Where Policy and Culture Collide: Perceptions and Responses of Swidden Farmers to the Burn Ban in West Kalimantan, Indonesia

Abstract

Catastrophic uncontrolled fires are a leading social-environmental challenge that now occur even the humid tropics. In 2015 extensive Indonesian peatland fires commanded national and international attention and resulted in a ban on all burning in the country extending to traditional farmers practicing small-scale fire-based agriculture on mineral soils. However, the impacts of, and responses to, the ban on these fire-dependent communities is not well understood. Understanding the mental models of communities exposed to environmental change, and its corresponding policy responses, can provide salient insights into the place-based experience of change to identify contested perceptions and serve to improve the distributional equity of associated impacts. We assessed the mental models of Dayak farmers in Kapuas Hulu, Kalimantan, in three distinct landscape contexts: i) oil palm (OP), ii) national park (NP), and iii) transition (T) sites. These locations enabled insights into how different contemporary landscape contexts and livelihood opportunities are related to experiences and coping strategies. We collected data using the Conceptual Content Cognitive Mapping approach in two communities in each landscape context (n = 24 participants per landscape), and 72 interviews in total. Results show that the NP and T sites were most similar, whilst the OP communities held distinct perceptions of fire. In addition to the agricultural value of fire, cultural and relational values are associated with fire use across sites and would be severed through fire prevention. Finally, we show that the burdens of the burn ban for farmers and forests were most pronounced in the NP

and T sites where farmers are most reliant on traditional agriculture, have the fewest livelihood alternatives and least external support to fight uncontrolled fires.

Keywords: Burning fallows, swidden agriculture, peat fires, mineral soils, mental models, fire policy, Dayak communities, West Kalimantan, Indonesia

Introduction

Catastrophic wildfires are a leading social-environmental challenge in Indonesia (Martin 2019; Tacconi and Muttaqin 2019) and are predicted to increase in extent and frequency globally (Jolly *et al.* 2015). In Indonesia, their significance has been recognized at the local, national, and international levels (Edwards and Heiduk 2015). In 2015, extensive uncontrolled fires occurred on Indonesian peatlands, covering at least 875,000 hectares (Peat Restoration Agency 2016). Transboundary toxic haze arising from the burning peatland disrupted the economy, school provision, and burdened the public health and daily freedoms of the local and regional population (Glauber 2016; World Bank 2016). The haze induced approximately 100,000 cases of premature death and significant long-term irreversible health defects (Koplitz et al. 2016; Uda et al. 2019). During the event, carbon emissions from burning peatlands surpassed those of the entire European Union (Huijnen *et al.* 2016). The transboundary nature of the haze affected the Association of Southeast Asian Nations (ASEAN) region including Singapore and Malaysia, which put diplomatic pressure on Indonesia to take action (Kapoor and Da Costa 2015).

The severity of the 2015 mega-fire event prompted the Government of Indonesia to initiate a number of policy responses, including a ban on all use of fire in land management (Presidential Instruction no. 11/2015) (Cabinet Secretariat of the Republic of Indonesia 2015).

Although motivated by and targeted to mitigate the extensive peat fire and (toxic) haze problem, the instruction blanket ban thus included fires on mineral soils used by small-scale traditional swidden farmers (Oeji 2016; Sutan 2016). The swidden mineral soil system is distinct from the diverse contemporary forms of land management in terms of its agricultural management and associated actors that now occupy peatland frontiers and are associated with peat fires.

Swidden agriculture involves rotational land clearing with a slash-and-burn technique (locally called *tebang dan bakar*) (Colfer *et al*. 2015). The practice is contested, and representations are polarized, from those that stigmatize swidden as a 'backward' land management technique (Dove 1983; Kull 2004; German 2010) to those that advocate its contribution to biocultural diversity and local food autonomy (Perfecto and Vandermeer 2010; Padoch and Pinedo-Vasquez 2010). Across the tropics, fire-based agriculture is critical for local food security yet access to fire is potentially threatened by panacea approaches and conservation policies (Carmenta *et al*. 2019). Indeed, policy targeting is a key requirement of effective and equitable environmental governance, panacea responses are ill-advised (Ostrom 2007; Jefferson *et al*. 2020), and fire-prohibiting policies have created adverse outcomes in other contexts. Perverse outcomes have included creating more illicit conditions surrounding burning to the extent that burning becomes riskier for farmers (Kull 2004; Carmenta *et al.* 2019), favoring ecologies that themselves are more fire-prone (e.g., see Rai *et al.* (2019) and introducing sanctions for burning that create ethical dilemmas (Carmenta *et al*. 2020). In these ways, the burn ban has potentially important implications for the agricultural practices, food security, and livelihoods of mineral soil farmers engaging in small-scale swidden practices.

In Indonesia, Dayak indigenous communities living throughout West Kalimantan have been practicing swidden agriculture on mineral soils over generations (Conklin 1961; Siahaya *et*

Commented [dB1]:

al. 2016). Neither the impacts of the ban on these fire-dependent communities nor the coping strategies mobilized by Dayak farmers in response are well understood. Understanding the mental models of farmers exposed to environmental change (i.e., increasing fire risk associated with landscape change and climatic events) and its policy responses can provide salient insights into the place-based experiences of and responses to that change. Further, it can remedy a lack of congruence between policy and practice that can otherwise be propagated, for example through a misunderstanding of the local realities of small-scale farmers, their fire use, and management practices (Carmenta *et al.* 2011; Thung 2018). We assessed the mental models of Dayak farmers in Kapuas Hulu, Kalimantan, in three distinct landscape contexts, close to: i) oil palm, ii) protected areas, and iii) transition sites (i.e., mosaic of forest and oil palm). The locations enabled insights into how different contemporary landscape contexts and livelihood opportunities associated with oil palm transitions are related to place-based fire experiences and coping strategies. Understanding the perceptions of Dayak farmers in relation to the burn ban can generate new knowledge that could inform more equitable, nuanced, and targeted policy responses to be formulated in the different landscape contexts that we address.

Methods

Mental Models

The information, perceptions, opinions, and ideas that a person holds are collectively known as mental models, which help us navigate and make sense of our world. Although mental models are held by individuals, they are formed through the social interactions of community members in a particular place with similar social, cultural, and environmental experiences (Quinn 2005, 2011). Mental models provide knowledge of specific phenomena, offer guidelines to interpret various situations and indicate the framework that people use to explain how the

93 world works (Roskos-Ewoldsen *et al.* 2006; Jones *et al*. 2011). They are the basis for the
94 establishment of social norms that in turn influence decision-making processes, including
95 decisions related to natural resource management (NRM) (Halbrendt *et al*. 2014; Gray *et al.*
96 2015; Bennett 2016). Understanding others' mental models can be challenging, however, since
97 people may not be conscious of the full range of details. NRM scholars and practitioners have
98 assessed mental models to help address and mediate contested perceptions around resource use
99 and improve the equitable distribution of burdens related to environmental change, resource
100 access, or policy responses among stakeholder groups (Carlton and Jacobson 2016; Friedrichsen
101 *et al.* 2017). A recent review of techniques to reveal mental models through cognitive mapping
102 strategies suggests the exercise has value in helping people understand their own ideas and the
103 nature of conflicts (Biedenweg *et al*. 2020).
104 Mental models often include three dimensions: *corpus*, *praxis*, and *kosmos* (Toledo 2002;
105 Barrera-Bassols and Zinck 2003). *Corpus* focuses on local cognitive systems and perceptions.
106 *Praxis* focuses on procedural strategies, for example the practices associated with the use and
107 management of natural resources, and can include adaptation strategies (e.g., following
108 environmental or policy change) (Barrera-Bassols and Zinck 2003; Vuillot *et al*. 2016). *Kosmos*
109 focuses on local belief symbols and rituals and includes the interaction between values and social
110 relations that contribute to cultural and spiritual identity (Rappaport 1979; Toledo 2002; Lewis
111 and Sheppard 2005). *Kosmos* is related to the community's understanding of the role of spiritual
112 beings mediating the relationship between humans and non-humans in a given landscape
113 (Johnson 1992). By using a framework grounded in the dimensions of corpus, praxis, and
114 kosmos, mental models then give an insight into the different dimensions of reality as understood
115 and practiced by the participants. Understanding the connections among these dimensions in

mental models is important to understanding decision-making processes within a group and assists interpretation of responses to environmental or policy changes (Abel *et al*. 1998; Kolkman *et al*. 2005). Differentiating among these dimensions enables identification of cultural flexibility that could suggest ways the community could adapt to a policy response, and ways in which policy interventions can be designed to be more equitable. Mental models can also provide an overview of stakeholders' perceptions of the cause-and-effect dynamics of a NRM phenomenon and the interaction of policy in a complex social-ecological system (Jones *et al*. 2011; Elsawah *et al.* 2015; Prager and Curfs 2016).

Conceptual Content Cognitive Mapping (3CM)

3CM is a methodological tool to gather information on the mental models held by individuals and communities (e.g., see Kearney and Bradley (1998); Kearney *et al.* (1999); Tikkanen *et al.* (2006); Kant and Brubacher 2008) and to explore how individuals embedded in a place think about and experience resource management problems and policy interventions (Biedenweg and Monroe 2013). It provides an opportunity for participants to explore and articulate their own perceptions through the combination of selecting and grouping cards and interviews to enhance equity in environmental governance (Bennett 2016). As well as using 3CM, we also practiced participant observation during our stay with our study communities, taking part in farming activities to gain farmers' trust and systematically record their farming practices.

We used a structured 3CM method with a set of cards which each had a color photograph and a label in the Indonesian language making it easier for participants to focus on exploring, visualizing, and organizing their own perceptions of the burn ban phenomenon. The card set (see Supplementary Material Table 1) ranged from the external agents involved in implementation

and enforcement of fire policy (e.g., police, government, etc.) to the traditional agricultural practices of the farmers (e.g., rituals, type of fallow, etc.). The set of cards was determined following a literature review and interviews with relevant stakeholders (e.g., academics in the field, NGO representatives, and community members). We was then tested the refined set of cards through three focus groups in a neighboring community with similar characteristics (e.g., rural Dayak farmers subject to the burn ban).

Cognitive mapping strategies can use as few of 14 participants (Biedenweg *et al.* 2020), but typically range from 30 to 50 (Hundemer and Monroe 2020). Individuals are asked to select the cards that are most meaningful to them, but if each person has a set of cards, groups of people may engage in this technique at the same time. Follow up discussions where participants explain their groupings are more effective with individuals. Data can be analyzed by coding similarities and understanding themes or by quantitative analysis. We conducted individual interviews with 12 participants in each of six villages and used both thematic and quantitative analysis to discern trends and similarities. Based on the concepts of saturation and "information power," (Malterud *et al*. 2016) coupled with our mental model framework, we felt that 72 participants provided sufficient information in each of the participating communities.

We followed the procedure as explained by Kearney (2015): we first proposed a specific scenario to each participant (n = 72): "Imagine that you are telling someone from another community about your experience. What things would you want them to know about how your community perceives the burn ban?" Next, we asked participants to select cards from the set of 50 and group them into themes that represented their answers. No specific guidelines were given to specify the number of groups (i.e., the collections of similar themed cards), or the number of cards in each group. For example, a participant may choose a "police" card derived from the

theme "implementation and enforcement" to be combined with a "type of fallow" card derived from the theme "traditional agricultural practices." The cards selected and their groups represent the structured knowledge and interpretation of the burn ban held by the respondent. We asked each participant follow-up questions after the scenario placements to enhance our understanding of the logic connecting the groups.

Study Population and Sampling Framework

Data were collected by the lead author over seven weeks in June and July 2017 in six communities in Kapuas Hulu, West Kalimantan, Indonesia. The region offered an ideal case for understanding the implications of the burn ban since its experienced implementation, and advocacy campaigns led by police officials with the explicit warning: “Do not burn forest and land. Burners will be sentenced to 15 years and a fine of IDR 15 billion (± USD 1,000,000; 2018).” The region is a mosaic of landscapes emblematic of its frontier nature, with distinct configurations of extents of oil palm and protected land that allowed us to explore how these different land uses and associated livelihood opportunities are related to perceptions and responses to the burn ban. We selected two communities living close (~15 km) to a National Park, two communities living close (~15 km) to extensive oil palm plantations, and two communities living in transitional areas (i.e., an area in the middle of the main route between the National Park and an oil palm plantation, with a landscape that is a combination of (mainly) forests and plantation crops (National Park, Oil Palm, and Transitional communities hereafter). The main source of livelihood for the National Park and Transitional communities is farming alongside other uncertain sources of income such as selling forest products and rubber latex. The main source of livelihood for the Oil Palm communities is working as laborers in oil palm

company plantations in addition to farming and selling crops or forest products. This selection provided the variation of context in reliance upon agriculture and access to alternatives, important factors in shaping responses to the burn ban (van Vliet *et al.* 2012; Rogers 2016). Within each community, participants were selected with purposive sampling (Guest 2015), which we are is appropriate because we were interested in capturing the responses of key informants from both male and female farmers and customary and administrative community leaders to enhance our understanding of the diversity of perceptions of the burn-ban. In each community we selected 12 respondents from these four categories (Table 1).

Data Analysis

We analyzed 3CM data using Hierarchical Clustering (Johnson 1967) through Anthropac's average linkage clustering procedure, which computes the average similarity distance matrix between cards and visualizes them in Multidimensional Scaling (MDS) patterns (Aldenderfer and Blashfield 1984; Borgatti 1996). Each MDS pattern indicates the relevance of cards that were important to the participants and this forms the basis and representation of the mental models (Kearney and Kaplan 1997). We collected mental model data from individuals within six communities in different landscape contexts, which we then aggregated to the community level to afford an understanding of the collective perceptions and practices and to enable inter-community comparison. We analyzed a variety of MDS patterns and selected the solution that created three groups based on the average number of card groups formed by the participants. Participants chose an average of 22 cards out of 50 cards and typically arranged them into three (70%) or four (30%) groups. Each group of cards can include any of the dimensions of corpus, kosmos, and praxis with a moderate number of cards (± 5) to provide clarity of interpretation.

We analyzed the data from the different communities separately to explore whether communities varied in the way they perceived and were impacted by the burn ban. As with other semi-quantitative approaches to understanding stakeholder perceptions, the researcher has a significant role in determining the final solution, based on case knowledge and the coherence of the groups. Despite the limited number of participants, we used the answer from the follow-up questions and fieldnotes as the basis of analysis in order to provide the details of explanation required by this study. The questions and scenario were about the condition of their community rather than of the individual, so that the answers analyzed can be considered to represent the community's perceptions. This is supported by the results of the competence matrix analysis from Anthropac that indicated that all participants in each category belong to a single culture (Table 2).

Results

Respondents across sites selected on average 21 to 23 cards to be grouped, namely National Park sites (n=23), Oil Palm (n=21), and Transitional (n=22). In each site type, 3CM analysis identified three distinct clusters (themes) representing how perceptions of the burn ban were organized in the mental models of community members (Fig. 1). Many of the cards within the clusters were consistent between sites, allowing for a consideration of the emergent thematic resulting from this broad overlap. The thematic areas associated with the three cluster themes were: 1. The relational value of fire: fire as culture and identity; 2. Local institutions and autonomous fire management; and 3. Impacts and a sense of injustice (Fig. 1, Table 3). Although these commonalities pervade, some specific differences associated with the sites and landscape contexts were evident.

Cluster 1: The relational value of fire: fire as culture and identity

The cards constituting Cluster 1 were common to all sites: seeds, ritual, agricultural practice procedures, fire, and fertilizer (Table 2). Participants from the three sites explained that knowledge about fire is an integral cultural part of their traditional intergenerational agricultural practices (i.e., corpus dimension). Fire clears remnant vegetation and creates natural fertilizer considered essential to support crops. The respondents also discussed the ritual significance of ancestor rice seeds, seeds that have been passed down from generation to generation and must be planted every year. For them, ancestor rice seeds are the personification of their fallow protectors and will determine the success of the harvest. As one participant explained: "We believe it can bring bad luck if we do not plant ancestor rice seeds. Even if, for example, somebody [is] getting married and moving into a new house or new village, he or she will take ancestor rice seeds with him or her, even if only a pinch." Participants could not imagine how to plant rice if the fallows were not cleared of remnant vegetation through fire. Several participants had tried not to burn the fallows and instead relied on chemical fertilizers that were considered inferior, as they said the harvest was not as good as when they burned the fallows, and they had to buy more rice to meet the needs of the household.

Fire is important for other forms of ritual. Participants explained that after all the community members have finished burning their fallows, usually in the last week of August or the first week of September, they gather to perform the "washing the charcoal ritual." This ritual was mentioned in all sites. To perform the ritual, each family carries the charcoal from their respective fallows to where the ritual is held. The customary leader delivers some prayers of thanksgiving to the spirits. The prayers convey that the initial and most intense process in the

planting process has been completed. The fallows have been burned, and the remains have become a useful fertilizer for the seeds of the rice. The chanting of prayers continues while the community members put charcoal on their feet and then wash it away with water. As the symbolic acts are completed, the farmers express hope for the next stage, which is planting the rice. The ritual continues with feasting on traditional food and drink as a sign of gratitude.

Through the 3CM process, several observations characterized the communities living close to oil palm plantations. Despite the similarities in the cards within this cluster (theme), these communities had additional cards relating to oil palm, harvest, and type of fallow. This result suggests that for these communities the function of fire is more than the creation of natural fertilizer and ritual. These farmers work every day in company-owned oil palm plantations. They have limited time to move every year to open a large fallow. As a result, they choose to manage smaller fallows and only plant and harvest ancestor rice seeds. Smaller plot sizes produce smaller harvests, but this is not a problem since people from these communities earn extra income from their employment at the oil palm plantations. Although the size of their fallows is smaller, fire remains an important tool to reduce vegetation and create fertilizer for the ancestor seeds, which also serves to preserve their cultural identity. However, in Oil Palm sites, respondents contended that the use of fire has decreased over time since they have more livelihood options and no longer open new fallows each year.

Cluster 2: Local institutions and autonomous fire management

Cluster 2 had the most similarity in the cards representing all three sites indicating a shared perspective across sites. This cluster highlights the rules in use, traditional management practices, and local institutions that constitute fire management in swidden systems. It helps to

explain why people across sites felt the burn ban was an unnecessary intervention. Participants explained that to maximize the utility of fire they follow procedural norms (i.e., *praxis*), namely reciprocal cooperation to manage fire. As households select their fallows, they communicate the locations to community members and organize into working groups of variable sizes, typically with farming neighbors. Work groups follow reciprocal customs of exchange and cooperation. As one participant explained: "If you send three people from your family to my place, tomorrow I will send three people to your place. When burning the field, we cannot do it alone, we need a lot of help from others [within the community]."

In terms of fire management, work groups serve to create fire break boundaries on each side of the fallow to prevent unwanted fire spread (e.g., to adjacent rubber gardens). Fire breaks are made by clearing two to three meters width of vegetation. Creating clean fire breaks is the most difficult stage and requires high labor investment. Burning begins after fire breaks have been established following agreed work schedules. Before burning, the farmers repurpose tanks used for spraying herbicide to carry water to the burn sites. Burning begins early in the day, after the damp of the night has passed, preferably on a day with some wind to help speed up the burning process. Farmers analyze wind direction and start burning from the side that they deem most vulnerable to fire escape (e.g., more combustible land), or that presents the most risk (e.g., next to someone else's field). The members of the work group position themselves around the fallows, each with a water tank. From their vantage points they monitor where the fire may spread beyond the intended boundaries.

Traditional fire management practices are also related to rubber tree planting and customary law. The combination of swidden agriculture and rubber trees is common in all sites, primarily due to the dissemination of both local and superior rubber tree seedlings initiated by

local agencies and NGOs. Customary laws support the efforts to contain fires from spreading into assets held in rubber plantations. This customary law has established sanctions that are targeted to farmers whose fires escape and damage neighboring rubber plantations. Sanctions are usually in the form of a fine (that serves as compensation) and are calculated based on the number and age of the damaged rubber trees. To avoid sanctions, participants explained that there are social norms, rules between the farmers who want to burn their fallows and the owners of neighboring rubber gardens. These rules included inviting or notifying the owners of neighboring rubber plantations about the burning schedule – failing to do so can result in sanctions, especially compensation if the fire spreads. Next, if the owner of a rubber tree plantation has been invited or informed, he or she must be present when the adjacent owner burns the fallow, to help monitor the fire since their presence annuls the need for compensation should the fire spread.

Cluster 3: Impacts of the burn ban - a sense of injustice

The National Park and Transitional communities held the most similar perceptions within cluster 3, whilst the oil palm communities were most distinct (i.e., shared only four of the cards). This theme represents the impacts of the burn ban and the sense of injustice related to the ban and its enforcement. Participants in all landscapes explained that they felt accused of being to blame for the peat fire and haze catastrophe, especially in West Kalimantan. They argued that the burn ban should not apply to them because they have an ancestral and cultural system that regulates burning, safeguards the environment and does not damage other people. The sense of injustice was further pronounced due to the ambiguity surrounding the burn ban. The ban had

taken various forms of implementation and created confusion and unease among local communities, especially for those who are vulnerable.

This confusion was illustrated by the selection of cards related to police and weather in the National Park and Transition Sites. In the former the card 'national park' was also present, and participants said that police and national park officers allowed them to burn the fallows but burning had to be done progressively through a sequence of smaller burns (i.e., a two-hectare fallow would have to be burned over two days). However, all participants highlighted the infeasibility of this solution, explaining that a successful burn is highly dependent on climatic conditions. It is difficult to predict the dry days that are necessary to complete a good burn (i.e., one in which all remnant vegetation is removed) due to unpredictable weather. For the farmers, the solution presented burdens including slowing the field preparation process and complicating the rotation schedule for community members. They have to finish burning before the rainy season comes to prevent the seeds that have been planted from rotting or not growing properly. Confusion also arose when police allowed the communities living in the Transitional sites to burn in small patches but with an additional condition such as only in the morning. For the participants, this solution did not solve the problem because a successful burn requires the dry conditions and some winds, neither of which occur in the morning.

The lack of adequate solutions and assistance from the state meant that across sites farmers continued with their long-standing burning practices. In at least two cases, this has led to conflict with the police, mainly in the Transitional communities where open fallows were along the roadside and therefore easier to target. In one example, community members were burning an area of land, maintaining the fire within the intended limits through customary fire management. The police arrived and threatened to arrest them if the fire was not immediately extinguished.

Community members responded forcefully to the threat, emphasizing that fallow clearing by burning supports their sole source of income and food security. In the other example, conflict with policy resulted in the arrest of a community member. The police had circulated warning letters banning burning the fallows along the roadside, especially on certain days in August 2016 in anticipation of a state official due to be passing through the region. However, community members already had burning schedules and they were hurrying following weather cues and time, so they continued burning. The police arrived mid-burn and some of the farmers ran away; however, one person was arrested and taken to the police station. Angry community members then followed and protested, demanding the release of the detained farmer. In each instance the police conceded or compromised their position and excused the farmers.

For people living in the Transitional and National Park communities the burn ban was anticipated to impact their agricultural practices, concerns which might have been heightened by the presence of the police and fear of enforcement. This was represented by the harvest and type of fallow cards in these two communities. In the interviews, the participants confirmed their worry that the burn ban would affect their harvests. They felt they had no choice but to continue to burn, but they changed the type and location of the fallows. The impact was distinct for participants living close to the national park, who chose to stay in last year's fallows. They said that because the fallows had been managed last year, they did not require as much fire, and so would likely not attract the attention of the police: "Since there was the burn ban, I noticed that many people opened the same fallow [not shifting], because the fires were not too big, but the expenses for fertilizers and herbicides became bigger." There was a trade-off between harvest size and avoiding police intervention. However, farmers experienced uncertainties related to

securing additional income if the harvest in the existing fallow was not sufficient. In this way the burn ban introduced additional burdens to already marginalized small-scale farmers.

Other perverse outcomes included those in Transitional communities, where in response to the fear of sanction, farmers began to choose plots further from the roadside – plots that were typically mature fallows (e.g., five to ten years), or primary forest. Before the ban fallows were routinely placed adjacent to the road (usually young fallows <5 five year) allowing for easier access and harvest transportation. One swidden farmer noted: "Nowadays, many people open fallows deep inside of the forest. Rarely anyone wants to open a fallow by the side of the road. They fear of being caught by the police." The farmers believed this was the best solution to obtain a satisfactory harvest, as primary or older secondary forests are usually more fertile and at the same time allowed the farmers to avoid the police.

In contrast to the Transitional and National Park communities, Oil Palm communities did not express concern about the police enforcing the law. Participants said it was natural for the police not to worry about their burning activities because they only open small plots and have other livelihood alternatives, such as work on oil palm plantations. In addition, these participants said that the palm oil companies helped them to extinguish fires by joining in mutual cooperative activities to protect their adjacent oil palm plantations. The communities inform the company, and the company sends the firefighters with fire extinguishers. This emphasizes that the burn ban has the strongest negative implications for those already most marginalized and least resilient communities, thus exacerbating existing inequalities and injustices.

Discussion

Interpreting stable and vulnerable states in Dayak's mental models

The process of selecting cards and discussing the groupings enabled the Dayak villagers to articulate their ideas about farming and the burn ban. Our interpretation of their mental models enables us to lend a new insight to this policy. The perceptions of community members expressed in Clusters 1 and 2 represent a "stable state" on the meaning, role, and practice of fire. In these stable state clusters, the three dimensions of corpus, kosmos, and praxis together denote the utilities, identities, institutions, and interactions that traditional fire management creates. For example, corpus is represented through hereditary and experiential local knowledge about using fire to burn leftover vegetation that has been cut down to fertilize the land and kosmos is represented by the function of fire as ritual and regeneration of ancestor rice seeds. For Dayak communities across sites, kosmos builds on a common perception of fire as a catalyst for natural fertilizers useful for ancestor rice seeds. The cultural obligation to plant ancestor rice seeds that must be passed to future generations is the embodiment of belief systems where ancestor rice seeds are the personification of the fallow protectors. The practice of ritual after burning the fallows is a representation of the fulfillment of cosmological values related to the relationship with the spirits, which in the Dayak belief system has been and will continue to be a positive outcome of the burning process. Praxis is noted through aspects of community reciprocal cooperation, experience of fire incidents, and customary law. These three dimensions represent how the Dayak communities manage the environment in relation to traditional agricultural practices. A difference was evident in Oil Palm communities where the use of fire had declined, there was less dependence on fire, and oil palm afforded other livelihood possibilities and a pathway to alternatives when presented with the fire ban.

The mental models also showed the shift in perceptions that occurred after the policy change was introduced through the burn ban. This situation reflects a "vulnerable state" as represented in Cluster 3. Interviews with community members highlighted feelings of injustice, which arose as a result of the external disruption to the traditional stable state of corpus, kosmos, and praxis in customary fire management. Additionally, the implementation of the burn ban created injustices because compliance with the ban is seen as unreasonable, unrealistic, and inconsistent with local corpus, kosmos, and praxis. Impact dynamics include perverse outcomes, such as how the Dayak changed their agricultural practices as a result of their own negotiations among corpus, kosmos, and praxis, which stem from their perception that the ban is unfair, confusion, and contact with police. Communities living close to the national park had direct contact with the police, which caused them to extend rotation cycles or shift field locations away from fallow sites close to the road further into the forest. For Oil Palm communities, the shift from permanent to semi-permanent practices was reinforced by their more diverse and more stable sources of outside income.

The stable state has long been part of the Dayak's daily life and culture and has been impacted through exposure to the burn ban. The stable state and understanding of fire are not transformed on exposure to the burn ban – as witnessed through farmers' resistance and conflicts with police officials. To retain their rightful traditional practices that have meaning for corpus, kosmos, and praxis through, for example, delivering community relations and connections to ancestors, ensuring food security, and providing income, Dayak communities have made the decision to continue to burn despite the burn ban. When sanctions were imposed in the form of threats of incarceration and fines communities successfully mobilized in protest. However, particularly in the National Park and Tranitional sites communities were forced into more

vulnerable conditions of food security, and to environmentally and economically unsustainable agricultural practices.

Insights for Future Fire Policy

A simple, one-size-fits-all national policy response to environmental challenges is rarely appropriate (Ostrom 2007). Rather, more targeted and nuanced interventions in polycentric governance arrangements are likely a better fit, including for fire management (Tacconi 2016; Jefferson *et al.* 2020). We have shown, the corpus, kosmos, and praxis dimensions of burning on mineral soils in Kalimantan have stable states that do not easily shift with policy change. Our results highlight that fire has significant cultural and relational value and is associated with traditional agriculture and food security that banning fire infringes on. Further, we show that the equity dimension of banning fire is not evenly distributed and is only viable in communities engaged with oil palm production or receive support from the oil palm private sector to manage uncontrolled fires.

Our analysis highlights ways in which policies that are more sensitive to local and indigenous ways of life can be developed. By understanding the burning practices of small-scale farmers across the dimensions of corpus, kosmos, and praxis, policy makers can identify approaches that align better with local customs, build on local institutions for fire management, and that are more equitable as a result. While mitigating uncontrolled fires is imperative, recognizing that mineral soil farmers were not responsible for the peat fire and haze disaster could help better target intervention effort to peat land managers and abate perceptions of injustice. Interventions that enable the survival of customs (e.g., the ancestral seeds) yet serve to mitigate the risk of uncontrolled fires may be more equitable.

Further, our results highlight that undesirable outcomes of prohibitive policy are not only humanitarian but also ecological. The ban resulted in farmers relocating their fields away from the road into the primary forest. Other studies have shown the direct and indirect negative effects of policy prohibiting traditional farming practices with fire in different contexts (Thrupp *et al.* 1997; Cramb *et al*. 2009; Carmenta *et al*. 2019). Swidden communities have historically been coerced to abandon their traditional practices in order to comply with conservation standards rather than a recognition of the role of shifting cultivation in the persistence of biocultural diversity (Padoch and Pinedo-Vasquez 2010).

The burn ban as top-down policy potentially exacerbates inequalities among swidden communities. We show that the burn ban disproportionately affected the most marginalized communities reliant on swidden agriculture for livelihoods and household food security. Another law that potentially has a similar impact to the burn ban is the omnibus law on job creation passed by the Indonesian government in 2020.This law has a potentially negative impact on the quality of the environment through weakening legal instruments regarding environmental protection (e.g., it recentralizes environmental permits and downgrades the penalties for concessionaires with fire on their lands) and the rights of local communities (Indonesian Center for Environmental Law 2020). The law bans all burning, including small scale traditional agricultural burns thus potentially punishing traditional farmers who still use burning to clear land. This law has the potential to negate the practice and knowledge of swidden agricultural practices of local communities to manage their natural resources.

There is a need for multi-stakeholder involvement including government agencies, local governments, and local communities to be directly involved in the process of formulating policies on the use of fire in agricultural practices. The government needs to recognize the

swidden communities and their traditional rights related to traditional livelihoods through the principles of sustainability, justice, and legal certainty. The participation and role of the local communities, especially those that still use fire in agricultural practice, should be encouraged, especially in the process of design and implementation of fire policies. The approach to formulating fire policies through local wisdom-based mechanisms can be effective and efficient. A potentially more sustainable and more equitable solution would be to incorporate the local utility, relational value, practice, and management of fire into adapted and targeted interventions (Kull 2002; Barlow *et al*. 2012; Carmenta *et al.* 2013).

Conclusion

We identified a stable state of traditional fire management perceptions that is central to local livelihoods, agricultural practices, and cultural identities of Dayak communities in West Kalimantan, and a chronic misfit between the burn ban and the stable state perceptions of fire management are pervasive across our study sites. We show that perceptions of inequity and injustice in relation to the burn ban are particularly pronounced in those communities most dependent on traditional agriculture. The Dayak farmers' perception that the burn ban was designed and enforced without considering their perspective contributed to their mobilization in protests and ultimate rejection of the policy. Our results suggest that fire management can potentially result in perverse outcomes through the instability and confusion that farmers reported and suboptimal outcomes for subsistence farmers, creating negative social and environmental consequences. A more flexible policy approach is required that would enable small-scale mineral soil farmers to address and mitigate risks associated with fire management while maintaining their traditional beliefs and practices that have been part of their socio-cultural

life for generations. This is particularly necessary given that the burn ban itself was in response to chronic fire events that occurred in entirely different landscape dynamics on peat soils by multiple actors using fire in non-swidden systems largely in pursuit of oil palm establishment. The distinctions between sites in perceptions of the burn ban suggest that future research could focus on understanding what other factors, in addition to location in the landscape, contribute to these distinctions.

Acknowledgments. This article is part of a Master's study that was conducted by the first author at the University of Florida with financial support from CIFOR (Center for International Forestry Research)/USAID (United States Agency for International Development) under Governing Oil Palm Landscapes for Sustainability (GOLS) fellowship program. The authors would like to also thank Dr. Steve Lawry and Dr. Yves Laumonier for their input. Rachel Carmenta acknowledges support from the Global Challenges Research Fund (Project code NE/T010401/1) and the Frank Jackson Foundation.

Funding: This research was funded by CIFOR (Center for International Forestry Research)/USAID (United States Agency for International Development) under Governing Oil Palm Landscapes for Sustainability (GOLS) fellowship program.

Conflict of Interest: The authors declare that they have no conflict of interest

Informed Consent:

References

Abel N, Ross H, Walker P (1998) Mental Models in Rangeland Research, Communication and Management. Rangel J 20:77–91. https://doi.org/10.1071/rj9980077

Aldenderfer MS, Blashfield RK (1984) Cluster Analysis. SAGE Publications, California

530 Barlow J, Parry L, Gardner TA, et al (2012) The critical importance of considering fire in REDD+ programs.
531 Biological Conservation 154:1–8. https://doi.org/10.1016/j.biocon.2012.03.034

532 Barrera-Bassols N, Zinck JA (2003) Ethnopedology: a worldwide view on the soil knowledge of local
533 people. Geoderma 111:171–195. https://doi.org/10.1016/S0016-7061(02)00263-X

534 Bennett NJ (2016) Using perceptions as evidence to improve conservation and environmental
535 management. Conservation Biology 30:582–592. https://doi.org/10.1111/cobi.12681

536 Biedenweg K, Trimbach D, Delie J, Schwarz B (2020) Using cognitive mapping to understand
537 conservation planning. Conserv Biol 34:1364–1372. https://doi.org/10.1111/cobi.13627

538 Biedenweg KA, Monroe M (2013) Cognitive Methods and a Case Study for Assessing Shared Perspectives
539 as a Result of Social Learning. Society & Natural Resources 26:931–944.
540 https://doi.org/10.1080/08941920.2012.725455

541 Borgatti SP (1996) Anthropac 4: Reference Manual. Analytic Technologies, Natick, MA

542 Cabinet Secretariat of the Republic of Indonesia (2015) Instruksi Presiden No. 11 Tahun 2015 tentang
543 Peningkatan Pengendalian Kebakaran Hutan dan Lahan (Presidential Instruction No. 11/2015 on
544 Improving Forest and Land Fire Control).
545 http://sipuu.setkab.go.id/puu/buka_puu/174708/inpres%20no%2011%20tahun%202015.pdf.
546 Accessed 11 Sep 2016

547 Carlton JS, Jacobson SK (2016) Using Expert and Non-expert Models of Climate Change to Enhance
548 Communication. Environmental Communication 10:1–24.
549 https://doi.org/10.1080/17524032.2015.1016544

550 Carmenta R, Coudel E, Steward AM (2019) Forbidden fire: Does criminalising fire hinder conservation
551 efforts in swidden landscapes of the Brazilian Amazon? The Geographical Journal 185:23–37.
552 https://doi.org/10.1111/geoj.12255

553 Carmenta R, Parry L, Blackburn A, et al (2011) Understanding Human-Fire Interactions in Tropical Forest
554 Regions: a Case for Interdisciplinary Research across the Natural and Social Sciences. Ecology
555 and Society 16:. https://doi.org/10.5751/ES-03950-160153

556 Carmenta R, Vermeylen S, Parry L, Barlow J (2013) Shifting Cultivation and Fire Policy: Insights from the
557 Brazilian Amazon. Hum Ecol 41:603–614. https://doi.org/10.1007/s10745-013-9600-1

558 Carmenta R, Zabala A, Trihadmojo B, et al (2020) Evaluating bundles of interventions to prevent peat-
559 fires in Indonesia. Global Environmental Change 102154.
560 https://doi.org/10.1016/j.gloenvcha.2020.102154

561 Colfer CJP, Alcorn JB, Russel D (2015) Swidden and Fallows: Reflections on The Global and Local Values
562 of Slash and Burn. In: Cairns MF (ed) Shifting Cultivation and Environmental Change: Indigenous
563 People, Agriculture, and Forest Conservation. Routledge, New York, pp 62–86

564 Conklin HC (1961) The Study of Shifting Cultivation. Current Anthropology 2:27–61

565 Cramb RA, Colfer CJP, Dressler W, et al (2009) Swidden Transformations and Rural Livelihoods in
566 Southeast Asia. Hum Ecol 37:323–346. https://doi.org/10.1007/s10745-009-9241-6

567 Dove MR (1983) Theories of swidden agriculture, and the political economy of ignorance. Agroforest
568 Syst 1:85–99. https://doi.org/10.1007/BF00596351

569 Edwards SA, Heiduk F (2015) Hazy days: forest fires and the politics of environmental security in
570 Indonesia. Journal of Current Southeast Asian Affairs 34:65–94

571 Elsawah S, Guillaume JHA, Filatova T, et al (2015) A methodology for eliciting, representing, and
572 analysing stakeholder knowledge for decision making on complex socio-ecological systems:
573 From cognitive maps to agent-based models. Journal of Environmental Management 151:500–
574 516. https://doi.org/10.1016/j.jenvman.2014.11.028

575 Friedrichsen C, Daroub S, Monroe M, et al (2017) Mental models of soil management for food security in
576 periurban India. Urban Agriculture & Regional Food Systems.
577 https://doi.org/10.2134/urbanag2017.08.0002

578 German L (2010) Local Knowledge and Scientific Perceptions: Questions of Validity in Environmental
579 Knowledge. In: German L, Ramisch J, Verma R (eds) Beyond the biophysical: Knowledge, culture,
580 and power in agriculture and natural resource management. Springer, Dordrecht, The
581 Netherlands, pp 99–125

582 Glauber AJ (2016) The Cost of Fire: An Economic Analysis of Indonesia's 2015 Fire Crisis. World Bank
583 Group, Jakarta

584 Gray S, Gray S, De Kok JL, et al (2015) Using fuzzy cognitive mapping as a participatory approach to
585 analyze change, preferred states, and perceived resilience of social-ecological systems. Ecology
586 and Society 20:. https://doi.org/10.5751/ES-07396-200211

587 Guest G (2015) Sampling and Selecting Participants in Field Research. In: Bernard HR, Gravlee CC (eds)
588 Handbook of Methods In Cultural Ethnography, Second Edition. Rowman & Littlefield, London

589 Halbrendt J, Gray SA, Crow S, et al (2014) Differences in farmer and expert beliefs and the perceived
590 impacts of conservation agriculture. Global Environmental Change 28:50–62.
591 https://doi.org/10.1016/j.gloenvcha.2014.05.001

592 Huijnen V, Wooster MJ, Kaiser JW, et al (2016) Fire Carbon Emissions Over Maritime Southeast Asia In
593 2015 Largest Since 1997. Nature 6:. https://doi.org/10.1038/srep26886

594 Hundemer S, Monroe MC (2020) A Co-orientation Analysis of Producers' and Environmentalists' Mental
595 Models of Water Issues: Opportunities for Improved Communication and Collaboration.
596 Environmental Communication 0:1–19. https://doi.org/10.1080/17524032.2020.1828128

597 Indonesian Center for Environmental Law (2020) Berbagai Problematika Dalam Undang-undang Cipta
598 Kerja Sektor Lingkungan dan Sumber Daya Alam (Various Problems in the Environmental and
599 Natural Resources Sector of Job Creation Law). Indonesian Center for Environmental Law,
600 Jakarta

601 Jefferson U, Carmenta R, Daeli W, Phelps J (2020) Characterising policy responses to complex socio-
602 ecological problems: 60 fire management interventions in Indonesian peatlands. Global
603 Environmental Change 60:102027. https://doi.org/10.1016/j.gloenvcha.2019.102027

604 Johnson M (ed) (1992) Lore: Capturing Traditional Environmental Knowledge. International
605 Development Research Centre, Ottawa, Canada

606 Johnson SC (1967) Hierarchical clustering schemes. Psychometrika 32:241–254.
607 https://doi.org/10.1007/BF02289588

608 Jolly WM, Cochrane MA, Freeborn PH, et al (2015) Climate-induced variations in global wildfire danger
609 from 1979 to 2013. Nature Communications 6:7537. https://doi.org/10.1038/ncomms8537

610 Jones N, Ross H, Lynam T, et al (2011) Mental Models: An Interdisciplinary Synthesis of Theory and
611 Methods. Ecology and Society 16:. https://doi.org/10.5751/ES-03802-160146

612 Kant S, Brubacher D (2008) Aboriginal expectations and perceived effectiveness of forest management
613 practices and forest certification in Ontario. The Forestry Chronicle 84:378–391.
614 https://doi.org/10.5558/tfc84378-3

615 Kapoor K, Da Costa AB (2015) UPDATE 1-Malaysia PM urges Indonesia to tackle fires, haze drifts to Thai
616 sky. In: Reuters. https://www.reuters.com/article/indonesia-haze-idUSL3N12527B20151005.
617 Accessed 20 Feb 2021

618 Kearney AR (2015) 3CM: A Tool for Knowing "Where They're At." In: Kaplan R, Basu A (eds) Fostering
619 Reasonableness: Supportive Environments for Bringing Out Our Best. Ann Arbor, Michigan

620 Kearney AR, Bradley G (1998) Human dimensions of forest management: an empirical study of
621 stakeholder perspectives. Urban Ecosystems 2:5–16. https://doi.org/10.1023/A:1009564812609

622 Kearney AR, Bradley G, Kaplan R, Kaplan S (1999) Stakeholder Perspectives on Appropriate Forest
623 Management in the Pacific Northwest. Forest Science 45:62–73

624 Kearney AR, Kaplan S (1997) Toward a Methodology for the Measurement of Knowledge Structures of
625 Ordinary People: The Conceptual Content Cognitive Map (3CM). Environment and Behavior
626 29:579–617. https://doi.org/10.1177/0013916597295001

627 Kolkman MJ, Kok M, van der Veen A (2005) Mental model mapping as a new tool to analyse the use of
628 information in decision-making in integrated water management. Physics and Chemistry of the
629 Earth, Parts A/B/C 30:317–332. https://doi.org/10.1016/j.pce.2005.01.002

630 Koplitz SN, Mickley LJ, Marlier ME, et al (2016) Public health impacts of the severe haze in Equatorial
631 Asia in September–October 2015: demonstration of a new framework for informing fire
632 management strategies to reduce downwind smoke exposure. Environ Res Lett 11:094023.
633 https://doi.org/10.1088/1748-9326/11/9/094023

634 Kull CA (2004) Isle of Fire: The Political Ecology of Landscape Burning in Madagascar. University of
635 Chicago Press, Chicago

636 Kull CA (2002) Empowering Pyromaniacs in Madagascar: Ideology and Legitimacy in Community-Based
637 Natural Resource Management. Development and Change 33:57–78.
638 https://doi.org/10.1111/1467-7660.00240

639 Lewis JL, Sheppard SRJ (2005) Ancient Values, New Challenges: Indigenous Spiritual Perceptions of
640 Landscapes and Forest Management. Society & Natural Resources 18:907–920.
641 https://doi.org/10.1080/08941920500205533

642 Malterud K, Siersma VD, Guassora AD (2016) Sample Size in Qualitative Interview Studies: Guided by
643 Information Power. Qual Health Res 26:1753–1760.
644 https://doi.org/10.1177/1049732315617444

645 Martin DA (2019) Linking fire and the United Nations Sustainable Development Goals. Science of The
646 Total Environment 662:547–558. https://doi.org/10.1016/j.scitotenv.2018.12.393

647 Oeji (2016) Petani Pedalaman Terancam Tak Bisa Berladang (Inland Farmers are Potentially Unable to
648 Farm). In: Kalimantan Post. http://www.kalimantanpost.com/petani-pedalaman-terancam-tak-
649 bisa-berladang/. Accessed 19 Mar 2017

650 Ostrom E (2007) A diagnostic approach for going beyond panaceas. PNAS 104:15181–15187.
651 https://doi.org/10.1073/pnas.0702288104

652 Padoch C, Pinedo-Vasquez M (2010) Saving Slash-and-Burn to Save Biodiversity. Biotropica 42:550–552.
653 https://doi.org/10.1111/j.1744-7429.2010.00681.x

654 Peat Restoration Agency (2016) Laporan Tahunan 2016: Mengawali Restorasi Gambut Indonesia (Annual
655 Report 2016: Starting Indonesia's Peatland Restoration). Peat Restoration Agency, Jakarta,
656 Indonesia

657 Perfecto I, Vandermeer J (2010) The agroecological matrix as alternative to the land-sparing/agriculture
658 intensification model. PNAS 107:5786–5791. https://doi.org/10.1073/pnas.0905455107

659 Prager K, Curfs M (2016) Using Mental Models to Understand Soil Management. Soil Use and
660 Management 32:36–44. https://doi.org/10.1111/sum.12244

661 Quinn N (2011) The History of the Cultural Models School Reconsidered: A Paradigm Shift in Cognitive
662 Anthropology. In: Kronenfeld DB, Bennardo G, de Munck VC, Fischer MD (eds) A Companion to
663 Cognitive Anthropology. Blackwell Publishing, Ltd., West Sussex, UK, pp 30–46

664 Quinn N (2005) Finding culture in talk: a collection of methods. Palgrave Miller, New York, USA

665 Rai ND, Benjaminsen TA, Krishnan S, Madegowda C (2019) Political ecology of tiger conservation in
666 India: Adverse effects of banning customary practices in a protected area. Singapore Journal of
667 Tropical Geography 40:124–139. https://doi.org/10.1111/sjtg.12259

668 Rappaport RA (1979) Ecology, Meaning and Religion. North Atlantic Books, California

669 Rogers C (2016) No fire, no food: tribe clings to slash-and-burn amid haze crackdown. Mongabay

670 Roskos-Ewoldsen B, Davies J, Roskos-Ewoldsen DR (2006) Implications of the mental models approach
671 for cultivation theory. Communications 29:345–363. https://doi.org/10.1515/comm.2004.022

672 Siahaya ME, Hutauruk TR, Aponno HSES, et al (2016) Traditional ecological knowledge on shifting
673 cultivation and forest management in East Borneo, Indonesia. International Journal of
674 Biodiversity Science, Ecosystem Services & Management 12:14–23.
675 https://doi.org/10.1080/21513732.2016.1169559

676 Sutan (2016) Pemda di Kalbar Dilematis Terapkan Larangan Bakar Lahan untuk Petani Tradisional (The
677 Regional Government in West Kalimantan is in a Dilemma of Implementing a Burn Ban for
678 Traditional Farmers). In: Suara Pemred Kalbar.
679 http://www.suarapemredkalbar.com/berita/kalbar/2016/08/30/pemda-di-kalbar-dilematis-
680 terapkan-larangan-bakar-lahan-untuk-petani-tradisional. Accessed 19 Mar 2017

681 Tacconi L (2016) Preventing fires and haze in Southeast Asia. Nature Climate Change 6:640–643.
682 https://doi.org/10.1038/nclimate3008

683 Tacconi L, Muttaqin MZ (2019) Reducing emissions from land use change in Indonesia: An overview.
684 Forest Policy and Economics 108:101979. https://doi.org/10.1016/j.forpol.2019.101979

685 Thrupp LA, Hecht S, Browder J, et al (1997) The Diversity and Dynamics of Shifting Cultivation: Myths,
686 Realities and Policy Implications. World Resources Institute, Washington D.C.

687 Thung PH (2018) A Case Study on the Persistence of Swidden Agriculture in the Context of Post-2015
688 Anti-Haze Regulation in West-Kalimantan. Hum Ecol Interdiscip J 46:197–205.
689 https://doi.org/10.1007/s10745-018-9969-y

690 Tikkanen J, Isokääntä T, Pykäläinen J, Leskinen P (2006) Applying cognitive mapping approach to explore
691 the objective–structure of forest owners in a Northern Finnish case area. Forest Policy and
692 Economics 9:139–152. https://doi.org/10.1016/j.forpol.2005.04.001

693 Toledo VM (2002) Ethnoecology: a conceptual framework for the study of indigenous knowledge of
694 nature. In: Stepp JR, Wyndham FS, Zarger RK (eds) Ethnobiology and biocultural diversity.
695 Atlanta: International Society of Ethnobiology. International Society of Ethnobiology, Atlanta, pp
696 511–522

697 Uda SK, Hein L, Atmoko D (2019) Assessing the health impacts of peatland fires: a case study for Central
698 Kalimantan, Indonesia. Environ Sci Pollut Res 26:31315–31327. https://doi.org/10.1007/s11356-
699 019-06264-x

700 van Vliet N, Mertz O, Heinimann A, et al (2012) Trends, drivers and impacts of changes in swidden
701 cultivation in tropical forest-agriculture frontiers: A global assessment. Global Environmental
702 Change 22:418–429. https://doi.org/10.1016/j.gloenvcha.2011.10.009

703 Vuillot C, Coron N, Calatayud F, et al (2016) Ways of farming and ways of thinking: do farmers' mental
704 models of the landscape relate to their land management practices? Ecology and Society 21:.
705 https://doi.org/10.5751/ES-08281-210135

706 World Bank (2016) The Cost of Fire: An Economic Analysis of Indonesia's 2015 Fire Crisis. World Bank
707 Group, Jakarta, Indonesia

708