Indigenous Fire Knowledge: Benefits, Barriers, and Best Practices Across Four International Cases

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Preface

Although I am interested in Indigenous Knowledge and its plethora of benefits to disaster risk reduction and community resilience, I am not Indigenous myself. I write from the unceded Anishinabe Algonquin territory, earnestly hoping that my research will amplify the pre-existing works and voices of Indigenous peoples.

Abstract

This major research paper examines the critical role of Indigenous Fire Knowledge (IFK) in mitigating the effects of climate change, namely wildfires. Today, there is a growing global call to revive IFK to improve wildfire management and uphold Indigenous rights. This study employed a document analysis and case study approach, integrating insights from peer-reviewed and grey literature using a blended coding strategy to inform its findings. Despite identified barriers to mobilising IFK such as societal perceptions of fire, jurisdictional challenges, and resource constraints, the analysis of case studies from the Karuk Tribe, Firesticks Alliance, the Secwépemc Nation, and Indigenous Fire Brigades finds effective approaches to mitigate wildfire impacts through Indigenous fire practices. The paper presents recommendations for Canada that include formal partnerships between governments and Indigenous communities/organizations, supporting bottom-up, Indigenous-led initiatives, and promoting education on IFK and accrediting cultural burning practices.

Keywords: *Indigenous Fire Knowledge (IFK), wildland fire, knowledge bridging, disaster risk reduction, Indigenous fire stewardship, community, self-determination*

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Introduction

Background

Wildfires have been a part of the environment and human experience since time immemorial. Yet, in recent years, they have started to grow in intensity and frequency across the world, fuelled by climate change (UNEP, 2022). Given their various costly impacts to the environment, wildlife, and humans alike, more attention is being paid to preparing for and mitigating the impacts of these disasters. As Indigenous Peoples have historically held an intimate relationship with the land, there is an emerging call to capitalize on their knowledge in both fire and land management. After all, much can be learned from IFK in the context of biodiversity conservation, ecosystem health, and wildfire risk mitigation.

Yet, the knowledge and use of fire by Indigenous Peoples has been hampered by restrictive fire policies and negative perceptions of fire by mainstream societies around the world. Indigenous communities also experience various barriers as they attempt to revitalize their fire knowledge, despite IFK representing a significant and mostly untapped potential for more effective and sustainable fire management strategies that mitigate the effects of climate change (UNESCO, 2023). Such is the case in Canada, where Indigenous Peoples are disproportionately impacted by wildfires and restricted in their ability to mobilise their fire knowledge to mitigate potential disaster impacts and conserve biodiversity (Hoffman, 2022). The purpose of this paper is to explore what precisely can be gained through mobilising IFK and fill in a timely research gap: what are contemporary limitations impeding the mobilisation of IFK? Through this research, mechanisms to overcome barriers and revitalize IFK will emerge, equipping readers with practical recommendations tailored to the Canadian context. Numerous

recent disastrous wildfires across Canada have exacerbated the need to reduce wildfire risk to both ecosystems and human communities (Hoffman et al, 2022). Additionally, approximately 60% of Indigenous communities in Canada inhabit remote and forested area (Hoffman et al, 2022). Due to its remote Indigenous populations and heightened wildfire risk, Canada represents an ideal starting point to explore the challenges inhibiting the mobilisation of IFK.

Objectives

This research examines the potential benefits of mobilising IFK through a document analysis and an in-depth examination of four case studies from different parts of the world. Ultimately, the research will be exploratory and answer the question, "what can be gained through mobilising IFK?" The paper also addresses the following sub questions:

- What are current barriers to mobilising IFK?
- Which mechanisms are effective for mobilising IFK?

Based on the findings from the document analysis and case studies (demonstrating best practices), recommendations are provided to enhance the mobilisation of IFK in Canada. As the Canadian government has committed to Truth and Reconciliation with Indigenous Peoples', this research provides practical next steps to capitalize on IFK to reduce wildfire risk and support Indigenous Peoples' right to self-determination. Additionally, the Canadian context is important to explore as the prevailing impacts of colonialism create significant barriers for Indigenous Peoples to engage in and lead cultural burning, regardless of the increasing concerns over wildfire risk and stated intentions to establish Indigenous Peoples as partners in wildfire management (Hoffman, 2022).

Conceptual and Theoretical Frameworks

Conceptual Framework

Indigenous Knowledge (IK) is referred to by many terms which tend to be used interchangeably. For example, IK may be called 'Indigenous technical knowledge,' 'ethnoecology,' 'local knowledge,' 'folk knowledge,' 'traditional knowledge,' 'ethnoecology,' 'traditional environmental knowledge,' or 'ecological knowledge,' (Mistry, 2009). Despite the variability in terms used to identify IK, this knowledge system possesses common characteristics noted in the table below.

Common Characteristics of Indigenous Knowledge	
Local	IK is context specific, with roots in a particular place and in the lived experiences of those that inhabit the location.
Oral transmission through imitation and demonstration	IK is rarely written down and is generally told through stories, myths, songs, or through observation and learning.
Adaptive capacity	IK is adapted through repetition, learning, experimentation, and adoption of novel situations over time. Thus, it is constantly changing.
Social memory	IK is shared to a greater extent than other forms of knowledge, establishing a long-term communal understanding of people's environment and the transmission of important experience.
Holistic	IK is situated within various interlinked facets of people's lives.

(Mistry, 2009)

In recent years, there has been a push to refrain from using the term 'traditional knowledge' when discussing this specific knowledge system. Vázquez-Varela et al (2022) draw attention to this, arguing that "tradition" has been and continues to embody a problematic word, tied to a reductionist vision of culture, which hinders the potential for a more holistic and broader view. After all, IK is dynamic and the term 'traditional knowledge' may imply that the knowledge

system is firmly grounded in traditions and consequently resistant to change. Given the paper's context of wildfire risk reduction, this paper will employ 'Indigenous Fire Knowledge,' (IFK) a term that is gaining increasing prominence as wildfires grow in frequency, thus demanding a range of diverse solutions.

Theoretical Frameworks

1. Resilience Theory in the Context of Disasters

The concept of resilience, as applied to risk and disaster management, underscores the importance of adaptive capacity, which is the ability of how systems and communities adjust to damage, capitalize on opportunities, and respond to challenges (Graveline & Germain, 2022). Resilience is generally understood as an ongoing process rather than a static outcome (Doorn, 2017), reflecting its basis in complex science theories emphasizing adaptation and renewal (Atkinson & Montiel-Molina, 2023). This renders resilience theory a valuable framework for examining how IFK can enhance wildfire risk reduction, specifically through a community's adaptive capacity.

Different disciplines approach resilience through various lenses, with natural and social sciences often focusing on either hazard reduction or vulnerability mitigation (Graveline & Germain, 2022). These perspectives aim to either diminish the hazard itself or reduce community vulnerability by addressing factors such as sensitivity or exposure. The relationship between resilience and vulnerability, however, is debated. Some scholars view them as opposing but interconnected concepts, while others see them as interrelated attributes (Doorn, 2017; Graveline & Germain, 2022). For this paper, Graveline and Germain's perspective is adopted,

understanding that resilience is an “independent concept, albeit one that is related to, and interconnected with, vulnerability” (2022, p. 332).

2. Knowledge Sovereignty and Self-Determination

While there is a push to mobilise IK in disaster planning contexts, it is imperative that Indigenous ways of knowing do not get lost in processes of ‘integrating’ knowledge into more dominant pre-existing paradigms. Indigenous scholarship, land-based practice, and grassroots organisations highlight that IK does not simply represent knowledge that can be “slotted into exogenous western scientific models,” (Latulippe & Klenk, 2020, p 7). Rather, IK carries ‘governance value’ to Indigenous communities according to Kyle Whyte (2018), playing a pivotal role in the resurgence of Indigenous governance and related legal orders, diplomatic protocols, land-based practices, and other collective capacities that promote the well-being of lands and peoples (Latulippe & Klenk, 2020). The mobilisation of IK systems or co-production of knowledge thus represents an avenue to strengthen Indigenous self-determination and land stewardship. It is crucial to acknowledge that IK and Indigenous peoples’ right to self-determination cannot exist in silos; they are inherently intertwined. In short, pushing to mobilise IK is also a pursuit of advocating for Indigenous self-determination. After all, the term ‘disaster’ can be seen as an opportunity to improve, change, and thus adapt (Graveline & Germain, 2022). In this vein, the landscape of intensifying wildfires may present an opportunity for IK and Indigenous practices to re-emerge or gain greater legitimacy.

3. Social Ecology Model

Another important theoretical framework upon which we can draw is the social ecology model. Social Ecological System perspectives view environmental challenges, such as wildfires,

as inextricably linked to underlying social and political contexts (Copes-Gerbitz et al, 2021). This view is especially important in the context of wildfires, which yield disproportionate impacts on communities due to histories of colonization, remoteness, and community capacity. Additionally, the social ecology model is important as it also pulls from theories of resilience. Copes-Gerbitz et al (2021) highlight that numerous social ecological system scholars deem that enabling resilience in fire-dependent landscapes necessitates context-specific solutions as well as locally desired relevant futures created through participatory processes. As this paper explores benefits to mobilising IFK– a place based, context-specific knowledge system – the Social Ecology Model's insights ring true to the aim of this research. Ultimately, this model draws attention to the non-environmental factors that exacerbate natural hazards, which are pivotal elements to address to achieve greater community resilience.

Design and Methodology

Design

This paper will be driven by two components: (1) a document analysis of relevant secondary sources, including academic and grey literature, and (2) an in-depth examination of four case studies to discover what can be learned from the mobilisation of IFK.

Document Analysis

A document analysis is a systematic procedure for reviewing or evaluating documents, both printed and electronic material (Bowen, 2009). It requires that data be examined and interpreted to elicit meaning, gain understanding, and create empirical knowledge (Bowen, 2009). The document analysis is mainly comprised of articles from academic journals, but also extends to grey literature, such as policy literature and reports from non-governmental organizations. For this research, all documents being examined have been published in the last fifteen years.

Boolean search queries for peer-reviewed materials:

1. *("Indigenous knowledge" OR "Indigenous ways of knowing" OR native science OR "traditional ecological knowledge" OR "Indigenous local knowledge" OR native knowledge)*

   AND

   (resilienc OR preparedness OR resilient)*

   AND

   (wildfire OR wildland fire* OR bush fires* OR forest fire)*

2. *("Indigenous" OR "Indigenous ways of knowing" OR native science OR "traditional ecological knowledge" OR "Indigenous local knowledge" OR native knowledge)*

AND

(wildfire OR wildland fire* OR bush fires* OR forest fire)*

Upon consulting with the subject librarian at the University of Ottawa, it was advised to conduct two searches, one omitting the term 'resilient' and 'preparedness,' as much literature is already likely to explore themes of resilience in articles concerning IK and wildfires.

The broader Internet search is conducted using the Google search engine, with the Incognito feature enabled to avoid bias in the results that were generated. A simple search of "wildfire" and "Indigenous Knowledge" is used to gather materials. Advertisements are excluded, along with any articles that repeat information and do not reveal any new information. Furthermore, news articles are omitted.

Data Extraction

Due to time constraints, the abstracts of the first fifty results are scanned for each database to identify appropriate articles for the document analysis, with time filters and "most relevant" filters being applied. The Omni and Science Direct searches for peer-reviewed journal materials yield fifteen materials from nine distinct journals, including: the International Journal of Disaster Risk Reduction (2 articles), Natural Areas Journal, Annals of the American Association of Geographers, Facets (1 article), Ecology and Society (3 articles), Fire (3 articles), Local Environment, Journal of Forestry (2 articles), and Environmental Science and Policy. These articles deploy varying methodologies and focus on contexts from across the world, including in Canada, the United States, Brazil, Australia, and Europe.

The public search results in five documents that provided global accounts of IFK and the increasing threat of wildfires. These documents originate from research institutes, one

intergovernmental organization, and non-governmental organization, including: the United Nations (2 documents), the World Economic Forum, the Post Carbon Institute, and the Institute for Research on Public Policy.

In total, twenty materials are used for the document analysis portion of this paper, with each meeting the inclusion and exclusion criteria below:

Inclusion Criteria	Exclusion Criteria
• Published within the last fifteen years. • Relevant to the topic. • Written in English.	• Published by for profit companies (ex. selling air scrubbers). • News articles. • Primary focus on fire ecology and technical aspects of fire regimes. • Not written in English.

Coding Strategy

A blend of inductive and deductive coding is deployed to allow for a comprehensive examination of the data. A deductive coding schedule is created using pre-existing theoretical frameworks and concepts, ensuring that relevant aspects of the data will be covered. However, inductive coding allows for the discovery of unexpected patterns and nuances, serving to mitigate bias. Initial deductive concepts are identified based on the paper's research questions:

- Potential codes: resilience, capacity, cultural burn, vegetation management, Western Scientific Knowledge (WSK), Indigenous Knowledge (IK), governance, fire stewardship, community, decolonization, reconciliation, community-based leadership, and bridging knowledge.

During the research phase of the document analysis, further codes are identified. The codebook below highlights central findings of the twenty materials being reviewed, thus informing the document analysis.

Code	Example
Fire Suppression (FS)	"**Fire suppression** policies have resulted in increased fuel load and elevated risk of fatality and property damage, especially with the proliferation of human developments near forested areas" (Slaton et al, 2019)
Integrated Fire Management (IFM)	"Dealing effectively with the increase in wildfires requires policies and incentives that promote integrated fire management approaches" (UNEP, 2022).
Wildfire Risk Reduction (WRF)	"By increasing the amount of cultural burning, Indigenous fire practitioners will significantly **lower risks of uncontrollable wildfire** in forests surrounding their communities" (Hoffman et al, 2022)
Cultural wellbeing	The literature reviewed also refers to Indigenous burning in support of culture through ceremony, knowledge expansion, **cultural wellbeing**, and connection to the land (Mihalus et al, 2024).
Self-Determination	Recognizing and supporting the inclusion of Indigenous and traditional fire knowledge within government policy, practice, and programmes can have multiple benefits (e.g., vegetation management, cultural, spiritual, social, economic, health and well-being benefits, and political-**self-determination**) (UNEP, 2022).
Knowledge Integration (KI)	"In practice, however, **integrat**ing TEK with conventional resource management is difficult" (Ray et al, 2012).
Biodiversity (B)	"Science and empirical evidence have likewise demonstrated that cultural burning can recreate landscape mosaics, enhance **biodiversity**, and reduce bushfire risk" (Atkinson & Montiel-Molina, 2023).
Cultural Burn (CB)	"**Cultural burning** or traditional burning has not just one specific practical goal, but a holistic, comprehensive and spiritual significance" (Atkinson & Montiel-Molina, 2023)
Prescribed Burn (PB)	"Unlike **prescribed burning** for hazard reduction, Indigenous fire management is part of a range of cultural practices that are not simply designed around asset protection" (Fletcher et al, 2021).
Climate Change (CC)	"The access and use of different types of knowledge to inform environmental decision-making will be increasingly important to steer systems through the emerging challenges of **environmental change**" (Bardsley et al, 2019).

Indigenous Fire Stewardship (IFS)	"**Indigenous fire stewardship** blends intergenerational knowledge, beliefs and values with advanced methods of controlling several aspects of fire" (World Economic Forum, 2021).
Resource Constraints (RC)	"Another important barrier to Indigenous involvement in wildfire management that emerged from our review is **resource constraints**" (Mihalus et al, 2024)
Decolonization (D)	"Thus, the reintroduction of cultural burning practices for land management and bushfire risk reduction may contribute to the ongoing process of **decolonization**" (Atkinson & Montiel-Molina, 2013).
Trust Based Relationships (TBS)	"Nongovernmental organizations and federal and state agencies are building collaborative partnerships with tribes that integrate traditional and Western fire knowledge through culturally sensitive consultation and **trust building**" (Ammerman, 2022).
Collaboration (C)	"The ability of social-ecological fire systems to function successfully in a hotter world will require proactive information sharing, inclusive **collaboration**, and a genuine interest in weaving together insights from multiple cosmologies" (Huffman, 2013).
Perception (P)	"This paper signifies the need for a change in Western societal **perception**s toward Indigenous knowledges related to fire, Indigenous burning, and community-level involvement and leadership in management of wildfires and wildfire evacuations," (Mihalus et al, 2024).
Training and Accreditation (TA)	"The inquiry into ecosystem declines of the Parliament of Victoria emphasized the need for **training and accreditation** in cultural burning and encouraged the Victorian Government to work in collaboration with TOs to offer accreditation in qualifications in conservation and Indigenous land management" (Atkinson & Montiel-Molina, 2023).
Jurisdiction* (J)	"Workshop participants, reiterating findings in the literature, identified obstacles to the use of prescribed fire to meet cultural and land management goals. These include lack of funding to support prescribed fire for purposes other than fuels management, administrative and **jurisdiction**al challenges to using prescribed fire across landscapes with mixed land management (e.g., WUI; federal, state, private, and tribal lands; and federal and tribal wilderness), conflict with policies (e.g., Clean Air Act, Endangered Species Act, and fire restrictions and burn bans), loss of knowledge regarding traditional uses of fire, concerns related to tribal intellectual property rights and compensation (CTWK 2014), and the use of fire to address climate change (Armatas et al. 2016, Gilles 2017)" (Lake et al, 2017).

The codes are used to better understand implicit overarching themes in the literature. For example, perception tends to be associated with difficulties in mobilising IFK, whereas wildfire risk reduction is often linked with the benefits from mobilising IFK. These codes guide key themes within the document analysis and examination of case studies, revealing central benefits, barriers, and mechanisms to mobilise IFK that emerge in the literature.

Examination of case studies

Case studies are one of the most extensively used methods of qualitative social research (Priya, 2021). They can be defined as empirical inquiries which investigate a phenomenon in its real-life context (Priya, 2021). Four case-studies from different nations, The United States, Canada, Australia, and Brazil, are used to identify the benefits to mobilising IFK, appropriate mechanisms to revitalize this knowledge, and remaining barriers to its implementation. To gather peer-reviewed materials, databases such as Web of Science and Omni are utilized. The selection of case studies is determined based on best practices identified in the literature, using the following inclusion/exclusion criteria:

Inclusion Criteria	Exclusion Criteria
○ Territory is prone to wildfires (with wildfires occurring within the last five years). ○ Written in English. ○ Revealed as a positive example in the literature from the document analysis. ○ Explores benefits of IFK.	○ Not written in English. ○ No specific mention of IK(ex. broadly discusses Indigenous Fire Stewardship).

○ Includes tangible mechanisms to mobilise IFK.	

A detailed description of each case study, including background information and contextual factors, is provided for each of the four cases. The blended coding strategy used in the document analysis is again used to identify commonalities, differences, and patterns across the case studies. In short, the examination of case studies revealed overarching themes and trends in mobilising IFK. In addition to the materials from the document analysis, supplementary materials were sourced to provide context for each case study using the Omni database and public searches. A simple search is conducted for each community/organization including the name of the community and the term 'IFK' for both peer-reviewed articles and publicly available materials. Useful articles are drawn from government websites, tribal council webpages, universities, and international not for profit organizations. This portion of the major research project also serves to answer the sub-question: what factors enable the mobilisation of IFK? For example, based on the preliminary research conducted, it is expected that IK proves most beneficial when combined with WSK. For example, a workshop conducted in the United States with tribal elders, Indigenous and non-Indigenous Scientists, resource managers, and academics revealed that the participants believe that IK and WSK, when considered together, can produce a resource management approach that is stronger than either knowledge system can provide alone (Mason et al, 2012). Moreover, it is anticipated that the case studies may reveal that communities that are of higher capacity (having little constraints related to financial and human resources) would be best positioned to use IK to enhance community resilience to wildfires.

Afterall, Mihalus et al (2024) highlight that resource constraints tend to represent a barrier to Indigenous involvement in wildfire management. The case studies aim to either confirm or challenge the findings from the document analysis, providing a clearer understanding of what contemporary IFK mobilisation should involve.

Document Analysis

The Growing Threat of Wildfires

In recent years, wildfires have gained attention worldwide, representing one of the hottest topics in the fields of environment and climate change. In a recent report by the United Nations and GRID-Arendal, 'Spreading like Wildfire', it was revealed that wildfires are burning longer and hotter in places they have always occurred, and are simultaneously occurring in unexpected places as well, such as in drying peatlands and on thawing permafrost (UNEP, 2022). Climate models over the next decades contribute to the mounting unease on the matter, predicting a noteworthy reduction in precipitation and increase in droughts that will increase the frequency and extent of wildfires (Ammerman, 2022).

The United Nations defines 'wildfire' as an "an unusual or extraordinary free-burning vegetation fire which may be started maliciously, accidentally, or through natural means, that negatively influences social, economic, or environmental values," (UNEP, 2022, p 8). From this definition alone, one can understand that the impacts of wildfires are far-reaching. This highlights the need for societies and individuals alike to determine how best to protect the aforementioned values which are presently at stake amidst a rapidly warming climate.

A review of recent literature demonstrates overwhelmingly that wildfires will continue to grow in severity and frequency. It should be noted that while such disasters have only recently started to plague the news, wildfire risk has been steadily growing since the late 19th century (Atkinson & Montiel-Molina, 2023). Several recent disastrous wildfires in Canada have exacerbated the need to reduce wildfire risk both to ecosystems and human communities (Hoffman et al, 2022). Moreover, although rural communities tend to predominantly be impacted

by such events, studies show that major cities, including Ottawa and Vancouver, are likely to be threatened by wildfires as well in the future (Sutherland, 2022).

One of the major concerns stemming from the increasing occurrence of wildfires is the creation of a feedback loop. With global warming increasing the occurrence and intensity of wildfires, the fires consequently emit higher amounts of greenhouse gases, thus exacerbating climate change (UNESCO, 2023). In layman's terms, wildfires are both the result of and contributing factor to rising temperatures and dryer conditions, with Figure 1 illustrating precisely how this process unfolds.

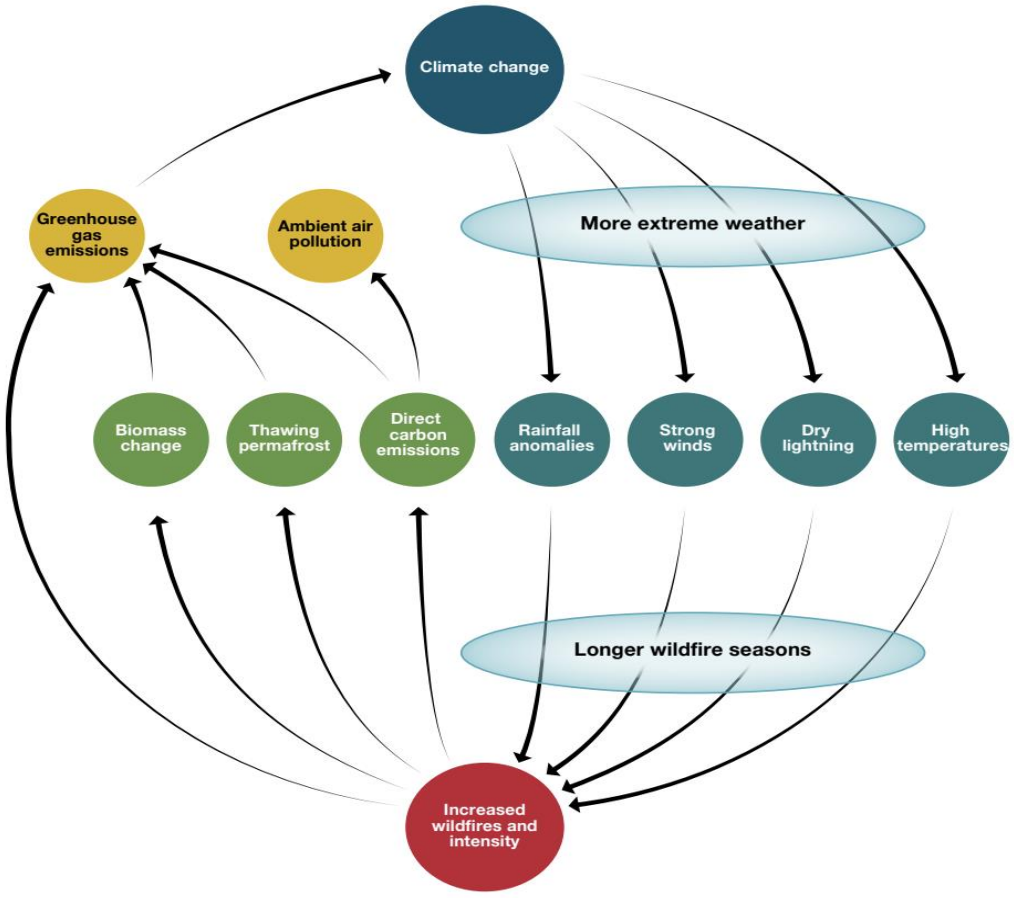

Figure 1. Potential reinforcing feedback loop of climate change on wildfires, by GRID-Arendal/Studio Atlantis (UNEP, 2022).

Indigenous Peoples and their Use of Fire

Since the beginning of time, Indigenous Peoples have cultivated land-based practices and legal systems that fostered a reciprocal relationship with the land (Ammerman, 2022). Fire represents one of the many resources that Indigenous Peoples use to maintain this relationship. Amos & Montiel-Molina (2023) highlight that fire represents a key cultural tool for the landscape management of Aboriginal communities in Australia. The case is similar in North America, where Indigenous Peoples used fire as a primary means to modify eco-cultural systems prior to Euro-American colonization (Eisenberg et al, 2019). The World Economic Forum (2021) echoes such sentiments, stating that Indigenous Peoples have intentionally used fire to shape the landscapes they inhabit for thousands of years. It should also be noted that historical practices for dealing with wildfires belong to Indigenous Fire Stewardship (IFS), which tends to be opposed with traditional Western forms of firefighting as it emphasizes prevention, rather than extinguishment (Sutherland, 2022).

Cultural burning – with some scholars using the term 'traditional burning' – is one such tool that Indigenous Peoples have mobilised to manage the landscape. Fletcher et al (2021) provide a useful and concise definition of the term, deeming cultural burning to be, "a holistic approach at landscape management that is based on an intimate understanding of places and is reflexive to local environmental conditions and cues," (p 4). This practice has been deployed to reduce wildfire risk for years, achieved by lessening fuel loads, enhancing pyrodiversity (the frequency, timing, and severity of fire), and assisting with the management of complex resources (Hoffman et al, 2022). Clearly, Indigenous Peoples did not only burn land to prevent wildfires, but some engaged in the practice to promote growth of plant foods, maintain access to water

supplies, to protect sites of cultural significance, and to guard themselves from dangerous animals (Cramer, 2019). Many authors, such as Atkinson and Molina (2023), stress the holistic nature and place-based approach to cultural burning. Not only has cultural burning represented an effective tool for reducing wildfire risk, but it has also embodied an ancestral and living practice of land management for Indigenous Peoples. Moreover, cultural burning brims with complexity, as it involves understanding the intricacies of fire, such as when, how, and where it should or should not be used, to preserve desirable ecosystem structures and enhance diversity and productivity of species for food, medicine, and ceremony (Hoffman et al, 2022). After all, any fuel treatment intervention is highly dependent on local conditions and context as well as the behaviour and burning conditions of any subsequent wildfire (UNEP, 2022).

In light of this, one must understand that Indigenous cultures and practices are nonetheless diverse, with each community's cultural burning practices being unique (Mihalus et al, 2024); Indigenous Peoples do not represent a homogenous or monolithic group. Still, it can be noted that most Indigenous Peoples have worked in tandem with fire for many years, embracing its utility for a myriad of reasons.

Colonization and the Rise of Fire Suppression Policies

The relationship that Indigenous Peoples across the world held with fire was significantly impacted by colonization. Not only did human activity stemming from colonization impact the biophysical environment, it also influenced Indigenous autonomy over fire practices. In Australia, for example, multiple numerous palaeo-ecological studies indicate that human activity has historically yielded a substantial impact on fire regimes and the composition of vegetation, with

post-colonial actions severely altering traditional Indigenous fire regimes and local ecosystems (Bardsley et al, 2019).

In Kira Hoffman's (2022) article exploring barriers and opportunities for Indigenous-Led Fire Stewardship in Canada, she writes that the forced removal of Indigenous Peoples from their land disrupted intergenerational knowledge transmission and continuity, hindered subsistence stewardship practices, and led to the loss of knowledge keepers. The influence of colonization clearly had an impact on certain cultural practices that were cherished by Indigenous Peoples. Larry et al (2021) further explains that as European concepts of property management started to dominate, the ability of Indigenous tribes to carry out cultural practices diminished. This sentiment is widely shared by scholars, with Lake et al (2017) specifying that fire suppression policies and management decisions are one of the factors hindering IK and wildfire use' utility for landscape management today.

It is essential to recognize that many fire suppression policies introduced during colonization were incited by a negative perception of both Indigenous Peoples and fire itself. Colonial powers viewed Indigenous practices as primitive and hoped to eradicate them, including their intimate relationship with fire (UNESCO, 2023). Rodríguez et al (2023) speak to this, deeming that the emphasis on a negative view of fire in national and international conservation policy fora, coupled with the increasing flammability of certain landscapes, continue to distort local fire management practices, triggering a rise in the criminalization of Indigenous uses of fire in some parts of the world. In Canada and the United States, historic wildfire management and suppression policy removed the use of Indigenous burning, yielding both negative social and ecological impacts (Mihalus et al, 2024).

Scholars such as Mihalus et al (2024), Huffman (2013), and Copes-Gerbitz account for the negative effects of command-and-control policies that contributed to increased flammability of landscapes and the suppression of IFK. According to Hoffman (2022), the command structure is both hierarchical and colonial, opposing collective responsible models of fire stewardship. In North America, for instance, Mihalus et al (2024) state that decades of suppression resulted in a landscape of "fire deficit." In other words, the command-and-control paradigm that forced wildfire management, policy, and resource allocation to focus on suppression throughout the twentieth century contributed to wildfire trends. Exclusion of traditional fire practices, especially in fire-prone ecosystems like tropical savannas, can lead to more intense and widespread fire from the accumulation of unburned combustible materials over time (UNESCO, 2023). Larry et al (2012) write that fire exclusion and cessation of Indigenous practices – among other things – have resulted in altered fire regimes, unprecedent forest fuel buildups, and increased incidence and severity of wildfires. The desire held by colonial powers to eradicate fire has proven problematic, as it discounts IK and puts both people and infrastructure at risk. Ammerman (2022) highlights that in increasing fuel load, fire suppression policies have led to an elevated risk of fatality and property damage, especially with the proliferation of human developments near forested areas. Ultimately, Western society's negative portrayal of fire as catastrophic and destructive has been detrimental (Mihalus et al, 2024). In short, the rise of command-and-control policies and domination of fire suppression disregards the ecological role that fire plays, which is crucial for the functioning of many ecosystems and for nature conservation (Tedim et al, 2016).

Furthermore, the document analysis reveals that the current wildfire management framework across North America is predominantly reactive. UNEP (2022) criticizes governments'

emphasis on the reactive approach, deeming that responses to wildfires are overdue, with numerous countries suffering from a chronic lack of investment and prevention. Atkinson & Molina (2023) summarize this finding, sharing that conventional wildfire risk management focuses on fire suppression and reactive firefighting for assets and people protection. This is contrary to certain principles of Indigenous Fire Stewardship, which focus on prevention.

Disproportionate Wildfire Impacts on Indigenous Peoples

As wildfires become more frequent and severe, it is paramount to identify those who are most at risk of being affected by these events. The literature reveals a broad consensus that Indigenous people and communities across the world tend to be disproportionately affected by wildfire. Put simply by Copes-Gerbitz et al (2021), many Indigenous communities face systematic biases against their needs, values, and concerns and face a higher risk amidst modern wildfire events. In their article regarding wildfire evacuations in Canada and the United States, Mihalus et al (2024) uncover the various factors leading to disproportionate wildfire impacts, including pre-existing health and social inequities, limited access to emergency services, and the ongoing effects of colonialism and structural racism. This becomes clear when delving into the Canadian context of wildfire evacuations over the years. Although Indigenous peoples make up less than five percent of the Canadian population, they are involved in one-third of wildfire-based evacuations (Mihalus et al, 2024). Hoffman (2022) also emphasizes that Indigenous Peoples are 30% more likely to be displaced by, and suffer from, the unintended outcomes of wildfires. Ultimately, the remote location of many Indigenous communities plays a role in their vulnerability to wildfires. The presence of Indigenous communities in remote areas or on

traditional reservation lands serves to increase susceptibility to wildfires, while also increasing the likelihood of evacuation (Mihalus et al, 2024).

Not only are Indigenous Peoples in Canada and across the world disproportionately impacted by wildfires, but they are also restricted in their ability to prepare for disasters due to current legal structures and policies. Mihalus et al (2024) find that within Canada and the United States, land use regulations and land tenure, along with wildfire management policies, standards, and permitting procedures often result in the separation between Indigenous people and wildfire management. In Canada, Hoffman (2022) reveals that the persistent impacts of colonialism pose significant barriers to engage in and lead cultural burning, regardless of the concerns over wildfire risk and stated intentions to signify Indigenous Peoples as partners in wildfire management. As wildfire management agencies in Canada evolved from colonial government systems, they monopolize power in the domain of wildfire management decision-making (Hoffman, 2022). This is especially problematic as community engagement is central to reducing wildfire risk. As explained by Tedim et al (2016), foregoing community engagement renders it difficult to reduce wildfire incidence and damages in the long-term, even when a strong suppression capacity and legislative body are present. As areas occupied by Indigenous Peoples are likely to be impacted by wildfires, they need to be present in the processes of emergency management and planning. After all, communities are able to determine for themselves what actions are needed to prevent and mitigate wildfires according to the level of risk they face, their sources of livelihood (Tedim et al, 2016).

Impacts of Wildfires

To combat the detrimental consequences of wildfires, societies and individuals alike must be equipped with a thorough understanding of the risks that wildfires pose. Building from the impacts listed in the recent fire report by the United Nations and GRID-Arendal, the consequences of wildfires will be explored below.

Wildfires generate significant implications for human health, specifically through its smoke, which contains particulates and toxic combustion products that have been proven to cause respiratory harm (UNEP, 2022). Sustained exposure to wildfire smoke can therefore be fatal, especially for those with pre-existing health problems. Models suggest that exposure to smoke particulates above safe levels may cause chronic impacts, reducing life expectancy and increasing pressure on public health systems (UNEP, 2022). Numerous studies support this claim, drawing attention to the health risks of wildfires and the dangers of failing to invest in prevention and mitigation of these disasters. According to a recent study in The Lancet, annual exposure to wildfire smoke resulted in over 30,000 deaths across the forty-three countries included in the study (UNEP, 2022).

Wildfires yield significant impacts to the environment in a number of ways. For example, wildfires can exacerbate climate change by accelerating positive feedback loops in the carbon cycle. Specifically, wildfires in petlands and rainforests, which store large amounts of irrecoverable terrestrial carbon, release vast quantities of CO2 into the atmosphere (UNEP, 2022). Moreover, as wildfires lead to the loss of vegetation, habitat, and wildlife, decreased biodiversity also represents an impact to the environment. For instance, in the summer of

2019/2020, the Black Summer bushfires in Australia resulted in the death of an estimated one billion mammals (Fletcher et al, 2021).

It is no surprise that wildfires also result in lasting impacts to economies. In Fletcher et al's (2021) article, the authors recount recent major wildfire events across the globe. According to the article, the Southeast Australian Black Summer bushfires, 2017 British Columbia wildfires, 2018 Californian wildfires, 2019 Amazon wildfires, and 2020 Californian wildfires yielded a total economic cost of more than US$1 trillion (Fletcher et al, 2021). Wildfires thus represent a very costly disaster, requiring firefighting and suppression resources, destroying property, garnering tremendous healthcare costs, resulting in widespread evacuations, and ravaging livestock. Of course, these items only represent the direct costs of such events, and the true cost is often a challenge to ascertain. Indirect costs span from loss of productivity, reduced property values, and long-term economic downturns in affected areas. In short, the more accurate cost of wildfires is almost certainly much higher than what is typically documented.

Call to Action: Bridging Knowledge Systems to Reduce Impacts

Amidst ever-intensifying wildfires, there is increasing support to mobilise IFK, both in Canada and across the world. The complexity of wildfires is becoming further understood, leading to the recognition of the need for holistic, multifaceted solutions to climate-change fueled disasters (Larry et al, 2012). As expressed by Ray et al (2012), panaceas – defined as popular solutions prescribed for diverse environmental problems – are destined to fail as they simplify complex environmental systems, assume homogenous human resource use, and ignore local context. Tedim et al (2016) also argue against policy panaceas, deeming them ineffective to address wildfires, which explicitly address interactions and form feedback loops between human

and natural systems. Like many scholars, Ray and Tedem et al maintain that the complex nature of the wildfire phenomenon cannot be addressed by ecological or social research alone. Especially in terms of resilience, it is more effective when created and maintained by utilizing the knowledge, resources, and skills of all stakeholders, which are required to build needed adaptive capacity (Eisenber et al, 2019).

There is an increasing emphasis on leveraging local knowledge in wildfire management paradigms. In using local knowledge about local variability in fire effects, fire management strategies can be developed that maximize benefits and minimize the negative effects of wildfire through landscape management (Ray et al, 2012). Due to its holistic and place-based nature, IK tends to be effective in filling in the gap between ecological and social research. In California, for example, Indigenous fire science has become recognized as a robust strategy for adapting to climate change over the last few decades (Ammerman, 2022). IK and fire science can fit within the overarching theme of Indigenous fire stewardship (IFS). This represents a dynamic knowledge system that adapts to changing environmental conditions (Hoffman et al, 2022). Furthermore, case studies of Indigenous People's use of fire have led to predominantly written recognition that it is both rich and useful (Huffman, 2013). Additionally, in the broader realm of disaster management, the UN Sustainable Development Goals and the Sendai Framework of Action 2015-2030 have focused on holistic approaches toward Indigenous disaster risk reduction processes (Vázquez-Varela et al, 2022).

Most scholars argue that IFK is most effective when bridged with Western Scientific Knowledge (WSK), but one cannot disregard the potential for IFK to be lost or marginalized as it is bridged with WSK. WSK is defined as collective understanding and documentation of natural

phenomena that result from observation, experimental manipulations, or modeling (Frank et al, 2017). This knowledge system aims to be objective, to differentiate among or between variables, to test hypotheses, to minimize assumptions, to identify casual factors, and to regard fire as a physical phenomenon affecting biological and socioeconomic relationships (Frank et al, 2017).

Importantly, Vázquez-Varela et al (2022) note the ethical issues that tend to arise during integration of local fire knowledge and Western fire management. Naturally, the process of knowledge integration risks imposing a Western bias in interpretation, leading to local or Indigenous ecological knowledge becoming submissive to Western paradigms (Vázquez et al, 2022). IFK must be mobilised in a meaningful way, ensuring that it is not simply an obligatory, complementing factor to the broader vision of WSK. When Indigenous Peoples are hired to integrate IK into provincial and federal fire management plans, fire stewardship is shifted away from community governance structures (Hoffman et al, 2022). The term 'integration' will therefore not be used throughout this paper, as IK deserves to stand alone as an empirical epistemology, rather than a mere addition to the Western Scientific worldview that can easily be lost in translation.

Slowly, local and Indigenous fire management practices have been regaining legitimacy and becoming more widespread (Rodríguez et al, 2023). As the role of Indigenous people in wildfire management has been limited, or outright dismissed, calls have grown for the revitalization and integration of IFKs and practices, along with engagement with Indigenous communities or organizations (Mihalus et al, 2024). In short, the cultural and environmental value of Indigenous fire management is being recognized, with increasing attention being paid to developing fire management systems that incorporate diverse perspectives of fire and forms of

environmental knowledge and documenting and legitimizing local fire use knowledge and practices (Rodríguez et al, 2023). The call-to-action stems not only from the perspective of enhanced preparedness for wildfires, but also from the lens of Indigenous rights. Put simply by Sutherland (2022), mobilising Indigenous fire stewardship would "show Canada's commitment to facing climate while being in accordance with its sacred obligations to Indigenous nations" (para. 13).

Call to Action: Status Update

The document analysis reveals that while there is consensus that IFK should be mobilised, progress is slow-moving. Mihalus et al (2024) attest to this, arguing that despite the shifts in wildfire management paradigms and the increasing inclusion of prescribed burning in the wildfire management toolkit, North American wildfire management policy has been largely slow to respond to the consequences of excessive suppression and to embrace IK and burning practices. In part, this is due to the continued hold of WSK on disaster risk reduction practices. Rodrigíguez et al (2023) explain this well, arguing that despite efforts to democratize knowledge and to integrate IK in fire management policies, epistemic domination in wildfire management perpetuates world-wide due to the position of the western scientific worldview in knowledge hierarchies within agencies and practitioners responsible for wildfire management. In Canada specifically, there is increasing pressure to ensure that IK leads land-based decision making through appropriate research and practice (Copes-Gerbitz et al, 2021). Despite this, fire-dependent social-ecological systems fail to adequately consider the context of this knowledge at present (Copes-Gerbitz et al, 2021).

Benefits of IFK

Within the literature, the benefits of mobilising IK not only to prepare for wildfires, but in the broader realm of disaster risk reduction, have been widely reported. Specifically, most scholars write that when bridged with WSK, IK is effective in promoting resilience. Ammerman (2022) explains that IK acquired over millennia can promote both resilience and adaptation to climate change when paired with new technologies and scientific knowledge. In addition to promoting ecological resilience and adaptation to climate change, bridging IK with WSK also results in advantages related to Indigenous rights to self-determination.

1. Environmental Benefits: Wildfire Risk Reduction, Increased Biodiversity, and Greater Ecosystem Health

One of the most important benefits of IFK is its ability to mitigate natural hazards. For example, in the Guyana Shield region of South America, Indigenous communities have harnessed fire through intentional and precise burns to manage their landscapes, nurture their ecosystems, and enhance their livelihoods (UNESCO, 2023). To prevent fires from encroaching upon their forests, the communities strategically reduced the accumulation of dry brush in areas prone to ignition, such as grasslands (UNESCO, 2023). Controlled burns thus served as a barrier, limiting the destruction that a wildfire would have otherwise caused in the forest. Of course, it should be noted that controlled burns – also known as prescribed burns – are not without their risks. This practice can result in decreased air quality and does lead to the potential for unintended consequences (UNEP, 2022). Yet, undertaking controlled burns are likely worth the risk. Unlike wildfires, smoke impacts from prescribed burns are more localised and can be managed to limit exposure and duration (UNEP, 2022).

In Hoffman's "The Right to Burn" (2022), she writes that cultural burns decrease the risk of severe wildfires that can threaten homes, businesses, and livelihoods, eliminate rodents and other pests, and promote the growth of plants that provide foods, medicines, and reduce the effects of spring flooding. In short, IK, specifically in the form of cultural/controlled burns, is instrumental in reducing wildfire risk. Indigenous communities rely on their intimate knowledge of the seasons to determine when it is appropriate to mitigate wildfire risk and conduct safe burns, all the while considering when to harvest, illustrated in Figure 2. For example, throughout Canada, Indigenous Peoples have specific times for burning, the majority of which taking place when fire risk is low (Hoffman et al, 2022).

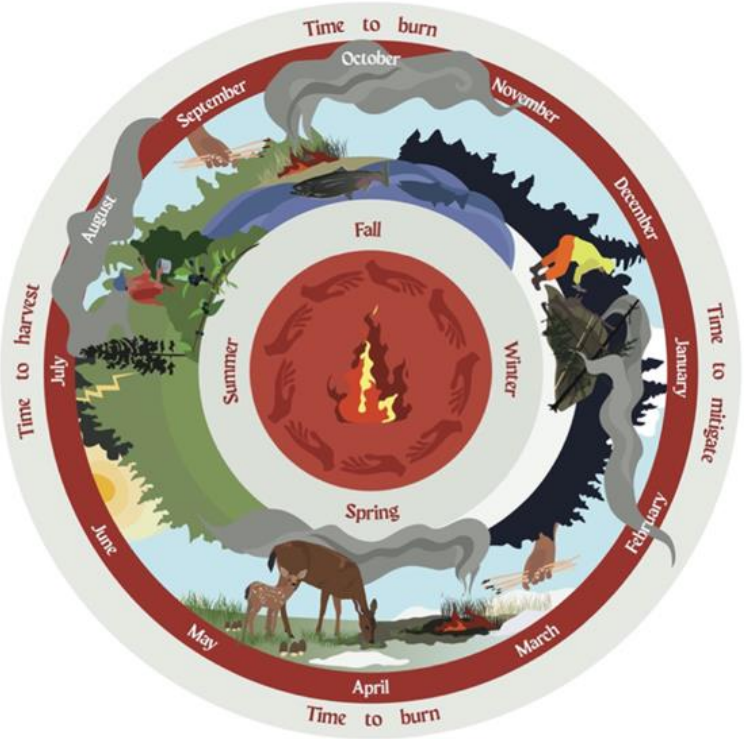

Figure 2. A seasonal calendar illustrating aspects of Indigenous Fire Stewardship, image concept by K.M Hoffman and A.C Christianson, design and illustration by Alexandra Langweider of Align Illustration (Hoffman et al, 2022).

The benefits of cultural burning have repeatedly been explored. Atkinson and Montiel-Molina (2023) assert that scientific and empirical evidence have demonstrated that cultural burning can recreate landscape mosaics, enhance biodiversity, and reduce bushfire risk. In terms of biodiversity, cultural burns have likely been paramount to ecological disturbance regimes to open out otherwise dense canopies, fertilize soils, and sustain or stimulate species regeneration (Bardsley et al, 2019). More broadly, the World Economic Forum (2021) reported that Indigenous fire stewardship increases biodiversity in nearly all of earth's terrestrial biomes. Biodiversity is incredibly important, especially in the face of climate change, as it renders ecosystems more resilient to disturbances while also providing immeasurable intrinsic, recreational, and societal value (World Economic Forum, 2021).

2. Self-Determination Benefits: Cultural Continuity and Economic Opportunities

The mobilisation of IFK also paves the way for Indigenous Peoples to actualize their rights to self-determination and strengthen cultural continuity. According to the United Nations, recognizing and supporting the inclusion of IFK within government, policy, practice, and programmes yield multiple benefits that transcend those that are ecological – including cultural, social, economic, health and well-being, and self-determination (UNEP, 2022). Bardsley et al (2019) explain that the documentation of Indigenous traditional ecological knowledge and the associated processes of land management are central arguments of continued ownership of and/or residency in a place, which consequently highlight Indigenous cultural rights and responsibilities over country. This can be emphasized by the nuance between controlled burns and cultural burns. Atkinson et al (2023) explain that while planned burns primarily aim to control fire, cultural burns return the fire to its natural environment and allow the country to determine

what needs to be burnt. In short, cultural burns also serve the purpose of healing, restoring, and decolonizing the land (Atkinson et al, 2023). Efforts to decolonize landscapes, with which Indigenous Peoples have an intimate relationship, represent a pivotal step in their journey to uphold their right to self-determination.

Barriers to Mobilising IFK

1. The Moulds of Western Science: Knowledge Bridging Challenges

The literature reveals numerous reoccurring challenges regarding the mobilisation of IFK. Among these is the difficulty of bridging IK with WSK. Efforts to bridge IK with WSK are often taxing due to the rigidity of western scientific models. Traditional ecological knowledge and IK rarely fit within these frameworks, as resource managers and Indigenous resource users tend to perceive environmental issues differently, with some Indigenous resource users being unwilling to generalize about natural processes, as their knowledge is place-based (Ray et al, 2012). Numerous scholars and practitioners highlight this challenge, including Atkinson and Montiel-Molina (2023), who acknowledge the different ways of thinking and acting between the Western system and Indigenous customary law and practice, which consequently impede the process of reconnecting fire culture of Indigenous communities with present-day wildfire risk management. Bridging IFK and WSK can also lead to different objectives and conflicting approaches to managing fire (Frank et al, 2017).

The shortcomings of knowledge integration are being widely documented in the Australian context, with Vázquez-Varela et al (2022) exploring how in the Northern parts of the country, attempts to integrate traditional ecological knowledge and Western Science are leading to a de facto transfer of the social and ritual responsibility of burning the country from specific

Indigenous custodians to Indigenous rangers, non-Indigenous fire ecologists, and other non-Indigenous actors. When the integration of knowledge system proceeds in manners like the aforementioned scenario, the effectiveness of IFK is limited and tokenism becomes a reality. Hoffman (2022) explains that tokenism results when knowledge is extracted from an Indigenous employee, allowing non-Indigenous agencies to replicate cultural burning techniques without involving Indigenous Peoples, or when knowledge appropriation is substituted for meaningful engagement with Indigenous fire practitioners. As stated in much of the literature, traditional ecological knowledge, along with IK, is most likely to succeed when it is based upon field experience, active participation among collaborators, and upon equal recognition of Indigenous and western scientific knowledge (Slaton et al, 2019). Therefore, the bridging of these two epistemologies – while necessary to enhance resilience to wildfires – remains plagued with challenges. On one hand, IK does not fit within rigid frameworks which are imposed by the western scientific worldview. On the other hand, IK can be appropriated by non-Indigenous individuals, limiting its effectiveness and resulting in tokenism, which eradicates the opportunity for Indigenous Peoples to simultaneously advance their rights to self-determination.

2. Policy, Governance, and Legal Considerations

An additional barrier to mobilising IFK pertains to current policies and laws, which impede the autonomy of Indigenous Peoples regarding their land management. Fletcher et al (2021) highlight this as a key barrier to the return of Indigenous fire management in Southeast forests, clearly stating that policy and legal barriers prevent Indigenous Peoples from managing landscapes according to their customary laws. A prime example of this dilemma is the Ngadju people of Australia who, despite having native title over 102,000 square kilometers of the Great

Western Woodlands, struggle to practice cultural burning (Cramer, 2019). The issue lies in the fact that responsibility for fire prevention and suppression on traditional lands is held by three state and local government agencies (Cramer, 2019). This jurisdictional challenge creates an environment that is not conducive to Indigenous-led fire management. The Ngadju risk being charged with arson if they conduct cultural burning due to their lack of official authority on land management (Cramer, 2019).

In Canada, legal and policy barriers pose similar challenges to the mobilisation of IFK. For example, Indigenous Nations wishing to burn on Crown land are required to submit a formal burn plan to a local wildfire management agency that serves as a gatekeeper to receive permission to use fire (Hoffman, 2022). Hoffman (2022) explains that such burn plans and permit applications focus on western science criteria, including fire weather danger ratings, fuel types, moisture codes, and smoke venting requirements, while also requiring specific western technical expertise for their completion. Unsurprisingly, the time and effort to gain approval to conduct cultural burning hinder the ability for Indigenous Peoples to mobilise their fire knowledge and undertake preventative measures. There are numerous examples of Indigenous communities investing months to prepare fire prescriptions that were not approved or could not proceed as conditions were not suitable to achieve desired cultural outcomes during the agency-assigned burning period (Hoffman, 2022). Additionally, the frameworks for these burn plans and permits along with their evaluation criteria are significantly misaligned with the priorities of Indigenous peoples. They tend to be incongruent with community practices, desired outcomes, and optimal conditions for cultural burning (Hoffman, 2022).

3. The Negative Public Perception of Fire and IFK

Furthermore, the public perception of fire as a destructive and dangerous element has impedes the mobilisation of IFK. In the United States and Canada, variability in perceptions and attitudes toward wildfire among Indigenous and non-Indigenous peoples represent a barrier to productive engagement between governments and Indigenous peoples (Mihalus et al, 2024). In fact, many participants in the study of Mihalus et al (2024) find that western society's negative portrayal of wildfire has been particularly detrimental in the mobilisation of IFK and management.

Negative perceptions of IFK also pose a barrier to the recognition of IFK. Many individuals still regard Indigenous Fire Stewardship as something of the past, rather than an ever-changing knowledge system that adapts to shifting environmental conditions (Hoffman et al, 2022). Fletcher et al (2021) highlights the issue of public perceptions in the Southeast Australian forest context, noting that mainstream society is uncertain about the degree to which Indigenous Peoples "actually manage science," and the degree to which Indigenous Peoples managed high biomass and extremely flammable forests prior the British Invasion. Fletcher and their counterparts accurately highlight the reality of society's reluctance to accept IFK and Stewardship as being effective and based on empirical data.

4. Resource Constraints

In Canada specifically, funding for disaster risk reduction tends to be directed toward the response and recovery pillars of emergency management. According to Hoffman (2022), despite major annual public investments toward wildfire management, little of the money is invested in wildfire risk reduction practices, such as Indigenous fire stewardship. Additionally, despite the growing - albeit slowly – attention to cultural burning and its benefits, there is little understanding

of the significant costs associated with the practice. Many Indigenous Peoples and Nations face challenges re-engaging in cultural burning as the forests that were historically managed with fire have accumulated flammable fuels as a result of over a century of fire suppression and timber-centric forest management (Hoffman 2022). Consequently, in some areas, cultural burns can only be undertaken once hazardous fuel mitigation techniques have been completed and reduced the potential fire intensity (Hoffman, 2022). Unsurprisingly, these measures require funding, time, and physical capacity. In Canada, and namely on reserves, the impacts of colonialism have rendered Indigenous Peoples financially vulnerablw. Colonial mismanagement of finances, infrastructure, and essential services on reserves have created a cycle of poverty for Indigenous communities, where Indigenous leaders have to acquire funding for basic human necessities, such as clean drinking water and housing (Hoffman, 2022).

Mechanisms to Overcome Barriers

1. Emphasize Meaningful Community Participation to Increase Trust and Protect IFK

In Canada, due to the federal government's history of colonization, Indigenous Peoples are sometimes skeptical of trusting programs that involve sharing traditional, sacred, and protected knowledge (Cramer, 2019). With this reality being well understood across scholars and practitioners, meaningful involvement with Indigenous Peoples has been emphasized throughout the literature in calls to mobilise IFK. As expressed in various sources, community participation is essential to avoid the appropriation of local knowledge systems by institutions and to more accurately reflect equitable fire governance (Vázquez-Varela et al, 2022). According to numerous scholars, the success management of wildland fire and fuels hinges on collaborative partnerships that share Indigenous and Western Scientific fire knowledge by means of culturally

sensitive consultation, coordination, and communication for building trust (Vásquez-Varela et al, 2022). This is especially important in the context of cross-jurisdictional management, where consulting with tribal elders and other key community members during planning and implementation of land management activities and fire use is central to fire management effectiveness (Frank et al, 2017).

There are also frameworks and guiding principle that can be mobilised to support the bridging of Western and Indigenous Knowledges. “Two-Eyed Seeing” and “Etuaptmumk – the Mi’kmaq word for “the gift of multiple perspectives” entail genuine engagement across the two knowledge systems, including the cultures and practices that make up the epistemologies (Mihalus et al, 2024). “Walking on two legs,” a method of Indigenous fire stewardship for fire-adapted landscapes, has also been proposed as a grassroots movement to defend Indigenous led-restoration of Indigenous lands, knowledges, and cultures (Vázquez-Varela, 2022). Emphasizing genuine engagement with Indigenous Peoples can ease mistrust during the process of knowledge bridging and allow for active participation between Indigenous Peoples and Non-Indigenous peoples. Appropriate and respectful bridging of knowledge may also serve as protection for IFK systems, which according to the United Nations, will recognize IFK as a significant cultural asset of possible adaptive solutions to climate change and enhance Indigenous leadership in the field of wildfire management (UNEP, 2022).

2. Change Mainstream Society’s Perception of Wildfire and IFK

The literature also emphasizes the importance of education and training in changing both the public’s and Indigenous youth’s perception of fire and IFK. In a workshop concerning bridging Indigenous and WSK, participants highlighted the need for targeted education to reduce

prevalent misconceptions and enhance cultural awareness across all agencies, organizations, and contractors whose work touches wildfires in culturally sensitive areas (Frank et al, 2017). In Canada, this is especially needed. Hoffman et al (2022) declare that although some Canadian postsecondary institutions offer programs in Indigenous environmental stewardship and Indigenous communities have partnered with universities to develop programs in Indigenous cultural heritage, the authors are not privy to any courses centred around Indigenous fire stewardship, cultural fire ecology, or cultural burning. The absence of these themes and the IFK system in education institutions keeps Canadians unaware to the benefits of fire use and place-based knowledge systems such as IK. Specifically, the infusion of IK into workforce training and education could increase community and tribal capacity for wildland fire management and use (Frank et al, 2017).

As explained by Frank et al (2017), education serves to promote fire as a crucial management tool, which enhances cultural practices and traditions along with functioning ecosystems. This perspective, which can be engrained in people through education and training, can alleviate the stigma that flares up in dialogue concerning wildfires. In Canada especially, Hoffman et al (2022) call for a change in western societal perceptions toward IK pertaining to fire, Indigenous burning, and community-level involvement and leadership in the management of wildfires and coordination of wildfire evacuations. The authors point to a ripple effect of perceptual change that could ensue, which would in turn make space for the opportunity to improve policy and adjust resources and funding to better support the development and maintenance of community capacity, and also mobilise traditional governance and self-determination, inclusion of culture,

norms, values, and goals to help revitalize Indigenous communities' capabilities in preparing for and protecting themselves against wildfires (Hoffman 2022).

3. Further Indigenous Peoples' Right to Resource and Fire Management

As briefly mentioned, the mobilisation of IFK cannot be separated from the broader theme of Indigenous Peoples' right to self-determination. Thus, strengthening Indigenous Peoples' rights to resource and land management represents an avenue to enhance the mobilisation of IFK. For example, the Ngadu – with native title over 102,000 square kilometers of the Great Western woodlands in Australia – fear being charged with arson if they conduct cultural burning (Cramer, 2019). This is because the responsibility for fire prevention and suppression on their traditional lands still remains with state and local government agencies (Cramer, 2019). Agreements can be made to strengthen Indigenous communities' ability to conduct cultural burns to help prevent wildfires, though they prove challenging. A memorandum of understanding represents one mechanism that the Ngadju are actively trying to negotiate, which would permit them to conduct cultural burning on government-owned lands over which their native title falls (Cramer, 2019).

Emphasizing community-based natural resource management also appears as a recommendation in the literature. In an article by Ray et al (2012), it is suggested that fire managers in Alaska and elsewhere utilize community-based natural resource management, which would recognize the right of resource-dependent communities to participate in environmental decision making and embrace community knowledge along with local resource management traditions. The United Nations also stresses the importance of community-based fire management that is locally operated, which would draw on assessments of social, economic,

cultural, and ecological conditions to mitigate damage and maximize fire benefits (UNEP, 2022). The benefits of community-based natural resource management would be twofold: mitigating the risk of wildfires and recognizing some of the rights of Indigenous Peoples. For example, in the United States, Indigenous communities retain federally protected rights to subsistence and the customary and traditional uses of wild resources on federal land (Ray et al, 2012). Community-based natural resource management, which would mobilise IK, would help federal wildfire management meet this obligation to Indigenous groups.

Examination of Four Case Studies

The document analysis highlights a number of contemporary best practices in mobilising IFK. However, due to time constraints, only four case studies are selected for this research paper. The chosen examples include initiatives from Australia, California, British Columbia, and the Amazon region, specifically Brazil. The cases are chosen partly due to vulnerability to wildfire and recent history of difficulties with wildfire management. The United Nations reported record-breaking wildfires in these areas, such as in Eastern Australia, the west coast of the United States in 2019-2020, and in British Columbia in 2017, where climate change significantly increased the burned area (UNEP, 2022). The selection of case studies includes two Indigenous communities, one Indigenous-led organization, and one Indigenous firefighting unit:

- Karuk Tribe, California, US – Co-Management (WKR Partnership)
- Secwépemc, British Columbia – Two-Eyed Seeing | Indigenous Led Restoration
- Firesticks Alliance Indigenous Corporation, Australia – Indigenous Led Organization
- Indigenous Fire Brigades, Brazil – Integrated Fire Management

The Karuk Tribe, Firesticks Alliance, and Indigenous Fire Brigades are all cited in the United Nations and GRID-Arendal Report 'Spreading Like Wildfire,' with no specific examples being mentioned from British Columbia, Canada.

Karuk Tribe, California

Community Profile and Historical Context

The Karuk Tribe inhabit the Western Klamath Mountains in northern California, a diverse and highly-fire prone ecosystem that has historically burned frequently with low or moderate

severity, but has in recent times experienced several uncharacteristically extensive or severe wildfires (Greenler et al, 2024). Karuk People have long used fire to manage Klamath forests as a mosaic of habitats, promoting a diversity of cultural resources, including plant and animal species used for Karuk subsistence foods and ceremonial regalia (Diver, 2016). However, a culture of fire suppression and command and control policies hindered the Karuk's ability to use fire. Many Karuk People directly link U.S fire suppression policy to the decreased production of Karuk cultural resources that rely on fire disturbance, such as basket-weaving plants, acorn-producing oak trees, and wildlife species like deer and elk (Diver, 2016). Additionally, Karuk's use of Traditional Ecological Knowledge has been at risk of decline due to forced assimilation, lack of region of TEK by non-Native management agencies, insubstantial tribal management capacity, and changes in ecosystems themselves (University of British Columbia, 2020). Also, the majority of Karuk ancestral territory presently remains under the jurisdiction of the Forest Service, Park Service, and private timber companies (Marks-Bloc et al, 2021). Fire suppression policies and the current land tenure arrangement of the community have clearly yielded direct implications for the Karuk's ability to practice their traditional ecological knowledge in the context of fire.

In Northern California, there is growing support for adaptive co-management that incorporates IK, modern tools, and western Science to advance numerous objectives, including ecocultural revitalization, landscape restoration, and community wildfire risk reduction (Greenler et al, 2024). In its recent report on wildfires, the United Nations account for the Karuk Tribe's Eco-Cultural Revitalization Branch, which is grouped with several initiatives in the United States that have developed opportunities to support Indigenous Burning Activities that engage in wildfire prevention and mitigation at the landscape level (UNEP, 2022).

Mobilisation of IFK

Recognizing that complete sovereignty over their land represents a longer-term goal for the Karuk tribe, the community has sought other ways to mobilise their fire knowledge. For example, the Karuk Tribe has made efforts to establish concrete co-management mechanisms to work with the Forest Service across its territory (University of British Columbia, 2020). After years of effort, the Tribe did secure a recognized co-stewardship role with the US forest service (University of British Columbia, 2020). By collaborating with the Western Klamath Restoration Partnership, the Karuk Tribe actively engages in fire management. In fact, the creation of interagency and intergovernmental partnerships such as the Western Klamath Restoration Partnership in the Karuk territory were viewed by surveyed managers throughout northern California as the most effective action to increase prescribed and cultural fire area (Marks-Block et al, 2021). Additionally, the Karuk Tribe has demonstrated innovation to harness resources to realize their agenda. To develop alternative funding streams, the tribe established an eco-cultural revitalization fund, serving to raise financial resources through private foundations and donors (Marks-Block & Tripp, 2021).

The Six Rivers National Forest and the Karuk Tribe have a successful partnership through which the National Forest contracts with the Karuk Tribe to conduct cultural resource reviews of proposed forest and prescribed fire activities under the National Environmental Policy Act (Marks-Block & Tripp, 2021). While there remain challenges within this example of IFK mobilisation, the relentless efforts of the Karuk Tribe to self-determination and cultural revitalization serve as an example. Even with the land tenure regime working against the tribe and limiting their ability to practice cultural burning and share their traditional ecological

knowledge, they have made undeniable progress through their partnerships. As put by Diver (2016), mobilising tools like co-management can help build tribal capacity in resource management decisions, so long as the approach fits within a community's broader self-determination goals. Furthermore, cultural resource collaboration through co-management provides the Forest Service with additional specialists and ensures that the Karuk Tribe is directly involved in forest and fire planning in their ancestral territory (Marks-Block & Tripp, 2021). This a prime example of a community mobilising their IFK to enhance modern forestry practices.

Remaining Challenges or Criticisms

Co-management does run the risk of co-optation for Indigenous communities, especially for those working to achieve greater self-determination. Ultimately, Indigenous relationships with state-based resource management institutions are embedded within colonial systems that have historically excluded Indigenous communities from land management decision-making (Diver, 2016). Despite the benefits of efforts to reduce fuels and re-introduce cultural and prescribed fire, state agencies do retain considerable regulatory power which can undermine efforts to decentralize fire planning and restore fire to the landscape (Marks-Block & Tripp, 2021). Several tribal managers would prefer to start fresh and form their own Indigenous resource management institutions, rather than operating within the constraints of existing state institutions and their engrained relations of power and privilege (Diver, 2016). Yet, the pervading reality is that creating Indigenous resource management initiatives within a multi-jurisdictional context will require time and resources for capacity building, for tribes and state agencies alike (Diver, 2016). Resource constraints do continue to pose an issue, with authors Marks-Block and

Tripp stating that managers report that existing personnel are still insufficient to meet prescribed fire objectives and that additional funds are imperative.

Secwépemc, British Columbia

Community Profile and Historical Context

The Secwépemc communities historically used fire on a regular basis for a myriad of purposes. Most prominently, fire represented a landscape management tool for the people. Specifically, fire stimulated the growth of important food and medicine plants and ungulate forage, while also creating a well-kept appearance of the territory (Dickson-Hoyle et al, 2022). However, in the late 19th century, Indigenous burning was outlawed in BC, followed by more than a century of colonial fire suppression that disrupted historical fire regimes in the areas (Dickson-Hoyle et al, 2022). In recent years, British Columbia has been prone to devastating wildfires which have disproportionally impacted Indigenous communities and evacuated many people. For example, in the summer of 2017, megafires burned 1.2 million hectares in British Columbia, driven both by climate change and a century of fire suppression and forest management (Dickson-Hoyle et al, 2022). The Secwépemc communities were no exception; the 2017 Elephant Hill megafire burned 192,000 hectares in the heartland of the Secwépemc Nation, consequently disrupting ecosystems and human wellbeing (Dickson-Hoyle et al, 2022). In 2021, the Nation was once again greatly impacted by widespread wildfires (Dickson-Hoyle et al, 2022).

Mobilisation of IFK

The Sexwepemcúl'ecw Restoration and Stewardship Society (SRSS), founded in response to the 2017 wildfire by eight Secwépemc bands, originated from a mission to promote a collective and collaborative approach to yecwemínem, also known as stewardship and caretakership (WWF

Canada, 2023). The forest restoration project under SSRS represents an Indigenous-led approach to achieving numerous goals such as the enhancement of ecosystem resilience to wildfires, carbon sequestration, and increased self-determination. The Salish Resource Society (n.d) summarizes the project well, deeming it a "cornerstone venture by the collective of eight Secwépemc communities under SSRC to increase capacity for Indigenous-led Forest regeneration towards increased carbon sequestration, wildlife habitat, and fire resilience," (para 6). Projects such as these highlight the range of benefits that can result for mobilising IFK– benefits that certainly surpass wildfire risk reduction.

The restoration project's success is partly owed to its approach to knowledge bridging. It is built around a fundamental principle of Indigenous led-conservation, specifically reliant on a Two-Eyed Seeing Approach that includes both leading Western Science, supported by WWF-Canada and the community's research partners, and a heavy emphasis on IK Systems (Salish Resource Society, n.d). Wildfires and the catastrophes that they induce are undoubtedly tragic, Yet, in this instance and throughout landscapes of the Secwépemc Nation, opportunities are arising for Indigenous peoples to reassess their sovereignty by leading restoration of their fire affected and fire adapted territories (Dickson-Hoyle et al, 2022). This ultimately encompasses an example of building capacity for an Indigenous owned-and-operated forest restoration program that highlights the strengths of Indigenous Peoples' implementation of nature-based climate solutions (WWF, 2023). Of course, the success of the program is owed to the presence of community members throughout the project's entirety. Similar to how IK and stewardship systems must be reclaimed in and by Indigenous communities, Indigenous communities must be

physically, intellectually, spiritually, and politically present throughout the restoration process, from project design all the way through to implementation (Dickson-Hoyle et al, 2022).

Key outcomes of this project are wildfire risk reduction, increased carbon sequestration, and increased self-determination. According to the SRSS Society, by planting 500,000 seedlings over the course of three years, this project – grounded in Indigenous rights and leadership – will yield a cumulative net emissions equal to 12,142 tonnes CO2e, while supporting the recovery of multiple at risk-species and increasing climate resiliency (Salish Resource Society, n.d). The use of IFK is clearly set to accomplish a number of goals, ranging from furthering Indigenous rights to habitat conservation.

Remaining Challenges or Criticisms

A noted challenge in this initiative stemmed from resource constraints, as the community experienced difficulties accessing seedlings for the reforestation efforts. However, SRSS is actively trying to own and operate a nursery so that they can grow their own trees as a solution (WWF, 2022). Additionally, climate change poses a challenge to the technical components of SRSS's reforestation challenges. Survivability rates for planted seedlings are impacted by climate impacts such as extreme heat and drought (WWF, 2022).

Firesticks Alliance Indigenous Corporation, Australia

Organization Profile and Historical Context

In recent years, Australia has been prone to catastrophic wildfires, such as the 2019 bushfires (Aboriginal Carbon Foundation, n.d). Yet, Australia's landscape and ecology is inherently connected with the process of fire (Mouritz & Breedon, 2022). Like in many parts of the world, Indigenous Peoples were historically at the centre of landscape management and fire

usage in Australia. After all, Mouritz and Breedon (2022) write that Aboriginal people have actively managed the Australian landscape through fire-stick farming since time immemorial, resulting in vast grasslands and open tree canopies across much of Australia. However, as seen in other case studies, fire suppression policies hindered the ability of Australia's Indigenous populations to use their fire knowledge to manage the land. To empower Indigenous Peoples and revitalize cultural burning practices, Firesticks Alliance was created. Firesticks Alliance is an Indigenous-led organization promoting traditional fire burning techniques as a land management tool throughout Australia (Mouritz & Breedom, 2022). The corporation uses traditional ecological knowledge as a foundation for education and advocacy on sizable landholdings in remote locations along with urban bushlands (Mouritz & Breedom, 2022).

Mobilisation of IFK

The New South Wales Department of Planning and Environment (2023) summarizes Firesticks' three key outcomes:

Outcome	Description
Healthy country	Through cultural burning, the ground is warmed, serving to regenerate landscapes from deep-time seed banks stored in the soil. Cultural fire remains low and cool, only burning grasses and protecting sacred tree canopy.
Healthy community	Through cultural learning pathways, the organization empowers communities to practise cultural management, Online platforms foster a community of practice through knowledge sharing.
Protection of Aboriginal cultural heritage	Through cultural fire credits, pathways are provided for First Nations' led and sustainably financed cultural burning practices.

Firesticks Alliance mobilises IFK in several ways, specifically through co-design partnerships. For example, the corporation works with the NSW Biodiversity Conservation Trust (BCT) to co-design frameworks for managing privately conserved lands in New South Wales (NSW

Department of Planning and Environment, 2023). An important element of this initiative is both acknowledging and removing barriers to implementing traditional ecological knowledge, which thus empowering Aboriginal landowners' through conservation agreements while facilitating cultural fire practitioners to use processes informed by cultural systems, such as indicators in the landscape to inform when and where Country can be burnt (NSW Department of Planning and Environment, 2023).

Additionally, Firesticks has paved the way for greater access to cultural burning through accreditation and training programs. The nationally accredited cultural burning training and education course facilitates cultural learning pathways for Aboriginal people, involving direct fire response training, cultural understandings of fire and fire application, implementation of on-ground works, and conducting scientific monitoring to establish a greater understanding of the biocultural and ecological impact of cultural burning practices (NSW Department of Planning and Environment, 2023).

Furthermore, as a large, national organization, Firesticks Alliance partners with Aboriginal Carbon Foundation to advance the Cultural Fire Credit. Members Dr. Victor Steffensen and Dr Peta Standley had worked together for several years exploring possible independent income sources for communities with the aim of increasing community implementation of cultural fire on Country, which in 2018 resulted in the initial idea for a Cultural Fire Credit (Aboriginal Carbon Foundation, n.d). Importantly, cultural fire credits are Aboriginal owned, ensuring that communities benefit from the carbon market. Through governance to market generation and verification, cultural fire credits are Aboriginal-owned, guaranteeing that projects engage the wider community and deliver equitable benefits and outcomes for communities among other

entities such as research institutions and individuals (NSW Department of Planning and Environment, 2023).

Remaining Challenges or Criticisms

Despite the successes of Firesticks Alliance's efforts to mobilise IFK, Indigenous Peoples do raise concerns about some of the initiatives they promote. For instance, colonial government programs in Australia which apply prescribed fire for biodiversity conservation and carbon sequestration have received criticism for altering the frequency and size of prescribed fires and for ignoring the spiritual and cultural systems that govern Indigenous burning (Marks-Block & Tripp, 2021). In reality, the commodification of nature, upon which the carbon market hinges, does not necessarily align with many Indigenous values. Mistry (2016) elaborates on this, explaining that although market-based interventions provide innovative solutions to environmental management, their ideological foundations are situated within a neoliberal agenda, contrasting rather starkly with Indigenous ontologies which are rooted in human – nonhuman – spiritual relationships.

Indigenous Fire Brigades, Brazil

Firefighting Unit Profile and Historical Context

Traditional and Indigenous communities have managed fire in neotropical savannas and other fire-prone landscapes for thousands of years (Oliveira et al, 2022). Namely, patch mosaic burning by Indigenous communities not only reduced the occurrence of dangerous fires, but also contributed to spatial and temporal vegetation heterogeneity and biodiversity in lowland South America (Mistry et al, 2016). However, like in many cases from around the world, a culture and slew of fire suppression policies hindered communities' ability to use their fire knowledge to

manage their landscapes. Brazil's Forest Code of 1934 prohibited the use of fire for most purposes, and even deemed fire as a crime subject to a fine or imprisonment (Miranda & Berenguerl 2022). Unsurprisingly, Brazil's adopted 'zero fire' policy with no burning proved ineffective, leading to fuel build up and more intense fires, yielding fire consequences for biodiversity and people (Oliveria et al, 2022). IK in fire management is instrumental, especially given the increasing threat and occurrence of wildfires. In August of 2019, there was an increase of 182% in the total number of hotspots affecting Indigenous lands in the Legal Amazon, compared to the same period in 2018 (Instituto Socioambiental, 2022).

There is ample evidence of the significant role of Indigenous communities in fire management in South America. Yet, the incorporation of IK into fire management policies is fairly recent (Oliveira et al, 2022). In Brazil, fire management policies only started to include IK in 2014 through Integrated Fire Management (IFM) (Oliveira et al, 2022). Integrated wildfire management is comprised of five interlinked and often overlapping phases: review and analysis, risk reduction, readiness, response, and recovery (UNEP, 2022). Namely, the central effort to engage Indigenous Peoples in fire management has been through fire brigades. As of 2022, there were 34 Indigenous brigades employed throughout the dry-season period to help combat fires (Oliveira et al, 2022).

Mobilisation of IFK

Indigenous fire brigades represent more than a firefighting unit, but also encompass individuals who both manage and maintain a deep relationship with the land (Oliveira et al, 2022). This proves beneficial when brigades can mobilise their intimate fire knowledge to reduce wildfire impacts. For example, local knowledge of Indigenous members of fire brigades permits

the rapid identification of wildfires and elevates the mobility of the brigades, which consequently reduces response time (Oliveira et al, 2022). Additionally, Indigenous fire brigades increase participation of Indigenous Peoples' in identifying important preservation sites. Every year, members of the Apinajé fire brigade and the wider community discuss and agree on significant sites to be conserved and where to apply prescribed burning (PCA Hub, 2023). When fires reach these previously burned areas at the height of dry season, they often have a smaller impact on the community (PCA Hub, 2023). Through the inclusion of IK, Integrated Fire Management sustains an ancestral practice for reducing forest fires and conserving ecosystems (Miranda & Berenguer, 2022). This permits Indigenous Peoples to continue practising their culture while also playing a vital role in fire management.

The example of Indigenous fire brigades in Brazil is also of interest due to its focus on women. The volunteer brigade Pé Apinajé Guardiãs is the first brigade to be formed exclusively by women in the Legal Amazon (Rainforest Journalism Fund, 2024). In all, 43 brigade members from the Apinajé Indigenous Land, located in northern Tocantins, successfully completed a preparatory course and received a certificate from Ibama (Rainforest Journalism Fund, 2024). From the first Indigenous Women's Fire Brigade, Maria Aparecida Apinajé from the Apinajé community shares that, "the fire brigade helps to give voice and prominence to us, Apinajé women. Our leadership role is recent. Traditionally women were expected to look after vegetable gardens, homes, and children and now we have seven female chiefs in our territory," (PCA Hub, 2023, para 10). Maria wanted to receive training for her community to guarantee preservation of their land and culture for future generations (PCA Hub, 2023). The document analysis and

other case studies failed to adopt a gendered lens regarding IFK, rendering the case of Brazilian Indigenous Fire Brigades unique.

Remaining Challenges or Criticisms

First, resource constraints represent one of the largest challenges that surfaced in the literature facing Indigenous Fire Brigades in Brazil. PrevFogo suffered from a funding crisis that has since 2015 impacted the government, leading to spending cuts in all areas (Instituto Socioambiental, 2022). Additionally, integrated fire management is still restricted to protected areas and not carried out in privately owned territory (Miranda & Berenguer, 2022). As most fires start on private property in the Brazilian context, this represents a major challenge (Miranda & Berenguer, 2022). Land tenure is clearly a complicated issue that hinders the effectiveness of Indigenous Fire Brigades. Furthermore, while Indigenous Fire Brigades are an important milestone in mobilising IFK, further, distinct efforts can be made to enhance IFK. As put by Mistry et al (2016), to empower Indigenous Peoples and ensure their active participation in decision-making, actions must be aimed at encouraging these communities to have more autonomy regarding the implementation of policies, including leadership and funding of fire management programmes.

Discussion

Mechanisms to Mobilise IFK

The four case studies demonstrate that there are numerous ways to mobilise IFK. At the community level, strategies to revitalize this knowledge system will inevitably vary according to a community's land tenure, resources, and values. For example, the Karuk Tribe in Northern California, with little land tenure, made consistent efforts to revitalize cultural burning.

Ultimately, this resulted in a co-stewardship role with the US Forestry Service, facilitated through a partnership. In British Columbia, the Secwépemc peoples aimed to mobilise their IFK through an Indigenous-Led restoration program following a series of devastating wildfires. On the other side of the world, Firesticks Alliance, an Indigenous led organization, promotes avenues for cultural burning training, knowledge sharing, and involvement in the carbon market. Finally, Brazil is supporting Integrated Fire Management through Indigenous Fire Brigades, which prevent loss of ancestral knowledge and enable Indigenous Peoples to be directly engaged in wildfire management. The document analysis reveals that collaborative partnerships rooted in trust and meaningful community engagement were paramount in mobilising IFK. Frameworks such as "Two-Eyed Seeing," and formal tools such as co-management can lead to successful partnerships, as observed in the Karuk and Secwépemc examples.

Partnerships, aside from promoting successful bridging of IFK and WSK, can also provide more sustainable funding for IFK mobilisation. For example, the World Wildlife Fund has played a pivotal role in providing resources for Secwépemc's restoration efforts. Furthermore, the Firesticks Alliance partnered with the government's Aboriginal Carbon Foundation to develop the Cultural Fire Credit program. The Karuk Tribe entered a co-management agreement with the US Forestry Service to enhance their resource management access. Given the jurisdictional – and occasional resource constraint – challenges of Indigenous communities across the world, partnerships with either State Agencies or International Organizations tend to represent a useful mechanism to enable IFK mobilisation.

Outcomes/Benefits

Both the document analysis and examination of case studies highlight that in mobilising IFK, the risks that wildfires pose are reduced, namely through cultural or prescribed burning. In some cases, mobilising IFK also leads to co-benefits such as carbon sequestration and increased biodiversity, with each of these outcomes reducing the effects of climate change. From a lens of environmental conservation and disaster risk reduction, there is a strong case to be made for the mobilisation of IFK.

From a socio-political standpoint, mobilising IFK is advantageous for Indigenous communities across the world. On one hand, Indigenous Peoples are able to practise their culture and maintain ancestral practices, combatting the loss of IK. Additionally, mobilising IFK can enable Indigenous Peoples to be more meaningfully involved in resource and land management, strengthening their right to self-determination. Moreover, mobilising IK can also result in economic opportunities for Indigenous Peoples, as seen through Karuk's Eco-Cultural Revitalization Fund and through the opportunity for Indigenous Peoples to participate in the carbon market through Firesticks' Alliance Cultural Carbon Credit program.

Remaining Challenges

The lack of land tenure, falling under the broader realm of policy and legal considerations, still hinders Indigenous Peoples' ability to conduct cultural burning to its fullest capacity. For example, in Brazil and parts of California, where the Karuk Tribe resides, cultural burning cannot be undertaken on private land despite the intricate territorial knowledge that Indigenous tribes possess. Efforts to return privately owned lands to dispossessed tribal members and to legislate the return of public lands to Tribes would increase Indigenous access to eco-cultural resources

and expand cultural fire led by families, and their collaborators, and also further contribute to Indigenous cultural revitalization (Marks-Block & Tripp, 2021). Granted, returning privately owned lands to dispossessed tribal members represents a longer-term goal, brimming with complexities.

Additionally, resource constraints remain a factor prohibiting further mobilisation of IFK. Both in the case studies of the Indigenous Fire Brigades in Brazil and the Karuk Nation in the United States, the literature highlights that financial constraints pose barriers to Indigenous Peoples fully mobilising their fire knowledge. With further investments toward Indigenous Fire Brigades and funding allocated to personnel responsible for wildfire management in the Karuk Tribe, IFK could be capitalized upon more sustainably and equitably.

Other challenges that surfaced in the document analysis section pertain to knowledge bridging challenges and negative perceptions of fire and IK. With respect to knowledge bridging, numerous authors flag that IK is at risk of being lost in processes of integration. This dilemma occurs when IK is forced into the mould of WSK, hindering its effectiveness and squandering any chances of knowledge sovereignty for Indigenous communities. Knowledge bridging can also be difficult when Indigenous communities do not have trust in governments, resulting in collaborative efforts being challenging. The negative perception of fire and IK contributes to this, as some individuals, organizations, and governments may discount the merit in IFK and be resistant to cultural burning practices as they see fire as an entirely negative and destructive element. This exacerbates communities' reluctance to share their fire knowledge and work in tandem with government agencies in wildfire management.

Recommendations Within the Canadian Context

1. Support Formal Partnerships Between Indigenous Nations and Organizations with Governments and Not-For-Profit organizations.

The case studies demonstrate that formal agreements between Indigenous Nations and organizations and State Agencies or not-for profit organizations prove to be a viable vehicle to mobilise IFK. In the document analysis, it was revealed that resource constraints encompass a barrier to the use of IFK in wildfire management. Specifically, many Indigenous communities in Canada do not have the capacity to engage in the burdensome, resource intensive process of conducting cultural burns. Examples such as the Secwépemc and Karuk demonstrate the validity in partnering with either governments or non-governmental organizations to mobilise IFK. The Karuk Tribe's recognized co-stewardship role with the U.S forest service attests to this, through which the community is able to use their fire knowledge to manage the land and maintain cultural practices. Additionally, the Secwépemc's partnership with World Wildlife Fund Canada has secured financial resources to restore wildfire-impacted forests in the region. These restoration efforts represent an Indigenous-led project where Two-Eyed Seeing is incorporated to respect IFK and ensure that it does not fade into the often dominating force of WSK.

2. Endorse training and accreditation programs that promote IFK and Cultural Burning.

As the document analysis demonstrates, Indigenous practice and knowledge remains marginalized in research, development, and policy-making circles, mainly owed to a mismatch in cultural understandings among Indigenous and non-Indigenous perspectives (Mistry et al, 2016). To combat this, educational curriculums should highlight IFK. This will also serve to change

mainstream society's perception of fire from a destructive element to something that is both ecologically and culturally beneficial.

To create space for prescribed fire training and accreditation, support should be given to Indigenous-led fire practitioner accreditation. This can be done through Prescribed Burn Associations and Prescribed Fire Training Exchanges, which provide cooperative ways to pool equipment, knowledge, and expertise across diverse partnerships including Indigenous communities, government agencies, private landowners, and scholarly institutions to pursue prescribed and cultural burning (Hoffman, 2022). Such associations are useful in supporting members to leverage skills and provide training. Moreover, Hoffman (2022) suggests endorsing a training program or certification that focuses specifically on cultural burning and Indigenous fire stewardship, which represents an effective way to mobilise IFK. The case studies of Firesticks Alliance and Brazilian Indigenous Fire Brigades exemplify this recommendation, as they promote accreditation and training, which serves to empower Indigenous peoples to revitalize their knowledge and be more actively involved in wildfire management.

3. Increase support for Indigenous led and owned bottom-up initiatives.

Furthermore, the document analysis and case studies emphasize the merit in Indigenous-led, bottom-up initiatives for wildfire management and knowledge mobilisation. Shayna et al (2022) explain that in the North American context, the fundamental challenge is the need to create space for self-determination and for Indigenous peoples and institutions to have additional control over central aspects of wildfire management and evacuation processes. One avenue to support Indigenous led, bottom-up initiatives is to fund an Indigenous National Incident Command team working parallel to the Canadian Interagency Forest Fire Centre (Hoffman, 2022).

This would contribute to Indigenous Fire Stewardship by enabling teams to deploy to incidents alongside wildfire agencies and Emergency Management teams to support Indigenous communities with wildfire assessment and response, sharing of resources, impacts to cultural and ecological values, and support for emergency evacuations and decisions to shelter in place (Hoffman, 2022). The document analysis also demonstrated that mistrust toward governments tends to be a barrier to mobilising IFK in Canada. The case study focusing on Firesticks Alliance reveals that Indigenous-led organizations can be instrumental in promoting IFK and in turn, protecting the land through the mitigation of wildfire risk. By endorsing Indigenous led and owned, bottom-up initiatives, the issue of state mistrust would be mitigated while Indigenous rights to self-determination would be strengthened.

Conclusion

Summary of Findings

The ever-increasing threat of climate change, and especially wildfires, requires solutions that are holistic and rooted in empirical data. As demonstrated in this paper, Indigenous Peoples across the world have maintained a reciprocal relationship with the land for centuries, using their fire knowledge to enhance biodiversity, maintain ecosystem health, and mitigate the risk of - and damages associated with - wildfires. Yet, colonization and the rise of fire-suppression policies worldwide hindered Indigenous Peoples' ability to use their knowledge and practice land stewardship. This, coupled with the effects of climate change, altered fire regimes and exacerbated the risk of wildfires in various territories across the globe. In light of increasingly frequent and destructive wildfires, there is now an intensifying call from scholars, emergency management professionals, international organizations, and governments to revitalize both IFK and, more broadly, Indigenous Fire Stewardship. This would result in the co-benefit of advancing Indigenous Peoples' Right to self-determination. After all, in mobilising IFK, Indigenous Peoples can ensure cultural continuity and secure economic opportunities by being active partners, or more preferably, leaders, in wildfire management.

Yet, this call to action is not being addressed quickly enough. Numerous barriers were identified in mobilising IFK, both in the Canadian context and in other countries. The document analysis reveals various challenges that Indigenous Peoples' experience as they revitalize their fire knowledge, including difficulties in bridging knowledge, mainstream society's negative perception of fire, policy and legal challenges, and resource constraints. However, solutions to combat such issues are proposed, such as changing mainstream society's perception of fire

through education, furthering Indigenous Rights to land and fire management, and promoting meaningful community participation in wildfire management that increases trust.

The examination of four case studies from international contexts demonstrates specific and effective avenues to promote IFK. These best practices emerge throughout the document analysis and serve as a reminder that even in face of numerous barriers, IFK can be successfully mobilised. Indigenous Peoples can be stewards of their lands, despite jurisdictional complexities and the dominating knowledge paradigm of WSK. Despite having no formal reserve land, the Karuk Tribe secured a co-stewardship role with the U.S forestry service. In collaboration with the Western Klamath Partnership, the Karuk Tribe mobilises their fire knowledge in modern forestry practices. In Australia, Indigenous-led Firesticks Alliance is providing training to Indigenous Peoples and partnering with governments to promote cultural burning throughout the nation. After having their lands be devastated by wildfires, the Secwépemc community is using a Two-Eyed Seeing Approach to restore their territory, exemplifying an approach to knowledge bridging that empowers Indigenous Peoples. As an approach to Integrated Fire Management, the Brazilian government is relying on Indigenous Fire Brigades to minimise wildfire risk. These case studies underscore that appropriate knowledge bridging and support for Indigenous led wildfire management initiatives further Indigenous Peoples' rights over the land and respect their right to cultural continuity.

These examples, paired with the document analysis, ultimately attest to the merit in mobilising IFK, both to minimize wildfire risk and maintain biodiversity, and to revitalize Indigenous Fire Stewardship. Three recommendations for mobilising IFK tailored to the Canadian context stem from the document analysis and case study examination. IFK should be mobilised

through 1) formal partnerships between Indigenous organizations/communities and government or not for profit organizations, 2) support for Indigenous-led, bottom up wildfire management initiatives, and 3) investments in education on IFK and accreditation for cultural burning.

Implications and Contribution to Knowledge

This paper reinforces what is actively being vocalized by Indigenous Peoples, scholars, international organizations, and various other entities – there is clear value in mobilising IFK, both from a risk reduction and climate change adaptation standpoint and from an Indigenous Rights perspective. The research builds upon the call to action to mobilise IFK through its examination of case studies from international contexts, which highlight effective mechanisms for IFK's mobilisation and reveal the barriers that continue to persist in this context. Importantly, the research demonstrates that there is no one direct path to mobilising IFK. Rather, avenues to enhancing Indigenous Fire Stewardship and IFK will vary based on numerous factors, such as a communities and organizations' capacity and resources, jurisdictional contexts, and respective self-determination goals. This paper also presents three feasible avenues toward greater mobilisation of IFK in Canada, a nation vulnerable to wildfire risk in which Indigenous populations bear the highest cost of such disasters. Overall, this research affirms that efforts to mobilise IK systems concurrently advance the broader cause of Indigenous rights to land stewardship and self-determination.

Limitations and Areas for Future Research

A limitation of this research is the depth of analysis applied to both the document analysis and case studies. Due to constraints in resources and time, the analysis is restricted to twenty documents and four case studies. Additionally, potential bias and subjectivity could impact the

findings. Although a blended coding strategy is employed to address these concerns, there remains a possibility that the researcher might unintentionally focus on documents that support existing hypotheses while overlooking contradictory evidence. Further research should explore how the impacts of climate change may threaten IFK systems, how IFK can be safeguarded from co-optation when partnerships between Indigenous organizations and government agencies are formed, and how IFK can be mobilised specifically in restoration efforts following wildfires.

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Appendix A. Addressing Second Reader Comments

Second reader comment	**How it was addressed**
"Change to IK rather than TK"	The term "Indigenous Knowledge" was used.
"Do we know anything about how IK has been used in other relevant disaster settings? Would also be important to define what 'disaster resilience' and 'wildfire preparedness' mean in the contexts you are looking at."	A current state of knowledge section was added to the proposal, discussing how Indigenous Knowledge has historically been used to mitigate the impacts of wildfires. Additionally, the term "resilience" was defined. The concept of "wildfire preparedness" did not emerge in the literature, so it was discarded.
"You also need to clarify the scale you are looking at - you're focusing on community-scale impacts/resilience, taking into account broader-scale factors/influences?"	The literature guided this paper in a slightly different direction. Rather than exploring how Indigenous Knowledge precisely enhances resilience to wildfires, the research question changed to, "what are the benefits of mobilising IFK?"
"Wildfires are not inherently disasters - they are natural processes that can cause disasters for humans - need to nuance this. On a related note, I've heard recently that some are switching from using 'natural disaster' language to 'climate-fuelled disaster' - maybe search for some literature on this."	The term 'natural disaster' was omitted. Instead, the research emphasizes how climate change exacerbates disasters.
"Choose a term - resilience or resiliency. There is a whole literature on resilience."	Resilience was chosen as a term.
"I'm wondering if you might use a mix of deductive and inductive. You'll have some terms that you are already clearly focusing on (e.g. those listed in bullet 1 below) - those are deductive. Then you'll have some that emerge from the data (those are inductive). Tim Cresswell's qualitative methods books are useful as sources. Braun and Clark's Thematic Analysis (or others by them) and Johnny Saldana's work on qualitative coding may be useful too."	A mix of deductive and inductive coding was ultimately used for the research.
"If there are only 3 cases being used, then tone down your title, which suggests you'll	The title was toned down.

look at cases all over the globe (rather just say something like ‘lessons from 3 international cases’).”	