Research Article

Indigenous Fire Use to Manage Savanna Landscapes in Southern Mozambique

L. Jen Shaffer

Department of Anthropology, University of Georgia
250A Baldwin Hall, Jackson Street, Athens, Georgia 30605-1619, USA

Tel.: 001-706-340-7455; e-mail: jinverde@gmail.com

ABSTRACT

Prescribed burn regimes for protected areas in southern Africa are often based solely on modeling of historic data and onsite experimentation. Most rural communities in this region continue to rely on fire to manage natural resources for subsistence needs, yet relatively few detailed studies of local fire knowledge and practices exist. The long history of anthropogenic fire in southern Africa suggests that traditional ecological knowledge (TEK) of fire could provide further insight into location-specific anthropogenic contributions to fire-savanna interactions. This study used an ethnographic approach to investigate how local people think about and manage fire as part of their daily activities in two rural communities in southern Mozambique. Residents use fire for a range of livelihood activities and identify both controlled and uncontrolled anthropogenic fire sources. Fire regimes are presented for five common livelihood activities including frequency, seasonality, area, and type of habitat burned. Comparisons between historic and contemporary fires revealed decreases in the number of controlled burns and consequent increases in the size and number of wildfires, but no changes in the purposes for conducting controlled burns or the methods people used to conduct burns. Community fire regulations aim to reduce personal and communal property destruction, as well as protect locally valuable biodiversity. The results highlight the importance in accessing indigenous fire TEK for understanding anthropogenic contributions to fire regimes. Furthermore, they demonstrate that despite different worldviews, indigenous and western fire experts share a common goal in maintaining regional biodiversity.

Keywords: anthropogenic burns, controlled burns, fire regimes, livelihoods, Maputaland, southern Africa, traditional ecological knowledge

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INTRODUCTION

Fires originating from lightning strikes and anthropogenic sources are a driving ecological force maintaining savanna ecosystems worldwide (Bond *et al.* 2005, Shorrocks 2007). Anthropogenic fires were critical in shaping the vegetation diversity, abundance, and distribution of southern African savannas over the last 1.5 million years (Hall 1984, Brain and Sillen 1988, Bond *et al.* 2005). These fires extended savanna into areas beyond those created by

lightning-caused fires. Today, most rural southern African communities continue to use fire to manage natural resources necessary for daily livelihood activities such as burning pasture to remove brush and improve forage, controlling pests, clearing cropland, and reducing wildfire threats (Kepe and Scoones 1999, Kull 2002, Kepe 2005, Sheuyange *et al.* 2005). Nevertheless, fire regimes developed to conserve and manage southern African savannas in protected areas are primarily based on natural, experimental, or archaeological evidence (Hall 1984; Roques *et al.* 2001; van Wilgen *et al.* 2003, 2004; Govander *et al.* 2006), largely ignoring traditional ecological knowledge of fire use and management (fire TEK) in contemporary rural communities. Incorporating fire TEK would improve our knowledge of savanna fire ecology and landscape management practice as this knowledge contains information about local adaptive fire management, recent human contributions to landscape pattern and process, and low-cost wildfire control practices for populated areas that also benefit livelihood activities. The resulting combined fire knowledge could support current community economies and conservation efforts.

Problems of ideological translation between worldviews have long generated resistance to incorporating local fire TEK into western scientific management of savannas in Africa and elsewhere. In this study, I use an ethnographic approach to analyze fire TEK in two rural communities located on the coastal savanna of southern Mozambique to clarify how, when, and why they use fire in their daily livelihood activities and to show how these activities contribute to the fire processes in this region. I address three issues particular to the development of appropriate fire regimes and management policies for the coastal savanna of southern Mozambique and northern KwaZulu-Natal, South Africa: 1) anthropogenic fire intentionality, 2) community fire knowledge-based practice, and 3) fire regulation at local and national levels. My results highlight the knowledge that can be gained by working with local communities for improving landscape management for both biodiversity conservation and livelihood practice, and demonstrate that residents use fire in a purposeful, controlled manner.

Integrating Knowledge and Improving Practice

Fire policies during the twentieth century enacted by protected area managers and national legislators throughout southern Africa varied spatially and temporally. Strict no-burn policies were actively promoted in Bantustans and other areas settled by indigenous and impoverished peoples, while policy for commercial agricultural and timber operations and protected areas paralleled developments in ecological knowledge, which ranged from no-burn policies in the first half of the century to prescribed burns and lightning strike regimes in the latter half (van Wilgen *et al.* 2000, Kepe 2005). The curtailing of anthropogenic fire because of misunderstandings surrounding pattern and process in the savanna landscape, a need to protect more economically important timber supplies, and a desire to control indigenous activity changed the fire regime (Kull 2002, Kepe 2005, Eriksen 2007). Over time, the last century's policies led to a loss of habitat patchiness and species diversity, a build-up of fuel, and a proliferation of invasive species (Bruton *et al.* 1980; Roques *et al.* 2007; R. Taylor, Ezemvelo KZN Wildlife, personal communication). To address problems created in protected areas, scientists and managers working in places like Kruger National Park, Greater St. Lucia Wetlands National Park, and Reserva Especial de Maputo (REM) want to establish fire regimes that mimic those used historically by people occupying those areas (Bond and Archibald 2003; van Wilgen *et al.* 2004; Govender *et al.* 2006; R. Taylor, personal communication).

Determining appropriate fire regimes for southern African savannas is difficult. Each

savanna region has slightly different climate and vegetation parameters and history of use, thus the optimal timing, frequency, intensity, and extent of fire needed to maintain the preferred environmental conditions varies (Whelan 1995). Fire helps native species thrive by opening up thickets and forest, maintaining open savanna, and reducing or removing invasive species. Both protected area managers and indigenous subsistence livelihood practitioners desire the increased biodiversity accompanying the habitat patchiness created by fires. Increased biodiversity signifies a wider range of potential foods, medicines, construction material, and herd forage to subsistence harvesters, while protected area managers see possibilities for population growth of native species. Experimental burn regimes, archival data analysis, and computer modeling provide details about biological and physical factors influencing fire ecology, but fire in southern Africa has a social component too. Humans use fire as part of household economic activities. Ethnographic information about how, when, and why people have used fire in a particular place, as well as their observations and memories surrounding historic fire events, can reveal specifics about climate, vegetation, and historic parameters for a particular savanna region. However, available records of human fire use may be fragmentary or biased against indigenous groups (Bowman 1998, R. Taylor, personal communication).

Traditional ecological knowledge studies of fire in other parts of Africa and the world suggest a promising approach that would allow ecological researchers to access historic data and develop location specific understandings of human contributions to fire-savanna interactions. Researchers working with Namibian herders combined herder knowledge and western scientific data about vegetation-fire interactions to produce a better model of the effects of anthropogenic fire on vegetation associations and responses at multiple scales (Sheuyange *et al.* 2005). Laris' (2002) interviews with Malian farmers about fire practices yielded a description of an annual burning regime wherein different habitats were seasonally targeted to manage the savanna landscape for hunting and agricultural production. This description of an annual burning regime elegantly explained the patchy mosaic of regional vegetation patterns observed in current and historic satellite imagery (Laris 2002). Historic ethnographic materials suggest that Aborigines skillfully manipulated the Australian landscape seasonally with fire to maximize their foraging efforts, and used their TEK to predict fire behavior and control the spatial extent of burns (Bowman 1998). More recent research in northern Australia found that continuous occupation and use of traditional fire practices by Aboriginal residents maintained the ecological integrity of their estate. Within Aboriginal managed lands, regular burns reduced wildfire risks, maintained flora and fauna diversity, removed invasive plants, and produced a patchy mosaic of habitat (Yibarbuk *et al.* 2001). Similarly, Krahô fire management practices within protected areas of Brazil's cerrado savanna created a patchy mosaic of diverse vegetation and reduced and prevented the spread of wildfire (Mistry *et al.* 2005).

Many livelihood activities practiced in southern Africa involve fire. The effects of these fires on the savanna landscape range from minimal to extensive, and target specific habitats depending on the season. Small fires used to cook, smelt iron, harden pottery, and gather honey have minimal effects on the landscape unless they get out of control. Controlled burns are used to hunt, clear land for crops, deter wildlife from eating crops or livestock, and encourage the growth of new livestock forage or preferred wild foods. These practices target specific habitats and generally burn a few hectares or less (Bruton *et al.* 1980, Kepe and Scoones 1999, Kull 2002, Laris 2002, Sheuyange *et al.* 2005). However, if such controlled burns are left unmanaged, they can affect tens to hundreds of hectares and de-

stroy the natural resources that a community depends upon for food, medicine, and construction materials. In order to minimize undesirable effects of fire in the landscape, communities have developed knowledge, practices, and beliefs for regulating fire size, timing, and frequency. This knowledge-practice-belief complex, or TEK, is based on long-term, cumulative observations and interactions with the surrounding landscape through the course of daily activities (Berkes 1999, Berkes *et al.* 2000). Consequently, community fire TEK should provide insight into anthropogenic contributions to a region's fire regime even if local practices altered slightly over time in response to larger political and environmental events.

Critics of using TEK for conservation purposes often are concerned about the validity of local knowledge derived from stories, songs, artwork, and religious practices and its translation into information useful to scientists and protected area managers (Berkes 1999). Furthermore, as Kaschula *et al.* (2005) observed in their research on rural fuelwood harvest, TEK and community-based resource management practices do not easily fit into categories designated and deemed important by western science. Validity assessments based on a western science rubric may gloss over important subtleties in local knowledge and practice or completely miss other aspects such as intentionality. Misconceptions about local TEK and practice intentionality feed into conflicts over TEK use stemming from power struggles between western science and traditional science practitioners. "Western experts and aboriginal experts… have different political agendas and… relate in different ways to the resource in question" (Berkes 1999: 11). Berkes (1999) references an ongoing argument between those who want to preserve nature apart from human use in protected parks and reserves and those who restrict personal use of a natural resource in order to ensure its future use in their home territories. Unfortunately, this division influences how government and non-governmental organizations interact with local communities and results in policies that prevent residents from accessing necessary resources. Socioeconomic and TEK studies of anthropogenic fire in contemporary indigenous African, Australian, and South American communities highlight the use of controlled burns to expand or maintain subsistence livelihood activities and resources, and reduce wildfires (Kepe and Scoones 1999, Yibarbuk *et al*. 2001, Kull 2002, Laris 2002, Kepe 2005, Mistry *et al*. 2005, Sheuyange *et al.* 2005). This intentionality of purpose suggests that despite their different worldviews, indigenous and western fire experts share a common goal in maintaining and fostering biodiversity.

METHODS

Landscape and Culture in Matutúine District

Matutúine District, the study location, is part of Maputo Province and the southernmost district in Mozambique (Figure 1). The 5403 km^2 district begins south of Maputo Bay and is bordered by the Indian Ocean to the east, Swaziland to the west, and KwaZulu-Natal, South Africa, to the south. A mosaic of grassland, wetland, woodland and thicket, swamp forest, and rare sand forest covers the sand dunes comprising Matutúine District's landscape. Freshwater and brackish lakes, along with the Maputo and Futí rivers, also contribute to ecosystem diversity and provide permanent water sources for human and non-human communities alike. This wide range of habitats contributes to the high diversity of flora and fauna found in the district. In fact, Matutúine District sits at the heart of the Maputaland Centre of Endemism, a 17 000 km^2 region containing 2500+ plant species including 225 endemic or near-endemic species and three endemic plant genera, 100 species of mammals, and 470 bird species including four species and 43 subspecies that are endemic or near endemic (van Wyk 1994, Smith *et al.* 2008). Several Mo-

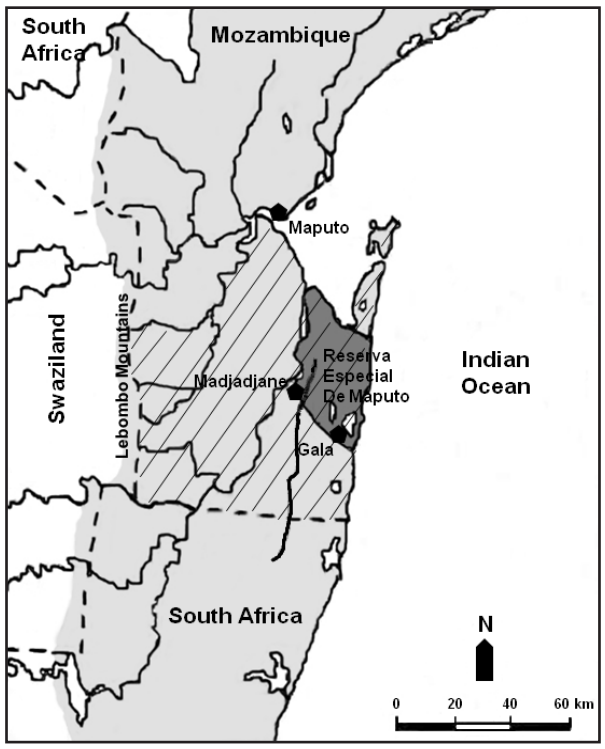

Figure 1. Map of Matutúine District, Mozambique. Hatching indicates district boundaries within Mozambique. Light grey signifies the Maputaland Centre of Endemism and the dark grey is the Reserva Especial de Maputo. Madjadjane and Gala are indicated with black pentagons.

zambican and South African parks and reserves exist in this region to protect biodiversity in the Maputaland Centre, including REM's 800 km^2 in Matutúine District (Tello 1972).

I worked with residents of Madjadjane and Gala, two rural communities adjacent to REM. Madjadjane's 331 residents reside in an area approximately 9 km^2, while Gala's 114 residents live over an area of 26 km^2. Approximately 90% of residents consider themselves to be Mazingiri Ronga. Ronga occupation of Matutúine District and northern KwaZulu-Natal dates back at least 500 years based on evidence from oral histories, archived documents, and archaeological materials (Junod 1927, Bruton *et al.* 1980). In order of descending percentages, smaller numbers of people identify themselves as Changaan, Zulu, Matsua, Makua, Portuguese, and Ndau. With the exception of the Portuguese who lived in this region prior to the 1960s, most non-Mazingiri arrived during the 1960s and 1970s for work, married local women, and adopted local customs.

Only 19 km separate Madjadjane and Gala, but the communities encompass a range of habitats available to district residents for resource exploitation. Riverine woodlands, open woodland, and sand thicket and forest give Madjadjane, stretched along the Futí River, a predominantly woodland landscape. The predominantly grassland landscape of Gala incorporates open and wooded savanna, hygrophilous grassland, sand forest-woodland mosaic, patches of swamp forest, and the shores of lakes Piti and Ntiti (de Boer 2000). A combination of swidden agriculture and foraging form the basis of the local economy. Livelihood activities like fishing, goat and cattle herding, mat and charcoal production, beekeeping, reserve work, and tourism supplement household resources and generate income. Intergenerational transmission of ecological and cultural knowledge remains strong despite large population losses in these communities during the Civil War (1986-1992) because survival depends upon accessing a wide range of wild and domesticated resources through their mixed subsistence-based economy.

Controlled burns are a part of many local livelihood activities. Historic descriptions indicate that many of the activities that residents currently practice have not changed significantly in the past century (Junod 1927). Furthermore, a 1575 map identifying a region encompassing Matutúine District and northern KwaZulu-Natal as Terra dos Fumos, the land of smokes, provides possible support for historic use of fire by Ronga in daily activities in this area. It is postulated that Portuguese explorer Manuel de Mesquita Perestrello named it so because of the endless grass fires lit by locals (Bruton *et al.* 1980). The evidence for long-term residence, maintenance of local TEK, comparative descriptions of subsistence activities, and the required use of fire for such

activities suggests that current Ronga fire TEK can provide information about anthropogenic contributions to fire regimes in this region.

Climate and weather significantly affect the timing and location of burns conducted by local communities as part of their regular livelihood activities. General climate patterns divide the year into a hot, rainy summer lasting from October to April, and a cooler, drier winter from May to September. Seasonal conditions depend primarily on the start and end of the rains, so timing of seasons may vary slightly from year to year. In general, rain falls heaviest along the coast (~1000 mm) and on the eastern slopes of the Lebombo Mountains (~800 mm). Precipitation decreases on the savanna plains, located midway between the coast and the mountains, to a minimum of approximately 600 mm annually (Tello 1972). Despite the variation in precipitation, temperature and relative humidity remain roughly constant. Temperatures average 24 °C during summer and 20 °C during winter. Mean relative humidity percentages range in the middle to low 70s year round (Tello 1972). Lightning strikes reach a maximum at the onset of summer rains and a minimum during the winter (Lopes 1973). Most winds blow roughly parallel (N-S) to the coast. Southerly winds predominate and carry high humidity. In some years, a prevailing southeastern wind brings greater than expected rain and humidity. Northerlies, while rare, generate and precede very dry conditions. Tello (1973) reports that they can lower relative humidity by 10 % to 15 %.

This research was part of a dissertation project investigating how local culture and livelihood practices in southern Mozambique contribute to the region's coastal savanna landscape pattern and process. Observations made during two field seasons—May to July 2004 and July 2007 to April 2008—initiated a series of fire interviews and later deepened the understanding of informant explanations. I first held extensive conversations about local fire TEK with three male informants in Gala and Madjadjane. Women also have fire knowledge and conduct burns, particularly when clearing agricultural fields. However, because several male and female residents told me that traditionally fires are lit and managed by men, I conducted these initial conversations solely with men. My youngest informant, aged 21, was my field assistant who had grown up in Madjadjane. We frequently talked about community practices and he directed me to speak with two more knowledgeable men—a reserve guard and Madjadjane resident (45 years old) and an elder from Gala (71 years old)—when my questions went beyond the scope of his knowledge. My conversations with these men centered on timing and location of controlled burns, local practices for controlling burns, the frequency of uncontrolled burns, changes to burn practices over time, and local regulation.

The topic of fire came up during semi-structured interviews with livelihood activity specialists that I conducted as part of my larger dissertation project. Men and women, ages 18 to 79, were interviewed about their work as farmers, fishers, cattle herders, homebuilders, thatchers, beekeepers, wild plant harvesters, wine makers, charcoal producers, artisans, and reserve guards. I chose these activity specialists based on recommendations made by residents during an initial community-wide household economic survey and chain referral by other specialists. Of the 33 specialists interviewed, 18 mentioned that they used fire as part of their practice. I asked these men and women additional questions concerning how, when, and why they used fire.

Semi-structured oral histories with 13 community elders, including 2 interviews with the regulos (chiefs) of Madjadjane and Gala, also provided fire practice information. I specifically asked male and female informants (ages 55 to 100) about why, when, and how people burned areas in the past; about community fire regulations; and about changes to fire regimes in the region over the courses of their lifetimes.

Throughout this study, I employed a grounded theory approach to systematically analyze my interview texts and field observation notes (Corbin and Strauss 1990). Unlike other methods that analyze text data at the end of a research project, a grounded theory approach allows key concepts and their relationships to emerge during data collection through ongoing coding and memoing analysis techniques (Birk *et al*. 2008, Morse *et al*. 2009). Each interview and observation, beginning with the first, builds on previous work, letting the interviewer create a holistic view of the process or event being studied as the work is carried out. Topical themes and local fire TEK concepts drawn from the initial conversations guided my later text analysis of the semi-structured interviews with livelihood activity specialists and oral historians. I used interview responses, combined with field observations, to identify intentionality and the five most common livelihood activities involving fire. Informants implied intentionality linguistically during interviews because certain activities require the use of controlled burns and community members all know this. For example, "cleaning a field" includes removing brush with fire as well as turning soil, while "preparing pasture" requires burning off moribund grass to improve cattle forage. Common is defined here as widely practiced in communities in this region either currently or historically. Explanations in the results section focus on knowledge and practices associated with these five common activities, as well as local fire regulations. Text analysis of field observation notes helped triangulate controlled burn seasonality, fire management practices, and location.

RESULTS

Fire sources and intentionality, community fire TEK, and fire regulation emerged as key topical themes during my initial conversations and observations of wildfires and deliberate burns. Given fire's important role in local livelihood activities, as well as strict regulation at the local and national levels to limit uncontrolled fires, I pursued these themes in later interviews and observations. I also used these topical themes to frame and organize my results. Information surrounding these themes is necessary, in addition to experimental burns, computer models and historic data, to demonstrate to protected area managers the contributions of contemporary human communities using controlled anthropogenic fire to landscape pattern and process.

Fire Sources, Intentionality, and Use

The debate surrounding fire use and control centers on intentionality; therefore, I first asked local residents to identify fire sources, whether a fire is considered controlled or uncontrolled, and intentionality (Table 1). Informants used the terms fire and uncontrolled burn to describe wildfires or uncontrolled burns that can occur anywhere at any time. Uncontrolled burns are unintentional or deliberately set. Unintentional, uncontrolled fire sources listed by informants include cigarettes, children, and lightning. Locals and visitors to REM start such fires by tossing burning cigarette butts into dry grass and brush. Children also accidentally start fires when playing with matches. One elder specifically mentioned that ready access to matches today makes it easier for children to play with fire. Lastly, residents noted that lightning strikes are a rare source of wildfire in this region. Archived records and personal observations support their remarks (Lopes 1973).

Deliberately set, uncontrolled fires are rare. Children sometimes mimic parents and build small charcoal mounds to practice charcoal production. Without adult supervision, the children's charcoal mounds may be placed in inappropriate locations containing dry vegetation that could catch fire and spread out of control. Rarely, individuals who are "not right in the head" burn down neighbors' homes delib-

Table 1. Fire sources in Madjadjane and Gala.

Fire Source	Controlled	Uncontrolled	Intentional
Anthropogenic:			
Cigarette butts		X	
Children playing with matches		X	
Children mimicking charcoal production		X	yes
Arson		X	yes
Reducing wildlife conflict in agricultural fields	X		yes
Snake removal	X		yes
Clearing area for homestead	X		yes
Removal of thatching trash	X		yes
Charcoal production	X		yes
Cooking	X	X (poaching)	yes
Cleaning agricultural fields	X		yes
Preparing and improving pasture	X		yes
Apiculture	X (mod/trad)	X (trad)	yes
Hunting and poaching	X	X (poaching)	yes
Sura production	X		yes
Natural:			
Lightning		X	

erately. While the arsonist targets a specific home, they make no effort to control the fire otherwise.

Intentionally set, controlled burns, used for many food production and construction activities, can cause wildfires if not carefully tended. Fire plays a role in reducing wildlife conflict. Fires are used to drive off animals like hippopotamuses (*Hippopotamus amphibious* L.) and bush pigs (*Potamochoerus larvatus* F. Cuvier) that eat sprouting crops. Later, as crops near harvest, farmers light bonfires along field perimeters to scare off the elephants (*Loxodonta africana* Blumenbach), monkeys (*Cercopithicus aethiops* L., *C. mitis* Wolf), and bush pigs that raid these fields at night.

The elephants come during the canhu season to eat the canhu [*Sclerocarya birrea* (A. Rich.) Hochst.] *growing in my field. They also eat all the other crops—sugar cane, maize… all. The elephants come at night. During the day they stay in Magale Forest* [a sacred forest inside REM]. *To get rid of the elephants, I make big fires and keep dogs. Elephants don't like the barking or the bonfires.* [Farmer, Gala]

Bonfires require tending throughout the night, so this practice is primarily observed in places with high elephant traffic, in cash crop fields, and where fields surround homes. During June 2004, I observed Gala residents burning grassy areas near their homes and fields to drive off and kill poisonous snakes such as the black mamba (*Dendroaspis polylepis* Günther). At construction sites, builders use controlled burns to clear spaces for new homesteads and community buildings like churches and schools. Thatchers build smaller bonfires

in these clearings to get rid of the seeds and stems combed out of grass as it is prepared for thatching. Charcoal makers normally place their mounds in open areas with no tree canopy and where the grass has been removed. This reduces the possibility of fires inside the mounds from getting out of control and helps to keep the high temperatures generated inside the mound from causing spontaneous combustion. Households in Madjadjane and Gala still cook in shallow fire pits hollowed into the sandy soil and sheltered from strong breezes.

Informants spoke of fire primarily in conjunction with common livelihood activities that field observations demonstrated as central to Ronga culture and community survival (Table 2). Residents gave cleaning agricultural fields for crop production as the primary reason for lighting controlled burns currently and historically. Farmers burn fields twice per year in order to remove grass and shrubs. At the start of summer, in October and November, farmers burn areas in woodlands and savannas near their homes to clear plots for crops like maize, peanuts, squash, beans, and manioc. The timing of the burn depends on previous rains. Farmers burn and plant in October if there have been "good rains." Otherwise, they wait until November. If an individual plans to use that same area in the following year for crop production, a second burning occurs towards the end of the hot, rainy season in Feb-

Table 2. Five common types of controlled anthropogenic burns. Summers, October through April, are hot and rainy, while winter, May through September, is cooler and drier.

Reason for burn	Habitat burned	Frequency	Seasonality	Patch size burned
Cleaning winter fields	Wetland along river and lake shores	Once, when cleared originally	Apr. – May	>0.5 ha to 5.0 ha
Cleaning summer fields	Open woodland, woodland	Every 4-5 years	Oct. – Nov. Fallows burned in Feb. prior to Oct. cleaning	>0.5 ha to 5.0 ha
Preparing and improving pasture	Open savanna (Gala) Wooded savanna (Madjadjane)	Every other year Every 2-3 years	February	>5.0 ha
Apiculture	Open woodland, woodland, closed forest Eucalyptus stands (plantation)	Annual	Nov. – Dec. June – July	Individual colonies
Hunting	Open savanna, wooded savanna, open woodland	Varies with need, poaching activities affect frequency	Grazing lawns likely burned in Feb. to improve forage Burning for snare lines might occur anytime Poaching activities have no seasonality	Depends on purpose
Sura production	Wooded savanna, open woodland	Annual	Anytime during the year	Individual stands of *Phoenix reclinata*

ruary or March to keep down the growth of woody plants in fallowed fields. April and May burns, also at the end of the hot, rainy season, prepare wet fields at swamp forest edges and along the river and lakeshores for sugar cane, banana, sweet potato, and vegetables grown during the drier winter season. Generally, these areas are cleared once and then used continuously. People rarely burn agricultural fields smaller than 0.5 ha, and instead clean these fields by hand.

Madjadjane and Gala residents grazed cattle communally in open savanna, wooded savanna, and open woodland areas prior to Mozambique's Civil War. "In the past, we burned to grow new grass in the pasture" [REM Guard A, Madjadjane]. Burning pasture removes moribund grass and encourages the growth of new forage. A Gala man, who herded cattle as a boy, spoke of burning half the pasture area one year, and burning the other half the next year to make the grass grow better. After the burn, grazing was banned for a year to let the area rest. He said that these burns occurred at mid-summer, in February, when the "grass was not big, so the fire could not spread far." Another former herder from Madjadjane described burning wooded savanna patches every two to three years to improve forage when she was a girl, more than 70 years ago. Burn practices to improve pasture changed following the Civil War. Herds that had been lost were not replaced and the need to burn was reduced. In addition, the national law now forbids burning. At present, cattle owners rely on frequent herd movement and wildfires to provide good forage. The few cattle owners I spoke to emphasized that burning was illegal, and I did not observe any intentional pasture burns.

Many residents mentioned using fire in conjunction with biannual honey and comb harvests. In the wet, early summer months of November and December, apiculturists visit hives in closed forest, woodland, and open woodland to harvest wild hives and bee boxes. Non-native eucalyptus trees produce a lot of pollen during the dry months of June and July when many native plants are not flowering. Wild honey is collected at this time in eucalyptus plantation stands and from boxed colonies located within 1 km of these stands. Traditional honey and comb collectors light a dry branch or bundle of grass, direct the smoke and fire at the hive to calm and kill bees, and usually take care to put out the fire before leaving the area. However, the combination of drought, dry vegetation, and tree resin makes eucalyptus stands particularly vulnerable to fire.

Wild bees can be very aggressive. The smoke may calm the bees but then as the person collects the honey the bees become aggressive again. The collector tosses the smoker [burning branch or bundled grass], *grabs as much honey as possible, and runs. If the smoker hits a dry patch of grass or brush, this may ignite and start a wildfire.* [REM Warden, Madjadjane]

One traditional collector uses a cigar to smoke bees because he is unlikely to drop the cigar from his mouth and accidentally ignite vegetation. Use of modern apicultural equipment, like fumigators and bee boxes, has significantly reduced the potential for wildfires in Madjadjane. Gala residents planned a group honey collection outing using traditional methods to a sacred forest area in late November 2007. The residents went as a group to watch out for the elephants that live within the forest. However, both the timing and group collection reduce the chances of wildfire ignition. The summer rains had already started, and more people were around to watch for sparks and help put out fires when a smoker was dropped.

Controlled fires are used for hunting and poaching in open savanna, wooded savanna, and open woodland habitats. However, few residents will admit to hunting and even fewer to using fire to hunt. Several elders explained that historically hunters used fire to drive game towards snare lines and to create grazing

lawns. Good forage on a grazing lawn draws wildlife and the removal of tall grass makes it easier for hunters to spot prey. The REM staff says that poachers continue to use these techniques. Most poachers in this area are young men from larger towns in Matutúine District and Maputo who have few or no ties to the local community where poaching occurs. As a result, they have little incentive to control the spread of fires into nearby communities like Madjadjane and Gala or to habitats that act as reservoirs for wildlife populations. Poachers may also start wildfires when cooking game in the bush. If reserve guards show up to arrest poachers and the men flee before dousing their cookfire, a wind might cause the fire to ignite surrounding dry brush and grass. As hunting and poaching occur year round, fires associated with these activities can be set at various times throughout the year.

Sura, or palm wine, makers harvest and ferment sap from kindu (*Phoenix reclinata* Jacq.) to make wine year round. The plant's spiny lower branches and dead material are burned off to make tapping the main stem easier. Plant material could be cut and removed by hand, but the large spines on the lower branches make this process difficult. Field observations demonstrated that burning does not kill the plant and actually stimulates new growth. Kindu grows in stands in open woodland near water and on slightly elevated sites in wooded savanna. After three to four months of use, the palms are left to regrow before the burn and harvest cycle begins again. Lala palm (*Hyphaene coriacea* Gaertn.) is harvested extensively for sura farther south, but not in Madjadjane or Gala.

Ronga Fire Knowledge and Practice

Temperature and precipitation are regionally important for determining the timing of controlled burns. Residents of Madjadjane and Gala consider daily and seasonal variation in these climatic factors when planning burns, and personal preferences reflect different experiences and habitats where burns take place. "Hot days are good for burning and also help dry out the grass so that it is ready to burn [Farmer, Madjadjane]." A Gala elder said, "it is better to burn in the early morning or very late afternoon as the cooler temperatures make the fire less intense." High temperatures dry out grass, which increases fuel load. Burn intensity, defined as the rate of heat release, increases as fuel loads grow larger (Whelan 1995). With cooler temperatures, grasses and woody vegetation retain moisture, the rate of heat release is less, and flame heights stay low, thereby giving people greater control over the burn.

The timing of fires also depends on precipitation. Residents say that, when it rains, starting fires is impossible because the "grass is green." Rain increases fuel moisture content, which decreases the likelihood of ignition, the combustion rate, and how fast the fire will spread (Whelan 1995). To increase controllability, local residents prefer to burn agricultural fields just prior to the start of the summer rains and again at the very end of that season. Historic burns of pastures in February, in the middle of the rainy season, would also have allowed for greater control of burns on large areas.

Residents harvest large woody vegetation for cooking fuel and, in Madjadjane, for charcoal production prior to burns. Smaller woody plants, and sometimes grass, are cut and piled on the future burn site. These practices contribute to greater fire control. People then create a firebreak around the area to be burned by either excavating a ring ditch 2.0 m to 2.5 m deep by 1.0 m to 2.0 m wide, or by cutting grass down to the soil in a band 0.5 m to 3.0 m wide. Field observations and interview comments indicate that creating a firebreak by cutting grass is the most common method used. The cleared band "keeps the fire from jumping and getting out of control" [REM Guard B, Madjadjane]. The grass is cut down to bare

soil using a machete or hoe, and roots are removed if they are at the surface. In addition to ringing the burn area, people make firebreaks around important medicinal and fruit trees growing in the middle of the burn site. Lower branches may brown from the heat and flames, but the trees survive.

On the day of the burn, the community member or members managing the fire checks wind strength and direction to determine ignition point placement. Personal preference and experience play a role in this placement. Some said that they prefer building controlled fires on days with light breezes, as stronger winds can blow the fire out of control. These farmers rely on the breezes to spread their headfire ignitions. More cautious and experienced fire managers "start their fires against the wind so that the fire doesn't have much force and can be controlled" [REM Guard B, Madjadjane]. This backfire ignition practice allows people to use controlled burns in periods of stronger winds, such as during winter. Burn site size determines the use of a single ignition point or a series of ignition points.

The number of people conducting a controlled burn depends on the fire's size, the purpose of the burn, and the experience of those involved. Most respondents indicated that they burned agricultural fields alone or with the help of a family member. Children frequently assist their parents to learn proper burn practices and to help tend the fire to prevent it from spreading outside the designated area. One Madjadjane woman said that friends with adjacent fields often burn the entire area together to save on effort and reduce the risk of wildfire. Community groups will form when very large areas need to be burnt. During October 2007**,** a group of five men burned a site of approximately 1 ha of thicket and open woodland that would later be used by the entire Madjadjane community for summer crops. These men lived adjacent to the site and thus had a vested interest in controlling the fire. Cattle pastures are communal areas, and historically herders worked together to burn them. The nature and questionable legality of hunting in Matutúine District makes obtaining specific details about hunting practices difficult. However, it is likely that groups of hunters burned areas together to drive wildlife into snare barriers. Given that individuals burn fields regularly, a single man could create a small grazing lawn for wildlife on his own. Sura makers and honey collectors work alone and only very small areas are exposed to fire.

Community elders say that people have not changed the reasons that they burn in Madjadjane and Gala. Additionally, the techniques used to manage fire are the same as those used by their parents and grandparents. One elderly woman (~100 years old) informed me that she learned proper fire management by helping her parents and grandparents during their daily activities in the fields and around the homestead. In October 2007, her 16-year old great-grandson prepared the firebreak and then helped her burn a field in preparation for planting. The woman proudly stated that her great-grandson learned the proper way to do things by assisting his mother, grandmother, and great-grandmother.

Elders and older residents have observed an increase in the numbers and severity of wildfires, with a simultaneous reduction in controlled fires. They believe these changes began during the Civil War.

When the Civil War began, the community started to think differently. Many things changed. There has been a mobilization of the community not to make fires. Now it is also dry and because people don't make many fires they are bigger and stronger. [REM Guard B, Madjadjane]

During the war, fuel accumulated because residents stopped burning areas for livelihood practices. The fires drew military patrols to investigate and endangered personal safety. When the war ended in 1992, people resumed

their use of controlled burns but the combination of a smaller population, fewer cattle, and new policies meant fewer controlled burns of fields and pasture. National censuses in 1980 and 1997, a time period covering the Civil War, show that in Matutúine District the population decreased 38.9% from an initial count of 57 509 people (Gaspar 2002), so fewer people now burn for livelihood activities. Non-governmental organizations entering the region after the war to provide economic and development aid pushed no-burn policies as part of their assistance packages. Community rules changed to accommodate these new requirements and certain areas in Madjadjane and Gala became off limits to controlled burns. The simultaneous reduction in controlled burns and resulting increased fuel accumulation during the war and afterward, as well as drought, have likely contributed to the observed increase in numbers and severity of wildfires observed by residents.

Local and Regional Fire Regulation

Article 40 of the Mozambican National Forest and Wildlife Law criminalizes fires that destroy all or part of forests, bush, thicket, or savanna, and requires offenders to serve one year in prison and pay corresponding fines (Serra and Chicue 2005). This no-burn policy does not distinguish between wildfires and controlled burns. Limited manpower and transport make it difficult for Matutúine District administration and REM staff to enforce this law. As a result, residents of Matutúine District communities are not punished for using controlled burns to clear agricultural fields. Non-governmental organizations, like the International Union for Conservation of Nature (ICUN) and the Swiss development group Helvetas, have been more successful in encouraging a no-burn policy as part of their assistance packages. In Madjadjane and Gala, the IUCN and Helvetas are working with residents to build ecotourism lodges and develop a cottage industry for local products such as honey and woodcarvings. "People have been told burning is very bad. It destroys nature, the animals suffer" [REM guard B, Madjadjane]. Ironically, the economic success of such projects depends on maintaining local biodiversity, which ultimately requires frequent burning of the landscape (Roques *et al.* 2001, van Wilgen *et al.* 2003, Bond *et al.* 2005).

The traditional authority of local regulos and the induna, a council of male and female community members ages 55 to 70, remains the strongest form of community fire regulation. As explained by the regulos, controlled burning is prohibited in Gala and residents of Madjadjane may only use controlled burns to clear fields. Moreover, community rules in Madjadjane and Gala have always prohibited uncontrolled burns and all burns in sacred forests. Residents recognize that wildfires can quickly raze traditionally built homes of wood, cane, and thatch. Fires may also wipe out crops, kill livestock, and destroy trees and plants that provide medicines, fruits, and construction materials. Sacred forests contain the graves of the chiefly ancestors, rare medicinal plants, and the sites where the regulo and community elders go to enact community rituals such as rain ceremonies. Residents spoke of the destruction wrought by uncontrolled burns on par with poaching animals and trees inside community boundaries. Junod's (1927: 446). discussion of Thonga [Ronga] law highlights that theft "is universally condemned, not so much for its immoral character as for the fact that it renders a normal social life impossible." That residents speak of a wildfire's effects in similar terms underscores the ability of an uncontrolled burn to destroy a person's livelihood and community institutions.

All research informants acknowledged community prohibitions on controlled and uncontrolled fires. The regulos of Madjadjane and Gala stated that residents respect these local laws and the authority of the regulo and induna to punish offenders if the need arises.

A system exists to resolve conflicts when problems arise. Occasionally a firebreak fails during a controlled field burn and neighbors find themselves at odds over the accidental destruction of property. In this case, the neighbors attempt to resolve the issue together. If they cannot come to an agreement over payment to replace the lost property, they ask the regulo to mediate.

Legal action for offenders starting uncontrolled burns, which destroy large areas of savanna, woodland, and communal property, depends on whether the individual is a local resident or an outsider. Locals are formally arrested and brought before the regulo and induna for trial to determine their guilt. Gala's regulo stated that arresting the offender lets both the individual and community know that uncontrolled fires are dangerous, and that starting one is a serious offense against the entire community. Namzadores, community police elected from the induna membership, collect evidence for the trial and present the case to the regulo and induna. Offenders who are found guilty are required to beg for forgiveness from the entire community, as well as pay a fine to all whose property was damaged. This fine may be more than 1000 metacais ($1 USD = 23.9 metacais based on conversion rates for 3 September 2008)—a steep fine for those earning on average 30 to 57 metacais per day. Outsiders caught starting wildfires receive different treatment. Non-local offenders are arrested and brought to district police stations in Bela Vista or Zitundo, as the community has no jurisdiction.

DISCUSSION

Combining Knowledge to Manage Matutúine's Landscape

The scientific conflict over fire knowledge and practice between western and indigenous experts plays out in the landscape of Matutúine District. Intentions behind fire use are very different for local communities and protected area management. In Madjadjane and Gala, residents carefully manipulate the landscape with fire for immediate food production and to ensure a sustainable resource base for future harvest. Their environmental knowledge and beliefs about climate, vegetation, and fire behavior assist their decision-making as to where, when, and how to build controlled fires for the various livelihood activities that they practice. Community institutions and fire regulations resolve disputes that arise when the resources that people depend upon are destroyed by wildfires ignited by people ignoring commonsense fire practices, or in the rare case of arson. In contrast, REM managers have discussed using controlled fire to manipulate the savanna landscape to maintain and generate biological diversity for its own sake. However, no formal plans had been made and present policies at REM are geared towards protecting biodiversity via wildfire prevention.

Population contraction following the Civil War, pressures to move people out of current and planned protected areas, and policies regulating fire use have altered the relationship between Ronga and their ancestral lands in Mozambique over the past 25 years. Many areas that were once frequently burned during the course of livelihood activities now experience less frequent fire in the form of more extensive and damaging wildfires. Madjadjane and Gala are small communities, both in population and land area, but residents share a common history, culture, and environment with other communities in Matutúine District and the greater Maputaland Centre region. This shared history and culture includes development of an appropriate fire regime, based on local environmental knowledge, to burn the savanna landscape regularly for livelihood purposes. My research with Madjadjane and Gala residents assesses this Ronga fire and examines the contributions that TEK have made to the region's fire regime. The information about anthropogenic fire frequency, seasonality, and size and type

of area burned can be used by protected area managers in this region to develop burn regimes and set the burn targets needed to create a patchy mosaic of vegetation within protected areas.

Current no-burn policies promoted by the national government of Mozambique and non-governmental agencies fail to incorporate recent scientific findings about the importance of fire for savanna diversity maintenance, and reflect historic ideologies that viewed all native burn practices negatively. As a result, these policies stand in direct opposition to rural livelihood practices in Matutúine District. Rather than impose blanket no-burn legislation without examination of local conditions and practices, this study highlights areas where Mozambique's Department of Natural Area Conservation and REM staff can work with communities in Matutúine District to incorporate local adaptive management practices. Knowledgeable fire users in the community could also be hired to assist with controlled burns inside protected area boundaries. Drawing on TEK would also aid local economies in communities like Madjadjane and Gala by supporting the continuation of livelihood activities, as well as recognizing and building on local conservation initiatives.

Examining anthropogenic contributions to the Maputaland fire regime in Matutúine District, Mozambique, deepens scientific understanding of the connections between humans and the ecological processes and patterns of this region. The ethnographic description of Mazingiri Ronga fire TEK presented here demonstrates the extensive range of information that can be gained from asking local communities how, why, and where they use fire. This sort of information cannot be gained quickly through experimentation, historic records, or computer modeling. At a broad level, the data offer another example of the intentionality of fire use by rural African communities for food production. The data highlight the beliefs, practices, and regulations that many communities have to protect species and habitats, as well as personal and communal property, from destruction. Despite different worldviews, indigenous and western fire experts share a common goal in maintaining regional biodiversity. Finally, the detailed and holistic nature of Mazingiri Ronga fire TEK provides insight into Maputaland Centre ecology and suggests specific ways to improve national-level resource management plans. Over the long term, incorporation of this fire TEK into conservation planning will contribute to protection of Maputaland Centre biodiversity by maintaining, and re-establishing where necessary, locally appropriate fire regimes both inside and outside protected area boundaries.

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