



Synthesis

How policy interventions influence burning to meet cultural and small-scale livelihood objectives

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ABSTRACT. Fire has cultural and economic significance for Indigenous and rural peoples worldwide, being used to manage landscapes for activities such as hunting, gathering, cropping, and forestry, and for ceremonial and spiritual purposes. Policy interventions by state and non-state organizations, such as regulations, economic incentives, and communication campaigns, can target fire use directly, or affect it indirectly, for example, by restricting land access. Yet evidence of such impacts has not been synthesized at the global scale. We analyzed 512 examples in 68 countries to describe the range of policy interventions by state and non-state organizations that target and/or affect fire use, categorizing interventions based on the broad actor types involved, their mode of operation (e.g., regulation) and their intentionality and/or possible effects vis-a-vis fire use. Of these interventions, 74% involved only state agencies in policy design and implementations, 4% involved only non-state organizations, and 18% involved collaboration between state and/or non-state organizations and/or communities. Three hundred and nine interventions directly targeted fire use, of which 87% aimed to eliminate or constrain fire use. Two hundred and three affected fire use indirectly, of which 88% led to reductions in or constraints upon fire use. Though there is some recognition in the 21st century of a need, in certain contexts, to support local fire use, for reasons related to environmental justice, ecology, wildfire risk and climate change, the literature we reviewed points to several challenges for contemporary efforts toward this end. These include contradictions between policy interventions, mistrust between actors following histories of fire suppression, greater fuel loads increasing the risk of burning where fire has been suppressed, and the need to consider the indirect effects of other types of policy, such as those related to land tenure.

Key Words: *fire use; global synthesis; livelihoods; participatory fire management; policy interventions*

INTRODUCTION

Fire is used worldwide to achieve a range of cultural and/or small-scale livelihood objectives, including hunting, fishing, gathering, cropping, forestry, pastoralism, social signaling, and ritual (Smith et al. 2022; hereafter “local” fire uses). For instance, fire clears vegetation for rotational fire-fallow (swidden) agriculture, fosters fresh forage for livestock, drives game, curbs insect and microbial tree infestations, and promotes desired plant species. The people using fire for such objectives include Indigenous peoples and other rural populations whose livelihoods rely primarily on household labor.

Local fire use practices are often subject to a range of social norms and governance structures determined communally by fire users themselves (Huffman 2013). Yet these locally constructed regimes almost universally interact with a range of policy interventions from state agencies and/or non-state entities (including non-governmental organizations [NGOs] and corporations), which are our focus in this article. Our focus here is on policy interventions involving state and/or non-state organizations. We understand policy interventions as actions taken or mandated by state agencies or non-state entities to achieve specific aims, including regulations, economic incentives, and interventions that elicit voluntary responses, such as communications campaigns. Some interventions target fire use directly, whereas others affect it indirectly, e.g., the enslavement and genocide of Indigenous peoples, privatization of land, and displacement of people to

make way for more intensive land uses, infrastructure, and protected areas have reduced anthropogenic fire in many landscapes (Nevle and Bird 2008, Pyne 2021).

Policy interventions by state and non-state organizations targeting or affecting fire use have a long history. In the Late Medieval period, some European states began instituting laws limiting peasant burning, to protect timber, breeding game species, and property (Pyne 1997). By the 18th to the early 20th centuries, anti-fire legislation and state-sponsored fire suppression operations were widespread across Europe and its colonies (Pyne 1997, Kull 2004). Since then, states and non-state organizations have continued to suppress anthropogenic fire in many places, believing (sometimes misguidedly) that this will protect natural resources, combat desertification and biodiversity loss, and/or reduce greenhouse gas emissions (Amanor 2002, Kull 2004, Laris 2004, Smith 2021). The 20th century also saw a shift in some official fire policies toward the limited acceptance of prescribed burning for wildfire mitigation, nature conservation, and carbon emissions reduction. Such policies usually prioritize burning by trained practitioners working for government agencies or non-governmental organizations (Pyne 2003, Mistry et al. 2019, Long et al. 2021, Croker et al. 2023a).

Since the 1980s, natural resource governance has been characterized by the decentralization of state power, including to local authorities, communities, and the private and third sectors

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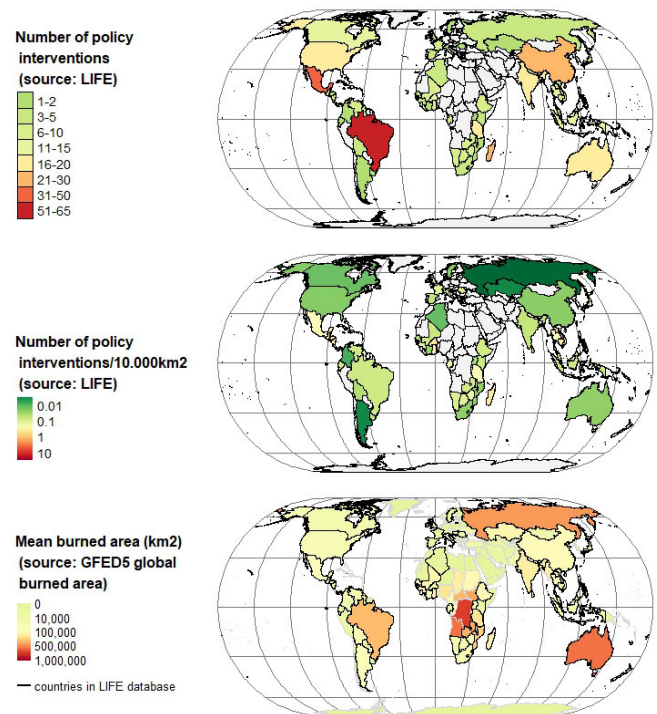
(Nunan 2018). In keeping with this broad trend toward multi-level governance there is increasing interest among some researchers and state and non-state organizations in supporting local people to use fire and in encouraging their participation in fire governance (Myers 2006, FAO 2011). For some (including ourselves), this is foremost an issue of environmental justice, because of fire's cultural and economic importance to fire users, and because of the links between fire suppression and colonialism (Thomassin et al. 2019, Oberholzer Dent et al. 2023, Weir 2023). Some efforts to support Indigenous burning, especially in settler colonial contexts (e.g., Australia, the USA, and Canada), accompany broader recognition of Indigenous rights and native land titling (Thomassin et al. 2019, Adlam et al. 2022, Weir 2023). Yet, for most agencies there is a strong pragmatic element to participatory fire management programs, linked to restoration of fire-dependent ecosystems and/or wildfire mitigation. A review crossing Earth's biomes found Indigenous fire use to be linked to biodiversity increases in 79% of studies and to increases in habitat heterogeneity in 63% of studies (Hoffman et al. 2021). Biomass accumulation in landscapes where fire has been suppressed, combined with longer fire weather seasons induced by climate change, is fueling intense wildfires that many agencies are under-resourced to manage (Jolly et al. 2015, Ammerman 2022). That pragmatic considerations are usually in the foreground for agencies is evidenced by a lack of support for fire use practices that meet cultural and/or small-scale livelihood objectives but do not clearly align with ecological or wildfire management aims, such as burning for swidden agriculture in fire-sensitive ecosystems like rainforests, or to drive game for hunting (Eloy et al. 2019, Croker et al. 2023a).

Regardless of their motives, to succeed, ongoing efforts to support local fire use will need to account for the effects and legacies of fire suppression policies, as well as other policy interventions that indirectly limit burning. Existing global syntheses point to the complex governance environment in which Indigenous fire management is situated (Nikolakis and Roberts 2020), and review governance theories that have been applied in the study of wildfires (Kirschner et al. 2023). More regional reviews examine collaborative fire management between state agencies and Indigenous peoples in Canada, Australia, New Zealand, and the USA (Thomassin et al. 2019), South America (Mistry et al. 2016), and East and Southern Africa (Croker et al. 2023a) specifically. Yet systematic knowledge of the effects of governance by state and non-state agencies on local fire use is lacking. Global studies of fire use governance are complicated by the fact that fire use practices and their governance are described (sometimes tangentially) in literature crossing academic disciplines, including anthropology, geography, environmental sciences, and agronomy. Given the difficulties of identifying global trends from such diverse literature, we focus our systematic analysis on the intended and/or potential effects of specific policy interventions, rather than on whole governance systems.

We draw on the Livelihood Fire Database (LIFE; Smith and Mistry 2021) to categorize the range of policy interventions by state and/or non-state organizations that directly target or indirectly affect fire use that meets small-scale livelihood and/or cultural objectives. The LIFE data include information about 512 examples of such policy interventions in 68 countries (Fig. 1) from publications crossing academic disciplines, and grey literature. We

systematically coded the policy interventions based on the broad actor types involved, their mode of operation (e.g., regulatory, economic incentive), and their intentionality and/or possible effects vis-a-vis fire use. Given the level of detail in much of the literature under study, we could not systematically analyze the wider governance systems within which these individual policy interventions sit, e.g., by examining the interactions between multiple interventions, their higher-level aims or outcomes (e.g., ecological, cultural), or the mechanisms by which collaborations between actors are organized. We nonetheless draw observations from the reviewed literature to speak to some of these wider questions, as a way of contextualizing the findings of the systematic analysis. In our conclusions we use examples from the reviewed literature to consider how previous and co-existing policy interventions may affect efforts to support local fire use.

Fig. 1. Maps showing (1) the number of examples of policy interventions in the LIFE database (including regulations, economic incentives, and voluntary interventions) by country; (2) the number of policy interventions in the LIFE database per 10,000 km² by country; (3) mean annual burned area over the years 2001–2020 in km² by country (source GFED 5: Chen et al. 2023)



METHODS

The Livelihood Fire Database (LIFE; Smith and Mistry 2021), from which we develop this synthesis, is a global repository of information about landscape fire use practices that meet cultural and/or “small-scale” livelihood objectives such as agriculture, hunting, and ritual. Here “small-scale” livelihood activities are understood as those that rely on family labor, or labor exchange with other households, rather than the employment of laborers. LIFE draws upon published and grey literature written since 1995,

including non-English language sources, reporting on original empirical research carried out since 1990. Smith et al. (2022) provide full details of the literature search methodology. For this synthesis we re-ran the literature searches (in October 2022) and updated LIFE with six additional sources. LIFE includes data about policy interventions described in the literature to target and/or affect the fire use practices included in the database. We analyze this data, focusing on interventions involving state and non-state organizations that were in effect, or had lasting effects, within living memory. LIFE is the only existing repository of information suitable for such an analysis. One other global database of human fire use, the Database of Anthropogenic Fire Impacts (DAFI; Perkins and Millington 2021, Millington et al. 2022), exists, but this was developed to improve representation of human fire use in global fire models and is therefore predominantly quantitative.

Relevant information was recorded in three parts of the original LIFE database: (a) information about policy interventions by state and/or non-state organizations targeting and/or affecting fire use, (b) information about efforts by state and/or non-state organizations to enroll local fire users in prescribed burning, and (c) information about changes in fire use over recent decades, and drivers of these changes. In each of these categories, the database includes text summarizing the information in the source text, ranging from approximately 10 to 600 words in length. For this synthesis, we identified discrete policy interventions involving states and/or non-state organizations (512 in total) from the database text. Where multiple interventions of different kinds were part of the same wider project or program, we treated them separately for the analysis. For example, if a development project included a training course and a grant of equipment, these would be treated as two discrete policy interventions. Where multiple sources discussed the same policy interventions, e.g., where multiple case studies in the same country described the same national regulations, we combined the information to avoid double counting.

We then introduced six variables (defined fully in Table 1) to systematically characterize each policy intervention. Many sources in LIFE do not focus primarily on policy or governance, as the literature search terms were intended as complete a set as possible of studies describing fire use to achieve cultural and/or small-scale livelihood objectives. On the one hand, this has the advantage of including sources with some information about policy implementation that may have been overlooked in a narrower literature search. On the other hand, this restricted the elements of governance systems that we could systematically study across all case studies, because the detail provided in many sources was limited. This required us to develop an analytical framework that was not over-specified for the level of information available in most of the sources (as the Social-Ecological Systems Framework [Ostrom 2009], for example, would have been). As such we took a grounded approach to coding and derived variables and categories through an iterative process of reading the papers with the core research aim in mind (Glaser and Strauss 1967). The coding framework was refined and adapted through the process of coding, with earlier papers re-coded each time an adaptation was made. Having read in detail all the studies that contributed to the LIFE database, we contextualize the results of

our systematic coding with examples and observations from the literature drawing on those studies that did discuss wider elements of governance systems in more detail.

Among our six variables, we recorded whether the actor(s) initiating and enforcing or implementing the policy interventions were from state agencies, non-state organizations (including private sector, third sector, and multi-lateral organizations), and/or fire user communities (committees or leaders, for instance, in settlement[s] within which fire users reside). We listed multiples of these categories in cases of multi-level governance, or if there was ambiguity, e.g., if the authority of customary village leaders is enshrined by the state. We also categorized each policy intervention by its mode of operation as regulation, economic incentive, or voluntary, adapting a framework by Ring and Schröter-Schlaack (2011; see full definitions of these categories in Table 1). We then categorized policy interventions as direct (intended to influence fire use, e.g., a regulation intended to reduce fire use), versus indirect (not intended to influence fire use, e.g., the forced settlement of a nomadic population, such that livelihoods involving fire use are lost). We also categorized the potential (in cases of indirect policy interventions) or intended (in cases of direct policy interventions) effect of the intervention on fire use (e.g., reduction vs maintenance in fire use), and whether it was specific to protected areas. We focused narrowly on effects on fire use itself rather than on wider policy aims or outcomes related, e.g., to carbon emissions, ecosystems, or livelihoods, both because these wider aims were far less commonly recorded in the source literature and as they often differ from the perspective of different actors in cases of multi-level governance. Where possible, we used the LIFE database text to categorize the policy interventions, but where this provided insufficient information, we returned to the source text. Sometimes, there was insufficient information in the source text to fully categorize the examples, and we recorded a category as “unknown.”

Throughout this paper we summarize the information in LIFE by giving total numbers of examples of different types of policy interventions. We stress, for several reasons, that these numbers are not necessarily indicative of the extent to which different types of policy intervention affect fire use in practice. First, certain policy interventions are more likely to be mentioned in the literature. For instance, we might expect more mentions of direct than indirect policy interventions, especially in sources where governance is not the primary focus of the analysis. Second, some policy interventions (e.g., national regulations), operate at larger spatial scales than others (e.g., projects targeting a single village), and so are more likely to be described. Third, LIFE does not systematically record information about how effective policy interventions are in practice (in terms of changing fire use as per the categories in Table 1), because this information is rarely provided in the literature. Finally, our sample of policy interventions covers only 68 countries, leaving certain regions of the world underrepresented, including central Africa, eastern Europe, and northern, western, and central Asia, and certain countries overrepresented, including Brazil (62 examples), Mexico (40 examples), China (22 examples), Madagascar (22 examples), the USA (20 examples), and Australia (20 examples; Fig. 1). In some cases, e.g., the USA, more so than others, this likely largely represents a literature bias. For other countries, e.g.,

Table 1. Variables related to policy interventions that were coded in the Livelihood Fire Database (LIFE).

Column heading in LIFE	Description	Categories
A AUT	Actor(s) initiating the policy intervention	S: State N: Non-state organization (including private sector, third sector, and multi-lateral organizations) C: Fire user community U: Unknown
A IMP	Actor(s) enforcing or implementing policy intervention	S: State N: Non-state organization (including private sector, third sector, and multi-lateral organizations) C: Fire user community U: Unknown
TY	Policy intervention type	R: Regulation: A rule set down by an authority where the contravention of the rule carries a proscribed punishment. Or an explicit exemption from such a rule based on specific criteria, e.g., geographical area/ cultural group. E: Economic incentive: The receiving of material benefit or granting of relief from an otherwise expected payment, conditioned upon a particular behavior. V: Voluntary: Any mechanism that seeks to change behavior, but does not directly change the actor's material incentives, i.e., there is no explicit reward or punishment. This includes, for example, informational campaigns, training, or community agreements. U: Unknown
PE	Potential or intended effect of policy intervention on fire use	R: Reduction or elimination of fire use practice(s) C: Change the conditions under which fire is used M: Maintenance or expansion of fire use practice(s) already existing in the area I: Reintroduction or introduction of fire practice(s) not already existing in the area U: Unknown
INT	Is policy intervention intentionally related to fire?	D: Direct: intention of policy intervention is related to fire use I: Indirect: intention of policy intervention is not related to fire use U: Unknown
PA	Is policy intervention specific to protected area (s)?	Y: Yes N: No

Brazil, the size of the country (meaning more scope for localized projects) and particularly widespread fire use in smallholder agriculture and Indigenous livelihoods may have contributed to high numbers of policy interventions targeting fire use. Conversely, we would expect few policy interventions targeting fire use in regions where climate and vegetation limit burning (e.g., the Sahara), and in industrialized and service-based economies where there is very little fire use (e.g., most Western European countries). The geographical scope of the examples is a limitation of our study, but it is worth noting that it improves on previous reviews related to fire governance that have been heavily biased toward the global north. The wildfire governance literature reviewed by Kirschner et al. (2023), for instance, covered 23 countries, with 76% of publications focused on Europe, North America, or Australia. Meanwhile, 65% of publications on Indigenous fire management reviewed by Nikolakis and Roberts (2020) focused on North America or Australia. By contrast, 16% of the policy interventions we examine are examples from North America, Europe, Australia, or New Zealand.

RESULTS AND DISCUSSION

In the LIFE database there are 512 examples of policy interventions involving states and/or non-state organizations, including 309 examples where fire use is directly targeted and 203 examples where fire use is indirectly affected. Of these, 381 (74%) involve only state agencies in designing and implementing policy interventions, 21 (4%) involve only non-state organizations, 40 (8%) involve

collaboration between state agencies and non-state organizations, 48 (9%) involve collaboration between state agencies and fire user communities, and 6 (1%) involve collaboration between non-state organizations and fire user communities. Two hundred and fifty-five (50%) of the policy interventions are regulations, 101 (20%) are economic incentives, 101 (20%) are voluntary, and for 55 examples (11%) the policy intervention type is unclear. Tables 2 and 3 summarize the categories of policy intervention included in the LIFE database, Appendix 1 expands Table 2 with illustrative examples from the literature.

Policy interventions directly targeting fire use

Of the 309 policy interventions that directly target fire use, 155 (50%) aim to reduce or eliminate fire use and 114 (37%) aim to change the conditions under which fire is used. Only 3 (1%) aim to maintain or expand existing fire use practices, while 30 (10%) aim to introduce new burning practices, sometimes based on historical fire practices or local knowledge. If there is a bias in reporting of policy interventions based on their aims, we might expect it to be toward fire (re)introduction efforts, because of growing academic interest in such cases. These percentages thus suggest that state and non-state organizations have a greater interest in mitigating (perceived) risks of anthropogenic fire, than in enabling people to meet cultural and/or small-scale livelihood objectives associated with burning.

Table 2. Descriptions of policy interventions that fit each combination of categories of policy intervention type, intended or potential effect and intentionality vis-à-vis fire use. Appendix 1 provides an expanded version of this table with illustrative examples and references for each.

Intended or potential effect	Policy intervention type					
	Regulation		Economic incentive		Voluntary	
Reduce or eliminate fire use	Direct:	Laws against burning (30 of which examples specific to protected areas)	Direct:	Payments for ecosystem services or carbon market schemes where people are paid not to burn; Subsidy schemes for agriculture that specify no burning; Provision of land or resource rights on the condition of fire exclusion	Direct:	Public information campaigns / propaganda / training with anti-fire message
	Indirect:	Laws that limit or criminalize livelihood practices that involve fire, (16 of which examples specific to protected areas); Land dispossession and/or forced (re) settlement by the state, to establish protected areas, infrastructure projects, permanent villages etc.	Indirect:	Provision of land titles conditional on land uses that replace land uses involving fire; Subsidies, grants of resources etc. to motivate adoption of livelihoods that replace livelihoods involving fire use; Carbon market schemes where people are paid to stop livelihood practices that involve fire use; Removal of economic supports for livelihood practices that involve fire use	Indirect:	Public information campaigns / propaganda / training to encourage adoption of livelihoods that replace livelihoods involving fire use
Change the conditions under which fire is used	Direct:	Laws specifying legal conditions for burning, e.g., certain weather conditions, times of year, having a permit; Decentralization of fire governance by granting of legal backing to village authorities to make rules related to fire	Direct:	Provision of equipment to accompany burning; Certain conditions for permitted burning under agri-environmental scheme	Direct:	Public information campaigns / propaganda / training to promote certain burning techniques; Introduction of village committees/ institutions to govern burning, where these do not have legal backing
	Indirect:	Introduction of new local leadership structure, replacing pre-existing leadership that governed fire use	Indirect:	No examples	Indirect:	No examples
Maintain or expand existing fire use practice	Direct:	No examples	Direct:	No examples	Direct:	Policies or projects that support local burning practices but without funding them
	Indirect:	Laws establishing rights for Indigenous peoples to practice cultural activities	Indirect:	Provision of land titles, subsidies, grants of resources, or creation of markets that expand livelihood practices associated with fire use	Indirect:	No examples
(Re)introduce fire practice	Direct:	Laws establishing rights for Indigenous peoples to use prescribed fire	Direct:	Payment schemes to support prescribed burning by Indigenous/local people, including through carbon markets	Direct:	Projects or policies that support prescribed burning by Indigenous/local people but without funding it
	Indirect:	No examples	Indirect:	Allocation of land, subsidies, grants of resources etc. that motivate adoption of new livelihoods that involve fire use	Indirect:	No examples

Policy interventions intended to reduce, eliminate, or constrain fire use

The LIFE database includes 98 examples of regulations aimed at preventing fire use, such as a total ban on burning introduced in Central Kalimantan in Indonesia in 2015 (Silvianingsih et al. 2020). A further 70 examples are regulations specifying legal conditions for burning, such as national regulations in Brazil requiring fire users to obtain a permit from the state, create fire breaks, and have a minimum of 4 personnel on-site until fire is extinguished (Carmenta et al. 2013). Sometimes such restrictions, were they enforced, would effectively make fire use impossible. For instance, in most municipalities in Campeche, Mexico, the legal burning period does not correspond with the times when climatic conditions are suitable for burning (Monzón-Alvarado et al. 2014).

All these cases of regulations involve state authorities, though 18 involve non-state organizations or communities in enforcement. For example, community forestry regulations developed in the Gambia in the 1990s, made burning illegal in community forests, and made communities responsible for enforcing anti-burning regulations through establishment of Community Forestry Committees who could penalize offenders and report activities to

the national Forestry Department (Sonko et al. 2002). Regulations against, or limiting, burning can apply at various scales. In many countries national regulations govern fire use, but regulations may also exist at provincial or local levels. In the Brazilian Amazon, for example, burning is covered by federal, state, and municipal regulations (Carmenta et al. 2013). In Mali, in the early 2000s, the government devolved control of village woodlands to the village level, making village leaders responsible for establishing and enforcing rules about fire use, provided they complied with national guidelines (Laris 2002). Some regulations are specific to certain land designations. There are 36 examples in LIFE where regulations apply specifically to protected areas. Other regulations are specific to certain fire uses. For instance, in Belize, agricultural burning is legal, while other fire uses, e.g., for hunting, are not (Smith 2021).

The reviewed literature suggests that regulations do not always effectively reduce or constrain burning. Sometimes strict enforcement of anti-fire regulations has led to reductions in fire use, as during the 1980s in Mali, when burning penalties contributed toward 37% of the Forest Service's budget (Laris 2004). Yet, for several reasons, people do not always comply with fire regulations, and enforcement is generally difficult. Sometimes,

Table 3. Number and percentage examples of policy interventions in the Livelihood Fire Database (LIFE) that fit each combination of categories of policy intervention type, intended or potential effect and intentionality vis-à-vis fire use.

Intended or potential effect	Policy intervention type				Total
	Regulation	Economic incentive	Voluntary	Unclear	
Reduce or eliminate fire use	Direct: 98 (19%) Indirect: 65 (13%)	Direct: 13 (3%) Indirect: 61 (12%)	Direct: 28 (5%) Indirect: 13 (3%)	Direct: 16 (3%) Indirect: 32 (6%)	Direct: 155 (30%) Indirect: 171 (33%) Total: 326 (64%)
Change the conditions under which fire is used	Direct: 70 (14%) Indirect: 5 (1%)	Direct: 6 (1%) Indirect: 0	Direct: 37 (7%) Indirect: 0	Direct: 1 (< 1%) Indirect: 0	Direct: 114 (22%) Indirect: 5 (1%) Total: 119
Maintain or expand existing fire use practice	Direct: 0 Indirect: 6 (1%)	Direct: 0 Indirect: 8 (2%)	Direct: 3 (1%) Indirect: 0	Direct: 0 (< 1%) Indirect: 1 (< 1%)	Direct: 3 (1%) Indirect: 15 (3%) Total: 18 (4%)
(Re)introduce fire practice	Direct: 3 (1%) Indirect: 0	Direct: 7 (1%) Indirect: 6 (1%)	Direct: 18 (4%) Indirect: 0	Direct: 2 (< 1%) Indirect: 2 (< 1%)	Direct: 30 (6%) Indirect: 8 (2%) Total: 38 (7%)
Unclear	Direct: 5 (1%) Indirect: 3 (1%)	Direct: 0 Indirect: 0	Direct: 2 (< 1%) Indirect: 0	Direct: 0 Indirect: 1 (< 1%)	Direct: 7 (1%) Indirect: 4 (1%) Total: 11 (2%)
TOTAL	Direct: 176 (34%) Indirect: 79 (15%) Total: 255 (50%)	Direct: 26 (5%) Indirect: 75 (15%) Total: 101 (20%)	Direct: 88 (17%) Indirect: 13 (3%) Total: 101 (20%)	Direct: 19 (4%) Indirect: 36 (7%) Total: 55 (11%)	Direct: 309 (60%) Indirect: 203 (40%) Total: 512

fire users are unaware of regulations. Of farmers interviewed in land bordering a Tanzanian protected area, for instance, 80% were unaware of legal requirements to obtain permits for burning (Denny 2015). Where burning is indispensable for meeting cultural or small-scale livelihood activities, especially where households lack access to heavy machinery and other alternative means of landscape management, people are unlikely to comply with fire bans or restrictions that jeopardize the quality of burns. For instance, in the Brazilian Amazon, smallholder farmers burn shortly after midday when hot, dry, and relatively windy conditions increase the likelihood of a complete burn, rather than early in the morning or evening as per the regulations (Carmenta et al. 2013). Here, following the regulations would increase the risk of needing to burn twice, increasing labor costs. People may also be unable to comply with regulations because of lack of human or material capacity. For example, in Russia, only individuals holding a fire security qualification are permitted to burn crop residues, but most smallholder farmers in Western Siberia lack financial capacity to obtain the qualification (Theesfeld and Jelinek 2017). Fire is also easily anonymized, making it, as Kull (2002a:942) puts it, “a powerful ally of fire-reliant peasants.” In Madagascar, peasants avoid detection by burning at night, out-of-sight, or using time-delay ignition techniques, letting fires run their course unattended, or allowing authorized fires to escape “accidentally” (Kull 2002a). In regions where fire use is widespread, the state agencies responsible for enforcement of fire regulations (generally state forestry services) often lack the necessary resources (see, e.g., Hoare 2004, Shaffer 2010). Finally, as in Madagascar (Kull 2004), Mexico (Mathews 2005), and the Philippines (Dressler et al. 2021), although central governments may regulate against burning, in practice, local officials often recognize the necessity of fire for local livelihoods and turn a blind eye.

The reviewed literature suggests that fire regulations can have unintended effects. Sometimes they lead to more covert burning. In the Bale Mountains National Park in Ethiopia, for example,

pastoralists now burn later in the dry season when the vegetation is very dry and it is easier to succeed with a quick point ignition “on the sly,” and individuals, including children who cannot be imprisoned, burn alone, when historically groups of men burned together (Johansson et al. 2019). This covert burning has contributed to a situation whereby large, uncontrolled wildfires have increased fivefold since fire use became illegal. Meanwhile, in Ireland, fire regulations undermine the intergenerational transmission of fire knowledge because pastoralists burning outside of the legal season usually do so alone (Carroll et al. 2021). Rodríguez (2007) describes another form of “silent resistance” to fire regulations, whereby Pemón people in Venezuela set small fires specifically to irritate the managers of the Canaima National Park, where burning is illegal.

LIFE also includes 19 examples of economic incentive schemes aimed at reducing or constraining fire use, with 13 examples designed by state agencies (including some cases of financing by foreign states), and 6 examples designed by non-state organizations (sometimes in collaboration with state agencies). These include cases where payments, subsidies, land or resource rights, or equipment are provided in exchange for, or to encourage, no burning, or burning under certain conditions. For example, under the Payments for Ecosystem Services (PES) scheme “SocioPáramo” in Ecuador, Indigenous or peasant cooperatives received annual payments to cease pastoral burning on their collective title lands (Bremer et al. 2014). Meanwhile, in Madagascar, the transfer of management rights for natural resources from the state to voluntary residents’ associations in the 1990s was conditional upon the creation of new *dina* (customary rules with legal status) to regulate fire use, which were required to conform with the national regulations restricting fire use (Kull 2002b). Few sources evaluate the effectiveness of these economic incentive schemes. Yet, as with enforcement of anti-fire regulations, we might expect limited capacity to ensure compliance with the rules in these schemes, both because fire users can burn covertly, and as noted by Bremer et al. (2014) and Kull

(2002b), because agencies often lack capacity for enforcement. In PES or carbon offset schemes there are also potential problems with additionality, as in the Ecuadorian case, where many areas of land covered by the PES scheme were already unburned and un-grazed, making it difficult to prove that the scheme itself had changed fire use (Bremer et al. 2014). Offset schemes can also lead to leakage, as in Ethiopia, where restrictions on burning within the Bale Mountains National Park, including as part of a Reducing Emissions from Deforestation and Forest Degradation (REDD+) project, led to unintended increases in fire use in land surrounding the park that was not covered by the scheme (Johansson et al. 2019).

LIFE includes 65 voluntary policy interventions aimed at reducing or constraining fire use, with 43 examples designed by state agencies, and 22 by non-state organizations (sometimes in collaboration with state agencies). These include public information campaigns or training events with an anti-fire message or promoting specific conditions for burning. An example is a communications campaign run by the state forestry agency in Bolivia in the early 2000s, employing posters, radio, cartoon books, and community workshops to promote safe burning practices (McDaniel et al. 2005). Very few literature sources evaluate the effectiveness of such campaigns, many of which are short-term. Given the evidence that fire regulations may be ineffective where fire use is indispensable to local culture or livelihoods, we might expect voluntary policy interventions to be similarly ineffective in such cases. There is evidence, however, that communication campaigns can change local perspectives on fire. In Venezuela, for example, following anti-fire education campaigns by the state agency managing the Canaima National Park, some Pemon people, especially youth, adopted an anti-fire rhetoric, generating intra-community conflict over fire and interrupting intergenerational transmission of fire knowledge (Rodríguez 2007).

There is evidence that policy interventions can have lasting effects on actors' understanding of fire as a problem beyond their implementation period. In Mali and Madagascar, for example, while recent policies support controlled fire use, in practice, government is still dominated by an anti-fire attitude with roots in the colonial era (Kull and Laris 2009). In Madagascar, pastoral burning is technically permitted in certain seasons, but after a history of anti-fire messaging, most peasants believe it is illegal (Kull 2002b). A history of anti-fire policy interventions may also leave mistrust between fire users and government and non-state organizations. Rodríguez (2007) and McDaniel et al. (2005) describe situations in which researchers and/or agency staff now struggle to discuss fire or collaborate with fire users for fire management.

The LIFE examples also suggest that where policy interventions do reduce fire use in fire-dependent ecosystems, this can change the risks associated with burning, due to fuel accumulation. In the montane heathlands of the Bale Mountains National Park in Ethiopia, for example, fire restrictions have reduced burning in the early dry season, making it harder to control late-dry season fires (Johansson et al. 2019). Similarly, in Malian savannas, during the 1980s, when fire regulations were strongly enforced, a reduction in anthropogenic fire led to larger wildfires (Laris 2004).

Policy interventions intended to expand or (re)introduce fire use
There are only three examples of policy interventions in LIFE which explicitly aim to maintain or expand existing fire use practices. All are examples of voluntary policy interventions where the importance of local fire use is recognized in policies without legal backing. For example, in the 1990s, the management policy for the Kakadu National Park in Australia was to “re-establish the patterns of traditional Aboriginal burning,” and Aboriginal residents could burn for hunting and gathering (Roberts 1997). In this case (and similarly in the other two reviewed examples), policy implementation was constrained by co-existing fire regulations. For instance, the park managers were liable for any fires that escaped the park boundaries and caused damage, which, in practice, led them to seek greater control over the fire regime in the park (Petty et al. 2015).

There are more examples in LIFE (30) where people are encouraged to adopt new burning practices, or reintroduce burning, through collaboration with agencies. These fire use practices draw to varying extents on local fire knowledge and technical or scientific knowledge. In these cases, burning may fulfil local cultural and/or small-scale livelihood objectives, but is usually also designed to fulfil external objectives such as wildfire risk mitigation or greenhouse gas emissions reduction. Of these policy interventions, 17 involve state agencies, 3 non-state organizations, and 10 both state agencies and non-state organizations.

Of these interventions aiming to (re)introduce burning practices, 18 are voluntary policy interventions and form part of short-term projects. For example, in 2009 in Honduras, members of local forestry cooperatives were trained by NGOs in prescribed burning, but this was not followed up with financing or a legal mandate to encourage the practice (Lineal and Laituri 2013). In a few cases (three in LIFE), regulations encourage re (introduction) of burning practices. For instance, in the USA the 2004 Tribal Forest Protection Act promotes cooperation between First Nations people and state agencies to carry out prescribed burning to reduce wildfire risk to tribal forest resources (Steen-Adams et al. 2017). In other cases (seven in LIFE), economic incentives encourage re(introduction) of burning practices. There is, for instance, growing interest in funding local fire management through carbon markets. This includes payments to communities to conduct prescribed burning to reduce emissions from uncontrolled wildfires, an accountable greenhouse gas emissions reduction activity under the 1997 Kyoto Protocol. In Australia, which has pioneered this approach since 2006, government authorities, non-governmental organizations, and private corporations have partnered with Aboriginal native title holders to develop Indigenous burning projects (Whitehead et al. 2008, Ansell et al. 2020). These generate carbon credits that are sold to private corporations or to the government through carbon abatement contracts. As of 2019, there were over 70 Indigenous burning projects in Northern Australia alone, accounting for 10% of Australia's carbon credit issuance. Drawing on the Australian example, there is now interest in developing similar prescribed burning projects with Indigenous people in savannas in Africa and Central and South America (ISFMI 2015, Lipsett-Moore et al. 2018, Russell-Smith et al. 2021, Croker et al. 2023b).

From the reviewed literature it is difficult to assess how successful many of these policy interventions have been in (re)introducing burning practices, given the short-term nature and recency of many projects, and a lack of long-term evaluation. The examples given above suggest that sustained financing makes the adoption of burning practices more likely. In the Honduran and USA cases, lack of funding was described as a barrier to prescribed burning (Lineal and Laituri 2013, Steen-Adams et al. 2017). Meanwhile, in Australia, where carbon credit schemes have provided sustained funding for Indigenous burning projects, they have been established at scale. In Arnhem Land, for example, carbon credits funded Aboriginal rangers to ignite prescribed fires along a yearly mean total of 80,891 km of transects from 2020 to 2023 (ALFA 2021, 2022, 2023). Examples in the literature also suggest that partnership between local people and agencies for prescribed burning rests on long-term commitment by individuals within fire user communities and external agencies to establish mutual trust, often in the face of entrenched inequalities. Neale et al. (2019), for example, argue that interpersonal relationships between Dja Dja Wurrung people and staff of wildfire management agencies in Victoria, Australia, and their mutual belief in the need for partnership, have been vital in bringing about collaborative fire management. In their review of engagement between Indigenous peoples and the state natural hazard sectors in Canada, Australia, New Zealand, and the USA, Thomassin et al. (2019:173) also surmise that the success of such partnerships rests not on policy but on “committed individuals willing to devote time and resources to shared aims.”

Where external aims and standardized protocols take priority over local aims and knowledge, attempts to encourage the adoption of new burning practices may undermine existing fire use practices and local fire governance. For example, in tropical savannas, funding is sometimes available to local people to conduct early dry season burns, as these are deemed to offset greenhouse gas emissions (Lipsett-Moore et al. 2018). Yet, Indigenous burning regimes in savannas are not limited to the early dry season and may extend throughout the year (Fache and Moizo 2015, Eloy et al. 2019, Laris 2021). In Arnhem Land, Australia, use of technologies such as aircraft in Aboriginal burning projects has caused controversy within some Aboriginal communities, where some people feel that their fire knowledge is being subjugated to technical expertise (Fache and Moizo 2015, Petty et al 2015). In Brazil, Eloy et al. (2019), suggest that the establishment and state funding of community fire brigades to conduct prescribed burning on behalf of other community members turned communities into “beneficiaries of a service.” Fire brigade activities, being planned months in advance, could not emulate traditional fire management, which is more opportunistic and responsive to local social, ecological, and spiritual factors.

Policy interventions that indirectly affect fire use

State and non-state organizations reshape landscapes and livelihoods, for example, through infrastructural development, land tenure reforms, trade agreements, or introduction of new local leadership structures. Such policy interventions can indirectly affect fire use. The LIFE database includes 199 examples of this, of which 69% involve states, 6% involve non-state organizations, and 10% involve collaboration between state and non-state organizations. Forty percent of these examples of interventions are regulations, 38% are economic, and only 7% are voluntary.

Policy interventions that indirectly reduce, eliminate, or constrain fire use

Most (88%) of the examples of policy interventions that indirectly affect fire use involve a reduction in, or cessation of, burning. In some cases, burning reduces or ceases because people lack access to sufficient land after forced displacement, (re)settlement, and/or villagization, for example, through the establishment of protected areas, infrastructure projects, or industrial land uses. For instance, in the Brazilian Cerrado, some Xavante people have been forced to abandon livelihoods involving hunting and associated fire use, because of large-scale conversion of land to oil palm and commercial cattle ranches, which has been promoted by the state (Welch and Coimbra 2021). In South Africa, under rural development schemes implemented by the state in the 20th century, people were relocated from dispersed settlements into centralized villages, abandoning agricultural land where fire had previously been used (Chalmers and Fabricius 2007).

Fire use can also change with land reform. Many states deny communities collective land tenure, claiming communally managed areas as state land and introducing private land ownership or leasehold. In Mizoram, India, provision of land titles to individual households under the New Land Use Policy of 2011 effectively prevented swidden agriculture, which relies on temporary clearance of plots across a large land area (Bose 2019).

Fire use is also indirectly affected when policy interventions promote intensive agriculture or conservation, and marginalize other livelihood practices including swidden agriculture, hunting, and nomadic pastoralism. This can be achieved through various mechanisms. In some cases, regulations forbid livelihood practices that involve fire. In Tanzania, for example, hunting is criminalized (Wood et al. 2022). Elsewhere economic policies promote change in livelihoods. In Mexico, for example, the North American Free Trade Agreement (NAFTA) has reduced the viability of small-scale agriculture, encouraging men in La Sepultura Biosphere Reserve to abandon swidden agriculture and migrate for contract work (Huffman 2010). Meanwhile, in Indonesia, REDD+ payments are conditional upon households limiting land use for swidden agriculture (Thaler and Anandi 2017). In some cases, public information campaigns encourage alternative livelihoods. In Sierra Leone, for example, the state and NGOs have run awareness campaigns promoting alley farming (cultivation of crops between hedgerows of trees) instead of swidden agriculture (Conteh et al. 2016).

The replacement of traditional local authorities can also indirectly alter fire use. Colonial regimes often changed the role of local chiefs in local resource politics, either replacing them with new governance structures, or co-opting them to extend state control. Fire use by the Teke-Alima in Gabon, for instance, was historically governed by land chiefs, but their authority was undermined when the French colonial state introduced nominated “traditional authorities” (Walters 2015). This change in governance has driven a transition from annual, communal hunting fires to semi-annual hunting fires set by individuals.

The reviewed literature suggests that where policy interventions indirectly lead to reductions in burning, this can increase wildfire risk. In some cases, the marginalization of fire use drives changes in local fire governance institutions. For example, engagement in wage labor, cattle-rearing, and permanent agriculture have

changed the social relations around swidden agriculture in Maya villages in Belize, such that burning is now more likely to be practiced alone rather than in shared labor groups, decreasing control over fire (Peller 2021). Changes in land use may also increase the flammability of landscapes, driving changes in fire use and local fire use governance. For example, in Pará, Brazil, landscapes dominated by pastures containing invasive grasses are more flammable, and collective action to control agricultural fires is also less likely in such landscapes, because these efforts may be futile (Cammelli and Angelsen 2019).

Policy interventions that indirectly drive increased fire use, or (re)introduction of fire use

There are 18 examples in LIFE where policy interventions have indirectly driven maintenance or increase in existing fire use practices. Six of these examples are regulations establishing rights for Indigenous or traditional peoples to practice cultural activities, where this could be interpreted to include fire use. In Australia, for example, the Federal Native Title Act of 1993 protects the right of native title holders to carry out hunting and gathering activities, which often involve burning (Hill et al. 1999). In this case, there is potentially conflicting legislation restricting burning, and it was unclear in Queensland in the 1990s which would take precedence in a legal case. In another eight examples, increases in fire use have been driven by economic policies. The Brazilian government, for instance, between 1960 and 1980, created colonization programs to develop the Amazon region, privatizing public land and granting it to immigrants (Vosti et al. 2003, Pokorny et al. 2021). This drove the expansion of semi-permanent agriculture and cattle-rearing involving fire use.

There are eight examples in LIFE where policy interventions have indirectly driven the introduction of new fire use practices. In Punjab, for example, in the late 20th century, minimum support price schemes and grants of seeds and irrigation infrastructure by the Indian State encouraged the intensification of smallholder agriculture and the adoption of rice-wheat double cropping (Sidhu et al. 1998). Under this agricultural system farmers adopted crop residue burning as the most efficient way to prepare land in the short window between crops. Fire use may also morph from a practice to meet cultural and/or small-scale livelihood objectives into a protest strategy against state policies when these clash with local land use preferences (Guha 2000, Seijo 2005, Gerber 2010).

CONCLUSIONS

Our synthesis suggests that, in living memory, policy interventions by state agencies and non-state organizations overwhelmingly reduced or constrained fire use and/or aimed to do so (this applies to 87% of examples in the LIFE database). Examples in the reviewed literature point to several potential challenges posed by this existing governance landscape for contemporary efforts to revive or support local fire use.

Where burning to meet cultural and/or small-scale livelihood objectives is supported, this is often in policies offering direction to government programs that are not mandated by law. Legislation often leaves the legality of burning by “small-scale” fire users unclear. In Belize, for instance, while national fire policy identifies the importance of fire in local livelihoods, legislation retained from the colonial period criminalizes burning other than for agriculture (Smith 2021). If burning is legal under certain

conditions, these may be overly restrictive, constituting de facto bans. Even in rare cases where the right to burn is enshrined in law, this can still contradict other legislation, as in 1990s Queensland, Australia, where it was unclear whether Aboriginal rights to practice cultural activities under the Native Title Act took precedent over other regulations restricting burning (Hill et al. 1999). These examples suggest a need for future research to systematically examine, across case studies, how different policy interventions interact to affect fire use.

Our synthesis also demonstrates how many policy interventions that reduce fire use do so indirectly, for instance by undermining livelihoods that involve fire use, restricting land access, or dividing communal lands into private parcels. This suggests that governance directed specifically at fire would, in most cases, be insufficient to support fire use. States will need to create wide-reaching enabling conditions, by upholding customary land tenure, leadership, and livelihoods. It is perhaps unsurprising that the most extensive existing programs to support/restore Indigenous fire management are in Australia, the USA, and Canada, all settler-colonial contexts with strong Indigenous social movements, where the rights of Indigenous peoples to customary land tenure and land use are increasingly recognized, and Indigeneity increasingly holds political capital (Ansell et al. 2020, Marks-Block et al. 2021, Nikolakis and Ross 2022, Neale 2023).

Where fire use has reduced, burning carries risks that burden fire user communities and that may challenge the revival of fire use (Carmenta et al. 2021). Fires are harder to control in landscapes carrying high fuel loads following reduced burning. Burning is also riskier where local fire knowledge and local fire governance arrangements have been lost, because controlled burning relies on understanding how fire interacts with specific environments, and upon cooperation between people.

Examples in the reviewed literature highlight how fire suppression histories have left some fire user communities internally divided over fire and have engendered mistrust between communities and external agencies. There may be a need to (re)build strong communication and interpersonal relationships within communities and between communities and external agencies. The Canaima National Park, Venezuela, provides an example here. After years of anti-fire messaging, Pemon communities in the park were internally divided over fire, and facilitated discussion within communities was key to developing new, shared, fire narratives with which to counter the fire suppression paradigm (Rodríguez et al. 2018). Indigenous leaders, institutional representatives, and academics have since engaged in a 4-day workshop, which allowed for a greater appreciation of others’ perspectives, helped to contest long-held assumptions about Indigenous fire use, and began a process of developing a shared vision for managing fire in the park (Bilbao et al. 2019).

As Neale et al. (2019) argue, focusing on Victoria State, Australia, strong interpersonal relationships between members of fire user communities and external agencies sustain trust and communication in the longer term. Such interpersonal relationships can be fostered in formal institutional settings, even as they also go beyond them. In Victoria, for instance, a formal Recognition and Settlement Agreement between the state and Dja Dja Wurrung people, and the integration of Dja Dja Wurrung people into government agencies as employees and advisors,

created a space in which interpersonal relationships between state agency staff and Dja Dja Wurring people could develop. These examples suggest a need for further research that systematically examines, across case studies spanning the Global North and South, how multi-level fire use governance is organized, and the factors that influence the longevity and success of collaborations between different types of actors. Thomassin et al. (2019) and Croker et al. (2023a) provide a precedent here, but each have a regional focus.

As state and non-state organizations move away from fire suppression toward support for local fire use, it will be important to clarify the reasons for this move. Examples from our analysis suggest that to date, projects supporting local fire use have often focused on participation in prescribed burning, with externally driven objectives of wildfire risk reduction, mitigation of carbon emissions, and biodiversity conservation (Mistry et al. 2016, Croker et al. 2023a). Fire use may not always be able to fulfil wildfire risk reduction, mitigation of carbon emissions, biodiversity conservation, cultural and/or small-scale livelihood objectives simultaneously (Laris 2021, Laris et al. 2021, Croker et al. 2023b). Future research should systematically examine, across case studies, how the objectives of different types of actors differ or align in multi-level fire use governance, and how trade-offs among objectives have been approached. It would be valuable to map out the types of actors involved in fire use governance in more detail.

Echoing Thomassin et al. (2019) and Weir (2023), we would argue that support for local fire use should be more strongly driven by desire for environmental justice or equity, taking local values more strongly into consideration. Following Schreckenber et al. (2016), we might understand more equitable fire governance to involve not only fairer distribution of the material benefits and costs of fire, but also greater recognition of how diverse communities interact with fire and greater participation by fire-user communities in political processes governing fire use. Future research might examine the outcomes of policy interventions in these terms of distribution, recognition, and participation.

Acknowledgments:

This research was funded by the Leverhulme Trust under grant RC-2018-23. We thank two anonymous reviewers for their helpful comments.

Data Availability:

The full LIFE database (including coding of governance examples done for this study) and accompanying metadata are freely available on Figshare at <https://doi.org/10.17637/rh.c.5469993>.

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Appendix 1 to the article ‘How policy interventions influence burning to meet cultural and small-scale livelihood objectives’

Expanded version of Table 2 in the main text of the article, with illustrative examples and references.

Intended or potential effect	Policy intervention type					
	Regulation		Economic Incentive		Voluntary	
Reduce or eliminate fire use	Direct	Laws against burning (30 of which examples specific to protected areas) - e.g., in Indonesia a national burning ban was introduced in 2015 (Silvianingsih et al. 2020)	Direct	Payments for ecosystem services or carbon market schemes where people are paid not to burn – e.g., the Socioparamo scheme in Ecuador (Bremer et al. 2014)	Direct	Public information campaigns / propaganda / training with anti-fire message – e.g., Anti-fire educational programs run by the management agency of Canaima National Park in Venezuela (Rodríguez 2007)
				Subsidy schemes for agriculture that specify no burning - e.g., agri-environment schemes in Hungary (Molnár 2014)		
				Provision of land or resource rights on the condition of fire exclusion - e.g. exclusion of fire as a condition of community forestry in The Gambia (Sonko et al. 2002)		
	Indirect	Laws that limit or criminalize livelihood practices that involve fire, (16 of which examples specific to protected areas) - e.g., prohibition on cutting mature vegetation for swidden agriculture in Mexico (Dobler-Morales et al. 2019)	Indirect	Provision of land titles conditional on land uses that replace land uses involving fire - e.g., land titling in Mizoram, conditional on use for settled agriculture, not swidden (Bose 2019)	Indirect	Public information campaigns / propaganda / training to encourage adoption of livelihoods that replace livelihoods involving fire use - e.g., awareness raising about alley farming as an alternative to swidden in Sierra Leone (Conteh et al. 2016)
Subsidies, grants of resources etc. to motivate adoption of livelihoods that replace livelihoods involving fire use - e.g., the Tanzanian National Maize Project, which provided maize seeds, fertilizers, and pesticides, encouraging shift from swidden to intensive maize production (Itani 2007)						
Carbon market schemes where people are paid to stop livelihood practices that involve fire use - e.g., Reducing Emissions from Deforestation and forest Degradation (REDD+) in Indonesia, which limits land area households can use for swidden agriculture (Thaler and Anandi 2017)						
		Land dispossession and/or forced (re)settlement by the State, to establish protected areas, infrastructure projects, permanent villages etc. - e.g., collectivization in Maoist China (Urgenson et al. 2014)				

				Removal of economic supports for livelihood practices that involve fire use – e.g., structural adjustments and trade liberalization in Mexico which reduced viability of smallholder swidden agriculture (Dobler-Morales et al. 2019)		
Change the conditions under which fire is used	Direct	Laws specifying legal conditions for burning, e.g., certain weather conditions, times of year, having a permit (6 of which examples specific to protected areas)- e.g., the Mexican national regulation on fire use (NOM-015-SEMARNAT/SAGARTPA-2007) (Monzón-Alvarado et al. 2014)	Direct	Provision of equipment to accompany burning - e.g., projects dispensing fire equipment to communities in Indonesia (Akbar 2011)	Direct	Public information campaigns / propaganda / training to promote certain burning techniques - e.g., posters, radio adverts, cartoon books and community workshops designed to educate rural residents in Bolivia about ‘proper’ techniques for burning (McDaniel et al. 2005)
		Decentralization of fire governance by granting of legal backing to village authorities to make rules related to fire – e.g., granting of responsibility to village leaders in Mali to establish and enforce rules about fire, within the guidelines of the forestry service (Laris 2004).		Certain conditions for permitted burning under agri-environmental scheme – e.g. scheme that pastoralists in the Cévennes National Park in France participate in (Dumez 2004)		Introduction of village committees/ institutions to govern burning, where these do not have legal backing – e.g., committees established by an NGO in Roboré in Bolivia (Devisscher et al. 2019)
	Indirect	Introduction of new local leadership structure, replacing pre-existing leadership that governed fire use - e.g., loss of power by Land Chiefs in Gabon, due to introduction of new local authorities by French colonial state (Walters 2015).	Indirect: No examples	Indirect: No examples		
Maintain or expand existing fire use practice	Direct: No examples		Direct: No examples		Direct	Policies or projects that support local burning practices but without funding them – e.g., maintenance of traditional Aboriginal burning is an explicit aim in the management policy of

					Kakadu National Park in Australia (Roberts 1997)
	Indirect	Laws establishing rights for Indigenous peoples to practice cultural activities - e.g., the Australian Federal Native Title Act (Hill et al. 1999)	Indirect	Provision of land titles, subsidies, grants of resources, or creation of markets that expand livelihood practices associated with fire use – e.g., Allocation of agricultural land to households in 1980s China, which drove expansion of swidden agriculture (Long and Zhou 2001).	Indirect: No examples
(Re) introduce fire practice	Direct	Laws establishing rights for Indigenous peoples to use prescribed fire – e.g., the Tribal Forest Protection Act 2004 in the USA promoted tribal government - federal agency cooperation to conduct prescribed burning to reduce wildfire risk to tribal forest resources (Steen-Adams et al. 2017)	Direct	Payment schemes to support prescribed burning by Indigenous/local people, including through carbon markets - e.g., Emissions Abatement through Savanna Fire Management in Australia that allows registered Indigenous fire projects to earn Australian Carbon Credit Units for early-dry season burning (Ansell et al. 2020)	Direct Projects or policies that support prescribed burning by Indigenous/ local people but without funding it - e.g., Training in prescribed burning for community forestry groups in Honduras (Lineal and Laituri 2013)
	Indirect: No examples		Indirect	Allocation of land, subsidies, grants of resources etc. that motivates adoption of new livelihoods that involve fire use - e.g., minimum support price schemes, and grants of seeds and irrigation infrastructure by the Indian state to support intensification of smallholder agriculture has indirectly driven increase in crop residue burning in Punjab state (Sidhu et al. 1999)	Indirect: No examples

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