Why It is Important to Understand the Relationship Between People, Fire and Protected Areas

Jayalaxshmi Mistry[1] & Marcelo Bizerril[2]

ABSTRACT – Fire and its impacts on biodiversity and natural resources has been an important focus of attention within protected areas and their management. However, protected areas are directly dependent on social-ecological processes beyond their boundaries for their long-term ecological viability, including fire. In this review, we put forward a case for greater understanding of what determines people's use (and abuse) of fire and management solutions they choose to practice in the wider landscape surrounding protected areas. Our contention is that only through multidisciplinary research that looks at why and how people burn and the local realities of fire management can we have a better chance at more effective fire control and use. Furthermore, only through participatory approaches focusing on adaptive learning by all stakeholders will real change occur.

Keywords: adaptive management; fire; local communities; management, protected areas.

RESUMO – O fogo e seus impactos sobre a biodiversidade e os recursos naturais tem se destacado nas discussões ligadas ao manejo das áreas protegidas. De outro lado, a viabilidade das unidades de conservação como locais de proteção da biodiversidade a longo prazo depende diretamente dos processos sociais e ecológicos que se dão em seu entorno, o que inclui o fogo. Na presente revisão, analisamos o tema buscando um maior entendimento a respeito do que determina o uso do fogo, assim como seu abuso pelas pessoas, e as soluções encontradas por elas para o manejo das vastas paisagens circunvizinhas às áreas de proteção. A tese defendida é a de que para haver efetivo controle do fogo e de seu uso é preciso que pesquisas multidisciplinares analisem as motivações e as formas de uso do fogo no contexto das realidades locais. Além disso, para que ocorram mudanças reais nesse cenário, são necessárias abordagens e metodologias participativas que enfoquem a experiência e os saberes de todos os atores sociais envolvidos na questão.

Palavras-chave: áreas protegidas; comunidades locais; fogo; manejo; manejo adaptativo.

Introduction

Adaptive management, or learning by doing, has become an increasingly powerful tool in dealing with the complex and unpredictable nature of natural resource management (Gunderson & Holling 2002, Berkes *et al*. 2003). However, operationalising adaptive management can be extremely challenging as it requires in-depth understanding of social-ecological systems. Governance of these systems is complicated when there are many stakeholders, each with differing worldviews on society and nature. Not only do these worldviews construct meanings and relationships, helping to define common sense and legitimate knowledge, they also influence peoples' behaviour and practice.

Fire is an age-old management tool, used widely in tropical land management and conversion. It continues to play an integral role in supporting the livelihoods of millions of people, playing a

[1]Department of Geography, Royal Holloway, University of London, Egham, Surrey TW20 0EX. E-mail: j.mistry@rhul.ac.uk
[2]Faculdade UnB Planaltina, Universidade de Brasília, Brasília, Brasil. E-mail: bizerril@unb.br

significant role in various agricultural and social practices. Yet, at the same time, it is a major driver of global environmental change (Bowman *et al.* 2009), damaging natural resources and built capital and changing local and regional ecological dynamics, whether through accidental or intentional use. Fire is connected to issues of human wellbeing, cultural identity, ecological sustainability, species diversity, as well as climate regulation, indicating the complexity surrounding fire use and management at a range of spatial and temporal scales. Nowhere is this complex web of interactions most acutely played out than in protected areas.

Fire has in fact played a pivotal role in the establishment of many protected areas in the tropics. Historical analysis of the trajectories of protected areas establishment in Africa, for example, indicates quite clearly how many local and indigenous people were accused by colonialists of causing land degradation through fire use (Kull 2002, Laris & Wardell 2006). 'Degradation' through fire and the associated assumption of 'bad' land management was used as the justification for evicting and/or appropriating land rights from local people and gazetting areas for protection. The idea of the inappropriateness and destructive nature of fire followed through in the management of those protected areas, where fire was actively suppressed. Even today, many protected areas around the tropics have 'no-action' suppression/protection policies when it comes to fire management (Bilbao *et al.* 2010). In the Brazilian *cerrado*, for example, an ecosystem within which fire has had a pivotal evolutionary role and where it maintains key ecological processes, fire is still seen as an evil by environmental and governmental institutions (Pivello 2006).

Yet, however well protected areas may protect resources within their boundaries, their long-term ecological viability is directly dependent on social-ecological processes beyond their boundaries (Mistry & Berardi 2005). This is illustrated by the almost predictable annual occurrence of large-scale fires within many protected areas around the world as a result of fuel accumulation in the dry season. In Brazil, a study by França (2010) of six national parks in the *cerrado* (savanna) region (Emas, Araguaia, Serra da Canastra, Brasília, Chapada dos Veadeiros and Chapada dos Guimarães) found that a total of 5897 km^2 was burned in 2010, representing 35% to 91% of the area of the parks. Long term studies also indicate that areas of conservation such as Emas National Park and Serra da Canastra National Park are regularly invaded by fires, almost annually for the past 25 years (Barreto, 1999, Medeiros & Fiedler 2004, França *et al.* 2007). The ignition points for the vast majority of these fires are human-induced and emerge from outside of the park boundaries.

Our contention is that effective fire management in protected areas, including Brazil, can only come about through greater understanding of what determines people's use (and abuse) of fire and management solutions they choose to practice in the wider landscape surrounding protected areas. Only by coupling this information with the ecological consequences of burning, can strategies for reducing the damaging ecological and social consequences of wildfire be developed, while at the same time the benefits to people and nature be enhanced. Here we provide evidence to support our case, using data from the literature and our experiences of working and living with rural agricultural and indigenous communities in the Distrito Federal, Tocantins and Minas Gerais of the Brazilian *cerrado*.

Understanding <u>Why</u> People Burn

"I burn because it's good for the earth, the crops. They will grow stronger. My father and grandfather burned and so do I" (Brazilian farmer, Distrito Federal, J. Mistry, unpublished data).

Most fires started in rural landscapes are linked with agricultural activities, independent of the ecosystem in which they are set. Farmers in Brazil, as elsewhere, use fire to clear vegetation from their fields for planting, sometimes burning to clear residues and pests/weeds, as well as for establishing and renewing pastures (see Pivello 2011). Indigenous peoples have been using fire as a management tool for millennia for shifting cultivation, grass re-growth, attracting and driving game, stimulating and gathering wild foods including fruits and honey, creating firebreaks,

as well as for cultural and spiritual reasons (e.g. Mistry *et al.* 2005, Rodriguez 2007, Schmerbeck & Seeland 2007, Mcgregor *et al.* 2010). Yet, greater insight into what determines why people choose fire as a management option is necessary.

For example, work by Mistry (1998) with subsistence farmers in the Distrito Federal of Brazil found that the two main factors limiting the choice of feasible options for farmers to meet their management objectives were income and time. When assessing the costs and benefits of different management options for clearing fields or for providing cattle with fresh feed during the dry season, most farmers found that using alternatives to fire would adversely impact their ability to maintain an income level for sustaining their livelihoods. So in most cases, farmers had no choice but to use fire. At the same time, and as illustrated by the quote at the start of this section, farmers' perceptions of fire use played an equal if not more important role in their management decision-making (Mistry 1998). These perceptions evolved around the 'good' and 'evil' aspects of fire, the influence of the lunar cycle on fire behaviour, as well as belief in luck and superstition. A variety of factors seemed to influence these perceptions including age, intergenerational transfer of knowledge, education and awareness. Although this and other studies (e.g. Laris 2002, McGregor 2010) go some way in our understanding of why people burn landscapes, Carmenta *et al.* (2011) highlight the need for identifying different types of landholders and their specific patterns of fire use and management. In, most studies have been done on smallholders, with very little work on large landholdings although in some regions such as the Amazon, they may be responsible for the majority of fire ignitions (Uhl & Buschbacher, 1985).

Several authors have highlighted that conservation interventions, such as protected areas, where the full social and environmental impacts on local people have not been considered, have actually increased the poverty of rural communities (Brockington *et al.* 2006, 2008, Igoe, 2006). Denied access to long established natural resources such as pastures for cattle, together with state anti-fire/fire control policies that criminalise customary fire practices, has led to the growing incidences of fire as a form of rural political protest (Pyne 1997, Kuhlken 1999). For example, fire has been a source of conflict since the establishment of the Serra da Canastra National Park in 1972. Official reports and park authorities assign the majority of fires in the park to be 'criminal' started by 'lawbreakers' (Medeiros and Fiedler 2004) and it is common to hear fire-fighters working in the conservation area impart blame on 'intentional' burning. "It is common after a fire to find local materials used by people to start the burn. Many [people] start fires in the park so that the burn will then pass through and burn their pastures" (Fire-fighter at Serra da Canastra National Park, Bizerril unpublished data).

Yet, although the evidence seemingly points to intentional burning as a form of retaliation against the deployment of the park, the principal cause of fire is the necessity to manage pastures for cattle and the difficulties in obtaining licences for prescribed burns (also found by Mistry 1998, in the Distrito Federal). The main impediments to controlled burning cited by landholders are the slow, bureaucratic and costly procedures for obtaining licences, as well as the federal requirements of demarcating Legal Reserves on their land (see below) and keeping up with government checks (M. Bizerril unpublished data).

Kull (2002, 2004) also points to the need for a more nuanced interpretation of illegal and/or criminal burning, questioning intentionality in the form of 'overt protest' or 'advantage-taking'. Working in Madagascar, he shows that more often than not, local landholders take advantage of opportunities to accomplish their burning needs, rather than as explicit protest: taking advantage of the nature of fire itself by letting fires escape 'accidentally', letting escaped fires run their course, piggybacking one fire on another etc.; taking advantage of village solidarity to blame fires on unnamed passersby, unknown people, children playing etc.; taking advantage of state weaknesses including the limited reach of government authority, its internal diversity in the form of varied institutions with differing goals and moments of state distraction such as during locust invasions when the state must choose between enforcing anti-fire laws or using fire to kill the economically-disastrous locusts (Kull & Laris 2009). Similar insights have been found from the Serra da Canastra

National Park where farmers blame wildfire inside the park on people from outside the communities or on unknown mad people (M. Bizerril unpublished data). A greater understanding of those fires categorised as 'criminal' or through arson is required.

Understanding <u>How</u> People Burn

When protected areas were first established, the dominant ecological paradigm posited equilibrium as the natural state of the environment i.*e.* the environment was in a stable state maintained by biotic interactions and feedbacks with people (and their associated activities) causing 'disturbance' to this stable state. These ideas and their associated worldviews on how protected areas should be managed are still retained today, but are in fact largely out of step with emerging paradigms in the field of ecology. Non-equilibrium theories focus on processes that generate spatial and temporal heterogeneity, including interactions between organisms, environmental variability, and disturbance (Picket *et al.* 2003). They accept unpredictability and dynamism as natural processes, and people as an integral part of the dynamic system (Mistry & Berardi 2006). In addition, climate change will inevitably change local and regional climate patterns around the world and potentially increase the dynamics and unpredictability of weather patterns, which in turn will affect fire hazard (Bowman *et al.* 2009). This will significantly challenge the notion of 'equilibrium' in the future.

Fire is an important agent of landscape heterogeneity. Using remote sensing analyses, Hudak *et al.* (2004) have shown that compared to fire exclusion, regular fire occurrence in the savannas of southern Africa promoted landscape heterogeneity. However interestingly, much of the work highlighting the role of fire in landscape heterogeneity has come from an on-the-ground understanding of the way indigenous and traditional savanna communities burn their landscapes. Australian Aborigines (Haynes 1985, 1991, Lewis 1989, Russell-Smith *et al.* 1997), Brazilian indigenous groups (Posey 1985, Anderson & Posey 1985, 1989, Mistry *et al.* 2005) and traditional communities in West Africa (Mbow *et al.* 2000, Laris 2002) all burn in what has been termed a 'patch-mosaic fire regime' (Parr & Brockett 1999). This involves burning from the early dry season through to the late dry season — burning throughout the dry season results in a landscape pattern comprised of patches in various stages of fire succession intermingled with unburned patches. The potential benefits of producing such a mosaic of patch types of differing fire histories within the landscape include the creation of natural firebreaks within the landscape where burned patches act to 'fireguard' particular vegetation patches (Laris 2002, Mistry *et al.* 2005), and the maintenance and enrichment of biodiversity through the creation and preservation of a variety of microhabitats that support different species (Braithwaite 1996, Vigilante & Bowman 2004).

For farmers and rural agriculturists, fire practices differ in terms of fire frequency, area burned and precautions taken. In the Distrito Federal, Brazil for example, Mistry (1998) found that although plot sizes were small (on average less than five hectares), most farmers tried to avoid burning *every* year. One or two years may be an insufficient fallow period in between burns, but the results from this study showed that many farmers do rotate burning and burnt small patches within their land. Anecdotal evidence from the Serra da Canastra in Brasil indicates that many older traditional farmers continue to use knowledge from their ancestors, advocating 'fogo frio' or 'cold burning' where they set fires during the night or in the early hours of the morning and also during the months of December and January in the rainy season after some days without rain (M. Bizerril unpublished data). According to reports, these burns are easily controlled and serve to renovate pastures while protecting the land from disastrous wildfires in the dry season: "In the old times, we never had these huge fires in the plateau [reference to the Serra da Canastra National Park] that we have today" (Elder traditional farmer, M. Bizerril unpublished data). Other, perhaps less traditional farmers, talk about the benefits of fire for their pastures or for clearing their fields, but tend to use fire mostly at the end of the dry season, the hottest, driest and most hazardous period when fires can easily go out of control (Mistry 1998).

Another reason why fires, started with the intention of burning small areas of land, may go out of control could be changes in local institutional arrangements with regards to fire management. Most local communities have their internal conflicts, tensions and rivalries. However, in the past there was a communal understanding and institutional structure/authorities (e.g. village elders, chiefs) of working together to manage natural resources in sustainable ways. In some cases, these structures may be breaking down. For example, Mistry (1998) found that the majority of farmers interviewed in the Distrito Federal undertook burning by themselves without any help, and few precautions were taken during the actual fire, normally as a consequence of lack of help. If farmers were friends with neighbouring landholders they tended to be much more careful, took precautions and warned their neighbours prior to burning. Intergenerational changes within indigenous communities also point to changes in fire use. Amongst the Krahô, for example, most burning occurred in groups and with the consensus of fire knowledge bearing individuals. However, many younger Krahô men that had been influenced by outsiders, namely farmers of European descent, openly criticised burning during communal meetings, resulting in many early season protective and resource enhancing fire practices not being implemented (Mistry *et al.* 2005). At the same time, because the fire practices of individuals were not under the scrutiny of the group, these continued to be used, mostly in the late dry season resulting in increasingly damaging fires that reinforced antagonisms against fire use. Our limited studies therefore indicate that although we have a broad awareness of how fires occur, we need much more detailed knowledge of different fire practices by different groups of people at different times of the year, coupled with an understanding of social structures and processes of communities living around protected areas and their impacts on natural resource management.

Understanding Local Fire-Related Realities

At the national and international scale, there seems to be a reliance on technological advances as a solution to fire (e.g. Nepstad *et al.* 2006, Adeney *et al.* 2009, Aragão & Shimabukuro 2010), with a clear (and dominant) discourse aligned with geospatial technology where voice and power over decision-making is in the hands of those with the technology (e.g. scientists, governments) rather than those without (e.g. local farmers, indigenous peoples) (Robbins 2003, Sletto 2008). In a recent review of fire studies in tropical humid forest areas, Carmenta *et al.* (2011) found that remote sensing techniques for detecting fire were favoured by resource/park managers and policy-makers because of their replicability and representation of a seemingly objective reality. In the cases where this data was correlated with secondary sources of social data to identify fire causality or hotspots, the use of coarse level indices such as human population density meant that only broad generalisations could be made, with little understanding of the dynamic and complex nature of fire use (Hayes & Rajão 2011).

It is clear that ground-based studies into the social and cultural aspects of fire use are required, to not only help identify fire hazard but to also align the current mismatch between higher level fire policies, policy-makers worldviews and local lived realities (see for example Porro 2005, Russell-Smith *et al.* 2007). In Brazil, there has been considerable research on the ecology of fire in various ecosystems, yet few studies have addressed the historical, social, economic and political aspects of fire use at the local scale. National laws and regulations on how individuals can use fire attempt to prevent and control the use of fire, especially around protected areas, but the extensive burning of these landscapes in the dry season signifies a mismatch between these fire management policies and what happens in practice (Sorrensen 2009).

Although understanding why and how people burn is vital, equally critical is the need for a more nuanced and critical examination of multi-scalar processes that basically leave local people with no land management choice but to burn. For example, the Amazon Fire and Deforestation Monitoring and Control Project (PRODESQUE – Projeto de Monitoramento e Controle de Desmatamentos e Queimadas na Amazonia) was developed following the 1998 Roraima fires, and changes were made to the Brazilian Forest Code. These included increasing forest reserves

on Amazon landholdings from 50% to 80% of total landholding so that increased forest cover could act as buffers against fire spread to more remote areas. In addition, IBAMA[1] instigated specific regulations for the use of prescribed fire including a permit system and certain physical and climate parameters/limits for fire use. The result of these federal policies was a decrease in the area of farmable agricultural land within farmer plots. At the same time, rural development policies favour initial land transfer, but the institutional arrangements to give farmers better security such as land tenure and agricultural credit, are weak. As Sorrensen (2009, p.789) points out "caught between conservation policy and limited rural development, farmers are left with few choices: the increasingly illegal option of slash/burn in their Legal Reserves to expand production, or the extended and eventual over use of the farmable portion of land".

Furthermore, fire management can only be successful if institutional frameworks can incorporate sensitivity to local level constraints, such as access to machinery or man power and norms of behaviour (Carvelheiro 2004, Eriksen 2007). Many government officials working for local or district level agencies around conservation areas find themselves in a difficult position: they are unable to adhere to federal level requirements commanded from central agencies headquartered in the capital, while at the same time find it impossible to come to agreements with local farmers to promote controlled fires. Kull (2002) explains how in the Madagascan context, since local communities cannot argue against ministries located in the distant capital, they make life difficult for field foresters in charge of managing fire. In turn, state officials can operate for their own personal goals, catching fire-starters but then letting them off, sometimes with bribes that are cheaper than official fines or the threat of a prosecutor process. In the Serra da Canastra, Brasil, local state representatives regularly complain about the disengagement of officials from the capital with local problems. There is also fear and distrust by local people of the environment agency, due to its regulatory role. On the other hand, the lack of equipment and personnel on the ground made firefighting extremely challenging; many firefighters came from urban centres and did not know how to fight vegetation fires; most firefighters were not willing to work at night when it is potentially easier to combat the fire; firefighters were only employed during the dry season, but all-year round employment could ensure better and greater firebreaks are constructed as well as other activities take place to reduce the risk of fire (Bizerril unpublished data).

Conclusion

The complexity involved in fire management and protected areas, characterised by multiple and often conflicting objectives, inherent unpredictability and decentralised control, calls for an approach to management where learning is at its centre (Berardi & Mistry, 2006). The notion of adaptive management suggests that more local-level, participatory, community-based forms of management involving various stakeholders are required (Berkes 2004). Although there is evidence from some protected areas of an adaptive management approach, involving local communities in various issues surrounding fire management (see examples from Kruger National Park, South Africa and Kakadu National Park, Australia, Parr *et al.* 2009, van Wilgen 2009, van Wilgen & Biggs 2011), the one-way, top-down, command-and-control style of management is still predominant. This is a major inhibition to social learning as feedback, from people that are intimately linked to protected areas systems, to researchers and institutionalised decision-makers (mainly sitting in urban offices) is severely curtailed (Berardi & Mistry 2006).

---

[1] IBAMA: Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis.

"It would be good if someone did some research on what they [the farmers] think about IBAMA[2], showing what are the problems they have with us. We need to have a meeting all together. But the people in Brasilia also have to agree." (Fire-fighter at Serra da Canastra National Park, Bizerril unpublished data). More integration among all parties involved in the fire decision making process - policy makers, scientists, park managers, and farmers – either to disseminate the necessary knowledge for management or to appropriately contemplate the needs and constraints existing in the system to be managed is necessary (Rodriguez 2007, Costanza & Moody 2011). There needs to be investment in amplifying communication channels between central national level decision-making, those responsible for implementing policies at the local level and local populations so that concrete strides can be made on reducing the risks of fire rather than focusing predominantly on fire fighting.

Understanding the complexity of the relationship between people, fire and protected areas requires a multidisciplinary, holistic and participatory approach, with a focus on adaptive learning from all stakeholders. Forsyth (1996) terms this 'hybrid knowledge' where both scientific and local land-user views and values are integrated for understanding management issues. Dialogue has to involve receptiveness, an indication that the others' points of view are understood, and an invitation to reflect on the issues that have been raised. This relationship has to be sustained in the long term for real change to occur. However, once this relationship has been established, the scene is set to implement the multidisciplinary research approach using plural methodologies e.g. blending social, historical, economic and biophysical research (see for example Laris 2002, 2006, Dennis *et al.* 2005, Simmons *et al.* 2004) to give better fire management outcomes for all.

References

Adeney, J. M.; Christensen, N. L. & Pimm, S. L. 2009. Reserves protect against deforestation fires in the Amazon. **PLoS One**, 4: e5014.

Anderson, A.B. & Posey, D.A. 1985. Manejo de cerrado pelos indios Kayapó. **Boletim do Museu Paraense Emilio Goeldi Botânica**, 2(1): 77-98.

Aragão, L. & Shimabukuro, Y. E. 2010. The incidence of fire in Amazonian forests with implications for REDD. **Science**, 328: 1275-1278.

Barreto, C.B. 1999. **Contribuição ao manejo e à restauração da Zona de Recuperação no Parque Nacional da Serra da Canastra (MG), com referência especial aos incêndios, por meio de geoprocessamento**. Dissertação de Mestrado. Universidade Estadual Paulista, Rio Claro-SP.

Berardi, A. & Mistry, J. 2006. A multidisciplinary and participatory research approach in savannas and dry forests. p.265-271. In Mistry, J. & Berardi, A. (eds.) **Savannas and dry forests: linking people with nature**. Ashgate Publications.

Berkes, F. 2004. Rethinking community-based conservation. **Conservation Biology**, 18(3): 621-630.

Berkes, F.; Colding, J. & Folke, C. eds. 2003. **Navigating social-ecological systems: building resilience for complexity and change**. Cambridge University Press.

Bilbao, B.A.; Leal, A.V. & Méndez, C.L. 2010. Indigenous use of fire and forest loss in Canaima National Park, Venezuela. Assessment of and tools for alternative strategies of fire management in Pemón indigenous lands. **Human Ecology**, 38: 663-673.

---

[2] In this discussion, the term IBAMA is used as a generic reference to the local environment agency. From 2007, the agency was dismembered and the Instituto Chico Mendes de Conservação da Biodiversidade – ICMBio – was created.

Bowman, D.; Balch, J.K.; Artaxo, P.; Bond, W.J.; Carlson, J.M.; Cochrane, M.A.; D'Antonio, C.M.; DeFries, R.S.; Doyle, J.C.; Harrison, S.P.; Johnson, F.H.; Keeley, J.E.; Krawchuk, M.A.; Kull, C.A.; Marston, J.B.; Moritz, M.A.; Prentice, I.C.; Roos, C.I.; Scott, A.C.; Sewtnam, T.W.; van der Werf, G.R. & Pyne, S.J. 2009. Fire in the earth system. **Science**, 324: 481-484.

Braithwaite, R.W. 1996. Biodiversity and fire in the savanna landscape. p.121-140. In Solbrig, O.T.; Medina, E. & Silva, J. (eds.). **Biodiversity and savanna ecosystem processes**. Springer.

Brockington, D.; Duffy, R. & Igoe, J. 2008. **Nature unbound. Conservation, capitalism and the future of protected areas**. Earthscan.

Brockington, D.; West, P. & Igoe, J. 2006. Parks and peoples: the social impact of protected areas. **Annual Review of Anthropology**, 35: 251-277.

Carmenta, R.; Parry, L.; Blackburn, A.; Vermeylen, S. & Barlow, J. 2011. Understanding human-fire interactions in tropical forest regions: a case for interdisciplinary research across the natural and social sciences. **Ecology and Society**, 16(1): 53 [online] URL: http://www.ecologyandsociety.org/vol16/iss1/art53

Carvelheiro, K. 2004. **Community fire management in the Marana region, Brazilian Amazonia**. Dissertation. University of Florida.

Costanza, J.K. & Moody, A. Deciding where to burn: stakeholder priorities for prescribed burning of a fire-dependent ecosystem. **Ecology and Society**, 16(1): 14 [online] URL: http://www.ecologyandsociety.org/vol16/iss1/art14

Dennis, R.A.; Mayer, J.; Applegate, G.; Chokkalingam, U.; Colfer, C. J. P.; Kurniawan, I.; Lachowski, H.; Maus, P.; Permana, R. P.; Ruchiat, Y.; Stolle, F.; Suyanto & Tomich, T. P. 2005. Fire, people and pixels: Linking social science and remote sensing to understand underlying causes and impacts of fires in Indonesia. **Human Ecology**, 33: 465-504.

Eriksen, C. 2007. Why do they burn the 'bush'? Fire, rural livelihoods, and conservation in Zambia. **Geographical Review**, 173: 242-256.

Forsyth, T., 1996. Science, myth and knowledge: testing Himalayan environmental degradation in Thailand. **Geoforum**, 27, 375-392.

França, H. 2010. Os incêndios de 2010 nos parques nacionais do cerrado. Technical report. **Universidade Federal do ABC**. <http://www.ufabc.edu.br/images/stories/comunicacao/queimadas-2010-1.pdf> (Accessed 16 May 2011).

França, H.; Ramos Neto, M.B. & Setzer, A. 2007. **O fogo no Parque Nacional das Emas**. Série Biodiversidade, v. 27, Ministério do Meio Ambiente.

Gunderson, L. & Holling, C.S. eds. 2002. **Panarchy: understanding transformations in human and natural systems**. Island Press.

Hayes, N. & Rajão, R. 2011. Competing institutional logics and sustainable development: the case of geographic information systems in Brazil's Amazon region. **Information Technology for Development**, 17: 4-23.

Haynes, C.D. 1985. The pattern and ecology of munwag: traditional Aboriginal fire regimes in north-central Arnhemland. **Proceedings of the Ecological Society of Australia**, 13: 203-214.

Haynes, C.D. 1991. Use and impact of fire. p.61-71. In Haynes, C.D.; Ridpath, M.G. & Williams, M.A.J. (eds.). **Monsoonal Australia: landscape, ecology and man in the northern lowlands**. A.A. Balkema.

Hudak, A.T.; Fairbanks, D.H.K. & Brockett, B.H. 2004. Trends in fire patterns in a southern African savanna under alternative land use practices. **Agriculture, Ecosystems and Environment**, 101: 307-325.

Igoe, J. 2006. Ecosystem dynamics and institutional inertia: a discussion of landscape conservation in northern Tanzania. p. 77-103. In Mistry, J. & Berardi, A. (eds.). **Savannas and dry forests: linking people with nature**. Ashgate Publications.

Kuhlken, R. 1999. Settin' the woods on fire: rural incendiarism as protest. **Geographical Review**, 89: 343-363.

Kull, C.A. & Laris, P. 2009. Fire ecology and fire politics in Mali and Madagascar. p. 71-226. In Cochrane, M.A. ed. **Tropical fire ecology: climate change, land use and ecosystem dynamics**. Springer-Praxis.

Kull, C.A. 2002. Madagascar aflame: landscape burning as peasant protest, resistance, or a resource management tool? **Political Geography**, 21: 927-953.

Kull, C.A. 2004. **Isle of fire: the political ecology of landscape burning in Madagascar**. University of Chicago Press. 324pp.

Laris, P. & Wardell D.A. 2006. Good, bad or 'necessary evil'? Reinterpreting the colonial burning experiments in the savanna landscapes of West Africa. **Geographical Journal**, 172: 271-90.

Laris, P. 2002. Burning the seasonal mosaic: preventative burning strategies in the wooded savanna of southern Mali. **Human Ecology**, 30(2): 155-186.

Laris, P. 2006. Managing a burned mosaic: a landscape-scale human ecological model of savanna fires in Mali. p. 155-186. In Mistry, J. & Berardi, A. (eds.). **Savannas and dry forests: linking people with nature**. Ashgate Publications.

Lewis, H.T. 1989. Ecological and technological knowledge of fire: Aborigines versus park rangers in Northern Australia. **American Anthropologist**, 91: 940-961.

Mbow, C.; Nielson, T.T. & Rasmussen, K. 2000. Savanna fires in east-central Senegal: distribution patterns, resource management and perceptions. **Human Ecology**, 28(4): 561-583.

McGregor, S.; Lawson, V.; Chritophersen, P.; Kennett, R.; Boyden, J.; Bayliss, P.; Liedloff, A.; McKaige, B. & Andersen, A.N. 2010. Indiegnous wetland burning: conserving natural and cultural resources in Australia's World Hertiage-listed Kakadu National Park. **Human Ecology**, 38: 721-729.

Medeiros, M.B., & Fiedler, N.C. 2004. Incêndios florestais no Parque Nacional da Serra da Canastra: desafios para a conservação da biodiversidade. **Ciência Florestal**, 14: 157-168.

Mistry, J. & Berardi, A. (eds.). 2006. **Savannas and dry forests: linking people with nature**. Ashgate Publications.

Mistry, J. & Berardi, A. 2005. Assessing fire potential in a Brazilian savanna nature reserve. **Biotropica**, 37(3): 439-451.

Mistry, J. 1998. Decision-making for fire use among farmers in savannas: an exploratory study in the Distrito Federal, central Brazil. **Journal of Environmental Management**, 54: 321-334.

Mistry, J.; Berardi, A.; Andrade, V.; Krahô, T.; Krahô, P. & Leonardos, O. 2005. Indigenous fire management in the *cerrado* of Brazil: the case of the Krahô of Tocantíns. **Human Ecology**, 33(3): 365-386.

Nepstad, D.; Schwartzman, S.; Bamberger, B.; Santilli, M.; Ray, D.; Schlesinger, P.; Lefebvre, P.; Alencar, A.; Prinz, E.; Fiske, G. & Rolla, A. 2006. Inhibition of Amazon deforestation and fire by parks and indigenous lands. **Conservation Biology**, 20: 65-73.

Parr, C.L. & Brockett, B.H. 1999. Patch-mosaic burning: a new paradigm for savanna fire management in protected areas? **Koedoe**, 42: 117-130.

Parr, C.L.; Woinarski, J.C.Z. & Pienaar, D.J. 2009. Cornerstones of biodiversity conservation? Comparing the management effectiveness of Kruger and Kakadu National Parks, two key savanna reserves. **Biodiversity and Conservation**, 18: 3643-3662.

Pickett, S.T.A.; Cadenasso, M.L. & Benning, T.L. 2003. Biotic and abiotic variability as key determinants of savanna heterogeneity at multiple spatiotemporal scales. p. 22-40. In du Toit, J.T.; Rogers, K.H. & Biggs, H.C. eds. **The Kruger experience. Ecology and management of savanna heterogeneity**. Island Press.

Pivello, V.R. 2006. Fire management for biological conservation in the Brazilian *cerrado*. p. 129-154. In Mistry, J. & Berardi, A. (eds.). **Savannas and dry forests: linking people with nature**. Ashgate Publications.

Pivello, V.R. 2011. The use of fire in the *cerrado* and Amazonian rainforests of Brazil: past and present. **Fire Ecology**, 7(1): 24-39.

Porro, R. 2005. Palms, pastures and swidden fields: the grounded political ecology of "agro-extractive/shifting-cultivator peasants" in Maranhão, Brazil. **Human Ecology**, 33(1): 17-56.

Posey, D.A. 1985. Indigenous management of tropical forest ecosystems: the case of the Kayapó Indians of the Brazilian Amazon. **Agroforestry Systems**, 3: 139-158.

Pyne, S.J. 1997. **Vestal fire**. University of Washington Press.

Robbins, P. 2003. Beyound ground truth: GIS and the environmental knowledge of herders, professional foresters and other traditional communities. **Human Ecology**, 31(1): 233-253.

Rodriguez, I. 2007. Pemón perspectives of fire management in Canaima National Park, southeastern Venezuela. **Human Ecology**, 35: 331-343.

Russell-Smith, J.; Djoeroemans, S.; Maan, J. & Pandanga, P. 2007. Rural livelihoods and burning practices in savanna landscapes of Nusa Tenggara Timur, eastern Indonesia. **Human Ecology**, 35: 345-349.

Russell-Smith, J.; Lucas, D.; Gapindi, M.; Gunbunuka, B.; Kapirigi, N.; Namingum, G.; Lucas, K.; Giuliani, P. & Chaloupka, G. 1997. Aboriginal resource utilisation and fire management practice in western Arnhem Land, monsoonal northern Australia: notes for prehistory, lessons for the future. **Human Ecology**, 25(2): 159-195.

Schmerbeck, J. & Seeland, K. 2007. Fire supported forest utilisation of a degraded dry forest as a means of sustainable local forest management in Tamil Nadu, South India. **Land Use Policy**, 24: 62-71.

Simmons, C. S.; Walker, R. T.; Wood, C. H.; Arima, E. & Cochrane, M. 2004. Wildfires in Amazonia: a pilot study examining the role of farming systems, social capital, and fire contagion. **Journal of Latin American Geography**, 3: 81-95.

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: 1938-1955.

Sorrensen, C. 2009. Potential hazards of land policy: conservation, rural development and fire use in the Brazilian Amazon. **Land Use Policy**, 26: 782-791.

Uhl, C. & Buschbacher, R. 1985. A disturbing synergism between cattle ranching practices and selective tree harvesting in the eastern Amazon. **Biotropica**, 17: 265-268.

Van Wilgen, B.W. & Biggs, H.C. 2011. A critical assessment of adaptive ecosystem management in a large savanna protected area in South Africa. **Biological Conservation**, 144: 1179-1187.

Van Wilgen, B.W. 2009. The evolution of fire management practices in savanna protected areas in South Africa. **South African Journal of Science**, 105: 343-349.

Vigilante, T. & Bowman, D.M.J.S. 2004. Effects of individual fire events on the flower production of fruit-bearing tree species, with references to Aboriginal people's management and use, at Kalumburu, North Kimberley, Australia. **Australian Journal of Botany**, 52: 405-415.