

Firing up: Policy, Politics and Polemics under new and old burning regimes

THE NEW FIRE REGIME

The recent alarm over widespread wildfires throughout the world has given extraordinary prominence to the extent and intensity of the 2018 fire season: a virulent wildfire period in Sweden involved more than 50 fires including some above the Arctic circle; deadly fires in Greece and Spain, and California's largest fire on record. The sharp drought accompanied by extensive lack of vegetation brought to light ancient archaeological sites in England; new Eucalyptus and pine vegetation reinforced continuing fire vulnerabilities on the Iberian Peninsula and the prevalence of fire systems even in peri-urban and urban situations such as the environs of Athens, and the massive fires in Northern and Southern Californian peri-urban regions are expressions of this new fire regime.

The effects of climate change and strong El Nino processes, and other elements of climate volatility, are enhancing fires related to land management that are now offsetting the gains of avoided deforestation (Soares-Filho et al. 2012; Uriarte et al. 2012; Morton et al. 2013; Coe et al. 2017; De Faria et al. 2017). Indeed, in many tropical regions, the link between deforestation and an forest fires is becoming less important than the link between forest fires and drought. As Aragao et al (2018) point out, in Amazonia, "despite a 76% decline in deforestation rates over the past 13 years, fire incidence increased by 36% during the 2015 drought compared to the preceding 12 years" (p. 1). " This generated an increase of gemissions from forest fires more than 50% greater than those from old-growth forest deforestation (Aragão et al. 2018).

FIRE DIVERSITY AND FIRE PRACTICES IN A CHANGING LATIN AMERICA

In Latin America, a well-developed body of literature discusses how and why people use fire, the complex local knowledge related to fire use, and the effects of such burning on landscape dynamics, soil fertility and agricultural diversity. With its in-depth analysis of grassland formation and management, shifting cultivation and many other fire-based production systems, especially in tropical forests formations, much of this early literature was pioneered by historical geographers, ethnographers and ethnobiologists who elaborated further on geographic studies of Indigenous knowledge systems, traditional settlement economics and in contemporary land use and development studies. All these areas gave this arena of scholarship its highly multidisciplinary stamp.

But changing fire regimes from climate change, new land uses (such as selective logging), road expansion and forms of land degradation have changed the scale and intensity of fires, and the range and complexity of new drivers has added further impetus to the need to capture information on fire practices (and events) beyond the classic ethnographic cultural logics of fire. Fire as it features in land use change, in ecologies, biodiversities, hydrologies, in carbon dynamics, its effects on climate change and as a profound marker in environmental history, has shifted analytics into more quantitative realms than the earlier emphasis on cultural ecology and symbolic meanings. Fire (and its more domesticated cousin, combustion) reside at the centre of the politics and polemics and policy structures at multiple levels. Fire remains a “cultural question”, but decarbonizing and low carbon politics stand at the heart of many kinds of current policies and practices, although these are typically quite distant from the more active engagement with flames. New research approaches have expanded our understanding of the complexity of modern fire regimes and enhanced the visibility of “fire studies”. Fire’s place in human-environment interactions has been discussed and analyzed by special journal issues, such as the *Philosophical Transactions of the Royal Society B* in May 2016 and the *Journal of*

Ethnobiology in March 2015, with further consolidation of this growing body of literature in a recent edited volume (Welch and Fowler 2018).

OLD AND NEW POLITICAL ECOLOGIES OF FIRE IN LATIN AMERICA

The new fire regime is illustrated by an alarming redoubling of calls for fire suppression from South America, especially from Amazonia and other Brazilian woodlands which have a long and complex burning history and have only recently characterized by catastrophic fires.. In addition, abrupt policy shifts and an array of other pressures (soy market expansion, forest code changes, degazetting of conservation areas and expanding colonist areas, marginalizing traditional forest populations and eroding their fire knowledge) are changing the image of Brazil from one of a place of complex forest stewardship (including fire) into a place of pyrophobia.

Fire research has generally converged on a sharp critique of widespread fire suppression policies all around the world. In many Latin American countries, fire suppression policies were adopted during the last decades in response to extensive misuse of fire for deforestation and conversion of natural vegetation into intensified agriculture and pasture plantations. However, eliminating fire in all landscapes is now seen by scientists as ecologically, but also socially and economically unviable. There is growing recognition that some ecosystems are fire adapted, such as tropical savannas, Mediterranean ecosystems and pine woodlands, and that “zero- fire” policies have led to disastrous large wildfires in these environments due to fuel accumulation (Schmidt et al. 2018)..

Landscape scientists from many disciplines highlight the importance of traditional burning of patch mosaics for 1) biodiversity conservation, 2) wildfire control and prevention, and 3) mitigation of carbon emissions in many kinds of ecosystem (Higgins et

al. 2007; Russell-Smith et al. 2013; Welch et al. 2013; Cordeiro et al. 2014; Eloy et al. 2018b; Batista et al. 2018). Even in fire sensitive ecosystems, like tropical rain forest, recent changes in fire regimes call for a better incorporation of fire management into environmental policies in light of the much increased vulnerability of tropical forest to fires as they become more fragmented, air temperatures become hotter, and human incursions more varied (Alencar et al. 2006; Vayda 2010; Barlow et al. 2012; Armenteras et al. 2013; Alencar et al. 2015; Anderson et al. 2015).

Fire suppression policies have created or increased conflicts between the state and traditional communities, in Latin America, Africa and in Europe. In Latin America, such research underscores the gap between local burning practices and fire policies, largely conceived in classic temperate zone conservation and/or forestry terms (Mistry et al. 2018) derived from increasingly discredited policies in US forest management that developed under the “Smokey the Bear” ideology of fire control. This suppression of practices also leads to a loss of traditional burning knowledge, as in Venezuela (Sletto 2008), Bolivia (McDaniel et al. 2005), and Brazil (Mistry et al. 2005; Pollini 2009; Eloy et al. 2012; Adams et al. 2013; Carmenta et al. 2013; Eloy et al. 2016), and reflects a broader problem of erosion of local knowledge systems more generally.

Since the 1980s and 90s, there has been an evolution in fire policies in the US, Australia, South Africa, Europe, and, very recently (2012), in Latin America, shifting from fire suppression to fire management policies (Mistry et al. 2018). The case of savanna fire management in northern Australia based on valuing and reinterpreting Indigenous burning practices is heralded as a model of the successful reintroduction of early dry season fire to prevent wildfires and has its antecedents in California Forestry’s controlled burn policies. More recently, in Australia, market-based instruments including goals for carbon cycling and reducing GHG emissions incorporated Indigenous fire knowledge (Russell-Smith et al.

2015) . Such models of "prescribed-burning", "integrated fire management", or "community-based fire management", are also used in Mediterranean ecosystems (Lambert 2010), and have been applied to African savannas (Brockett et al. 2001; Goldammer et al. 2004), and, more recently to Latin American countries through networks of expertise and international cooperation (Barradas 2017; Mistry et al. 2018).

POWER AND FIRE KNOWLEDGE

Local knowledge about fire management has become strategic for mitigation and adaptation to climate change, at least at the discursive level. Internationally, such knowledge is advanced in the fight against climate change (Article 7.5 of the Paris Agreement)¹, and for biodiversity conservation and ecosystem services (as in the IPBES platform²). In this context, land (or fire) management knowledge, not just land rights, has become a new node of contestation, especially as carbon politics and other environmental services become more important in the structuring of autonomy over land uses by local populations and change their autonomy over their terrains, such as through blanket fire prohibitions.

Moreover, fire has a long history in landscape construction (Anderson and Posey 1989; Denevan 1992; Butzer and Butzer 1997; Hecht 2009 ; Abiodun et al. 2012; Cordeiro et al. 2014), but now plays an increasingly significant role in greenhouse gas emissions and biodiversity loss as part of the more generalized regional transformations to pasture and large-scale monocrops (Oliveira and Hecht 2018). Latin American countries are characterized by strong regional tensions associated with environmental policies, agriculture and infrastructure development that often compete with local livelihoods and

¹ "Parties acknowledge that adaptation action [...] should be based on and guided by the best available science and, as appropriate, traditional knowledge, knowledge of indigenous peoples and local knowledge systems[...]"

² Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES)

traditional management. These conflicts are often mediated by ideas of primitivism about historical land uses which demonize non-monocrop systems as archaic. Anti-fire discourses are adopted by powerful agribusiness landowners interested in denigrating fire use as part of a political narrative contesting Indigenous and traditional people's rights to land (Welch et al. 2013; Eloy et al. 2016) even as most of the agribusiness holdings rely on a deforestation phase (Oliveira and Hecht 2016; Merry and Soares-Filho 2017).

"Fire free" discourses offer up alternatives, such as agroforestry, to swidden agriculture, and these are becoming more salient with multiplication of payments for ecosystem services, such as REDD³(Hecht, 2012). Climate change politics have in one stroke conflated massive agro-industrial clearing and small-scale transformations as equally culpable for the burgeoning deforestation emissions Under this model, smallholder farmers who maintain highly adaptive systems, like mixed swidden cultivation systems, are targeted (Padoch and Pinedo-Vasquez 2010; Corbera et al. 2011; Steward et al. 2016). Finally, the reliance of Latin American fire policies on geospatial technologies in part due to significant regional expertise in remote sensing tends to exclude local knowledge and power over decision-making (Carmenta 2013). These dynamics represent new forms of expropriation linked less to the actual physical removal of populations through threat of or actual violence and elimination of traditional rights to land, but rather to increasing livelihood instabilities through environmental control and technology: that is *loss of rights to autonomous management*. This is especially ironic given the important environmental contributions of such systems to landscape complexity and biodiversity conservation.

Within this larger debate, however, there is increasing interest in understanding and incorporating local knowledge in fire management as part of hybrid systems for regional management. In Latin America there are exciting examples of innovative territorial rights,

³ Reducing Emissions from Deforestation and Forest Degradation

environmental policies, and intercultural education that rely on the recognition of Indigenous and traditional ecological knowledge. In Brazil, for example, the government implemented new public policies to support Indigenous and *Quilombola* communities⁴ that are engaged in environmental management of their territories, which are recognized as protected areas since 2007. Changing national policies, such as those recently advanced by Brazil's incoming president, however, may undermine such territorial spaces, making such cross cultural knowledge practices far more difficult to sustain. Fire is one of the most important issues in these initiatives, and Indigenous and peasant communities are seeking partnerships to understand and manage fires that have become increasingly difficult to control under new climate regimes. Nevertheless, "efforts to actively involve Indigenous people in fire management have to date mostly been in the form of fire brigades" (Mistry et al. 2016: 6); that is, as bodies rather than minds.

OUR CONTRIBUTION

Inspired by a session at the Annual Meeting of the Association of American Geographers in San Francisco in March 2016, this themed section uses research conducted in different countries and biomes of Latin America to explore the historical and current tensions around forms of knowledge construction within different disciplines—that is the development of the science of burning by local populations and stakeholders, the relationships between fire control policies, science, and rural livelihoods, and the evolution of political factors and ideologies that contribute to fire management conflicts and solutions. These transversal themes cut across the four papers in the section. What our

⁴ *Quilombola* communities are autonomous communities of afro-descendants. Originally associated with slave refugees, they later have become independent settlements (rural or urban) of diverse ethnicities. These social groups assert themselves by engaging in daily practices of resistance, by maintaining and reproducing their way of life and by consolidating their own territories. These land rights were enshrined in the 1988 Brazilian constitution, but ultimately depend on land demarcation

studies and the papers in this collection make clear is the mismatch between policy, science and local realities.

Focused on savanna ecosystems in Brazil and Venezuela, Ludivine Eloy et al. highlight how decision-makers increasingly recognize that fire suppression policies do not work and point to the relevance of local peoples' fire practices for effective fire management (Eloy et al. 2018a). This paper analyzes the new articulations between local communities and environmental managers produced by the recent recognition of the importance of fire in tropical savannas. The current situation appears to support improved dialogue and knowledge exchange between scientists, institutions, Indigenous and local communities with controlled and prescribed fire management in spite of obstacles to forging a truly participatory approach. Savanna management issues are especially important because they have been seen as the "odd man out" in tropical development debates in spite of their considerable complexity, and also the massive level of threat that they face throughout the Americas by agroindustrial expansion, replacing nearly half of the Brazilian Cerrado (Oliveira and Hecht 2018). Little is known about recuperating these landscapes once they are destroyed, although subtle forms of fire management most certainly play a key role.

The issue of limited knowledge on burning practices highlighted by Eloy et al. is also tackled by Rachel Carmenta et al. in their paper on smallholder farmer fire use in the Brazilian Amazon (Carmenta et al. 2018). They point out that in the tropical forest biome "the anti-fire approach has underperformed" and the anti-fire discourse targeting smallholders disregards the history, local use and cultural significance of fire to these communities. Comparing three areas home to smallholder communities of *ribeirinhos* (riverside people), and *assentados* (smallholders settled through agrarian reform), they show how both conservation initiatives and fire policies criminalize practices that remain

indispensable to smallholders, thus generating a situation where intentional fires become illicit and smallholders bear the burden of increasingly flammable landscapes.

The significance of place-based understandings of fire dynamics in forest biomes is further explored by Tahia Davisscher et al. in the Bolivian Chiquitania (Devisscher et al. 2018). They investigated the different perceptions and forms of knowledge that shape the understanding of fire, and ways to deal with wildfire risk by multiple actors, ranging from local fire users to municipal and national government authorities and fire researchers working in different institutes. They found that there were several wildfire risk strategies introduced in the Chiquitania; fire suppression, regulation and monitoring, awareness raising, fire management and a regional fire platform. However, there was a discernible disconnect between the strategies, and a latent tension between the national institutions meant to control fire, and the on-the-ground practitioners. Most favoured formal scientific ecological knowledge to inform decisions, building on a singular notion of “sound science” and a technocentric approach, where less legible and less formal knowledge systems were largely dismissed.

The efficacy of formal fire mitigation policies in the Amazon is further discussed by Aline Silva de Oliveira et al., who use spatially-explicit modelling to value the economic losses to sustainable timber harvesting by fire in Brazil (Oliveira et al. 2018). They found that the most important factor that drives up economic losses from forest fires is the proximity of sustainable timber production to the agricultural frontier i.e. where the different economic practices of sustainable logging and agriculture compete. In addition, economic losses tend to be highest in the first few years of the 30-year logging cycle, after which sustainable logging activities are likely to move away from the agricultural frontier. Their study shows that current fire mitigation programmes deployed in the Amazon are not targeting all the fire ‘hotspots’ identified in their analysis.

key insight revealed by this issue are the need to open spaces for learning, adaptation and dialogue amongst different actors. Local fire users should be playing a central role as active agents to manage fire and fire risk and should be included in management decision-making processes, and as informants for scientific understanding of ecosystem dynamics and relationships with fire. Traditional fire users in Chiquitania are aware of increased climatic variation and the human-related factors that lead to fire accidents, and experiment with new techniques for controlled burning. Carmenta et al. (2018) discuss transcending the taboo of fire in the Brazilian Amazon by creating spaces for social learning that enable the emergence of innovative solutions adapted to local conditions. They further argue that unless a broader agreement is reached between different rural producers, fire mitigation policies are unlikely to succeed.

The research explores the experiences in fire management in Latin America revealing the engagement (and/or disempowerment) of local communities in territorial management. The research emphasizes the role of production, application and circulation of knowledge about fire and its consequences using classical descriptive models, analytics from political ecology, as well as the more complex arena of Science and Technology Studies (STS). More research is needed to understand fire policies, norms, sciences and use practices in the context of the territories in which they are practiced, each with its own dynamics and logics. This is relevant in the context of the more conflictual dynamics associated with the “new fire management” which relies both on more technological means of fire control as well as legislation, payments, and new governmentalities to transform traditional practices. Overall, the papers in this issue place fire management in its new active political and ecological framing, namely at the heart of current development debates in the Latin American tropics.

References

- Abiodun B J, Adeyewa Z D, Oguntunde P G, et al.** 2012 Modeling the impacts of reforestation on future climate in West Africa. *Theoretical and Applied Climatology* 110 77-96.
- Adams C, Chamlian Munari L, Vliet N, et al.** 2013 Diversifying Incomes and Losing Landscape Complexity in Quilombola Shifting Cultivation Communities of the Atlantic Rainforest (Brazil). *Human Ecology* 41 119-37.
- Alencar A, Nepstad D & Diaz M C V** 2006 Forest Understory Fire in the Brazilian Amazon in ENSO and Non-ENSO Years: Area Burned and Committed Carbon Emissions. *Earth Interactions* 10 1-17.
- Alencar A A, Brando P M, Asner G P, et al.** 2015 Landscape fragmentation, severe drought, and the new Amazon forest fire regime. *Ecological Applications* 25 1493-505.
- Anderson A & Posey D A** 1989 Management of a tropical scrub savannah by the Gorotire Kayapo of Brazil. in **Posey D A and Balee W** eds *Resource management in Amazonia: indigenous and folk strategies. Advances in Economic Botany* 7. New York Botanical Garden, New York, USA 159-73.
- Anderson L O, Aragão L E O C, Gloor M, et al.** 2015 Disentangling the contribution of multiple land covers to fire-mediated carbon emissions in Amazonia during the 2010 drought. *Global Biogeochemical Cycles* 29 1739-53.
- Aragão L E O C, Anderson L O, Fonseca M G, et al.** 2018 21st Century drought-related fires counteract the decline of Amazon deforestation carbon emissions. *Nature Communications* 9 536.
- Armenteras D, Rodríguez N & Retana J** 2013 Landscape Dynamics in Northwestern Amazonia: An Assessment of Pastures, Fire and Illicit Crops as Drivers of Tropical Deforestation. *Plos One* 8 e54310.
- Barlow J, Parry L, Gardner T A, et al.** 2012 The critical importance of considering fire in REDD+ programs. *Biological Conservation* 154 1-8.
- Barradas A C S** 2017 A Gestão do fogo na Estação Ecológica Serra Geral do Tocantins, Brasil. Master thesis. *Mestrado Profissional em Biodiversidade em Unidades de Conservação*. Instituto de Pesquisas Jardim Botânico do Rio de Janeiro, Rio de Janeiro.
- Batista E K L, Russell-Smith J, Franca H, et al.** 2018 An evaluation of contemporary savanna fire regimes in the Canastra National Park, Brazil: Outcomes of fire suppression policies. *Journal of Environmental Management* 205 40-49.
- Brockett B H, Biggs H C & van Wilgen B W** 2001 A patch mosaic burning system for conservation areas in southern African savannas. *International Journal of Wildland Fire* 10 169-83.
- Butzer K W & Butzer E K** 1997 The 'natural' vegetation of the Mexican Bajío: Archival documentation of a 16th-century Savanna environment. *Quaternary International* 43-44 161-72.
- Carmenta R** 2013 From Earth Observation to Ethnography: Examining smallholder fire management in the Brazilian Amazon. PhD thesis. *Environmental Sciences*. Lancaster University, Lancaster, UK.
- Carmenta R, Coudel E & Steward A M** 2018 Forbidden fire: Does criminalising fire hinder conservation efforts in swidden landscapes of the Brazilian Amazon? *The geographical journal* doi: 10.1111/geoj.12255.
- Carmenta R, Vermeylen S, Parry L, et al.** 2013 Shifting Cultivation and Fire Policy: Insights from the Brazilian Amazon. *Human Ecology* 41 603-14.

- Coe M T, Brando P M, Deegan L A, et al.** 2017 The Forests of the Amazon and Cerrado Moderate Regional Climate and Are the Key to the Future. *Tropical Conservation Science* 10 1940082917720671.
- Corbera E, Estrada M, May P, et al.** 2011 Rights to Land, Forests and Carbon in REDD+: Insights from Mexico, Brazil and Costa Rica. *Forests* 2 301.
- Cordeiro R C, Turcq B, Moreira L S, et al.** 2014 Palaeofires in Amazon: Interplay between land use change and palaeoclimatic events. *Palaeogeography, Palaeoclimatology, Palaeoecology* 415 137-51.
- De Faria B L, Brando P M, Macedo M, N., et al.** 2017 Current and future patterns of fire-induced forest degradation in Amazonia. *Environmental Research Letters* 12 095005.
- Denevan W** 1992 The pristine myth: the landscape of the Americas in 1492. *Annals of the Association of American Geographers* 82 369-85.
- Devisscher T, Malhi Y & Boyd E** 2018 Deliberation for wildfire risk management: Addressing conflicting views in the Chiquitania, Bolivia. *The geographical journal* 0 doi:10.1111/geoj.12261.
- Eloy L, Aubertin C, Toni F, et al.** 2016 On the margins of soy farms: traditional populations and selective environmental policies in the Brazilian Cerrado. *The Journal of Peasant Studies* 43 494-516.
- Eloy L, Bilbao B, Mistry J, et al.** 2018a From fire suppression to fire management: advances and resistances to changes in fire policy in the savannas of Brazil and Venezuela. *The geographical journal* 00 1-13. <https://doi.org/10.1111/geoj.12245>.
- Eloy L, Méral P, Ludewigs T, et al.** 2012 Payments for Ecosystem Services in Amazonia. The challenge of land use heterogeneity in agricultural frontiers near Cruzeiro do Sul (Acre, Brazil). *Journal of Environmental Planning and Management* 55 685-703.
- Eloy L, Schmidt I, Borges S L, et al.** 2018b Seasonal fire management by traditional cattle ranchers prevents the spread of wildfire in the Brazilian Cerrado. *Ambio* 10.1007/s13280-018-1118-8.
- Goldammer J G, Frost P, Jurvelius M, et al.** 2004 Community participation in integrated forest fire management: some experiences from Africa. in **Goldammer J G and de Ronde C** eds *Wildland Fire Management Handbook for Sub-Saharan Africa*. Global Fire Monitoring Center, Freiburg, Alemania. 382-402.
- Hecht S B** 2009 Kayapó Savanna Management: Fire, Soils, and Forest Islands in a Threatened Biome. in **Woods W I, Teixeira W G, Lehmann J, Steiner C, WinklerPrins A M G A and Rebellato L** eds *Amazonian Dark Earths: Wim Sombroek's Vision*. Springer, Heidelberg 143-62.
- Hecht S B** 2012 From eco-catastrophe to zero deforestation? Interdisciplinary, politics, environmentalisms and reduced clearing in Amazonia. *Environmental Conservation* 39 4-19.
- Higgins S I, Bond W J, February E C, et al.** 2007 Effects of four decades of fire manipulation on woody vegetation structure in savanna. *Ecology* 88 1119-25.
- Lambert B** 2010 The French prescribed burning network and its professional team in Pyrénées-Orientales. Lessons drawn from 20 years of experience. in **Montiel C and Kraus D** eds *Best practices of fire use - Prescribed burning and suppression of fire programs in selected case-study regions in Europe*. European Forest Institute 89-108.
- McDaniel J, Kennard D & Fuentes A** 2005 Smokey the Tapir: Traditional Fire Knowledge and Fire Prevention Campaigns in Lowland Bolivia. *Society and Natural Resources* 18 921-31.
- Merry F & Soares-Filho B** 2017 Will intensification of beef production deliver conservation outcomes in the Brazilian Amazon? *Elem Sci Anth* 5 <http://doi.org/10.1525/elementa.224>.

- Mistry J, Berardi A, Andrade V, et al.** 2005 Indigenous Fire Management in the cerrado of Brazil: The Case of the Krahô of Tocantins. *Human Ecology* 33 365-86.
- Mistry J, Bilbao B A & Berardi A** 2016 Community owned solutions for fire management in tropical ecosystems: case studies from Indigenous communities of South America. *Philosophical Transactions of the Royal Society of London B: Biological Sciences* 371.
- Mistry J, Schmidt I B, Eloy L, et al.** 2018 New perspectives in fire management in South American savannas: The importance of intercultural governance. *Ambio* <https://doi.org/10.1007/s13280-018-1054-7>.
- Morton D C, Le Page Y, DeFries R, et al.** 2013 Understorey fire frequency and the fate of burned forests in southern Amazonia. *Philosophical transactions of the Royal Society of London. Series B, Biological sciences* 368 20120163.
- Oliveira A S, Rajão R G, Soares Filho B S, et al.** 2018 Economic losses to sustainable timber production by fire in the Brazilian Amazon. *The geographical journal* 0 [doi:10.1111/geoj.12276](https://doi.org/10.1111/geoj.12276).
- Oliveira G & Hecht S** 2016 Sacred groves, sacrifice zones and soy production: globalization, intensification and neo-nature in South America. *The Journal of Peasant Studies* 43 251-85.
- Oliveira G & Hecht S B** 2018 *Soy, Globalization and Environmental Politics in Latin America* Routledge, New York.
- Padoch C & Pinedo-Vasquez M** 2010 Saving Slash-and-Burn to Save Biodiversity. *Biotropica* 42 550–52.
- Pollini J** 2009 Agroforestry and the search for alternatives to slash-and-burn cultivation: From technological optimism to a political economy of deforestation. *Agriculture, Ecosystems & Environment* 133 48-60.
- Russell-Smith J, Monagle C, Jacobsohn M, et al.** 2013 Can savanna burning projects deliver measurable greenhouse emissions reductions and sustainable livelihood opportunities in fire-prone settings? *Climatic Change* 1-15.
- Russell-Smith J, Yates C P, Edwards A, et al.** 2015 Deriving Multiple Benefits from Carbon Market-Based Savanna Fire Management: An Australian Example. *Plos One* 10 e0143426.
- Schmidt I B, Moura L C, Ferreira M C, et al.** 2018 Fire management in the Brazilian Savanna: first steps and the way forward. *Journal of Applied Ecology* 00 1-8, <https://doi.org/10.1111/365-2664.13118>.
- Sletto B** 2008 The Knowledge that Counts: Institutional Identities, Policy Science, and the Conflict Over Fire Management in the Gran Sabana, Venezuela. *World Development* 36 1938-55.
- Soares-Filho B, Silvestrini R, Nepstad D, et al.** 2012 Forest fragmentation, climate change and understory fire regimes on the Amazonian landscapes of the Xingu headwaters. *Landscape Ecology* 27 585-98.
- Steward A M, Rognant C & Vieira do Brito S** 2016 Roça sem fogo: a visão de agricultores e técnicos sobre uma experiência de manejo na Reserva de Desenvolvimento Sustentável Amanã, Amazonas, Brasil. *Biodiversidade brasileira* 6 71–87.
- Uriarte M, Pinedo-Vasquez M, DeFries R S, et al.** 2012 Depopulation of rural landscapes exacerbates fire activity in the western Amazon. *Proceedings of the National Academy of Sciences* 109 21546-50.
- Vayda A P** 2010 Explaining Indonesian Forest Fires: Both Ends of the Firestick. in **Bates G D and Tucker J** eds *Human Ecology: Contemporary Research and Practice*. Springer US, Boston, MA 17-35.
- Welch J & Fowler C** 2018 *Fire Otherwise. Ethnobiology of Burning for a Changing World* The University of Utah Press, Salt Lake City, USA.

Welch J R, Brondizio E, Hetrick S S, et al. 2013 Indigenous Burning as Conservation Practice: Neotropical Savanna Recovery amid Agribusiness Deforestation in Central Brazil. *Plos One* 8 e81226.