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The 2023 wildfires in British Columbia, Canada: impacts, drivers, and transformations to coexist with wildfire

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Abstract

In 2023, all regions of British Columbia (BC) experienced record-breaking fire weather and wildfires, with extreme behavior and social-ecological effects. In total, 2245 wildfires burned 2840 545 hectares. Contemporary wildfires are the culmination of a century of altered human–forest–wildfire relationships, exacerbated by climate change. Transformative change is urgently needed for the ecosystems and communities to be resilient to wildfire. We present six interrelated strategies needed to amplify the pace and scale of change in response to recent wildfire extremes: (1) Immediately diversify wildfire response strategies and restore the ecological and cultural role of fire in BC's ecosystems. (2) Invest in suppression capacity at local and national scales. (3) Support innovations to overcome the economic barriers for mitigating risk and building resilience within communities and the wildland-urban interface. (4) Apply landscape fire management to drive a paradigm shift in forest management to increase ecological resilience to wildfire. (5) Transform wildfire governance to support collaborative and community-based solutions. (6) Strengthen expertise and capacity to uplift diverse ways of knowing, managing, and coexisting with fire. These strategies, combined with bold policy and governance changes and supported by sustained funding programs, provide a holistic approach to transform management and coexist with wildfire.

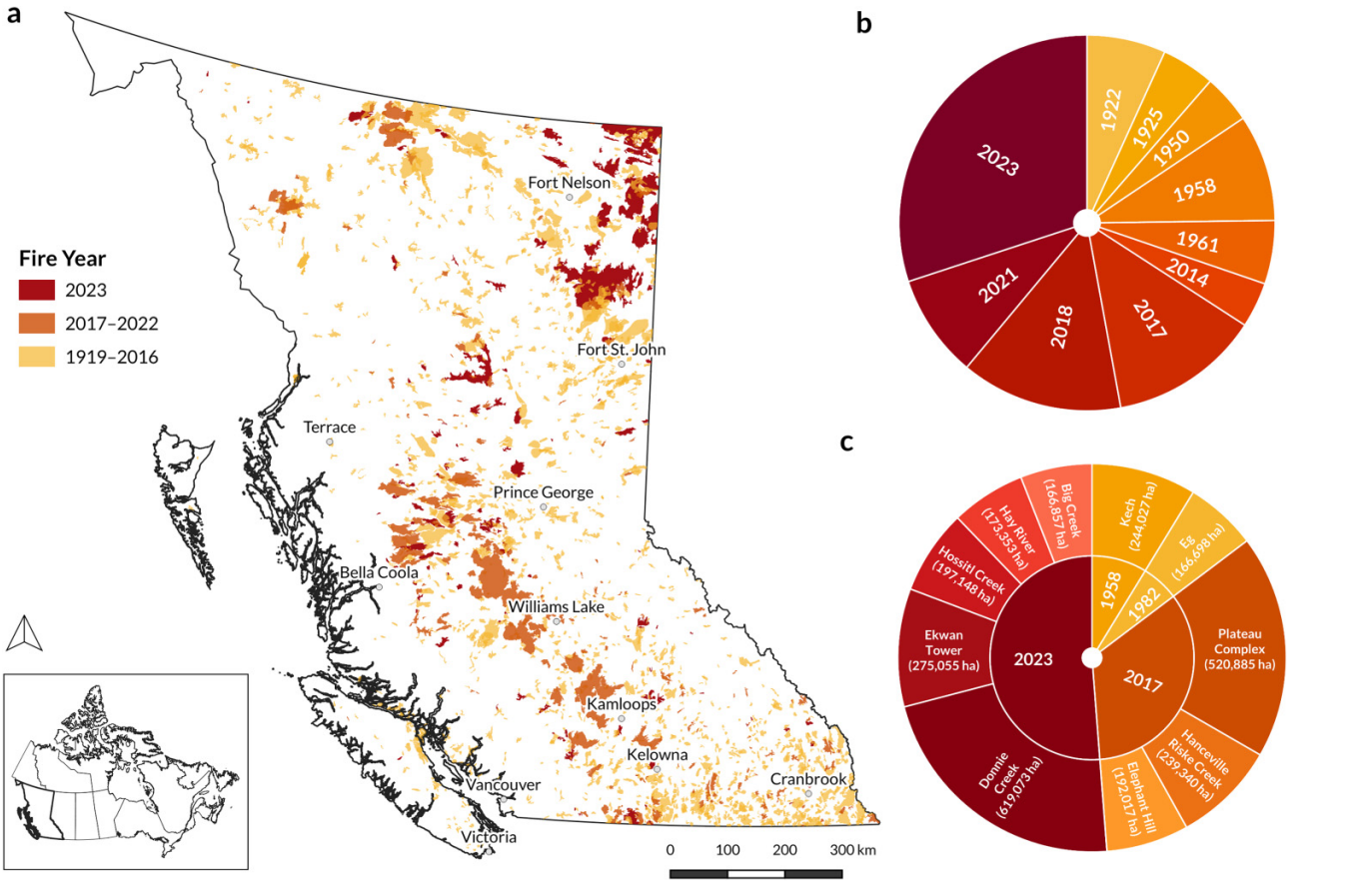
Key words: Indigenous fire stewardship, landscape fire management, fuel mitigation, paradigm shift, prescribed and cultural fire, resilience

Introduction

Wildfire is an essential ecological process and primary agent of disturbance across the diverse ecosystems of British Columbia (BC). From 2003 to 2022, an average of 1350 wildfires burned 284 000 hectares each year (Taylor et al. 2022; BC Wildfire Service 2023*a*). However, recent years have seen significant increases in the number and frequency of extreme wildfire events and fire seasons, with unprecedented ecological, social, and economic impacts (Baron et al. 2022; Hoffman et al. 2022*a*; Parisien et al. 2023).

In 2023, all regions of BC experienced record-breaking fire weather and wildfires that exhibited extreme behavior and effects. The fire season began early, with ignitions in northern boreal and subboreal forests and southern coastal temperate rainforests of BC starting in April and May. By July and August, at the peak of the fire season, 481 wildfires simultaneously burned throughout BC (BC Wildfire Service 2023). New ignitions across the province continued into October, and more than 100 wildfires were still classified as active at the end of December. Throughout the fire season, the majority of ignitions were caused by lightning (72%); 25% were human-caused and 3% remain undetermined (BC Wildfire Service 2023). In total, 2245 wildfires burned 2840 545 hectares (ha) of forests (Fig. 1)—more than twice the area-burned records set in 2017 (1215 685 ha) and 2018 (1355 271 ha) and ten-times the 20-year average (284 000 ha) (Fig. 1). Over 80% (2276 938 ha) of the total area burned was concentrated in north-eastern BC, where the Donnie Creek complex burned 619

Fig. 1. (*a*) Historical (1919–2016) and recent (2017–2023) wildfires (≥1000 ha) in British Columbia. (*b*) The ten largest fire seasons and (*c*) ten largest wildfire events since 1919, based on burned area in hectares. This figure was created using QGIS version 3.38.2 and assembled from the following data sources: historical fire perimeters and current fire perimeters (BC Wildfire Service 2023b; 2023c), Atlas of Canada populated places (Government of Canada 2014), provincial/territorial cartographic boundary file (Government of Canada 2016).



073 ha and set a new record for the largest wildfire recorded in BC (BC Wildfire Service 2023).

Sixty fires of note threatened public safety, resulting in 208 evacuation orders and requiring 48 000 people to leave their homes (BC Wildfire Service 2023). Another 386 evacuation alerts warned 137 000 people to leave, if necessary, with the largest evacuation alert affecting 1.5 million ha in northeastern BC. Many of these evacuation orders and alerts were issued in August and September, when extreme fire weather—superimposed on months of cumulative drought—caused multiple wildfires to spread rapidly and exhibit extreme behavior, triggering a 28-day provincial state of emergency. On 17 August, the McDougall Creek fire grew from 64 to 6800 hectares, spreading downslope 12 km through neighbourhoods of West Kelowna and the Westbank First Nation and spotting across Lake Okanagan to ignite new wildfires in Kelowna and Lake Country. On the same day, the Kookipi Creek fire grew by 2000 hectares, spotting across the Fraser River, closing the TransCanada Highway, and forcing evacuations from Boston Bar to Lytton. On 18 August, the Lower East Adams Lake and Bush Creek East fires merged, spreading 20 km in 12 h, also closing the TransCanada Highway, and forcing evacuations north and south of Shuswap Lake. Over these 48 h, societal impacts included the evacuation of 15 000 people and the loss of over 460 homes and businesses (BC Wildfire Service 2023). On 1 September, the Patry Creek fire spread more than 30 km, forcing evacuations north of Fort Nelson, closing the Liard Highway, and delaying evacuees returning home to Yellowknife, NWT. Similarly, on 22 September rapid spread and extreme behavior of the High Level fire simultaneously affected northeast BC and northwest Alberta.

With insured losses exceeding $720 million, the 2023 fire season in BC was the 10th most costly natural hazard related disaster in Canadian history (Weltman 2023). The 2023 fire season was also the most-costly in provincial history: the estimated cost for direct suppression is $817 million, with finalized costs expected to exceed $1 billion (BC Wildfire Service 2023). Tragically, the 2023 fire season was also unprecedented in terms of loss of life. Over the course of the 2023 fire season, six wildland firefighters were killed in BC, reflecting the unacceptable human cost of extreme fire seasons.

The 2023 fire season in BC was not an aberration; rather, it was a direct consequence of over 100 years of altered human–forest–wildfire relationships, exacerbated by climate change. The past 20 years have seen a distinct increasing

trend of escalating wildfire size, behavior, and ecological and socio-economic effects (Baron et al. 2022; Parisien et al. 2023). Twenty years ago, "Firestorm 2003" resulted in the most significant wildfires in the wildland–urban interface that British Columbians had experienced at the time, serving as a harbinger of fire seasons to come. The 2003 Okanagan Mountain Park (25 600 hectares) and McLure (26 420 hectares) wildfires forced 36 850 people to evacuate and burned 310 homes (BC Wildfire Service 2003). Since 2003, large and destructive wildfires have become increasingly common: the 2023 fire season was responsible for five of the ten largest wildfire events since 1919 in BC (Fig. 1). The four most impactful fire seasons on record have also occurred over the past eight years: 2017, 2018, 2021, and 2023, collectively burning 6.28 million hectares and costing more than $3 billion for suppression alone. The extensive ecological, social, and economic impacts have repeatedly demonstrated that the ecosystems, infrastructure, and communities in BC are not resilient to wildfire.

A holistic, landscape view of the wildfire problem and transformative changes to wildfire and forest management are urgently needed to achieve resilience to contemporary and future wildfires. Transformative change refers to fundamental, system-wide reorganization across technical, economic, and social factors (IPBES 2023). Transformation is a form of resilience that complements but is distinct from adaptation, which generally describes incremental changes (Folke 2016). While continued catastrophic fire seasons are forcing reactive and adaptive change, intentional transformative change responds to the broad and complex drivers and impacts inherent to wildfire. It is imperative that decision-making systems, planning and operations, and legal and policy frameworks are intentionally altered to support proactive wildfire management (Folke 2016). Transformative change has repeatedly been identified as a key need to support wildfire resilience in BC (Daniels et al. 2020; Copes-Gerbitz et al. 2022*a*, 2022*b*; Hoffman et al. 2022*b*).

In this perspective article, we have collaborated across disciplines and institutions to highlight the changes required to tackle the complex challenges posed by wildfire (e.g., Copes-Gerbitz et al. 2024). To understand the proximate and underlying drivers of extreme wildfires affecting BC, we first explore biophysical, social, and political factors. We then pose six interrelated strategies to proactively transform wildfire and forest management and achieve *wildfire coexistence*—recognizing that human and ecological communities must learn to live with wildfire at community and landscape scales.

Wildfire drivers

Wildfire activity is strongly influenced by weather, fuels, and ignitions. In a warmer world, the potential for wildfires increases due to the longer fire seasons, increases in extreme fire-conducive weather, and increased lightning activity (Baron et al. 2022; Hanes et al. 2019; Parisien et al. 2023). Increases in maximum temperatures and concurrent decreases in relative humidity cause vapour pressure deficits. Vapour pressure deficits are linked to prolonged droughts, which both dry fuels and support greater convection, leading to an increase in lightning activity and making it easier for wildfires to start and spread (Flannigan et al. 2016; Coogan et al. 2020; Kochtubajda and Burrows 2020). In BC, these climate change effects are superimposed on increasingly flammable and at-risk landscapes resulting from a century of fire suppression, exclusion of Indigenous fire stewardship practices, industrial land management (e.g., forestry, agriculture, and energy development), population growth, and urban expansion in fire-prone environments (Nitschke 2008; Baron et al. 2022; Parisien et al. 2023). Combined, these anthropogenic impacts drive larger, more frequent, and severe wildfires (Coops et al. 2018; Coogan et al. 2019) and contributed to the record-breaking 2023 wildfires that affected multiple forest types in BC.

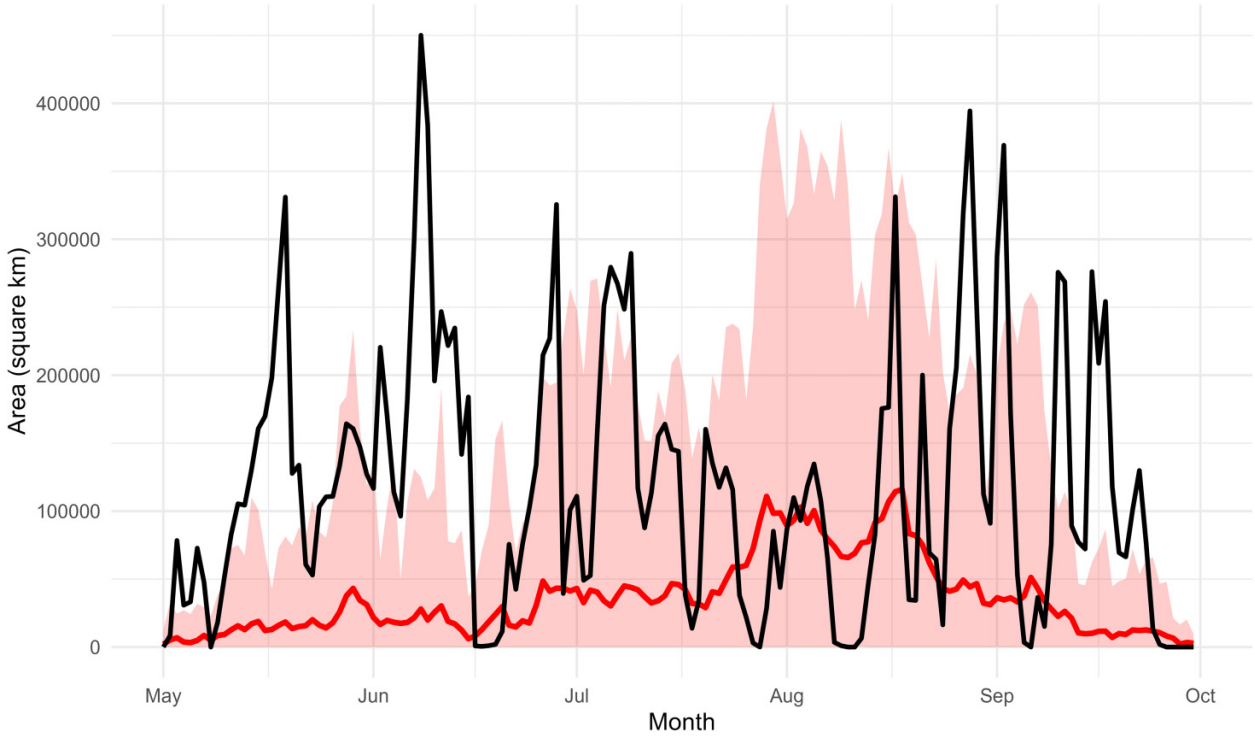
Biophysical drivers

Fire weather and climate change

Driven by climate change, extreme fire weather has been increasing over western North America, bringing warmer and drier conditions to BC during the fire season (Jain et al. 2022). Concurrently, there has been an abrupt increase in wildfire activity (Baron et al. 2022; Parisien et al. 2023), with more area burned in the last seven years (2017–2023) than the previous 58 years (1959–2016, Fig. 1). Kirchmeier-Young et al. (2019) directly attributed wildfires in 2017 to anthropogenic climate change, which made the extreme fire weather 2–4 times more likely and increased the area burned by a factor of 7–11. Strongly paralleling 2017, the 2023 fire season was primed by antecedent multi-year drought and below-average (88% of normal) snowpacks measured on 1 April 2023 over much of the province (BC Ministry of Forests 2023). Cumulatively, May through September were the warmest five consecutive months on record in BC, resulting in a summer temperature anomaly that was 2.1 °C above normal (Phillips 2024). Warm, dry conditions persisted through much of the summer, setting records in various locations across the province. For example, Kamloops, located in the southern interior, experienced daily maximum temperatures exceeding 30 °C on 62 days, almost twice the average of 33 days per summer, while rainfall was only 17% of normal (Phillips 2024). Drought levels across two-thirds of watersheds in BC triggered water restrictions and emergency responses (Phillips 2024; BC Water Management Branch 2023), while also increasing flammability of fire-prone landscapes. Associated with this heat, 170 000 lightning strikes (55% more than normal) were recorded in July (Phillips 2024), when the majority of the >1600 natural ignitions started in 2023 (BC Wildfire Service 2023).

These noteworthy climatic anomalies were reflected in the fire weather indices calculated throughout the 2023 fire season in BC (Figs. 2 and 3; see Supplemental Material for analytical methods). The fire weather index (FWI), which indicates fire danger in forested areas of Canada (Forestry Canada Fire Danger Group 1992), exceeded 95th percentiles over much of BC in May, June, and September, reflecting the early start and prolonged fire season (Fig. 2). Across most of the province, other fire weather indices had positive anomalies relative to 30-year means (1991–2020), signifying persistently

Fig. 2. Fire weather index (FWI) anomalies during the 2023 fire season in British Columbia. Total area exceeding the 95th percentiles of local FWI (black line), compared with the mean (red line) and 5th to 95th percentiles (red shade) values for 1991–2020.



dry fuels, elevated likelihood of wildfire ignition and spread, and cumulative drying of the duff and deep organic fuels—particularly in central and northeastern parts of the province (Fig. 3). The greatest anomalies of the daily severity rating (DSR), a numeric rating of the difficulty of controlling wildfires and expected effort for full suppression (Forestry Canada Fire Danger Group 1992), corresponded with the location of many of the largest and highest-impact wildfires of the 2023 season.

In general, 3% of wildfires in Canada account for 97% of area burned, and are concentrated during a relatively small number of hot, dry, windy days (Hanes et al. 2019; Wang et al. 2017; 2023). This trend is enhanced by climate change and was reflected during the 2023 fire season in BC. A related trend is the development of persistent positive anomalies in the upper atmosphere that are often associated with high-pressure blocking ridges, resulting in heat waves and extreme fire weather (Jain and Flannigan 2021; Sharma et al. 2022). Under these conditions, large wildfires burning >500 ha are seven times more likely in western North America (Sharma et al. 2022). The breakdown of these blocking ridges is also commonly associated with the passage of cold fronts that can result in aggressive fire behavior (Brotak and Reifsnyder 1977; Tymstra et al. 2021). In August 2023, the breakdown of a persistent upper-atmospheric ridge propelled strong, erratic winds that shifted direction as a cold front passed across BC. Simultaneously, multiple wildfires exhibited explosive growth and extreme behavior including long-range spotting of fire brands, formation of pyrocumulonimbus clouds, and fire whirls. The 2023 fire season in BC saw the formation of 51 pyrocumulonimbus events, breaking the previous Canadian record (David Peterson, personal communication).

Fire regimes and forest fuels

Across much of BC, current forest conditions and fuel loads largely reflect the disruption of historical fire regimes and the effects of extensive industrial forest management. Whereas high-severity disturbances dominate contemporary landscapes (e.g., large and severe wildfires or insect outbreaks and clearcut harvesting), the diverse ecosystems of BC were sustained by variable and complex historical disturbance regimes (Burton and Boulanger 2018; Hessburg et al. 2019), depicted in Fig. 4. Historical fire regimes strongly influenced biomass accumulation and supported stabilizing feedbacks that determined wildfire frequency and severity across multiple environmental gradients (e.g., elevation, latitude and continentality, Fig. 4*a*). And, across the diverse ecosystems of BC, Indigenous fire stewardship played a key role in creating patch mosaics of meadows, grasslands, and forests with varying composition, structure and age classes (Turner et al. 2000; Christianson 2015; Hoffman et al. 2022*a*; 2022*b*). In the driest ecosystems (e.g., leeside of Vancouver Island and southern interior of BC), warm dry summer weather is conducive to burning in most years. In these systems, mixed-severity fire regimes were historically dominated by frequent (return intervals <15 years), low-severity surface wildfires ig-

Fig. 3. Fire season (May to September) anomalies for fire weather indices illustrating pronounced drought and sustained high fire danger across BC in 2023. This figure was created using QGIS version 3.22.16 and assembled from the following data sources: Canadian Wildland Fire Information System calculated as in Jain et al. (2022) using ERA5 reanalysis data (Hersbach et al. 2020), provincial/territorial cartographic boundary file (Government of Canada 2016).

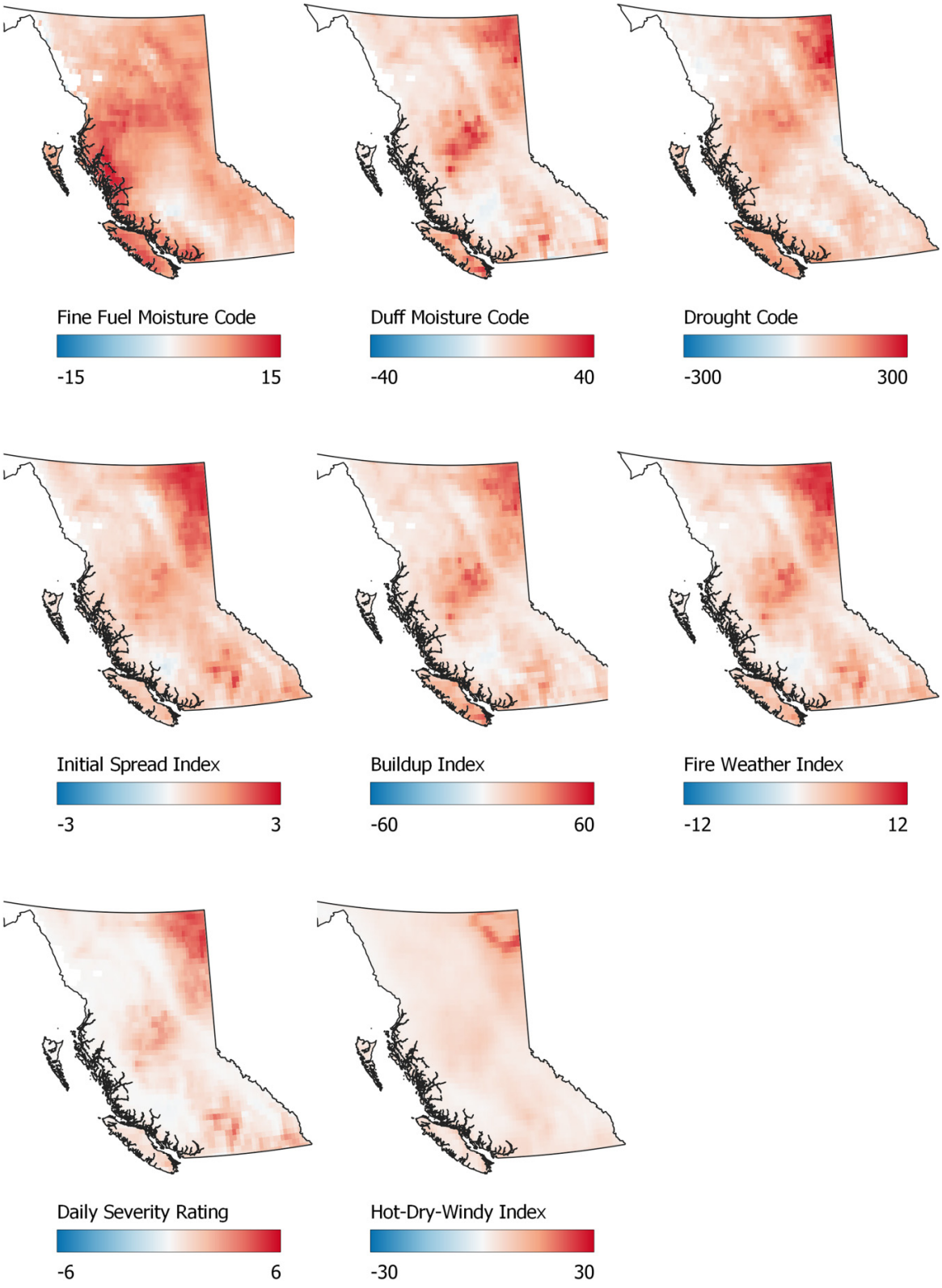
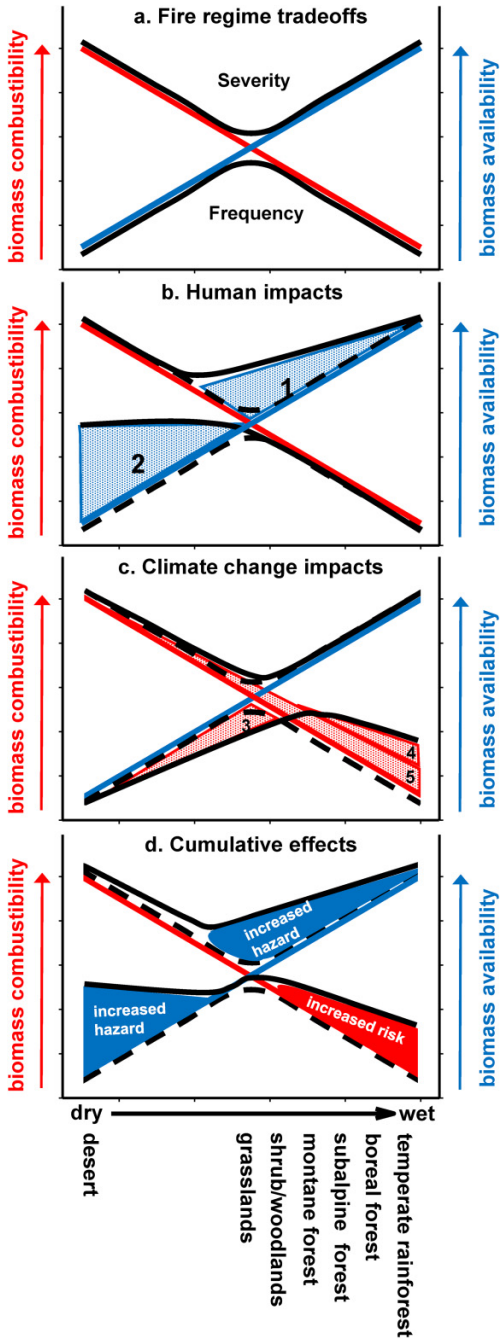


Fig. 4. Conceptual model of historical fire regimes and anthropogenic disruptors in temperate and boreal forests. Ecosystems in British Columbia include grasslands through temperate rainforests. (*a*) Fire severity and frequency vary across a moisture gradient. In dry environments, biomass availability limits wildfire; in wet environments, biomass combustibility is limiting. (*b*) Human impacts increase biomass availability by [1] excluding or suppressing wildfires so that woody fuels accumulate and landscapes homogenize and [2] introducing invasive grasses so that fine fuels are continuous. (*c*) Climate change is [3] decreasing productivity and biomass availability but [4] increasing mortality and [5] biomass combustibility, although effects vary with moisture. (*d*) The cumulative effects of humans and climate change increase fuel hazards across the moisture gradient and fire risk increases from intermediate to wet environments.



nited by Indigenous fire stewardship and augmented by lightning, which limited fuel accumulations while creating and maintaining grasslands and open forests (Heyerdahl et al. 2007, 2012; Pellatt and Gedalof 2014; Harvey et al. 2017; Brookes et al. 2021; Copes-Gerbitz et al. 2023). In contrast, wildfires in mesic forests were more climate-limited, as regional temperature, precipitation, and seasonality strongly influenced biomass combustibility (Fig. 4*a*). Subalpine, subboreal and boreal forests (e.g., high elevation in mountains and northern interior BC) had mixed-severity fire regimes dominated by large, moderate-to-high severity wildfires during seasonal drought in early spring through summer (Marcoux et al. 2013, 2015; Courtney Mustafi and Pisaric 2014; Brown et al. 2017; Leverkus et al. 2017). Higher-severity crown fires initiated conifer and mixed conifer-broadleaf forests in which surviving trees and island remnants provided habitat refugia and seed sources for regeneration (Andison and McCleary 2014; Krawchuk et al. 2016). In general, vegetation and fuels accumulated over long intervals of decades to centuries between infrequent higher-severity wildfires. Wet temperate rainforests (e.g., windward side of Vancouver Island and the mid- and north-coastal mainland) experienced the least wildfires, limited by the ocean-moderated climate and rare lightning (Gavin et al. 2003; Daniels and Gray 2006). Despite being the wettest forests in BC, these ecosystems were historically managed through Indigenous fire stewardship near settlement areas (Hoffman et al. 2016, 2017), and coastal forests did occasionally burn during pronounced droughts (Daniels and Gray 2006).

Across BC, contemporary fuel hazards and risk of extreme wildfires reflect anthropogenic impacts on historical fire regimes, combined with the effects of climate change (Fig. 4). Colonial disruption of Indigenous fire stewardship, followed by fire suppression, effectively eliminated all but the most extreme wildfires and created widespread fire deficits (Hagmann et al. 2021; Baron et al. 2022) (Fig. 4*b*). As a consequence of reduced wildfire occurrence in dry montane forests, trees encroached into grasslands and woodlands, ladder and surface fuels accumulated within stands, and forest landscapes have homogenized across elevational gradients (Chavardès and Daniels 2016; Brookes et al. 2021; Baron et al. 2022; Copes-Gerbitz et al. 2023). Concurrently, climate change has contributed to increased tree mortality and biomass combustibility during amplified summer droughts (Fig. 4*c*). For example, a legacy of the mountain pine beetle epidemic is 18.3 million hectares of forest with various proportions of dead lodgepole pine (Government of British Columbia 2021), which has contributed to amplified fire behavior and effects at the stand-level (Talucci et al. 2022; Romualdi et al. 2023; Woo et al. 2024). As well, there is growing concern about decreased productivity and delayed post-fire regeneration due to acute or prolonged droughts, potentially indicating state changes from forest to grasslands or shrublands—as documented in the western United States (Stevens-Rumann et al. 2022).

High fire risk across much of BC (BC Wildfire Service 2021) is also partly the result of extensive industrial forest management focused on stand-level sustained-yield timber harvesting and salvage logging after wildfires and insect out-

breaks (Leverkus et al. 2021; Forest Practices Board 2023*a*; Sutherland et al. 2023). The misconception that high-severity fires burn at intervals of 100 to 350 years in most forests (e.g., Natural Disturbance Type classification in BC Ministry of Forests and Ministry of Environment Lands and Parks 1995) has justified stand-level even-aged silviculture across the timber harvesting land base of BC (e.g., 22 million hectares in which harvesting is legal), simplified landscape age-class distributions, and enabled widespread fire suppression (Daniels et al. 2020). After harvesting, abundant logging residues persist in the absence of broadcast burning, a silvicultural practice that was virtually eliminated in BC in the mid-1990s (Hoffman et al. 2022*b*). A recent analysis of logging residues across forest types in BC found that 7%–26% of merchantable volume was left in cut areas, in addition to non-merchantable tops, branches, and foliage (Nance 2023). Of the total residue generated during harvesting, 20%–31% was dispersed in cut areas, while the corresponding 69%–80% was piled at the roadside. In coastal forests, 15% of roadside slash piles were burned and the remaining 85% were left to decompose, while 59% of slash piles in interior forests were burned (Nance 2023). Logging residues connect high surface fuel loads across stands, even where canopy fuels have been fragmented by harvesting, so that harvested areas contribute to wildfire spread and severity rather than serving as fuel breaks (Baron et al. 2024). Reforestation with preferred conifer species, including densely planted lodgepole pine monocultures, and brushing or spraying herbicides to limit broadleaved shrubs and trees, further removes natural fuel breaks and heterogeneity from the landscape (Hessburg et al. 2019; Forest Practices Board 2023*a*; Sutherland et al. 2023). Strategies that increase planting densities to sequester carbon in the short-term can increase drought vulnerability and further predispose forest to burn at high severity under a warming climate (Prichard et al. 2021). Cumulatively, these stand-level effects and a lack of planning at the landscape scale have decreased ecosystem resilience to wildfire (Hessburg et al. 2019; Hagmann et al. 2021; Forest Practices Board 2023*a*).

Socio-political drivers

Wildfire risk and the wildland–urban interface

Changes in stand-to-landscape forest and fuel structures are indirectly reflected in the provincial strategic threat analysis of public lands (also called "Crown" lands) that account for c. 95% of the total area of BC (BC Wildfire Service 2021). In 2021, 45% of public lands was classified at high risk of wildfire and another 28% was at moderate risk, particularly in the central and southern interior of BC (Forest Practices Board 2023*a*). Although privately-owned values at risk, including homes, infrastructure, and some large land holdings, are not included in this provincial assessment, almost half of the 203 First Nations, 161 municipalities, and numerous unincorporated communities across the 28 regional districts situated within 2 km of wildlands are embedded in these flammable landscapes (BC Climate Action Secretariate 2019; Taylor et al. 2022). Across the province, 5.5 million hectares is classified as interface with urban areas (Johnston and Flannigan 2018) and is increasing, given population growth in many fire-prone areas in southern BC (BC Stats 2024). Another 1.7 and 17.6 million hectares form the interface with industrial areas and critical infrastructure such as highways, railways, pipelines, electricity and communication corridors (Johnston and Flannigan 2018). Moreover, an average of 40% of annual ignitions are caused by human activity, concentrated around human communities and transportation corridors (Taylor et al. 2022; Coogan et al. 2020).

BC was an early adopter of FireSmart™ principles at the community level (Filmon 2004); however, proactive mitigation of hazardous fuels in the wildland-urban interface (WUI) and adjacent landscapes has not matched the pace and scale of wildfire impacts (Forest Practices Board 2015, 2023*a*; Daniels et al. 2020). Between 2003 and 2023, $300 million CAD of provincial funds were invested to implement fuel mitigation treatments on 40 000 hectares. In stark contrast, BC has spent over $6 billion CAD on suppression, with indirect costs associated with evacuations, economic disruption, rebuilding and recovery, and health impacts in the tens of billions of dollars (Daniels et al. 2020; Taylor et al. 2022; Forest Practices Board 2023*a*). Given limited funds, treatments have been prioritized in the hottest, driest parts of the province and where structure density and property values are highest. This approach has left many smaller, rural communities, especially First Nations communities, with very little funding to support fuel mitigation and to protect values such as watersheds, biodiversity and traditional use sites (Copes-Gerbitz et al. 2022*b*).

Although recent fire seasons have increased perception and concern over wildfire risk throughout BC (Dickson-Hoyle et al. 2023), limited capacity in smaller and rural communities, inadequate funding, and the high costs of fuel treatments are persistent barriers that impede progress (Copes-Gerbitz et al. 2022*b*). Ultimately, the overwhelming emphasis and disproportionate expenditure on reactive suppression response and recovery efforts and inadequate investment in proactive wildfire management remains a primary limitation (Taylor et al. 2022). Simultaneously, climate change is decreasing the effectiveness of fire suppression (Flannigan et al. 2016; Wotton et al. 2017) and will likely make suppression more expensive in the future (Hope et al. 2016). Climate change further contributes to multiple interacting hazards, such as the 2021 heat dome, wildfires, and floods, greatly exacerbating costs (Taylor et al. 2022; Forest Practices Board 2023*a*).

Governance and management

Governance and management of wildfires, forests, and climate change, including authority, decision-making power, and prioritization of knowledge, influence the growing impacts of recent catastrophic wildfires (Copes-Gerbitz et al. 2022*a*). On provincial public lands, formal mandates rest with the BC Wildfire Service for wildfire management, the Ministry of Forests for forest management, and the Ministry of Emergency and Climate Readiness for emergency and disaster management. This siloed framework results in disconnected governance processes and priorities. For example, for-

est management decisions, such as how to harvest and what species to replant, largely have not considered impacts on fire behavior and effects. Furthermore, the highly regulated and hierarchical structures of wildfire and emergency response, and associated requirements for formal accreditation and privileging of professional-technical expertise, also limit opportunities for leadership and input from local or First Nation communities (Hoffman et al. 2022*a*).

Communities have an important role to play in proactively mitigating risk and contributing to disaster resilience (SFU Mitigating Wildfire Initiative 2023). To date, however, the focus on shared responsibility and wildfire risk reduction has emphasized community responsibilities for wildfire prevention, preparedness, and mitigation, without adequate funding, administrative supports or other resourcing, while restricting the ability of communities to participate in wildfire response or suppression (Copes-Gerbitz et al. 2022*b*). This governance structure also imposes Provincial decision-making authority over Indigenous governance, sovereignty and jurisdiction that extends throughout traditional territories (Borrows 2017; Caverley et al. 2019). First Nations have repeatedly called for additional support while demonstrating leadership in addressing wildfire risk and setting priorities specific to their needs (First Nations Leadership Council 2024). Recent shifts toward empowering local-scale decisions include opportunities for First Nations and rural communities to have greater decision-making authority, such as through the BC Community Forest license (Dickson-Hoyle et al. 2023). However, local actions remain embedded in and operate under Provincial requirements that can constrain innovation and privilege certain communities over others (Hoffman et al. 2022*a*; Copes-Gerbitz et al. 2022*b*).

Strategies to coexist with wildfire

Over the past 20 years, numerous reports and inquiries into wildfires in BC have highlighted the need to diversify wildfire management and improve planning, prevention, mitigation, and preparedness (Filmon 2004; Forest Practices Board 2015; 2023*a*; Abbott and Chapman 2018), with the responsibility to reduce wildfire risk shared among multiple levels of government, including local communities and First Nations (Public Safety Canada 2019; Taylor et al. 2022). In 2018, the Province of BC adopted the United Nations Sendai Framework for Disaster Risk Reduction, which recognizes the importance of building a diverse, inclusive, all-of-society approach for managing risk (United Nations 2015). Positive change has been incremental, but is not keeping pace with the impacts of escalating wildfires in BC. Transformative change is urgently needed to address the socio-ecological impacts of contemporary wildfires and to enable our society to coexist with future wildfires.

Coexisting with wildfire represents a transformational shift in understanding of the ecological, cultural, and social benefits, in addition to costs, of wildfire. It encompasses a paradigm shift away from the dominant command-and-control approaches toward shared decision-making focused on restoration of wildfire as a vital ecosystem process and Indigenous cultural practice, as well as proactive management to decrease risk and increase community resilience in fire-prone landscapes (McWethy et al. 2019; Tedim et al. 2019). Coexisting with wildfire requires recognizing and strengthening the diverse knowledges, capacities, and social relationships that contribute to community resilience, while providing adequate funding, resources, and policy frameworks to support local communities, First Nations and land managers in proactively managing wildfire risk.

Building on the lessons learned over the past 20 years in BC, we pose six interrelated strategies for transforming management and supporting coexistence with wildfire. First, we emphasize the immediate need to diversify wildfire response strategies and restore the ecological and cultural role of fire in BC's ecosystems (Strategy 1), while simultaneously investing in suppression capacity at local and national scales (Strategy 2). We then highlight progress and priorities for mitigating risk and building resilience within communities and the WUI (Strategy 3), before scaling up to the landscape level, presenting the concept of landscape fire management and how this can be applied in the context of forest management to increase ecological resilience to wildfire (Strategy 4). Next, we identify the need for transforming wildfire governance to support collaborative and community-based strategies (Strategy 5). Finally, we underscore the need to strengthen and diversify expertise and capacities to uplift diverse ways of knowing, managing, and coexisting with wildfire (Strategy 6).

Strategy 1: diversify wildfire response and restore prescribed and cultural fire

Coexisting with wildfire requires transformation from suppression-focused models of management toward diversifying wildfire response and management across BC's landscapes. Over recent decades, annual area burned in BC was strongly limited by suppression, as 92% of wildfires were suppressed before reaching 4 ha in size under a mandate to protect people, property, and natural resources (BC Wildfire Management Branch 2012). Although short-term benefits were achieved, the long-term, unintended consequences included the fuels accumulation and homogenization across landscapes that contribute to increasingly large and severe wildfires (Baron et al. 2022; Forest Practices Board 2023*a*; Parisien et al. 2023). Ironically, past success underlies societal expectations for immediate suppression and reinforces negative perceptions of wildfire. For most British Columbians, first-hand experiences have been limited to the 8% of wildfires that escaped suppression, often during extreme fire weather, and caused significant social-ecological impacts. Overcoming this observational bias and allowing the reintroduction of fire to these landscapes is critical to avoid the perpetuation of the fire suppression paradox (Kreider et al. 2024).

Diversifying wildfire response in BC requires the consideration of multiple operational response approaches, as opposed to full suppression by default. In 2012, the mandate for wildfire management in BC expanded to encourage sustainable, healthy, and resilient ecosystems in addition to protecting human life and values (BC Wildfire Management Branch 2012). A shift to risk-based appropriate response allows a

spectrum of operational responses to ignitions that pose low risk to life, property, or critical infrastructure (Tymstra et al. 2020). Modified response or managed wildfire has been increasingly promoted in the literature as a tool to address fuel and forest management objectives, particularly in remote and rugged areas with reduced accessibility (Prichard et al. 2021; Stephens et al. 2016; Huffman et al. 2020). Managed wildfires that are allowed to burn in designated locations and under prescribed weather and fuel conditions (in contrast with wildfires that are not suppressed during peak fire weather conditions because resources are limited), tend to be smaller in size and include more low- and moderate-burn severity patches and smaller high-severity patches (Parks 2014, Stevens et al. 2017). Managed wildfires can serve as a cost-effective tool to restore ecosystem resilience, diversify forests, create natural fuel breaks, and lower risk of subsequent uncontrollable wildfires (Huffman et al. 2020; Prichard et al. 2021); however, additional work is needed to understand the range of fuel and fire weather conditions in BC that are conducive to a managed wildfire response. Expanding applications of managed wildfire, and its associated proactive planning for multiple values and objects, is needed to support the ambitious pace and scale of landscape fire management targets (Strategy 4). For example, potential fire suppression and mitigation cost savings associated with managed wildfire can be in the tens of millions of dollars (Houtman et al. 2013) and can help restore forest resilience at landscape scales (Barros et al. 2018).

In addition to diversifying wildfire response, we identify the need to reintroduce fire as a process through the restoration of prescribed and cultural fire. When used safely, prescribed fire and cultural burning are effective fuel reduction tools, providing significant benefits to restore fire-dependent ecosystems and protect human communities (Leverkus et al. 2017; Lake and Christianson 2019; Prichard et al. 2021). Although silvicultural broadcast burning was once widespread, it was replaced by pile burning at landings in the mid-1990s, leaving behind remnant surface fuels (Hoffman et al. 2022*b*; Baron et al. 2024). Despite well-documented benefits, the province has been slow to reimplement prescribed fire due to limited capacity, opportunities for training and certification, and liability concerns (Hoffman et al. 2022*b*; Forest Practices Board 2023*a*). A new provincial Prescribed and Cultural Fire Program, led by BC Wildfire Service, aims to expand the use of prescribed fire and support Indigenous-led revitalization of cultural burning: the intentional use of fire differentiated from prescribed fire by its distinct cultural objectives, techniques, and community governance and participation (Lake and Christianson 2019; Hoffman et al. 2022*a*). In 2022, the First Nations Emergency Service Society launched an On-reserve Cultural and Prescribed Fire Revitalization program to address the unique needs of First Nations communities, providing support to identify logical cultural or prescribed fire units, develop burn plans, and conduct burns (FNESS 2023). However, persistent power imbalances associated with provincial wildfire governance structures, such as the requirements for government-issued permits for cultural burning off-reserve, continue to pose a barrier to Indigenous-led fire stewardship (Hoffman et al. 2022*a*). Addressing these barriers, while strengthening diverse local partnership models and processes of Indigenous-led fire stewardship, are key pathways to restoring fire as an ecological and cultural process in BC.

Strategy 2: increase capacity for suppression response

Although fire is an important ecological and cultural process, wildfires that threaten lives, communities, and critical infrastructure continue to require a full suppression response. However, suppression resources have proven insufficient during periods of extreme fire weather, particularly when lightning outbreaks ignite dozens of fires in rapid succession that threaten public safety at multiple locations across the province simultaneously. In 2023, the BC Wildfire Service relied on a combination of agency and private-sector fire suppression resources, supplemented by personnel from 13 other countries and the Canadian Armed Forces (BC Wildfire Service 2023). Options to enhance support for fire management agencies include national and local strategies. A federal emergency management agency has been proposed to augment existing capacity during extreme conditions. Supported by an enhanced early-warning system to predict when and where extreme fire weather and potential ignitions may occur, national resources can be mobilized when rapid full suppression may prevent wildfire disasters from developing. This early-warning system would use machine learning (Jain et al. 2020) and would be part of a broader risk approach that incorporates response decisions, mitigation opportunities, and land management objectives (Dunn et al. 2020).

Investment in local response capacity offers multiple benefits, while engaging local communities and First Nations that are increasingly calling for and demonstrating greater involvement in emergency and wildfire response (Abbott and Chapman 2018). Wildfire management organizations have increasingly relied on centralized decision-making models to allocate provincial resources to respond to incidents and meet excessive demand by employing resources from other jurisdictions, which overlooks local knowledge and capacity to both respond to wildfires and set management objectives (Nikolakis and Roberts 2022). Building local capacity, rather than relying on out-of-province or out-of-country suppression crews, benefits from local land-based experience and ensures consideration of Indigenous knowledge, jurisdiction, territories, and coordination protocols (Sharp and Krebs 2018; Verhaeghe et al. 2019; Dickson-Hoyle and John 2021). Investing in local capacity provides an opportunity for improved integration of suppression response with emergency planning and proactive fuels mitigation, which are the responsibility of local governments or First Nations in BC (Sharp and Krebs 2018; Verhaeghe et al. 2019; Dickson-Hoyle and John 2021; Copes-Gerbitz and Comeau 2023). Pivoting to explicitly link expertise in wildfire response with proactive mitigation would bolster the suppression workforce during the fire season, while providing local employment to plan, prepare, and implement prescriptions to treat hazardous fuels during the rest of the year. Stable, potentially year-round, career oppor-

tunities that pay a livable wage would provide individuals and companies the security to invest in the equipment and innovation needed to transform suppression response (Copes-Gerbitz and Comeau 2023).

Building, incorporating, and supporting local capacity may also help alleviate mistrust in government agencies (Sharp et al. 2013) and address the perceived need for self-reliance (Dickson-Hoyle and John 2021), which result from negative experiences during evacuations, lack of engagement during past wildfires, and perceptions that government is not fixing the problem (McGee et al. 2021). Such perceptions have increased in BC, with many residents defying evacuation orders to defend their homes and communities. Minimizing future conflicts requires understanding peoples' motivations, values, and existing knowledge and capacities (Kruger and Beilin 2014; Dickson-Hoyle and John 2021), as well as exploring pathways for enhancing and coordinating local response capacity (Copes-Gerbitz and Comeau 2023). This is a topic under continued development, which opens important opportunities to connect to community-led prevention and preparedness activities across the province.

Strategy 3: mitigate risk and build resilience in communities

Catalyzed by the 2003 fire season, wildfire risk reduction in BC initially focused on developing community-level wildfire plans and conducting fuel hazard reduction ("fuel treatments") in the WUI (Filmon 2004; BC Government 2012). Provincial funding programs have evolved over 20 years, starting with a focus on community planning and evolving to more broadly include the FireSmart™ disciplines of education, vegetation management (including fuel treatments), legislation and planning, development considerations, interagency cooperation, cross-training, and emergency planning (UBCM 2020). Since 2018, the Community Resiliency Investment Program funds local authorities, including First Nations, to develop a Community Wildfire Resilience Plan and deliver FireSmart™ activities at homeowner, neighbourhood, and community levels (FireSmart BC 2023). Funding for larger-scale projects on public land are delivered by the Forest Enhancement Society of BC and the Wildfire Risk Reduction Program, administered by the local Natural Resource Districts of the Ministry of Forests.

The provincial FireSmart™ BC program, established in 2017 and directed by the BC FireSmart Committee (FireSmart BC 2021), is based on the national model to educate and advocate proactive measures for reducing hazards and mitigating wildfire risk (Bénichou et al. 2021). In BC, homeowners, neighborhoods, and communities can gain FireSmart™ recognition status, receive grants for education campaigns, and enlist local representatives to conduct local wildfire risk assessments and identify solutions for mitigating risk (FireSmart BC 2021). An engaging and informative public education campaign promotes homeowner actions to reduce susceptibility to wildfire through home maintenance, landscaping, design, and construction. For individual homes, research has shown a $14–$32 CAD return on investment for retrofitting and a $34–$93 CAD return for new construction that incorporates ignition-resistant building materials and vegetation (Porter et al. 2021). As an incentive, local wildfire management bylaws that regulate construction of new residential development (e.g., City of Nelson 2013) are an effective, although underutilized, tactic for mitigating risk (Kovacs 2018).

In addition to housing and community design considerations, fuel treatments around communities are designed to reduce vegetation fuel load in the forest to diminish aggressive fire behavior and effects (Abbott and Chapman 2018). Across BC, the diversity of forest types, historical disturbance regimes, and contemporary land management practices necessitate that treatments be ecosystem-specific. For example, to reduce crown fire behavior and spread rates in the seasonally-dry mixed-conifer forests of south-central British Columbia, fuel reduction treatments involving mechanical thinning and removal of residual biomass have been shown to be highly effective (Prichard et al. 2010; Kalies and Yocom Kent 2016; Rutherford 2023), but may be further enhanced by prescribed broadcast burning (Stephens et al. 2012; Prichard et al. 2021). Additional research is needed to understand how fuel treatments interact with suppression efforts across all forest types, particularly in coastal and boreal forests (Beverly et al. 2020; Thompson et al. 2020).

Implementing fuel treatments at the scale needed requires investment and innovation to overcome multiple economic barriers. Currently, high costs associated with planning and implementing treatments, including transportation costs to centralized infrastructure, result in a median cost for fuel mitigation of $5000 per ha (Forest Practices Board 2015) or an estimated $3.425 billion to treat 685 000 ha of WUI classified as high to extreme hazard (Daniels et al. 2020). To remove large quantities of low-value unmerchantable biomass requires rethinking existing approaches to enable cost recovery. Opportunities for innovation include harvesting technologies, engineered wood products, and market infrastructure for small-diameter stems and biomass. Innovations in bioenergy and the bioeconomy sectors have tremendous untapped potential to address this challenge in BC. For example, the Esk'etemc First Nation has demonstrated the viability of contributing biomass from treatments to produce heat energy for local use (Forest Practices Board 2023*a*). The viability of bioenergy systems is influenced by various factors, including the type of biomass and costs for extraction, comminution, and transportation. To achieve cost reduction, meticulous supply chain planning is required, along with the effective integration of equipment tailored to specific forest conditions (Spinelli and Magagnotti 2010; Röser et al. 2011; Ghaffariyan et al. 2017). Nevertheless, a scaled-up program linking fuel treatments with bioenergy production for remote communities, many of which currently depend on fossil fuels, offers a model for simultaneously mitigating wildfire risk, achieving emission reductions through substitution of fossil fuels (Blanco et al. 2015; Smyth et al. 2017), and creating much needed employment in rural communities across British Columbia.

Proactively mitigating wildfire risk to communities also requires multi-year funding and resourcing, including provision of technical expertise and administrative support. This is especially important for small and remote communities

who face persistent barriers to accessing funding and implementing risk reduction activities (Copes-Gerbitz et al. 2022*b*). The First Nations Emergency Service Society has been instrumental for accessing both federal and provincial funding to facilitate plans and treatments on First Nations reserves. Similarly, Community Forests, an area-based forest tenure held by local governments, First Nations, and/or community groups, have emerged as leaders in proactive wildfire management responsive to local values and needs, including by applying for funding, developing partnerships across levels of government and with diverse stakeholders, and providing forestry and wildfire-related expertise (Devisscher et al. 2021; Dickson-Hoyle et al. 2023). Local and regional wildfire planning organizations, such as the Mackenzie Wildfire Advisory Committee and the Williams Lake and Area Community Wildfire Roundtable, provide another grassroots mechanism for building capacity and coordinating wildfire risk reduction across scales. These local networks and social relationships are critical for supporting community resilience to wildfire — the ability of communities to navigate change and uncertainty in the face of wildfire evacuations and impacts, while maintaining key social processes and structures (Duit et al. 2010).

Strategy 4: implement landscape fire management

Landscape fire management seeks to reduce potentially irreversible negative consequences of catastrophic wildfires by reintroducing fire as an ecological process and restoring ecosystem resilience to disturbance (Hessburg et al. 2019). Across the timber harvesting land base of BC, patchworks of dense, even-aged conifer forests are a legacy of landscape-level departures from historical fire regimes (Hessburg et al. 2019). To reverse the cumulative negative impacts of the last century and adapt to future climates, active management interventions should reduce fuel accumulations, increase landscape heterogeneity, and create barriers to wildfire spread (Prichard et al. 2021; Forest Practices Board 2023*a*, 2023*b*). Restoring the stabilizing feedbacks that enable resilience to disturbance will require transitioning contemporary landscapes back toward diverse mosaics of conifer, broadleaf, and mixed-wood forests with closed and open canopies, intermixed with restored non-forest woodlands, grasslands, wetlands and meadows (Hessburg et al. 2019; Povak et al. 2023). The reconfiguration of landscapes must reflect the dynamic nature of ecosystems and the ephemeral nature of fuel reduction treatments, and be tailored to align treatments with explicitly identified values. Regional-scale fire regime attributes provide an ecological framework for landscape planning and treatments (Hessburg et al. 2015). Spatially, the boundaries of firesheds, areas in which ignitions are likely to spread and be contained, and treatment units within firesheds should align with topoedaphic features that govern fire behavior and effects (Thompson et al. 2013, 2015; Dunn et al. 2020).

From its inception, proactive wildfire management in BC was intended to include landscape fire management planning to create fire-adapted communities and fire-resilient ecosystems (Filmon 2004). Despite growing recognition of the need to manage wildfire at the landscape level (Forest Practice Board 2023*a*, 2023*b*), provincial investments in proactive management have been primarily restricted to public and private lands in the wildland-urban interface. As a consequence, the current pace and scale of treatments is insufficient relative to the extent of communities and ecosystems exposed to wildfire hazard across BC. Given the extent of BC forests managed by licensees for industrial timber harvesting (22 million ha) and the rural communities directly embedded in these managed forests (BC Ministry of Forests 2021), there is also increasing recognition that forestry and wildfire management are inextricably linked and that status quo is neither sustainable nor effective at reducing wildfire risk (Copes-Gerbitz et al. 2022*b*). Thus, in addition to diversifying wildfire response and restoring prescribed and cultural fire (Strategy 1) and scaling the implementation of fuel reduction treatments (where appropriate) to the landscape level (Strategy 3), forest management in BC must be transformed in order to implement landscape fire management and restore ecological resilience to disturbance (Forest Practices Board 2023*a*).

To achieve landscape resilience to wildfire will require fundamental shifts to forest management in BC (Daniels et al. 2020; Forest Practices Board 2023*a*). We propose a two-step approach: (i) take immediate actions to ensure that ongoing management does not exacerbate wildfire risk; (ii) facilitate long-term programs to restore landscape resilience and transform the forestry sector in BC. Within this general framework, specific management actions must actively address legacies of historical forest management decisions that constrain opportunities for transformative change (Sutherland et al., 2023). Broad strategies to increase resilience to wildfire across all stages of ecological succession including (but are not limited to): diversifying silviculture to prioritize uneven-aged systems; augmenting pile burning at landings with low-severity broadcast burning; evaluating the need for post-fire fuel reduction and planting (Collins et al. 2018; Whitman et al. 2019; Clason et al. 2022; Hoecker and Turner 2022); promoting naturally regenerating broadleaved trees (DeRose and Leffler 2014; Nesbit et al. 2023); and, thinning to improve resistance of maturing stands (Forest Practice Board 2023*a*; 2023*b*). Multi-decadal management schedules must also maintain uneven-aged forests with low fuel loads in strategic locations that can modulate wildfire behavior and intensity well beyond the WUI (Smith et al. 2016; Bowman et al. 2020; Prichard et al. 2021). Several initiatives are underway in BC to explore the optimal implementation of these strategies (e.g., Silviculture Innovation Program, Interior Broadleaf Working Group) and the required amendments to policy and regulations to operationalize them.

Substantive changes to forest management are required to restore and sustain landscape resilience to wildfire. Recent amendments to the BC Forest and Range Practices Act emphasize forest landscape planning and incorporate a new objective for preventing, mitigating, and adapting to impacts of forest disturbances, including wildfire (Forest Practices Board 2023*a*). To succeed, we reiterate the need to explicitly plan for the role of fire as an ecological process, at present and in the future, as the foundation of all future resource planning through collaborative processes. Concurrent with the

planning process, target-based management goals that address wildfire risk to local values, and conversely the benefits of restoring altered fire regimes, should be implemented immediately. Although forestry values have historically motivated land management decisions in BC (Copes-Gerbitz et al. 2022*b*; Sutherland et al. 2023), landscape fire management should broadly engage the whole-of-society to reflect underrepresented but critical perspectives. These changes will impose short-term costs and require investments from multiple levels of government to support necessary innovation and diversification, transforming the current approach in BC to implement landscape fire management at scale.

Strategy 5: transform wildfire governance

Addressing the complex wildfire challenge and supporting landscape fire management in BC requires transforming wildfire governance to bridge institutional silos and improve coordination, collaboration, and decision-making across multiple scales (Copes-Gerbitz et al. 2022*b*; SFU Mitigating Wildfire Initiative 2024). Recent wildfire seasons in BC have highlighted the need to shift away from top-down, largely centralized wildfire governance and to empower local decision-makers throughout all phases of wildfire prevention, preparedness, response and recovery (Abbott and Chapman 2018; Copes-Gerbitz and Comeau 2023; Dickson-Hoyle et al. 2023). First Nations and rural communities are increasingly advocating for local, place-based governance solutions (Labossière and McGee 2017; Sharp and Krebs 2018; Verhaeghe et al. 2019; Dickson-Hoyle et al. 2021; McGee et al. 2021; Nikolakis and Roberts 2022; Hoffman et al. 2022*a*; Whitehead 2023). These shifts toward local and collaborative wildfire governance and true partnerships with First Nations require understanding local needs and priorities to ensure equitable sharing of both power and resources and to avoid simply shifting risk and responsibility for prevention and preparedness to local communities (Abbott and Chapman 2018).

Sustained changes in wildfire governance and management are integrally linked to BC's Declaration on the Rights of Indigenous Peoples Act, which establishes the United Nations Declaration on the Rights of Indigenous Peoples as the framework for reconciliation (BC Government 2019). Unlike other parts of Canada, most of BC is unceded land, as treaties were not signed with First Nations. Proposed amendments to the BC Land Act define shared decision-making between the province and First Nations over the use of public land in their territories (BC Government 2024). BC's recent Emergency and Disaster Management Act established coordination agreements as a model to enable Indigenous governing bodies to exercise their inherent rights of self-government in the context of emergency response or recovery. With respect to wildfire, First Nations are reasserting their rights and jurisdiction throughout their territories by revitalizing cultural burning (Lewis et al. 2018; Dickson-Hoyle et al. 2021; Nikolakis and Myers Ross 2022), implementing Guardians programs (Popp et al. 2020; Reed et al. 2020), actively participating in wildfire response (Dickson-Hoyle and John 2021; Copes-Gerbitz and Comeau 2023), and advocating for joint decision-making in land-based wildfire recovery (Dickson-Hoyle and John 2021). Although steps are underway to support Indigenous fire stewardship in BC, persistent colonial barriers and power imbalances still exist for Nations wanting to exercise their right to burn on their terms and lead cultural burning across their traditional territories (Hoffman et al. 2022*a*). Transformative change in wildfire governance will require addressing these barriers while simultaneously centering Indigenous values through collaborative efforts at all levels of government. While there are efforts to allocate more funding to wildfire mitigation, synergisms between Indigenous values, fire stewardship, and landscape fire resilience provide a framework for achieving real change in wildfire governance.

Strategy 6: strengthen and diversify training and expertise

Diversifying expertise and expanding training opportunities are needed to support a transformational shift from management focused on wildfire suppression to landscape resilience and empowering local communities. Holistic and equitable solutions for resilience require transdisciplinary approaches that focus on complexity, incorporating diverse ways of knowing fire, enhancing opportunities for transformational learning, and implementing problem-centered research (Copes-Gerbitz et al. 2024). Many current initiatives are supported by boundary spanners, individuals and organizations with specialized training, expertise, and skills to work across knowledge boundaries and build trust to enable collaboration (Hoffman et al. 2024). Dedicated programs and positions are needed to support this ongoing work, particularly to engage communities and promote reciprocal learning and cross-training to educate industry and western-trained fire managers on distinct and legitimate forms of expertise held by Indigenous fire practitioners (Sankey 2018). Increased investment in and valuing of social science and transdisciplinary research that examines the social and political dimensions of wildfire is key to informing these collaborative processes of trust building, shared decision making and ethical knowledge co-production (Sankey 2018; Hoffman et al. 2024).

New and accessible training opportunities are also needed to support the broad range of professionals, contractors, knowledge keepers and community leaders who are increasingly making decisions on wildfire mitigation, response, and recovery. However, a lack of training opportunities in fire ecology and management is a primary barrier to transforming wildfire management (SFU Mitigating Wildfire Initiative 2023; Hoffman et al. 2024). Moreover, it is imperative to ensure that operators and contractors involved in fuel treatments and forest operations are proficiently trained to use state-of-the-art technology. Universities across BC have responded by increasing faculty positions and supporting new applied research programs, such as the Institute for Wildfire Science, Adaptation and Resiliency at Thompson Rivers University and Centre for Wildfire Coexistence at UBC, both established in 2023. In 2024, UBC—Okanagan launched the Wildland Fire Ecology & Management program, a series of interactive online micro-credentials designed to increase accessibility to a broad range of learners inside and outside

the university. This program provides a balance of perspectives from Indigenous and western science on the role of fire as an ecological process, departures from historic fire regimes, and societal challenges of contemporary wildland fire management. Future offerings provide tools to understand landscape-scale fuel complexes and strategies for navigating wildfire mitigation planning. Building on partnerships throughout BC, expansion of this program includes a prescribed fire training centre that will reduce barriers for non-government agency practitioners. In parallel to these new program offerings, there is a need to formally recognize Indigenous experiences and expertise (Sankey 2018) in ways that avoid imposing requirements for credentialing onto Indigenous peoples. Developing comprehensive training and capacity-building frameworks is also essential for effecting change in on-the-ground practices. The successful adoption of new technologies and methodologies depends on the implementation of thorough and suitable training and capacity-building programs that encompass all involved stakeholders. In combination, these expanded research, education, and practical training opportunities facilitate the shift toward more holistic approaches for coexisting with wildfire.

Conclusions

Transformative change is urgently needed to coexist with wildfire in BC. We, as co-authors, share a grave concern that future wildfires like the one that burned 90% of homes and businesses in the Village of Lytton in 2021 are inevitable, but will cause even greater loss of life. Without paradigm shifts in wildfire response, mitigation, and governance—combined with meaningful action at federal and provincial levels to mitigate climate change through emissions reduction by transitioning away from fossil fuels—BC will be increasingly overwhelmed by extreme wildfires that jeopardize landscape and community resilience.

Coexisting with wildfire requires recognizing and strengthening the diverse knowledges, capacities, and social relationships that contribute to community resilience, while providing adequate funding, resources and policy frameworks to support local communities, First Nations and land managers in proactively managing wildfire risk. We have presented six interrelated strategies, with associated actions needed to amplify the pace and scale of change in response to recent wildfire extremes:

(1) Diversifying wildfire management to include managed wildfires, prescribed fires, and cultural burning, requires strengthening local partnerships and Indigenous-led fire governance and stewardship.
(2) Increasing local capacities for suppression response, combined with emergency planning and proactive fuel mitigation, creates stable and sustained career opportunities in multiple communities.
(3) Shifting efforts toward proactive management to reduce wildfire risk at home-to-landscape scales requires long-term and stable funding and innovation to overcome the economic barriers to fuel mitigation treatments. Building trust and relationships across scales is also critical for community resilience.
(4) Implementing landscape fire management to reduce the negative consequences of catastrophic wildfires and restore ecosystem resilience requires fundamental shifts to forest management in BC. A two-step approach includes immediate actions to minimize harm, while simultaneously planning and implementing long-term actions to shift ecosystems and transform the forestry sector.
(5) Transforming wildfire governance includes a shift from centralized decision-making to empowering and supporting local communities and promoting true partnerships with First Nations. Immediate changes are driven by extreme fire seasons, while sustained changes are integrally linked to BC's *Declaration on the Rights of Indigenous Peoples Act* and commitments to reconciliation.
(6) Diversifying expertise and expanding capacity building to support the ongoing shifts in wildfire and fuel management in BC. Transdisciplinary boundary spanners work across diverse knowledge systems and build trust to enable collaboration, while universities, colleges and trade schools throughout BC are expanding research, education, extension, and training programs in wildfire science and management as well as supply chain and bioenergy operations.

Integrating these six strategies provides a holistic, all-of-society approach to minimize the negative social and ecological impacts from wildfires. Coexistence requires recognizing that not all wildfires can or should be suppressed, and that negative impacts will continue unless transformative changes to wildfire and forest management are made, such as those outlined here. Transformative change can be catalyzed by a new vision for the forest-based economy of BC, bold changes to policy and governance, sustained funding programs, and a long-term commitment from the government of BC to work collaboratively with First Nations, regional and municipal leaders, and the public.

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Data availability
Data presented in Fig. 1 are available from the BC Wildfire Service: https://catalogue.data.gov.bc.ca/dataset/fire-perimeters-historical; https://catalogue.data.gov.bc.ca/dataset/fire-perimeters-current.
Data presented in Figs. 2 and 3 are available from the corresponding author upon reasonable request.

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