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Facilitating Prescribed Fire in Northern California through Indigenous Governance and Interagency Partnerships

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Abstract: Prescribed burning by Indigenous people was once ubiquitous throughout California. Settler colonialism brought immense investments in fire suppression by the United States Forest Service and the California Department of Forestry and Fire Prevention (CAL FIRE) to protect timber and structures, effectively limiting prescribed burning in California. Despite this, fire-dependent American Indian communities such as the Karuk and Yurok peoples, stalwartly advocate for expanding prescribed burning as a part of their efforts to revitalize their culture and sovereignty. To examine the political ecology of prescribed burning in Northern California, we coupled participant observation of prescribed burning in Karuk and Yurok territories (2015–2019) with 75 surveys and 18 interviews with Indigenous and non-Indigenous fire managers to identify political structures and material conditions that facilitate and constrain prescribed fire expansion. Managers report that interagency partnerships have provided supplemental funding and personnel to enable burning, and that decentralized prescribed burn associations facilitate prescribed fire. However, land dispossession and centralized state regulations undermine Indigenous and local fire governance. Excessive investment in suppression and the underfunding of prescribed fire produces a scarcity of personnel to implement and plan burns. Where Tribes and local communities have established burning infrastructure, authorities should consider the devolution of decision-making and land repatriation to accelerate prescribed fire expansion.

Keywords: prescribed fire; fire governance; fire suppression; Indigenous peoples; American Indians; settler colonialism; tribal sovereignty; California



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1. Introduction

In the last decade, wildfires in California and the American West have caused unprecedented property destruction and human fatalities [1,2]. In response, federal and state land and fire management agencies have embraced prescribed burning to reduce wildfire intensity, rate of spread, and property destruction [3]. However, in the early 20th century these agencies initiated fire exclusion and suppression policies to eliminate prescribed burning by Indigenous peoples, ranchers, and timber companies to purportedly sustain timber harvests [4–6]. The fire suppression infrastructure developed a command and control culture akin to US military campaigns, and received large financial investments to ensure the protection of timber and residential structures [7,8]. However, fire suppression increased surface fuel loads and tree densities [9–11], contributing to amplified wildfire size and severity, compounded by the effects of climate change [12–14]. Fire suppression policies and investments remain persistent and constrain efforts to expand the pace and scale of prescribed burning in California [15–17].

Indigenous prescribed burning, also described as cultural burning by Indigenous leaders, supported the subsistence and cultural needs of families and small-scale societies in what is now known as California [18]. These fires were set to mitigate wildfire spread and to improve gathering and hunting by maintaining ecological communities (e.g., oak

woodlands and savannas), enhancing plant qualities for basketry, and reducing acorn infestation [19]. Indigenous prescribed burning and fire stewardship remains connected to generational systems of knowledge that are deeply grounded in spiritual practice [20]. Indigenous fire governance, in comparison to colonial fire governance, was decentralized and occurred within circumscribed “firesheds” [21]. Colonial fire governance and management was bolstered by a Western science philosophy historically aligned with the timber industry [4,7] that fundamentally altered and misconstrued Indigenous fire knowledge and practice in California [22–25]. Now, northern California fire managers, residents, and Tribes, such as the Karuk and Yurok, are working toward expanding cultural and prescribed burning to re-establish fire-adaptive behaviors and communities, and to revitalize Indigenous culture and ecology [20,26–28].

Here, we use a political ecology framework [29,30] to examine how governance, land tenure, resource distribution, and Indigenous cultural revitalization movements affect fire policy and the re-introduction of cultural and prescribed burning in northern California. Political ecology applies political-economic analyses to issues of environmental governance. Political ecologies of fire have illuminated the ideological divides at the foundation of colonial fire suppression and Indigenous prescribed burning worldwide [8,31–35]. In California, Pyne [5,7,36], Simon [36], Norgaard [24,25], and Davis [37] have scrutinized the effects of political economy on fire by showing how powerful timber and real estate interests have dominated state land and fire politics to encourage residential sprawl and fire suppression. As an example, Davis contrasts the state’s fire suppression largesse for protecting large estates in Malibu, California, with the state’s austerity measures that limit funding for fire code enforcement in urban tenements [37]. He also argues that the construction of mansions in fire-prone areas and property owner opposition to prescribed fire is associated with colonial hubris and manifest destiny.

Similarly, we ground our political ecology approach in the theory of settler colonialism [38] and apply this framework, like Norgaard [24], to Indigenous and relatively rural communities in California. Settler colonialism is a political structure that, through occupation and genocide, has attempted to erase, dispossess, and disenfranchise Indigenous peoples in California of their land, culture, and political autonomy [24,39,40]. This framework, alongside an examination of Tribal sovereignty, has been applied by American Indian scholars to analyze environmental and Indigenous governance throughout North America [41–43]. Settler colonialism is inseparable from the capitalist project to maximize individual and corporate profits through the commodification and exploitation of land and human labor [38,44]. Furthermore, settler colonialism is justified through white supremacist ideology, as European colonialism racializes Indigenous peoples as inferior subjects [45,46]. The denigration and subjugation of Indigenous peoples and their cultural practices parallels efforts to dominate and control other species, and fire, by colonial scientists and foresters, to increase profits and state hegemony [4–6]. Therefore, settler colonialism undergirds fire suppression policies worldwide [47,48], and American cultural symbols, like Smokey Bear, reinforce a general fear and phobia toward fire amongst public agency staff and the general public [8,49].

In contrast, Indigenous peoples of California are leaders in a movement to revitalize cultural fire and their fire-dependent culture [20,50,51]. This longstanding commitment to maintaining cultural fire is representative of a broader movement to revitalize Indigenous culture and Tribal sovereignty in opposition to settler colonialism [52–57]. Indigenous cultural revitalization movements are efforts to restore cultural practices grounded in worldviews of radical relationality and reciprocity with non-human species and the earth [58–62]. Indigenous worldviews contrast with anthropocentric colonial views that separate humans from nature and seek to control and profit from other species [63–65]. With Indigenous worldviews at their foundation, American Indian political movements have successfully changed law and policy to support self-governance, and have pressured colonial governments to uphold Tribal sovereignty [66–68]. This has given Tribes opportunities to insert and integrate their cultural objectives into forest and fire management [27,69–72].

While efforts to reduce fuels and re-introduce cultural and prescribed fire have facilitated community and Indigenous engagement in decision-making and planning [27,73–76], state agencies retain considerable regulatory power, which may undermine these efforts to decentralize fire planning and restore fire to the landscape [77]. Furthermore, settler colonialism privatized and nationalized the ancestral lands of Indigenous peoples making their lands inaccessible to them. The partial devolution of decision-making without the concurrent repatriation of land limits the ability of Indigenous peoples to conduct cultural burns [78].

Meanwhile, Indigenous cultural burning practices have also been appropriated and narrowly re-conceived by government agencies [79]. The primary goal of state-led prescribed burning is to reduce fuel to protect settler colonial resources and infrastructure (e.g., private estates and timber) from wildfire [80]. When fuel reduction is the primary (or only) objective of prescribed burning, Indigenous and ecological objectives are compromised [23,26]. For example, to increase revenue, a private contractor in Karuk territory destroyed ceremonial trees and trails in a Forest Service fuels reduction project [81,82]. Thus, when forest management is incentivized by profit, larger trees may be felled to finance fuel reduction projects [81–84]. Furthermore, colonial government programs in Australia that apply prescribed fire for biodiversity conservation and carbon sequestration have been criticized by Indigenous communities for altering the frequency, and size of prescribed fires, and for ignoring the spiritual and cultural systems that govern Indigenous burning [85,86].

Here, we examine how settler colonial structures permeate prescribed fire policies and management in California, and how Indigenous fire revitalization movements are influencing prescribed and cultural fire expansion. Specifically, we use an anthropological approach to evaluate participant observations from cultural fires led by Karuk and Yurok fire managers, and surveys and interviews with fire managers from throughout northern California. We use these data to answer two overarching questions: (1) How do settler colonial fire policies constrain efforts to expand cultural and prescribed fire in northern California? (2) What actions are facilitating the expansion of cultural and prescribed fire in northern California?

1.1. Background

1.1.1. Prescribed Fire History

For millennia, California Indians intentionally set fires to reduce wildfire risks and to sustain critical subsistence and cultural resources [18,87]. The Indigenous economy depended on the frequent and widespread use of fire to enhance local resources [18], much like other pre-industrial, non-capitalist societies worldwide [35,88].

The advent of US settler colonialism in California (~1849) wrought widespread genocide and land dispossession that damaged Indigenous cultures [89–91]. Colonialism established an economy based on intensive resource extraction that led to a fire suppression infrastructure [5]. Foresters trained in Germanic silviculture led efforts to increase timber production across the United States [4,92]. Ethnocentrism ignored and denigrated Indigenous applications of fire, and powerful foresters and timber companies believed fire had to be eliminated from the landscape in order to encourage timber regeneration and sustainable revenues [5,93–95]. The conversion of Indigenous lands to National Parks and National Forests, as well as to commercial timber estates and ranches, also suppressed Indigenous fire governance and practices [24,96–99]. This political-economic shift radically changed the distribution of fire throughout California. Federal and California state agencies reduced fire frequency and extent by 94% in the 20th century with industrial-scale fire suppression [100].

Attempts to re-introduce prescribed fire in 20th century California met resistance from powerful state actors [101,102]. However, beginning in the 1970s, some public land agencies began to embrace prescribed fire as a tool to meet ecological restoration objectives [103]. By the 1990s the US Forest Service signaled that it would integrate prescribed fire into

forest management [103]; however, fire managers continue to face major constraints to the implementation of prescribed fires. A 2009 survey of managers found that major constraints were: a narrow burn window (political and ecoclimatic conditions that limit prescribed burning), environmental and air quality regulations, and a paucity of trained personnel to conduct burns [104]. In response to these constraints, Tribes and non-governmental organizations (NGOs) began to develop programs and advocate for political changes to expand prescribed fire. For example, the Karuk and Yurok Tribes in the Mid-Klamath watershed have initiated successful efforts to revitalize cultural burning [27,28,105,106] by building polycentric (intergovernmental and interinstitutional) coalitions to manage fire across complex jurisdictional boundaries [107,108]. These Tribes have used changes in federal Indian law that require Tribal consultation [68,72,109], as well as changes in federal fire policies, to put pressure on agencies to include Indigenous objectives in fire and land management planning [26,69].

1.1.2. Fire Policies and Programs

The increased density of human settlements near fire-prone National Forests and public lands has shifted fire suppression from a focus on protecting commercial timber to defending residential communities [15,110,111]. Vacation properties and absentee land ownership proliferated in the 20th century, and such property owners are less likely to implement fuel reduction measures, including prescribed fire [112–115]. Potential liability associated with the growth of subdivisions has also increased the complexity of prescribed fire planning [116–119]. In response to wildfire property destruction, the US Congress passed the Healthy Forests Restoration Act (HFRA) in 2003 to increase hazardous fuel reduction activities, including prescribed burning, in the Wildland-Urban Interface [120,121]. The HFRA and the FLAME act of 2009 increased fuel reduction on National Forest lands, but treatments have not reached pre-colonial levels of fire frequency and area in California [122,123].

In California, several state initiatives aim to support community-based fire planning and restoration [124–126]. In 1993, the California Department of Forestry and Fire Protection (CAL FIRE) developed the California Fire Safe Council, which eventually became an independent non-governmental organization (NGO) supporting community-based Fire Safe Councils (FSCs) throughout the state [124]. FSCs typically educate community members on defensible space, and also may conduct larger-scale fire planning and hazardous fuel reduction [124,125]. In 2018, CAL FIRE also initiated the Forest Health Grant Program using funds from the state cap-and-trade carbon market under the California Air Resources Board (Assembly Bill 32) [126]. This program has funded prescribed fire projects across multiple jurisdictions. These state frameworks, combined with federal projects that incentivize multi-jurisdictional collaboration, are facilitating the development of local efforts to expand prescribed fire.

The development of multi-jurisdictional collaborative fire restoration programs through the US Department of Agriculture (USDA) increased opportunities for Tribes and communities in northern California to initiate prescribed fire management plans by providing unprecedented resources [108,127,128]. The Fire Learning Network (FLN), initiated as a partnership between the Nature Conservancy (an NGO) and the USDA Forest Service in 2002, funds collaborative fire planning and prescribed fire TRaining EXchanges (TREX) to increase community capacity for prescribed fire expansion [76,129]. In the Mid-Klamath watershed of northwest California, the FLN has supported the coordination of the Western Klamath Restoration Partnership (WKRP) led by the Karuk Tribe and the Orleans-Somes Bar Fire Safe Council (OSBFSC) [105]. The WKRP is working to expand prescribed and cultural burning within ancestral Karuk territory under the jurisdiction of the USDA Forest Service. In 2018, the Partnership completed the NEPA review process on a pilot project to burn ~2250 ha [130]. On the Yurok reservation, the FLN supports the Cultural Fire Management Council (CFMC) that partners with the Yurok Tribal government and CAL FIRE to expand cultural burning.

2. Materials and Methods

From 2014–2019, we observed and participated in cultural and prescribed fire planning and implementation in Karuk and Yurok Indian territories within the Klamath River watershed of northern California. The region has a Mediterranean climate, with wet winters and dry summers. Annual average precipitation ranges from as low as 10 cm to >400 cm [131], but generally decreases to the south and east, and increases with elevation [132]. Prescribed burning in the region usually occurs during seasons of transition (dry-wet) when 10-h fuel moistures are between ~7% and 15%, which is typically in spring and fall months [133].

The Yurok and Karuk Tribes are two of the most populous federally recognized Tribes in California (currently 109 Tribes) [134,135], the Yurok with over 6000 members, and the Karuk with ~3700 members and ~5000 descendants. In ancestral Karuk territory, the federal government did not establish a reservation or ratify treaties, but unilaterally created Forest Reserves—now the Klamath and Six Rivers National Forests—that occupy the majority of their territory [98,136–138]. In ancestral Yurok territory, multiple overlapping jurisdictions occur, including Redwood National Park [139], Six Rivers National Forest, and the reservation established by the federal government [28]. The reservation is located along a mile-long (1.6 km) buffer following the Klamath River from its estuary to ~80 km upriver near the confluence of the Klamath-Trinity Rivers (~225 km²) [99]. However, 106 km² (47%) of the reservation is under private timber company ownership [140].

Observations of cultural and prescribed fire planning and decision-making in Karuk territory occurred through the day-to-day responsibilities of B. Tripp as an employee of the Karuk Tribe's Department of Natural Resources. T. Marks-Block observed prescribed fire planning at 13 Cultural Fire Management Council meetings and at prescribed fire training exchanges. Participatory observations were conducted during prescribed burning at the Yurok (2015–2019; $n = 8$) and Klamath (2016–2019; $n = 4$) prescribed fire training exchanges. During these events, we discussed decisions made with fire managers and participants who conducted burns. We also spoke with managers about specific prescribed burns conducted by the USDA Forest Service on the Klamath and Six Rivers National Forests.

Participant observation in the Klamath watershed was supplemented with an online survey and interviews that targeted northern California fire managers to expand the sample with those working in other parts of the region. Surveys and interviews were developed based on cultural and prescribed fire constraints observed in the Karuk and Yurok territories. We used Qualtrics surveying software and distributed online surveys in February–March, 2019, to 190 fire managers from 26 Northern California counties that extended from the Oregon border to Marin, Sonoma, Napa, Solano, Sacramento, and El Dorado counties to the south (136,318 km²). From the initial invitations to participate, 75 managers completed surveys or participated in interviews producing a response rate of 39%. Fire managers were employed by the USDA Forest Service, National Park Service, Bureau of Land Management, US Fish and Wildlife Service, US Natural Resource and Conservation Service, CAL FIRE, California Fire Safe Councils, and Tribes (Figure 1). Managers are defined here as individuals who plan and supervise cultural and prescribed burning as opposed to those who only conduct burns. Participant contact information was collected from National Forest Schedule of Proposed Action reports and prescribed fire announcements, as well as from agency or organizational databases, and directly from regional fire managers for various agencies. This online survey included questions on what actions facilitated the expansion in area and frequency of prescribed burns as well as perceived constraints and what managers believed could materially or politically alleviate constraints to prescribed burning (Survey Questions S1). Based on survey results, we conducted and transcribed semi-structured interviews with 18 fire managers (six of which worked for Tribes or Indigenous fire organizations). Participants indicated their interest in an interview on their survey, or communicated their preference for an interview in place of conducting the survey. To analyze these data, we generated descriptive statistics and used a grounded theory approach to inductively code survey and interview responses [141].

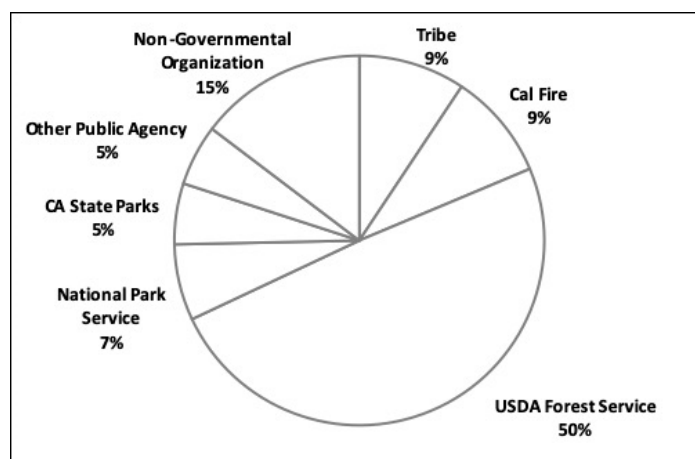


Figure 1. Affiliation of Fire Managers Who Participated in Surveys and Interviews. A total of 75 fire managers participated from 2016–2019.

We also collated reported data on Forest Service budget appropriations (2002–2020) and full-time equivalent positions (2006–2020) from fiscal year budget justifications. Actual appropriations and full-time equivalent positions for the ‘suppression,’ ‘preparedness,’ and ‘FLAME’ (2010–2020) categories were combined into a general fire suppression category, and ‘hazardous fuels’ appropriations and full-time equivalent positions were placed into a fuel reduction category. Although ‘preparedness’ is somewhat ambiguous, it is distinguished from hazardous fuels, and the National Wildfire Coordinating Group definition (<https://www.nwcg.gov/term/glossary/preparedness> accessed on 5 July 2021) suggests that preparedness activities are associated with wildfire suppression activity. CAL FIRE budget expenditures were collected from California Department of Forestry and Fire Protection budget reports (2005–2021). The budget categories ‘fire control,’ ‘cooperative fire protection’ and ‘emergency fire suppression’ were combined into a fire suppression category, and the budget categories ‘fire prevention’ and ‘resources protection and improvement’ were combined into a ‘resource protection & fire prevention’ category. Although these capacious categories are crude and cannot fully capture all state and federal expenses associated with fire suppression or those associated with fuel reduction and prescribed fire, they allow for a coarse comparison of budget priorities. Reported quantities were not adjusted for inflation.

3. Results and Discussion

3.1. Wildfire Suppression and Underfunding Constrain Prescribed Fire Expansion

As a consequence of the devastating wildfires in northern California in 2017 and 2018, many surveyed managers sense that some prescribed fire policies and funding are improving. However, wildfire suppression is also preventing managers from prescriptively burning by reducing available personnel. In the survey, managers identified ‘wildfires reducing available personnel’ as the top constraint limiting their ‘burn window’ or opportunity to burn (Figure 2). In northern California, burn conditions are often ideal when southern California is experiencing wildfires, and personnel are requested to support in suppression efforts. Surveyed managers observed that current budgetary incentives favor sending personnel to wildfires instead of maintaining their availability for prescribed burning within their home unit, a trend also observed by other scholars [16,142]. In an interview one manager stated: “Quite often we have to be on stand-by because there is a fire that doesn’t even exist. This is preventing us from burning”. Hence, in the fall prescribed fire season, northern California prescribed fire teams are unable to burn because agency leaders keep them available for suppression if a wildfire occurs elsewhere.

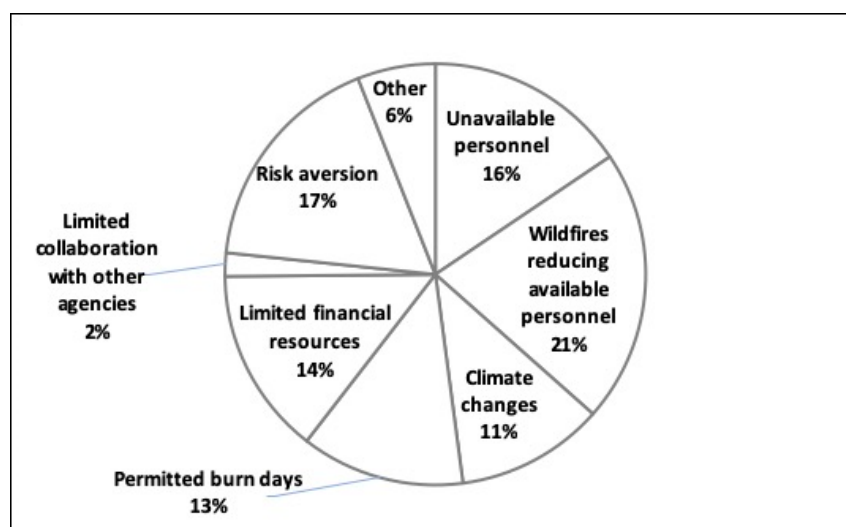


Figure 2. Top Three Burn Window Constraints. Fire managers were asked to rank the top three constraints to their agency’s burn window. Responses were not weighted and were totaled. Other responses included National Environmental Policy Act procedures, ecological objectives, and endangered species, limited available contractors and specialists, and air quality permits.

Another major constraint surveyed managers recognized is an institutional culture of risk aversion that developed over decades of implementing fire suppression policies (Figure 2), despite a low (1.76%) rate of prescribed fire escape in California [17]. As one interviewee shared, “[The] current forest supervisor comes from the old timber mindset and has been known to be risk-averse to burning”. Interviewed managers say that amongst some agency staff there is a perception that prescribed fires may destroy timber (revenue) and adjacent houses (liability), which has made some uncomfortable or unfamiliar with prescribed fire. Hence, lower-level managers are pulled in different directions by rhetoric coming from the regional or national level that supports prescribed burning, and the apprehension of national forest supervisors or CAL FIRE unit chiefs who must deal with complex political realities. CAL FIRE, for example, only recently re-embraced prescribed burning as an important strategy under the leadership of director Ken Pimlott (2010–2018). As one CAL FIRE manager stated in an interview, “In the 2000s, when we got away from large scale broadcast burns, we brought on a lot of firefighters, and many of those folks are now battalion chiefs and leadership. So, they may not have participated in [prescribed fire] projects”.

Examples observed from Karuk and Yurok territories reflect this risk-averse orientation. The Humboldt-Del Norte CAL FIRE Unit revoked a permit for the Yurok TRES in 2016 because they considered conditions to be too risky despite a recent rainfall event. In 2017 and 2018, large wildfires in other areas prompted the USDA Forest Service and CAL FIRE to shut down fall season prescribed burning throughout the state. In 2019, an escaped prescribed fire (that did not destroy structures) in the El Dorado National Forest in the Sierra Nevada prompted the Forest Service to suspend ignitions in other National Forests in Region 5. This decision prevented the Klamath River TRES, organized by the Karuk Tribe and the Orleans-Somes Bar Fire Safe Council (OSBFSC), from implementing cultural burns for one week. These centralized decisions are especially demoralizing for TRES because they convene volunteer fire professionals from around the world who are working to increase their skills and qualifications for a 1–2 week period established months in advance. Thus, to have permits revoked during excellent burning conditions has been frustrating for participants and leaders who have invested considerable time and funds to conduct cultural and prescribed burns. We observed that officials within state and federal management agencies argue that allowing prescribed burns while wildfires burn elsewhere

could create misperceptions that the government is not doing enough to protect houses and built infrastructure.

Across northern California, fire managers are hampered by these centralized decision-making processes regarding the permitting of cultural and prescribed burning [77]. Specifically, the prohibition of cultural and prescribed burning across the state by Forest Service regional staff and CAL FIRE upper management during wildfires or severe fire weather prevents implementation when the suspensions coincide with optimal prescribed fire conditions in other regions. Even without a statewide burn ban, wildland fire teams are prioritized for wildfire suppression, preventing them from conducting prescribed burns.

Hence, surveyed fire managers consistently identified that increasing the availability and quantity of wildland fire crews would be the most effective means to expand prescribed burning capacity, and that hiring personnel to implement burns was the highest priority among all budget categories (Figure 3). One surveyed manager stated: “There is going to be a workforce shortage to accomplish the acres needed to be treated. California will need a guest worker program or a civilian work program. [We] will need more funding to treat more acres. Our burn budget has been stagnant for decades”.

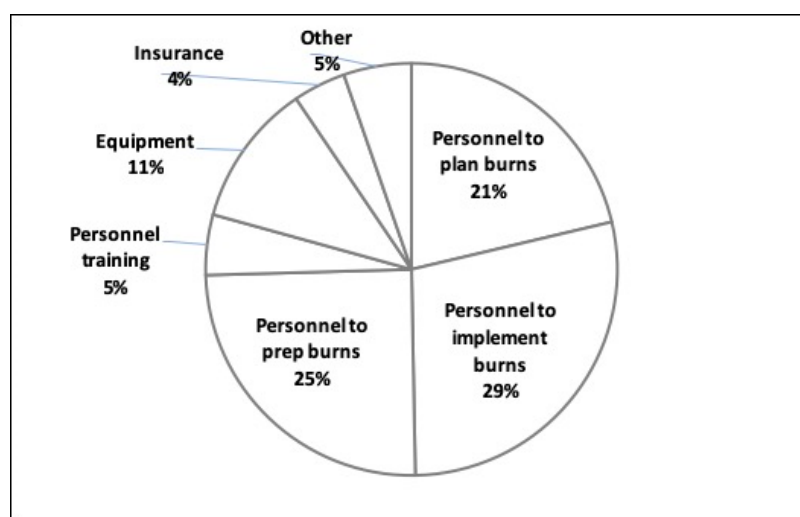


Figure 3. Highest Priority Budget Items to Increase Financial Resources for Prescribed Fire Expansion. Fire managers were asked to rank the top three budget items to increase financial allocations to expand prescribed burn area. Their responses were not weighted and were totaled. Other items included National Environmental Policy Act specialists, public education, and specific equipment needs (e.g., vehicles).

In response to destructive 2017 and 2018 wildfires, and the advocacy of organizations like the Northern California Prescribed Fire Council, the State of California adopted new legislation to expand personnel for prescribed burning [143]. As required by Senate Bill 901 (2018), the State increased appropriations for prescribed burning (Figure 4); when compared with the 2017–2018 budget, the 2019–2020 State budget funded ten new prescribed fire crews with 157 new positions [143,144]. New sources of financial support for prescribed burning have also been created within local jurisdictions. For example, after repeated destructive wildfires in Sonoma County, residents voted in 2018 to increase the sales tax to generate funds for fuel reduction in county parks. In addition, six parcel taxes for local fire protection districts have passed in the county since 2018 [145]. These changes may be an indication that voters are willing to reverse decades of anti-tax policies that have defunded wildfire prevention efforts (including prescribed fire) across California [36].

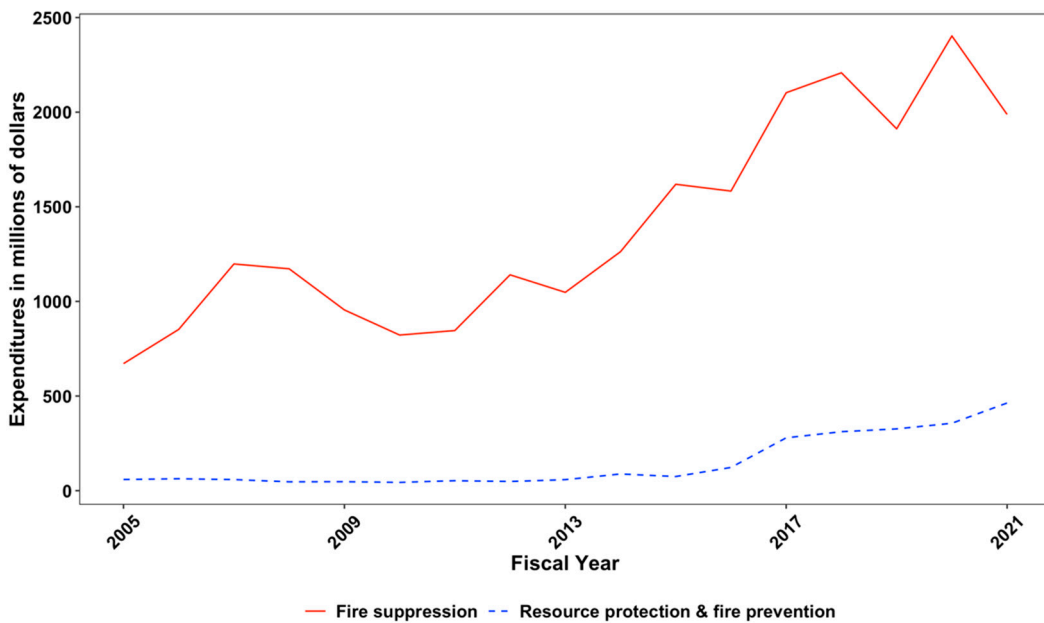


Figure 4. CAL FIRE fire suppression (in red) and resource protection & fire prevention (in blue) expenditures 2005–2021, not adjusted for inflation.

Some surveyed federal managers are hopeful that the changes created in wildfire suppression funding from the 2018 Consolidated Appropriations Act [146] will make more funds available for prescribed burning in coming years. However, federal and state budgets for prescribed fire and other fuel reduction personnel remain consistently less than funds allocated for fire suppression (Figures 4–6). A total of 72% of surveyed managers observed that their budgets have been either stagnant or in decline. This situation exemplifies the wildfire paradox in action, where a positive feedback loop exists for reactive suppression activity that results in limited resources for proactive preventative measures [110,147,148]. A significant increase in funds will be necessary to expand prescribed fire. As one Forest Service manager stated in a survey response, “You can have all the NEPA in the world, but if you can’t obtain funding . . . then the program is not effective”.

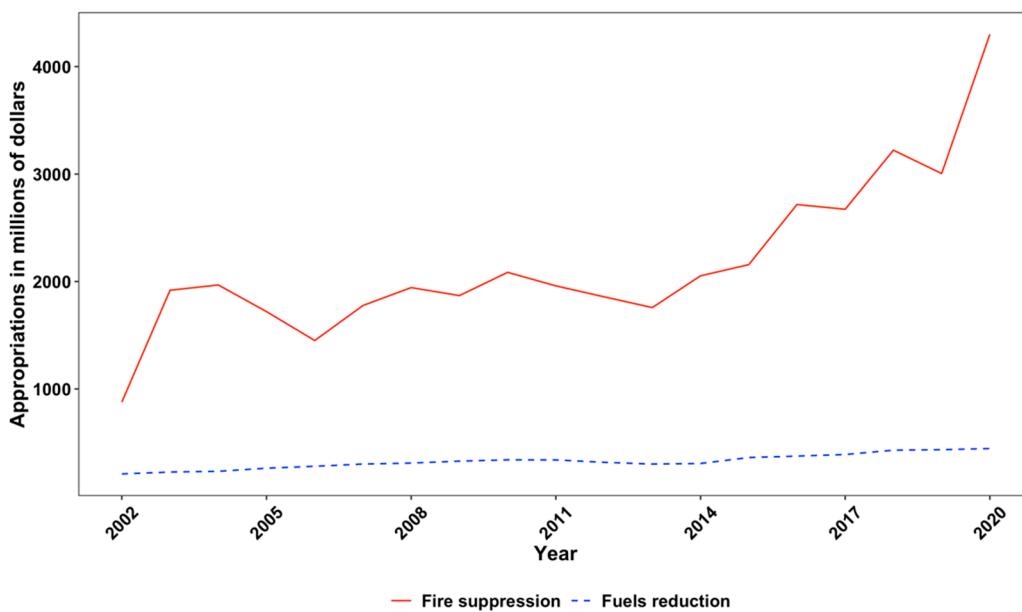


Figure 5. United States Forest Service fire suppression (in red) and fuels reduction (in blue) appropriations 2002–2020, not adjusted for inflation.

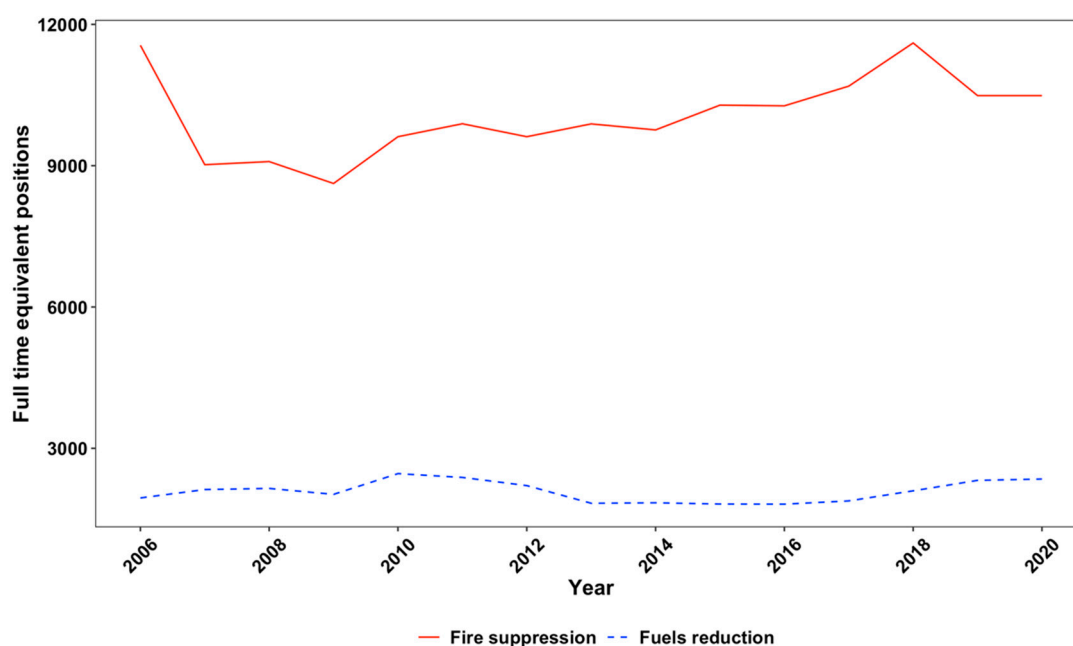


Figure 6. United States Forest Service full time equivalent positions for fire suppression (in red) and fuels reduction (in blue), 2006–2020.

For example, the Six Rivers National Forest has flexibility to conduct prescribed burns throughout the year, however, we observed that upper management often limits prescribed burning because of insufficient personnel or funds. Additionally, the fall prescribed burning season typically occurs at the beginning of the fiscal year (October 1), and upper management are reportedly hesitant to allocate funds for prescribed burning if they anticipate a budget shortfall. Because of the long hours required to prepare and monitor a burn to ensure it does not escape, prescribed burning also typically requires that staff receive overtime pay. Overtime pay must be pre-approved for prescribed burns, which is another bureaucratic hurdle for prescribed burning in the region.

Surveyed managers also noted the problems created by understaffing cultural resource specialists, wildlife biologists, and environmental planners who help conduct NEPA and California Environmental Quality Act (CEQA) proposed burn reviews and studies (Figure 3). For CAL FIRE projects, CEQA or internal reviews are required, and few specialists are available to support with the necessary reviews. One surveyed manager stated: “Recruitment of specialists to rural areas is difficult. Retention is also difficult due to heavy workloads and lack of support”. Even with the elimination of NEPA and CEQA regulations for fuel reduction projects (e.g., through the HFRA and SB 901), agencies remain understaffed. Hiring and training additional specialists to conduct environmental reviews, instead of scapegoating NEPA and CEQA, would expedite back-logged projects. The Six Rivers National Forest and the Karuk Tribe have a successful partnership wherein the National Forest contracts with the Karuk Tribe to conduct cultural resource reviews of proposed forest and prescribed fire activities under NEPA. This cultural resource collaboration provides the Forest Service with additional specialists and ensures the Karuk Tribe is directly involved in forest and fire planning in their ancestral territory. Similar collaborations are successful in the American West, and would support efforts to expand Tribal sovereignty [109,149].

The formation of interagency and intergovernmental partnerships like the Western Klamath Restoration Partnership in Karuk territory, were viewed by surveyed managers throughout northern California as the most effective action to increase prescribed and cultural fire area (Figure 7, Table 1). Over 50% of managers reported that these interagency partnerships assisted them to surmount funding, personnel, and equipment limitations (Table 2). At a state level, the creation of the Interagency Air and Smoke Council (IASC) in

the late 1990s between the California Air Resources Board and federal agencies, has improved communications to streamline prescribed fire air quality permitting [150]. Similarly, the Karuk and Yurok Tribes, CFMC and the OSBFSC, have established positive communication with the North Coast Air Quality Management District. These and other efforts to establish polycentric fire governance demonstrate the potential for effective collaboration across diverse entities to revitalize prescribed fire in California.

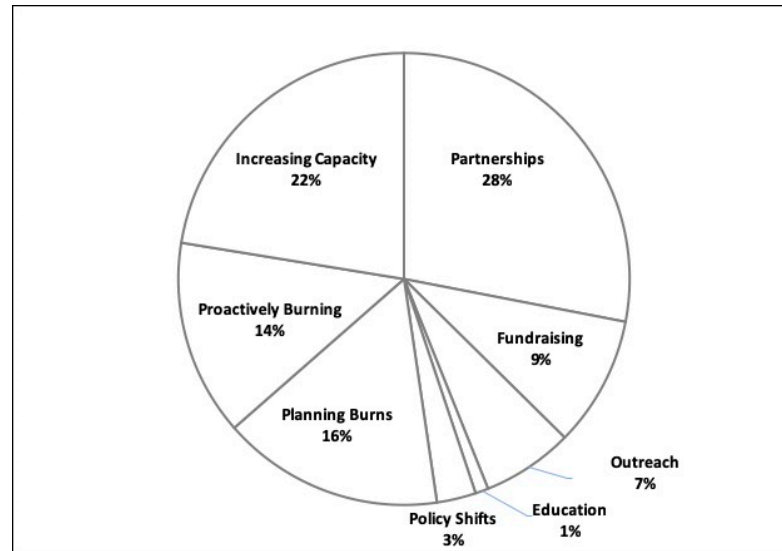


Figure 7. Effective Actions That Increased Prescribed Burning in Northern California. Fire managers were asked to identify the top three actions they took to increase prescribed burning in their agency, organization, or Tribe. Their responses were not weighted and were totaled.

Table 1. Actions taken or proposed by Tribes, United States Forest Service (USFS), CAL FIRE and Non-Governmental Organizations (NGOs) to alleviate prescribed fire constraints in northern California. Actions summarized from surveys and interviews with 75 fire managers, and from participant observations (2015–2019).

Prescribed Fire Constraints	Actions Taken or Proposed (<i>in italics</i>) to Alleviate Constraint by Entity			
	Karuk and Yurok Tribes	USFS	CAL FIRE	NGOs
NEPA & CEQA	Developed cultural resource specialist positions to support NEPA process; Partner with public agencies	Interdisciplinary NEPA teams more collaborative; Partner with Tribes; Streamlining NEPA for prescribed fire; <i>Hire more specialists</i>	Programmatic Environmental Impact Review (California Vegetation Treatment Program); Partner with Tribes and property owners; <i>Hire more specialists</i>	Partner with public agencies and Tribes; Specialists volunteer to support CEQA process
Air Quality Permits	Partner with air quality management districts; Developing independent air quality agencies within Tribal governments	Partnered with and improved relationships with California Air Resources Board and air quality management districts; formed Interagency Air and Smoke Council	Beginning to partner with California Air Resources Board and air quality management districts	Some NGOs have good communication with air quality management districts, whereas others are working to develop positive relationships.

Table 1. Cont.

Actions Taken or Proposed (<i>in italics</i>) to Alleviate Constraint by Entity				
Prescribed Fire Constraints	Karuk and Yurok Tribes	USFS	CAL FIRE	NGOs
Burn Bans	Fostering relationships with CAL FIRE and USFS to streamline and devolve permitting	<i>Reduce risk averse mindset in upper management</i>	<i>Reduce risk averse mindset in upper management</i>	Opposing statewide burn bans; Advocating for devolution of permitting
Wildland Fire Personnel	Developed Tribal wildland fire teams, volunteer and family-based burns (Indigenous Peoples Burn Network)	Participation in TRESX; Interagency personnel collaboration; <i>Increase permanent wildland fire teams; Increase overtime for prescribed fire</i>	Increasing permanent wildland fire teams for prescribed fire; <i>Work collaboratively with Indigenous and local leadership</i>	Creating independent prescribed fire teams; Establishing volunteer prescribed burn associations; Partnering with agencies and Tribes
Financial Resources	Advocating for more funds from government and private funders	Legislated new budgetary process for wildfire; Applying for more collaborative grants; <i>Increase budget appropriations for prescribed fire</i>	State is allocating more funding for prescribed fire each year	Greater access to grants through collaborative projects; Volunteer Prescribed Burn Associations; Advocating for more funds from government agencies and local tax measures
Land Access	Collaborating with public agencies to co-manage public lands; Repatriating federal and privately owned lands in ancestral territories	Establishing land co-management agreements with Tribes and NGOs; <i>Return neglected lands to Tribes</i>	Establishing land co-management agreements with Tribes and NGOs; <i>Return neglected lands to Tribes</i>	Collaborating with public land agencies for shared stewardship of lands; Establishing co-management agreements with Tribes; <i>Return lands to Tribes</i>
Liability and Risk Aversion	Hiring personnel with expertise in prescribed fire; Increasing Tribal expertise in prescribed fire	Social media presence, newspaper articles, outreach to NGOs and schools; Successful high-profile burns	Considering state-backed insurance; Assume liability for vegetation management/treatment program burns. Property owner outreach	Advocating for state-backed insurance for prescribed fire; Successful burns; Property owner outreach

Table 2. Agency or Organization Participation in Collaborative Prescribed Fire Programs. Surveyed managers were asked if their agency or organization participated in these collaborative programs. ‘Other’ programs included the California Deer Association (5%), and a variety of other local programs, such as the Sierra Nevada Conservancy, the USDA Natural Resource Conservation Service Environmental Quality Incentives Program, and local fire departments.

Collaborative Prescribed Fire Program	Agency Participation (%)
Prescribed Fire Training Exchanges (TRESX)	64
CAL FIRE programs	63
California Fire Safe Council	41
Joint Chiefs Landscape Restoration Partnership	20
Tribal Forest Protection Act	9
California Department of Fish and Wildlife	7
Other	32

Tribal governments are strong advocates of revitalizing cultural fire, yet remain constrained by the Forest Service, CAL FIRE, and other state agencies to achieve their goals [77]. Tragically, Tribes must convince these agencies to let them burn on their ancestral territory. In the short-term, subsets of funds from these agencies partially support the cultural

burning programs of Tribes (Table 2), but reliance on external funds that fluctuate with the politics of Washington DC and Sacramento is unsustainable. It will take time and investment on the part of agencies to produce a paradigm shift away from the fire suppression culture that dominates CAL FIRE and the Forest Service [7]. To create alternative funding streams, the Karuk Tribe recently established an eco-cultural revitalization fund to raise financial resources through private foundations and donors, and the Yurok Tribe has entered the carbon sequestration market to generate longer-term funding for its forest and fire restoration program [126]. Although this market funding mechanism remains controversial [151,152], the US Congress does not adequately fund Tribal self-governance and fire management programs [153], leaving Tribes with few viable alternative funding streams.

3.2. Cultural Fire Expansion in the Mid-Klamath Watershed

Leadership by Karuk and Yurok Tribal members has been instrumental to expanding cultural burning in California's Mid-Klamath watershed. In public statements and interviews Indigenous leaders have strongly criticized the relationships among commercial timber extraction practices, fire suppression policies, and the production of the wildfire crisis [26,50,69,154]. To support cultural revitalization, Tribes have established regional partnerships and plans with cultural burning as a key restoration priority, in addition to advocating for increased Tribal sovereignty over ancestral territory.

After decades of advocating for the expansion of cultural burning and Tribal sovereignty, interviewed Karuk and Yurok fire managers and leaders state that they have overwhelming support for expanding cultural burning from Native and non-Native residents in the region. Margo Robbins, president of the Cultural Fire Management Council (CFMC) that leads prescribed burning on the Yurok reservation, shared that a 2012 grassroots survey of residents in the southeastern half of the Yurok reservation identified expanding cultural burning as the highest priority for the community. That survey led to the creation of the CFMC. In interviews fire managers expressed that there is more demand for prescribed and cultural burns on privately owned properties that they can provide; they do not sense any opposition to burning from residents. Because many property owners in this region cannot obtain fire insurance [155], they feel that they must reduce risks on their own, and prescribed burning is an effective means to do so. Furthermore, the demand for fire-enhanced resources such as basketry materials and traditional foods necessary for Indigenous ceremonies and livelihoods have made these burns very popular [28,156]. The success of initial cultural burns has garnered managers enhanced public support to expand the practice [106,157].

Indigenous leaders report that TREX initially brought personnel to the region with the necessary qualifications to conduct and plan permitted burns because the Karuk Tribe, CFMC, and the OSBFSC did not have expertise recognized by the federal or state governments to independently conduct burns. CAL FIRE has broad latitude to grant or deny permits for prescribed and cultural burns, and they typically require burn plans (developed by specialists such as burn bosses and registered foresters) that usually request the presence of >20 qualified personnel during the burns, depending on the burn area [77]. Recently, TREX has helped train Tribal members, local personnel, and residents to increase their agency qualifications to support future prescribed burning expansion and establish year-round prescribed fire teams. Tribal fire managers expressed that adhering to colonial qualification systems subverts their sovereignty over fire governance, yet it has also enabled them to meet more of their cultural burning objectives. Developing infrastructure to engage in state and federal management systems has put Tribes in a position to assert greater sovereignty over fire management in the future.

The increase in qualified personnel has strengthened capacity and expanded cultural burning in the region; however, managers report that existing personnel are still insufficient to meet prescribed fire objectives, and additional funds are necessary. Observed cultural burns, on average, used 23 personnel, and spent 41–65 personnel hours per hectare burned (Table 3), which is expensive if fire personnel are paid. The regional cost of prepar-

ing privately owned fire-excluded sites for prescribed and cultural burning is between \$1500–\$2500/acre (\$600–\$1000/ha, N. Bailey, personal communication) and burning is ~\$3800/acre (\$1520/ha; E. Darragh, personal communication) based on wages in FY 2018. Managers believe with this local capacity Tribal members will begin to be able to set fires in a traditional manner.

Table 3. Average Personnel Hours and Fuel Used by Prescribed Burn Managers by Affiliation in the Klamath Watershed. Personnel hours were calculated by multiplying the time spent at a burn site by the total personnel conducting the burn. Personnel included all staff including burn bosses and wildland fire crews. USDA Forest Service (USFS) burns were conducted on the Klamath and Six Rivers National Forests in 2017. Prescribed Fire Training Exchange (TREX) burns were observed from 2017–2019. Standard errors (\pm) shown in parenthesis.

Affiliation	Burn Area (ha)	Personnel (Individuals)	Personnel (h)	Personnel h ha ⁻¹	Fuel (L ha ⁻¹)
USFS (<i>n</i> = 7)	12.6 (8.0)	23.1 (4.6)	222.8 (71.1)	40.5 (4.5)	17.0 (2.3)
TREX (<i>n</i> = 19)	7.0 (2.2)	23.7 (1.3)	213.2 (39.8)	64.8 (13.1)	17.8 (2.6)

While TREX brought welcomed resources to the region that enabled an expansion of cultural fire, the training events highlight the importance of Indigenous expertise and the distinct objectives of cultural burning. Non-Indigenous fire managers are educated largely in a Western fire suppression framework, and have less experience burning within the local ecological context. On multiple occasions when humidity and 10-h fuel moistures were high (i.e., >15%) we witnessed Indigenous cultural fire leaders identify ecological communities within pre-defined burn units that could carry fire and accomplish objectives, when burning from set fire lines would not carry flames. Cultural burns occur according to ecological properties and eschew the artificial fire lines typically created by old logging roads or colonial private property boundaries. Thus, cultural burning is adaptive, and does not adhere to the frequently rigid and narrow protocols (e.g., requiring fire lines and climatological metrics) associated with agency prescribed fire burn plans that are developed, in part, to determine potential liability.

We also witnessed that those trained in a suppression background are more concerned than Indigenous fire leaders with preventing tree mortality and suppressing fire in tree canopies. Indigenous fire leaders believe that a low intensity fire burning dead wood in the canopy of an oak or other hardwood can be beneficial, as it can reduce potential fungal infection sites. However, when fire enters the canopy via trunk-growing mosses, those trained in fire suppression are quick to douse all such fires with water. These contrasting objectives are opportunities for learning about fire benefits that challenge a singular objective of reducing surface fuel loads and tree mortality. These examples illustrate the ways in which holistic Indigenous fire epistemologies can produce different ecological outcomes and expand the application of prescribed fire [26,65,158]. In contrast, Western approaches to prescribed fire retain reductionist and risk averse tendencies that tend to control fire behavior as much as possible. Thus, non-Indigenous participants in cultural burns acquire new perspectives in fire stewardship that can contribute to the transformation of the dominant fire suppression paradigm.

3.3. Indigenous and Decentralized Fire Governance

The Indigenous Peoples Burning Network (IPBN) is an intertribal grassroots organization that formed in 2015 with support from the Fire Learning Network [159]. One of the primary goals of the IPBN in northwest California is to support autonomous family-based burning for fuel reduction and to support the revitalization of relatively small-scale fire-dependent cultural practices [21,22,50,159]. Families volunteer to cooperatively support each other to burn on their land, and have access to equipment from the CFMC, thus reducing burning costs. Leaders in the IPBN say that this form of decentralized burning reflects traditional governance of land and fire, and is a way to assert Tribal and familial

sovereignty. As CFMC President Robbins stated at a TREX event, “There is too much land for the agencies to take care of. We need to put the right to use fire into the hands of people”. This is a critique of the centralized, settler colonial model of fire governance that has disrupted Indigenous autonomy over fire and land management, and failed to invest in its own prescribed fire infrastructure [23].

The IPBN effort to collaboratively burn highlights the challenges of expanding prescribed burning under the existing land tenure regime, in which the majority of Karuk and Yurok ancestral territory remains under the jurisdiction of the Forest Service, Park Service and private timber companies [24,25,99]. In its initial stages, we observed that this model has been more effective at conducting burns in Yurok territory where Tribal members still retain property or allotments on the reservation. In Karuk territory, however, Indigenous leaders shared that there are fewer lands that remain under Indigenous tenure, and most traditional eco-cultural resources remain under the jurisdiction of the Forest Service. Generally, extensive California Indian land dispossession substantially limits the efficacy of this decentralized burning network, as it is challenging for Indigenous families to restore fire when they no longer have access to their ancestral lands, or when they have properties that are highly fractionated [70,160]. As Agrawal & Ostrom emphasize, if governments permit decentralized decision-making, but do not also devolve property use or access rights to Indigenous and local communities, then it is unlikely that efforts to reform management will succeed [78]. Therefore, efforts to return privately owned lands to dispossessed Tribal members [161,162], and to legislate the return of public lands to Tribes [126,163] can increase Indigenous access to eco-cultural resources and expand cultural fire led by families, the IPBN, and their collaborators. Increased land access and a shift in land management objectives will contribute to Indigenous cultural revitalization.

Efforts to decentralize prescribed fire are growing throughout northern California as a means to decrease the costs associated with paying professionals. The Northern California Prescribed Fire Council, University of California Cooperative Extension, the Fire Learning Network, and others have supported the development of decentralized prescribed burn associations (PBAs). Fire managers representing NGOs shared that they were hopeful that PBAs would help facilitate prescribed fire expansion throughout the region. These cooperative burn associations train property owners and volunteers to conduct burns on privately owned land [143,164,165]. Many of the leaders of these organizations have developed relationships of trust with regulators and managers through their professional roles. These relationships assist them in circumventing regulatory concerns and accessing equipment to support burns [164]. The social capital built into the structure of PBAs extends a social insurance to allay liability concerns, which is necessary given the difficulty and expense associated with purchasing insurance on the market [77]. These relationships also expand social networks of landowners and burners, and serve to enhance trust among community members and facilitate the expansion of a positive prescribed fire culture [165]. These associations have organized to change fee structures for burn permits and, thus, have been effective political forces to change local regulatory structures [143]. The PBA model may prove to be effective in expanding prescribed fire in California by empowering property owners to collaboratively burn, but the model does not resolve the question of land redistribution and access raised by Indigenous peoples.

4. Conclusions

Fire suppression emerged alongside state policies to control and eliminate Indigenous peoples in California [90,91]. Fire suppression developed from a white supremacist settler colonial culture that effectively denigrated Indigenous prescribed burning to protect timber and houses on stolen native lands. While there is now support for prescribed burning by the timber industry, land management agencies, and rural homeowners, when a wildfire is perceived to threaten houses, suppression is the default (and costly) reaction. As a result, fire suppression remains embedded in federal and California state budgets, and

the expansion of settlements across former California Indian lands reify a political and material commitment to suppression and settler colonialism.

Where governments and communities have acknowledged the benefits of prescribed fire, interagency partnerships have developed and supported diverse modes and innovative mechanisms to expand prescribed fire, including professional prescribed fire crews, Indigenous fire ranger programs, and prescribed burn associations [85,86,143,164–166]. However, despite favorable federal and California state governmental rhetoric about prescribed fire, centralized government funding and associated programs have been insufficient to sustain proactive prescribed fire programs in northern California [17,104,167]. Furthermore, these centralized agencies often lack the local fire knowledge or relationships that have co-evolved with fire ecologies. As a result, they often impose burning prescriptions that are incompatible with diverse cultural or ecological needs; an emphasis on prescribed burning for hazardous fuel reduction, for example, will not generate the same effects as cultural burning to sustain reciprocal relationships with non-human species [23,26]. Cultural revitalization and integration of Indigenous fire objectives will likely lead to increased ecological functionality, biodiversity, and abundance of species threatened by settler colonial extraction and development [168–171]. Including the social-ecological objectives associated with Indigenous cultural revitalization could increase the benefits of prescribed fire beyond the reduction of fuels to protect private housing.

To expand prescribed and cultural burning and create fire-adaptive communities, polycentric governance bodies must grapple with a divestment from fire suppression and the haphazard construction of settlements across California. Specifically, Tribal fire managers articulate that major structural changes in political economy, land use, and legal frameworks are required [77]. Along with increasing funding, reparations are necessary to address settler colonial inequities in the current distribution and control of land tenure, and Tribal sovereignty over fire management must take precedence over centralized state regulatory powers [154]. Examples of polycentric fire governance in Venezuela, Brazil, and Australia suggest that this collaborative approach is effective for expanding Indigenous prescribed burning in other contexts where fire suppression has been pervasive [172]. Yet, the IPBN framework of decentralized, family-based fire regimes is an alternative, and parallel proposition that anticipates the dissolution of repressive colonial land tenure and fire governance structures. In exceptional Australian and South American contexts where fire governance is comparatively decentralized and Tribal sovereignty and land title are no longer as encumbered by colonial regulations, Indigenous cultural burning is achieving desired social and ecological outcomes without a heavy reliance on external funding and metrics [173,174].

Therefore, governments and institutions should adjust regulations to transfer decision-making to local communities that have autochthonously established rules, norms, and infrastructure for burning, and that have allied themselves with Indigenous land management objectives and Tribal sovereignty. Given their deep temporal and place-based ties that have motivated the rehabilitation of human-fire relationships integral to their culture, Indigenous communities, such as the Karuk and Yurok, are particularly well positioned to self-determine the application of prescribed and cultural fire in their territories.

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