FIRE MANAGEMENT IN VEREDAS (PALM SWAMPS): NEW PERSPECTIVES ON TRADITIONAL FARMING SYSTEMS IN JALAPÃO, BRAZIL[1]

SÍLVIA LAINE BORGES[2]
LUDIVINE ELOY[3]
ISABEL BELLONI SCHMIDT[4]
ANA CAROLINA SENA BARRADAS[5]
IVANILTON ALMEIDA DOS SANTOS[6]

Introduction

Fire is responsible for molding ecosystems and selecting species in savanna ecosystems (BOND, 2005; PAUSAS & KEELEY, 2009; SIMON et al., 2009). In Cerrado, fire occurs naturally, but it is also used traditionally for managing natural vegetation and for productive purposes (MISTRY, 1998; MISTRY et al., 2005; SCHMIDT et al 2007; SCHMIDT et al 2011; FALLEIRO, 2011; MELO & SAITO, 2011). Traditional fire use strategies have a central role in the maintenance of spatial heterogeneity and important ecological processes, as demonstrated for savannas in Africa (BROCKETT et al., 2001; Laris, 2002) and Australia (RUSSELL-SMITH et al., 1997; BIRD et al., 2008).

Currently, a 'No Fire' policy is prevalent in protected cerrado areas (RAMOS-NETO & PIVELLO, 2000). However, this attempt to prevent and suppress any and all fire contradicts the evolutionary history of cerrado ecosystems. In addition, the ban of fire use as a tool for productivity and for landscape management generates conflicts

1. We thank the European Union for their financial support through FP7-2010 (agreement No. SSH-CT-2010-266.710) for the Environmental Governance in Latin America and the Caribbean (ENGOV) project. We also thank Gesellschaft für Internationale Zusammenarbeit (GIZ) for financial support to research within the scope of the project "Cerrado Jalapão".
2. Master on Sustainable Development (CSD / UNB), PhD student in Ecology at the Department of Ecology at the University of Brasilia. Collaborating Researcher at Sustainable Development Center (CDS/UnB) silvialainebio@gmail.com
3. Master in Agronomy from AgroparisTech (France) and a PhD in Geography from the University Sorbonne Nouvelle (France), researcher at National Center for Scientific Research (CNRS UMR ART-DEV Montpellier, France), collaborating researcher at Sustainable Development Center (CDS/UnB). ludivine.eloy@gmail.com
4. PhD in Botany from Hawai'i Uniersity, associate professor at Department of Ecology at the University of Brasilia. isabelbschmidt@gmail.com
5. ICMBio's environmental analyst (Chico Mendes Institute for the Biodiversity Conservation). carolbarradas@gmail.com
6. Member of the Quilombolas Association (Comunidades Quilombolas das Margens do Rio Novo, Rio Preto e Riachão -Ascolombolas Rios).

between the managing body of the protected areas and the local communities. Within this context, scientific research may shape management models of protected areas in savanna ecosystems by helping recognize fire as a management tool. For instance, fire may be used strategically to constrain fire propagation and preserve the landscape (MYERS, 2006).

In many Cerrado areas, especially those with well-drained, nutrient-poor sandy soils, most of the agricultural activity occurs near water bodies, primarily in veredas (*Mauritia flexuosa* palm swamps). These areas are preferred for creating fields because the soil is more fertile and water availability is higher (DAYRELL, 1998; RIBEIRO & WALTER, 1998). However, veredas are legally protected as "Áreas de Preservação Permanente" (Permanent Preservation Areas), where any use is restricted, and the use of fire in these areas is prohibited (BRASIL, 2012). Therefore, the conflicts between the social actors that defend the use of these areas to establish family farming and those that support the conservation of the veredas become even more evident in CUs (CARVALHO, 2011; MISTRY & BIZERRIL, 2011; LÚCIO et al., 2014). The clash between land use and legal protection is compounded by the great gap in scientific knowledge on the ecological impacts of traditional, non-mechanized, small-scale agricultural activities in vereda areas within the Cerrado biome.

It is essential to understand how to minimize the conflict between use and conservation, particularly in these environments. Due to their Permanent Protection Area status, use of these areas and fire management are restricted by the Brazilian legislation (BRASIL, 2012), particularly in cases where the areas are within the limits of legally protected areas (BRASIL, 2000).

The present study evaluated the consequences of local practices of use of fire for agricultural purposes in veredas of the Estação Ecológica Serra Geral do Tocantins (EESGT, Serra Geral do Tocantins Ecological Station), a full protection conservation area in Jalapão (Tocantins state, Brazil). A groundbreaking agreement signed in 2012 between the managing body of a and the people living in and around the protected area regulated the use of fire by residents for productive activities and established research programs on the traditional systems of fire management and their environmental impact on wetlands within this protected area. We described the local knowledge and use of fire in veredas based on interviews and commented field walks with residents. We identified active (intensively cultivated) and inactive (fallow) fields *in situ*, and compared them in terms of agrobiodiversity, plant cover, and water regime.

Conservation, management and farming: fire control policies and traditional uses

Fire control policies usually prioritize interventions to restrict fires, creating or aggravating conflicts between conservation and production interests, particularly in protected areas, both in Latin America (MCDANIEL ET AL., 2005; RODRÍGUEZ, 2007; MISTRY & BIZERRIL, 2011) and in the United States (PYNE, 1997), Africa (BASSETT & ZUELI, 2000; KULL & LARIS, 2009), and Europe (RIBET, 2007).

In Europe, Mediterranean and mountainous ecosystems adapted to fire were affected by fire exclusion policies in the 1970s and 1980s. These policies, magnified by rural drift, elicited changes in fuel availability, and the number of fires increased as a consequence. These issues led the managers of the protected areas to reintroduce the use of fire in these ecosystems. This paradigm shift was called "ecological rehabilitation of fire" by Ribet (2007). This is a new debate for Cerrado and no consensus has been reached, especially for protected areas (RIBEIRO & FIGUEIRA, 2011). As a result of the official attempts to completely suppress fire (the "no fire" policy), fires may become more frequent and contribute to the occurrence of late fires near the end of the dry season (MOUTINHO, 2014).

Over the last 50 years, the transformation of the traditional, non-mechanized farming systems in Cerrado brought about significant changes in fire regime[i]. Where before fires were set mostly at the beginning of the dry season, now they have been replaced by fires at the end of the dry season, causing large-scale, intense fires that result in greater mortality of plants and have consequences for the water supply (Silva et al., 2011). However, the definition of rules to implement an ideal fire regime in Cerrado is a particularly complex task, because farming and livestock raising were not adopted with the same intensity and in the same form across different Cerrado regions (ELOY et al., in press).

In areas with uneven topography, frequently inside protected areas, farming systems predominantly consist of "roças de toco" (slash-and-burn farming) and extensive cattle ranching on natural pastures. These practices continue today in Brazil, especially in northern Minas Gerais, western Bahia, Piauí and western Tocantins (NOGUEIRA 2009; Correia et al. 2010; Carvalho 2011). They are employed by indigenous groups, traditional farmers, quilombolas (descendants of escaped slaves), and family farmers. Families often use different Cerrado phytophysiognomies for different ends: "gerais" (general) areas[ii] are used to turn cattle out to pasture[iii], whereas forested areas (gallery forests, valley forests and veredas) are used for farming following the clearance of vegetation from small. In addition, fruits, fibers and wood are gathered in various plant formations. These production practices usually depend on access to forested areas, such as veredas, and burning is an essential management tool. In many regions, the veredas are the only areas that simultaneously provide cultivable soils (with no need for inputs and machinery) and access to water and natural pastures during the dry season, from May to October (GALIZONI, 2000, 2005; NOGUEIRA, 2009; LÚCIO et al., 2014).

Because veredas are important for aquifer recharge, however, they have special protection status in the Brazilian legislation, both inside and out of protected areas (TUBELIS, 2009). The Brazilian Forest Code (Law No. 12.651 from May 25, 2012) designated veredas as Áreas de Preservação Permanente (Permanent Preservation Areas), subject to use restrictions. Therefore, there is a conflict between the conservation goals and the use of fire in the vereda environment (MAILLARD et al., 2009; CORTÊS et al., 2011; FALLEIRO, 2011). Although these areas need protection, fire is generally viewed as a low-cost, indispensable tool for farmers with few or no resources and no access to alternative methods. As a result of deforestation and desiccation of many vereda areas caused by large-scale agricultural activities (especially after the establishment of center-pivot irrigation and/or eucalypt plantations), the predominant discourse is that any type of fire in veredas must be halted, with no appreciation for the associated goals and management practices (LÚCIO et al., 2014; ELOY et al., 2015). Cultivation practices and traditional fire management in "roças de esgoto" (see below), observed in the *veredas* (swampy palm forests) of the Jalapão region bring, however, new perspectives on the impacts of fire in these environments.

Research methods

Case study

The Jalapão region is located on the eastern part of the Tocantins state, near the border with the states of Maranhão, Piauí, and Bahia. The population size is 30,644, with 37% living in rural areas (MDA, 2013). This region has the largest cluster of protected cerrado areas and it represents an important remnant of this biome. The study site, Estação Ecológica Serra Geral do Tocantins (EESGT, Serra Geral do Tocantins Ecological Station, Figure 1), is the second largest Cerrado reserve, with a total area of 707,078.75 ha (ICMBio, 2013).

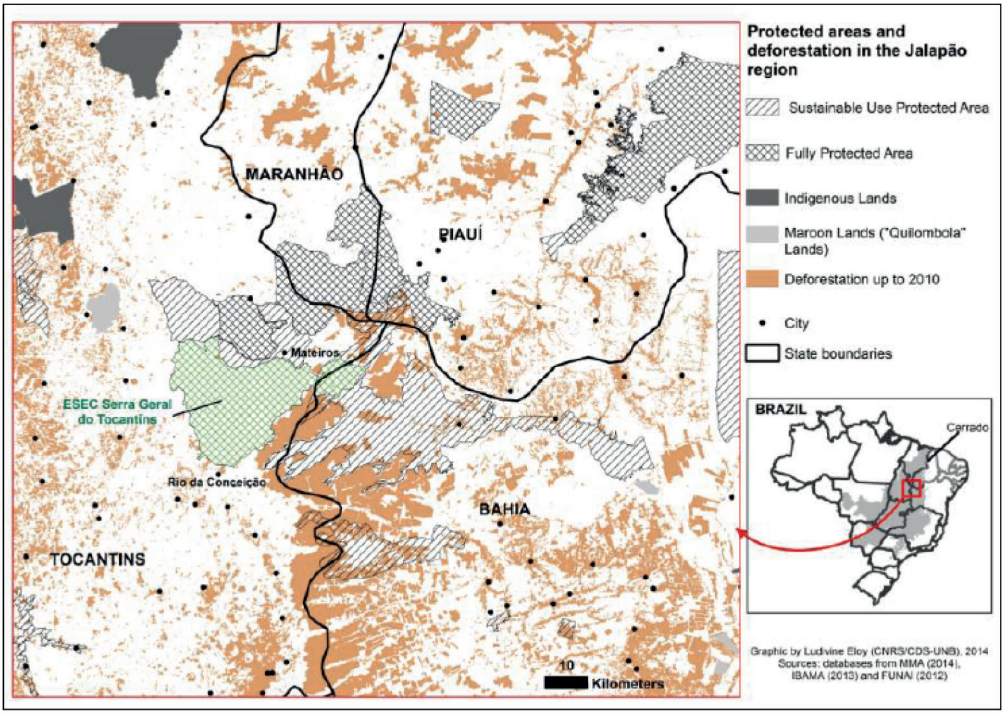

Figura 1: Map showing the Serra Geral do Tocantins Ecological Station (EESGT), in green. Note the nature reserves surrounding EESGT, forming a mosaic of protected areas. This region represents the largest cluster of protected cerrado areas. Up until 2010, regions around the protected areas had been deforested, mostly to establish new agricultural areas, especially for soybeans. This region, called MATOPIBA (acronym with the names of Maranhão, Tocantins, Piauí, and Bahia states), was recently recognized by the Brazilian Federal Government as one of the main areas of expansion for grain production in Brazil. Fonte Eloy e Lúcio, 2013.

In Jalapão, most agricultural activity consists of swidden cultivation for self--consumption, extensive cattle ranching and, more recently, the production and sale of objects hand-crafted with capim-dourado (golden grass). All these activities depend, to some degree, on the veredas, and fire is the primary management tool (SCHMIDT et al., 2011; LINDOSO & PARENTE, 2013).

The EESGT was demarcated in an area traditionally occupied by families originating from Bahia, who first arrived in the region approximately 120 years ago. They self-identify as remnants of quilombola communities (formed by descendants of runaway slaves) and are demanding territorial rights (LINDOSO, 2011). This occupied region is located in the northern part of the EESGT. As a result, the challenge of managing the reserve is to reconcile the conservation goals with the natural resource use requirements inside the reserve, until land ownership is defined. In an effort to find management and conflict mediation tools, in 2012 the Chico Mendes Institute for the Conservation of Biodiversity (ICMBio) signed an agreement with a local association, Ascolombolas-Rios, to regulate the traditional use of fire for the establishment and management of crop fields and native pastures, including in vereda areas. According to the agreement, the activities that were allowed should be monitored and evaluated in cooperation with local residents (ICMBio, 2012).

Methodological procedures

The present research was conceived in collaboration with ICMBio to generate knowledge to support monitoring of the agreement. The methods were based on the participatory methodology (FREITAS et al., 2007; CORREIA et al., 2013) and we strived to include members of the Ascolombolas-Rios association, who contributed to all steps of planning, from visits to crop fields to validation of collected data. Data collection occurred in two stages, the first between July 6 and July 21, 2013, and the second from August 29 to September 3, 2013. There were two organized meetings with members of Ascolombolas-Rios.

Data were obtained through open interviews with farmers, field data surveys (GPS, photographs), questionnaires and remote sensing.

The proceedings that supported the agreement proposal listed 12 families who declared their use of fire for productive purposes, out of 15 families registered by ICMBio. As a consequence, we interviewed all 12 household heads (six women and six men). During the interviews, we mostly explored questions related to family history, local place names, and history of occupation and transformation of the agricultural systems. In addition to interviews, we administered 12 questionnaires on agricultural practices and local socioeconomics.

Commented walks with nine farmers were also used to identify, through notes, the GPS points. We also took photographic records of landscape components: native vegetation, burned areas, rivers, topography, and soil types. We georeferenced each field ("roça") that was visited. A waypoint was recorded approximately every 20 m with a GPS system to define field boundaries. Fifteen active fields (six "drained peat swamp swidden fields", eight "pasture field" and one "rainfed swidden fields", see descriptions in the Results section) and 18 fallow areas ("capoeiras", i.e. secondary forest), including seven capoeiras from roças de toco and 11 from roças de esgoto.

We used remote sensing tools and a Geographic Information System (GIS) to verify the type of phytophysiognomy in each capoeira in order to evaluate the impact of the crop fields on the vereda vegetation cover and the water regime.

Using the software Arcmap (version 10.0), we mapped different types of fields and capoeiras, based on GPS points, onto an IRS (Indian Remote Sensing Satellites) P6 satellite image (ResourceSat-1/LISS-3, Aug 07, 2013, scene 328/084, 23.5 m resolution and WGS 1984 UTM projection), obtained from the site of the Instituto Nacional de Pesquisas Espaciais (National Institute for Space Research), with bands 2, 3 and 4 combined in Multispec (Freeware Multispectral Image Data Analysis System).

A vegetation cover map of EESGT generated from a supervised classification of a 2010 Landsat image was used to analyze the vegetation cover of capoeiras. Image analysis identified six main classes: campo sujo, campo limpo, cerrado *stricto sensu*, gallery forest, riparian forest and human-disturbed area. Using GIS tools, we extracted the pixels in the polygons of each studied capoeira. Later, we calculated the number of pixels corresponding to each class. To evaluate the impact of crop fields over the vereda water regime, we collected information on the functioning, location, and size of drainage channels of roças de esgoto compared to veredas and soil humidity control practices, and we visually inspected soil humidity. Visits were carried out in the months of July and September, in the dry season (from May to October)

Results

Characterization of agricultural practices

Our research identified three types of fields in the areas of use in EESGT: Drained peat swamp swidden fields (*Roça de esgoto*), rainfed swidden fields (Roça de toco), and pasture fields (*Roça de pasto*). These are created in different areas of the landscape (Figure 2).

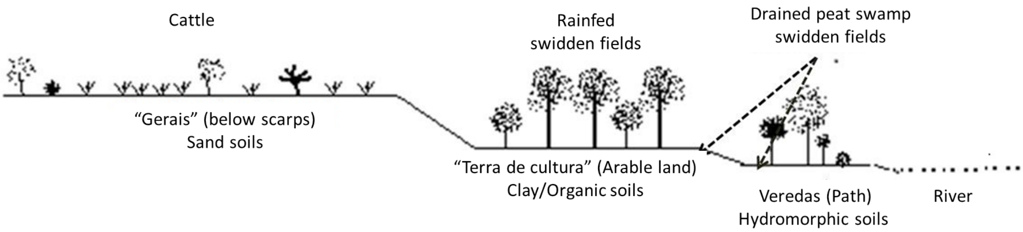

Figure 2: Illustrative transect of the landscape in Jalapão, including land uses. Adapted from Galizoni, 2005.

The rainfed swidden fields are cultivated in so-called dry lands ("terra seca"), also called cultivation lands ("terra de cultura"), inside forest formations known as "capão" (non-flooded gallery forest). In these fields, one period of intense farming (mostly of cassava, banana, and squash) alternates with a long fallow period that ranges from 8 to 20 years.

Since rainfed swidden fields are gradually being abandoned due to rural drift and intensification of cattle ranching, farmers are converting these areas into pasture fields, which provide supplementary feed to cattle during the rainy season. In pasture fields, the forest fallow period is replaced by permanent crops of exotic grasses, mostly grasses *Urochloa* spp. (signalgrass), *Andropogon* spp. and *Pennisetum clandestinum* (kikuyu), which complement the supply of native grasses for the livestock. Since this is not the focus of this article, we will not discuss pasture field and cattle ranching.

The drained peat swamp swidden fields, in turn, are cultivated plots in areas locally known as "pantâmo", or swamp, which correspond to veredas and/or seasonably flooded gallery forests. After the soil is drained by ditches opened with hoes, the site, usually less than 0.5 ha in size, is burned and cultivated for a variable amount of time (between 4 and 20 years). The cultivation period is followed by a forest fallow period of at least five years. Unlike rainfed swidden fields, drained peat swamp swidden fields (Figure 3) continue to be a key element of the local farming system. Their origin certainly dates back to the indigenous occupation of the Jalapão region (ELOY & LÚCIO, 2013). The peat soil, rich in organic matter, allows cultivation without fertilization.

Figure 3: Drained peat swamp swidden fields (*Roça de esgoto*) at Serra Geral do Tocantins Ecological Station. Photo: Ludivine Eloy.

Drainage of these areas is made possible by the opening of ditches, which also improve the control of the humidity of the cultivated soil. Therefore, during the rainy season the ditches are unobstructed and drain water from the cultivated area, while in the dry season the farmers block the farthest end of the each ditch to prevent water drainage. As a result, the water level rises and soil humidity is maintained. However, when visiting fields with interviewees, it was evident that the ditches may also be used strategically to irrigate the fields, since farmers manipulate water flow depending on the needs of the crops.

Based on interviews, opening a drained peat swamp swidden fields requires an initial "esgotamento" (drainage) of the area, which happens between January and March. In June or July, when the soil is drained ("esgotado"), the farmers dig ("brocam") the area, removing all undergrowth and cutting thin trees with a sickle. Larger trees are then felled with an axe. Tree felling is selective, because some species deemed useful, such as pindaíba-do-brejo (*Xylopia emarginata*), buriti (*Mauritia flexuosa*), pindaíba de capão (*Xylopia sericea*) and pau d'óleo (*Copaifera* sp.), are saved from deforestation,

After thinning, the area is burned, usually around June or July (Figure 4). The farmers reported that they make a firebreak to prevent the fire from spreading, usually on the same day as the "broca" (felling), by removing combustible materials from the perimeter of the field. It is important to note that we observed during field work that the use of fire in roças de esgoto is only associated to opening of new fields.

Figure 4: Fire in a new drained peat swamp swidden fields (*Roça de esgoto*); note the main ditch. Photo: Ludivine Eloy.

Both men and women contribute for the maintenance of the fields. In some cases, couples work together to weed, plant, harvest and process crops, such as cassava. However, the activities related to the preparation of the field (felling, cutting, burning and draining) are essentially carried out by men.

It is important to note that farmers manage the fire to control its intensity, keeping it low so that it does not burn the peat in the soil. The farmers reported that if the fire reaches the peat layer, causing an underground fire, the soil may become dry and hardened, rendering farming unfeasible. According to the interviewees, fires are set in the beginning of the dry season, at the end of the day, when temperatures become milder. Controlling water level in ditches also thwarts long and/or underground fires, in addition to preventing desiccation and acidification of the peat soils.

Immediately after the fire (Figure 4), fruits and legumes, such as watermelon, squash, and beans, are sown. Cassava and banana are planted later, starting in November, and remain in the field throughout the years.

In the second and third years, cassava takes up most of the field. It is possible that drained peat swamp swidden fields act as a repository of agrobiodiversity at a regional scale. In total, we found 45 cultivated varieties, 28 of those exclusively in roças de esgoto. There was considerable overlap of the varieties cultivated in roças de esgoto and in roças de toco (Sorensen similarity index: 0.73). There were 41 agricultural varieties in total; 27 of these were found exclusively in drained peat swamp swidden fields, and only 2 were exclusive to rainfed swidden fields (Table 1).

Table 1: List of cultivated plants and their presence in different types of fields.

Species	Varieties	Drained peat swamp swidden fields	Rainfed swidden fields	Parture Field
Watermelon (*Citrullus lanatus*)	Elongated/striped	x	x	
	Round	x	x	
Squash (*Cucurbita* spp)	Common	x		
	Cabutiá	x		
Beans (*Phaseolus* spp.)	Carioca	x	x	
	Black	x		
	Catador	x		
	Andu		x	
Banana (*Musa* spp.)	Nanica	x	x	
	Maçã	x		
	Purple-white	x		
	Angola	x		
Cassava (*Manihot esculenta*)	Amarelona	x	x	
	Quiri quiri	x	x	
	White-purple	x	x	
	Pimanê	x	x	
	Pé d’anta	x	x	
	Serrana	x	x	

Species	Varieties	Drained peat swamp swidden fields	Rainfed swidden fields	Parture Field
West India gherkin (*Cucumis anguria)*	-		x	
Potato (*Solanum* spp.)	White	x	x	
	Purple	x		
Ginger (*Zingiber officinale)*	-	x		
Turmeric (*Curcuma longa)*	-	x		
Pineapple (*Ananas comosus)*	-	x	x	
Wild pineapple (*Ananas ananassoides*)	-	x		
Fava bean (*Vicia faba)*	-	x		
Papaya (*Carica papaya*)	-	x		
Sugarcane (*Saccharum* spp.)	Black	x		
	Striped	x		
	Caiana	x		
	Puba	x		
	Black	x		
	Sugary	x		
Lemongrass (*Cymbopogon citratus*)	-	x		
Chili pepper (*Capsicum* sp.)	-	x		
Taioba (*Xanthosoma sagittifolium*)	-	x		
Taro (*Colocasia esculenta*)	-	x		
Cacao (*Theobroma* cacao)	-	x		
Orange (*Citrus sinensis*)	-	x		
Sorghum* (*Sorghum* spp.)	-	x		
Millet* (*Zea* spp.)	-	x		
Signalgrass (*Brachiaria* sp.)	-			x
Andropogon grass (*Andropogon* sp.)	-			x
Kikuyu grass (*Pennisetum clandestinum*)	-			x

Source: field data.
* For the cattle

Farmers reported that roças de esgoto ensured the survival of many cultivated plants that propagate vegetatively during the dry season. These plants, such as cassava and taro, may be stored and transplanted to other fields. Each field is intensively cultivated for a period ranging from 4 to 20 years. This variation stems from different factors, such as: early termination of farming activities due to rural drift or temporary unavailability of the family; immediate need to shift areas to expand the size of the field (the conditions to establish roças de esgoto are heterogeneous); or simply because there are sites where soil fertility decreases more quickly, a process that is not yet understood. Thereafter the farmers stop managing the land. The ditches either naturally clog over time, due to the accumulation of soil and/or dead organic matter, or they are blocked by the farmers. The surrounding area becomes flooded again and native species establish through the process of natural succession.

Farmers will plant a new field on the same site after a fallow period that lasts between 10 and 15 years, taking advantage of pre-existing ditches. Thus, the group of fields, capoeiras and old ditches form a family productive space that may be used continuously for several decades (Figure 5).

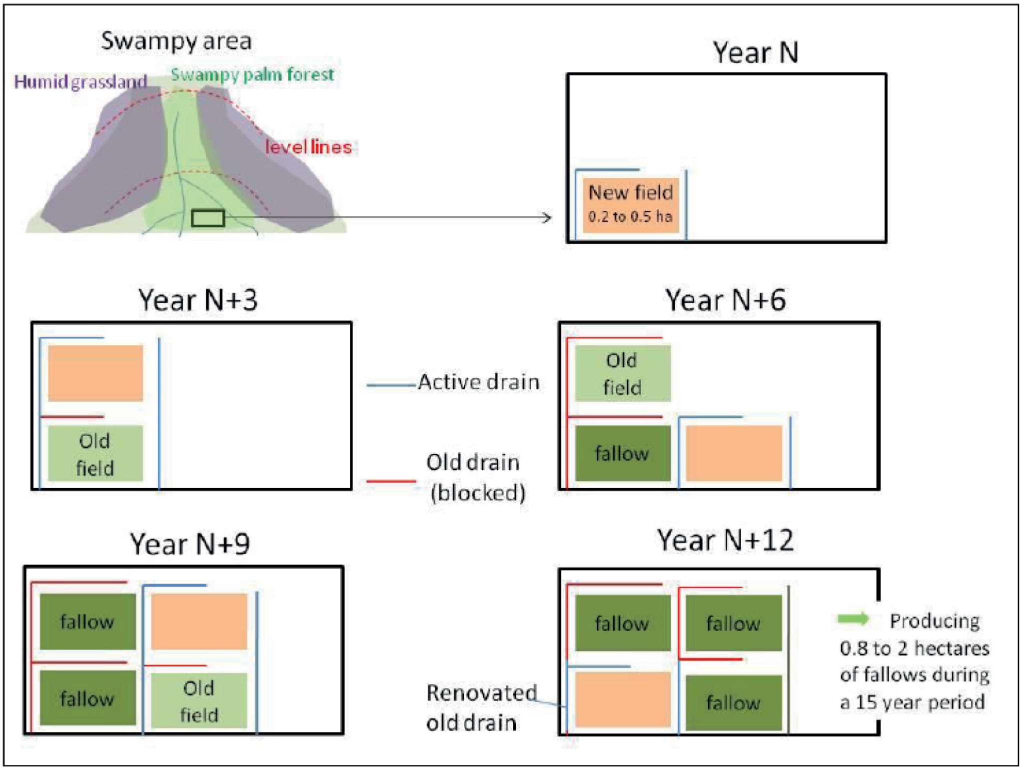

Figure 5: Cultivation cycle: capoeira (secondary forest) in a drained peat swamp swidden fields. Each field is intensively cultivated for a period ranging from 4 to 10 years, followed by a forest fallow. At this point a new area is cleared. This area is also used for 4 to 10 years, and so on, until the farmers return to the first area after 10 to 15 years (N+12), "reactivating" pre-existing drainage channels. In this system, farmers "create" 0.8–2.0-ha capoeira plots in a period that varies from 10 to 15 years.

Capoeiras from drained peat swamp swidden fields, as the fields undergoing regeneration during the fallow period are called, are important in terms of agrobiodiversity. In fact, fallow roças de esgoto had higher agrobiodiversity than recently active ones, mostly geared towards cassava production (which occupies almost the entire plot). During the fallow period, ditches are not dug regularly, therefore they fill up and the soil becomes soaked again. Drainage, therefore, is temporary.

nmental impacts of farming in veredas

There was a strong agreement among interviewees on the fact that "the esgoto [drained peat swamp swidden fields] renews the land", that is, forest regeneration after agricultural production is abandoned makes the forest become denser than before the cultivation period. In addition, capoeiras from drained peat swamp swidden fields are renowned among interviewees for having a higher density of buritis (*Mauritia flexuosa*) than other veredas.

The capoeiras from drained peat swamp swidden fields that we visited had some species typical of gallery and riparian forests, such as pindaíba (*Styrax ferrugineus*), buriti, araruta (*Maranta arundinacea*) and embaúba (*Cecropia* sp.). However, these observations need to be verified by detailed phytosociological surveys.

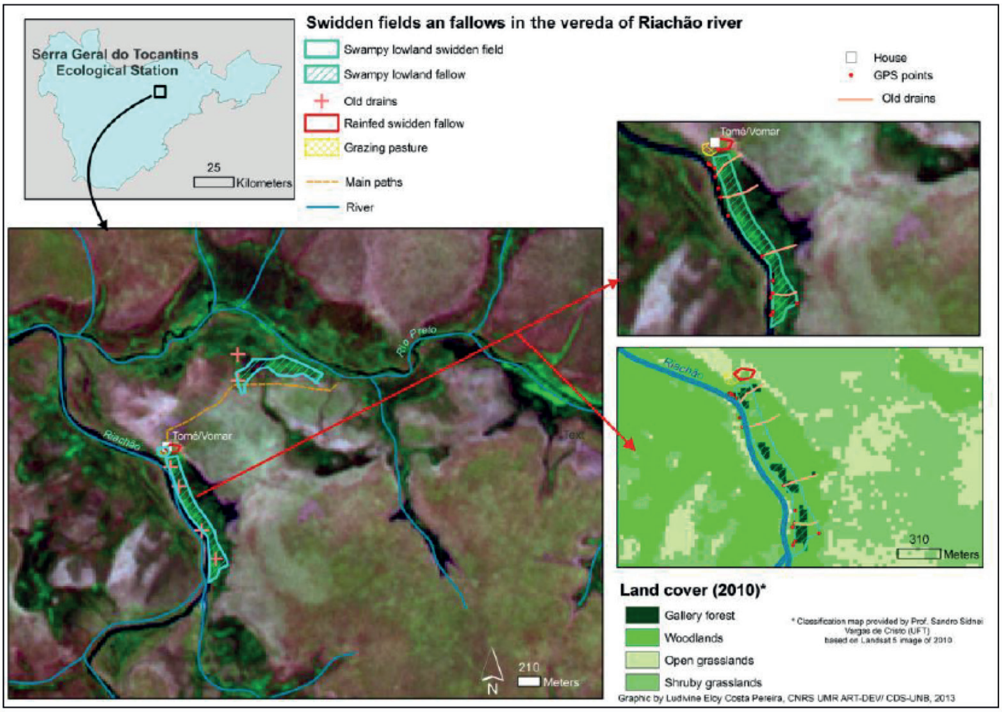

Figure 6: Mapping of two important roças de esgoto and capoeiras in the Riachão region (EESGT, 2013). Highlighted areas were validated by field observations and correspond to old fields located in veredas, but the image is classified as "gallery and riparian forest". This supports the interviewees' perception that abandoned fields, previously occupied by veredas, are succeeded by forest formations.

Capoeiras from roças de esgoto also have a dense vegetation cover, which is classified in the satellite image as gallery forest and cerrado *stricto sensu* based on the remote sensing techniques used in this study. Table 2 presents the number of pixels corresponding to each class.

Table 2: Vegetation cover of the capoeiras from roças de esgoto mapped in the Serra Geral do Tocantins Ecological Station.

Vegetation class	Capoeiras from roças de esgoto*	
Description	Number of pixels**	% of pixels
Unidentified	1	0.2
Gallery forest	130	21.2
Cerrado *sensu stricto*	373	60.8
Campo limpo	17	2.8
Campo sujo	92	15
Total	613	100

*11 plots with an average fallow period of 19 years (ranging from 6 to 50 years)

**1 pixel = 30 m × 30 m.

Source: Supervised classification of vegetation cover based on a 2010 Landsat image. Mapping of capoeiras: field data (commented walks with farmers) and position of old ditches in 2013.

In the polygons that were mapped as capoeiras from drained peat swamp swidden fields, 82% of the pixels were identified as arboreal vegetation (gallery forest and cerrado *sensu stricto*).

In relation to the water regime of the veredas, we found that, due to the small size of the roças de esgoto (0.4 ha on average) and the fact that these plots have to be established below the vereda recharge area (Table 3), opening roças de esgoto does not affect the amount of water or its percolation, since the drainage channels (ditches) simply deviate the water flow, which continues to the main water course.

Table 3: Location of the studied fields in relation to the sources and mouths of the veredas.

Roças de esgoto	Area (ha)	Distance between the field* and the mouth of the vereda (confluence with the river) (m)	Distance between the field* and the source of the vereda (m)
1	0.267	16	5154
2	0.305	155	279
3	1.055	142	165
4	0.068	146	1109
5	0.989	155	n.f.**
6	0.085	48	n.f.**

*calculated from the center of the field
** source not found
Source: 2011 Landsat satellite image and field data

All ditches identified in the active roças de esgoto that we visited had water, either welled or running, even during the dry season (July). In capoeiras, the ditches were blocked, therefore the soil was soaked.

Discussion

Within the context of savanna climate seasonality, veredas and seasonably flooded gallery forests have been identified as stability islands of water availability (CIANCIARUSO & BATALHA, 2008). In addition, they act as refuge areas for the fauna (REDFORD & FONSECA, 1986). Previous research addressed the use of fire to manage capim-dourado (golden grass, *Syngonanthus nitens*) in wet vereda fields adjacent to swamps in Jalapão (SCHMIDT et al., 2011), but it is rare to find any description of the farming practices or their impact on these wetlands. Since veredas and gallery forests are considered vulnerable to fire, there are no studies that employ experimental fires in these environments, and all the information available in the literature comes from accidental fires. Thus, although the vereda environment is culturally and economically important for Cerrado communities, few studies have described local fire use practices in these areas and their impacts.

Two authors described a farming system similar to a drained peat swamp swidden fields. Dayrell (1998) reported that during the dry season people in the north of Minas Gerais cultivate crops in "brejos de pindaíba" (pindaíba swamps), which have organic (fertile) soils. These lands are used by opening drainage channels to cultivate rice, beans, corn (milho-de-santana), vegetables, sugarcane, banana, and cassava. According to Bosgiraud (2013), the roças de esgoto of northeastern Goiás are planted in more remote settlements, near river sources, but chemical fertilizers are used.

Chemical fertilizers and agrochemicals are not used in the roças de esgoto of Jalapão. In terms of work force, it is a more intensive cultivation system than the rainfed swidden fields, but it brings several advantages to farmers. Its historical importance and persistence in Jalapão are related to several factors: it ensures productivity throughout the year, yields greater income and includes greater agrobiodiversity. To have a drained peat swamp swidden fields means depending less on roças de toco for food, and therefore less need for setting fires. Lastly, roças de esgoto also reduce the susceptibility to variations and instabilities in the rain schedule.

The results of the present research indicate that, at the study site, the practice of setting fire to veredas to establish farming fields does not lead to deforestation at the landscape level. On the contrary, it promotes tree cover after farming is abandoned. In fact, the prevalence of arboreal vegetation in capoeiras from roças de esgoto, confirmed through the analysis of satellite images, corroborates the traditional knowledge that "the esgoto renews the land". However, the observations of the farmers go beyond that. According to them, roças de esgoto make the vereda vegetation denser, "making the forest denser than before farming". Thus, it is essential to study the diversity of species that colonize and form the tree cover in veredas after the farming activities managed with fire stop. This increase in density may be related to ecological succession in veredas, which could be accelerated by local changes in the regime of water soaking the soil after ditches are opened.

Bahia et al. (2009) and Maillard et al. (2009) reported that vereda fires that happen at the peak of the dry season are catastrophic for the vegetation. According to Maillard et al. (2009), these fires are hard to fight and may last several days or even weeks. In general, the species that form the vereda vegetation have no protection mechanisms against fire. Underground fires are common due to the prevalence of peat soils. Characterized by their long duration and high temperatures, these fires cause serious damage to the peat layer. In addition, the vereda soil is highly sensitive to erosion. Vegetation removal from veredas triggers an erosive process that lasts for decades (WANTZEN et al. 2006).

Paleoecological studies in veredas (FERRAZ-VICENTINI & SALGADO-LABOURIAU, 1996; SALGADO-LABOURIAU et al., 1997; BARBERI et al., 2000; MENESES et al., 2013) recorded fire events in the prehistoric past, indicated by the presence of charcoal in soil sediment. These authors, however, do not discuss the ecological impacts of fires in these environments. In Venezuela and Colômbia, fire is needed to preserve the veredas, locally called *morichal* (RULL, 1992; MONTOYa et al., 2011; MONTOYA & RULL, 2011; VEGAS-VILARRÚBIA et al., 2011).

Sampaio et al. (2012) demonstrated that biennial fires in veredas may reduce the sizes of buriti populations because there is not enough time for the population to recover from the previous fire event. Since it takes over three years for the buriti populations to recover after a fire, the authors suggest a minimum interval of 10 years between fires to ensure the maintenance of buriti populations in the long run. Farmers interviewed in Jalapão did, in fact, indicate that the fire interval ranges from 10 to 20 years. Roças de esgoto are only burned once, at the beginning of the productive cycle, in a managed and low-intensity manner. That means that the use of fire in roças de esgoto includes special precautions, such as the creation of firebreaks, the selection of a day and time for the fire, and the control of the water flow to prevent underground and widespread fires. This way, soil properties are preserved, including the high concentration of organic matter and restricted drainage conditions. If the fire occurs at the peak of the dry season, the underground organic matter may burn for several days, sterilizing the soil. Thus, the combination of low intensity and low frequency fire, with the dynamic management of agrobiodiversity, the control of soil moisture through the flexible and temporary use of drainage channels and long fallow periods allow forest regeneration and thus prevent dryness and soil acidification.

Studies that address the catastrophic effect of farming and fire in veredas usually have permanent crops as references. These occupy extensive mechanized areas, for instance in commercial farms or pastures, which cause soil compaction that suppresses the herbaceous vegetation and triggers the degradation process. This scenario was observed in the Cochos river (northern Minas Gerais), which was completely silted in several sections, engulfed by layers of soil carried from areas where large-scale agricultural and/or charcoal activities resulted in deforestation of the surrounding plateaus and floodplains (RIBEIRO, 2010).

Cultivating roças de esgoto in veredas (palm swamps) may be more common than recorded in the Cerrado literature. Valley bottoms, which usually have low natural fertility, are commonly drained in tropical savanna regions marked by alternating dry and rainy seasons, suggesting that these practices are (or were) important in the Cerrado, both in socioeconomic and in environmental terms. What makes this practice more difficult to discern is that farmers are reluctant to admit the changes they make to wet areas, since they are Permanent Preservation Areas whose use is restricted by the environmental legislation. Using fire, however, continues to be the only option for many family and traditional farmers.

Based on the statements of Jalapão farmers regarding the “reforestation effect” of the farming fields, it is likely that roças de esgoto favor the transformation of savanna landscapes (veredas) into forest formations (seasonally flooded gallery forest with marked presence of *Mauritia flexuosa*) after this farming activity is abandoned, accelerating the natural succession process of that environment. This succession occurs when fires are absent or infrequent (BAHIA et al., 2009; FERREIRA, 2008). Management by draining soils and burning to clear the field (once every 10 to 15 years or more) may be a catalyst for the plant succession process in veredas, since soil drenching constrains the growth of numerous species. When the soil becomes drier, many tree seeds present in the soil seed bank and/or dispersed into these areas may find a more favorable environment to germinate and establish.

If this is confirmed, it could mean that part of the gallery forests in the valleys of Jalapão is anthropic in origin. Erickson (2006) described many pre-Columbian indigenous practices that led to the conversion of wet (native) areas to productive (farmed) areas in the savannas of the Bolivian Amazon (Llanos de Mojos), recognized for their high biodiversity. Pre-Columbian peoples of Llanos de Mojos permanently changed topography, hydrology, soil structure and fertility, local climate, and biodiversity by using fire, moving large quantities of soil, creating forest groves, and managing artificial wet zones, therefore creating “domesticated landscapes”. Denevan (2001) described similar landscapes in the flooded savannas of Colombia, Ecuador, Venezuela, and Surinam, and in the Andean regions of Peru, Bolivia, Colombia, and Ecuador.

Conclusion

In Brazil, the fire management rules codified by law (BRASIL, 1979, 1998, 1988, 2012) are not considered sound by many communities, because they incorporate little to no local knowledge. In addition, they do not take into account the obstacles and constraints faced by these communities (CARVELHEIRO, 2004; CARMENTA et al., 2013). When coupled with rural drift, these measures tend to weaken the collective systems of controlled fire use, both in the Cerrado (MISTRY & BIZERRIL, 2011) and in the Amazon (TONIOLO, 2004; URIARTE et al., 2012), and to discount traditional agricultural systems. That often explains the occurrence of catastrophic fires, because the difficulties and restrictions related to obtaining a permit to burn leads to illegal fires and may even result in the loss of fire-related knowledge and practices.

A groundbreaking agreement between the managing body of a full protection Cerrado conservation area and a local association enabled the development of a research program to document non-regulated practices of fire management. We validated the farmers' statements regarding the impacts of these practices on the landscape in terms of increase in vegetation cover density. These results contradict the idea that any fire in veredas is catastrophic, and provide a framework to define management rules to develop an appropriate fire regimen for each phytophysiognomy and each productive use of Cerrado, with the goal of reconciling use and conservation of these areas.

The research in Jalapão, a partnership with the residents and users of the protected area, demonstrates that a historical reconstruction of the traditional use of fire and changes in soil use over time is an essential step for an improved understanding of fire dynamics in Cerrado and for integrating traditional and scientific knowledges to manage protected areas and preserve the Cerrado.

Notes

i The fire regime and its effects on ecosystems are primarily defined by the timing and frequency of fire events. In addition, these effects are influenced by the behavior of fire, which is characterized by the air temperature as it spreads, residence time of high temperatures, flame height, and spread rate and intensity of the fire front. These aspects, combined with the attributes of each ecosystem, determine the effects of each fire and of a given fire regime over ecosystems (Rothermel, 1983; Whelan, 1995; Miranda et al., 2010). Vegetation structure and composition affect the kind of fire and propagation rate and the responses of each ecosystem to this disturbance (Whelan, 1995).

ii These correspond to campo limpo (open grassland), campo sujo (grassland with scattered shrubs) and cerrado sensu stricto areas on quartz sands.

iii Traditional cattle ranching with elements of pastoralism. Grazing usually occurs in the commons. For more information, see: Lúcio, S. L. B. Gestão participativa e conflitos socioambientais em áreas protegidas no Cerrado mineiro: a pecuária de solta na RDS Veredas do Acari/MG. Masters thesis. Centro de Desenvolvimento Sustentável. Universidade de Brasília, Brasília. 2013.

References

Bahia, T. O; Luz, G. R; Braga, L. L; Menino, G. C. O; Nunes, Y. R. F; Veloso, M. D. M; Neves, W. V; Santos, R. M. Florística e fitossociologia de veredas em diferentes estágios de conservação na APA do Rio Pandeiros, norte de Minas Gerais. **MG Biota.** Belo Horizonte. Vol. 2. Nº3. 2009. 42p.

Barberi, M; Salgado-Labouriau, M.L.; Suguio, K. Paleovegetation and paleoclimate of “Vereda de Águas Emendadas”. central Brazil. **Journal of South American Earth Sciences**, **13**, 2000. p. 241-254.

Bassett, T.J.; Zueli, K.B. Environmental discourses and the Ivorian Savanna. **Ann Assoc Am Geogr. 90**:1**,** 2000. p.67-95.

Beerling, D. J.; Osborne, C. P. The origin of the savanna biome. **Global Change Biology**, **12**, Issue 11, pages 2023–2031, November 2006.

Bird, R.B; Bird, D.W; Codding, B.F; Parker, C.H. The “fire stick farming” hypothesis: Australian Aboriginal foraging strategies, biodiversity, and anthropogenic fire mosaics. **Proceedings of the National Academy of Sciences**. 2008.

Bond W.J. & Keeley J.E. Fire as a global ‘herbivore’: the ecology and evolution of flammable ecosystems. **Trends Ecol. Evol. 20**, 2005. p. 387-394.

Bosgiraud, M. **Normes environnementales et transformation des pratiques de gestion des ressources dans le Cerrado : l’exemple de l’Aire de Protection Environnementale (APA) Nascentes do Rio Vermelho, Goiás**. ISTOM, Paris. 2013.

Brasil. Decreto nº 84.017, de 21 de setembro se 1979. Aprova o regulamento dos parques nacionais brasileiros. **Diário Oficial da União**. Available at: <https://www.planalto.gov.br/ccivil_03/decreto/1970-1979/D84017.htm> (Accessed on Sept 28, 2015). 1979.

Brasil. Resolução CONAMA nº 11, de 14 de dezembro de 1988. Dispõe sobre as queimadas nas Unidades de Conservação. **Diário Oficial da União**, Seção 1, 11/08/1989: 13661. Available at: <http://www.mma.gov.br/port/conama/legiabre.cfm?codlegi=75> (Accessed on Sept 28, 2015). 1988.

Brasil. Decreto nº 2.661, de 8 de julho de 1998. Regulamenta o parágrafo único do art. 27 da Lei nº4.771, de 15 de setembro de 1965 (código florestal), mediante o estabelecimento de normas de precaução relativas ao emprego do fogo em práticas agropastoris e florestais, e dá outras providências. **Diário Oficial da União**, 9/07/1998. Available at: <https://www.planalto.gov.br/ccivil_03/decreto/D2661.htm#art28> (accessed on Sept 28, 2015). 1998.

Brasil. Lei nº 12.651, de 25 de maio de 2012 (novo código florestal), art. 38 que trata trata da regulamentação do uso do fogo, no inciso II. **Diário Oficial da União**, 28/05/2012. Available at: http://www.planalto.gov.br/ccivil_03/_ato2011-2014/2012/lei/l12651.htm (accessed on Sept 28, 2015). 2012.

Brasil. Lei nº 9.985, de 18 de julho de 2000. Regulamenta o art. 225, § 1o, incisos I, II, III e VII da Constituição Federal, institui o Sistema Nacional de Unidades de Conservação da Natureza. Available at http://www.planalto.gov.br/CCivil_03/leis/L9985.htm (accessed on Aug 28, 2015). 2000.

Brockett, B.H; Biggs, H.C.; Van Wilgen, B.W. A patch mosaic burning system for conservation areas in southern African savannas. **International Journal of Wildland Fire**, **10**:2**,** 2001. p. 169-183.

Carmenta, R; Vermeylen, S; Parry, L; Barlow, J. Shifting Cultivation and Fire Policy: Insights from the Brazilian Amazon. **Human Ecology, 41**:4**,** 2013. p. 603-614.

Carvalho, I. S. H. de. **Serviços ambientais e campesinato: o caso do assentamento americana (Gão Mogol, Minas Gerais, Brasil)**. III Congreso sobre Manejo de Ecosistemas y Biodiversidad de la VIII Convención Internacional sobre Medio Ambiente y Desarrollo. La Habana, Cuba: 1-18. 2011.

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

Cianciaruso, M. V; Batalha, M. A. A year in a Cerrado wet grassland: a non-seasonal island in a seasonal savanna environment. **Brazilian Journal of Biology 68**, 2008. p.495-501.

Cole, M.M. Cerrado, caatinga and pentanal : the distribution and origin of the savanna vegetation of Brazil. **Geogr. J. 126,** 168-179. 1960.

Correia, J. R., Bustamante, P. G., Emperaire, L., Mitja, D. **Desafios da Pesquisa Participativa e Restituição em Projeto de Pesquisa junto a Pequenos Agricultores. Estudo de caso: Projeto Rio Pardo**, Embrapa/Brasil. Dossier: Sciences participatives et restitution. n. 72-73. 2013. p. 123-140.

Coutinho, L.M. Aspectos ecológicos do fogo no cerrado. II As queimadas e a dispersão de sementes em algumas espécies anemocóricas do estrato herbáceo-arbustivo. **Bol. Botânica**. USP **5**, 57-64. 1977.

Coutinho, L.M. O cerrado e a ecologia do fogo. Ciência Hoje 12, 22-31. 1990.

Dayrell, C.A. **Geraizeiros e biodiversidade no Norte de Minas: a contribuição da agroecologia e da etnoecologia nos estudos dos agroecossistemas tradicionais**. Tese. Universidade Internacional Andalucia, La Rábida. 1998.

Denevan, W.M. **Cultivated Landscapes of Native Amazonia and the Andes**. University Press: Oxford. 2001.

Eloy, L., I. S. Carvalho, Figueiredo, I. (In Press). **Sistemas agrícolas tradicionais no Cerrado: caracterização, transformações e perspectivas.** Agrobiodiversidade e agroecologia. Coleção Transição Agroecológica J. Santilli, P. Bustamante and R. L. Barbieri. Brasilia, ABA /Embrapa.

Eloy, L.; Lúcio, S. L. B. **Caracterização agronômica e socioeconômica das roças de toco e de esgoto na Estação Ecológica Serra Geral do Tocantins**. Brasilia: GIZ/ICMBio. 2013.

Eloy L; Aubertin C; Toni F., Lúcio, S. L.B; Bosgiraud M. On the margins of soy farms : traditional populations and selective environmental policies in the Brazilian Cerrado. **Journal of Peasant Studies**, 2015, DOI : 10.1080/03066150.2015.1013099

Erickson, C.L. The domesticated landscapes of the Bolivian Amazon.In. Balée, W; Erickson, C.L. (eds.) **Time and complexity in historical ecology: studies in the neotropical lowlands**. Columbia University Press: New York. 2006.

Fairhead, J.; Leach, M. **Misreading the African Landscape: Society and Ecology in a Forest-Savanna Mosaic**. Cambridge University Press: Cambridge. 1996.

Falleiro, R.de.M. Resgate do Manejo Tradicional do Cerrado com Fogo para Proteção das Terras Indígenas do Oeste do Mato Grosso: um Estudo de Caso. **Biodiversidade brasileira**, **2**, 2011. p. 86-96.

Ferraz-Vicentini, K.R. Salgado-Labouriau, M.L. Palynological analysis of a palm swamp in Central Brazil. **Journal of South American Earth Sciences**, **9**, 1996. p.207-219.

Ferreira, I. M. **Cerrado: classificação geomorfológica de vereda**. I*n* Embrapa-Cerrados, editor. IX Simpósio Nacional do Cerrado. 2008.

Freitas, L. A do S., Guimarães, A. M., Ferner, J. S., Alves, M. A., Dissiuta, S., Diesel, V. Metodologias participativas e D&D de sistemas agroflorestais. **Rev. Bras. Agroecologia**, **2**: 1, fev. 2007

Galizoni, F. M. **A terra construída: família, trabalho, ambiente e migrações no alto Jequitinhonha/Minas Gerais**. São Paulo: USP/FFLCH. 2000.

Galizoni, F. M. **Águas da vida - população rural, cultura e água em Minas Gerais**. Dissertation (Ph.D. in Social Sciences). IFCH/Unicamp, Campinas, 2005.

Jeltsch, F., Weber, G. and Grimm, V. 'Ecological buffering mechanisms in savannas: A unifying theory of long-term tree-grass coexistence'. **Plant Ecology**, **150**:1-2**,** 161-171. 2000.

ICMBio.Termo de Compromisso nº14/2012. Termo de Compromisso que o Instituto Chico Mendes de Conservação da biodiversidade (ICMBio) celebra com a ASCOLOMBOLAS-Rios. Available at http://www.icmbio.gov.br/intranet/download/arquivos/cdoc/biblioteca/resenha/2012/setembro/Res2012-09-05DOUICMBio.pdf (accessed on Aug 29, 2015). 2012.

ICMBio. **Estação Ecológica Serra Geral do Tocantins**. Available at http://www.icmbio.gov.br/portal/biodiversidade/unidades-de-conservacao/biomas-brasileiros/cerrado/unidades-de-conservacao-cerrado/2068-esec-serra-geral-do-tocantins.html Accessed on Oct 02, 2013. 2013.

Kull, C.A. and Laris, P. '**Fire ecology and fire politics in Mali and Madagascar**'. *In* M. Cochrane (ed.) *Tropical Fire Ecology: Climate Change, Land Use and Ecosystem Dynamics*. Springer-Praxis: Heidelberg, Germany. 2009.

Laris, P. 'Burning the seasonal mosaic: Preventive burning strategies in the wooded savanna of southern Mali'. **Human Ecology**, **30**:2**,** 155–186. 2002.

Lindoso, L.d.C. '**Termo de Ajustamento de Conduta com População Quilombola Residente na Estação Ecológica Serra Geral do Tocantins**', *V Seminário de Áreas Protegidas e Inclusão Social,*. UFAM, Manaus-AM. 2011.

Lindoso, L.d.C. and Parente, T.G. '**Fogo e liberdade nos gerais do Jalapão: uma análise à luz do conceito de recursos de uso comum**', *VI SAPIS: Seminário Brasileiro sobre Áreas Protegidas e Inclusão Social.* Belo Horizonte. 2013.

Lúcio, S. L. B. **Gestão participativa e conflitos socioambientais em áreas protegidas no Cerrado mineiro: a pecuária de solta na RDS Veredas do Acari/MG**. M.S. Thesis. Centro de Desenvolvimento Sustentável. Universidade de Brasília, Brasília. 2013.

Lúcio, S. L. B; Eloy, L; Ludewigs, T. O Gado que Circulava: Desafios da Gestão Participativa e Impactos da Proibição do Uso do Fogo aos Criadores de Gado de Solta da Reserva de Desenvolvimento Sustentável Veredas do Acari. **Biodiversidade Brasileira**, **4**(1): 130-155, 2014.

Maillard, P., D. B. Pereira, and C. G. Souza. Incêndios florestais em veredas: conceitos e estudo de caso no Peruaçu. **Revista Brasileira de Cartografia 61**:321-330. 2009.

McDaniel, J., Kennard, D. and Fuentes, A. 'Smokey the Tapir: Traditional Fire Knowledge and Fire Prevention Campaigns in Lowland Bolivia'. **Society and Natural Resources**, **18**:921–931. 2005.

Melo, M.M.d. and Saito, C.H. 'Regime de Queima das Caçadas com Uso do Fogo Realizadas pelos Xavante no Cerrado'. **Revista Biodiversidade Brasileira,** p. 97-109. 2011.

Meneses, M. E. N. S., Costa, M. L., Behling, H. Late holocene vegetation and fire dynamics from a savanna-forest ecotone in Roraima state, northern Brazilian Amazon. **Journal of South American Earth Sciences. 42**:17-26. 2013.

Ministério do Desenvolvimento Agrário - MDA (2013). **Território da cidadania: Jalapão – TO**. Available at http://www.territoriosdacidadania.gov.br/dotlrn/clubs/territriosrurais/jalapoto/one-community?page_num=0. Accessed on Oct 02, 2013.

Miranda, H.S., Neto, W. N., Neves, B. M. C. Caracterização das queimadas de Cerrado. In. **Efeitos do regime de fogo sobre a estrutura de comunidades de Cerrado: Projeto Fogo**. Ibama: Brasília. 2010.

Mistry, J. '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. 1998.

Mistry, J., Berardi, A., Andrade, V., Krahô, T., et al. 'Indigenous Fire Management in the cerrado of Brazil: The Case of the Krahô of Tocantíns'. **Human Ecology**, **33**:3**,** 365-386. 2005.

Mistry, J., Bizerril, M. Por Que é Importante Entender as Inter-Relações entre Pessoas, Fogo e Áreas Protegidas?. **Revista Biodiversidade Brasileira**, **2,** 40-49. 2011.

Montoya, E., Rull, V. Gran Sabana fires (SE Venezuela): a paleoecological perspective. **Quaternary Science Reviews**, **30,** 3430-3444. 2011.

Montoya, E., Rull, V., Stansell, N. D., Abbott, M. B., Nogué, S., Bird, B. W. e Díaz, W. A. Forest-savanna-morichal dynamics in relation to fire and human occupation in the southern Gran Sabana (SE Venezuela) during last millennia. **Quaternary Research**, **76,** 335-344. 2011.

Moutinho, S. Fogo amigo: estudos mostram que a prática indígena de queimar grandes áreas de Cerrado é benéfica para o bioma. **Ciência Hoje.** 314. Maio, 2014.

Myers, R.L. **Convivendo com o Fogo - Manutenção dos Ecossistemas e Subsistência com o Manejo Integrado do Fogo.** The Nature Conservancy - Iniciativa Global para o Manejo do Fogo: Tallahassee, USA. 2006.

Nogueira, M. C. R. **Gerais a dentro e a fora: identidade e terrotorialidade entre Geraizeiros do Norte de Minas Gerais**. Ph.D. Dissertation. Departamento de Antropologia, Universidade de Brasília. Brasília, 2009.

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

Rawitscher, F. **O problema das savanas brasileiras e das savanas em geral**. An. Brasil. Econ. Flor. **3**, 32-38. 1950.

Pausas, J. G; Keeley, J. E. A burning story: The role of fire in the history of life. **Bioscience**. **59:** 7, 2009. pp. 593-601.

Ramos-Neto, M.B., Pivello, V.R. Lightning fires in a Brazilian savanna national park:rethinking management strategies. **Environmental Management 26**: 675-684. 2000.

Redford, K. H. and G. A. B. d. Fonseca. The role of gallery forests in the zoogeography of the Cerrado's non-volant mammalian fauna. **Biotropica 18**:126-135. 1986.

Ribeiro, J F ; Walter, B M T. **Fitofisionomias do bioma Cerrado**. In: SANO, S.M.; ALMEIDA, S.P. de, ed. Cerrado: ambiente e flora. Planaltina: EMBRAPA-CPAC, 1998.p.89-166.

Ribeiro, E.M. **História dos gerais**. Editora UFMG: Belo Horizonte. 2010.

Ribeiro, R.C.; Figueira, J.E.C. Uma Abordagem Histórica do Fogo no Parque Nacional da Serra do Brasil, **Biodiversidade Brasileira**, p.212-227, 2011.

Ribet, N. 'La maîtrise du feu : un travail "en creux" pour façonner les paysages ', in D. Woronoff (ed.) **Travail et paysages**. Éditions du CTHS: Paris. 2007.

Rodríguez, I. 'Pemon Perspectives of Fire Management in Canaima National Park, Southeastern Venezuela'. **Human Ecology**, **35**:3**,** 331-343. 2007.

Rothermel, R. C. **How to predict the spread and intensity of forest and range fires**. General Technical Report INT-143. Available at http://www.fs.fed.us/rm/pubs_int/int_gtr143.pdf (accessed on Aug 30, 2015).

Rull, V. Successional patterns of the Gran Sabana (southeastern Venezuela) vegetation during the last 5000 years, and its responses to climate fluctuations and fire. **Journal of Biogeography**, **19,** 329-338. 1992.

Russell-Smith, J., Lucas, D., Gapindi, M., Gunbunuka, B., et al. 'Aboriginal Resource Utilization and Fire Management Practice in Western Arnhem Land, Monsoonal Northern Australia: Notes for Prehistory, Lessons for the Future'. **Human Ecology**, **25**:2, 159-195. 1997.

Salgado-Labouriau, M.L., Casseti, V., Ferraz-Vicentini, K.R., Martin, L., et al. ' Paleogeography, Paleoclimatology, Palaeoecology'. **Palaeoecology**, **128**, 215-226. 1997.

Sampaio, M. B., T. Ticktin, C. S. Seixas, and F. A. M. d. Santos. Effects of Socioeconomic Conditions on Multiple Uses of Swamp Forests in Central Brazil. **Human Ecology** **40**:821-831. 2012.

Schmidt, I., Figueiredo, I. and Scariot, A. 'Ethnobotany and effects of harvesting on the population ecology ofsyngonanthus nitens (bong.) ruhland (eriocaulaceae), a NTFP from Jalapão region, central Brazil'. **Economic Botany**, **61**:1**,** 73-85. 2007.

Schmidt, I.B., Sampaio, M.B., Figueiredo, I.B. and Ticktin, T. 'Fogo e Artesanato de Capim-dourado no Jalapão - Usos Tradicionais e Consequências Ecológicas'. **Biodiversidade brasileira**, **2**:67-85. 2011.

Silva, D. M.; Loiola, P. de P.; Rosatti, N. B., Silva, I. A.; Cianciaruso, M. V.; Batalha, M. A. Os efeitos dos regimes de fogo sobre a vegetação de cerrado no parque nacional das emas, go: considerações para a conservação da diversidade. **Biodiversidade Brasileira**, **2**. 2011.

Simon, M. F.; Grether, R.; Queiroz, L.P. de; Skema, C.; Pennington, R. T.; Hughes, C. E. Recent assembly of the Cerrado, a neotropical plant diversity hotspot, by in situ evolution of adaptations to fire. **PNAS**, **106:** 48. December 1, 2009. 20359–20364.

Sletto, B. 'The Knowledge that Counts: Institutional Identities, Policy Science, and the Conflict Over Fire Management in the Gran Sabana, Venezuela'. **World Development**, **36**:10**,** 1938-1955. 2008.

Toniolo, A. **The role of land tenure in the occurrence of accidental fires in the Amazon region: Case studies from the national forest of Tapajos, Para, Brasil**., Indiana University, Bloomington. 2004.

Tubelis, Dárius Pukenis. Veredas and their use by birds in the Cerrado, South America: a review. **Biota Neotrop.**, **9**, n. 3, Sept. 2009 . Available at <http://www.scielo.br/scielo.php?script=sci_arttext&pid=S1676-06032009000300031&lng=en&nrm=iso>. Accessed Jan 15, 2015.

Uriarte, M., Pinedo-Vasquez, M., DeFries, R.S., Fernandes, K., et al. 'Depopulation of rural landscapes exacerbates fire activity in the western Amazon'. **Proceedings of the National Academy of Sciences**, **109**:52**,** 21546-21550. 2012.

Vegas-Vilarrúbia, T., R., V., Montoya, E. and Safont, E. 'Quaternary palaeoecology and nature conservation: a general review with examples from the neotropics'. **Quaternary Science Reviews**, **30,** 2361-2388. 2011.

Walter, B. M. T; J. F. Ribeiro. **Diversidade fitofisionômica e o papel do fogo no bioma Cerrado**. In Efeitos do regime de fogo sobre a estrutura de comunidades de Cerrado: Projeto Fogo. , edited by Miranda, 59-76. Brasília: IBAMA. 2010.

Wantzen, K. M.; Siqueira, A.; Cunha, C. N.; & De Sá, M. F. P. Stream-valley systems of the Brazilian Cerrado: impact assessment and conservation scheme. *Aquatic Conserv: Mar. Freshw. Ecosyst*., **16**: 713-732. 2006.

Whelan, R. J. **The fire ecology**. 1st ed. Cambrige University Press, 1995.

Submitted on: 14/03/2015
Accepted on: 10/11/2015
http://dx.doi.org/10.1590/1809-4422ASOC20150020R1V1932016

FIRE MANAGEMENT IN VEREDAS (PALM SWAMPS): NEW PERSPECTIVES ON TRADITIONAL FARMING SYSTEMS IN JALAPÃO, BRAZIL

SÍLVIA LAINE BORGES
LUDIVINE ELOY
ISABEL BELLONI SCHMIDT
ANA CAROLINA SENA BARRADAS
IVANILTON ALMEIDA DOS SANTOS

Abstract: The veredas (palm swamps) of the cerrado biome are legally protected as Áreas de Preservação Permanente (Permanent Preservation Areas), and the use of fire in these wetlands is prohibited. We carried out a preliminary assessment of environmental impacts of the local use of agricultural fire in veredas through a collaborative research project in Jalapão (Tocantins, Brazil). We found that "roças de esgoto" (drained peat swamp swidden fields) form the basis of the agricultural system of this region. These fields ensure production throughout the year, provide more income than "roças de toco" (rainfed swidden fields), and may function as a repository of agrobiodiversity on a regional scale. This study suggests that the use of fire in veredas associated with roças de esgoto does not lead to significant deforestation, that is, to the disappearance of the forest physiognomy, but instead helps maintain tree cover during the fallow period, possibly accelerating natural succession.

Key Words: cerrado, agriculture, fire, protected areas, traditional populations

Resumen: En el Cerrado, las veredas (bosques pantanosos) están protegidos legítimamente (las áreas de preservación permanente) donde está prohibido el uso del fuego en estos ambientes humedales. Se hizo una evaluación preliminar de los impactos ambientales de los usos locales de incendio agrícola en los bosques pantanosos, a partir de la colaboración con actores locales en la investigación conducida en Jalapão (estado de Tocantins). Se encontró que las "roças de esgoto" (cultivo de roza y quema en bosques pantanosos con drenaje) son la base del sistema agrícola en la región de estudio; asegúrese de producción durante todo el año; producen más que las "roças de toco" (cultivo de secano de roza y quema), y pueden funcionar como el repositorio de la agrobiodiversidad en la escala regional. Se deduce de este estudio que el uso del fuego en las rutas asociadas a " drained peat swamp swidden fields " no conduce a la deforestación en escala significativa, pero ayuda a mantener la vegetación arbórea en la fase de barbecho, posiblemente haciendo más rápida la sucesión vegetal.

***Palabras clave*:** Cerrado, agricultura, fuego, áreas protegidas, poblaciones tradicionales.

***Resumo*:** No Cerrado, as veredas são consideradas Áreas de Preservação Permanente (APPs), sendo que o uso do fogo nestes ambientes úmidos é proibido. Realizou-se uma avaliação preliminar dos impactos ambientais decorrentes dos usos locais do fogo agrícola em veredas, a partir de uma pesquisa colaborativa realizada no Jalapão (TO). Identificou-se que as "roças de esgoto", abertas por meio da drenagem do solo e da derruba/queima da vegetação de vereda, constituem a base do sistema agrário na região estudada; asseguram uma produção durante o ano todo; provêm mais rendimentos que as roças de toco; e podem funcionar como repositório de agrobiodiversidade em escala regional. Infere-se, a partir deste estudo, que o uso do fogo em veredas associado às "roças de esgoto" não leva ao desmatamento, ou seja, desaparecimento da fisionomia florestal, e propicia a manutenção da cobertura vegetal arbórea na fase de pousio, possivelmente acelerando o processo de sucessão ecológica natural.

***Palavras-chave*:** Cerrado, agricultura, fogo, unidade de conservação, populações tradicionais.