Fire Primer for the Batéké Plateaux, Central Africa

G. Walters

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Foreword

This document is intended to give the reader a background in fire research and management, with a particular angle for the Batéké Plateaux, Central Africa. This work is by no means complete and many aspects are currently being researched. There are many partners who have worked on the ground for many years before I came along looking at plant, people, and fire interactions. I am very grateful for the support and contributions of the park conservator, the Projet Protection des Gorilles, the Wildlife Conservation Society, and the many researchers and observers in the study area. Their insight and support are what will make the implementation of a fire plan for the Batéké Plateaux National Park work in the long term. I thank also CENAREST for the research permit required for this work, the Herbier National du Gabon and IPHAMETRA for support and plant export permits, and the MBG team for specimen processing and field support. The understanding of cultural practice and perceptions would only be possible with the participation of the villagers in the study site, the support of the many Chefs, and the field assistance of S. Touladjan; I thank each participant. This document was also partially reviewed by P. Burnham, K. Homewood, B. Sharpe, and O. Hymas.

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If there are additions or recommendations on this document, please do not hesitate to share them with me.

Sincerely,

Gretchen Walters
Ekouyi-Mboma, Gabon
(University College London and the Missouri Botanical Garden)

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Summary

Savannas are formed by a variety of factors from social intervention to climate change. In a recent synthetic study on African savanna research, all savannas attaining a rainfall sufficient to support forest were primarily maintained by natural and anthropogenic fire and secondarily by grazing. Thus today's wet tropical savannas are largely dependent upon man's activities.

For many years, the role of anthropogenic fire in these systems was not appreciated. Colonial anti-fire policy is still entrenched in numerous countries with bans on anthropogenic fire still in place. Such policies had ill effect on local people and ecosystem structure. It is only recently that science-based investigation about anthropogenic fire and its effects are beginning to change policy.

However in Gabon, where only 20% of the landscape is savanna, there has been no post-independence policy banning or encouraging fire to manage savanna resources. Attitudes towards fire in Gabon are generally positive, looking to fire as a tool to clean the savannas. Local people have been burning savannas for millennia, as has been the case in Gabon's Batéké Plateaux. However, in recent years, resource extraction has increased and traditional land tenure systems have been abandoned. In Plateaux Bateke National Park, both overuse of fire by poachers in the south and eastern portions of the park and the absence of burning by managers in the northwestern portion of the park leave the park in between two approaches: no fire and haphazard fire. PBNP is making majors efforts to block all poaching activity within park boundaries. Once this activity is stopped, there will then by no fire in the park unless prescribed by management activities. However, before management-related fire is used by the park, it is best to understand the historical, biological, and cultural contexts of fire, especially its impacts on the ecosystem. Furthermore, lost-cost approaches to fire management must be considered.

This project will address the following questions:

1. What traditional management systems governed burning in the past?
2. How is fire used today?
3. How do current practices affect the ecosystem (particularly the vegetation, mammals and birds)?
4. Can this information be integrated into management and policy?
5. What approaches can be used to incorporate fire into PBNP management?

Captions for cover:

Top: Field assistant surveying fire extent near Ekouyi-Mboma village.

Bottom right: *Hymenocardia acida* tree in a recently burned savanna.

1: Tropical savannas: distribution, drivers, origins, and management

Savannas defined

Savannas are generally defined as grassland ecosystems with a woody component. There has been much debate over the *exact* meaning of this definition with schools of thought preferring savannas to be more herbaceous or more arborescent. This discussion is not meant to be exhaustive, as the concepts on savanna classification and etymology have been covered by others (Solbrig 1996; White 1983; Bourlière & Hadley 1983;Menaut 1983). Bourlière suggests that due to the confusion over the various meaning of the word "savanna", and whether trees are included or not (and even in what percentage of coverage), a precise definition cannot be used (see White 1983). However, savanna is a useful term, but needs to be defined with reference to the system in which it is used.

In the savannas of Gabon, this woody component can be quite variable, even within a few hundred meters (see Ndong 2005). Due to these difficulties, a more general definition will be employed in this document while the study being undertaken examines patterns on the ground. Bourlière suggest the following definition (Bourlière & Hadley 1983):

> *"Tropical and subtropical formations where the grass stratum is continuous and important, occasionally interrupted by trees and shrubs, where bush fires occur from time to time and where the main growth patterns are closely associated with alternating wet and dry seasons"*.

The Batéké language considers two types of savanna that are visually classified according to tree coverage. These definitions are not yet quantified, but work is being undertaken to better understand these terms in relation to diversity and density of tree species.

> *Kapé:*a savanna that is primarily herbaceous, but often has scattered trees. Examples include most of the savanna between Ekouyi-Mboma and the herbaceous savanna along the Congolese border of the park.
>
> *Mpila:* a savanna that is arborescent to a degree that visibility is significantly reduced. Examples include the savanna in the valley just south of Ekouyi-Mboma along the road towards the park and the unburned savannas north of PPG.

Tropical Savanna Distribution and drivers

Tropical savannas are found primarily in Africa, South America, and Australia, and the Indian subcontinent. In Africa, savannas (woodlands and grasslands) comprise almost 50% of the landscape (Mayaux et al. 2004).

Generally speaking, savannas are found in areas that are transition zones between forest and desert areas. This fact has been the centre of debates of savanna origin for several decades. The vegetation of some of these areas, particularly the edges, can transition into forest or desert states, a process which can be accelerated by changes in climate or disturbance. Other savannas are edaphic, that is, locally controlled by soil factors such as nutrition or hydrology.

Rainfall in tropical savanna areas can range between 200mm – 1800mm, with a dry season duration of 3-9 months. Soils are variable; disturbance by grazers and fire are common. All of these factors relate to the distribution of today's savannas.

Normally four "determinants" drive the location of savannas. The two primary determinants are plant available moisture and plant available nutrients, followed by the secondary factors of disturbance by fire and herbivory (Solbrig et al. 1996).

Where the primary determinants have high values, transitions to forest vegetation are expected, where these values are low, savanna will become desert. The compensation of high rainfall by low nutrients can also change expected vegetation transitions. The secondary determinants of fire and herbivory also interact to create the savannas of today.

In a landmark synthetic work of over 800 African savanna studies (Sankaran et al. 2005), savannas grouped into those which were stable, depending on low rainfall (< 650mm/yr) alone to maintain savanna structure versus those that were unstable (>650mm/yr.), requiring disturbance to maintain savanna structure. For unstable savannas, fire was found to be the largest determinant. Fire return periods significantly affected woody cover with areas; areas experiencing higher fire frequency generally have less woody cover.

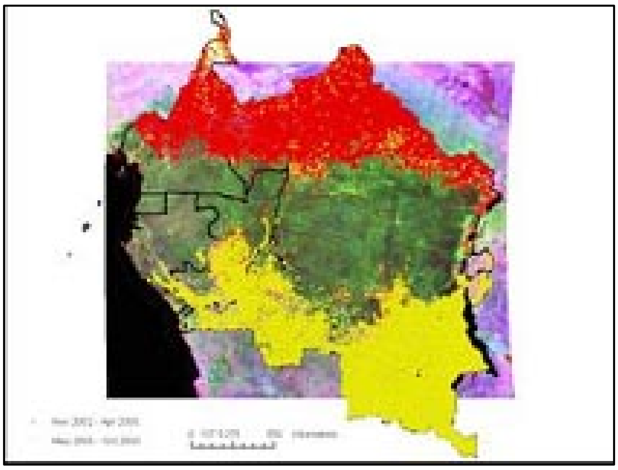
Role of Fire in the Ecosystem

Fire, as pointed out in the previous section, is a major factor in shaping savanna ecosystems including those of North America (Knapp et al. 1999), Brazilian cerrado (Mistry & Berardi 2005), and Australia (Brathwaite 1996). All African savanna systems are affected by fire including those of Madagascar (Lowry et al. 2005), South Africa (Pyne 1995), East Africa (Dublin 1996), and West Africa (Laris 2002). This is not surprising since subsaharan Africa has a long-term history with fire (Bird & Cali 1998), going back potentially more than 400,000 years. Humans have inhabited these savannas for a long time, perhaps as long as two million years. The manipulation of fire is the factors that probably lead to expanded use of these areas in Africa, specifically relating to fire as a tool for hunting and for gathering (Harris 1980).

Regardless of whether fire is anthropogenic or "natural" (eg. lightening), fire has several affects on savanna structure and diversity, sometimes acting in concert with other factors such as climate or animal disturbance.

How fire affects savanna structure: fire frequency and intensity

Annual fires are reported for several areas of African savannas; burned areas can account for up to 80% of the Sudano-Zambezian zone (Lock 1998) or even as much as 100% (Koechlin 1961a) for the Guineo-Congolian forest-savanna mosaic. For Central African savannas, including those in the aforementioned zones, fires typically burn in the long-dry seasons: northern savannas burn from November-April (fig. below, red areas) while those areas south of the Equator burn from May –October (yellow) (figure compliments of the University of Maryland).



Most of these areas receive rainfall greater than 650mm per year, and according to Sankaran's model, are thus primarily maintained by disturbance. Rainfall levels are a factor in burn intensity: increased precipitation means increased vegetation growth. This in turn means increased fuel for fires, once growing parts have dried out. In tropical areas where dry seasons alternate with rainy ones, fire can become widespread, particularly in the Guinean savannas (Gillon 1983).

Fire return period, the frequency of fires an area typically experiences, is one factor significantly affecting the structure of African savannas. Sankaran et al. notes that areas experiencing fire more than at least once every 10.5 years had significantly less woody cover than those that experienced fire at intervals greater than 10.5 years (2005). In studies in South Africa's Kruger National Park, fire return period was found to be critical to maintaining savanna structure. Fire that was too frequent (every year) encouraged constant resprouting of branches from the bases of trees, preventing saplings from graduating into the larger sizes classes, in what is called a "fire trap" (Higgins cited in (Enslin et al. 2000)); however a return period of 3 years allows saplings to grow beyond fire damage height to become trees (Enslin et al. 2000). Variation in fire intensity has been found to be essential for simultaneous growth and regrowth of trees (Govender et al. 2006). While precipitation is required for seedling establishment, fire frequency is what determines the likelihood that a sapling will reach maturity (Higgins et al. 2000).

Fire intensity and frequency are also important for West African savannas. In Ivory Coast's Comoé National Park, low intensity anthropogenic annual fires were found to maintain savanna structure while not altering forest extent (Hennenberg et al. 2006). In this particular system, the forest-savanna mosaic seems to be stable; in a recent comparison of aerial photos spanning 50 years, fire had not seriously affected forest extent (Goetze et al. 2006). However, reduction in grazing ungulates has occurred on a large scale due to poaching (Fischer & Linsenmair 2001) which is believed to have reduced patchiness of the grass layer of the savanna, and in conjunction with altered fire regimes, is suspected to affect savanna structure (Hennenberg et al. 2006).

Fire regime and savanna structure: the case of Kruger National Park

South Africa began experimenting with fire and management over 80 years ago (van Wilgen et al. 2004). Despite their acceptance of fire as part of the ecosystem, their attitude to the role of prescribed or anthropogenic fire has changed over the years with policy and practice swinging from strict prescribed fire regimes to a "natural fire policy" (lightening only). Recent analyses of long term studies have elucidated how changes in fire management policies affect diversity and savanna structure (van Wilgen et al. 2004; Enslin et al. 2000). These management approaches consequently altered savanna structure, favouring at times shorter or less dense woody cover (see van Wilgen et al. 2003). Thus, South African managers have adopted a patch-mosaic burning system that varies fire frequency, intensity, and fire extent to favour overall biodiversity and habitat diversity (Brockett et al. 2001). Before adopting the patch mosaic system, the park maintained a uniform fire application which only rendered a uniform landscape. Without a succession of fires which created multi-aged grazing sites, the rare Sable antelope lost critical foraging habitat (Brocket et al. 2001).

> *We are thus not seeking to impose a 'natural' [ie. lightening only] regime on the ecosystem, but rather we are attempting to simulate a situation which may have existed when early humans ignited the vegetation in the past.*
>
> Brockett et al. 2001

The effect of early vs. late season burns

When fires are burned throughout the season, the standing crop of dead grass in the savanna becomes fragmented, being interspersed with regrowth of new, humid (and relatively inflammable) grass. This in effect, stops large fires from sweeping through an entire landscape, while at the same time creating serial grazing sites for wildlife (as in the case of Lope National Park). Early fires cannot completely burn as some of the vegetation is still green, whereas later in the season, most vegetation is completely dry. In Nigeria, early season burns destroyed only 25% of the vegetation while late season burns destroyed up to 96% (Hopkins 1965).

Late burning can also affect the woody component of savannas. In Nigeria, tree populations were reduced by 32% over a five year period where late fires had occurred (Hopkins 1965). Tree survival increased with tree height, as sapling emerged from the so-called “fire-trap”. Trapnell’s work in Zambia’s miombo (*Brachystegia-Julbernardia)* woodlands found that tree seedling less than 2 ft. tall suffered from almost 100% dieback if the fires were late in the season (Trapnell 1959). Fire, however, is not the only driver of vegetation change in the miombo woodlands. Combinations of land tenure and management techniques (including fire) can significantly affect woody cover (Chidumayo 2002). This work was fundamental in understanding how fire cycles can change forest or savanna succession and has been supported by more recent research into the fire sensitivity of the miombo woodlands (Cauldwell & Zieger 2000).

Effect of fire on herbaceous diversity

The effect of fire on grasses can be positive or negative depending on frequency and other intervening factors such as grazing or variable precipitation. By the passing of fire, dead growth is removed. A new flush of growth follows for two reasons: the root systems have already translocated nutrients from the dead layer, storing them for later use and secondly sunlight can now penetrate to ground level stimulating new growth, something which would have been impossible with standing dead vegetation. In fact burning can increase production, perhaps in part to the nutrients released from the ash (Scholes & Walker 1993). However, when fires are repeated too frequently or are set late in the dry season (when fires are typically hotter), perennial grasses can become less abundant (Scholes & Walker 1993), reacting almost in the same manner as if they were overgrazed (Menaut 1983). On the other hand, absence of burning in northern Ghana saw changes in cover and composition from shorter grasses to taller ones over a period of 11 years (Gillon 1983; Ramsay & Rose-Innes 1963).

Interactions between fire and mammals: cases from east Africa

Interactions between animals and fire can have significant impacts on savanna ecosystems, with the decrease of large animals generally resulting in an increase in woody vegetation (Hopkins 1983). Grazing has a notable impact on creating patches of burnable or un-burnable grass (Adler et al. 2001), which, if burned will create further patchiness. Thus grazers, in some cases have been called keystone species, maintaining habitat structure and diversity (Knapp et al. 1999).

Similar cases of ecosystem interactions have been reported for elephants in the savannas of east Africa. The case of the Serengeti-Mara ecosystem provides an interesting example. Previous vegetation states were reconstructed with colonial documentation, aerial photographs, and vegetation plots yielding a story of a 100 year conversion from grassland to woodland back to grassland. Conversions from one state to the other were results of decreases in animal populations, Colonial administration preservation of the then-woodland, and rainfall patterns, and later increases in elephant populations which grazed tree seedlings. Like the fire-trap, seedlings of a certain height can escape grazing and eventually allow them to mature into trees. However, intense grazing eliminates the woody component of the landscape recreating a grassland state (Dublin 1996). Thus, savanna can be transformed significantly over 100 years as ecosystem factors such as grazers, disease, and population changes occur.

In the similar case of Tsavo National Park in Kenya, interlinkages between animals, fire, and savanna structure were discovered with a documented conversion of woodland to wooded grassland to woodland. Through the use of photo-points (photos taken between years at the same location), changes in vegetation over time were recorded. These were matched with changes in elephant densities and fire incidence. Changes in elephant populations and fire regime were found to be the drivers of vegetation change (Leuthold 1996).

In Murchison Falls National Park, Uganda, a similar trend was reported linking increasing elephant populations to decreased woody growth in the *Terminalia* woodlands. Elephants removing bark from trees which were later killed by fire was responsable for the conversion to grassland. Late season fires were also found to significantly harm tree reproduction resulting in 30-40% of fire-resistant trees being unable to attain maturity (Beuchner & Dawkins 1961).

These cases underscore the dynamics between animals, humans, and ecosystems. As in the case of Mkomazi Game Reserve in Northern Tanzania, the impression that humans were the largest negative force in ecosystem change resulted in eviction of local people (Homewood & Brockington 1999). However, the evidence above suggests an interaction of factors which contribute to ecosystem change.

Indigenous Use of Fires in Savannas and Resulting Policies

Fire had long been seen as a negative actor in savannas. Various colonial administrations had a poor understanding of ecosystems under their direction including a lack of historical documentation and a lack of understanding of broader patterns such as rainfall and climate, all of which led to erroneous conclusions about the causes of deforestation (Fairhead & Leach 1998) and desertification (Leach & Mearns 1996; Aubréville 1962; Aubréville 1949), the two processes with which savanna environments seemingly were linked. Current research on the myths associated with transformation of global land cover has brought to light the synergistic effect of numerous factors on landscapes, often involving economic opportunities and expansion of global markets; there seems never to be a single factor in cover change (Lambin et al. 2001).

Recent international concern over altered fire regimes resulted in an international push to investigate and better manage fire dependent areas (Global Fire Initiative 2004). Their findings indicate that 84% of the global terrestrial systems suffer from a degraded fire regime. Solutions to altered fire regimes include prescribed fire, integration of historically appropriate frequencies and methods, and fire suppression, depending on the needs of the ecosystem.

West Africa: fire policy and local people

For years, West African countries outlawed anthropogenic fire believing it to be the main cause of deforestation. In Schmitz's review of 1996 west-African fire policy and practice, he sites the recent fire policies of

- Burkina Faso, where all fire-setting is a crime,
- Mali where only uncontrolled fires are illegal,
- Senegal where all fire is banned in the Sahelian zone, and
- Benin where all plantation fires are banned and only security fires (those creating a zone of protection around fields and villages) may be lit by authorities.

Centralization of control over natural resources is not limited to savannas, but includes forests as well (see Becker 2001). Such approaches have limited the extent to which local people can use fire for managing natural resources. In several countries, research has since concluded that anthropogenic fire is an important tool for managing resources and protecting villages from late-season fires—this research is beginning to change some policies (Laris 2004).

In the case of the forest-savanna mosaic of Guinea-Conakry, local use of fire had been banned since colonial times. Fire was a poorly understood influence on the ecosystem and most colonial foresters at the time were reoccupied with deforestation and proper use of resources (Aubréville 1949). Anthropogenic fire was thought to be the main inhibitor of forest growth. Indeed, most believed that the savannas were "ex-forest" and were invading the forest at a rapid rate. This poor understanding of the forest-savanna mosaic placed man as the major modifier of the landscape, giving less credence to climate, soil conditions, rainfall patterns, or a combination of these factors. Colonial and later African state policy banned anthropogenic fires in several West African countries. Through careful historic and ethnographic documentation, Fairhead and Leach have described a forest-savanna mosaic that has existed for centuries with anthropogenic fire, where deforestation was not happening, and villagers actively create forest around village sites (Fairhead & Leach 1996). This re-interpretation of the landscape has been received variously by researchers, particularly as this research has been erroneously used to argue that forest conservation isn't needed in Guinea Conakry (pers. Comm. Martin Cheek, Kew Gardens). Despite this interpretation, this work has given a new perspective on human impacts to the forest-savanna mosaic, giving credence to traditional/historic resource use strategies.

In recent investigations into current fire regimes in West Africa with landsat image analysis and ethnographic study have shown a remarkable knowledge about fire setting. In Senegal, one study noted that the general term for "fire" was negative while that for "fire management" was positive; indeed the latter is essential since managed fire is critical for creating cattle fodder in this region. Bans on fire in Senegal thus place local livelihoods at risk (Mbow et al. 2000).

In Mali, an era of a presidential anti-fire campaign in the 1980's radically changed the way fire was used, effectively banning all use. Local people suffered heavily from this policy paying heavy fines and enduring constant animosity from forestry officials (Laris 2004). Research of current fire use results show that a-seasonal mosaic of early fires, as confirmed in interviews and with landsat images, is important. Such a strategy fragments the savanna-woodland, preventing late season destructive fires from sweeping through the countryside (Laris 2002). Fire control is now being decentralized and placed under the control of villages in Mali.

North American indigenous fire and no-burn policies

In the United States, indigenous fire had been used for centuries to shape the landscape (Williams 2002; Pyne 1988), but was outlawed in the early 1900's after a a government surveyor deemed native American fire-setting as "always evil, without a single redeeming feature" (Wolfinger et al. 2002). This practice lead to a government policy of 100% fire suppression in 1910, following a single destructive fire. Large tracts that had once been prairie were converted to forest by a simple change in policy removing social intervention in the landscape (see Schoolcraft 1955). The United States Forest Service initiated a public anti-fire campaign with "Smoky Bear", so effective that fire was nearly wiped out of the system. Additionally, vast networks of fire towers were constructed to site and exterminate all fire within range. Crews of fire fighters, even today, have nearly unlimited budgets to exterminate fire (Pyne 1988). Similar policies and practices have been adopted in Mexico at the expense of local knowledge and ecosystem needs (Matthews 2005).

The results of the U.S. fire policy came to a head in 1988, when Yellowstone National Park was destroyed by fire that could have been prevented had natural fire been allowed to regularly reduce highly flammable dead wood that had built up on the forest floor. Scientists have since conducted numerous studies that prove the value of fire in maintaining ecosystems (Knapp et al. 1999). Native Americans no longer practice fire drive hunts and much of that knowledge has been lost (Williams 2002)**.**

Fire policy now includes prescribed fire for managing protected areas and utilizes data from regular monitoring missions to determine if fire regimes are effective in achieving management goals (U.S.Fish and Wildlife Service 2004).

Northern Australia: the case of Kakadu National Park

The humid savannas of northern Australia present an interesting case of incorporation of aboriginal fire regimes into park management. Much research has been conducted on the effects of fire on Australian savannas (Gill et al. 2003, Andersen et al. 1998). Pre-aboriginal fire regimes, were related to lightening strikes while more recent aboriginal and management changes in the fire regime at Kakadu have been cited for changes in the woodland structure (Brathwaite & Estbergs 1985). Explorations of traditional fire use in these habitats have lead to management strategies, though caution is continually applied when considering the applications of these regimes to modern landscapes:

> *"This historic disturbance regime will produce patch sizes which have been most common historically. This is one reason why the documentation of the traditional fire regime of indigenous hunter-gatherers is of significance for contemporary conservation. However…the traditional regime, as expressed on the landscape as a whole, is an emergent property of the activities of many quasi-independent individuals and groups. It was not the result of a brilliant ecological master-plan which we can simply take down from the historical shelf and naively apply it in a contemporary context (Redford 1991) of roads, tourists, exotic invader problems, contemporary technology, and changed Aboriginal culture. It is necessary to reconstruct the historic pattern of burning as best we can using knowledge from any source." (Brathwaite 1996)*

In the Kakadu area, Aboriginal land tenure was handed down in patrilineal descent groups to clans who shared an area called a "*gunmoggurrgurr*". The clans were responsible for utilisation of resources, land management through fire, and maintaining spiritual places in the landscape. Fires were set during the 7 month long dry season in a patch-mosaic. Early-mid season burning was used to attract wallabies and other game to grazing sites or clear patches for later hunting and gathering activities; most fires stopped during the hot windy season, to avoid uncontrollable fires (Russell-Smith et al. 1997). Further research into historical fire regimes of this same area believe that burning occurred throughout most of the year, with peaks in July and October (Braithwaite 1991).

In 1991, the stated objective for fire management in Kakadu National Park was to "maintain, as far as practicable, traditional *bininj* [Aboriginal] burning regimes within the Park" (cited in (Russell-Smith et al. 1997). Incorporating this knowledge was not easy at the outset, as there was great resistance from western park managers learning from aborigines (Lewis 1989), mostly due to the differing ideologies that each group had about fire in the ecosystem.

These different approaches lead western Australian managers to criticize the value of current aboriginal knowledge, assuming that the modernizations of aboriginal culture meant a loss of traditional knowledge. For example, Lewis writes of the belief held by some Kakadu park managers:

> *"…while acknowledging that indigenous burning practices may have been effective during pre-contact times, the central part of the argument in 1983 was that Aborigines were no longer traditional and that management concerns are now paramount." (Lewis 1989)*

Despite these issues, Australia's incorporation of traditional fire regimes into protected area management 15 years ago is noteworthy. Recent reports seem to indicate greater acceptance of traditional methods of fire-setting (Yibarbuk et al. 2001).

The case of the Batéké Plateaux: Savanna origins proposed by explorers, foresters, botanists & palynologists

Explorers first came to the Batéké Plateaux sometime in the mid-1500's (Pigafetta 1597). By the mid-1800's the Batéké and their control of the Stanley Pool area, now Brazzaville, made them central to colonial politics. Brazzaville's position on the Congo River was key to regional trading. The Téké leader, the Makoko, known to exert great influence over local leaders (Pakenham 1991) signed a treaty with de Brazza which gave trading rights to the French and military protection of the Téké (Dion 2006). The former hoped to expand trade and control of the interior while the latter wished for coastal trade routes; it essentially created the French colony Moyen-Congo (N'nah 1981) and spurred on the colonial race for the rest of Central Africa (Hochschild 1999; Pakenham 1991).

The first written descriptions of the landscape of the Batéké Plateaux are numerous. These vast savannas dotted with woodlands and riparian areas seemed to suggest to many first-time observers that forest once was far more prevalent than at the time of their writing.

In de Brazza's words (1888):

> "*Le pays Batéké, aux longues pentes douces, a un aspect grandiose. Ses assises de grès apparaissent seulement au bord des rivières encaissées. Les grandes forêts ont disparu, ainsi que la végétation exubérante des terres, plus fertiles. La végétation forestière, confinée sur le bord des rivières, cesse des que les racines ne peuvent plus atteindre les eaux du sous-sol. Parfois, sur les plateaux se détache la silhouette des palmiers ou des bouquets de verdure. Mais il faut attribuer leur présence au séjour prolongé de l'homme.*"

The landscape was further described by Léon Guiral, who accompanied de Brazza on several expeditions on the Plateaux. Guiral's landscape description (Guiral 1889), as does de Brazza's could have been written today:

> *"Les pentes et les vallées sont couvertes d'herbe, mais les graminées a tige fine qui la composent ne dépassent guère vingt-cinq centimètres de hauteur; sur les pentes, les plantes ligneuse sont très rares, et c'est seulement de loin en loin qu'on rencontre un arbre rabougri. Les hauts où le sable manque sont tantôt ouvertes de graminées arborescentes qui atteignent près de trois mètres, tantôt couronnées de forts peu étendues, isolées comme des oasis."*
>
> Guiral, 1889

The early description of the landscape's savannas and riverine forests must have been taken into account by the French colonial forester, Aubréville, in his analysis of climate and desertification in Africa. At the time of his writing he believed that the band of savanna bordering the equatorial forest was essentially "ex-forest" having been converted to savanna by anthropogenic fire (Aubréville 1949). The only way he was able to explain the vast transition zone surrounding the equatorial forest, was by "*une ère des grands incendies*" prior to the advent of white explorers.

Despite this, he considered the Batéké situation of planting forest around their villages an anomaly:

> *"We observed a very curious case, incontestably the installation of the forest by people in poorly wooded savanna of* Hymenocardia acida.*Batéké country (Middle Congo), near Okoyo and Evo, is scattered with islands of dense forest; at a glance one can see 10, 20 in the landscape. Each one marks the site of an old village. The Batéké always install their villages in savanna and cultivate their manioc only in savanna; in the rare vestiges of ancient forest which remain, they only plant a few yams, and some sugar cane; only the women cultivate, and they do not want to enter the forest. In the villages, to make their houses and fences the inhabitants use poles of iron-wood,* Millettia laurentii*...and* Ficus *sp. These trees propagate by cuttings very easily, the poles take root, oil palms spontaneously establish around houses, other species disseminated by seed subsequently establish. After a few years, this forest vegetation becomes too dense for the taste of the Batéké, who do not like forest, and the village is moved a little further, in clean savanna. The old site transforms in a dozen years into a thick wood, mixed with palms. Whereas in general the populations of the forest zone seek forest for hiding in, living in and for defense, and clearing it for cultivation, the Batéké form an original exception, fleeing the forest, and re-creating it."*
>
> Aubréville 1949
> As translated by Fairhead and Leach 1996

By the late 1950's, the French colonial administration, was very interested in Central African savannas and their potential for pasture for domesticated animals. This lead to a series of floristic and pasture studies on many savannas, including those of the Batéké Plateaux (Descoings 1974; Koechlin 1961b). Koechlin, after consideration of the origins of the Plateaux savanna flora, found it to be rich in plants of sudano-angolan origin and therefore proposed that these savannas were of potentially an ancient origin, formed during a drier phase (Koechlin 1961a).

> "*Il semble que la coexistence des forêts et des savanes soit très ancienne et qu'il ne faille pas attribuer à l'homme une ro1e trop important dans la déforestation, ni le rendre directement responsable de la plupart des savanes de ces régions*. »
>
> Koechlin 1961

Koechlin felt strongly that the forest was advancing on the savanna despite bush fires. This novel (at the time) stance on a more climatic and less anthropogenic origin of the Plateaux savannas was later supported by palynological work.

More recent work on African vegetation classifications categorise the Batéké Plateaux as part of the Guineo-Congolian forest-savanna mosaic transition zone (White 1983); this zone constitutes a band of savanna around the equatorial and west African humid forests. This area then transitions into sudano-sahelian and zambesian savannas and eventually into desert areas to the far north and south. The floristic composition of the Batéké Plateaux is influenced by both the forest block and the savannas regions (Walters et al. 2006).

Palynological work on origins of the savannas of the Batéké Plateaux suggest that they were created in previous climatic shifts which repeatedly converted forest to savanna back to forest (Salzmann et al. 2006; White et al. 2005; Achoundong et al. 1996; Dechamps et al. 1990; Elenga & Vincens 1990). The last phase of savanna expansion occurred 3500 B.P. during a dry phase; this expansion concurs with the Bantu migration into the area. Fire was noted in the pollen record only 2100 BP (Schwartz 1988).

Current research supports the idea of anthropogenic fire maintaining these grasslands (Sankaran et al. 2005; Favier et al. 2004; Oslisy 2001). In the Batéké Plateaux of south-eastern Gabon, present day fire practices in this landscape continue to shape the vegetation with large expanses of rolling wooded grassland dominated by fire resistant shrubs.

The biological context

The Batéké Plateaux are situated in south-eastern Gabon and central Republic of Congo (approximately at 2ºS, 14ºE). The Plateaux are a series of elevated areas dominated by grassland and riverine forests. These plateaux are part of an ancient sand dune system originating in the Kalahari Desert (Haddon 2000). Some of the deepest sand dunes in the world, these sands abruptly end in south-eastern Gabon where laterite soils and the rainforest begin in Gabon. This meeting of two substrates creates of forest-savanna mosaic creating a diversity of habitats for both forest and grassland dwelling people and organisms.

Plant diversity is not exceptionally rich, but the diversity is unusual for this part of Gabon, containing over 500 species of plants, some of which find their range extensions in the Plateaux (Walters 2007). In this region, lions once roamed the savanna, Grimm's duiker finds its range limit (Kingdon 1997), as do numerous plant species more common in the zambesian vegetation to the south. The most common animal species in these savannas are *Tragelaphus scriptus*, *Sylvicapra grimmia*, *Canis adustus*, *Cephalophus silvicultor* ,and to a lesser extent *Civettictis civetta*, *Syncerus caffer nanus* and *Potamochoerus porcus* (Bout 2006).

New species are discovered in the forest (Stone et al. 2005) but most grassland species are not endemic (Walters et al. 2006). The savanna vegetation ecology has been studied in depth (Koechlin 1952, Koechlin 1957).

In the Plateaux Batéké, several habitats exist from grassland to forest (White 1993b). All streams and rivers are bordered by gallery forest containing *Ancistrophyllum* and *Eremospatha* (Arecaceae), *Palisota* (Commelinaceae), and *Anonidium mannii* (Oliv.) Engl. & Diels (Annonaceae), though sometimes with only dense monocultures of *Aframomum* spp. (Zingiberaceae) and *Cyrtosperma senegalense* (Schott) Engl. between the river and the forest. The forest extends into swamp forest with *Uapaca* spp. (Euphorbiaceae), *Carapa* sp. (Meliaceae), and various Marantaceae spp. As the forest increases in elevation from the streams and rivers, it becomes drier, with *Memecylon* spp. in the understory (Melastomataceae) eventually transitioning into grassland. Wooded grassland abuts the edge of the forest and is dominated by *Hymenocardia acida* Tul. (Euphorbiaceae) and *Annona senegalensis* Pers. (Annonaceae) with swards of varying dominant grass species consisting of *Loudetia simplex, Elionurus hirtifolius, Schizacrhryum tholloni,* and *Sporobolus congoensis.*

Most hills (only an occasional hilltop is capped in a small bosquet) are grassland. Recently burned grasslands are often populated by numerous Cyperaceae species and later bulb species. Some hills form catchments where wet grasslands or peat bogs form (Makany 1972). These are dominated by *Xyris* (Xyridaceae), *Utricularia* (Lentibulariaceae), Eriocaulaceae, and *Loudetia phragmatoides* Hochst. (Poaceae) species.

Effects of Fire on the Plateaux ecosystem

The following section presents the effects of fire on Grimm's duiker, Abdim's stork, and plant communities based on data from the Plateaux itself. These specific examples can be viewed in the context of current and past fire regimes.

The case of Grimm's Duiker (*Sylvicapra grimmia*)

Grimm's duiker is a wide-spread sub-Saharan African savanna species (Kingdon 1997). This species finds its range limit in the Plateaux Batéké of south-eastern Gabon where it is a fully protected species (but not so, in adjacent Republic of Congo). Amongst all animals hunted, the meat of Grimm's, *ntsa* in Téké, is the most desired. In addition to its preferred taste, according to Vansina (1973) its meat was part of the pride-price and the horns were blown to avert thunderstorms and to evil spirits (Vansina 1973, pers. obs.). Grimm's is still hunted today and informants talk about it being the object of the communal fire drives of the past, where large swathes of savanna were burned in the dry season.

The biology of *S. grimmia* is interesting, as it relates to fire. This grazer has a diet of primarily low level dicotyledonous material, as opposed to monocotyledonous material, or grasses (Spencer 1995). In fact, 83% of their diet comprises dicots (Gagnon & Chew 2000). Dicotyledons are plants which are not grasses or bulbs, both of which are components of the Plateaux flora. Low level dicots in the case of this flora would include herbs, perhaps the post-fire low sprouts of *Hymenocardia* trees, and certainly that of *mbli-ntsa*, or Ntsa's cola (*Parinari capensis)*, a small woody mat-forming plant consumed by ntsa (reported by several informants), and most likely encouraged to grow by the passage of fire. Koechlin reports that dicots are part of the flush of plants that sprout during the dry season fires (Koechlin 1961a), as opposed to the flush of grasses common after short dry season fires. This long dry-season flush would coincide with the period in which *ntsa* is most hunted.

Fire creates grazing sites in the Plateaux: when the old grass is burned away, the young shoots attract gazelles that graze, some game arriving the next day to feed on the cinders of the recent fire (cited by numerous informants). Fires also encourage the resprouting of the savanna dominant, *Hymenocardia acida*. Several informants reports that these sprouts hide young *ntsa* while the mother forages. Others report that unburned areas also served as refuges for reproducing *ntsa*. This is confirmed by field observations indicating that females need tall herbs (unburned areas) prior to calving (Estes 1999) and that most prefer having easy access to tall grass (Keyner 1969).

Recently, mammal observations were conducted over 18 months in PBNP. Results for this study are relevant as populations of Grimm's were found to be concentrated in two areas: those which were most frequented by hunters (and most burned, see (Ndong 2005), and those where the grass was tallest (Bout 2006). Independent data from Grimm's answering call's, where these duiker responded positively to imitated calls of young duikers, were found to be concentrated in the areas least burned, in the northwest of the park.

The case of Abdim's Stork (*Ciconia abdimsii)*

Abdim's Stork purportedly has a range of approximately 10,000,000 km^2 and 300,000-600,000 individuals. Its distribution ranges from southern to west and eastern Africa, as far north as Saudi Arabia. According to the IUCN, they have an endangered species status of "least concern."

Along their migration route between west and southern Africa, following the forest-savanna mosaic, Abdim's is hunted *only* in the Plateaux (pers. comm. P. Christy). Just after the small dry season, Abdin's Stork (*Ciconia abdinsii)* migrates through Téké territory (see van Perlo 2002). Fires are set in January or February, when the rains halt for a few weeks. Insects, particularly grasshoppers, attacking the new foliage, attract these storks, which in turn are hunted by the Téké. These storks require water after feeding, so are most likely to be hunted in adjacent areas, according to one informant. The primary diet of adult Abdim's and nestlings alike, is grasshoppers (Falk et al. 2006).

Vansina (1973) is the only written work that reports this type of hunting, however, it has been confirmed by several informants. The burning required for this type of hunting is in accordance with Koechlin's observations. After peak growth by savanna grasses in January, the accumulated dry plant material in the little dry season would burn well.

When considering the effects of fire on other bird species, some require the intervention of anthropogenic fire in their life cycle, and are not the object of hunters. The passage of fire is critical to creating bird habitat for several the Temmink's Courser (*Cursorius temminckii),* Senegal Plover *(Vanellus lugubri),* Common Nightjar *(Caprimulgus fossii)* all of which require low vegetation for successful reproduction (pers. comm. Patrice Christy). However, fires should also be avoided at other times of the year for those species which are reproducing.

Effect of fire on plants in the Plateaux

Most of the grass species encountered in the Plateaux are perennial bunch-forming species. These grasses are interspersed with annual plants, bulbs, and mat-forming low shrubs, all of which are susceptible and/or responsive to fire.

Both bulbs and the mat-forming shrubs (eg. *Anisophyllea quangensis*) flourish after the passage of fire (Koechlin 1961a). Annuals seem to arrive only in the absence of a dense canopy of grasses, something which fire would eliminate (see Scholes & Walker 1993; Menaut 1983).

Koechlin provided as ecological explanation for the seasonality of fire-setting in the Batéké Plateaux. Much of the Plateaux are covered by perennial grass species that reach peak development by January. These are then ready to burn during the short dry season (January or February). This is then followed by a flush of plants which can then be burned in the long dry season. He reported for lower Congo, that most areas were annually burnt, even twice a year (Koechlin 1961a).

Most, if not all of the savanna trees are fire-resistant, and thus not greatly affected by the passing of fire, that is, not outright killed. However, as suggested by

the South African literature, too much fire can stimulate excessive regrowth of shoots from existing root systems of trees. This is particularly the case of the dominant fire-resistant tree, *Hymenocardia acida.* There seem to be several possible results including: annual fires stimulate overgrowth of these trees, thus not allowing the production of new trees or alternatively, the excessive rains allow the resprouts to grow quickly and to escape the fire trap. Koechlin reports, that after extensive study of the region, he never saw a single *H. acida* seedling (1961), thus suggesting that vegetative reproduction is how the Plateaux savannas are structured. The figure above shows the extent of this regrowth in some trees, forming a ring of low new growth from the extensive root system surrounding the parent tree. This formation is termed "*káchò*" by the local Batéké and seems to be the basis for regeneration of *H. acida* trees.

Another typical fire strategy that Plateaux plants employ is the underground maintenance of woody structures, such as stems and trunks. This allows most portions of the plant to remain unaffected by fire. This is what is termed as a geoxylic suffrutex, a growth form that finds its centre of diversity in the Zambesian savannas

(White 1993a). After analyzing the Plateaux flora, there were several examples of this growth form found, namely *Annona senegalensis,* and *Anisophyllea quangensis* (Walters et al. 2006).

2: Fire Management of the Savannas in Gabon's Batéké Plateaux

Gabon's national park system

Gabon created its park system in 2002, setting aside 10% of the national territory in a network of 13 parks. These parks rely heavily on the aid of non-governmental agencies (NGO's) for technical and logistical assistance which is not enough to fulfil park management goals. Most park directors are without state logistical support or staff and only have a small operational budget. This park system is young and despite its current plight, is hoped that in the coming years, it will become more functional.

Savanna management in Gabon's parks

In the national parks, fire is not a completely accepted management tool. Only one park, Lopé, has an established burning plan to serially burn areas each year in order to create buffalo grazing sites and stop forest advancement. Other parks such as Loango, forbid burning, and its savannas are endanger of forest encroachment (Harris & Walters 2006); see also (Favier, de Namur, & Dubois 2004). However, in yet other parks, such as Mayumba or the Plateaux Batéké, the only fire application is that of hunters. Thus in the absence of management, parks apply rules that seem appropriate to the current managers or simply are not able to manage, as in the case of excessive fire-related poaching.

The role of fire in the Gabon is not very well understood by policy makers and managers. Different fire plans have different repercussions on the ecosystem under management such as creating grazing sites or encouraging or discouraging forest encroachment; many managers do not realise the different outcomes that different fire policies have. Despite these inconsistencies, the fire ban of Moyen-Congo in the late 1940's was never enforced. Perhaps it is Gabon's preoccupation with the economic benefits of its forest zone, which has stopped it from framing fire policies (Code Forestière 2001). Thus, Gabon offers an opportunity for fire studies that demonstrate the effects of different fire management strategies on the ecosystem.

Creation of the Plateaux Batéké National Park and management

When PBNP was created only four years ago, the area was carved out of vast savannas along the Congo border that were without established villages (though use by nearby villages was still occurring). The nearest villages are at least 10 km from the boundaries. A pre-existing lowland gorilla sanctuary was incorporated into the park and today, this project (Howlett's Zoo Projet Protection des Gorilles) helps to fund the anti-poaching and biological monitoring missions conducted throughout the park. The Wildlife Conservation Society (WCS) and CIRMF are also active partners sharing in these costs while additionally setting up elephant monitoring projects and a research station in the park. WCS and PPG form the base upon which PBNP works, employing every park worker and working directly with the state-funded park director towards management goals.

Creation of a contiguous Congolese is planned in the near future. The Congolese and Gabonese sides are now working on creating trans-boundary management agreements. Both parks suffer from illegal hunting activities and thus numerous fires.

Poaching by commercial bushmeat hunters is the primary threat to depleted wildlife populations in this area (Bout 2006; Aczel 2005). Regular patrols are conducted whose missions aim to stop hunting and its associated fire-setting. Areas of the park are continually plagued by two scenarios: regular hunting and burning *or* no hunting and no burning. The park is therefore under two fire regimes. Those areas which remain unburned are found closest to Park or NGO camps; some areas have remained unburned for up to five years and no longer support grazing populations. Recent security fires near the park camps have seen an upsurge in grazing buffalo sightings (pers. comm. Paul Aczel, *Chef d'Antibracconage*). Selected burning is recognized as a management tool for conserving animal habitats in the park, however managers of the park do not have sufficient information to establish a burn plan.

In PBNP, the greatest hunting pressure is found to the south and north east; leaving the areas around the park camps well protected (Bout 2006). However, the high pressure area to the southeast coincides almost perfectly with Grimm's duiker and striped jackal (*Canis adustis)* distributions (yellow circle in figure). This latter area was also the most burned in the park, as evidenced by analysis of landsat images from 2002 (Ndong 2005; Consiglio & Walters 2004) (fig. 1).

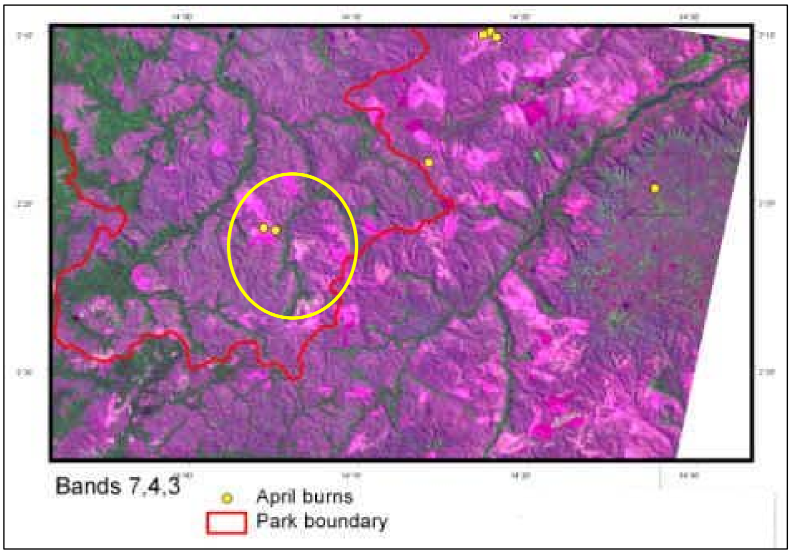


Fig. 1. Landsat from 2002 of the park area. Fire scars are featured in pink and are most concentrated in the south-eastern portion of the park. (Consiglio & Walters 2004)

Application of fire management (implementing fires in protected areas) or hunting law (banning hunting and associated fires in protected areas) are far from the reality of today. Gabon invests little in its nascent park system depending largely on the goodwill of NGO's to support park administration. Hunting laws are also lax. While Gabonese guns must be registered and hunters must have permits, very few-- if any have the necessary paperwork making tracking trends difficult. Whereas records of hunting in east and south-central Africa can go back 50+ years for poaching arrests, hunting permits, or gun registrations (Arcese et al. 1995; Marks 1977), Gabon only passed a gun permit law in the 1980's (République Gabonaise 1983). The absence of permits is rarely enforced. Thus, working towards fire management strategies in a law enforcement vacuum may seem delusional. However, one would hope that given the right allocation of resources and good will, there may come a time when the social and biological role of fire in the ecosystem is understood and applied towards management objectives.

3: Fire-setting today: the case of Batéké villages in Gabon

In Gabon, savanna covers 20% of the country, and attention turns more towards forestry rather than savanna resources. In fact, the Code Forestière (2001) and hunting licenses (République Gabonaise 2006) only gives one guideline to fire utilization in Gabonese savannas: that it not be used in conjunction with hunting.

Generally speaking, the Gabonese are pyrophiles. Setting "cleaning" fires in roadside or urban savannas is socially acceptable. In the Batéké Plateaux, where savanna fires seem to cover every inch of burnable savanna, villagers walk with matches when going elsewhere, be it fishing, hunting, visiting, or to the plantation. In field visits, some Téké research assistants found it difficult to refrain from setting fires in the study sites containing mature, dry grass.

Reasons for lighting fires in the study site are numerous and include plantation clearing, security, ease of walking, visibility, creating grazing site for hunted ungulates and birds, stimulation of new growth of gathered plants, and gathering of grasshoppers.

The cultural context

The Batéké people occupy a series of savanna plateaux spanning more than 12,000 km^2 (Elenga & Vincens 1990) across south-eastern Gabon, central Republic of Congo, and south-western Democratic Republic of Congo. These plateaux also represent distinct language subgroups (Guthrie 1953), however some works refer to them as "Western Téké" (Vansina 1973), whiles others distinguish various geographically separated subgroups (Etsio 1999). The Western Teke group in this study straddles the Gabon-Congo border, however, this study will only deal with the populations in Gabon.

The Batéké have a matrilineal society. In the past, small villages tend to form around familial or political associations, typically not numbering more than 100 people. These populations were quite mobile, relocating village sites every 6-7 years, according to one informant. Numerous bosquets (small forests often on the summits of hills) dot the Téké landscape. These are a visible testimony to historic settlement and migration patterns (Guillot 1980; Pelissier 1980). Such movements may have been caused by several reasons including limited resources (such as sufficient cultivation area, or water supply) or sorcery accusations causing a village to divide (Vansina 1973).

Researchers have been perplexed by the low densities found in Batéké territory, some of the lowest in Central Africa as less one person/km^2. Explanations for this centre around lack of water availability (despite high rainfall, there are few permanent streams), population declines tied to sleeping sickness, and population migration towards work centres for the Congolese railroad (Sautter 1960).

The Batéké Kingdom was considered to be one of the most powerful in Central Africa, greatly respected by other tribes (Walker 1870) and had already ruled for years when the Portuguese first arrived in the 1500's (Pinçon 1991). The Batéké kingdom was quite an anomaly given the low population density (Vansina 1973), however, their power was known throughout Central Africa. This powerful political position made the Téké key in the colonial struggle for Stanley Pool where the French signed a treaty with their ruler, the Makoko, giving the French trading rights to the region (Packenham 2005). Today, the Téké are far removed from the international political scene (yet integrated into local and sometimes national politics).

Changing pressures on the landscape

Today, hunting by fire is still important, however commercial bushmeat hunting has increased so increasing fire frequency and adding pressure on wildlife. Lions became locally extinct in 1994 though were common in the 1960's (pers. comm. Pierre Ngovora, General Director of the *Eaux et Forets;* Henschel 2006). Villagers remember lion calls in the park when they were younger, however the presence of lions was often seen as a mystical event, invoked out of calabashes by *ngàa* or powerful men.

Buffalo were probably also more common during colonial times (see (Chavannes 1935), but herds have been since seemingly declined. Congolese Téké hunters report having to walk further and further for a successful hunt, using guns obtained during the Congolese wars in the 1990's (Gami 2003). Around larger cities, such as Leconi, meat is no longer used strictly for subsistence, rather is sold commercially in the markets, however Gabonese villagers tend to rely on subsistence hunting. In Congo, division of the meat follows the sharing principle like in earlier times, though the prime meat goes to the owner of the gun, rather than the chief of the domain (Gami 2003). Indeed, most savanna hunting today occurs with guns, while nets and spears were abandoned along with the fire-drives.

Landsat images from recent years show widespread fires over much of the landscape. It appears that the savannas are now treated as a common pool resource, where winners take all (Hardin 1968). The change from traditional tenure of hunting domains, subsistence hunting, and low-tech methods to commercialized hunting may have affected wildlife populations and perhaps general grassland biodiversity. This scheme is well-illustrated by a conceptual model written by the Batéké local authorities (Ikamba 2005). According to the model, the elites hire villagers to hunt protected bushmeat (like the locally endemic Grimm's Duiker *Sylvicapra grimmia*). With little access to other monetary gains, villagers are more or less economically forced into this arrangement. It is widely acknowledged that subsistence hunting is not the problem. However, the elites are also family members of the villagers with whom they hunt or political figure, thus adding a family and/or political dimension to the hunting issue. The elites in the study area tend to be those relatives who were able, through education and political connections, to become civil servants, entitling them to very high incomes. Cars are acquired and when they return to the plateaux for vacations, hunting is a typical activity, and probably a tie to the village tradition within with which they are no longer in constant contact. Given this scenario, large expanses of savanna are regularly burned every year, and sometimes multiple times a year.

However, mixed perceptions about fire in the landscape create confusing messages. In the conceptual model developed by local authorities (Ikamba 2005), fire is listed as a by-product of hunting practices and a threat to the park's flora and fauna. At the same time, most informants advocate burning to create grazing habitat. Fire is simultaneously considered a threat and a necessity, probably pointing to a mixture of over use versus appropriate use.

Present day fire trends and hunting strategies

Firemapper is a satellite reporting tool which detects fire activity occurring at a scale of greater than 1 km^2. These data are managed by the University of Maryland

and made available to researchers upon request. These datasets are conservative reports on fire activity since cloud cover may prevent the reporting of an active fire.

Firemapper points have been collected for sub-Saharan Africa since the year 2000. The University of Maryland has granted access to these data (University of Maryland 2006). These data indicate current seasonality and frequency of fires.

The dataset provided from the Firemapper database included fire points from across the Batéké Plateaux, in both Gabon and Congo. Using a dataset from 2000-2005 (University of Maryland 2006) from 2000-2005, fire seasonality was analysed. The addition of a second satellite in 2003 and 2004, which detected more fires, also added a layer of duplication within the dataset. These data will be re-analysed (without duplication) at the end of the study together with data from 2006 and 2007.

In an earlier analysis of these data made by the author, from 2000-2005, fires are shown to peak in the large dry season (June – September), with a secondary peak in the small dry season (Jan-February). In general, high fire season occurs during the long dry season June-September, which is the season of game hunting, cricket collection, and plantation burning. There is a secondary peak of fires in the small dry season February-March, when hunting of Abdin's Stork occurs. Despite the peaks, there is a reported level of fire activity at all times of the year, except perhaps in October - November (fig 2), when little of the landscape is left to burn.

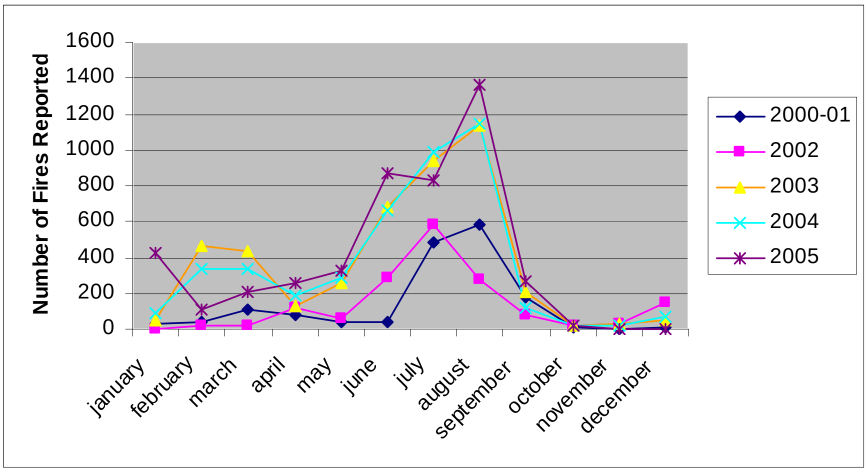


Fig. 2. Fire frequency across Batéké territory. Fire peaks in the large and small dry seasons.

These trends differ from informants who say that "*avant*" they only burned once a year, but that today, they burn in every season.

4: Landscape burning in the Plateaux during the time of the Chef de Terre

Investigations into the current approaches to savanna burning in the Batéké Plateaux and their effect on savanna structure and diversity can be placed into a historical context by documenting the former land tenure system that governed fire-setting in Gabonese Téké territory.

The Chef de Terre (*Ngântsè*) system

Maps from de Brazza's and other expeditions to the Batéké Plateaux in the late 1800's yield interesting information on village organization common to the Western Téké. In one map, describing the rivers Alima and Ogooué, between which the *Téké* live (then and now), numerous "*terres*" are noted, with the proprietors name ascribed (Pobeguin 1888).

These lands refer to the domain over which Chef de Terre, or *Ngântsè*, presided. *Ngântsè* was the person in charge of a particular area of land and responsible for protecting the area from witchcraft, authorizing hunting and burning privileges, settling disputes, and collecting tribute. According to several informants, an *Ngântsè* was equivalent to a present day *Chef du Canton*, presiding over a district that contained numerous villages. Several "*terres*" would be under the jurisdiction of the *Ngântsè's* domain. These were primarily delimited by rivers or other natural features such as canyons.

In Vansina's in-depth discussion, he describes (Vansina: *Ngáantsii;* Sims: *Nganscie*; de Brazza: *Nn'ga-ntché)* a type of rule over land utilization while also assuming the responsibility of protecting the domain from witchcraft. The role of *Ngântsè* was quite separate from that of a lord, who ruled over him, yet was also shared in the duties of protection and justice. However, the lord had no authority over the land, despite having more wealth and prestige. Vansina (1973) writes:

> *The authority of the squire [Ngântsè] derived from the 'unbreakable mystical bond' which had always existed between [him] and the nkira [land spirit] of the domain.*
>
> *1973 (p. 323)*

Thus the responsibilities of the *Ngântsè* included maintaining favor with the land spirits, while authorizing hunting access and fire setting. He also reserved the right to leave areas unburned for a period of time (Vansina sites 1 year; informants site 2-5 years), to serve as a "refuge" (this word is used in the literature and also by francophone informants for the unburned areas) for animals. Hunters were always required to give the hind quarters of any game killed to the *Ngântsè* (Vansina 1973; also confirmed by numerous informants) as a tribute. This tribute was demanded since the animals hunted were connected to the domain's land spirit.

According to Vansina, *Ngântsè* had no right to agricultural products, only dealing with land outside this domain. He also had no right to regulate the movement of settlers into or out of his domain. New settlers were expected to comply with the existing *Ngântsè* tribute system. This was confirmed by several informants, when asked what happened when villages migrated into new territories, as was often the case.

The first *Ngântsè* encountered in the literature on the Plateaux is de Brazza's interview with N'jayole (Brazza 1888)

> *« Mon apparition au long avait été depuis longtemps signalé; néanmoins N'jayole se donne la satisfaction de me faire attendre. Lorsqu'il pensa que cette pause avait inspire une haute idée de sa personne, il parut, entoure des chefs de terres voisines, parents ou amis, réunis pour lui faire honneur. Dans cette circonstance N'jayole avait exhumé la coiffure de grande cérémonie, sorte de perruque en fibres textiles, rappelant un casque; les appendices qui la surmontaient, vus a distance, ressemblaient a des cornes C'est la le signe distinctif du "nn'ga-ntche", chef de terre, qui a sous sa dépendance tous les villages du district. »*
>
> de Brazza 1888

de Brazza soon realized that his operations in Batéké territory would only be successful if authorized by the *Ngântsè,* and not the village chiefs. This insight perhaps laid the foundation for the French colonial administration's choice in 1947 of naming effectively the last *Ngântsè* as the first *Chef du Canton* of the study area, *Kakogo Sylvestre*.

Historic control of fire: rotation and fire-setting

Several ethnographic and explorer accounts discuss the ways in which fire-setting was controlled in the Plateaux. According to these, the *Ngântsè* had strict control over when and where fires were lit *(Vansina 1973; Vansina 1966; Sautter 1960)*. The largest fires were set during the long-dry season from July to September as part of the communal fire drive hunts (Vansina 1973; Sautter 1966; Papy 1949; Guiral 1889). Vansina further noted a short fire season in February for hunting Adbim's stork. This seems to imply that most fires were set only one time per year, as cited by de Brazza's colleague, Chavannes (Chavannes 1935). Areas were reported to be left unburned "refugia" in order to provide animals protection (Vansina 1973; Sautter 1960), an interpretation which has been confirmed by several informants. Others have talked about an area left unhunted in order to allow for animal reproduction. Some Batéké groups left areas unburned for a period of 2-5 years and then rotated the area back into annual burning (noted by several informants), while others seem to burn the same areas year after year, without rotation (Sautter 1960). Sautter was the only person to make notes on fire size and number; he reported during his stay of an average estimated fire size of 2-4 km^2, noting over 200 such fires around 4-5 villages. He, as well as Vansina, writes that cultivation was prohibited in hunting areas, indicating that most of the Batéké landscape was used for hunting alone. This information is summarized in the table below.

Ngântsè controls fire-setting	Premature fire permitted	"Refuge" for animals	Unburned areas rotated	Length of time an area not burned/size of burns	Frequency	Seasons burned	Source
--	--	--	--	--	1 time/year	--	Chavannes (1886)
--	--	--	--	--		September	Guiral (1889)
--	--	--	--	--	--	Long dry	Papy (1949)
yes	no	--	No	2-4 km^2	--	Long dry	Sautter (1960)
	--	--	--	--	1-2 times/year following grass life cycles	January-September	Koechlin (1961)
Yes	--	Yes	--	1+ years	--	February (Congo Cranes); Long dry	Vansina (1973)
In past, yes	no	Yes	Yes	2-5 years	1-2 times/year	March (cranes) and long dry season	Pilot Study (2006)

Many reasons are provided for fire-setting and the Batéké were critical of those who did not adhere to the fire regulations. Fires were set foremost for hunting purposes (mammals and birds), security (to ensure that later fires did not burn undesirable areas), cleaning, ease of walking, visibility, and even for the joy of watching things burn. Fires that were set without permission were serious offences. In the case of the study site, one informant reported a case of one man giving his daughter in marriage to pay a fine. The Batéké were so serious about fire regulation that they stopped granting usage of their territories by the bordering Balali people to the south, who had a tendency to burn hunting reserves (Sautter 1960).

Beyond hunting, fires are set for other reasons, some reported in the literature, others not. Security was important thus, early season fires were lit around areas in an effort to protect them from later season fires, particularly straw houses and fou-fou drying stands.

Fires were also used for ease of walking and visibility. This is easy to imagine once one has walked through unburned savannas. Visibility was probably only historically important during times of war or when predatory animals were present, such as the now-locally extinct lion (Henschel 2006).

Other uses of fire include those to attract Abdim's stork in February-March (pers. Comm. Patrice Christy, Ornithologist (Vansina 1973), those to gather grasshoppers in the long dry season (pers. obs.).

Hunting and agricultural areas defined

In the past, and seemingly today, there is little overlap in cultivated and hunting areas. According to Vansina (1973), cultivation was forbidden in hunting areas, with hunting taking up the largest portion of the landscape. In terms of resource areas used versus nutrition extracted, it would be hard to argue that this was a good investment.

Sautter (1960) reports that after participating in 8 hunts, only 14 animals were captured. Other food sources were far more important in daily life, such as manioc and yam cultivation, fishing, and the gathering of leaves and insects for sauces. Sims noted numerous words for collected caterpillars by season and habitat pointing to the importance of this particular gathered resource (Sims 1886).

Cultivation areas today occur within 2 km of the village site. Two types of cultivation are conducted: manioc and pineapple cultivation in forested zones and yam cultivation in savanna zones. Swidden agriculture is practiced on a rotational basis in riverine forests or old village sites, both of which provide a better soil structure than the adjacent savanna. Forested areas are cut down in June and July and burned in August when the site has dried. Fire does not carry into adjacent savanna, as this has already been burned. Cultivation areas for the entire village presently rotate between two sites over a period of at least a decade, thus giving the forest a chance to rehabilitate, and not incurring on new forest farther away.

Savanna cultivation is primarily for yam production of three varieties, though manioc, and “oseille” (*Hibiscus* sp.) are also cultivated. These fields are prepared in November, after the rains have begun. Clumps of savanna are piled into “sillons” or strips of raised beds. The vegetation is allowed to decompose in order to generate nutrients for the yam to be planted later. According to aerial photographs, these latter fields comprised much of the space around villages in the 1950’s, probably indicative of a larger (less urbanized) population.

Cultivation does not seem to cross large rivers. This is primarily a logistical issue, that in the absence of bridges, it would be nearly impossible to transport heavy loads of cassava back to the village. Thus in aerials from PBNP, a former village and its numerous yam fields are found to the east of the Mpassa River, but not on the west bank. This is the same at the study site where cultivation does not traverse the Djouya River, despite suitable cultivation sites.

Thus cultivation and hunting space was respected and most likely not a point of dispute given the wide expanses and low population densities of the Plateaux.

Batéké hunting in the past

Vansina’s ethnographic study of the Batéké Tio group indicated a disproportional love of hunting amongst the Tio. Despite the fact that both agricultural and gathering practices supply a greater portion of the food supply, these practices were not nearly as esteemed nor ritualistic as hunting. However, despite gender, not even the male activity of trapping merited ritual of like hunting (Vansina 1973).

Hunters in the past were garbed in raphia skirts and armed with weapons such as arrows, spears, lances, and flint-lock rifles (Papy 1949). Vansina depicts the preparation for the hunt as follows (1973). Hunting prowess was typically increased by charms, amulets, and rituals, often dependent upon the collection and utilization of specific plants. Hunters offered prayers to their ancestors and the nature spirits, consulted medicine men, and recited mantras to guarantee a successful hunt. A good hunt indicated success in life, the blessing of the ancestors, and harmony with the natural world. Songs specific to hunting practices have been reported (pers comm. Sophie Le Bomin, musicologist) where the cadence of the song set the pace of the fire being set. Bells were formerly attached to dogs in a divination hunting practice (Dupré 1998).

Hunting by spear and net occurred throughout the early wet season from July to January, when the grass was not too high to walk through. Trapping occurred in the short dry season in January-February. Fire drives occurred in the dry season from May to September and was a group activity involving men, women, and children. Vansina cites these fires as *driving* the animals towards nets: men collected the animals while women and children collected rodents and frogs. Most informants in their 40's and 50's have reported hearing these stories from their parents, but had not themselves participated in such types of hunts.

Abandonment of the *Ngântsè* system and decline of the communal fire drive
Ngântsè is no longer in practice in Gabon. It is unclear exactly why this system has fallen out of practice, but there several possibilities including influence of the colonial administration and the desire for independence from a tribute system.

According to a source dating from 1949 which commented on Congolese Téké hunting techniques, fire drives were outlawed by the French colonial administration (Papy 1949). This was probably attributed to the perceived destruction of bush-fire on tropical forests. Forests were a colonial resource for timber and destruction of potential income was taken seriously (Consigny 1937a;Consigny 1937b). Koechlin (1961) cites numerous works that intensively studied this issue (Pitot 1953;Humbert 1953;Collin 1951;Humbert 1938;de Wildman 1938;Consigny 1936). One curious case is presented where the Belgian colonial administration favoured the indigenous practice of "*nkunku*" which protected savannas from fire with the goal of creating forest for future cultivation (Biernaux 1954). Anti-fire policies were established in many West African countries under French administration (Schmitz 1996), however not in Gabon.

Another colonial impact possibly contributing to the decline in power is "*regroupement*", the colonial policy which sought to aggregate villages along roads. This policy often applied force to encourage villages to relocate, and many villages were unwilling (Burnham 1975). In the local case of one village in the study site, *regroupement* only happened in 1967 when several villages were forced to move as far as 20 km to a new location, thus disconnecting them from locally based natural resource knowledge, such a nearby cultivation, fishing, hunting, or gathering sites. Old village sites are used today as primarily camping sites when the Téké go far afield for hunting or gathering activities. This relocation to new sites may have also disrupted the way in which the *Ngântsè* system functioned, displacing people from hunting domains, and probably changing how hunting occurred in these domains.

Ancestral hunting claims to Plateaux Batéké National Park (PBNP), still exist. This park lies 21 km to the west of Ekouyi-Mboma and was within the *terre* formerly ruled by the extant *Ngântsè* of the area. The case of Mboua village is such an example. Formerly located in west PBNP, the village relocated some 40 km to the west in the forested zone near Boumango. Mboua was the seat of the *Ngântsè* of the western portion of the park. He has in recent years disputed park jurisdiction in this ancestral hunting area (pers. comm. M. Ikamba).

Likewise, just across the border in Congo, hunters recently interviewed in several villages in the Lekana area, a mix of *Koukouya* and Western *Téké* subgroups, lay claim to ancestral hunting rights in the eastern part of the park, east of Lac Lulu. They continue to hunt there, despite efforts to stop poaching within the park, delineating their current hunting territory by the Mpassa River and Lac Lulu (Gami 2003, p. 19).

Indirect rule may have also been a contributing factor. The French were known for utilizing the powerful rulers of a region to form alliances that would serve the colonial administration; village chiefs and other local authorities became paid by the Administration thus swaying their decisions in favour of French rather than local concerns (see Burnham 1975) and the Téké are no exception to this rule. The last effective *Ngântsè* of the area was *Kakogo, Sylvestre* who ruled four "*terres*": Djouya, Haute Leconi, Bongoville, and Akieni, today corresponding to two rivers and two larger villages respectively. *Kakogo* was chosen as the first *Chef du Canton* in 1947 due to his regional authority and his previous work with the French. He died in 1957 and was buried 5km from the Congo border in the former village of *Voubi*.

The Ngântsè system is a mixture of political and spiritual power. This combination might be a relict of the mixing of Bantu and early autochthonous societies that were found in the Plateaux. Vansina writes of the mixing of these culture cultures in the context of the origin of the savanna kingdoms (Vansina 1966).

The implications for the abandonment of the *Ngântsè* system seem grave. Domains are no longer respected, and while hunting fires typically peak at the end of the large dry season, as they did in the past, there is no longer an active effort to leave large areas unburned. It seems that these savannas have become common pool resources which are hunted by anyone coming from anywhere. The curious combination of affluency and prestige on the Gabonese side of the border and war-related poverty in the Republic of Congo leave the landscape overhunted (Gami 2003).

The Téké Refuge theory

The *Ngântsè* system of burning set aside parts of the hunting domain that remained unburned for 1-5 years, on a rotational basis. The rationale behind this has been reported as an effort to create a "refuge" for the hunted animals (Vansina 1973)—whether this area was intended for animal reproduction, is unclear. Grimm's duiker, the most-sought animal by the Téké, has particular need for tall grass in order to hide young. On the opposite end of the spectrum Grimm's also prefers burned areas for grazing. The refuge may be key in maintaining habitat essential for duiker populations. Was the reported "refuge" provided in unburned areas a direct attempt at management for increasing hunting success? Was there an ecological rationale behind rotational non-burning? If only present day informants discussed this aspect of management, or, as one called it, "technique de conservation", one would be sceptical. However, rotational non-burning is in fact reported in the literature from fieldwork in the 1960's, when management issues were not of regional concern, nor were informants as educated in western systems of thought. These facts seem to suggest that, the Téké were intentionally managing their savannas for a particular resource. However, one cannot be absolutely sure unless one goes back in time to observe the beginning of the practice itself.

In distribution maps of park fauna, concentrations of animals are found to be in areas where park staff and NGO's are based. These areas are not burned and not hunted. Conversely, the concentrations of animals such as the jackal or Grimm's duiker find their greatest concentration in burned, hunted areas (Bout 2006). Fires burned early in the long-dry season are responsible for the flush of dicots needed by Grimm's duikers as a primary food source (Gagnon & Chew 2000). This provides some possible evidence of the Téké refuge theory, where unburned areas are important in maintaining habitat for reproduction while burning creates the pasture and a flush of dicots needed by Grimm's.

There seems to have been indirect, non-hunting related, consequences for rotational non-burning. Early burning in February/March for attracting Abdim's stork populations would have created a mosaic of burned and unburned areas critical for stopping later hot fires during the long-dry season. These burned areas also serve other birds as essential habitat during their breeding cycle. When considering the woody component of the landscape, studies on structural change and fire regimes studies may serve us well. In those cases, over burning results in basal sprouting of trees and the repeated killing of young shoots thus not allowing them to graduate stems to larger size classes. However, bi- or triennial burn cycles were all that were needed to alleviate the problem. In areas burned every year, it has been noted that the common *Hymenocardia acida* Tul. vigorously resprouts after a fire. If areas remained unburned for several years (and rotated), as was done under the *Ngântsè* system, perhaps the savanna structure was affected. Sankaran's synthetic savanna study (2005), noted an elevated and unexplainable density of savanna trees, despite the current fire frequency for the Kalahari sands (30%); this was contrasted with an average 9% coverage for all over savanna sites with a similar fire frequency. Perhaps burn schemes, tree biology, and substrate properties offer partial explanations.

5: Synthesis of existing and new ecosystem information for management

Science has primarily focused on the negative impacts of man on nature (Salick & Ethnobiology Working Group 2002; Lewis 1989). Putting local experience of resource management into a positive light has encouraged conservationists and resource managers to consider including traditional management techniques into new management plans (Drew 2005; Gilchrist et al. 2005; Kaschula et al. 2005; Ellis 2005; Huntington et al. 2004; Whiteman 2004; Ticktin & Johns 2002). This approach must always be taken in light of ecosystem affects as local resource use does not necessarily mean *better* use of resources. Thus these knowledge systems, if to be applied to management, should be first analyzed for an appropriate fit for management's needs. On the other hand, managers might also consider local systems, and if applicable, integrate them into modern management systems.

When Gabon created their national park system in 2002, they severely lacked the resources to manage these areas. In Gabon, 6 of the 13 parks contain savanna habitat and only one has a fire management plan in place. Fire is culturally and biologically important in Gabon from using fire to create animal grazing sites for hunting to "cleaning" their savannas, a sentiment not unique to Gabon (Mistry et al. 2005). However, fire practices among Gabonese parks are not uniform. Given the long term use of fire in the landscape, understanding its biological role is critical for management. If certain landscapes are to be maintained such as savannas, understanding different fire treatments, fire effects, and local techniques including historic ones might help in the management of these national parks.

Next steps in developing a fire plan for PBNP

Given the role that fire has historically and currently plays in the Batéké Plateaux and the management goal of PBNP to maintain the forest-savanna mosaic within its borders, it is critical to understand the role that fire plays in this ecosystem and how fire might be applied as a management tool.

The previous literature review has provided a basis for the current vegetation and anthropological work taking place in the park and the villages around PBNP. The next steps for understanding the role of fire in PBNP are to undertake studies or analyze existing observations on the people, flora, and fauna. These studies can then form the basis for a science-based fire management plan. The final steps will be in finding and using low-cost techniques to undertake prescribed fire within PBNP and to evaluate the fire plan's effectiveness in maintaining management goals.

Anti-poaching reports

For the past several years, anti-poaching teams have been observing and changing hunting and fire patterns in PBNP. These reports and input from park administration and the anti-poaching team will be critical for understanding opportunistic fire use in the park and how to best apply prescribed fire practice under the current poaching threats.

Bird Surveys
Fire can be necessary and detrimental for the life cycle of the Plateaux bird species. However, PBNP needs some guidance on the timing of burning and on which species require it. Therefore, observations on bird reproduction (seasons in which to avoid fire) and on habitat requirements (those species which require low grass or burned areas) are critical.

Patrice Christy has for many years been observing the birds of the Leconi area. This detailed knowledge has given him a basis for understanding bird reproduction in several seasons. His data set, however, is incomplete, missing a few seasons. He has agreed to undertake at least two missions to PBNP during seasons for which his data is insufficient. He has already completed one mission (June 4-17, 2007) and will complete the second mission at the end of 2007.

His observations will provide the first guidance for PBNP on the seasonality of fires that are best for bird species of the Plateaux. In the future, students or researchers may wish to undertake more detailed studies on particular bird species to deepen our understanding of the effects of fire on bird ecology in PBNP.

Cultural studies
Fire has been employed by local people in the Plateaux for thousands of years. Thus understanding the historic usage of fire and the current regime are important for management. In addition to literature review in the Centre des Archives Outre-Mer in Aix-en-Provence, France, in February 2006, field work is currently being undertaken in 5 villages to understand the perceptions and practice of current fire usage. In the villages of Kibiri, Ekouyi, Mboma, Lewu, and Saaye, resident and non-resident individuals aged older than 15 are being questioned on knowledge and utilisation of savanna resources, as well as fire practices. These surveys will be analysed for differences in resource use and knowledge by age group, income, and primary residence.

In-depth interviews are being undertaken with older informants on previous savanna resource utilisation, particularly on the techniques used during the now-extinct communal fire drives that were common prior to independence.

Park administration and WCS conduct work in park adjacent villages related to tourism, sensibilisation, and environmental education. The experience and reports of these groups will be relevant to understand cultural practices, current resource use, and expectations. Additionally, integration of the results of this work may be useful to the environmental education campaign.

Landuse inside the park
Stakeholders in PBNP are several. Any attempt at developing a fire plan should be inclusive of these experiences. There may be stakeholders missing from the list; if so, these need to be added.

For many years, gorilla reintroduction has been taking place within PBNP. Fire within this zone, planned or unplanned, may have serious consequences for these populations. PPG's experience in this area is necessary to understand the implications for fire presence or absence within this area.

CIRMF will be establishing a research station with PBNP. Researchers may need a variety of savanna habitats, including unburned zones. CIRMF and park researchers will need to advise on needs of habitats within the park.

Tourism is a long-term possibility for the Park. How fire would affect animal populations and a tourist's visit are also aspects to consider. Studies on tourism will need to be considered at some point.

Mammal Surveys

Fire affects the food distribution of forage in the Plateaux, while also affecting the distribution of tall grass cover required by other species. Particularly the distribution of Grimm's duiker and possibly buffalo seem to be affected by fire. Understanding the habitat and feeding requirements by these species is fundamental for managing the habitats within PBNP to their gain.

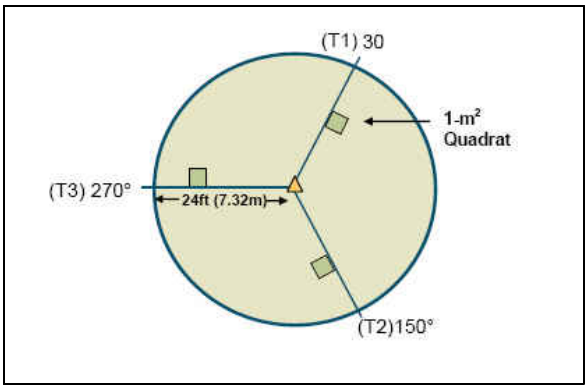
Extensive mammal surveys were undertaken in 2005-2006 by the monitoring team. Observations were always made on the savanna habitat in which the mammals were found, including whether or not the savanna had been burned recently. These observations may provide PBNP with the first direct insight into animal population densities and fire.

Bout has agreed to analyze his dataset in terms of fire. While this analysis needs to be taken conservatively given that the monitoring data collection was not planned with this analysis in mind, this dataset is currently the only one which can serve PBNP to understand the relationship between mammals and fire. In addition to other literature, Lisa Korte's studies of buffalo populations and the development of the fire plan at Lope National Park will be relevant.

Vegetation Surveys

As seen in the previous literature survey, fire and savanna vegetation are tightly linked in the Plateaux. Pilot studies undertaken in mid 2006 underscored the link between species diversity and fire. This study has now been expanded to include studies on the woody structure of the savannas.

Plant Diversity:



From May 2007-March 2008, plant diversity will be examined in May 2007, October 2007, and February 2008 (post fire seasons) to understand how fire in different seasons affects diversity. Secondly, in July and November, studies on the effects of *not-burning* on plant diversity will be undertaken. These studies utilise a method developed for measuring change in herbaceous plant communities (Stohlgren et al. 2005). Diagrammed below (drawing by Stohlgren et al.), each plot consists of three sub-plots. In each burned or unburned area, three circular plots of a radius of 7.32 m (each with three subplots of 1 m^2) are established. Percentage of cover per species is recorded. Nine plots are established in five burned areas each season to record plant diversity two months after fire has burned an area. These results will be compared with unburned areas in the park in July and November.

Savanna Structure:

To understand the structure of the savanna, we need to know the distribution of stem diameters in biennially burned and unburned savannas. Two transects of 6 x 50m are established in five areas each burned or unburned for a total of 10 areas. In each transect, stems greater than 1cm are identified and measured. Measurements are taken above the stem swelling at the base of the stem. Since individuals cannot be separated, particularly in the case of *Hymenocardia acida,* all stems are measured. Based on these transects, the distribution of stem diameter will be graphed. This will yield an understanding of how the absence of fire affects stem structure.

To understand how fire affects the vegetative reproduction of *H. acida*, 10 1-m^2 plots will be established in 5 areas prior to burning. The same areas will be measured three months after being burned. Cover and number of stems of *H. acida* will be recorded. Post burn, the diameter and height of living stems will be additionally recorded. This will detail the effects of fire on the mortality of young stems.

Implementation of the fire plan

Once the role of fire is understood in PBNP based on the available data, decisions on how to use those datasets will be required.

Preliminary results and observations suggest that fire is a necessary requirement for maintaining the flora and fauna of the park's forest-savanna mosaic. However, determining how and where fire should be used is another issue. It may be useful to consult with approaches used in South African parks, such as the South African National Parks Conservation Management Policy for fire management of wild fires (2004), some of whose concerns are addressed below.

Primary Considerations

Zonation

Should the park be zoned into areas which require different or no fire application? In PBNP, there are several concurrent activities that might require different approaches.

Gorilla habitat: PPG will need to advise on the needs of the gorilla groups and whether fire is needed or fire breaks to remove fire threat from the forest edge.

Anti-poaching efforts: The anti-poaching team will need to advise on whether it is best to burn in areas currently burned by hunters. Fire reporting by Firemapper and direct observation by team members currently serves as a warning of hunter position within the park. If the park starts burning these areas, then this warning system will no longer be effective.

Research areas: It may be advisable to leave certain areas unburned for research and management reference. This approach is used in Lope where certain enclosed savannas are left unburned or are only burned every 2 or every 3 years. If data is collected at the beginning of the fire plan implementation, then subsequent monitoring efforts will help determine the long term effects of various fire management practices in PBNP. Similar treatments have been successfully used in parks in southern and eastern Africa, and it may be desirable for PBNP.

Camps: Security fires are already lit around camps to avoid undesirable fires near outbuildings. As they currently are, these fires should remain a separate activity from planned fires for management.

Implementation

Fire teams can be very costly to manage, particularly if costly approaches are used. Given the budget constraints of PBNP, implementation will have to be low-cost.

Delineation: areas to be burned will need to be separated from areas to be left unburned or burned later. Many parks employ the use of fire breaks. If these are to be used in PBNP, they will need to be placed in areas where forests or bosquets are well positioned (ie. close together) to eliminate the need for several kilometres of fire breaks. Areas might also be delineated by creating backburn areas with controlled small fires.

Timing and frequency: these two questions, in addition to those outlined above, are still being investigated. The implementation of a fire plan is not a stagnant process. In deed, many parks over time, change their approaches to burning, often resulting in radical changes to habitat, as seen in the South African literature. PBNP will have to carefully consider its management objectives and staff limitations before deciding on timing and frequency, but acknowledge that management with fire will most likely evolve.

Staffing: only one Gabonese national park, Lope, has developed a fire plan with the goal of maintaining the savanna and forage habitat for its buffalo populations (Lope 2005). However, the implementation of this particular fire plan requires the help of numerous Eaux et Foret Brigade and WCS staff to create extensive firebreaks. These breaks create burn units which are serially burned from July – August every year. Several savannas are left unburned as a control measure. This approach requires a lot of manpower and in consideration of low-budgets for most parks it is advisable to consider alternative methods to burn savannas.

One possibility is to use local manpower and local techniques. Techniques employed by Batéké hunters and gathers to control fires have historically been reported and have been recently observed in practice by villagers controlling security and grasshoppers fires near the village of Ekouyi-Mboma. During the current fire research stage, local techniques for lighting and controlling fires will be investigated as a possible application. A separate budget will be sought for the testing of these techniques.

Monitoring: Once techniques are tested, a monitoring system should be put into place to ensure that the management objectives are being achieved. In most cases, this can be done by placing vegetation plots prior to the first burns and then at regular intervals thereafter (5 year re-measures, for example). Secondly, monitoring for effects on birds and mammals should be put into place. However, this will require consulting with other specialists.

This whole process will require several steps, integration of view points, observations, and research. It will most likely take several years to “get it right”. Hopefully, we can all work together to understand and apply fire for management in PBNP.

Timeline

Activity	**Time Frame**	**Notes**
Vegetation Surveys	ongoing-March 2008	
Social surveys	Finish September 2008	To be followed up by recorded interviews with informants
Bird Surveys	June and November 2008	

Fire information synthesis meeting	January 2008?	With all stakeholders and contributors
Fire Techniques Investigation	2008	Funding pending
Monitoring	2008-2009	Funding pending

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