduce the state of knowledge in fire science and key knowledge gaps. Then I provide the study context of my dissertation as it relates to these key knowledge gaps. Finally, I describe the conceptual framework and broad methodological approach of my research.

1.2 Literature review

The literature review provided here briefly summarizes existing fire-related research in ecological systems (Section 1.2.1) and social systems (Section 1.2.2) and their recent integration (Section 1.2.3). It ends with an outline of the key theoretical, geographical, and temporal research gaps (Section 1.2.4) within fire-related research that this dissertation addresses.

1.2.1 Fire in ecological systems

Fire is a primary natural disturbance in landscapes of western North America that has long created diversity and heterogeneity at different scales (Turner 2010, Hessburg et al. 2019). Following a paradigm shift in the discipline of ecology that acknowledged non-equilibrium dynamics as a key principle of ecosystems (Holling 1961, 1973), the ‘disturbance regime’ concept emerged to describe the spatial and temporal characteristics of fire, including

frequency, seasonality, size, and severity¹ (Pickett and White 1985, Krebs et al. 2010, Turner 2010). In western North America, fire regimes exist along a continuum. At one end, the fire regime is dominated by high-frequency, low-severity (stand-maintaining) fires primarily driven by bottom-up factors (e.g., topography, fuels, ignitions). At the other end, fire regimes are dominated by low-frequency, high-severity (stand-replacing) fires primarily driven by top-down factors (e.g., climate) (Agee 1993, Schoennagel et al. 2004, Perry et al. 2011). In contrast to traditional approaches of classifying low-severity versus high-severity fire regimes, mixed-severity fire regimes that contain some proportion of low- to high-severity fire through time are increasingly recognized as the dominant fire regime in western North America (Perry et al. 2011, Hessburg et al. 2016, Daniels et al. 2017).

Mixed-severity fire regimes are inherently complex, driven by variations in fire regime characteristics across climatological, topographical, ecological and anthropogenic disturbance gradients (Hessburg et al. 2016, 2019). Historically, the complexity of mixed-severity fire regimes resulted in heterogeneous, successional-diverse landscapes with high species and landscape diversity (Perry et al. 2011, Hessburg et al. 2016). Importantly, this historical complexity was considered a source of resilience to disturbances such as fire, defined as species-adaptations to landscape-level conditions that interact to enable the continued existence of fire-adapted landscapes (Drever et al. 2006, Johnstone et al. 2016, Hessburg et al. 2019). Characterizing historical mixed-severity fire regimes is an emerging line of enquiry that is primarily undertaken through dendroecological methods (Heyerdahl et al. 2012, Marcoux et al. 2015, Daniels et al. 2017, Harvey et al. 2017), which illustrate the implications of changing fire regimes on landscape resilience through time.

Reflecting a trend in fire regimes globally, mixed-severity fire regimes have been heavily altered through colonial approaches to land use and fire, including displacement of Indigenous peoples, urbanization, intensive silviculture, industrial agriculture and policies of fire prevention and suppression (Bowman et al. 2011, Perry et al. 2011, Hessburg et al. 2016). These approaches to land use and fire often result in fire exclusion, causing landscapes to shift to a more homogenous, less diverse, younger, and more dense state (Perry

¹ Fire severity is defined by above and below ground loss of organic matter (Keeley 2009). In this dissertation, severity is used to describe aboveground tree mortality and injury that can be reconstructed through dendroecological methods (Daniels et al. 2017).

et al. 2011, Marcoux et al. 2015, Hessburg et al. 2016). Worryingly, altering mixed-severity fire regimes results in landscapes that are more susceptible to uncharacteristic high-severity fire and can exceed resilience thresholds (Perry et al. 2011, Stephens et al. 2013, Johnstone et al. 2016). To reduce this susceptibility and promote coexisting with fire, management recommendations include restoring and emulating historical mixed-severity fire regime effects, such as heterogeneity at multiple spatial scales, particularly through the use of prescribed and managed fire (Hessburg et al. 2016). In addition, management must embrace and plan for uncertainty to ensure resilience (Thompson and Calkin 2011, Day and Pérez 2013, Stephens et al. 2013) even under climate change that is continuing to alter fire regimes (Abatzoglou and Williams 2016, Hanes et al. 2019, Kirchmeier-Young et al. 2019). Importantly, however, management must be context-specific and balanced with other landscape values; in practice, this requires attention to the human dimensions of fire embedded within broader social, cultural, and political contexts.

1.2.2 Fire in social systems

As the impacts of the modern fire challenge on lives and livelihoods grow, the human dimensions of fire are garnering increased attention (McCaffrey 2015, McGee et al. 2015). The ways in which humans interact with fire are embedded within a governance system that includes structures (e.g., actors and organizations), institutions (e.g., laws, objectives) and processes (e.g., decision-making) (Lemos and Agrawal 2006, Armitage et al. 2012, Bennett and Satterfield 2018). Consideration of the governance system is key because it dictates the social mechanisms through which objectives (such as fire control or fire coexistence) are created and implemented (Buizer and Kurz 2016, Neale et al. 2019). In colonial systems, centralized fire governance – in which powerful government actors primarily dictate the objectives – is a common model that results in ‘command-and-control’ management objectives with maladaptive effects (Smith et al. 2016, Steelman 2016, Tedim et al. 2019). These maladaptive effects can produce unintended consequences to both social and ecological systems (Fischer et al. 2016). A prime example of these unintended consequences is the fire suppression paradox, in which excluding fire from fire-adapted landscapes results in a build-up of hazardous fuels, which in turn increases fire risk and decreases resilience (Stephens et al. 2013, Fischer et al. 2016, Hessburg et al. 2019). Recent fire governance

research has highlighted the need for new governance models that aim to intentionally coexist with fire through proactive, rather than reactive, fire objectives (Steelman 2016, Paveglio et al. 2018, Kelly et al. 2019, Tedim et al. 2019).

In contrast to modern colonial fire governance in western North America, Indigenous communities have stewarded fire and fire-adapted landscapes since time immemorial (Lake and Christianson 2019). Indigenous fire stewardship is its own form of governance that includes: 1) processes such as intergenerational knowledge transmission, decision-making, customs and rights, power dynamics, and cosmology; and 2) knowledge of fire behavior, fuels, weather, fire effects, and fire operations that have adapted through time (Carmenta et al. 2011, Huffman 2013, Miller and Davidson-Hunt 2013, Martínez-Torres et al. 2016, Lake and Christianson 2019, Nikolakis and Roberts 2020). Indigenous fire stewardship is richly recorded in oral histories (Lake and Christianson 2019), journals of early settlers (Boyd 1999), and ethnographic research (Lewis and Ferguson 1988, Gottesfeld 1994, Turner et al. 2000, Kimmerer and Lake 2001, Ignace et al. 2016). Despite these long traditions, however, the imposition of colonial land and fire governance (which actively suppressed Indigenous ways of life) altered Indigenous fire stewardship such that Indigenous perspectives continue to be subjugated in modern fire contexts (Eriksen and Hankins 2014, Christianson 2015, Nikolakis and Roberts 2021). The future of Indigenous fire governance will depend on overcoming colonial ‘traps’ - such as contested land sovereignty, disrupted knowledge transmission systems, and declining landscape quality - that continue to constrain the ability of Indigenous communities to actively coexist with fire (Long and Lake 2018). Ultimately, Indigenous peoples must be able to restore their stewardship according to their own definitions of resilience that transcend fire (Miller and Davidson-Hunt 2013, Christianson 2015, Nikolakis and Roberts 2020, Dickson-Hoyle et al. 2021).

1.2.3 Linking fire in social and ecological systems

“Only by considering the ongoing and holistic processes of how fires interact with past, current and future human-natural systems will communities be able to achieve resilience sufficient to coexist with fire.” (Smith et al. 2016, pg. 138)

Catalyzed by the emergence of social-ecological systems analyses (Liu et al. 2007, Ostrom 2009, Binder et al. 2011), and underpinned by increasing recognition of the two-way

interactions between humans and fire (Bowman et al. 2013), fire research has moved towards understanding the linked dynamics across scales between ecological and social systems (Bowman et al. 2011, Moritz et al. 2014, Roos et al. 2014, Spies et al. 2014, Fischer et al. 2016, Smith et al. 2016). Key lessons from this research demonstrate the temporal lag between the two systems, whereby ecological changes are either outpacing the social capacity to adapt, or the social interventions that are taken (such as policies or management objectives) are slow to manifest ecologically (Spies et al. 2014, Fischer et al. 2016). In part, this disconnect results from historically siloed understandings of fire (Smith et al. 2016) and maladaptive and unanticipated feedbacks between the two systems (Spies et al. 2014, Fischer et al. 2016). Collectively analyzing fire as a social-ecological system helps address these maladaptive feedbacks through attention to the unique contexts and desired future conditions at the local scale (Stephens et al. 2013, Moritz et al. 2014). Critically, these unique local contexts and desired future conditions have implications for whether and how social-ecological systems are able to achieve resilience and coexist with fire in the future (Higuera et al. 2019, McWethy et al. 2019).

1.2.4 Research gaps and a way forward

Building on the last decade of research connecting fire in social and ecological systems, this dissertation aims to address three key theoretical, temporal, and geographical research gaps. First, the environmental governance literature clearly demonstrates that governance attributes such as decision-making power strongly dictate environmental outcomes (Lemos and Agrawal 2006, Bennett and Satterfield 2018). However, the governance dimension in the fire context, especially as it relates to power, continues to receive little attention (Schultz et al. 2019, Tedim et al. 2019). This is particularly problematic given that the ‘socializing resilience’ literature asserts that the governance dimension specifically addresses power imbalances (Adger 2000, Cote and Nightingale 2012, Brown 2014, Ingalls and Stedman 2016) and grapples with the question “for whom is resilience being enabled and at what cost to others?” (Cote and Nightingale 2012, pg. 485). Addressing these theoretical gaps in fire research is imperative, especially given the ongoing, unequal power relationships between colonial versus Indigenous fire systems in western North America (Christianson 2015) and the ways in which integrating Indigenous knowledge into colonial processes can perpetuate

power imbalances (Bohensky and Maru 2011) (see Section 1.4.3 for further discussion). As a prime example, only recently has Indigenous fire stewardship been acknowledged as a key driver of historical fire regimes in dendrochronology and fire ecology research (Fulé et al. 2011, Stambaugh et al. 2013, Taylor et al. 2016, Roos et al. 2018, 2021, Larson et al. 2020) – a gap that has consequences for interpreting the past and defining how we coexist with fire in the present and the future.

The second research gap in the fire context is the inattention to change over time in social systems. There is a strong and deep research agenda on the ways in which historical ecological legacies influence future pathways of ecological resilience (Johnstone et al. 2016), informed by palaeoecological (Whitlock et al. 2010) and historical ecology (Swetnam et al. 1999, Higgs et al. 2014) methods, including dendrochronology (Daniels et al. 2017), and the links between them across scales (Buma et al. 2019). From a social systems perspective, however, the past also influences the future: governance operates along a dynamic trajectory of change, in which the future is both enabled and constrained by current and historical attributes of governance (Offen 2004, Davis 2009, Mathevet et al. 2015). For example, how can the benefits of coexisting with fire be equally experienced if colonial governance attributes (such as organizations, laws, and decision-making processes – all of which exert power) continue to marginalize Indigenous perspectives, values and knowledge (Eriksen and Hankins 2014, Christianson 2015)? An awareness of which historical governance attributes may be constraining equitable changes will help navigate the complexity of coexisting with fire in the future (Steelman 2016, Schultz et al. 2019).

Third, all social-ecological systems fire research points to the importance of local context (Carmenta et al. 2011, Moritz et al. 2014, Spies et al. 2014, Fischer et al. 2016, Smith et al. 2016, Higuera et al. 2019, McWethy et al. 2019), and yet the research agenda is largely driven by research in the United States. Despite sharing some similar social-ecological histories, Canada is distinct for its fire and land governance approaches (McGee et al. 2015, Tymstra et al. 2020), the “infancy” of its fire risk research (Johnston et al. 2020), and its (stated) commitment to reconciliation with Indigenous peoples (Truth and Reconciliation Commission of Canada 2015). There have been notable advances in Canadian fire research and management (Coogan et al. 2020, Tymstra et al. 2020), and yet a social-ecological systems resilience perspective is currently missing to understand the unique fire context in a

Canadian setting. This dissertation addresses the above theoretical, temporal, and geographical research gaps through an interdisciplinary, multi-method, collaborative research approach that critically examines our assumptions and opportunities for coexisting with fire in the future.

1.3 Study context

1.3.1 Objectives

The overall objective of this research is to examine the relationship among people, fire, and landscapes in a social-ecological system in British Columbia (BC), Canada through time. The following dissertation chapters contribute to this objective through three distinct but interrelated research objectives:

1. Identify attributes of historical fire governance that enable or constrain a vision for future fire governance.
2. Explore the context of how Indigenous knowledge is situated within a fire-dependent social-ecological system.
3. Explore the Indigenous contribution to the historical fire regime in a dry forest ecosystem.

Recognizing the importance of scale when analyzing social-ecological systems (Ostrom 2009, Binder et al. 2011), this research attends to provincial, regional and local scales to better understand the dynamic feedbacks across different geographical scales in a fire context. Specifically, given that in Canada fire decision-making is primarily made at the provincial scale (Tymstra et al. 2020), Research Objective 1 examines provincial fire governance while acknowledging and incorporating data at the higher federal and lower regional scale. Research Objectives 2 and 3 were developed as part of a collaborative, community-based research program and as such are situated at a more local scale. This local (place-based) scale also reflects a key characteristic of the forms of knowledge that contributed to answering Research Objectives 2 and 3: Indigenous knowledge is inherently place-based and relational (Turner et al. 2000, Whyte et al. 2016) while dendroecology samples are collected from specific points on a landscape and represent distinct ecological

legacies (Swetnam et al. 1999), respectively. Together, these questions will help explore the relationship among people, fire, and landscapes at multiple scales through time in BC.

1.3.2 Study area

The province of BC on the west coast of Canada (Figure 1.1) is biogeographically diverse, covering 95.2 million hectares divided into 16 distinct ecosystem classification zones heavily influenced by the coastal to continental climates (Meidinger and Pojar 1991). These ecosystems are adapted to periodic abiotic and biotic disturbances, including fire, from infrequent, stand-initiating events to frequent, stand-maintaining events (Wong et al. 2003). Governance over these ecosystems is complex and contested (Caverley et al. 2020). Throughout most of BC, treaties with Indigenous peoples were never negotiated and challenges for sovereignty continue today on approximately 95% of land area (Borrows 2017; Wilson 2019). Even where treaties were negotiated in the 1800s, in the far northeast (Treaty 8) and on a portion of Vancouver Island (Douglas treaties), questions remain as to whether they have been upheld in good faith by the federal and provincial government (Wilson 2019). From the perspective of the ~200 First Nations governments and under Indigenous law, First Nations communities have stewarded the lands and waters since time immemorial prior to the formation of the colony of BC in the 1850s, and today retain ownership and jurisdiction over their unceded territories (Wilson 2019). From the perspective of the provincial legal system, about 94% of land in BC is classified as provincial “Crown land.” The remainder is private (4.9%), federal Crown (1%), and First Nations Treaty settlement land (0.2%) (MFLNRO 2011). For the provincial Crown land, about 67% is forested while the timber harvesting land base is about 23% of the total provincial area (MFLNRO 2011).

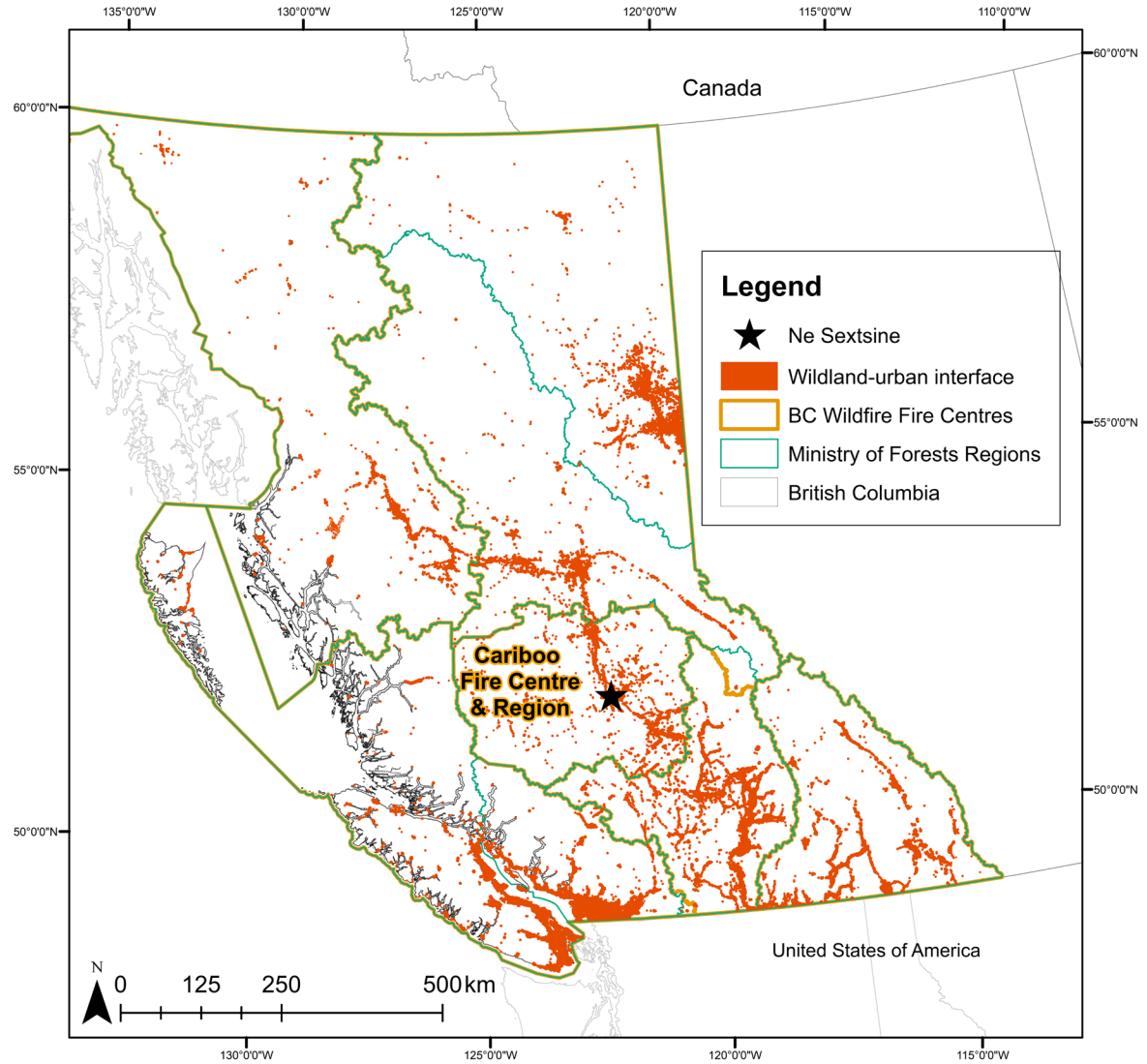


Figure 1.1: Areas of interest in British Columbia referenced in dissertation.

Areas shown include British Columbia (BC) Wildfire Service Fire Centres (orange), Ministry of Forest Regions (green), the wildland-urban interface (red), and Ne Sextsine (black star).

Despite contested sovereignty for the land, decision-making power on provincial Crown land is currently held by the provincial government. Under the provincial government, the BC Wildfire Service is mandated to oversee wildfire management on land outside of municipalities, including parks and protected areas and federally-managed Indian Reserves. Historically until 1995, the BC Wildfire Service was under the jurisdiction of the provincial forest organization, currently known as the Ministry of Forests, Lands, Natural Resource Operations and Rural Development (Ministry of Forests). The BC Wildfire Service currently operates in six Fire Centres across BC, which are roughly contiguous with the Ministry of Forests Natural Resource Regions.

Between 1998 and 2018, BC experienced six significant wildland-urban interface (WUI) fire seasons, with over 125,000 people evacuated and ~3.4 million ha (~8.4 million acres) burnt. Total suppression costs during these significant fire seasons were over \$2.6 billion CAD (adjusted for inflation to 2020 dollars; Figure 2.1), accounting for over one-third of suppression costs since records began in 1912 (BCWS 2021). The significant fire season in 2017 was – until 2018 – the most widespread based on area burned (1.2 million ha), of which ~73% burned in the Cariboo Fire Centre (contiguous with the Cariboo Forest Region; hereafter, the Cariboo). The Cariboo is in the central interior of British Columbia, and includes grassland, dry forests, and mesic mixed-conifer forests. Until Covid-19, the 2017 fire season prompted the longest provincial state of emergency lasting 70 days, during which over 65,000 people were evacuated, including 26 First Nations communities (Abbott and Chapman 2018). The 2017 fire season resulted in the most recent independent provincial review into the causes and consequences of catastrophic fire-related impacts; in consultation with fire-affected communities, this review called for strategic changes to fire governance to minimize the impacts of future wildfires (Abbott and Chapman 2018).

One of the First Nations whose people and territory were affected during the 2017 fire season in the Cariboo was the *T'exelc* (Williams Lake First Nation). The *T'exelc* (people of the Williams Lake First Nation) are members of the Northern Secwépemc te Qelmuw (Northern Shuswap Tribal Council) who have stewarded the land since time immemorial and are still present within their territory. A portion of their traditional territory was incorporated into the *Ne Sextsine* (Flat Rock) block of the Williams Lake Community Forest in 2014. *Ne Sextsine* encompasses about 5900 ha of dry forest dominated by interior Douglas-fir

(*Pseudotsuga menziesii* var. *glauca*) forests, including a drier component (~2400 ha) along the Fraser and Williams Lake River benches and a more mesic component (~3500 ha) on a higher elevation plateau (WL Community Forest LP 2015). Aerial photos from the 1960s-70s show grasslands at *Ne SEXTSINE* covered ~340 ha, which is mandated for grassland restoration as part of the Grasslands Strategy of the Cariboo-Chilcotin Land Use Plan (Steele et al. 2007). The mesic forest also includes trembling aspen (*Populus tremuloides*) and hybrid spruce (*Picea engelmannii* x *glauca*) in the wetter areas, and a small living component of lodgepole pine (*Pinus contorta*) that survived the 2000s mountain pine beetle epidemic (WL Community Forest LP 2015). Given its location in the *T'exelc* territory and adjacent to the City of Williams Lake, community protection from wildfire while simultaneously managing for multiple cultural, social, ecological, and economic values is a key management objective driving decision-making at *Ne SEXTSINE*.

1.4 Conceptual framework

The conceptual framework for this research draws from four interrelated bodies of literature that help describe and investigate relationships among people and landscapes (Table 1.1), including: 1) social-ecological systems and resilience; 2) environmental governance; 3) Indigenous knowledge and 'integration'; and 4) historical and historical political ecology. The important insights from these literatures are discussed briefly below.

Table 1.1: Four bodies of literature and their key insights applied in this dissertation for each research objective (RO)

Body of literature	Insights from literature	Contribution of this research
Social-ecological systems (SES) and resilience	<p>Linked systems with dynamic feedbacks at multiple scales – system behavior framed as resilience</p> <p>Pathways to resilience include embracing change, uncertainty and multiple forms of knowledge</p> <p>Critiques of SES resilience shifted conversation to governance, including how actors with power operate and whose knowledge is being used</p>	<p>RO 1: Actors with power dictate system behavior</p> <p>RO 2: Indigenous definitions of resilience and situated knowledge</p>
Environmental governance and management	<p>Governance attributes include institutions, structures, and processes that influence actions and outcomes</p> <p>Centralized, government actors traditionally held sole decision-making power (e.g., command-and-control) to dictate management</p> <p>Movement towards increasing diversity of actors and importance of local knowledge to address complex environmental challenges</p>	<p>RO 1: Identifying attributes influencing fire governance; role of different actors through time</p> <p>RO 2: Shifting governance context within which Indigenous knowledge is applied</p> <p>RO 3: Managing fire regimes linked to broader fire governance opportunities</p>
Indigenous knowledge and ‘integration’	<p>Indigenous knowledge tends to be viewed as abstract data source</p> <p>Traditional ‘integration’ means decision-making still driven by dominant colonial paradigms</p> <p>Place-based relationality, practice of knowledge transmission, and respect key elements of Indigenous knowledge</p>	<p>RO 1: How Indigenous knowledge is incorporated into fire governance</p> <p>RO 2: All elements of Indigenous knowledge informing resilience</p> <p>RO 3: Indigenous knowledge guiding fire regime</p>
Historical ecology and historical political ecology	<p>Legacies of the past influence the future</p> <p>Multiple, complementary methods that incorporate diverse sources of knowledge (data)</p> <p>Political context interested in promoting “environmentally appropriate and socially just” future</p>	<p>RO 1: Attention to governance change through time; future enabled or constrained by past</p> <p>RO 2: Combining multiple sources of knowledge for holistic historical context</p> <p>RO 3: Combining multiple sources of knowledge for historical context</p>

1.4.1 Social-ecological systems and resilience

Social-ecological systems (SES) thinking has emerged from different disciplines into diverse frameworks for characterizing and defining linked systems (Binder et al. 2011, Schoon and van der Leeuw 2015). SES thinking can be applied as a boundary object to describe system behavior (Liu et al. 2007) or an epistemic object for identifying relevant variables (Ostrom 2009). Although each approach has its strengths and limitations (Binder et al. 2011), they commonly emphasize the important linkages and feedbacks between both systems and across scales that create complexity within SES (Liu et al. 2007, Ostrom 2009, McGinnis and Ostrom 2014). While SES thinking has been widely applied in the context of modern environmental challenges (including fire), there are critiques that the ecological system is better conceptualized than the social system (Schoon and van der Leeuw 2015, Stojanovic et al. 2016). These critiques center on attempting to quantify intangible elements that drive social systems, such as worldviews and power. Failure to acknowledge these more intangible elements can result in reductionist and top-down analyses of the system. Scholars argue that to address these critiques, SES is instead more useful as a heuristic that has emergent (and evolving) properties (Schoon and van der Leeuw 2015, Stojanovic et al. 2016). In this dissertation, specific attention is given to the dynamic and evolving linkages between the social and ecological systems and the intangible elements that drive the system dynamics.

A commonly used analytic for describing the dynamics within an SES is resilience. Resilience theory emerged from a non-equilibrium ecology perspective and described the ability of an ecosystem to absorb and bounce back from an external disturbance (Holling 1961, 1973, Gunderson 2000, Carpenter et al. 2001). Translating ecological resilience to SES again overlooked intangible elements such as power and agency (Cote and Nightingale 2012, Ingalls and Stedman 2016) and resulted in prescriptive recommendations to build resilience that failed to acknowledge resilience in SES is normative (Adger 2000, Brown 2014). Supported by advances in complex adaptive systems (Gunderson and Holling 2002), resilience has since evolved into a broader descriptive approach for building capacity within SES to navigate uncertainty and change at multiple scales – embracing both adaptation and transformation (Folke 2016, Hahn and Nykvist 2017). Importantly, applying resilience in an SES requires acknowledging the historical contexts and multiple epistemologies that make

resilience normative (Cote and Nightingale 2012, Blythe et al. 2017, Stone-Jovicich et al. 2018). Interestingly, critiques of reductionist SES resilience have shifted the conversation to governance because of its attention to power influencing resilience in SES (Folke 2006). In this dissertation, the way in which power influences resilience in the SES is a key line of inquiry.

1.4.2 Environmental governance

Environmental governance is defined as the suite of attributes that influence environmental actions and outcomes (often framed as management choices), including institutions (e.g., laws), structures (e.g., organizations or actors) and processes (e.g., decision-making and knowledge) (Lemos and Agrawal 2006, Bennett and Satterfield 2018). In the SES context, governance is a primary variable that influences system resilience by defining the rules within which actors can operate (Ostrom 2009, McGinnis and Ostrom 2014). Multiple types of environmental governance have been described, with recent attention to adaptive governance, which aims to build resilience, to transformative governance, which aims to actively shift to a more desirable set of governance attributes (Walker et al. 2004, Chaffin et al. 2016). Although the literature on governance has advanced to recommending a new form of governance (reflexive governance) that incorporates system-wide learning (Voß and Kemp 2006, Feindt and Weiland 2018), I chose to focus on transformative governance because of the inadequate attention to socially desirable governance attributes in the BC case study thus far.

In addition to governance attributes themselves, attention to how they interact through time is key for understanding how transformative governance may be enabled or constrained by certain factors (see Section 1.4.4). For example, certain organizations or actors can accumulate power through time by implementing institutions and processes that reinforce their authority (Mathevet et al. 2015). When power accumulates in an organization, it can lead to path-dependency and rigidity, or resistance to change, which maintains the status quo of decision-making – a primary constraint on transformation (Farrelly and Brown 2011, Westley et al. 2011, Chaffin et al. 2016). In natural resources settings, these powerful actors are often centralized colonial governments (Lemos and Agrawal 2006, Armitage et al. 2012, Cockerill and Hagerman 2020). As an alternative, scholars have proposed the need for and

trend towards decentralized, community-based decision-making power (Jasanoff and Martello 2004, Offen 2004, Davis 2009, Armitage et al. 2012). In this context, transformative environmental governance allows this research to critically engage with the way power is distributed in fire-related decision-making.

1.4.3 Indigenous knowledge and ‘integration’

In modern environmental contexts (including fire), Indigenous peoples continue to have disproportionately little decision-making power despite being original stewards and guardians of landscapes globally (Agrawal 1995). In many cases, the lack of decision-making power held by Indigenous peoples is a result of decision-making processes imposed by colonial governments that privilege colonial forms of knowledge (such as Western science) over Indigenous knowledge and broadly disregard Indigenous peoples’ rights (Nadasdy 1999, Usher 2000, Lake et al. 2018). In this dissertation, rather than Indigenous fire knowledge, I use the term Indigenous fire stewardship to describe the holistic, interconnected, place-based knowledge and practice held by Indigenous peoples following the definition by Lake and Christianson (2019, pg. 1):

“the intergenerational teachings of fire-related knowledge, beliefs, and practices among fire-dependent cultures regarding fire regimes, fire effects, and the role of cultural burning in fire-prone ecosystems and habitats.”

This definition embraces an Indigenous worldview of stewardship to include the philosophical (spiritual) wisdom, practices and strategies, and acts of communication and exchange that evolve through time and underpin Indigenous peoples’ relationships and obligations to their environment (Turner et al. 2000, Houde 2007).

Recognizing that Indigenous knowledge and stewardship has long been marginalized, ‘knowledge integration’ emerged as a pathway for incorporating both Western science and Indigenous knowledge into environmental governance (Bohensky and Maru 2011).

Knowledge integration has been catalyzed by the literature on SES which recognizes Indigenous and local knowledges as important contributors to resilience (Walker and Salt 2006, Berkes 2009). However, in practice, attempts at knowledge integration often treat Indigenous knowledge as a static form of data that can be extracted and applied elsewhere (Pierotti and Wildcat 2000, Usher 2000). In treating Indigenous knowledge in this way,

‘knowledge integration’ is viewed as a technical problem, yet is inherently flawed because less privileged knowledge, often Indigenous and local, is forced to fit into paradigms more privileged, often colonial or Western science knowledge (Agrawal 1995, Nadasdy 1999, Bohensky and Maru 2011). To contrast this flawed approach to knowledge integration, scholars have called for more ethical collaborations between Indigenous and non-Indigenous people in the research space (Ban et al. 2018, Wong et al. 2020). The research presented here incorporated a collaborative research approach (Section 1.5.2 below) to avoid the problematic assumptions and outcomes of knowledge integration (Bohensky and Maru 2011).

1.4.4 Historical ecology and historical political ecology

With the recognition that disturbances (such as fire) are integral to the non-equilibrium dynamics of ecological systems (Holling 1973, Turner 2010), historical ecology emerged through an ecological lens as an interdisciplinary and multi-scale approach to understanding the patterns and processes in ecological systems through time (Landres et al. 1999, Swetnam et al. 1999). Historical ecology is a powerful approach that combines multiple sources of historical information – including tree-rings, historical documents, Indigenous oral histories, and historical aerial photographs – through cross-referential analyses to overcome limitations of individual sources (Swetnam et al. 1999). Importantly, historical ecology informs ecological management by describing the range of variability of ecosystem structures, functions, and processes (including disturbances such as fire) that can be emulated through management interventions (Long 2009, Mori 2011). In recent decades, with the dynamic interactions of climate change and land use creating opportunities for management of historical, hybrid, and novel ecosystems to occur (Hobbs et al. 2014), the role of history guiding the future has changed (Higgs et al. 2014). Specifically, history is increasingly being leveraged to demonstrate a range of future pathways, moving beyond the ecological realm to consider the important social dimensions of history (Higgs et al. 2014, Petty et al. 2015). Understanding these social-ecological linkages is supported by a form of historical ecology that evolved through anthropology and geography lenses (Balée 1998, Crumley 2004).

Concurrent to the evolution of applied historical ecology, historical political ecology developed as a distinct field of political ecology concerned with nature-society interactions

through time and its implication for more “socially just and environmentally appropriate” futures (Davis 2009, pg. 1). To interpret history in this way, historical political ecology investigates the way in which power, held and utilized by certain actors, contributes to modern environmental challenges (Offen 2004, Mathevet et al. 2015). Scholars of historical political ecology demonstrate that the tendency for centralized, government actors to hold sole decision-making power in environmental contexts is a result of power that has accumulated over time – stressing the importance of the historical context to overcome entrenched power (Offen 2004, Davis 2009, Mathevet et al. 2015). Importantly, historical political ecology shares three key principles with historical ecology, including (1) the attention to change over time, (2) the deep focus on a particular social-ecological case study, and (3) the use of multiple forms of knowledge or data (Offen 2004, Davis 2009). These three principles underscore the interdisciplinary, long-term, case-study approach taken in my research.

1.5 Methodology

1.5.1 Case study research design

In this dissertation, I employ a case study research design undertaken through mixed methods because of its strength connecting quantitative and qualitative inquiry into a single research design (Yin 1994, Creswell 2014). This research approach is underpinned by both a pragmatic (problem-oriented) and transformative (social justice) philosophical worldview (Creswell 2014) given the urgency of the modern fire challenge and the unequal distribution of power (e.g., in favor of colonial governments over Indigenous communities) that continues to influence decision-making. The mixed-methods, case study approach also lends itself to overcoming the intellectual dichotomies and knowledge silos, which is imperative for addressing the complex fire challenge (Roos et al. 2016, Smith et al. 2016) while accounting for multiple epistemologies and sources of knowledge (Tengö et al. 2014, Blythe et al. 2017, Stone-Jovicich et al. 2018). Importantly, this approach addresses a key criteria for ensuring research validity (Maxwell 2013) through triangulating multiple sources of knowledge and types of data while respecting the validity of individual sources (Tengö et al. 2014). Each chapter focuses on internal generalizability, or ensuring the case is thoroughly

understood based on the variables of interest, at the appropriate geographical scale (provincial to local) through strategies such as data saturation (Small 2009) and closeness to data through grounded theory (Charmaz 2006), particularly in Chapters 2 and 3.

1.5.2 Collaborative research design

A primary tenet of transformative research is collaborative and participatory processes that are built into the research design (Kemmis and Wilkinson 1998, Creswell 2013). Particularly for Chapters 3 and 4 that focus at the local scale on Indigenous stewardship and resilience, our collaborative research approach incorporated elements of decolonizing methodologies (Smith 2012) and participatory research (Runk 2014, Datta et al. 2015), including trust-building and empathy, collaborator empowerment, upholding spiritual and relational knowledge, supporting a political stand, and researcher accountability. This collaborative research approach followed ethical standards through free, informed, and ongoing consent (CIHR et al. 2014) through formal processes including a University of British Columbia Behavioural Research Ethics Board certification (H18-00779) and a signed Memorandum of Understanding between the researchers, Williams Lake Community Forest, and Williams Lake First Nation. In addition, I actively engaged with community research partners over the course of five years (ongoing since 2016) through living nearby for approximately six months, attending ten community meetings and seeking ongoing guidance on the research design, results, and interpretation from representatives of the Williams Lake First Nation and managers of the Williams Lake Community Forest. These processes helped to ensure appropriate (non-extractive) research relationships and follow best practices for engagement with Indigenous collaborators (Stevenson and Natcher 2009, Datta et al. 2015, Ban et al. 2018). Furthermore, these collaborative processes included multiple validity strategies (Maxwell 2013), including prolonged engagement with research partners (Stevenson and Natcher 2009, Smith 2012), flexibility and reflexivity in the research approach (Smith 2012) and peer review (Runk 2014), member checking (Tengö et al. 2014) and external audits (Smith 2012) by research partners.

A key element of successful collaborative research is identifying and clarifying researcher bias (Maxwell 2013) through reflection on one's positionality (Sultana 2007) – imperative for recognizing and addressing potential power imbalances between the

researcher and collaborators. A positionality statement situates the research approach and outcomes through researcher transparency – essentially the personal lens through which the research occurred. I am a non-Indigenous *semé7* (white person) settler in British Columbia with formal education in post-positivist natural sciences. As an outsider with privilege coming into the community for the first time in 2016, I carefully worked to minimize my power through listening and learning from community partners and allowing space for reflexivity throughout the research process. While at times an extremely steep learning curve, this approach was imperative especially after the 2017 wildfire season in British Columbia during which myself and my research team, and eventually my community partners, were evacuated. Although I witnessed the anxiety and fear experienced by people whose families, homes and livelihoods were threatened, I again felt the privilege at being able to evacuate back to my home in Vancouver. In response, the pace and focus of my research was heavily altered as the communities sought new ways to aid their ongoing recovery. This experience, as an outsider to the community who also witnessed the 2017 fire season, was an opportunity for both personal and professional growth and continues to shape the ways in which my research has unfolded in response to community needs.

1.6 Overview of dissertation

Chapter 1 presented here is the introduction to the dissertation and sets the theoretical and methodological context for the following three data chapters. Chapter 2 addresses Research Question 1 on the history and future of fire governance in BC. Chapter 3 addresses Research Question 2 on how Indigenous knowledge is conceptualized in a fire-based social-ecological system. Chapter 4 addresses Research Question 3 on how fire governance has influenced the fire regime in a dry forest ecosystem. Finally, this dissertation concludes with Chapter 5 which outlines the key insights and contributions, areas for future research, and final reflections.

Chapter 2: Transforming fire governance in British Columbia, Canada: Reimagining stewardship to overcome constraints on change

2.1 Introduction

Globally, 21st century fire seasons are revealing the inadequacy of conventional ‘command and control’ (Holling and Meffe 1996) models of fire governance that prioritize reactive, rather than proactive, fire management (Smith et al. 2016, Steelman 2016, Tedim et al. 2019). In response, transformative change is needed towards fire governance that aims to better coexist with fire (Moritz et al. 2014, Higuera et al. 2019, McWethy et al. 2019, Tedim et al. 2019). Such calls for transformation are catalyzed by fires that increasingly threaten human lives and livelihoods (Bowman et al. 2013), exacerbated by climate change (Jolly et al. 2015) and shifting land use (Bowman et al. 2011). While new governance models have been proposed (Steelman 2016, Tedim et al. 2019), existing research has yet to adequately consider how potential transformative pathways may be enabled or constrained by legacies of historical fire governance.

Charting transformative pathways for fire governance requires attention to history because modern environmental challenges are deeply rooted in the outcomes of contested decision-making (Offen 2004, Mathevet et al. 2015). In the fire context in western North America, for example, historical policies of fire suppression imposed by colonial government actors (and contested by Indigenous peoples) had unintended ecological consequences, resulting in a build-up of hazardous fuels which in turn increases fire risk and decreases forest resilience (Stephens et al. 2013, Hessburg et al. 2019). Historical governance includes a suite of attributes that influence environmental actions and outcomes, including institutions (e.g., laws), structures (e.g., organizations or actors) and processes (e.g., decision-making and knowledge) (Lemos and Agrawal 2006, Bennett and Satterfield 2018). The interaction of these attributes through time is also key; certain organizations or actors can accumulate power by implementing governance attributes that reinforce their authority (Mathevet et al. 2015). In environmental contexts, centralized government (often colonial) actors tend to wield the most power and authority (Lemos and Agrawal 2006, Armitage et al. 2012, Cockerill and Hagerman 2020). An historical lens that considers how actors came to power, and the injustices of excluding diverse actors from decision-making, helps identify more

“socially just and environmentally appropriate” futures (Offen 2004; Davis 2009, pg. 1) – a key need for transforming fire governance.

Despite growing awareness of the linked social-ecological dynamics of fire (Moritz et al. 2014, Spies et al. 2014, Fischer et al. 2016, Smith et al. 2016), governance continues to receive little, if any, attention (Schultz et al. 2019, Tedim et al. 2019), especially as it relates to power and history. Recent research highlights that governance needs further consideration because the future of fire is inevitably linked to preferences of certain actors (Higuera et al. 2019, McWethy et al. 2019). These preferences are situated within a social and political context in which certain powerful actors are more likely to influence outcomes. Acknowledging that current governance models are unlikely to incorporate preferences of less powerful actors, some scholars have proposed “anticipatory” (Steelman 2016), “shared” (Tedim et al. 2019), or “polycentric” (Kelly et al. 2019) fire governance that embraces diverse actors and forms of knowledge. To achieve these proposed models in practice, however, it is imperative to first understand (and overcome) historical governance attributes that may make transformation untenable.

Lessons from environmental governance suggest that a key constraint on transformation is institutional or organizational rigidity (Farrelly and Brown 2011, Chaffin et al. 2016). Organizational rigidity is a manifestation of the path-dependency of entrenched power, whereby certain actors maintain the status quo (Offen 2004, Westley et al. 2011, Chaffin et al. 2016). In the case of the United States Forest Service (a primary decision-maker on federal land), organizational rigidity constrained two siloed sub-organizations responsible for forestry and fire because of conflicting definitions of the fire problem (Schultz et al. 2019). To overcome entrenched power and rigidity, historical political ecology (Offen 2004, Davis 2009) and environmental governance (Jasanoff and Martello 2004, Armitage et al. 2012) disciplines suggest re-distributing power to community-based actors - a primary tenet of proposed models of governance for coexisting with fire (Moritz et al. 2014, Fischer et al. 2016, Tedim et al. 2019). Importantly, redistribution of power ideally redresses historical and ongoing injustices, such as those experienced by Indigenous peoples who are marginalized from environmental (Agrawal et al. 2008) and fire governance (Eriksen and Hankins 2014, Lake and Christianson 2019). Understanding transformative governance requires attention to both a focal scale of interest and the appropriate social-ecological and

temporal scales that influence opportunities for transformation (Offen 2004, Hagerman et al. 2010, Cockerill and Hagerman 2020).

2.1.1 Study context

Fire governance is understudied in Canada, where command and control governance relies primarily on reactive fire suppression objectives managed by provincial governments (McGee et al. 2015, Tymstra et al. 2020). Catastrophic fire seasons are increasingly exceeding fire suppression capacities, a trend expected to continue under climate change (Stocks and Martell 2016, Wotton et al. 2017, Tymstra et al. 2020). This fire governance challenge is underpinned by thousands of evacuations annually (Beverly and Bothwell 2011), many of which disproportionately affect Indigenous communities (Christianson 2015, McGee et al. 2019, Zahara 2020). In one case, recent catastrophic fire seasons in 2017 and 2018 in the western province of British Columbia (BC) prompted calls for new fire governance that prioritizes fire preparedness and prevention objectives and redistributes decision-making power to Indigenous and local communities (Abbott and Chapman 2018, Sankey 2018).

Current land and fire governance in BC's 95.2 million hectares - all of which is adapted to periodic fire (Wong et al. 2003, Hoffman et al. 2017) - is complex and contested (Caverley et al. 2020). Across ~95% of BC, treaties with First Nations² were never negotiated and today they are actively contesting sovereignty over their unceded lands (Borrows 2017, Wilson 2019). Since time immemorial, First Nations have stewarded the lands using fire according to their own forms of governance (Gottesfeld 1994, Lewis et al. 2018, Lake and Christianson 2019, Verhaeghe et al. 2019). The colonial land governance system, imposed when BC became a province in 1871, now classifies ~94% of land as provincial "Crown land," of which about two-thirds is forested. The remainder is private (4.9%), federal Crown (1%), and First Nations Treaty and Title (0.2%) lands (MFLNRO 2011). Despite contested land sovereignty, decision-making power in BC is currently held by

² The Constitution of Canada recognizes three groups of Indigenous peoples, including First Nations, Métis, and Inuit. First Nations were the primary land holders prior to colonization in BC, so we use First Nations unless specific sources or statements refer to Indigenous peoples more broadly.

the provincial government. As part of the provincial government, the BC Wildfire Service³ is mandated to oversee wildfire management⁴ on provincial Crown land, federal Crown land, local government land on request of the local government, Treaty Settlement lands, and private lands. The BC Wildfire Service is divided into six Fire Centres (Figure 1.1). These Fire Centres are roughly contiguous with the Ministry of Forests, Lands, Natural Resource Operations and Rural Development (hereafter Ministry of Forests⁵) Regions. The BC Wildfire Service was embedded within the Ministry of Forests at the sub-regional (district) level until 1995 at which time it began operating at the provincial level. Since 2017, the BC Wildfire Service has been slowly reintegrating into the Ministry of Forests Natural Resource Operations Regions.

Between 1998 and 2018, ~3.4 million ha (~8.4 million acres) burned in BC, including six seasons with significant wildland-urban interface (WUI) fires that forced evacuation of ~125,000 people. Total suppression costs during these six fire seasons were over \$2.6 billion CAD (adjusted for inflation to 2020 dollars; Figure 2.1), accounting for over one-third of suppression costs since records began in 1912 (BC Wildfire Service 2021, Public Safety Canada 2021). Total indirect costs to livelihoods are much higher (Sankey 2018, Johnston et al. 2020). The 2017 fires burned a record area of 1.2 million ha (surpassed in 2018 when 1.35 million ha burned), of which ~73% was in the Cariboo Fire Centre (hereafter, the Cariboo). Until Covid-19, the 2017 fire season prompted the longest provincial state of emergency lasting 70 days, during which 65,000 people were evacuated, including 26 First Nations communities (Abbott and Chapman 2018). In consultation with fire-affected communities, an independent review in response to the 2017 fire season called for strategic changes to fire governance to minimize the impacts of future fires (Abbott and Chapman 2018).

³ The BC Wildfire Service is the organization name as of publication. We use BC Wildfire Service throughout; however, it has undergone multiple name changes through time, starting as the Forest Protection Division (1912), then the Protection Branch (1978), then the Wildfire Management Branch (2010).

⁴ We use the definition of ‘wildfire management’ from the Canadian Wildland Fire Management glossary (2017) which encompasses all activities relating to wildfire prevention, preparedness, response, and recovery objectives.

⁵ The Ministry of Forests, Lands, Natural Resource Operations and Rural Development (Ministry of Forests) is the organization name as of publication. We use Ministry of Forests throughout; however, it has undergone multiple name changes through time, starting as the Forest Branch (1912), then the Forest Service (1945), and was elevated to a ministry in 1978.

The aim of this study is to trace historical fire governance attributes in BC, identify key factors driving change, and to understand how historical governance attributes may enable or constrain implementation of proposed transformative changes. The governance attributes of interest include actors, decision-making power, objectives, strategies to achieve objectives, legislation, and worldviews of fire. While the primary scale of interest is the province of BC and the Cariboo, we recognize that governance attributes and drivers of change exist at multiple scales. Thus, we consider how the broader (Canadian and international) and finer (local) scales interact with the key attributes through time.

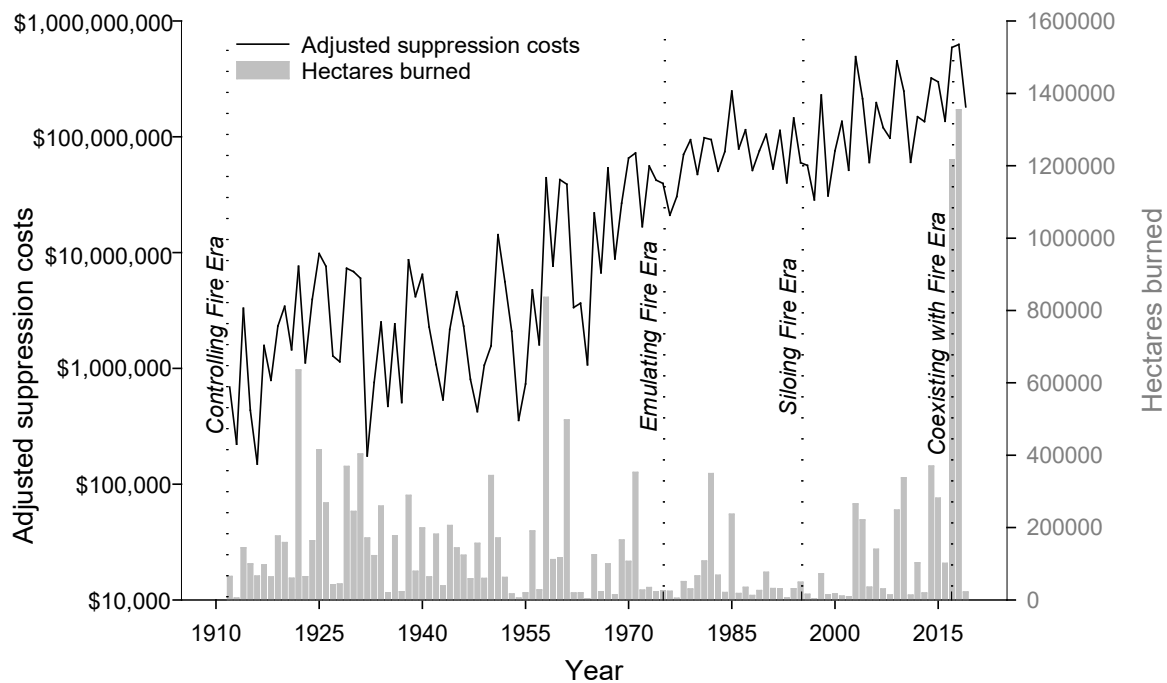


Figure 2.1: Adjusted (for inflation to 2020) fire suppression costs (note logarithmic scale) in Canadian dollars (black line) and hectares burned (grey bars) in British Columbia from 1912–2019.

Data from BC Wildfire Service Annual Reports, compiled and provided by John Parminter and confirmed by Arial Eatherton.

2.2 Methods

We take a case study approach (Creswell 2013) to address three specific questions: (1) How has fire governance in BC changed through time? (2) What drivers have shaped fire governance through time? (3) What do fire experts envision for the future of fire governance

in BC and to what extent do current governance attributes support this vision? Our analyses draw on two sources of data: (1) historical documents and (2) in-depth, semi-structured interviews. Systematic coding was undertaken in NVivo software (12.6.0 2020) using a combined deductive (identifying specific governance attributes of interest) and inductive approach (identifying emergent themes) (Coffey 2013).

All documents written by provincial or federal authorities with stated objectives on fire in BC from 1874 to 2020 were analyzed for a total of 157 documents (13,339 pages). These included provincial forestry reviews (n=7); annual reports (n=110) and strategy documents (n=5) of the BC Wildfire Service; research reports of the provincial forestry research program (n=36); provincial fire season reviews (n=2); federal forestry or fire strategy documents (n=4); and provincial fire legislation (n=4). Coding also captured information about the social-political context within which documents were produced, such as the purpose and potential biases (Bowen 2009, Coffey 2013). We note that these provincial and federal documents are inherently biased and do not reflect the perspectives of non-government (e.g., First Nations or local community) actors (Bowen 2009, Coffey 2013).

Complementing document analysis, we conducted 19 semi-structured interviews (Holstein and Gubrium 1995, Schensul et al. 1999) with fire experts that have direct knowledge of fire governance in BC. Interviews were conducted between 2019 and 2020 to explore historical attributes and visions for the future of fire governance (Appendix B), and thus the results presented here do not reflect the challenges, losses, and lessons learned from the 2021 fire season. Experts were defined as fire or forestry practitioners within provincial government organizations (the Ministry of Forests or BC Wildfire Service) or in roles directly related to fire outside government (e.g., consultants or other non-governmental organizations, hereafter NGOs). Interviewees were selected through a combined stratified purposeful and snowball sampling approach (Palinkas et al. 2015) until saturation of key themes was met (Small 2009). Interviewees included 11 provincial experts, of which five represented NGOs. Eight Cariboo regional experts were also interviewed to capture recent experiences during the 2017 fire season, including interviewees affiliated with the BC Wildfire Service (four), Ministry of Forests (three), and an NGO (one). Interviews were audio-recorded with permission and transcribed (for a total of 328 pages). To preserve

confidentiality where requested, interviewees are referred to by number (e.g., Expert #1); otherwise, interviewees are referred to by their affiliation and a number (e.g., BCWS #2).

2.3 Fire eras in British Columbia

Since 1912, the BC provincial government has been the primary decision-making authority that implements objectives, strategies, and legislation around fire. Embedded in these governance attributes is the worldview of fire as destructive to timber, in contrast to the worldview of fire as beneficial held by First Nations practicing fire stewardship for millennia prior. In response to the 2017 and 2018 fire seasons, experts share a renewed vision of stewardship that embraces diverse actors and worldviews of fire into decision-making processes. Despite this shared vision, organizational rigidity, underpinned by entrenched power, and siloed expertise between fire and forestry organizations, are key constraints on transformative change. Nevertheless, changes made since 2017 are intended to actively overcome these constraints. We present our analysis in five distinct governance eras that are delineated based on changes to actors with decision-making authority, worldviews, objectives and strategies, and legislation (Figure 2.2).

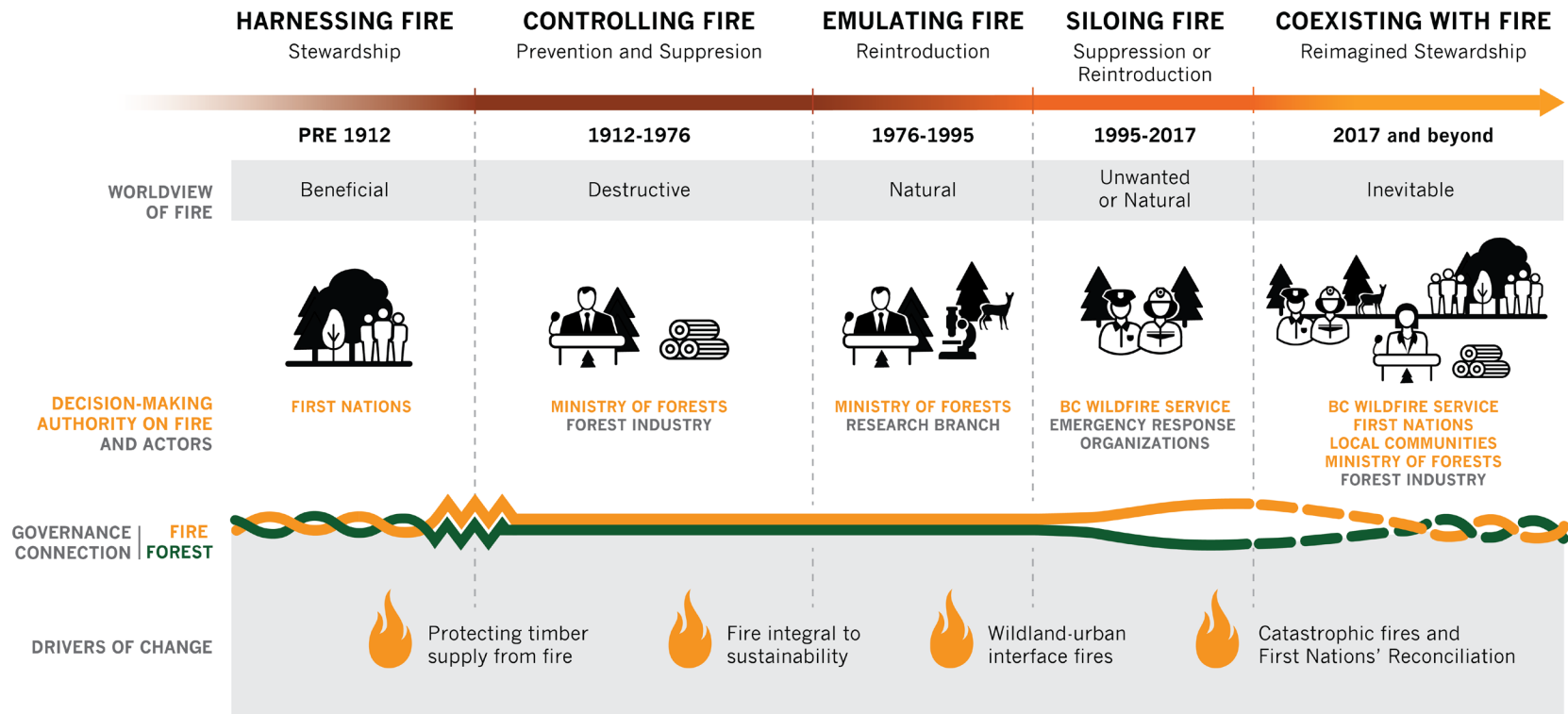


Figure 2.2: Fire governance eras in British Columbia, Canada.

2.3.1 Harnessing fire (pre-1912)

Prior to the formalization of colonial authority over fire in the 1912 BC Forest Act, First Nations actors harnessed fire under their own systems of governance for a variety of cultural, spiritual, and ecological objectives. These systems of governance reflected a worldview of fire as beneficial (Turner et al. 2000, Huffman 2013, Lewis et al. 2018, Lake and Christianson 2019), although experiences with fire varied and burning practices were not universal (Lake 2013). Referring to practices prior to 1912, the Ministry of Forests noted that First Nations “*burned the forest every year to ‘light the salmon up the Fraser River,’ as well as to improve hunting*” (Province of BC 1914, pg. 82). Early settlers, likely emulating First Nations practices, similarly held the worldview that “*fire was more beneficial than otherwise*” (Whitford and Craig 1918, pg. 126). They perceived it as a “*natural accompaniment to the routine of progress and development*” (Fulton 1910, pg. 59) and intentionally set fires for land clearing and agriculture.

In contrast to early settlers, federal and provincial government actors sought progress by denying the benefits of First Nations’ fire stewardship in colonial documents. The colonial BC government began to institutionalize their worldview of all fire as damaging or destructive to timber by passing the Bush Fire Act in 1874, which focused on fire prevention objectives through strategies such as financial penalties for setting fire and prohibiting burning except by permit (Parminter 1981). Although the Bush Fire Act did not apply to the entire province until 1887, it marked the transition towards a colonial system of fire governance that superseded First Nations fire governance in BC, mirroring colonial suppression of Indigenous fire across North America (Murphy et al. 2007, Lake and Christianson 2019, Nikolakis and Roberts 2020). This transition towards colonial governance was achieved through the establishment of Indian Reserves and Residential Schools by the federal Indian Act, pre-emption policies restricting First Nations’ access to land, and the smallpox epidemic that killed up to two-thirds of First Nations peoples in BC (Caverley et al. 2020).

As timber emerged as “*the most valuable asset in the hands of the Government*” (Fulton 1910, pg. 67), the colonial government objective of fire control became “*the supreme need of [BC’s] forests*” (Fulton 1910, pg. 60). At the end of the *Harnessing Fire* era, the Bush Fire Act “*lacked an adequate organization for enforcement*” and the fire wardens who

held decision-making authority for fire control were considered “*ineffective and subject to...ridicule*” because of their limited access and numbers (Whitford and Craig 1918, pg. 126). Recognizing this inefficiency, and driven by colonial worldviews of fire, the Royal Commission of Inquiry on Timber and Forestry in 1910 advocated for a single fire objective, stronger legislation, and a new organization to enforce it:

“*we have in mind the active **prevention** of fire by the systematic work of a well-knit [government] organization...That the timber, upon which our whole future as a lumber-producing country depends, should be left...under the imminent menace of fire so heavy...is so absurd...that regulation is imperative*” (Fulton pg. 65, emphasis in situ).

Despite First Nations harnessing the benefits of fire for millennia, colonial actors, worldviews, and legislation introduced in 1912 forcibly limited First Nations fire stewardship into the 20th century (Lake and Christianson 2019).

2.3.2 Controlling fire (1912-1975)

The *Controlling Fire* era cemented colonial dominance of fire governance through the creation of the Ministry of Forests by the Forest Act in 1912. The Forest Act enshrined the worldview of fire as a “*common enemy*” of the timber industry actors who were the “*commercial backbone*” of BC (Province of BC 1914, pg. 57). Because of the “*perceived – real or not – timber shortage*” (NGO #14), fire control became the central objective for ensuring continued timber supply through the “***prevention** of forest fires [and] the **fighting** of those that have been allowed to spread*” (Fulton 1910, pg. 59, emphasis in situ). Fire control was also needed to prevent destruction of new communities, a need clearly demonstrated by the Fernie Fire in 1908 that killed over 100 people. Three interrelated objectives – fire control through prevention and suppression – dominated this era and reflect the command and control fire governance model that prevailed across colonial North America (Folke 2006, Smith et al. 2016, Minor and Boyce 2018).

To achieve fire control objectives, the Ministry of Forests required new legislation and compliance of a broad range of actors: “*to be effective, a forest protection service must be supported by [1] comprehensive legal authority [and 2] close co-operation of all the allied interests*” (Whitford and Craig 1918, pg. 129). The 1912 Forest Act was the legal authority that mandated the Ministry of Forests, who oversaw the BC Wildfire Service, to

control fire on provincial Crown land, excluding ~6 million ha of lands that were protected by the Dominion Forestry Branch until 1930 (Parminter 1981). The Forest Act also gave the Ministry of Forests authority to enforce fire prevention objectives through strategies such as financial penalties and jail time for members of the public who “*wilfully set fire*” without a burn permit or refused to provide firefighting assistance (Province of BC 1914, pg. 90). These strategies disproportionately affected Indigenous peoples, who attempted to continue their fire stewardship practices but were forced to uphold colonial worldviews and objectives (Christianson et al. 2013, Eriksen and Hankins 2014). For industry actors, the Forest Act mandated broadcast burning in the Vancouver Forest District, a universal fire prevention strategy used to minimize the “*slash evil*” left after logging (Province of BC 1913, pg. 13). By the end of this era, however, the use of this prevention strategy waned in the Vancouver District until the Report of the Commissioner (Sloan 1945) recommended that it no longer be compulsory related to industry concerns over cost and liability.

To ensure “*co-operation of all the allied interests*,” (Whitford and Craig 1918, pg. 129), the Ministry of Forests relied primarily on “propaganda” to raise awareness to public and industry actors for fire prevention objectives: “*The number of fires started by [the public] is still far too high, but...we may confidently assume that our propaganda is bearing fruit*” (Province of BC 1920, pg. 23). This propaganda was developed to remind people of their “*obligation to assist the Government in preventing fires*” (Province of BC 1914, pg. 90) and evolved from fliers and radio advertisements to signage on highways throughout the era. Combined, these strategies further engrained the colonial worldview of fire as destructive to the broader public.

While provincial government actors relied on allied interests to ensure fire prevention objectives, the BC Wildfire Service was the actor primarily responsible for the fire suppression objective once ignitions occurred. They desired to be:

"an organization so equipped and manned that every fire is spotted immediately [when] it starts and is extinguished... Every holocaustic conflagration is, in its incipency, small enough to be crushed beneath a man's heel" (Sloan 1945, pg. 131).

To successfully ‘crush’ every fire, the Forest Act introduced the Forest Protection Fund. Initially, the fund required equal financial contributions from timber-owners and the province, although it was replaced with an annual government appropriation by the end of

this era. The fund invested in two strategies, including fire suppression personnel and equipment (Parminter 1981), colloquially (and paternalistically) referred to as “*the boys and the toys*” (NGO #11; BCWS #13). Organizationally, the “boys” or fire suppression personnel were embedded in the Ministry of Forests in regional districts. The “toys” were developed in collaboration with research-based actors such as the Canadian Forest Service, and eventually included the province-wide weather network that supported the application of the Canadian Forest Fire Danger Rating System (Stocks et al. 1989, Coogan et al. 2020) and the aerial attack fleet which was implemented after proving its utility during World War II.

Although the Ministry of Forests continued to promote the worldview of fire as destructive throughout this era, by the early 1970s, an alternative worldview of fire as natural began to emerge: “*Mother Nature puts nutrients back into the soil by the use of fire*” (Province of BC 1974, pg. 37). This new worldview of fire heralded a shift in fire governance that provided decision-making authority to new actors outside of the Ministry of Forests, embedding complex and contrasting worldviews in emerging objectives.

2.3.3 Emulating fire (1976-1995)

After more than half of century of increasingly effective fire control, the Royal Commission on Forest Resources in 1976 acknowledged that “*controlling fire and other **natural** forces*” was permanently changing ecosystems in BC (Pearse, pg. xv, emphasis added). One interviewee described this transition in BC: “*We go back to when the [Ministry of Forests] was born and the primary objective was timber production and to...put out fire...that management philosophy I think failed...because the natural process was stopped*” (NGO #19). This new worldview of fire as natural, which recognized “*the historical relationship between fire and the major ecosystem types*” (Province of BC 1981, pg. 107), emerged through the lens of enhanced wildlife protection, advances in ecosystem classification in BC, and a paradigm shift in ecological theory that acknowledged disturbance as integral to ecosystem sustainability (Hagerman et al. 2010, Turner 2010, Coogan et al. 2020). Reflecting this worldview shift, a new objective of reintroducing fire was established that required collaboration with actors outside of the Ministry of Forests.

To concurrently achieve the new objective of reintroducing natural fire, the Ministry of Forests worked with the “*forest, ranching and wildlife industries...and the Ministry of*

Environment,” who retained authority over wildlife and parks (Province of BC 1989, pg. 15). Organizationally, balancing the conflicting objectives of fire control and reintroducing natural fire was perceived as straightforward because decision-making authority for fire and forests ultimately rested with the Ministry of Forests district manager who was a “*specialist in a smaller geographic area*” (BCWS #6). For example, prescribed fires set under planned conditions were a key strategy that helped reintroduce fire for ecosystem benefits and helped fire control objectives by removing hazardous fuels. Because the objective to reintroduce fire contrasted the previous fire control objective, public education campaigns supplemented fire control messaging to “*explain the importance of fire and fire management to forest and range resources*” (Province of BC 1983, pg. 14).

Collaborating with two key actors outside of the provincial government helped incorporate a worldview of fire as natural. First, the Canadian Forest Service, in collaboration with the Ministry of Forests, undertook research to advance computer-assisted decision-making for “*whether or not to let a wildfire burn*” based on fire behavior and known values, a strategy known as modified or appropriate response or managed fire that continues today (Province of BC 1980, pg. 87; Tymstra et al. 2020). Second, forest industry licensees employed silvicultural strategies to emulate the effects of fire on forest structure. For example, fire was called the “*natural counterpart of clear-cutting*,” justifying clear-cutting as a primary forest management technique (Pearse 1976, pg. 281).

Despite the emphasis on reintroducing and emulating natural fire, the BC Wildfire Service continued to focus on its fire control objective from the *Controlling Fire Era*, self-identifying as a “*world leader in fire control and suppression*” (Province of BC 1994). Fire regulations (1981 and 1992) during this era clarified liability (especially compensation) around fire control objectives for industry actors. In addition, the Ministry of Forests Act (1979) required BC Wildfire Service to set a fire control target for area and volume of timber burnt annually. This target, and the half-century of ‘successful’ fire control during the previous era, created and perpetuates a dangerous expectation that complete fire control is possible: “[*The public*] expect government to be able to do everything they can to save us with suppression, and the reality is, we’re never going to be able to suppress Mother Nature” (NGO #18).

By the end of the *Emulating Fire* era, the worldview of fire as natural was embedded in the 1995 Biodiversity Guidebook, which guided the efforts of multiple government and industry actors to achieve objectives of reintroducing fire. However, these objectives diminished in priority as growing concerns over wildland-urban interface (WUI) fires, smoke, and climate change reemphasized the fire control objective and largely eliminated the strategies of broadcast and prescribed burning. The 1994 wildfire season, which was “*marred by the tragic loss of 18 homes in B.C.'s worst interface fire ever*” (Province of BC 1995), foreshadowed the emergence of catastrophic fire seasons as a key driver of change during the next era. It catalyzed an organizational shift that disconnected the BC Wildfire Service from the Ministry of Forests at a time when new actors (such as emergency response personnel and local communities) created complex fire governance issues.

2.3.4 Siloing fire (1995-2017)

In this era, the worldview of fire as natural continued, but needed to be balanced against the worldview of fire as unwanted where it negatively affected values: “*Fire is a natural and essential ecological process...however, it can also have undesirable social and economic impacts.*” (Canadian Council of Forest Ministers 2005, pg. 1). From the BC Wildfire Service perspective, the ability to prevent undesirable impacts was constrained by a lack of provincial oversight of resources since only “*the district manager could determine if people could respond or not*” (BCWS #13). The district manager was responsible for all forestry (and fire) objectives in a district and could prevent personnel from traveling to other districts to control fire elsewhere. To remedy this lack of provincial oversight, the BC Wildfire Service became a stand-alone organization in 1995. Referred to as the “*big divorce*” (NGO#18, BCWS #12), this separation divided fire and forest actors into silos with contrasting worldviews and objectives of fire: “*the forest sector went and did forestry and the fire people went and did fire*” (BCWS #10). The Ministry of Forests continued the objectives of reintroducing or emulating natural fire, while BC Wildfire Service returned primarily to fire control objectives: “*we became a fire department and we waited for the alarm to go, we went and put out the fire, and then we came back to the station...[we became] disconnected to land management decisions*” (BCWS #12). These organizational silos created uncertainty over the

responsibility of different actors to address a key driver of change during this era: catastrophic fire seasons.

The “2003 Firestorm” was a catastrophic fire season that forced evacuation of over 45,000 people and demonstrated that relying on fire control as practiced in previous eras was inadequate: *“There was never a fire that didn’t have enough resources. And then all of a sudden, in 2003, we had more fire than we had resource availability”* (BCWS #6). A subsequent independent provincial review into the causes and consequences of the 2003 Firestorm (the Filmon Report) acknowledged that the ‘success’ of fire control objectives since 1912 contributed to the widespread negative impacts. The Filmon Report urged the *“concentration of resources and effort on issues that anticipate, prevent and prepare for disasters”* (2004, pg. 76). Another contributing factor was the silos created by the ‘big divorce,’ after which *“decisions [were] made by one group without necessarily considering the implications for the other”* (Filmon 2004, pg. 32). Ultimately, the Filmon Report made several key recommendations to overcome these silos through ‘shared responsibility’ with actors that had not yet been part of fire decision-making processes.

A key new actor was local communities who were acutely vulnerable to WUI fires. A new funding source was developed to support communities achieve fire prevention objectives through Community Wildfire Protection Plans and hazard reduction in the WUI. The funding was administered by new actors in fire, the Union of BC Municipalities and the First Nations Emergency Services Society (FNESS). FNESS’ inclusion, who *“had a seat at the table right from the [funding] design”* (NGO #19), mirrored the broad shift in BC toward (re)instating First Nations’ decision-making power and sovereignty over land (e.g., *Delgamuukw v British Columbia*, 1997 3 SCR 1010). Despite many barriers faced by communities successfully accessing the funding (Ravensbergen et al. 2020, Copes-Gerbitz et al. 2020), the new funding source provided an important foundation for decision-making authority by communities that had not existed since colonial dominance of fire started in the *Harnessing Fire* era.

After the 2003 Firestorm, the province introduced internal and external structures to help all actors understand their roles and responsibilities undertaking multiple fire objectives. First, the new Wildfire Act and Regulations (2004) aimed to improve accountability and clarify liability, especially for forest industry actors. This legislation intended to provide

“greater regulatory freedom for the forest industry” (Province of BC 2003, pg. 42). In doing so, however, it created more *“gray areas”* where the BC Wildfire Service had less authority over strategies such as logging and slash removal that supported fire prevention objectives (BCWS #13) - further entrenching the forest-fire governance silo. Second, the BC WUI Consequence Management Plan agreement was signed by multiple provincial actors including the BC Wildfire Service, Ministry of Forests, the Provincial Emergency Program, the Office of the Fire Commissioner, Emergency Management BC, the Ministry of Public Safety, and the Solicitor General. This agreement aimed to guide prevention and suppression objectives on WUI fires but blurred lines of responsibility among the signatories. Third, an internal-to-government ranking exercise was conducted to identify response priorities. In ranked order, these are: protecting human life and safety; protecting community and critical infrastructure; mitigating impacts on areas with high environmental values; and maintaining natural resource values (BCWS #13; MFLNRO 2012 pg. 8). Multiple actors working simultaneously increased the complexity of fire governance in BC, as contrasting worldviews and objectives were implemented in different places.

During this era, recognizing that they were increasingly *“becoming out of touch with land management decisions”* (BCWS #12), BC Wildfire Service called for a *“strategic shift”* to prioritize proactive objectives and overcome the silos that were created by the ‘big divorce’ (Province of BC 2010, pg. 4). Despite these stated intentions, subsequent significant WUI fire seasons in 2009, 2010, and 2014 demonstrated that progress towards prioritizing proactive objectives was *“slower and more costly than originally envisioned”* (Canadian Council of Forest Ministers 2016, pg. 5), with *“disappointingly little progress on the goal of enhanced community safety”* (Abbott Chapman 2018, pg. 7). From the BC Wildfire Service perspective, it took the fire seasons of 2017 and 2018 to highlight just how damaging these silos had become:

“we knew our connection with communities, with industry, and internally was starting to be strained and distant...we finally hit the inflection point in ’17 and ’18 where we didn’t have the relationships and it created a whole bunch of tension at the worst possible time” (BCWS #12).

Following this inflection point was a collective vision for (re)building relationships internally within the Ministry of Forests and BC Wildfire Service, externally with diverse actors, and a return to some of the objectives and worldviews of fires of previous eras.

2.3.5 Coexisting with fire (2017 and beyond)

The catastrophic 2017 and 2018 fire seasons introduced a new worldview: fire as inevitable. Although many actors within BC Wildfire Service “*knew it was a matter of time*” (BCWS #3) until a fire season of the 2017 magnitude occurred,

“the perspective of [the Ministry of Forests] and the forest industry was significantly shifted in terms of recognizing that those kind of fire seasons back-to-back are...part of our world moving forward” (BCWS #10).

Similarly, interviewees from the Cariboo noted a marked shift in public perception of the modern risk of fire: “*it opened people’s eyes as to the real risk out there; having people really running for their lives in some cases*” (MFLNRORD #7). These shifting perspectives towards recognizing the inevitability of fire among government, industry, and public actors prompted urgent calls (again) for prioritizing proactive objectives. One interviewee worried about the potential future impacts if transformative change does not occur:

“if things haven’t changed after [2017 and 2018] drastically in how we manage fire, what’s it going to take? One, a community burning down and two, fatalities. Because really, 2017 and 2018 were mind-blowing seasons” (Expert #1).

Following the 2017 fire season, a new vision for coexisting with fire emerged as a focal point for transformative change in fire governance. The vision for coexisting with fire put forward by interviewees, and shared by recent documents, centered on the provincial organizations strengthening their collaborations: “*following 2017 there was the opportunity to start to create some additional focus around [internal and external engagement with partners]*” (BCWS #8). Similarly, the 2018 Flood and Fire Review identified the need for community (First Nations and local) actors to have more decision-making authority since the “*the overwhelming majority of respondents indicated a need to incorporate local knowledge...into wildfire planning*” (Abbott and Chapman 2018, pg. 59). Increased decision-making authority for First Nations and local community actors is critical for coexisting with fire because it acknowledges that “*every British Columbian has a role*” (BCWS #12) and

helps build and leverage the ‘social license’ needed to undertake proactive objectives (BCWS #4, BCWS #8, NGO #15, Copes-Gerbitz et al. 2020). Despite this stated vision, interviewees agreed funding is inadequate to meaningfully address the inevitability of wildfire (NGO #15) and must be increased from several million dollars to “*potentially several billion dollars over the next 5–10 years*” (Expert #17).

Mirroring a key finding from the independent 2018 Flood and Fire Review, interviewees stressed that coexisting with fire requires sharing decision-making power with First Nations - the primary actors of the *Harnessing Fire* era - through reimagined stewardship. One pathway for implementing reimagined stewardship is the reintroduction of cultural burning that incorporates the worldview of fire as beneficial and natural:

“First Nations want to bring burning back. If [the BC Wildfire Service] are working with them then they can’t be stopped because [First Nations] are holding a lot of political power in the province right now...I think that’s probably the biggest collaboration to help move things forward” (Expert #3)

While all interviewees agreed that communities are central actors for enabling proactive objectives, there were varying opinions as to the spatial scale at which proactive objectives should occur. Some advocated that FireSmart initiatives to create defensible space around the home and in the WUI is the “*the best tool we can use to help public safety*” (BCWS #3). Others stressed that in addition to protecting the high concentration of values within the WUI, community protection also includes addressing fire risk at the landscape level where many communities’ livelihoods are drawn from. Across all scales, community input is key to making decisions on potential trade-offs: “[*The public*] says ‘we don’t want another season like 2017, ’18,’ so what does it look like to avoid that?” (BCWS #13). From the perspective of those interviewees outside of the BC Wildfire Service, such as those in the Ministry of Forests or NGOs, avoiding fire seasons like 2017 and 2018 will require a provincial planning strategy at the landscape scale that incorporates First Nations and public input. One interviewee described the ideal planning strategy as one that:

“causes us to create an adaptive-management framework, engage the public, recognize our goals and objectives and set out strategies and implement, learn, monitor, learn, adjust, and go forward” (NGO #2).

Currently, there is a “*huge policy vacuum around planning*” (NGO #2), but interviewees envisioned a collaborative planning process that incorporates diverse actors, including First Nations, industry, and local communities, because “*expertise is everywhere*” (BCWS #6). Collaborative planning processes that are currently being implemented (including a pilot in the Cariboo Region) aim to contrast historical efforts that were centralized and top-down: “*this isn’t the same old government process that’s been pushed down our throats for 100 and something years. This is something new...we’re actually listening*” (MFLNRORD #7). All interviews who envisioned a landscape-level planning process agreed that it needs to explicitly consider how fire interacts with decision-making on forests and lands more broadly because fire does not operate in isolation. Although the need for diverse actors was central, interviewees outside and within BC Wildfire Service agreed that a planning process should be initiated by the Ministry of Forests because they are “*experts in land management,*” with input from the BC Wildfire Service who are “*experts in fire*” (NGO #11).

To ensure that future planning incorporates diverse actors and proactive objectives, interviewees stressed it must be supported with appropriate legislation because “*what really drives change is a requirement in legislation...that is crafted [with] the involvement of key stakeholders*” (NGO #11). Commenting on the existing fire-related legislation, a provincial BCWS interviewee (#12) said: “*tell me where it addresses preparedness, and tell me what addresses response and recovery, it’s kind of mingled and it’s not clear.*” Both the Flood and Fire Review (2018) and interviewees recommended adding fire as a stated value in the Forest and Range Practices Act (FRPA), which would require forest practices to meet fire risk reduction goals in the WUI and reconnect fire into landscape decision-making. Such legislation would allow decision-makers to make trade-offs between risk reduction and other values by managing “*for fire resiliency in a community where there are multiple values; it’s not about fire over everything*” (BCWS #10). Furthermore, it could support landscape-level fire prevention objectives by “*directing industry [actors] in a compliance way to [undertake strategies] on the landscape that benefit wildfire risk reduction*” (BCWS #13). Mandating practices for forest industry actors is key because “*conventional harvesting doesn’t typically address surface and ladder fuels...and from a fire behaviour perspective, this is often the most critical piece we can address*” (BCWS #16). This approach would help overcome

challenges with the model of ‘professional reliance’ that some interviewees felt was disconnected from fire prevention objectives (BCWS #3, #12). Since 2017, there has been a strong push within BC Wildfire Service to “*continue driving policy change to keep up [as] conditions in society and values change*” (BCWS #4). Impending changes to FRPA and the Wildfire Act and Regulations will show whether this has been the case.

To adequately prepare for the inevitability of fire in the future, the Flood and Fire Review (2018) called for a return to the organizational structure prior to the “big divorce,” with BC Wildfire Service “*operationally reintegrated into regional operations*” of the Ministry of Forests (2018, pg. 94). Interviewees agreed that the “*disconnect between land management and fire that [resulted] from a culture of suppression needs to be bridged*” (Expert #1). Currently, the BC Wildfire Service and Ministry of Forests are sharing personnel through cross-training, collaborating on fuels risk reduction projects, incorporating fire science into post-secondary curriculum and incident management training, and creating pathways for knowledge exchange with university and private-sector researchers. One interviewee noted that their training in both fire and forestry helped them have a “*better idea of managing the landscape and how making decisions on fires might impact management*” (Expert #5).

In addition, both the BC Wildfire Service and Ministry of Forests have committed to prioritizing proactive objectives. For example, as of 2020, the BC Wildfire Service reports a new target of “*improve community resilience through proactive and collaborative hazard management*” (pg. 10). This target is reflected in the Cariboo Region Ministry of Forests vision, where fire is now a central theme of “*vibrant, connected and resilient communities*” (MFLNRORD #9). At the same time, some interviewees were hesitant at how much progress could be made towards proactive objectives given the dominant paradigm of forestry in BC: “*how do you shift land management from producing the next two by four to more of an ecology outlook?*” (Expert #1). Collectively, this vision for coexisting with fire - supported by diverse actors, worldviews, and objectives - relies on empowering First Nations and local community actors with funding, reintegrating fire and forestry actors to lead landscape-level planning, and updating legislation: “*this is a shared responsibility, from the provincial government all the way down to the individual homeowner...That's the only way we're going to solve it because it is so complex*” (BCWS #10).

2.4 Discussion

Our historical analysis reveals three key insights for understanding the future of fire governance in British Columbia. First, interviewees and recent strategic documents share a vision for coexisting with fire through transformational change in governance attributes, including redistributing decision-making power to diverse actors and a focus on proactive fire objectives. Second, achieving this vision - particularly when it comes to increased decision-making authority for First Nations - must contend with and overcome entrenched colonial legacies of power in decision-making that have strongly shaped fire governance in BC over the past century. Third, siloed expertise and organizational rigidity, which has constrained change through time, needs to be addressed through intentional intervention by powerful actors. We argue that enabling transformative fire governance in BC requires leveraging opportunities for change created by social drivers, including political will resulting from recent catastrophic fire seasons and reconciliation with First Nations.

2.4.1 A multi-actor vision for future fire governance

Reflecting the shift away from centralized government authority towards diverse actors in environmental governance (Martello and Jasanoff 2004, Armitage et al. 2012), experts interviewed for this study agree that other actors, including First Nations and local communities and the forest industry, must be a part of the solution. This vision aligns closely with recommendations for transformation identified in the Flood and Fire Review (2018) and an interdisciplinary white paper (Daniels et al. 2018) in BC and federal calls for transformation since catastrophic fire seasons in Canada (Sankey 2018, Tymstra et al. 2020). Importantly, this vision embraces multiple worldviews of fire (natural, unwanted, and inevitable) and thus represents a unified understanding of the complex fire challenge (Tymstra et al. 2020) - a factor important for enabling transformation (Chaffin et al. 2016, Schultz et al. 2019). Diverse actors are key for enabling a variety of proactive objectives and strategies (Tedim et al. 2019), in stark contrast to reactive fire control and suppression objectives that have dominated fire management across Canada for over a century (McGee et al. 2015, Tymstra et al. 2020).

A central component of the vision for transformed governance is a shift towards community empowerment (Filmon 2004, Abbott and Chapman 2018). Examples of strategies to encourage empowerment at the local to landscape level include homeowner preparedness initiatives such as FireSmart, WUI risk reduction (such as Community Resilience Plans, evacuation plans, and fuels treatments) within and adjacent to communities, and community input into forest management planning more broadly. The need for community expertise in forest management planning was echoed in the adjacent province of Alberta after a catastrophic fire season in 2016. Similar to BC Wildfire interviewees, fire agency managers acknowledged that planning for and prioritizing human values in a fire context was beyond their expertise (Sherry et al. 2019). Despite calls for community empowerment, experience in BC since the 2003 Firestorm (BC Forest Practices Board 2015, Ravensbergen et al. 2020) mirrors that of Australia (Lukasiewicz et al. 2017, Reid et al. 2018) where the rhetoric of ‘shared responsibility’ does not necessarily amount to meaningful devolution of decision-making power with appropriate support structures to address persistent capacity barriers. While empowering communities is a critical step towards transformation, the paucity of social science research to understand the unique perspectives and needs of both Indigenous and local community actors remains a key knowledge gap in BC (Paveglio et al. 2016, Abbott and Chapman 2018, Sankey 2018, Sherry et al. 2019, Nikolakis and Roberts 2021).

Another actor central to the vision of transformed fire governance in BC is the forest industry because they are integral to proactively addressing fire risk at the landscape scale (Lieffers et al. 2020). Given a long history of industry power in forest and fire management, interviewees and documents agreed that forest industry involvement needs to be legislated. Interviewees advocated for mandatory and somewhat more prescriptive legislation and guidelines, such as the Wildfire Act and Regulations, the Forest and Range Practices Act, and the Hazard Abatement Guidelines. Mandatory, rather than voluntary, accountability is key for compliance of market-based actors in transformative change (Lemos and Agrawal 2006). Revised legislation with clearer proactive objectives would supplement the current model of professional reliance of industry actors. This model can be problematic because the primary objective of the forest industry in BC is short-term profit maximization (Mitchell et al. 2017, Haddock 2018), which limits longer-term perspectives on broader objectives such as ecological resilience (Devisscher et al. 2021). Ultimately any legislation that addresses and

influences fire - including addressing climate change - must help industry (and other) actors navigate short- vs long-term tradeoffs of different objectives (e.g., fire suppression vs. reintroducing fire) in a way that prioritizes proactive objectives (Steelman 2016, Schultz et al. 2019, Tymstra et al. 2020).

2.4.2 Siloed expertise and organizational rigidity constrain change

Silos of expertise, resulting from historical processes of centralization, are pervasive in environmental governance (Cumming et al. 2006) and must be actively overcome to enable transformative change (Smith et al. 2016, Schultz et al. 2019). In the fire context, siloed expertise is a primary constraint on transformational change (Smith et al. 2016, Steelman 2016, Schultz et al. 2019, Tedim et al. 2019) and the division between fire and forestry in BC is a prime example of this. While siloed expertise exists in Canadian forestry more broadly (Hirsch et al. 2001), in BC it resulted from the “big divorce” of 1995 when decision-making power was effectively split between two actors: the BC Wildfire Service, with fire control objectives, and the Ministry of Forests, with primarily forest management objectives. In the BC Wildfire Service today, connected expertise on fire and forest interactions is limited to people who were in the organization prior to the “big divorce” or who have personally sought a professional forester designation. Recognizing this gap in expertise, the BC Wildfire Service is actively working to support the development of fire competencies for professional foresters and collaborating closely with Ministry of Forests districts to undertake wildfire risk reduction activities.

Centralizing fire control in a singular organization with entrenched power constrains transformational change because they tend to favor the status quo (Farrelly and Brown 2011, Chaffin et al. 2016). In Canada (Sherry et al. 2019, Tymstra et al. 2020) and the United States (Schultz et al. 2019), rigid control-based fire organizations are the norm, including BC. Interestingly, the United State Forest Service, although it retains jurisdiction for fire and forests, is similarly challenged by organizational rigidity (Schultz et al. 2019). The historical lens demonstrates that rigidity of the BC Wildfire Service resulted from power accumulating through time, as colonial worldviews of fire became institutionalized in legislation, objectives, strategies, and decision-making processes (Mathevet et al. 2015, Nikolakis and Roberts 2021). This power is a result of both internal and external factors (Steelman and

McCaffrey 2011). The internal “*culture of suppression*” is reinforced through training on fire suppression rather than fire science (Expert #1, *Coexisting with Fire* era) and the external public expectation of suppression effectiveness (NGO #18, *Emulating Fire* era).

Organizational rigidity is mirrored in the broad forest management context in BC: although the Ministry of Forests retains responsibility for forest management, the forest industry continues to wield decision-making power (Kamieniecki 2000), evidenced by the entrenched worldview of fire as destructive to timber values that started in the *Controlling Fire* era. For both rigid organizations, the 2017 fire season challenged entrenched government power and organizational norms.

2.4.3 Overcoming constraints to enable transformation

The 2017 fire season demonstrated that governance-as-usual is inadequate to address fire risk in BC and opened an opportunity for transformation towards coexisting with fire, which has become a mantra for fire researchers globally (Moritz et al. 2014, Roos et al. 2016, Schoennagel et al. 2017, McWethy et al. 2019, Tedim et al. 2019). Critically, however, transforming fire governance will require intentional intervention by organizations to alter rigid and path-dependent structures that are constraining change (Folke et al. 2010, Westley et al. 2011, Chaffin et al. 2016, Hahn and Nykvist 2017, McWethy et al. 2019), especially given that the public does not necessarily demand change after experiencing a destructive fire season (McCaffrey 2015). The historical perspective presented here indicates that siloed and rigid organizations are the key constraints on change, yet there is evidence that the BC Wildfire Service and the Ministry of Forests are intentionally making changes to overcome their internal silos, prioritize proactive objectives, incorporate multiple worldviews of fire, and address the power imbalances by redistributing decision-making power to communities. Nevertheless, several interviewees expressed skepticism as to how transformational change would be despite the provincial government’s response to the Abbott Chapman Report indicating that 92 of 108 recommendations were complete or underway (Emergency Management BC and Ministry of Forests 2018), especially given the slow and incomplete change after the 2003 Firestorm (Abbott and Chapman 2018, *Coexisting with Fire* Era).

In addition to leveraging the 2017 fire season as a catalyst for transformation, the political context in BC provides an opportunity for First Nations to become “*partners and*

leaders” in fire governance (Abbott and Chapman 2018 pg. 8, *Coexisting with Fire* era). Ensuring that transformative governance *is defined by* Indigenous and local communities is key for success (Sankey 2018, Lam et al. 2020, Nikolakis and Roberts 2021). Given new legislation in BC applying the United Nations *Declaration on the Rights of Indigenous Peoples*, transformation of fire governance can be guided by and support reconciliation with First Nations. Equal partnerships with First Nations would address existing objectives and strategies (e.g., modified response or evacuations) that are implemented based on non-Indigenous priorities and negatively affect Indigenous communities (McGee et al. 2019, Zahara 2020). Objectives to reintroduce fire provide pathways for First Nations peoples to “reassert” their knowledge on cultural practices of using fire (Martello and Jasanoff 2004, Armitage et al. 2012) by holding decision-making authority. This authority is key for transformative governance because fire-related objectives are intimately playing out on First Nations’ unceded traditional territory (Wilson 2019, Caverley et al. 2020) and Indigenous fire governance offers its own worldviews of fire (Nikolakis and Roberts 2020, 2021). New First Nations-led or co-governance models could share decision-making among actors (Wyatt 2008). In BC, Community Forestry is an area-based forest tenure model that provides flexibility for First Nations- or co-governance that can enhance community resilience to fire (Ambus and Hoberg 2011, Copes-Gerbitz et al. 2020, Devisscher et al. 2021). Ultimately, supporting the vision of reimagined stewardship requires devolution of entrenched government power, and appropriate community supports, to ensure transformation to “socially just and environmentally appropriate” fire governance (Offen 2004, Nayak et al. 2016, Bennett and Satterfield 2018).

2.5 Conclusions

Transformative change to coexist with fire requires organizations, policy-makers, and communities to explicitly consider which actors, objectives, and worldviews influence forest governance in BC (Stojanovic et al. 2016, Caverley et al. 2020). Transformation of the fire governance system by changing the way BC Wildfire Service approaches fire will continue to be constrained unless forest governance by the Ministry of Forests changes simultaneously. In BC, the mechanism for such change is a Forestry Commission that intimately considers the interactions between forest governance and fire. The last

Commission occurred in 1976 and coincided with a new era of fire governance. This Forestry Commission should be led or co-led by an Indigenous person to ensure First Nations' unique knowledge, perspectives, values, and needs are recognized in designing recommendations – perhaps following the model of the Flood and Fire Review (2018). Revelations from the catastrophic fire seasons of 2017 and 2018 and BC's commitment to reconciliation with First Nations should be leveraged towards a new Forestry Commission to review and incorporate new worldviews, objectives, and actors of fire to enable the vision for coexisting with fire in BC.

Chapter 3: Situating Indigenous knowledge for resilience in fire-dependent social-ecological systems

3.1 Introduction

Indigenous peoples coexisted with and stewarded fire for millennia (Lewis 1982, Bowman et al. 2011, Huffman 2013, Lake and Christianson 2019). While there are many examples of Indigenous fire stewardship that continues to adapt to modern contexts (Lake and Christianson 2019), the ongoing impacts of colonialism and ‘command and control’ approaches to fire governance (Holling and Meffe 1996) have often displaced and marginalized Indigenous peoples and suppressed their stewardship practices (Eriksen and Hankins 2014, Christianson 2015). Furthermore, against the backdrop of recent global mega-fires that have significantly impacted human livelihoods (Stephens et al. 2014, Smith et al. 2016), many Indigenous communities face systematic biases against their needs, values and concerns and are often at higher risk during modern wildfire events (Christianson 2015, McGee et al. 2019). Understanding and addressing these inequalities in the context of current wildfire challenges has emerged as a key research need (Sankey 2018) and one that can be aided by taking an integrated social-ecological systems (SES) perspective (Berkes and Folke 1998, Liu et al. 2007, Ostrom 2009).

From an SES perspective, social and ecological systems are complex and have dynamic feedbacks across multiple spatial and temporal scales (Liu et al. 2007, McGinnis and Ostrom 2014). Importantly, the SES perspective demonstrates that environmental challenges, such as wildfire, are inextricably linked to underlying social and political contexts (Berkes and Folke 1998). While fire itself has long been understood as an ecological process (Bowman et al. 2009, Krebs et al. 2010), the SES perspective demonstrates that fire depends on social and political contexts (Bowman et al. 2011, Moritz et al. 2014, Spies et al. 2014, Fischer et al. 2016, Smith et al. 2016). For example, some wildfire SES scholars have mapped modern fire-dependent SES to illustrate the multiple levels of governance (from local to national) that influence fire (Moritz et al. 2014, Spies et al. 2014, Fischer et al. 2016) while others have described the extent to which people interacted with and shaped fire through time (Bowman et al. 2011, Roos et al. 2014).

In addition, the concept of resilience is often applied to environmental challenges to better understand and navigate uncertainty and complexity (Berkes et al. 2003, Folke et al. 2010, Binder et al. 2011, Folke 2016). Several fire SES scholars argue that enabling resilience in fire-dependent landscapes requires context-specific solutions and locally-relevant desired futures (Stephens et al. 2013, Moritz et al. 2014) developed through participatory processes (Fischer et al. 2016). These processes can benefit from stronger social networks that increase capacity (Spies et al. 2014, Fischer et al. 2016) and overcome knowledge silos (Smith et al. 2016). Critically, these scholars underscore the key role of local actors, including Indigenous peoples, in achieving fire-resilient communities (Moritz et al. 2014, Smith et al. 2016). These insights are an important foundation for bridging the research silos of social versus natural science (Smith et al. 2016) and providing tangible pathways for applying resilience concepts to fire governance (Steelman 2016, McWethy et al. 2019). However, what has not yet been addressed in the context of wildfire are some of the shortcomings of applying SES resilience in this way, including the unequal attention to the social dimensions of resilience and the power inherent in different forms of knowledge (e.g., Indigenous, Western science, practitioner).

The gap in analytical attention to the role of knowledge in fire SES research is a point of contention within SES research more broadly. Critiques of SES resilience center on the tendency to inadequately recognize, understand, and incorporate social dimensions of resilience (Adger 2000, Brown 2014). Specifically, past SES research has tended to view knowledge as apolitical and detached from power - ignoring power imbalances between different sources of knowledge who may experience resilience differently (Cote and Nightingale 2012, Brown 2014). While resilience scholars have long valued multiple forms of knowledge (including Indigenous) for developing solutions to environmental challenges (Walker and Salt 2006, Berkes 2009), Western science has largely focused on the *content* of the knowledge rather than the political *context* in which it is embedded (Cote and Nightingale 2012, Ingalls and Stedman 2016). From a Western science perspective, the content of knowledge is viewed as factual observations or data about an ecological or social system of interest (Pierotti and Wildcat 2000, Usher 2000, Houde 2007). In contrast, the context of knowledge includes the social, cultural and political factors that drive dynamics in a SES (Berkes and Folke 1998), including decision-making systems, knowledge transmission

processes, cosmology, and cultural identity (Turner et al. 2000, Houde 2007, Bohensky and Maru 2011). Viewing the content of knowledge as static, extractable data can lead to the “knowledge integration trap,” whereby knowledge that is less connected to structures of power are subsumed into the dominant paradigm (e.g., command and control) without addressing the power imbalance between knowledge systems (Agrawal 1995, Nadasdy 1999, Bohensky and Maru 2011). Treating knowledge as apolitical can lead to prescriptive management approaches that perpetuate power inequalities between different knowledge holders (Davidson-Hunt and O’Flaherty 2007, Pelai et al. 2021) and may result in inequitable solutions guided by unfounded assumptions of what knowledge is appropriate for resilience (Cote and Nightingale 2012).

In the fire context, for example, the Western science community is beginning to acknowledge the contribution of Indigenous peoples to fire-adapted landscapes and incorporate Indigenous fire knowledge (Huffman 2013, Christianson 2015, Lake et al. 2018). In many cases, however, these efforts are solely focused on integrating the content of Indigenous fire stewardship that is easily translated into Western science frameworks, such as objectives of fire use (Boyd 1999) and biophysical categories of fire knowledge, including geology, topography and soils; vegetation and fuels; weather; fire behavior; fire operations; and fire effects (Huffman 2013). From an Indigenous fire stewardship perspective, however, the context of knowledge includes spiritual elements (Turner et al. 2000, Miller and Davidson-Hunt 2013), intergenerational processes of knowledge transmission, decision-making and adaptation (Turner et al. 2000, Huffman 2013, Lake and Christianson 2019), and the political and governance settings within which Indigenous fire stewardship exists (Eriksen 2007, Rodríguez et al. 2013, Martínez-Torres et al. 2016). Despite recommendations from Indigenous fire stewards and supporting researchers to promote more meaningful engagement with Indigenous communities through Indigenous-led research and practice (Miller and Davidson-Hunt 2013, Lake et al. 2017), current SES resilience literature around fire has yet to adequately conceptualize and incorporate the context of Indigenous fire stewardship. Failure to address this shortfall will continue to narrowly define what constitutes appropriate knowledge in an SES by focusing only on the content and discount Indigenous perspectives of resilience in developing solutions to the modern fire challenge (Eriksen and Hankins 2014, Christianson 2015).

The concept of ‘situated resilience’ provides a potential way forward for addressing some of the shortfalls outlined. A situated resilience approach centers the context of knowledge and stresses that knowledge is fundamentally changed if it is viewed solely as content and extracted from the broader social, cultural and political contexts within which it sits (Agrawal 1995, Cote and Nightingale 2012). Proponents argue that situating resilience challenges researchers and managers to move beyond a preoccupation with collecting the right data, to acknowledging knowledge as contested and embedded within uneven structures of power (Cote and Nightingale 2012). Situating resilience is fundamental for addressing the question of whose resilience is being enabled and how it may affect others (Cote and Nightingale 2012, Brown 2014, Cretney 2014, Cutter 2016). In these ways, employing situated resilience may help address the existing gap in the fire SES resilience literature with regard to Indigenous perspectives (Adger 2000, Cote and Nightingale 2012). Moreover, this concept aligns with Indigenous epistemologies by embracing the context of knowledge creation (Smith 2012) as fundamental to understanding the relationship among people, fire, and the land (Miller and Davidson-Hunt 2013, Lake and Christianson 2019) than more conventional (or western scientific institutional) approaches to resilience (Cote and Nightingale 2012).

The aim of this study is to examine the context of Indigenous knowledge in a fire-dependent SES by utilizing the concept of ‘situated resilience.’ Specifically, this study applies ‘situated resilience’ to a case study in a portion of the ancestral territory of an Indigenous (First Nation) community in the land now known as British Columbia (BC), Canada, where contestations over land ownership are ongoing (Borrows 2017, Wilson 2019) and modern wildfires are increasingly threatening livelihoods (Abbott and Chapman 2018, Hanes et al. 2019). We address two research questions: (1) What is the context of fire knowledge for the T’exeic (Williams Lake First Nation)? (2) How can understanding this context help guide decision-making for future forest and fire management? We demonstrate that our collaborative research process helped shift the context of T’exeic knowledge and situate Indigenous definitions of resilience in future forest management. This analysis illuminates a set of novel recommendations for managers and researchers seeking to learn from, work with, and support Indigenous definitions of resilience as they relate to wildfire specifically and forest management more broadly.

3.2 Research context

The T'exelc are members of the Northern Secwépemc te Qelmucw (Northern Shuswap Tribal Council) whose ancestral territory is within the modern boundaries of the Cariboo Region in the dry forest ecosystems in the interior of British Columbia (BC), Canada. Across BC, including in the Secwepemcúl'ecw (the ancestral territory of the Secwépemc), Indigenous fire stewardship historically achieved a variety of cultural and ecological objectives, including maintaining food and medicinal species and reducing wildfire risk to communities through practices such as intentional landscape burns (Gottesfeld 1994, Turner et al. 2000, Ignace et al. 2016, Lewis et al. 2018). Although some of these practices continue today in an adapted form (Lewis et al. 2018, Lake and Christianson 2019), the privileging of non-Indigenous knowledge about fire in the 21st century through command and control environmental governance has resulted in colonial policies of fire suppression actively limiting Indigenous fire stewardship (Holling and Meffe 1996, Lake et al. 2018, Nikolakis and Roberts 2020). The extent to which Indigenous fire stewardship survives within individual communities is inherently linked to the historical and modern social and political dynamics - particularly the ways and extent to which colonial land governance systems historically superseded Indigenous land governance systems and continue to permeate modern landscape governance (Lake et al. 2018, Lake and Christianson 2019, Nikolakis and Roberts 2020). Across most of BC, treaties with Indigenous peoples were never negotiated before the province was officially incorporated into Canada in 1871 and legal contestations over sovereignty continue today on ~95% of the land area (Borrows 2017, Wilson 2019).

In 2014, a portion of the T'exelc ancestral territory was incorporated into the Ne Sextsine (Flat Rock) portion of the Williams Lake Community Forest (hereafter Community Forest; Figure 1), a 5900-hectare area of forest and grassland co-managed by the T'exelc and the City of Williams Lake. While its long-term tenure agreement as a community forest dictates that it must be managed for “social, ecological, and economic sustainability” (BCCFA 2020), community safety from wildfire is a key mandate driving land-management decisions given its location in the wildland-urban interface adjacent to major population centers. During the wildfire season of 2017, 1.2 million hectares burned across BC. This was the largest area burned in the provincial written record (although surpassed in 2018), with

much of the impact centered in the Cariboo Region. The T'exelc were one of 26 First Nations communities evacuated during the 2017 wildfires (Abbott and Chapman 2018), and the nearest fire came within 200 meters of Ne SEXTSINE. In response to the unprecedented impacts of the 2017 wildfire season, a provincial-level review in consultation with fire-affected communities provided recommendations to mitigate future negative impacts. Of the 108 recommendations made, 40 of these aimed to increase the input and decision-making power of Indigenous peoples (Abbott and Chapman 2018). In keeping with these recommendations, this research seeks to empower Indigenous communities by engaging in a collaborative process (described below) with research partners including the T'exelc Elders, archaeologists, and community forest managers to generate insights for future management of Ne SEXTSINE.

3.3 Methodology

3.3.1 Approach

We used an iterative, reflexive, collaborative approach to be responsive to our research partners' needs and to meaningfully address the research questions for which support and recognition of different forms of knowledge is critical. Our approach is informed by principles from community-based participatory research (Datta et al. 2015), and collaborative and decolonizing methodologies (Smith 2012, Runk 2014). In particular, these principles include ethical protocols for engagement with Indigenous communities (Smith 2012) that include long-term engagement, reciprocity, and flexibility of the research design. Validity strategies (Creswell, 2013) were applied to address researcher positionality and bias (Sultana 2007) such as prolonged engagement (Smith 2012), triangulation through iterative data collection and analyses with collaborators (Tengö et al. 2014), and a focus on place-based relationality (Datta et al. 2015) and land-based learning (Simpson 2017). Importantly, our approach also incorporates transformative and pragmatic paradigms (Creswell, 2014) which aim to empower Indigenous perspectives (Datta et al. 2015) that are under-represented in wildfire research and management spheres (Christianson 2015, Neale et al. 2019).

Our approach embraces the idea of collaborative research as a “decolonizing experiment,” through which different worldviews can be explored to help inform the

development of alternative futures (Neale et al. 2019). By recognizing power and knowledge as endogenous processes embedded within a unique context (Davidson-Hunt and O’Flaherty 2007, Cote and Nightingale 2012, Ban et al. 2018), our approach provides the methodological and operational link to the concept of ‘situated resilience.’ Likewise, it provides space for experimentation and learning, which are fundamental for maintaining the inherent validity of different forms of knowledge (Sultana 2007, Stone-Jovicich et al. 2018) and for encouraging epistemological transparency when working across worldviews (Blythe et al. 2017, Stone-Jovicich et al. 2018). For this research, we describe our broad approach as a ‘collaborative experiment’ that incorporates reflexivity, learning, and long-term ethical engagement and responds directly to community needs, as informed by participatory and decolonizing methodologies.

Community partners were instrumental in identifying and determining appropriate protocols around data collection, ownership, and dissemination, including data collection through land-based forest walks with T’exelc Elders, data sharing with the Natural Resources and Treaty Departments of the Williams Lake First Nation, and appropriate dissemination methods including annual reports and community presentations. These design elements were ensured through the signing of a Memorandum of Understanding between the T’exelc Chief, manager of the Community Forest, and researchers at the University of British Columbia in the early stages of the research. The research presented here reflects of the ongoing process of engagement since 2016, including two meetings with the T’exelc Chief and Council, six meetings with the T’exelc Elder Council, two Community Forest open-house meetings, and extensive guidance on the research design and results from representatives of the Williams Lake First Nation Natural Resources Department and managers of the Community Forest. The research process was initiated on request of a gatekeeper in 2016 who represented the interests of the T’exelc in the Community Forest. To support this engagement, the first author spent approximately nine months in the study area directly engaged with the research partners.

In working with Indigenous communities, clarity of researcher positionality and bias is central to interpreting the validity of the research process (Sultana 2007). The researchers are non-Indigenous or *semé7* (white person) settlers to British Columbia, with the lead researcher (K. M. Copes-Gerbitz) originally from Hawaii and L. D. Daniels and S. M.

Hagerman from other parts of Canada. L. D. Daniels has worked with Indigenous and non-Indigenous communities in this area of British Columbia since 2013 in the context of fire research, and this collaboration is a continuation of the relationships built through that time with an early advocate of the research (a non-Indigenous partner from the Williams Lake Community Forest) acting as a preliminary ‘gatekeeper’ to facilitate the development of an ethical research relationship (Creswell 2013). Recognizing our identities as external to the community, reflexivity ensured that we first and foremost maintained accountability to the community needs (Smith 2012, Runk 2014, Datta et al. 2015).

3.3.2 Data collection and analysis

Through the process detailed above, it was collectively decided that group forest walks with the T’exelc Elders was the most appropriate data collection strategy. Forest walks were designed in the spirit of the collaborative experiment, in which all people present shared their knowledge of Ne SEXTSINE and wildfire in an effort to co-produce a deeper, place-based understanding of the context of T’exelc fire knowledge and visions for future forest management. These forest walks were offered to all attendees of the T’exelc Elder Council meetings and organized collectively to maximize participation. We recognize, however, that the attendees’ perspectives are likely not representative of all T’exelc Elders nor of all T’exelceme (people of the T’exelc), and thus we focus our analyses on learning directly from the Elders that did attend.

Two forest walks averaging three hours each were undertaken in September 2018 and June 2019, during which a total of eight T’exelc Elders, two Community Forest managers, four archaeologists, and three researchers attended and contributed. The aim and guiding topics for the forest walks were to share experiences, perspectives, and knowledge about the history of the land, including (but not limited to) fire, and visions for future forest management. Forest walks were audio-recorded with consent and transcribed for a total of 40 pages of transcription. Transcripts were analyzed in NVivo (v. 12.6.0 2020) software using iterative and inductive coding to identify key themes “grounded” in the data from the participants’ perspectives (Charmaz 2006). Identified themes were triangulated with a close reading of oral histories documented in 29 interviews (24 in the 1990s and five in 2012) conducted as part of traditional use studies undertaken by the Williams Lake First Nation

with T'exelc Elders (not available for coding because of data confidentiality), maps of known archaeological and cultural heritage sites (as provided and interpreted by the archaeologist), archival documents of the history of the T'exelc and settlers (available at the Museum of the Cariboo Chilcotin), tree-ring based fire histories developed by K. Copes-Gerbitz (from a complementary portion of their PhD dissertation research), and through iterative feedback from research partners.

3.4 Results

This collaborative experiment revealed two key findings around the context of T'exelc fire knowledge: 1) the intentional use of fire is today considered a “lost practice,” which was disrupted by colonialism, and 2) the future of forest management should center on restoring the context of T'exelc knowledge more broadly, which is rooted in respect and achieved through place-based, intergenerational knowledge exchange. Through this analysis, we demonstrate how the concept of situated resilience can be employed to guide future forest management by focusing on the context of Indigenous knowledge within a fire SES. Quotes are attributed to Elders by name where possible following appropriate knowledge protocols outlined in the Memorandum of Understanding and at the expressed permission of individuals.

3.4.1 A “lost practice” disrupted by colonialism

In the early stages of the collaborative experiment, it was clear that intentional burning by the T'exelceme (the people of T'exelc) was not an active practice within the boundaries of Ne Sextsine. However, among the eight Elders who attended the forest tours, several remember hearing stories from their elder family members about the use of intentional burning in the Secwepemcúl'ecw by previous generations:

“[My aunt] would talk about they'd burn. And then when they were talking about where they're going to go the one who knew [about fire] would tell the Chief “Well no we can't go there we just burnt” or “Maybe we should go there because last year, or whenever, we burnt there so it should be good now.” So, they never overharvested...an area.” [Elder Estkwelálnik]

“That’s something I really don’t know anything about...like normally it was the...horse people...and they were out...on the range...hunting or whatever. And they would be the ones that would...do those kind of things [like burning] ...I had an uncle that possibly would have done it” [Elder Jean William]

When describing the objectives for which intentional burning may have been used, Elder Estkwelálnik spoke of its importance for maintaining desired landscape conditions and associated food species. For example, this Elder understood that *“in some places, raspberries will come back stronger”* after the right kind of fire. Elder Estkwelálnik went on to describe the right kind of fire in contrast to the recent (2017) fires, which burned an area that Elders Jean William and 3 used to visit to teach the youth about important cultural plants: *“it has burned so hard the ground was going to be useless for a long time.”* This content of fire knowledge (e.g., objectives for burning) as beneficial to food and medicinal species is highlighted as a conclusion of the 1998 *Final Report for the Williams Lake Indian Band Traditional Use Study* (Traditional Land Use Team):

“Natural conservation is practiced among people who go out on the land. If an area can no longer support an abundance of certain plants or wildlife, T’exelc members usually leave it alone for a few years so it can replenish itself. Other natural occurrences are taken into account for traditional gathering such as burn areas. These are known for good berry picking areas three years after the burn has occurred.” (pg. 27)

In addition to conveying the benefits of fire, Elder Estkwelálnik and Elder Jean William also described how the landscape looked without intentional fire - noting that the context of fire knowledge had changed through time, from being an active practice supporting their livelihoods to today being a *“lost practice”* [Elder Estkwelálnik]. Elder Estkwelálnik reflected that part of the forest in the Secwepemcúl’ecw had gotten *“too thick,”* such that when they visited 30 years ago, they had to tie *“markers on trees”* so they could find their way through the forest. In this *“too thick”* state, Elder Estkwelálnik was told that the forest, and associated plant species of importance, were *“no good because...they just let it grow, they haven’t burnt it.”* At Ne Sextsine specifically, Elder Jean William noted that the land adjacent to the main travel route to her summer fishing camp was also thicker with trees than when she was last at the site over 30 years ago. Supporting Elder Jean William’s recollections, this area was demarcated through a separate ecological study as an area of

historical grassland and is currently the site of grassland restoration (WL Community Forest LP 2015). The fact that only two Elders (Jean William and Estkwelálnik) of eight had memories of the content (in this case, objectives) of intentional fire further speaks to how it had become a “*lost practice*” among the T’exelcmec, which was largely attributed to the context of historical and ongoing colonial impacts on their community.

The colonial context in which the T’exelc fire knowledge had become “lost” was attributed to multiple converging impacts: policies of pre-emption which allowed settlers but not Indigenous peoples to acquire “rights” to land for settlement and agriculture (ca. 1859), the smallpox epidemic which is estimated to have killed up to two-thirds of the Indigenous population in BC (1860s), the reservation and residential school systems implemented by the Indian Act which forcibly removed people from their land (1876) (Ignace and Ignace 2017, Truth and Reconciliation Commission 2015). While these were historical events, Indigenous peoples in BC and Canada continue to face ongoing animosity and racism as a result of systematic colonial structures that still exist (e.g., the Indian Act) despite stated intentions to address these colonial impacts through reconciliation (Fisher and Lundberg 2015, Ignace and Ignace 2019, Caverley et al. 2020). As a result of this colonial context, place-based knowledge transmission within their traditional territory, including Ne SEXTSINE, was disrupted and, in many cases, silenced - which fundamentally altered the current T’exelc Elders’ lived experiences with fire stewardship.

There were several examples of Elders who had memories of both intentional burning and other interactions with fire in a colonial context. For example, some Elders recalled intentional burning from when they were children (about 40–60 years ago), but only within their reserve lands: “*I remember that because...they’d be burning on the reserve and they’d...make ditches for runoff*” [Elder Estkwelálnik]. Similarly, Elder Millie Emile remembered the burning around the reserve primarily occurring during the springtime. In another example, Elder 7 spoke of their job as a firefighter during the “*big fires in 1977*” - a job which was required by law (and therefore punitive) for able-bodied citizens should they be called upon in BC at least until the 1970s. Elder 7 contrasted the “*big fires in 1977*” with those that occurred in 2017: “*Here and in the Chilcotin [Region], just across the river, those [in 1977] were not big fires. I would say they were manageable, not like a couple years ago [2017]. Not that big fire.*” In the 2012 Traditional Use Study, two different Elders also spoke

of their experiences as firefighters undertaking prescribed burns in the Secwepemcúl'ecw. Together, these Elders' lived experiences of firefighting and burning around their reserve collectively represent fire knowledge in a colonial context once the intentional use of fire had become a "lost practice" in the Secwepemcúl'ecw.

Colonial contexts disrupted more than the intergenerational transmission of fire knowledge across their traditional territory historically, it also disrupted all place-based practices and continues to do so today. At Ne SEXTSINE specifically, there is extensive archaeological evidence of winter village sites and many oral histories describing it as an important summer fishing camp, but these activities do not continue today even though Ne SEXTSINE is technically co-managed by the T'exelc. Reflecting on why this may be, Elder Estkwelálnik said:

"I think is because of all the pre-emptions...like when I used to go out with [my family] and we'd go berry picking...and we'd run into places and [my family] would get so upset...there's no trespassing, there's fences and my mother just got to a point where she said, "I don't want to do it anymore". Everywhere you go...there's fences...you can't go there anymore."

Although several Elders remembered having a meaningful trade relationship with a local settler whose private property was adjacent to Ne SEXTSINE, their relationship soured to the point that they had not visited in 20 or 30 years:

"...because the gate [allowing entrance to their fishing camps] started to be locked...And then we had to ask for permission to come... basically we just lost the fight. We didn't want to have to be hassled. I've had a really bad experience trying to get to... [Ne SEXTSINE]"

[Elder Jean William].

Of the Elders who contributed to the forest walks, only the older generation (in their late 70s and early 80s) had memories of life at Ne SEXTSINE. These lived experiences were critical times of learning by practice in their youth through knowledge transmission from their elders; Elder 7 reflected that they knew "a century plus" of tradition because "we were there, we saw it, we were with [our grandparents]." The importance of the context of this knowledge, transmitted through place-based practice, is exemplified by this story from Elder Virginia Gilbert remembering their childhood at Flat Rock:

“I wasn’t allowed to go down the river until I was about 12. And when I went down the river I had to help pack salmon back up...So that was one of my teachings, was when I went down there I had to help. Pretty neat.”

The younger generation of Elders, in contrast, had often only heard stories of Ne Sextsine because of the colonial context in which their place-based knowledge could exist. Elder Estkwelálnik, for example, was told by an aunt about culturally modified trees that marked primary travel corridors but said *“I didn’t understand what she was saying”* because that Elder had never seen one - a clear example of divorcing the content of knowledge (e.g., culturally modified trees) from the context (the place in their traditional territory where they existed). These marker trees are still visible at Ne Sextsine today, and upon seeing one during the forest walk this Elder remarked *“this is just unbelievable. [I remember] hearing stories about these when we would go hunting...they know their directions from these, but I never seen it.”* These quotes speak to the importance of access to place for providing context for knowledge transmission between generations, which was mirrored in the *Final Report for the Williams Lake Indian Band Traditional Use Study* (Traditional Land Use Team, 1998) which found disparities in land-based knowledge between different generations and attributed these disparities to colonial contexts: *“Older members in the community had a wider use of the land than the younger members. This is because of the restrictions placed on the land.”* (pg. 26).

The implications of this restricted access to their land - and the colonial context more broadly - is exemplified by the late Chief William’s (Chief of the Williams Lake First Nation) letter to a local newspaper published in 1879 (*“An astonishing state of things at Williams Lake,”* 1879), the same year he traveled to begin treaty talks with the colonial government of BC:

“The land on which my people lived for five hundred years was taken by a white man; he has piles of wheat and herds of cattle. We have nothing - not an acre...Any white man can take three hundred and twenty acres of our land and the Indian dare not touch an acre. Her Majesty sent me a coat, two ploughs and some turnip seed. The coat will not keep away the hunger; the ploughs are idle and the seed is useless because we have no land.... The whites have taken all the salmon and all the land and my people will not starve in peace. Good

friends to the Indian say that 'her Majesty loves her Indian subjects and will do justice.'
Justice is no use for a dead Indian."

3.4.2 (Re)activating place-based knowledge through our collaborative experiment

Despite the colonial context that disrupted knowledge transmission, our collaborative experiment and forest walks helped create a new context for (re)activating the Elders' knowledge - one that illuminated the Elders' enduring connection to Ne SEXTSINE and provided a pathway for this new context of knowledge to guide future forest management. Specifically, the Elders' enduring connection to place was demonstrated through stories about important plant species and their commitment to upholding respect for the land and their ancestors. To uphold this enduring connection to place in future forest management, the collaborative experiment helped facilitate a trust-building process between T'exelc Elders, archaeologists, community forest managers, and researchers and provided a new context for situated resilience that contrasted colonial suppression of Indigenous knowledge.

Although the content of fire knowledge may have been lost, contextual knowledge of important practices (such as fishing and hunting), food and medicinal species endured. Reactivating these memories was stimulated by questions from the archaeologists through questions like "*How would you catch the sturgeon?*" (Courtney Lawrence) and photos of projectile points found within the broader T'exelc traditional territory. Elder Virginia Gilbert remembered "*camping down there with [their] parents, and the men would fish mostly during the night, and [the] women we had to look after picking up the wood for the fire...and sometimes we'd be picking berries.*" This focus on berries for food, and plants in general for multiple uses, was a primary topic of conversation, with multiple Elders making note of specific plants or plant products visible during the forest walks that were important to their livelihoods (Table 1). While these plants did not necessarily relate to fire knowledge (e.g., as fire-dependent species that were cultivated through intentional burning), they provide an important context for the knowledge that does endure. Elder Jean William, reflecting on her enduring connection to Ne SEXTSINE, spoke about all the ways the land supported their community:

"Money wasn't a big thing back then. And that's why I say I was self-sustained because we lived on the land, we got our medicines from the land...food or medicines,

technology...Where we were we had two springs, one for us that sustained us for our water, and the other spring sustained our horses...And so it looked after all of our needs.”

Central to upholding this enduring knowledge was demonstrating respect for the land and the Elders’ ancestors who were still present at Ne Sextsine. During both forest walks, we were among historical winter village sites, which encompass up to 35 individual dwellings [archaeologist Whitney Spearing]. These winter homes, also called pit houses or *c7istkten’* in Secwepemctsín (the Secwépemc language), were typically occupied from November to March; however, the last recorded occupation of village sites in Secwepemcúl’ecw was likely several generations prior to the Elders’ memories [archaeologist Whitney Spearing]. Nevertheless, the Elders exhibited deep respect for their ancestors through placing of tobacco and singing a song to honour them. Of placing the tobacco, Elder Estkwelálnik said, *“They say when...you’re coming here, they come around, the ancestors...That’s why we’re putting the tobacco down because we want them to know that we’re thinking about them, and we know that they’re here.”* Elder Virginia Gilbert, who drummed and sang a song in Secwepemctsín along with four other Elders, said *“I went four rounds of the four directions to call in the four spirits to come here to welcome our ancestors to be with us today.”* After this song, Elder 7 stated, *“I have a great sense that they’re still here with us today.”* These practices and quotes illustrate the ongoing reverence for their ancestors, which they also requested of the researchers and managers:

“It’s really, really important for people that are working...in archaeology, or doing any forestry work, [to] always remember that...our people have been here... And you always try to remember them in reverence...You can, do your practice anyway you know how. Just the reverence and respect that you have for them...Because our ancestors are here, they’re watching us, they hear us.” [Elder Jean William]

Discussions during the forest walks highlighted the importance of our collaborative experiment for helping to (re)activate this place-based knowledge and, perhaps more importantly, building trust among participants to create a new context for the Elders’ place-based knowledge to guide the future of forest management. Reflecting on the management of Ne Sextsine prior to it becoming a Community Forest in 2014, several Elders were frustrated by the visible *“cultural invasion”* [Elder Jean William] or *“cultural alteration”* [Elder 7] by non-Indigenous peoples who had no respect for Ne Sextsine, exhibited in logging, bike trails,

and snowmobile trails that cut through or were built upon the winter village sites. Elder Jean William continued to describe how the “*cultural invasion*” erased the context of their knowledge, focusing solely on the content through the process of ‘consultation’ with Indigenous communities in BC: “*In the past, their maps were already made out, tons of work was already done, and you think, ‘what I’m going to say now is not going to mean anything, it’s already on paper.’*”

In contrast to the historical process of consultation described above, several Elders appreciated the opportunity provided through our collaborative experiment to engage and build trust with the community forest managers. When advocating for the Elders’ preferred approach to forest management, Elder Jean William said to the community forest manager: “*I guess it’s just the awareness and how meaningful it still [is] ... I think any [management] is acceptable if... you know the respect. And I think you gathered that.*” Similarly, Elder Virginia Gilbert said, “*...respect, that’s all we’re asking.*” Community forest Manager 1 agreed and described their approach to forest management decision-making: “*On the community forest, we don’t do much work where there is so much archaeology and cultural heritage because we don’t want to be disrespectful of what’s there.*” Clearly, respect is a shared value that will continue to guide management at Ne SEXTSINE.

In the context of the proposed grassland restoration, one community forest manager reflected on how the collaborative experiment provided a pathway for the Elders’ knowledge to guide the process: “*We’ve got a few grasslands... that are really closely associated with First Nations values, so it’s one that we want to put on the map, and these forest walks really help introduce the subject and start from there*” [Manager 1]. Furthermore, as demonstrated above (“*...I think you gathered that*” [Elder Jean William]), the Elders had faith that the community forest managers would uphold respect and continue to provide a pathway through which both the content and context of their knowledge could guide future forest management because of the trust built through our collaborative experiment. Of the importance of this trust, community forest Manager 1 reflected: “*I think these forest walks have helped us as a management team become known to the Elders...it’s sort of an informal meeting place between [Western science and traditional ecological knowledge], and I find that really valuable.*”

Although the colonial context disrupted knowledge transmission for the T'exelc, visiting Ne SEXTSINE again as part of our collaborative experiment helped create a pathway for this context to shift towards one in which their knowledge was (re)activated and (re)connected to place, and, ideally, (re)vived the process of intergenerational knowledge exchange. Sharing his excitement at visiting Ne SEXTSINE again, Elder 7 reflected that *"I was just wondering actually if I was ever going to be able to do a trip like this down to Flat Rock, and just take a look back at my younger day."* Decades of restricted access to Ne SEXTSINE - because of gates, fences, government policy, and ongoing animosity towards the T'exelc - limited opportunities for Elders to pass on their knowledge to the youth of their community. Although Ne SEXTSINE became part of the Williams Lake Community Forest in 2014, access is still contested by adjacent private landowners, providing few opportunities (these forest walks being an exception) for the Elders and youth to visit. This inability to facilitate place-based, intergenerational knowledge transmission weighed heavily on the minds of Elders, exemplified by Elder Estkwelálnik's reflection on the importance of visiting Ne SEXTSINE with the youth:

"We have our legends that we want to pass on from my generation to the next...There's two legends that I know that were given to me and that needs to be passed on. And those are really, really important because that's part of puberty...and how...you're brought up to respect everything that we walk on, that we see...And so that's how much it means to all of us."

One Elder lamented at only being able to share stories, rather than lived experience, with the youth in their family:

"My children, I got five, 10 grandchildren and 4 great-grandchildren, and none of them seen Flat Rock. Except [three of them], but my grandkids didn't. I tell them about it and I have it written down...[but] my grandchildren never experienced what I went through down there"

[Elder Virginia Gilbert].

This inability to access their traditional territory and share both the content and context of knowledge through place-based practice with younger generations was summarized by Elder Virginia Gilbert who said they *"aren't aware of our ways."* Most Elders present for the forest walks indicated their desire to bring the youth out to Ne SEXTSINE because *"our youth don't*

know the land...it's a different era" [Elder Jean William], demonstrating their vision for a new context for their knowledge of Ne SEXTSINE to thrive once again.

3.5 Discussion

Through our collaborative experiment, we highlight three key considerations for understanding and incorporating situated resilience in a fire-dependent SES. First, we argue that the situated resilience concept helped illuminate the context of T'exelc fire knowledge and is highly relevant for land managers working with Indigenous communities whose content of traditional fire knowledge may be "lost". Second, we demonstrate how our collaborative experiment helped shift the context of T'exelc knowledge at Ne SEXTSINE away from being integrated into dominant colonial paradigms towards Indigenous-led visions of resilience. Finally, we discuss the ways in which fire-dependent SES should be conceptualized to ensure that resilience is situated to prevent inequitable solutions to modern wildfire challenges.

3.5.1 Situating resilience at *Ne SEXTSINE*

Employing situated resilience helped emphasize the importance of the context of fire knowledge, centering the voices of the Elders as they shared their memories and stories of place. In this case study, the fact that the T'exelc Elders described their fire knowledge as a "lost practice" could have signaled the end of our research collaboration if this was the only knowledge deemed 'appropriate' by researchers and/or managers - which would have reflected the problematic assumption by non-Indigenous researchers more broadly that fire (and other Indigenous) knowledge is universal and uninterrupted (Lake 2013, Fernández-Llamazares et al. 2021). To avoid this, we focused on the context of the fire knowledge, which included the extent to which colonialism disrupted place-based practices of intentional fire use, as well as the knowledge and practices that endure despite colonialism.

These altered experiences with fire as a result of colonialism are consistent with other Indigenous communities in British Columbia (Lewis et al. 2018) and around the world, including Australia and the United States (Eriksen and Hankins 2014, Lake and Christianson 2019), Brazil (Mistry et al. 2005), Mexico (Martínez-Torres et al. 2016), and Venezuela (Sletto 2009, Rodríguez et al. 2013). As a result of colonialism, for example, younger

generations often have less experience intentionally using fire for traditional purposes and instead tend to perceive fire control or suppression as favorable (Mistry et al. 2005, Rodríguez et al. 2013, Martínez-Torres et al. 2016). This was true even of several of the younger T'exelc Elders, who had no lived experience of intentional burning or whose experiences with intentional burning were only around their reserve (in a colonial context). Similarly, younger participants from the Lytton First Nation in a case study in the adjacent Nlaka'pamux territory recalled mostly localized burning for hazard abatement rather than for ecological benefits at landscape scales (Lewis et al. 2018).

Despite disrupted fire knowledge, the context of this knowledge also illustrated rich and enduring connection to Ne SEXTSINE – a critical and often overlooked context but one that provides the foundation for Indigenous-led situated resilience. For land managers and natural scientists working with Indigenous communities, respecting this context is key for overcoming the “invisible losses” of colonialism, such as knowledge lost when place-based intergenerational knowledge transmission can no longer occur (Turner et al. 2008). At Ne SEXTSINE, for example, the area of grassland restoration visited during the forest walks was initially designated through an ecological assessment based on historical aerial imagery from the 1970s (WL Community Forest LP 2015). From the Elders’ stories, however, we learned that this area was a primary travel corridor to summer fishing camps, which effectively enlarged the area of grassland restoration that needed to occur beyond the boundaries identified in the historical imagery and connected it to one of the culturally modified way marker trees. Furthermore, although the Elders did not specifically remember using fire to maintain open conditions in this area, the descriptions they provided of important plants at Ne SEXTSINE (Table 1) that reflected the broader context of their knowledge, in combination with evidence of past fires in tree-rings (collected as part of a complementary study to this one), helped illustrate that certain plants associated with frequent, low-severity fire, such as soapberry (*Shepherdia canadensis*; Walkup 1991), were primary food sources during the Elders’ summer visits to Ne SEXTSINE. These examples illustrate how situated resilience can help land managers and natural scientists acknowledge and center Indigenous knowledge in leading forest management (Wong et al. 2020, Buxton et al. 2021).

3.5.2 Collaborative experiment to shift context

In BC, the unprecedented 2017 wildfire season illustrated the stark power imbalance between the dominant, western command and control fire management paradigm and the many ways in which Indigenous peoples relate to, learn from, and live with fire in ecocultural landscapes (Miller et al. 2010, Abbott and Chapman 2018, Martínez-Torres et al. 2018). As a result of the 2017 wildfire season, many Indigenous communities worked to shift this imbalance through revitalizing their fire stewardship (Xwisten Nation et al. 2018) and Indigenous-led approaches to future fire management (Verhaeghe et al. 2019), advancing goals of restoration and reconciliation simultaneously (Dickson-Hoyle et al. 2021). At Ne SEXTSINE, by framing our research as a collaborative experiment, we also sought to address the power imbalance (context) by centering the needs of the T'xelc Elders, essentially moving research from a positivist paradigm grounded in reductionist and empirical information (e.g., 'technical fire knowledge') to a transformative paradigm focused on minimizing power inequalities between different forms of knowledge (Creswell 2014, Christianson 2015, Datta et al. 2015, Neale et al. 2019). While we researchers acknowledge that this collaborative experiment did not actively lead to formal T'xelc authority over Ne SEXTSINE - which is the ideal place from which power over knowledge could be decolonized (Smith 2012, Midzain-Gobin and Smith 2021) - we argue that this process did help shift the context of knowledge towards more equal balance of power between collaborators in contrast to historical processes of consultation (Usher 2000).

As reflected both by the T'xelc Elders and the community forest managers, the collaborative experiment embedded a trust-building process in which different knowledge of fire and Ne SEXTSINE could be respectfully discussed. This trust-building process is central to respectful research relationships between Indigenous and non-Indigenous actors (Datta et al. 2015, Wong et al. 2020), and has successfully been implemented in other fire contexts where Indigenous and non-Indigenous perspectives of fire were potentially contentious (Rodríguez et al. 2013, Devisscher et al. 2019, Mistry et al. 2019). Through the collaborative experiment framing, we (researchers and managers) relied on the process (rather than a checklist) of collaboration to learn from the T'xelc Elders appropriate engagement protocols (e.g., land-based knowledge exchange) and management guidelines (e.g., operating with respect for the land and ancestors) for addressing the Elders' needs. This process has successfully helped

non-Indigenous researchers better understand the context of Indigenous knowledge and expose power imbalances between Western science and Indigenous forms of knowledge in addressing complex fire management questions (Christianson 2015, Neale et al. 2019, Nikolakis and Roberts 2021). Critically, the trust-building process helped to address the power imbalance by centering Indigenous knowledge and knowledge systems which rely on the process of place-based, intergenerational knowledge transmission (Turner et al. 2000). At Ne Sextsine, our collaborative experiment helped situate T'exelc resilience in a transformed context by (re)activating the Elders' enduring place-based knowledge and discussing future opportunities for forest walks with Elders and T'exelc youth. We see our collaborative experiment as a form of reflexive governance because we actively engaged with multiple, often contested, understandings of the system itself and we co-developed a process to reveal how different forms of knowledge are situated within their context (Voß and Kemp 2006, Leach et al. 2007, Rodríguez et al. 2013).

3.5.3 Situating Indigenous resilience in fire-dependent SES

Against the backdrop of a much broader literature on incorporating Indigenous and Western knowledge in forest management (Nadasdy 1999, Klooster 2002, Bohensky and Maru 2011, Hill et al. 2012, Ban et al. 2018, Lake et al. 2018), here we argue that situated resilience can help ensure that incorporating Indigenous knowledge does not fall into the “knowledge integration trap” (Bohensky and Maru 2011). Instead, situated resilience helps overcome the potential ‘social-ecological traps’ that can occur when land management authority is held in colonial systems and contested by Indigenous peoples by acknowledging the ways that colonial contexts have affected Indigenous knowledge (Long and Lake 2018). In fire-dependent SES, failure to interrogate this context will continue to privilege Western science-based knowledge and solutions (Bohensky and Maru 2011, Cote and Nightingale 2012), for example, by ‘subjugating’ Indigenous experiences in firefighting (Eriksen and Hankins 2014) or fire management (Lake and Christianson 2019, Sherry et al. 2019). In Canada, there are increasing calls to ensure that Indigenous knowledge leads land-based decision-making through appropriate research and practice (Christianson 2015, Sankey 2018), and yet fire-dependent SES do not yet adequately consider the context of this knowledge.

Several key fire SES research scholars acknowledge that Indigenous knowledge can be leveraged to develop solutions to modern wildfire management challenges (Moritz et al. 2014, Smith et al. 2016), and that Indigenous governance adds complexity to fire SES (Moritz et al. 2014). While this is an important first step, it stops short of recognizing how Western science-based knowledge used to conceptualize fire SES may be discounting the context of Indigenous knowledge. Reflecting to the question posed by the advocates for situated resilience (Cote and Nightingale 2012), we must ask for whose resilience is Indigenous knowledge is being leveraged? If we situate resilience according to the context of Indigenous knowledge, for example, we may include elements such as respect and intergenerational knowledge exchange as a primary input into building resilience that reflect Indigenous ontologies and epistemologies (Turner et al. 2000, Nikolakis and Roberts 2020). Furthermore, in the context of modern wildfire challenges, the SES may be situated to include areas where we not only see fire affecting visible human “development,” such as the wildland-urban interface (Moritz et al. 2014), but could be situated to include the ecocultural landscapes more broadly to which Indigenous peoples are still connected (White et al. 2011, Miller and Davidson-Hunt 2013). In these ways, we challenge land managers and fire SES thinkers to more deeply question transformational change (McWethy et al. 2019) and consider the myriad ways in which Indigenous peoples can contribute to and lead solutions to modern wildfire challenges according to their own definitions of resilience (Miller and Davidson-Hunt 2013, Christianson 2015).

Chapter 4: The Indigenous fire regime of *Ne Sextsine*, Williams Lake Community Forest, British Columbia, Canada

4.1 Introduction

People and fire have coexisted for millennia in fire-prone landscapes, and yet today there is widespread concern that fire is increasingly threatening the things we value (Bowman et al. 2009, 2011, Doerr and Santín 2016). Globally, climate change, population growth, and a legacy of fire exclusion through disruption of Indigenous stewardship and fire suppression policies are interacting to create a complex wildfire challenge that cannot be solved by a one-size-fits-all approach (Krebs et al. 2010, Bowman et al. 2011, Stephens et al. 2013).

Disentangling the complexity of the modern wildfire challenge requires an historical perspective that recognizes the dynamic interactions among fire, people, and the land through time (Moritz et al. 2014, Spies et al. 2014, Fischer et al. 2016, Smith et al. 2016). This historical perspective is necessary for enabling a continuum of resilience approaches that support a return to coexisting with fire (Moritz et al. 2014, Smith et al. 2016, McWethy et al. 2019).

The fire regime concept is a framework for characterizing patterns and processes of fire across multiple spatial and temporal scales (Krebs et al. 2010, Turner 2010). Fire regimes are often described along a continuum of two key characteristics - fire frequency and fire severity. At one end of the continuum fire regimes are dominated by high-frequency, low-severity fires causing low levels of plant mortality, while at the other fire regimes are dominated by low-frequency, high-severity fires causing higher levels of plant mortality (Agee 1993, Schoennagel et al. 2004). In recent decades, mixed-severity fire regimes (MSFR) that contain some proportion of low- to high-severity fires (Daniels et al. 2017) are increasingly recognized as a primary type of fire regime in western North America (Amoroso et al. 2011, Perry et al. 2011, Heyerdahl et al. 2012, Marcoux et al. 2015, Chavardès and Daniels 2016, Hessburg et al. 2016).

In addition to frequency and severity, fire regimes are often described as being driven by top-down (e.g., climate) or bottom-up (e.g., topography, fuels) factors (Agee 1993, Perry et al. 2011). Fire regimes that are driven by top-down factors tend towards low-frequency, high-severity fires whereas fire regimes that are driven by bottom-up factors tend towards

high-frequency, low-severity fires. MSFR occur when top-down and bottom-up drivers interact (Daniels et al. 2017). Despite these more complex characterizations of historical fire regimes, a lack of consideration of ignition sources as a bottom-up fire regime driver may overlook a key control on fire frequency and severity (Moritz et al. 2005, Krebs et al. 2010). Failure to thoroughly explore ignition sources may inappropriately assume topography or fuel type is the key driver of fire on the landscape, particularly where Indigenous stewardship was the main ignition source or it was embedded in a matrix of biophysical fires (White et al. 2011, Lake and Christianson 2019).

Ethnographic research, oral histories and contemporary fire knowledge keepers describe Indigenous fire use for multiple objectives at a variety of scales (Huffman 2013, Lake and Christianson 2019). In western North America, Indigenous fire stewardship was historically used for a variety of cultural and ecological objectives, including increasing abundance of preferred resources, promoting desired landscape conditions, and fulfilling an obligation to respect the land (Turner et al. 2000, Kimmerer and Lake 2001, Huffman 2013, Miller and Davidson-Hunt 2013, Trauernicht et al. 2015, Lewis et al. 2018, Lake and Christianson 2019). These objectives were spatiotemporally heterogeneous, with higher incidence of fire use during appropriate seasonality depending on desired conditions and near communities and along travel corridors that connected highly-valued resource areas and (Turner et al. 2003, Lake and Christianson 2019, Roos et al. 2021). This heterogeneity represents a unique pyrodiversity that results from Indigenous fire stewardship with the added benefit (or intentional purpose) of reducing the likelihood of future detrimental fires (Trauernicht et al. 2015, Bird et al. 2016, Mistry et al. 2016, Taylor et al. 2016). Despite severe limitations on the continuation of these practices because of the impacts of colonization, Indigenous fire stewardship (including knowledge and practice) continues to adapt to modern social, ecological and climatological contexts (Eriksen and Hankins 2014, Lewis et al. 2018, Lake and Christianson 2019). In places where this fire stewardship was disrupted or lost, it follows that the homogeneous landscapes that arose no longer support Indigenous livelihoods nor maintain the benefit of minimizing the impact of future fires (Hoffman et al. 2021).

This modern landscape homogenization also results when MSFRs are altered, leading to simplified forest structure and composition that increase the likelihood of uncharacteristic,

large, high-severity fires (Schoennagel et al. 2004, Stephens et al. 2013, Marcoux et al. 2015, Chavardès and Daniels 2016, Hessburg et al. 2019). MSFRs are characterized by pyrodiversity that drives patch- to landscape-scale diversity (Hessburg et al. 2016), which parallels the local- to landscape-scale objectives of fire use by Indigenous peoples (Kimmerer and Lake 2001, Lake and Christianson 2019). Understanding the contribution of Indigenous stewardship to fire regimes is critical because characterizations of historical fire regimes help drive and inform management approaches in a social-ecological system, especially those that seek to reintroduce fire (White et al. 2011, Hessburg et al. 2016). Understanding the influence of Indigenous ignitions on fire regimes is an emerging area of historical fire ecology through dendroecological (Fulé et al. 2011, Stambaugh et al. 2013, Taylor et al. 2016, Guiterman et al. 2019, Larson et al. 2020) and palaeoecological methods (McWethy et al. 2013, Roos et al. 2014, 2021). Nevertheless, for lessons from historical ecology to continue to be relevant in a management context - such as ecosystem management based on historical fire regimes - it must embrace emerging trends (Swetnam et al. 1999, Higgs et al. 2014), such as acknowledging the devastating impacts of colonialism on Indigenous fire stewardship and a commitment to learn from and work with Indigenous communities in addressing the modern risk of fire (Lake et al. 2017, Lake and Christianson 2019).

In the dry forest ecosystems of British Columbia (BC), Canada, modern wildfires have negatively impacted communities and their livelihoods, with six significant fire seasons affecting the wildland-urban interface since 2000. The 2017 fire season, as an example, prompted the evacuation of over 65,000 people, burned multiple homes and over 1.2 million hectares, and initiated a 70-day provincial state of emergency (Abbott and Chapman 2018). The fires in 2017 were consistent with a pattern of increasing area burned, number of large fires (>200 ha), and lightning-caused fires, and a lengthening of the fire season in the southern Canadian cordillera (Hanes et al. 2019) and were exacerbated by anthropogenic climate change (Kirchmeier-Young et al. 2019). Wildfires of this magnitude will continue to challenge future suppression efforts (Wotton et al. 2017) and drastically increase expenditures (Stocks and Martell 2016) without significant interventions to address existing risk (Johnston et al. 2020).

In multi-value landscapes, such as those where Indigenous traditional territories and the wildland-urban interface overlap, interventions must reflect both the ecological and

cultural context (Blum 2004). This context includes an understanding of how the relationship between fire, people, and the land has changed through time. Thus, our study sought to: 1) characterize the historical fire regime, including fire frequency and fire severity, and 2) explore the contribution of Indigenous fire stewardship to the fire regime. We focused this study in a Community Forest that is within the *Secwepemcúl'ecw* – the traditional territory of the Secwépemc peoples – where our ongoing collaborative research provides a foundation for supporting Indigenous-led approaches to addressing wildfire risk (Copes-Gerbitz et al. *in press*). In keeping with recommendations for natural scientists working with Indigenous communities, we centered Indigenous knowledge in interpreting the fire history story rather than the problematic approach of integrating only “relevant” knowledge into Western science frameworks, which can be considered an ongoing form of colonization (Bohensky and Maru 2011, Mistry and Berardi 2016, Wong et al. 2020).

4.2 Methods

4.2.1 Study area

Ne SEXTSINE is a ~5,900-hectare (ha) area that is part of the broader territory of the *T'EXELC* (Williams Lake First Nation), who have continuously stewarded the area since time immemorial. In 2014, *Ne SEXTSINE* was incorporated into the Williams Lake Community Forest (WLCF) and is currently co-managed by the *T'EXELCEMC* (the people of the Williams Lake First Nation) and the City of Williams Lake for a broad range of social, cultural, ecological, and economic values (WL Community Forest LP 2015). *Ne SEXTSINE* is located in the wildland-urban interface of the City of the Williams Lake (population ~12,000) and the Cariboo-Chilcotin Forest Resource District in south central BC (Figure 4.1). *Ne SEXTSINE* was not directly affected by fires in 2017, but ~12% (870,000 ha) of the Cariboo-Chilcotin Forest Resource District was burned and the communities in the wildland-urban interface of *Ne SEXTSINE* were evacuated (Government of BC, 2017). As such, community protection from wildfire is a key mandate driving land-management decisions at *Ne SEXTSINE*.

Ne SEXTSINE is bounded by steep river valley cliffs to the west and north, with gently rolling topography to private and municipal land to the south and east. The elevation ranges from 400–1000 m above sea level (m.a.s.l.). Climate is continental and strongly controlled by

the rain shadow of the Coast Mountains; average monthly temperature ranges from -7°C in December to 16°C in July (Environment Canada, 2020). Total annual precipitation is 451 mm, with highest rainfall in June (59 mm) and highest snowfall in December (45 cm) (Environment Canada, 2020). Based on fire-weather data from 2005–2019, 17% of days during the calendar year on average were rated as high to extreme fire danger; in 2017, 30% of days were rated as such (Government of BC, 2021).

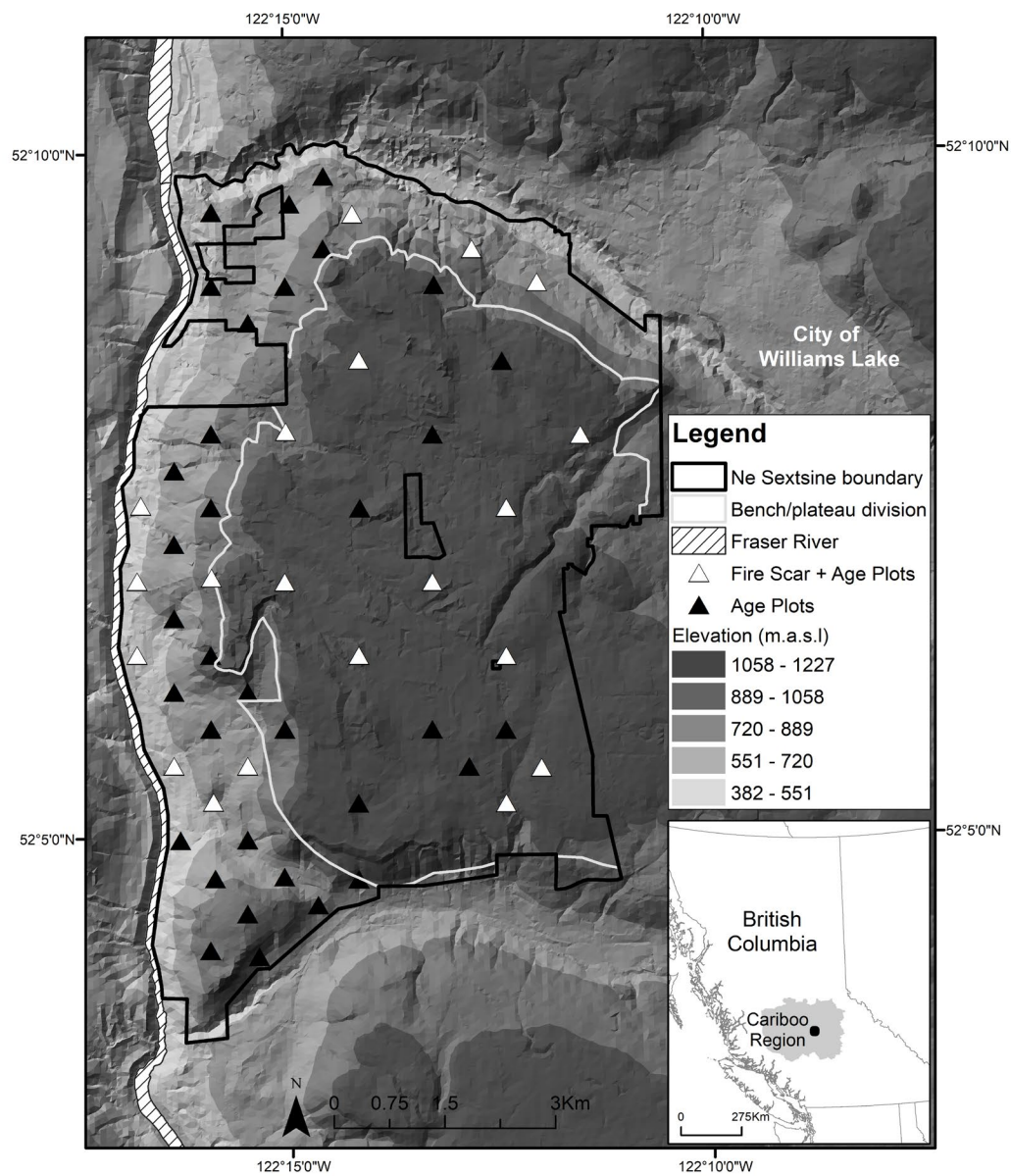


Figure 4.1: Location of 20 fire plots (white triangles) and 34 age plots (black triangles) at *Ne SEXTSINE*, Williams Lake Community Forest, British Columbia, Canada

The landscape at *Ne Sextsine* is dominated by interior Douglas-fir (*Pseudotsuga menziesii* var. *glauca*) forests, including a drier component (~2400 ha) primarily along the benches of the Fraser River and more mesic component (~3500 ha) on a higher elevation plateau, with about 100 ha of existing grassland that gradually transitions to forest (WL Community Forest LP 2015). Aerial photos from the 1960s-70s show grasslands at *Ne Sextsine* covered ~340 ha, which is mandated for grassland restoration as part of the Grasslands Strategy of the Cariboo-Chilcotin Land Use Plan (Steele et al. 2007). The mesic forest includes trembling aspen (*Populus tremuloides*) and hybrid spruce (*Picea engelmannii* x *glauca*) in the wetter areas (WL Community Forest LP 2015). It also includes a small living component of lodgepole pine (*Pinus contorta*), although mature lodgepole is largely absent in the canopy due to the mountain pine beetle epidemic in the early 2000s (WL Community Forest LP 2015).

4.2.2 Field methods

Based on early conversations with the Williams Lake First Nation archaeologist, we aimed to capture the full range of known archaeological and ecological variation at *Ne Sextsine*. To do so, we used a stratified-systematic sampling design to differentiate the dry forest benches (hereafter, “bench”) from the mesic forest (hereafter, “plateau”) (Figure 4.1). We placed a 0.5 km grid over the study site and selected alternate vertices on the bench (plots 1 km apart) and every fourth vertex on the plateau (plots 2 km apart). Of the 59 potential sample plots, five were excluded because they were not safely accessible. At the 54 accessible plots (n=34 and 20 on the bench and plateau, respectively), location, elevation (m.a.s.l.), slope angle and aspect were recorded. Where plots landed within a recorded archaeological site or where archaeological evidence was identified in the field, the plot location was moved on a random bearing up to 100 m away so as not to disturb cultural sites.

We used a modified n-tree design (Jonsson et al., 1992; Lessard et al., 2002) to sample the 20 living trees or snags (snag stage ≤ 4 ; Thomas et al., 1979) closest to plot center, including 10 canopy and 10 subcanopy individuals with diameter at breast height (DBH) ≥ 12.5 cm. For each individual, we recorded species, DBH, height class (canopy or subcanopy), status (live or dead), and snag decay class (Thomas et al. 1979). To estimate age, one increment core was collected as close to the pith (center) as possible and near the root

collar, with coring height recorded to calculate an age-height correction factor (Daniels et al. 2017). The distances from plot center to the outermost tree or sound snag (decay class ≤ 4) in the canopy and subcanopy classes were recorded to calculate scaling factors for circular plots to convert individual trees to a number of trees ha^{-1} , which we used to calculate relative and total tree density (Lessard et al. 2002). Stumps and decayed snags (decay class ≥ 5) were counted in the larger of the two canopy or subcanopy circular subplots. Saplings were tallied by species in a 3.99m radius subplot (0.005 ha) around plot center.

In a ~ 1 ha circular area (radius = 56.4 m) around each plot center, we searched for fire-scarred trees, snags, logs, and stumps (hereafter “scarred trees”) and noted potential culturally modified trees. From the 37 plots with fire evidence, we selected 20 plots (10 on the bench and 10 on the plateau) with at least five scarred trees with multiple visible scars of potentially varying ages. We prioritized snags, logs and stumps for chainsaw sampling cross-sections, took partial sections on living trees where safe to do so (Cochrane and Daniels 2008), and avoided all trees of archaeological significance that are protected by law in BC (Archaeology Branch 2001). Plots where fire scars were collected are hereafter “fire plots” (that contain both age data and fire scar data) where plots with no fire scars collected are hereafter “age plots” (and contain just age data).

4.2.3 Dendrochronological analyses

Increment cores and fire-scar samples were mounted on wooden supports and sanded to reveal ring structure (Stokes and Smiley 1996). Samples were scanned at high resolution (2400 dots per inch) and measured using the program CooRecorder (Larsson 2011a). Ring widths were visually and statistically dated against a master chronology for the region (Daniels and Watson 2003) using the programs COFECHA and Cdendro (Holmes 1983, Larsson 2011b); seven samples (one increment core and six fire scars) could not be accurately crossdated and were not used in further analyses. We recorded inner- and outermost ring dates for each sample (Swetnam and Baisan 1996). Tree ages were estimated by applying (1) an age-height correction and (2) a pith correction where tree cores missed the pith (Duncan 1989). The age-height formula for fast-growth of *P. menzeisii* and *P. contorta* (the primary species of interest) was applied based on the average width of the last three rings prior to pith (Daniels and Watson 2003). A species-specific age-height correction for

Picea sp. Was not available so the *P. menzeisii* formula (also a moderately shade-tolerant species) was applied. Cores with total age corrections ≤ 25 years were retained ($n=1049$) and 92% of age corrections were <15 years, so age structures were presented in 15-year classes.

Year and seasonality (earlywood, latewood, dormant, unknown) for each fire scar was noted (Swetnam and Baisan 1996). The year of dormant season scars, those positioned between rings formed in the current and subsequent year, were assigned as: (1) the current year if a latewood scar was present in another tree in the same or a proximal plot, (2) the subsequent year if an earlywood scar was present in another tree in the same or a proximal plot, or (3) otherwise, the current year given the modern peak fire activity in this forest type.

4.2.4 Reconstructing fire frequency and severity

We compiled fire chronologies for individual fire plots, and composite fire chronologies for plots located on the bench, plateau and entire study area using FHAES software (v 2.0.2). For each chronology, we calculated the length of the fire record (first to last scar), and the number, Weibull median, and range of scar-to-scar intervals (Brewer et al. 2020). Fires that scarred trees in $\geq 30\%$ recording plots were considered widespread. Fire severity was determined at the plot-scale (in fire plots and age plots) based on the presence of fire scars and even-aged cohorts (Heyerdahl et al. 2012).

Cohorts were identified as a 15-year period in which $\geq 25\%$ of trees ha^{-1} established in the plot (Marcoux et al. 2015). We chose a 15-year period because it was less than the median plot-level fire return interval, allowing us to assess if cohorts were initiated by fire. Starting from the oldest pith date in the plot, we tested successive pith dates to determine the start of the cohort, which was defined by the oldest pith date from which $\geq 25\%$ of trees ha^{-1} established in a 15-year window. We continued testing whether subsequent pith dates met the cohort criteria; the end date of the cohort was the last pith date that contributed to the $\geq 25\%$ of trees ha^{-1} criteria in the last 15-yr window. We tested whether excluding cohorts with some tree establishment in the 15 years immediately preceding the cohort start year was warranted (Heyerdahl et al. 2012); however, this criterion did not detect visible pulses of establishment and was thus not used in our analyses.

To determine whether cohorts were initiated by fire, we examined multiple lines of evidence. Cohorts were classified as fire-initiated if the cohort start date was within 15-years

after or 5-years before a fire-scar date (to account for age correction errors). Because fire scars were only collected at 20 fire plots, fire-scar dates included those within a fire plot or in an adjacent fire plot up to 2km away. Cohorts that did not meet these criteria were deemed ‘unattributed’; these unattributed cohorts were not considered a result of abiotic (windthrow, freezing events) or biotic (insects and pathogens) disturbances because we did not observe groups of dead or down canopy trees in any plots. Fire-initiated and unattributed cohorts were further classified based on timing and persistence. First, we determined whether cohorts established prior to or after the most recent widespread fire (1870), given that post-1870s cohorts may be a legacy of decreasing fire frequency. Second, cohorts were considered persistent if their end date was after the last fire scar in individual fire plots or in ≥ 1 fire plot adjacent to age plots.

Finally, we combined multiple lines of evidence to determine fire severity through time at the plot scale. We focus on fire severity through time rather than event-level fire severity following the methods applied in other dry conifer forests of BC (Heyerdahl et al. 2012, Harvey et al. 2017) and given the methodological challenges reconstructing event-level fire severity through time (Daniels et al. 2017). All fire and age plots had cohorts; therefore, plots were assigned either low-, mixed-, or high-severity fire history through time depending on the cohort attribution (fire-initiated or unattributed), timing and persistence. Fire and age plots were assigned either: (1) low-severity if all cohorts (regardless of attribution) persisted in the absence of subsequent fire; (2) mixed-severity if ≥ 1 cohorts (regardless of attribution) established prior to 1870 and survived subsequent fires; or (3) high-severity in an age plot if an unattributed cohort established prior to 1870 and no sampled trees were alive prior to cohort establishment. Plots that could not be assigned a severity were undetermined.

4.2.5 Indigenous contribution to the fire regime

Through ongoing collaborative work with the *T'exelc*, we explored the spatial and temporal differences in the dendroecological fire regime in the context of place-based oral histories and ethnographic records (Chapter 3). This included comparing spatial distribution of known land use practices, governance changes (Chapter 2) and key dates associated with changes to these practices to fire regime characteristics. Temporally, we tested for changes in cumulative fire frequency using piecewise linear regression in SigmaPlot (v 13.0) and

compared the break points to key dates of land use change. We applied this regression to plots in the following categories: (1) bench, (2) plateau, (3) low-severity, (4) mixed-severity, and (5) all *Ne Sextsine* to identify potential differences in changes to the fire history. Spatially, we also tested for differences between physical plot attributes between the bench and plateau using Mann-Whitney U tests (Mann and Whitney 1947), except for aspect which was compared using a t-test after transformation to linear scale ranging from 0 (45°) to 180 (225°) along a cool to warm gradient. We then interpreted these results based on our understanding of the *T'exelc* history at *Ne Sextsine* over the length of the fire scar record.

4.3 Results

4.3.1 Forest structure and composition

Psuedotsuga menzeisii accounted for 98% of trees sampled; a small component of *Picea engelmannii* x *glauca* (2%) and *Pinus contorta* (1%) was present in the plateau plots. Plots on the plateau were significantly ($P < 0.05$) higher in median elevation (912 m.a.s.l) and on shallower slopes (5°) than plots on the bench (621 m.a.s.l and 14°, respectively) (Table 4.1). Plateau plots were generally more south-facing whereas bench plots were more west-facing. Median canopy tree density was higher in plateau plots (159 versus 103 trees ha⁻¹ in bench plots; $P = 0.094$), while median subcanopy tree density was higher in bench plots (335 versus 287 trees ha⁻¹ in plateau plots; $P = 0.220$); however, these differences were not significantly different. Density of stumps was significantly higher ($P < 0.001$) in plateau plots than bench plots (median 68 and 0, respectively). There was no significant difference in sapling or snag density between plot types ($P = 0.532$ and $P = 0.636$, respectively).

Table 4.1: Plot and tree characteristics from plateau and bench forest plots at *Ne Sextsine*.

Median (range) presented for plot characteristics and stand structure. Slope aspect transformed to 0–180° (NE–SW; cool–warm) scale. P-values are the result of Mann-Whitney U tests of median values, except for slope aspect which is a result of a two-tailed t-test.

	Median (range)		
Plots	Plateau (n=20)	Bench (n=34)	p-value
Plot Characteristics			
Elevation (m.a.s.l)	912 (693–967)	621 (477–859)	P<0.001
Slope Aspect	100° (3°–175°)	122° (8°–173°)	P=0.288
Slope Angle	5° (1°–35°)	14° (1°–34°)	P=0.019
Stand Structure			
Canopy trees/ha	159 (39–496)	103 (30–397)	P=0.094
Sub-canopy trees/ha	287 (70–882)	335 (58–1705)	P=0.220
Saplings/ha	300 (0–1000)	200 (0–1800)	P=0.859
Snags/ha	7 (0–196)	11 (0–328)	P=0.636
Stumps/ha	68 (0–355)	0 (0–129)	P<0.001

4.3.2 Fire occurrence, frequency and severity

At the site-level, samples from 118 fire-scarred trees yielded 189 indicators of fire (including 172 fire scars and 17 supporting scarlets); nine samples were excluded because of significant decay. Between 1553 and 1982 CE, 82 fire events were recorded (~16% of years; Figure 4.2a, b, c). Starting in 1628, the first year with ≥ 5 trees to potentially record fires, 35% of fire events burned at only one plot while 9% of fire events were widespread (1628, 1663, 1679, 1768, 1794, 1805, and 1870). No widespread fires were detected in three northeast fire plots (44, 58, 59).

Site-level and plot-level Weibull median fire intervals were 4 and 18 years, respectively; within plots intervals ranged from 2–189 years (Table 4.2). Two plots (44 and 59) had ≤ 2 intervals. Bench plots had a Weibull median fire interval of 22 years compared to 16 years for plateau plots but the differences were not significant. Most fires occurred in the dormant season (late summer in these ecosystems; 56%) and the remainder occurred in the late summer (27% latewood) or early summer (11% earlywood); 17% of fire years (n=14) had scars in two different seasons (e.g., 1768 had two earlywood and four latewood scars which were considered two distinct fire events). Seasonality could not be determined for 6% of scars. Over the length of the fire record, the 1694 and 1727 earlywood fires occurred in one plot on the bench, while the others in the 1700s and 1800s occurred on the plateau. The

earlywood fires in the 20th century occurred near an area of historical grassland in the southeast corner of *Ne Sextsine*.

Of the 1086 trees cored, we estimated the age of 1049 trees that established between 1585 and 1990; 37 trees were omitted because total age correction exceeded 25 years. At the site-level trees established in three modal age classes: 1810–1825 (926 trees ha⁻¹), 1840–1855 (2448 trees ha⁻¹), and 1885–1900 (4350 trees ha⁻¹; Figure 4.2d). The last mode accounted for 25% of contemporary canopy trees.

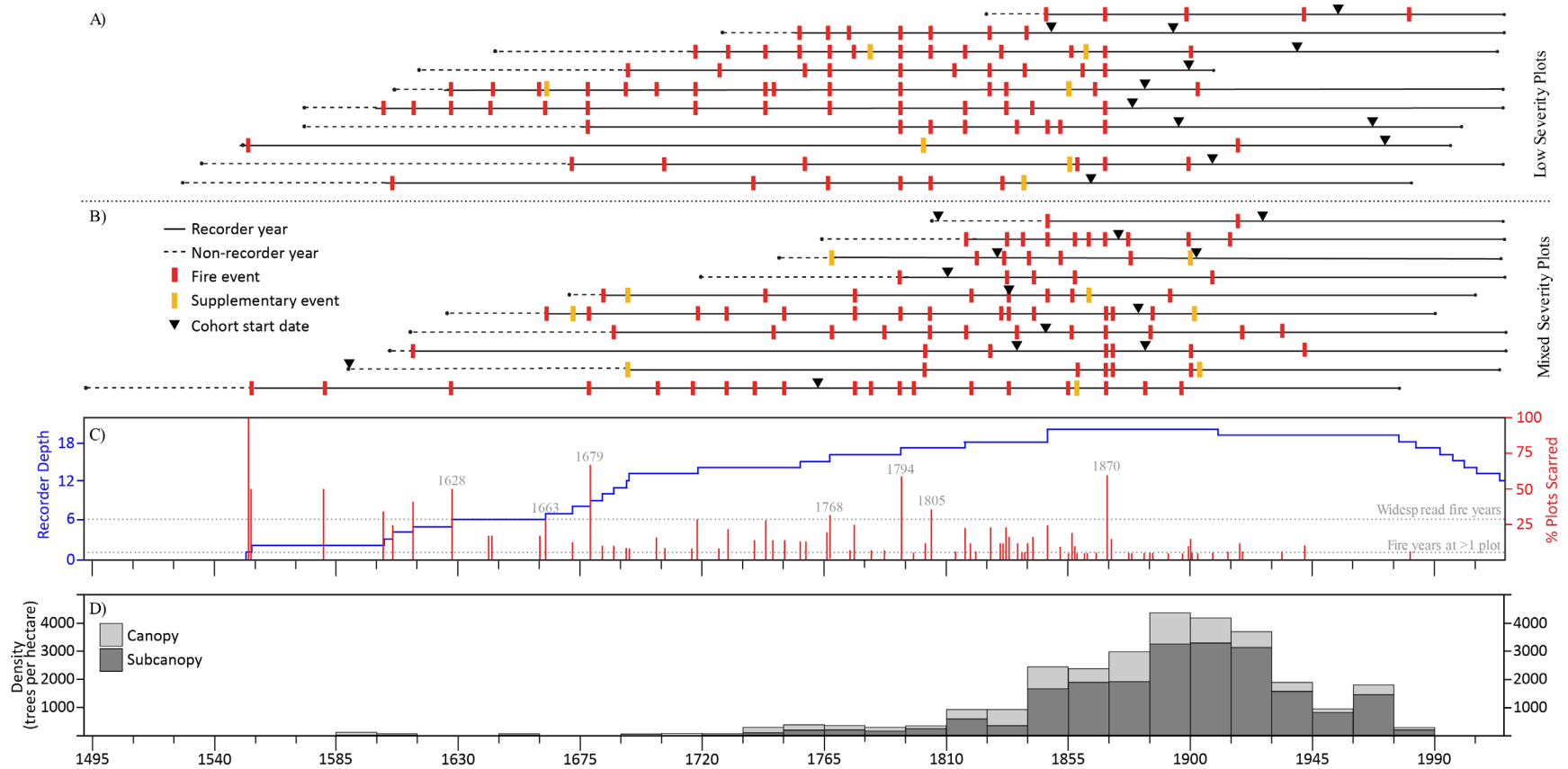


Figure 4.2: Fire regime of *Ne Sextsine*.

Horizontal lines represent plots by fire history through time as low-severity (A) or mixed-severity (B). The site-level composite (C) summarizes the percentage of sites that burned relative to the number of fire plots that could have recorded fire (“recorder depth”) in each fire year. Forest age structure (D) indicates the density of tree establishment in each 15-year age class.

Table 4.2: Fire record for 20 fire plots in *Ne Sextsine*.

Plots are stratified by fire regime severity and arranged from the shortest to the longest fire record within severity type. Order corresponds to plots in Figure 4.2 A (low-severity) and B (mixed-severity).

Plot Number	Location	Fire record	n	Fire return intervals		Fire-initiated cohort	Fire severity		Fire regime severity
				Weibull median (yr)	Range (yr)		Other cohorts	Persistence of cohort	
14	Plateau	1848–1982	4	34	22–43	1	0	Yes	Low
12	Bench	1757–1841	6	14	8–22	2	0	Yes (both)	Low
42	Plateau	1719–1902	14	12	6–32	0	1	Yes	Low
25	Bench	1694–1870	9	19	8–33	1	0	Yes	Low
28	Plateau	1628–1904	16	16	2–38	1	0	Yes	Low
33	Plateau	1603–1870	13	20	10–40	1	0	Yes	Low
45	Plateau	1679–1870	7	18	5–115	1	1	Yes (both)	Low
44	Plateau	1553–1919	2	--	--	0	1	Yes	Low
35	Bench	1673–1901	6	28	2–98	1	0	Yes	Low
15	Bench	1606–1840	6	28	8–134	1	0	Yes	Low
59	Bench	1848–1919	1	--	--	1	1	Yes (second)	Mixed
18	Plateau	1818–1915	9	10	5–22	1	0	No	Mixed
16	Bench	1768–1901	6	20	9–54	2	0	Yes (second)	Mixed
38	Plateau	1794–1909	4	26	10–51	1	0	No	Mixed
58	Bench	1684–1893	9	21	6–51	1	0	No	Mixed
32	Plateau	1663–1902	15	14	2–40	1	0	No	Mixed
57	Bench	1688–1935	11	21	13–59	1	0	No	Mixed
30	Bench	1614–1943	6	35	2–189	2	0	No	Mixed
31	Bench	1693–1904	6	20	2–110	0	1	No	Mixed
27	Plateau	1554–1898	19	16	3–51	1	0	No	Mixed

At the plot-level, all 54 plots had cohorts, and plots had two distinct cohorts (Figure 4.3 and Figure 4.4). Of the 64 total cohorts identified, 63% established asynchronously 10 to 50 years following the last widespread fire in 1870. In fire plots (Figure 4.3), 20 cohorts were classified as fire-initiated and three of the five unattributed cohorts established after 1870. In age plots (Figure 4.4), 25 cohorts were fire-initiated, 10 unattributed cohorts established after 1870, and four were undetermined because they were further than 2km from any sampled fire scars.

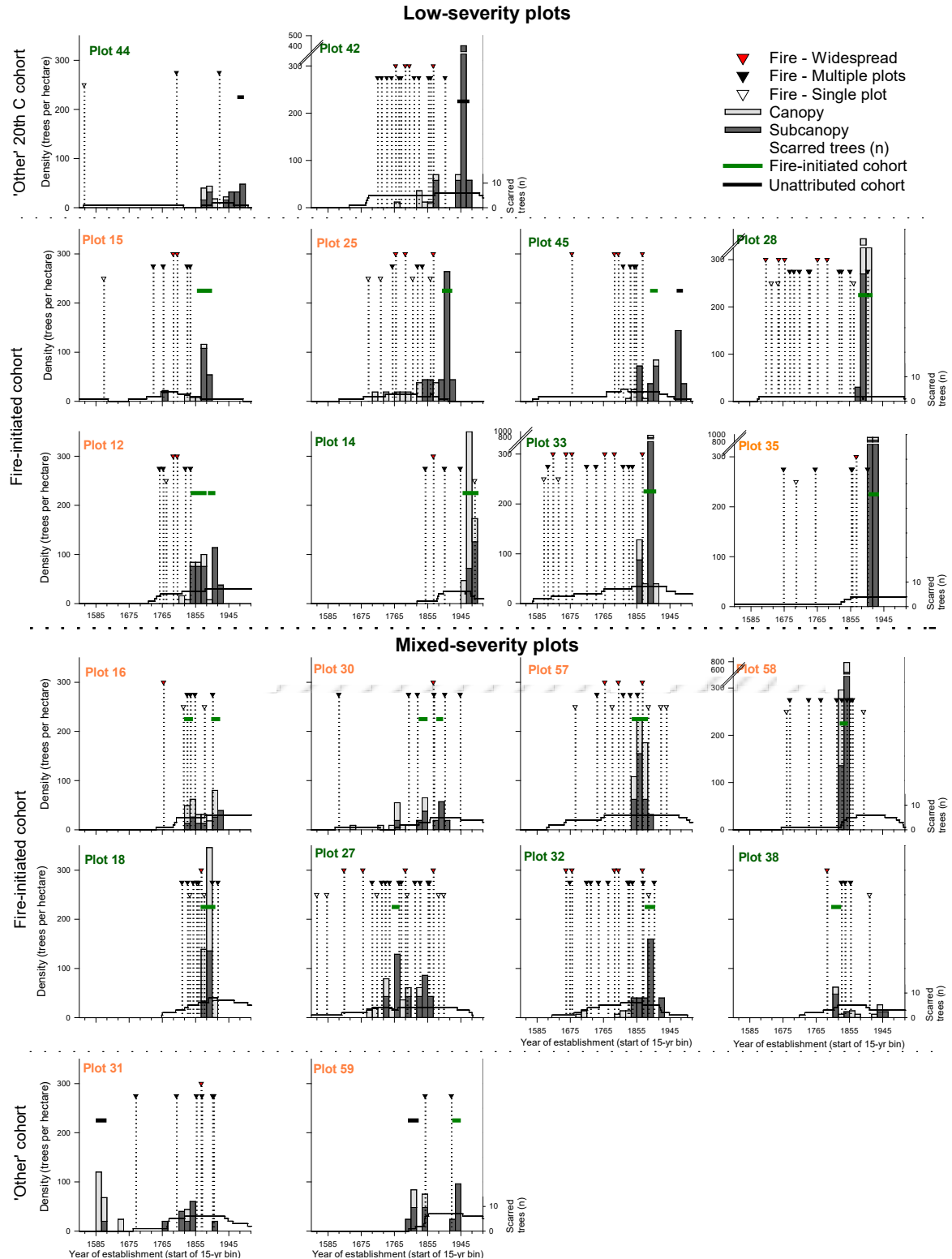


Figure 4.3: Fire history and forest demography in 20 fire plots, including plot-level fire events (triangles), density of establishment (grey bars), presence of cohorts (vertical lines), and sample depth of scarred trees (hashed). Plot numbers in green/orange are located on the plateau/bench.

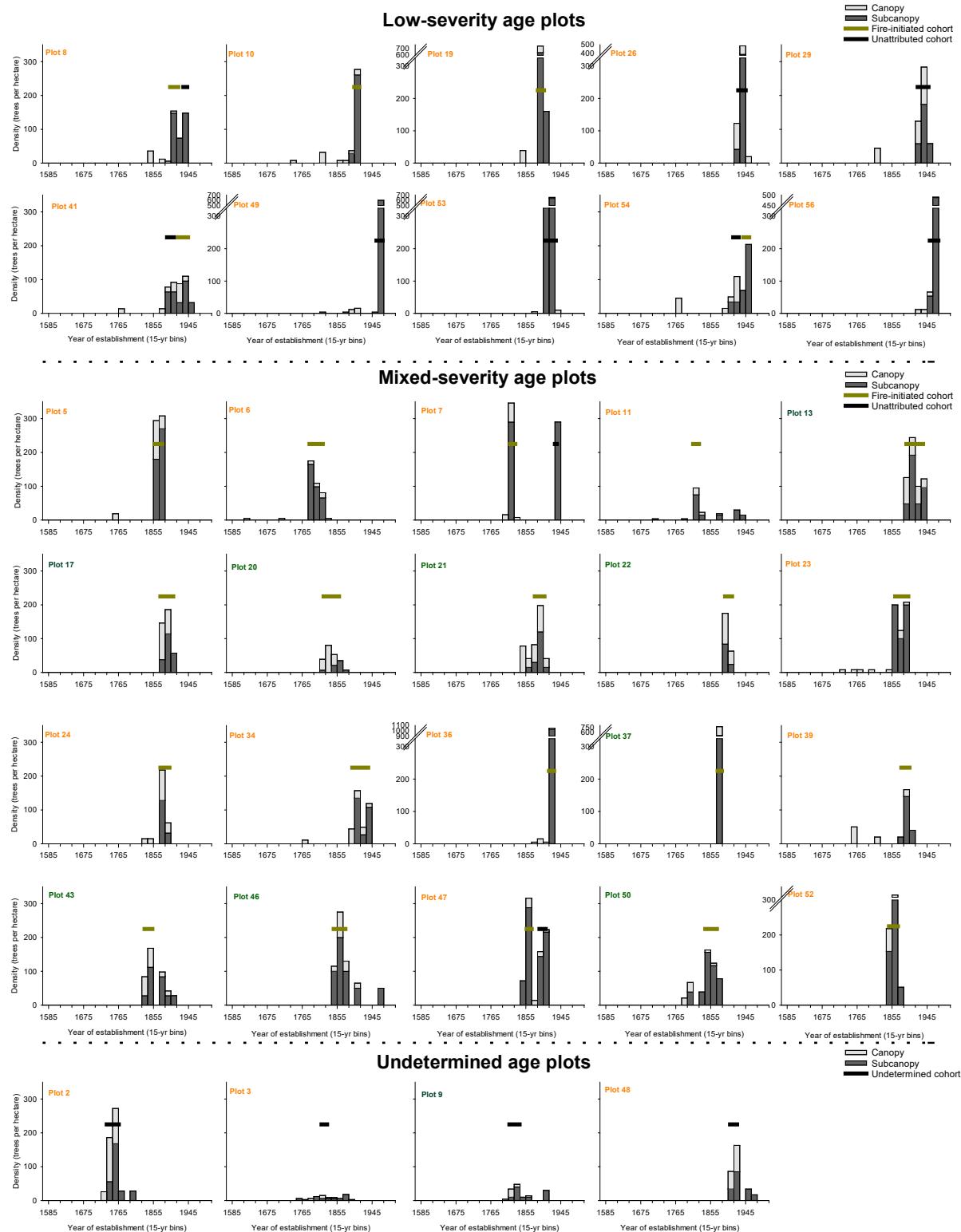


Figure 4.4: Forest demography in 35 age plots, including plot-level density of establishment (grey bars) and presence of cohorts (lines). Plot numbers in green/orange are located on the plateau/bench.

Ten fire plots were classified as low-severity and ten were classified as mixed-severity through time (Table 4.2 and Figure 4.3); both classes included plateau and bench plots. No plots were classified as high severity because they all included fire scars. Each low-severity plot included 3–17 fires indicated by scars, plus ≥ 1 cohort(s) that persisted in the absence of fire. Seven of these plots had fire-initiated cohorts. The remaining three plots had one unattributed cohort with ($n=1$) or without ($n=2$) a second fire-initiated cohort. Two plots had unattributed post-1870 cohorts, and one plot had one fire-initiated and one unattributed post-1870 cohort. All low-severity plots had veteran trees (“scarred trees”) that survived the cohort establishment. Each mixed-severity plot included 2–20 fires, plus at least one cohort that survived subsequent fire(s). Eight of these plots had fire-initiated cohorts. The other two plots had an unattributed cohort that established prior to 1870 with ($n=1$) and without ($n=1$) a second fire-initiated cohort. The two unattributed cohorts established in the absence of veteran trees and may indicate a locally high-severity fire (Plot 31) or grassland invasion (Plot 59) based on landscape position. Plots categorized as low-severity had a Weibull median fire interval of 19 years compared to 18 years for mixed-severity plots. In low- (mixed-) severity fire plots, seasonality of fire scars was 55% (64%) dormant, 15% (9%) earlywood and 30% (27%) latewood.

Of the age plots (Figure 4.4), 10 were classified as having low-severity and 20 were classified as having mixed-severity fire history through time. All low-severity plots were located on the western bench overlooking the Fraser River. Five low-severity plots had a fire-initiated cohort that persisted in the absence of fire, three of which also had an unattributed cohort that established after 1870. The remaining five low-severity plots each had only one unattributed cohort established after 1870. Of the 20 mixed-severity plots, all had a fire-initiated cohort. Two of these plots also had an unattributed cohort that established after 1870 but were considered mixed-severity because of the presence of the fire-initiated cohort that survived subsequent fires. Nine mixed-severity plots were on the bench and 11 were on the plateau.

4.3.3 Indigenous contribution to the fire regime

Piecewise linear regression detected four distinct periods of fire frequency that were generally consistent across and between plot type (bench vs plateau) and assigned fire

severity through time (low- vs mixed-severity). Across *Ne Sextsine* as a whole, there were fires were burning more frequently over the second period starting around the turn of the 19th century, indicated by the break points in 1787 (bench plots), 1804 (plateau plots), 1806 (mixed-severity plots) and 1825 (low severity plots). After this break point, fires become even more frequent during the third period. In the fourth period, in contrast, there is a clear decrease in fire frequency. The timing of this final break point is relatively consistent across all records, except in the low-severity plots when fire frequency begins to asymptote ~50 years earlier (1873; Figure 4.5a) than in the mixed-severity plots (1922). In contrast, the start of the asymptote is less than ten years apart between the plots on the bench (1905) and the plateau (1914; Figure 4.5b). At *Ne Sextsine*, the final break point (1916) is most similar in timing to that of the plots on the plateau (1914) and the mixed-severity plots (1922), suggesting that these plots are driving site-level cumulative fire frequency.

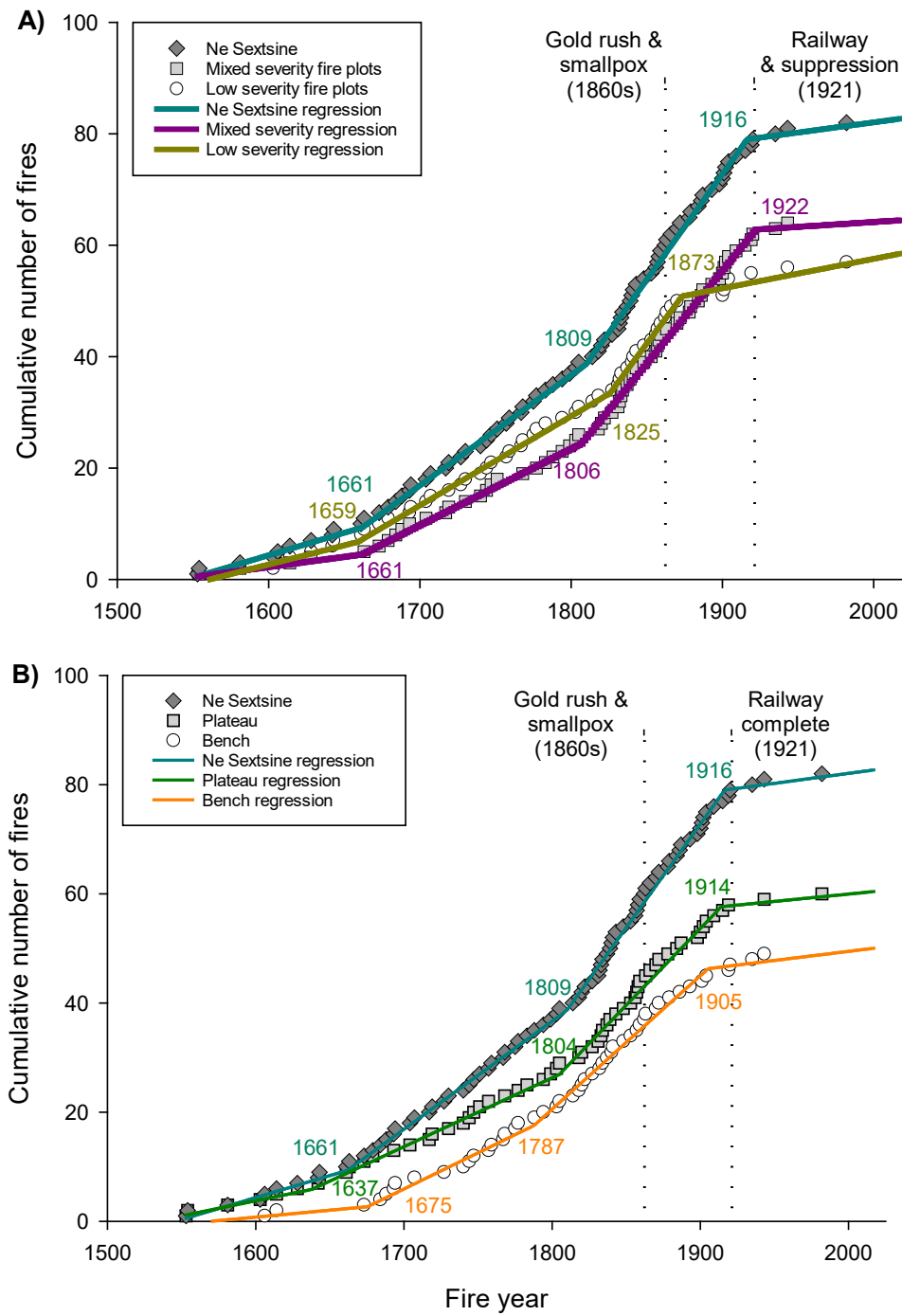


Figure 4.5: Temporal shifts in cumulative fire frequency at *Ne SEXTSINE* relative to key colonial events for (A) low-severity, mixed-severity, and all fire plots, and (B) bench, plateau, and all plots.

4.4 Discussion and conclusions

4.4.1 A mixed-severity fire regime

Historically, fires at *Ne SEXTSINE* burned frequently as part of a mixed-severity fire regime. This mixed-severity fire regime had a high proportion of low-severity fires indicated by fire scars that burned at local to widespread spatial scales, punctuated by patches of higher-severity fire indicated by cohorts at the local (plot)-scale only (Heyerdahl et al. 2012, Harvey et al. 2017). At the site-level, the mean fire return interval between 1628 and 1982 at *Ne SEXTSINE* (21 years) is consistent with mean intervals in other mixed-severity fire regimes in dry forest ecosystems in BC (Daniels and Watson 2003, Heyerdahl et al. 2012, Marcoux et al. 2013, Harvey et al. 2017, Brookes et al. 2021). Compared to mixed-severity fire regimes in higher-elevation montane forests in BC (Marcoux et al. 2013, Chavardès and Daniels 2016), the fire regime at *Ne SEXTSINE* contained little evidence of spatially extensive high-severity fire events. This contrasts the assumption currently guiding disturbance-based management in BC that spatially extensive high-severity fire events every c. 250 years were a component of mixed-severity fire regimes in dry forest ecosystems (BC Ministry of Forests and BC Ministry of Environment 1995) and helps to refine our understanding of the relative influence of low- to high-severity fire effects in dry forest ecosystems (Hessburg et al. 2016).

Traditionally in fire history research, even-aged cohorts are interpreted as indirect evidence of high-severity conditions that create large openings for groups of trees to establish, whereas a lack of cohorts and presence of fire scars is interpreted as evidence of low-severity fires (Heinselman 1973, Heyerdahl et al. 2012, Daniels et al. 2017). At *Ne SEXTSINE*, however, since all fire plots contained fire scars and cohorts, we interpreted cohorts that persisted in absence of fire to be a feature of low-severity fire histories at the plot level. This aligns with other interpretations of cohorts that persisted in the absence of frequent, low-severity fire as a legacy of high tree survival rates in altered fire regimes (Guiterman et al. 2018) rather than as evidence of a spatially extensive high severity fire. This criteria was also important at the nearby dry forest ecosystems in the (~100km south) Churn Creek Protected Area (Harvey et al. 2017) and the (~35km east) Alex Fraser Research Forest (Brookes et al. 2021). At *Ne SEXTSINE*, eight plots (Figure 4.3) were classified as low-severity and contained a fire-initiated cohort that established after the last fire (Plots 15, 25, 45, 12,

14, 35) or was still forming after the last fire (Plots 28, 14). In these low-severity plots with 3–17 fire-scar years, we interpreted these cohorts as persisting in the absence of subsequent fire that would have likely killed small and vulnerable trees. Low-severity fires were also a feature of the mixed-severity fire plots, but the cohorts (both fire-initiated and unattributed) survived 1–11 subsequent fires that must have been of low enough intensity to not kill vulnerable young trees. This interpretation is supported by a clear reduction in fire-frequency, especially in the low-severity plots, starting in the 1870s and strong evidence of forest encroachment and increases in density in dry forest ecosystems in the absence of frequent fire in BC (Turner and Krannitz 2001, Harvey et al. 2017, Brookes et al. 2021) and similar frequent-fire ecosystems in North America (Hessburg et al. 2016, Larson et al. 2020).

In four fire plots (42, 44, 31 and 59) the cohorts were not attributed to a fire, but the timing of the cohort helped distinguish low-severity from mixed-severity fire history at the plot-level. Following similar logic described above, we interpreted Plots 42 and 44 as low-severity because the cohort persisted in the absence of fire, whereas we interpreted Plots 31 and 59 as mixed-severity because the cohorts survived subsequent fires. Of the unattributed cohorts not associated with fire scars, we interpreted two as likely representing a high-severity fire event (Plot 31 and the earliest cohort in Plot 59) since these cohort were preceded by no remnant trees, and two as post-logging cohorts (Plot 42 and 44) given the presence of stumps in those plots. Alternatively, it is possible that these cohorts were fire-initiated but no fire scar evidence remains because subsequent fires eliminated evidence, modern logging disturbance removed evidence, or due to the fading dendroecological record back in time (Swetnam et al. 1999). Other possibilities include these cohorts resulted from rapid grassland invasion in the absence of fire given the historical presence of grassland at *Ne SEXTSINE* or were climate-driven; however, we would expect synchronous establishment dates if they were climate-driven rather than cohorts distributed through time (Figure 4.2). Nevertheless, these alternative explanations for the attribution of the cohort do not change our interpretation of low- versus mixed-severity fire histories at the plot-level or that the mixed-severity fire regime was dominated by low-severity fire.

In contrast to the fire plots, the age plots did not contain direct fire-scar evidence and, thus, were more challenging for interpreting fire severity through time. Our sample design distributed fire plots equally across the bench and plateau and all but four age plots (n=30)

were within 2km of at least one fire plot from which we inferred severity. As with the fire plots, the timing of the cohort was key for differentiating low- from mixed-severity. In the low-severity plots (n=10), all cohorts (fire-initiated or unattributed) established at some point after the last widespread fire in 1870. However, in one of these plots (53) the cohort that initiated in 1905 did not persist in the absence of fire but was nevertheless interpreted as low-severity; this was because the fire that could have affected that cohort was only locally recorded at Plot 57 (versus at multiple plots) and because it occurred after the last widespread fire. All the mixed-severity plots (n=20) had at least one fire-initiated cohort that may have survived (likely low-severity) subsequent fires. With this approach, we may have overestimated the number of mixed-severity plots and underestimated low-severity plots because we relied on any adjacent evidence within a 2km radius (maximum of eight adjacent fire plots); if this is the case, low-severity fire was perhaps more frequent than our findings suggest. Some plots with only a single cohort and no veteran trees (e.g., Plots 13, 17, 20, 22, 37) may have experienced higher-severity fires or alternatively grassland invasion, especially since there were no fire scars visible at these plots. Traditionally, the cohorts in these plots would have been interpreted as evidence of high-severity fire, however, given the amount of historical grassland present in this environment we think the latter explanation is more likely. It is notable that no low-severity age plots had this pattern. In addition, while this indirect evidence from adjacent plots and reliance on cohorts alone may not accurately represent the conditions within a plot given the variability of burn severities within a fire (Daniels et al. 2017), this approach, perhaps in combination with additional methods (e.g., spatial interpolation, Greene and Daniels 2017), may offer a possible alternative for fire-severity interpretations where it is not feasible to undertake intensive sampling of fire scars.

4.4.2 Indigenous contribution to the mixed-severity fire regime

Mixed-severity fire regimes are recognized for their complex interactions between topography, fuels and weather (bottom-up and top-down drivers) that help to create heterogeneity at different spatial and temporal scales (Schoennagel et al. 2004, Halofsky et al. 2011, Perry et al. 2011, Daniels et al. 2017). Inherent in contributing to this heterogeneity, although less well explored in studies on mixed-severity fire regimes, is the role of Indigenous land and fire stewardship. Oral histories and ethnographic research in BC

describe the historical role of Indigenous burning and ongoing fire stewardship that has adapted to modern conditions (Turner et al. 2000, Lewis et al. 2018, Xwisten Nation et al. 2018, Lake and Christianson 2019). Previous dendroecological studies have acknowledged the complex and context-specific relationships between Indigenous peoples and fire regimes in the USA (e.g., Stambaugh et al. 2013, Liebmann et al. 2016, Taylor et al. 2016, Guiterman et al. 2019, Larson et al. 2020) and Mexico (Fulé et al. 2011), but this is an emerging area of research within BC (Hoffman et al. 2017). Here, we discuss multiple lines of evidence used to interpret the role of Indigenous fire as a key driver of the mixed-severity fire regime at *Ne SEXTSINE*.

The complex distribution of fire severity at the plot-level is likely tied to diverse land use across *Ne SEXTSINE* since spatial variation in fire severity is not distinguished by contrasting topographic positions or forest (fuel) types. Oral histories, archaeological evidence, and ongoing collaborative research with the *T'EXELCEMC* indicate varied activities across *Ne SEXTSINE*, with areas of historically high occupancy centered at winter village sites and seasonal summer camps on the bench above the Fraser River (Chapter 3, Williams Lake Indian Band Traditional Land Use Team 1998). At and near these village sites, constant campfires fueled by local wood sources were necessary for warmth, cooking, and drying fish in the late summer months. Berry-picking also occurred in open areas and forest edges near the Fraser River, where the berries would ripen earliest; soapberry (*Shepherdia canadensis*) is a key medicinal and food species that can be maintained by frequent, low-severity fires (Walkup 1991; Chapter 3). Hunting for mule deer was likely concentrated up on the plateau where there was more continuous forest cover (Chapter 3 Williams Lake Indian Band Traditional Land Use Team 1998); managing for mule deer winter range continues to be a guiding land-use objective (Steele et al. 2007). This complexity of land use likely increased the need for localized fires for different purposes, with 35% of fire years at *Ne SEXTSINE* recorded at only one plot. Similarly in fire regimes in the southwestern US, a high number of small fires is interpreted as an indication of Indigenous ignitions (Swetnam et al. 2016, Taylor et al. 2016).

These spatial patterns of use are also clearly differentiated in the plot-level fire severity: areas of high occupation are spatially coincident with plots classified as low-severity through time. The frequent use of intentional fire adjacent to village sites is a known

practice in dry forest ecosystems and across the larger the Secwépemc traditional territory (Turner et al. 2000, Ignace et al. 2016, Lake and Christianson 2019). However, low-severity fire plots are more widely distributed than known winter village sites, which may be explained by several, not mutually exclusive, hypotheses: (1) not all winter village sites have been recorded (W. Spearing, WLFN archaeologist, *pers. comm.*); (2) frequent, low-severity fire was used to maintain travel corridors (Lake and Christianson 2019, Larson et al. 2020) or to manipulate forest structure further from village sites (Lake and Christianson 2019, Roos et al. 2021); and/or, (3) low-severity fire was a natural feature of historical grasslands (Steele et al. 2007, Harvey et al. 2017). We anticipate that hypotheses (1) and (2) are most likely, given the presence of culturally-modified way marker trees identifying travel corridors, the wide variety of land uses by the *T'exelcenc* documented across *Ne SEXTSINE* (Copes-Gerbitz et al. *in review*) and that all low-severity fire plots are within the boundaries of or within 300 meters of areas of high archaeological potential (Wilson et al. 1998). Despite this likely association, the complexity of land use is mirrored in the complexity of fire-severity, unsurprising given that cultural burning has different objectives in different locations (Gottesfeld 1994, Lake and Christianson 2019). The mixed-severity plots were also within areas of high archaeological potential. As these mixed-severity plots also have a high frequency of fire, we interpret the presence of mixed-severity plots as those where occupation may have shifted over time (e.g., abandonment of a site temporarily stops frequent fire in the area), resource needs (and thus severity of fire) differed (e.g., forest-grassland edge requirements for berries), or areas that were purposely managed at lower intensities and may have been more amenable to lightning-ignited fires. Shifting priorities and fire use through time is a feature of Indigenous landscapes elsewhere in Canada (Davidson-Hunt and Berkes 2003), creating a mosaic of locally-intensive land use where fires may have been concentrated (Larson et al. 2020).

Perhaps the most compelling line of evidence indicating the historical fire regime resulted from Indigenous land use is the collapse of fire frequency during early colonization (Figure 4.5), a pattern that supports Indigenous oral histories in the region (Turner et al. 2000, Lewis et al. 2018, Xwisten Nation et al. 2018, Lake and Christianson 2019, Dickson-Hoyle et al. 2021). At *Ne SEXTSINE* fire was excluded in the low-severity plots after 1873 and in the mixed-severity plots after 1922, corresponding to critical events associated with

colonial impacts on Indigenous peoples in BC: the smallpox epidemic of 1862–63 killed up to two-thirds of the Secwépemc peoples, regional pre-emptions that sold unceded land to settlers, and the federal Indian Act and Residential Schools program that forcibly removed Indigenous peoples from their territories and attempted to assimilate Indigenous children (Turner and Ignace 2000; Ignace and Ignace 2017, Chapter 12, pg.442). These colonial impacts are also recent and ongoing, with the local residential school closing in 1981 and land sovereignty still being contested by Indigenous peoples in the *Secwepemcúl'ecw* (Dickson-Hoyle et al. 2021). This was also the timing in which fire exclusion started to be legislated: in 1874 the BC Bush Fire Act in BC was passed and punished intentional fire use except by government authorization (Parminter 1981), which was unlikely to be granted to Indigenous peoples (Copes-Gerbitz et al. 2021; Hoffman et al. *in revision*).

In the mixed-severity plots, the frequent fires ceased around 1922, not long after Williams Lake was made divisional headquarters of the Pacific Great Eastern Railway, which brought an influx of European settlers, supported a boom in cattle ranching, and prompted the establishment of the first local bush mills in the 1940s (Day 1998, 2007, Mather 2000). This collapse in frequent low-severity fire in areas of high Indigenous land use is a common pattern emerging in dry forests throughout BC and the Alberta foothills (Greene and Daniels 2017, Pogue 2017, Naficy et al. *in preparation*) and in frequent fire regimes in other parts of North America, where changes in social-ecological context are the primary driver of fire regime changes (Taylor et al. 2016, Larson et al. 2020). Importantly, disentangling the drivers of altered fire regimes (e.g., exclusion of Indigenous fire stewardship vs. fire suppression) is key for identifying appropriate pathways to return pyrodiversity to these landscapes.

We acknowledge that Indigenous ignitions likely augmented a fire regime that also included lightning ignitions, such as those experienced in 2017. Widespread fires (but not grassland fires) at the nearby Churn Creek Protected Area occurred during anomalously dry, warm years following antecedent drought conditions (Harvey et al. 2017). Even the most widespread fires at *Ne SEXTSINE*, however, experienced only low- to moderate-severity effects at the plot scale. For example, in the 1794 fire which scarred 56% of recording plots, only one plot (38) had a cohort that possibly established as a direct result of moderate-severity effects; this perhaps provides evidence of the self-limiting nature of frequent fire regimes in

Indigenous territories (Stambaugh et al. 2013, Swetnam et al. 2016, Taylor et al. 2016), especially when coupled with other stewardship practices such as wood collection (Roos et al. 2021). Importantly, interpreting the fire regime of *Ne Sextsine* as a whole or only focusing on topographical differences between the plateau and bench (a common bottom-up driver) may have led to the interpretation that the Indigenous fire regime was not disrupted by settlement and instead continued until more intensive grazing and active fire suppression occurred. Differentiating between low- and mixed-severity fire at the plot scale provided a key piece of evidence that supports Indigenous oral histories that describe a disruption to Indigenous fire stewardship due to colonization (Lake and Christianson 2019).

4.4.3 Culturally and ecologically relevant landscape management

At *Ne Sextsine*, we explicitly recognize that Indigenous stewardship contributed to the patch heterogeneity that characterizes mixed-severity fire regimes (Perry et al. 2011). After the collapse of the fire regime at *Ne Sextsine*, the landscape transitioned into a dense, homogenous forest mostly devoid of Indigenous stewardship, with nearly two-thirds of cohorts establishing in the century after 1870. This contrasts the common interpretation that high-severity fires produced cohorts at the end of the 1800s and that fire suppression altered fire regimes in other mixed-severity fire regimes (Chavardès and Daniels 2016). The homogenization of landscapes under altered fire regimes is a common pattern in mixed-severity fire regimes that can result in increased vulnerability to uncharacteristic, large, high-severity fires (Perry et al. 2011, Hessburg et al. 2016). This vulnerability is enhanced under current and future predicted climate change that identify a warming and drying trend (and subsequent lengthening of the fire season) in the southern Canadian cordillera (Wang et al. 2017, 2020, Hanes et al. 2019), with dry forest ecosystems especially at risk when modern forest structures do not provide resistance or resilience to crown fires (Turner 2010, Johnstone et al. 2016, Hessburg et al. 2019).

Given the degree of change from historical forest conditions and ongoing climate change impacts, many advocate for learning to coexist with fire through adaptive management approaches that incorporate diverse strategies to deal with risk (Day and Pérez 2013, Christianson 2015, Hessburg et al. 2016, Smith et al. 2016, Coogan et al. 2019). These diverse strategies must reflect the unique forest context, including a refined understanding of

the location-specific mixed-severity fire regime and the relative influence of low- versus high-severity fire events through time (Stephens et al. 2013, Hessburg et al. 2016). In BC, this context includes reflecting on the accuracy of the Natural Disturbance Type system that underrepresents the prevalence of mixed-severity fire regimes and overestimates the contribution of high-severity fire (Marcoux et al. 2013). In addition, addressing fire risk must be weighed against other forest values, such as where managing for mule deer winter range may influence forest susceptibility to insects and fire (Leclerc et al. 2021). Ecologically-based forest management in mixed-severity fire regimes suggests creating and maintaining successional heterogeneity at multiple scales and expanding the use of prescribed and managed wildfire (Hessburg et al. 2016). Beyond these ecologically-informed strategies, future management must first recognize the contribution of Indigenous peoples to historical fire regimes and include ecocultural strategies such as cultural burning and a return of Indigenous land stewardship if we are to minimize the high-severity impacts such as those experienced directly adjacent to *Ne Sextsine* in 2017 (White et al. 2011, Christianson 2015, Lake and Christianson 2019, Dickson-Hoyle et al. 2021).

Central to future management of these ecocultural landscapes is embracing the diversity of relationships between people and fire and explicitly recognizing how this relationship has changed through time (Bowman et al. 2011, 2013, Moritz et al. 2014, Smith et al. 2016, Hessburg et al. 2019). Indigenous fire management has historically contributed to pyrodiversity (Huffman 2013, Trauernicht et al. 2015) and despite the ongoing impacts of colonialism, continues to do so (Eriksen and Hankins 2014, Martínez-Torres et al. 2016, Lake and Christianson 2019), including areas where fire was intentionally used or where Indigenous peoples benefitted from fire (Miller et al. 2010, White et al. 2011). The interpretations made from dendroecological and other palaeoecological methods can potentially erase or misconstrue the relationship between Indigenous peoples and fire when not undertaken in collaboration with Indigenous scholars, elders and other knowledge keepers – which became clear in a recent debate in the literature around the interpretation of Indigenous fire use in the northeastern USA (Abrams and Nowacki 2020, Leonard et al. 2020, Oswald et al. 2020, Roos 2020). To understand historical fire regimes, it is imperative to overcome the duality of fire as ‘natural’ or ‘cultural’ (Bowman et al. 2011, White et al. 2011, Roos 2020) and, instead, embed a process that meaningfully engages with Indigenous

peoples and supports Indigenous-led management approaches that reflect their understanding of the dynamic role of fire and people in the landscape (Lake 2013, Eriksen and Hankins 2014, Mistry and Berardi 2016, Lake and Christianson 2019, Larson et al. 2020). These place-based approaches are key for enabling the adaptive capacity of communities (Roos et al. 2016) and for providing pathways towards Indigenous revitalization (Kimmerer and Lake 2001, Lake and Christianson 2019, Dickson-Hoyle et al. 2021). In this way, future fire regime research can more holistically incorporate diverse perspectives necessary for coexisting with fire in a culturally and ecologically relevant way (McWethy et al. 2019, Larson et al. 2020) and ensure future natural science research is led by Indigenous peoples (Mistry and Berardi 2016, Wong et al. 2020).

Chapter 5: Contributions and conclusions

5.1 Key insights

The fire paradigm in British Columbia (BC) continues to evolve, and this dissertation examines the nature of that evolution through an interdisciplinary, social-ecological, spatiotemporal lens. Answering the three research questions in this dissertation yielded two integrative insights into the fire paradigm in BC: (1) the dominant colonial fire governance model, in place since 1912, has had cascading consequences for social and ecological communities through time, and (2) opportunities for coexisting with fire in the future must center around shifting the governance model towards one that redistributes decision-making power for more equitable fire governance.

The first primary insight from this dissertation is the cascading consequences of colonial fire governance. At the provincial scale, Chapter 2 demonstrates the many ways that colonial governance disrupted Indigenous fire stewardship, resulting in the localized loss or alteration of the knowledge and practice of cultural burning. Chapters 3 and 4 provide localized evidence of the social and ecological outcomes of the shift away from Indigenous fire stewardship, respectively. At *Ne SEXTSINE*, the *T'exelc* were unable to continue place-based, intergenerational knowledge transmission of fire and landscape stewardship practices due to colonization, and the mixed-severity fire regime maintained by *T'exelc* stewardship was dramatically altered. Consequently, *Ne SEXTSINE* today is a dense, homogenous dry forest landscape that is more likely to burn at uncharacteristic high severities, threatening adjacent communities and the *T'exelc* values and obligations that endure. While the legacies of the colonial fire governance model, including entrenched power of government actors, “lost” practices of Indigenous fire stewardship, and highly susceptible dry forest ecosystems, may be difficult to overcome, this thesis identifies several pathways and potential opportunities for coexisting with fire.

The second primary insight from this dissertation is the ways in which the fire governance model needs to transform to support the proposed vision for coexisting with fire. The proposed vision aligns with current literature on coexisting with fire through increasing decision-making for communities (Moritz et al. 2014, Roos et al. 2016, Schoennagel et al. 2017, McWethy et al. 2019, Tedim et al. 2019) and ensuring an inclusive and equitable view

of resilience is applied. Transformational change in BC requires addressing the power imbalance that often devalues and marginalizes Indigenous peoples' decision-making authority – ideally to ensure that fire resilience is also defined and led by Indigenous peoples (Miller and Davidson-Hunt 2013, Christianson 2015). This scale of transformative change goes beyond transforming the built environment or landscape-level fuel treatments (McWethy et al. 2019) and aligns with the observation that transformative change must be underlined by high levels of social acceptability (Higuera et al. 2019). Chapter 2 outlines a socially acceptable fire governance vision from the perspective of provincial and regional fire and forest managers, while Chapter 3 demonstrates the acceptability (by the *T'exelceme*) of land governance more broadly that operates on the principal of respect. Shifting the fire governance model to one that embraces diverse perspectives and aims to restore historically-mixed severity fire regimes in the dry forests under the guidance of Indigenous stewards will help ensure that context-specific solutions are leveraged for social-ecological systems resilience in BC (Stephens et al. 2013, Moritz et al. 2014, Spies et al. 2014, Fischer et al. 2016, Paveglio et al. 2016). Below, I summarize the key contributions of each individual data chapter.

5.1.1 Chapter 2 – Fire governance in BC

Chapter 2 addressed Research Objective 1: Identify attributes of historical fire governance that enable or constrain a vision for future fire governance. In the BC case study, a key constraint on transformative change is the centralized, rigid, government organizations with decision-making authority that have accumulated power over fire-related decision making since 1874, when Indigenous fire stewardship was formally outlawed. Another key constraint is the siloed expertise between fire and forest organizations that resulted from the “big divorce” of 1995, which led to disconnected land (forest) management decisions. Overcoming these constraints will require a devolution of decision-making authority to Indigenous and local communities. This devolution must return to and honor Indigenous fire stewardship and the natural ecological role of fire, both key worldviews of fire illustrated in historical fire governance eras. Importantly, the vision for transformation put forward by interviewees – and the efforts currently being undertaken to achieve that vision – will ideally

enable a reimagined form of stewardship that succeeds in better coexisting with fire in the future.

5.1.2 Chapter 3 – Situating Indigenous knowledge

Chapter 3 was guided by Research Objective 2: Explore the context of how Indigenous knowledge is situated within a fire-dependent social-ecological system. The key insight from this Chapter, and the collaborative research approach employed, is that the *context* of knowledge (the place-based processes associated with it) is more important than the *content* of knowledge in considering resilience defined by the *T'exelc*emc. Fire (or forest) governance that incorporates the context of Indigenous knowledge, and reflects their enduring connection to place, will result in more respectful and ethical management decisions. Finally, the collaborative experiment that we employed helped to shift the context of Indigenous knowledge out of a colonial forest management approach at *Ne SEXTSINE* by providing a trust-building process between the *T'exelc* elders, Williams Lake First Nation archaeologists, and Williams Lake Community Forest managers. It is our collective hope that this collaborative experiment helped define and situate *T'exelc*-led resilience at *Ne SEXTSINE*.

5.1.3 Chapter 4 – Historical fire regime of *Ne SEXTSINE*

Chapter 4 centered on Research Objective 3: Explore the Indigenous contribution to the historical fire regime in a dry forest ecosystem. The dendroecological case study of the 5900ha *Ne SEXTSINE*, interpreted through the lens of *T'exelc* oral histories, demonstrates that Indigenous fire and land stewardship historically maintained pyrodiversity in a high-frequency, mixed-severity fire regime with a median fire return interval of 18 years at the plot-level and 4 years at the study-site level. A clear collapse of the Indigenous fire regime in the 1870s after devastating colonial impacts (particularly in those plots classified as low severity), interrupted the *T'exelc* stewardship that created and helped maintain pyrodiversity – and by the 1920s largely eliminated fire from *Ne SEXTSINE*. Without frequent fire on the landscape, a dense, homogenous forest developed that is more likely to burn at uncharacteristic high severities today. This chapter provided a clear case study of the ecological consequences of a colonial model of fire governance and the importance of centering Indigenous knowledge in interpreting tree-ring fire histories.

5.2 Contributions

5.2.1 Empirical contributions

The empirical contribution of this dissertation is the rich, multi-source data set describing fire in BC across several spatiotemporal scales. First, is the collation and analyses undertaken on 157 historical documents covering the period from 1874 to 2020. These documents are primarily provincial in scale, but also include Canadian strategies that informed the development of provincial-level documents. Second is the site-specific sources collected (Chapter 3 and 4) and collated (Chapter 3) for *Ne SEXTSINE*. For Chapter 3, I conducted two place-based group interviews with *T'exelc* Elders and paired these with a close reading of 29 previous elder interviews (traditional use studies) and maps of known archaeological and cultural heritage sites provided by the Williams Lake First Nation – who retain the rights to the data. Furthermore, for Chapter 4 I collected and analyzed 1049 increment cores for tree-age data and 118 fire-scarred trees that yielded 189 scars and scarlets which provided evidence of the fire history of *Ne SEXTSINE* from 1550 to 2020. The tree-ring data set from *Ne SEXTSINE* contributed to the interpretations made in Chapter 3, and the oral histories (Chapter 3) and historical documents (Chapter 2 and 3) contributed to the interpretations made in Chapter 4. Importantly, the tree-ring data set also contributes to the network of similar fire history studies that currently exist and are being developed in the dry forest ecosystems of the Cariboo Region to better understand mixed-severity fire regimes in BC.

5.2.2 Implications for policy and practice

Ultimately, coexisting with fire cannot be achieved in BC without attention to land governance more broadly. At both the provincial and local scale, this research demonstrates that BC's approach to fire governance is embedded within bigger issues of land sovereignty and forest governance that continue to be dictated by centralized government authorities. Only through multiple policy and practice interventions can BC work to address these issues, including by:

- Actively addressing contested Indigenous land sovereignty. Uncertainty over long-term forest governance is a major barrier to reconciliation, to forest management, and to addressing fire risk in equitably and ethically.
- Adding fire as a value in the Forest and Range Practices Act to bridge the forest management and fire silo. As a value, tenure holders would be legally required to manage for fire resilience at the landscape-scale and in the wildland-urban interface. A fire resilience value would be associated with guidelines describing important social-ecological contexts of fire, such as Indigenous fire stewardship and fire regimes.
- Legislating forest planning and developing a provincial model with regional flexibility. The provincial model should be developed by and with Indigenous governments, the forest industry, and regional and provincial fire experts (among other stakeholders). The requirement to engage in open, early, and collaborative planning processes will ensure that addressing fire risk is achieved while balancing for other landscape values.
- Revisiting the Natural Disturbance Type classification in BC that underrepresents the prevalence of mixed-severity fire regimes and overestimates the contribution of high-severity fire (e.g., Marcoux et al. 2013). In the dry forest ecosystem at *Ne Sextsine*, forest management should actively work to remove the build-up of hazardous fuels, increase heterogeneity at the stand and landscape-scale, and, when possible, reintroduce low-severity, high-frequency fire. These interventions should be guided by values prioritized by the *T'exelcenc*, such as the importance of certain camp spots for fishing, forest structures for hunting or gathering, pathways and trails to restore their access to culturally important sites, and protection from catastrophic impacts of fire on their lives and livelihoods.
- Humbly, openly, and ethically collaborating with First Nations. Fire managers and forest managers must be willing to learn from First Nations about the meaning of place, no matter what the expected or existing content of ecological knowledge may be. Current methods of engagement (e.g., consultation or free, prior, and informed consent) are inadequate to develop relationships that support learning and to capture the enduring connection to place First Nation peoples have.

5.3 Strengths and limitations

5.3.1 Strengths

The primary strength of this dissertation is the interdisciplinary approach that combined qualitative and quantitative methods with a collaborative research design to produce a holistic understanding of the dynamics of fire in BC across multiple spatiotemporal scales. The use of multiple forms of knowledge and data allowed for a multi-centurial, provincial to local understanding of the relationship between people and fire across social and ecological dimensions. This approach directly responds to the need to investigate the social-ecological complexities of fire (Carmenta et al. 2011, Roos et al. 2016, Smith et al. 2016). Following best practices of interdisciplinary research (Tengö et al. 2014, Blythe et al. 2017, Stone-Jovicich et al. 2018), this research actively bridged disciplinary silos and incorporated multiple sources of (fire) knowledge while maintaining the inherent validity of individual sources.

5.3.2 Limitations

While the interdisciplinary approach taken in this research was a primary strength, it also resulted in some breadth-for-depth trade-offs. For example, the collection and collation of tree-ring records, oral histories, historical documents, expert interviews, and other anecdotal historical records (aerial photos, journals, newspapers) meant that I was limited in the quantity of each that I could include. This limitation was confounded by the 2017 fire season in BC and the 2020 COVID-19 pandemic which halted data collection and engagement with the community. Another limitation to the interdisciplinary approach was the relatively shallow level of community-based research I undertook. While I incorporated many important ethical community-based research strategies (e.g., long-term engagement, open and ongoing communication), I was not able to fully embed myself within community in the way that other researchers working with Indigenous communities have advocated for (Smith 2012, Weir et al. 2019, Wong et al. 2020). Coupled with my identity as a settler and outsider to the community, and the short duration of a PhD project, I anticipate that this limitation means my understanding of *T'exelcenc* worldviews are also limited and it is unlikely that I

fully captured the spirit of what *Ne SEXTSINE* means to them. Similarly, for Chapter 2, the vision for future fire governance in BC is that of a select group of provincial and regional fire and forest experts. As such, I explicitly recognize that Indigenous peoples, forest industry workers, private landholders, and the general population of BC may have a wholly different vision. It is to address this last limitation that I propose future research below.

5.4 Future research

Future research on fire in BC must continue to engage directly with understanding the opportunities and constraints for diverse people and knowledges to guide coexisting with fire. This includes research with Indigenous communities, on fire and forest governance, and on the social and ecological consequences of that governance. Potential future research questions could include:

- What vision do Indigenous peoples have for fire governance in BC? How can this be enabled?
- What is the role of different actors (government, Indigenous peoples, industry, private citizens) for advancing fire governance?
- How can forest planning processes more ethically engage with Indigenous peoples?
- How does knowledge of historical Indigenous pyrodiversity contribute to forest management and restoration?

5.5 Final reflections

Completing this dissertation has been both professionally and personally challenging. Partly this was due to external circumstances, such as evacuating during the 2017 fire season at the start of my PhD and pivoting to a virtual world during COVID-19 near the end of my PhD. The other source of the challenge was internal – a combination of my disciplinary training (as a natural scientist) and positionality (as a settler and outsider) that made the social science research an (ongoing) uphill battle. While the result is nowhere near what I imagined it would be when I first started in 2016, I hope that I have upheld my obligations to my colleagues, the communities, and the experts who trusted me to undertake this research. The internal and external challenges I faced helped me grow as a researcher and, more importantly, as a citizen that values and works to elevate the voices of those who have been

marginalized for too long. I experienced new ways to look at fire and the forest and learned how intimately tied our perceptions of the world are to the things we value. It was uniquely rewarding to stand in a forest and see it as the home of oral histories, an economic benefit, a potential fire hazard and threat to communities, a beautiful spot for recreation, and the keeper of secrets. It was truly a privilege to be united with so many diverse people working towards positive change.

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Appendices

Appendix A Fire governance semi-structured interview schedule (Chapter 2)

Researcher Introduction

Interview objective: Expert views on wildfire governance (including policy, actors, and decision-making inputs) in British Columbia

Introduction

1. Could you tell me a bit about your current role and how it relates to wildfire?
 - a. How did you come to this role? When/how long?
 - b. What was your experience with wildfire before you started in this position?

Views of Wildfire (Worldview)

2. Depending on a person's disciplinary or professional background, people tend to think about fire in many different ways. How do you think about wildfire? (*e.g., cultural practice vs. emergency management & Smoky the Bear vs. economic impacts vs. ecological process*)
 - a. Does this view reflect how you think about wildfire personally or in your current role or both? *Are these the same?*
 - b. Has your view changed over time? Why? *Probe - Did the 2017/2018 wildfire seasons change your view? Can you describe to me your experience during the 2017/2018 wildfire seasons?*

Values Affected by Wildfire

3. Here in BC, particularly in recent decades, it's become clear that wildfire can pose a risk to things we value. What values do you think are most at risk from wildfire here in BC? (*e.g., communities, timber, ecosystems*)
 - a. How do these values vary depending on where you are in BC? Or at different spatial scales?
4. What do you think are the most important strategies to mitigate the risks to those values from wildfire? (*e.g., policy, research, programs, collaboration OR small-scale actions such as treatments, education*)
 - a. Why?
 - b. At what scale should these strategies be applied? (*e.g., landscape, community*)
 - c. How successful do you think these strategies are? How do you define success?

Legislation

5. What key policies shape your decision-making around wildfire today?
 - a. At what scale are these policies apply? (*e.g., provincial, regional*)
 - b. How do these policies influence your decision-making? (*policy into practice*)
 - c. What do you think were the intended outcomes of these policies?
 - d. Do you think these outcomes have been achieved? (*If not, why not? What would need to happen to support a successful outcome?*)
6. What is your understanding of how past policies may have shaped historical decision-making processes?

Knowledge Inputs

7. Can you describe to me how you go about making decisions? Aside from policy, what other kinds of information shapes your decision-making today? (e.g., *economic considerations, public opinion, science, land rights/title; Who do you work with?*)
 - a. What is the relative importance of these different sources of information?
 - b. How is this other information used in your decision-making process?
 - c. Has this changed through time? If so, how?

Vision for Future Wildfire Governance

8. What is your vision for the future of wildfire governance in BC?
 - a. Are there any current barriers you perceive to achieving this vision? If so, what?
 - b. What would be required to support this vision? (e.g., *policies, collaborations, research, etc.*)
9. What role do you think you can play in helping support this vision?

Closing

10. Is there anything else you would like to share that we haven't covered today?

Appendix B Forest walks open-ended group interview schedule (Chapter 3)

Researcher introduction

Introduce yourself and project: This forest tour and research is taking place to acknowledge and incorporate Indigenous knowledge into management in the Williams Lake Community Forest. Specifically, we are interested in landscape-level fire (fire that burns over an area rather than fire used for cooking).

1. Do you have any questions for me about the research?

T'exelc landscape paradigm

2. Tell me about your traditional territory. What does it mean to you? To your community?
 - *E.g., Ceremonies, Food – berry picking, fishing, hunting, Living spaces – summer home, winter home, associated practices*
 - *What did this place (Ne SEXTSINE) mean? (Show map: area now bounded as WLCF. East of Fraser River between Flat Rock Reserve (Hwy 20) and Williams Creek Valley)*
3. How did you come to learn about this place? OR How did you gain knowledge of this place? (*Probe – stories from your Elders, land-based activities*)

Indigenous Fire Knowledge

4. Did you or your community use burning on the land here?
 - If so, how? When? [VALUES]
 - *Reasons (berries, hunting, clearing, medicines, etc)*
 - *Timing (time of year, seasonal cues)*
 - *Decision-making (individual, group, family, leaders)*
 - Has the traditional burning you described changed over time?
5. What do you think of the fires in the area today? [MODERN FIRE] (*Probes – Are they similar or different to fires in the past? How are they similar/different?*)
6. How do you think we should approach fire prevention today? [FUTURE FIRE]
 - Should traditional practices be used today? Why or why not?

Follow-Up

7. Is there anything else about landscape fire / values at Ne SEXTSINE you would like to share with me today?