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Traditional fire management: historical fire regimes and land use change in pastoral East Africa

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Abstract. Although there is considerable research on the ecological effects of fire in sub-Saharan Africa, research on traditional fire practices is very limited and the consequences of substantial changes to historical fire regimes have not been adequately explored. The present paper examines historic and contemporary uses of fire as a land management tool among Maasai pastoralists in northern Tanzania and explores the potential impacts of changing fire management and fire suppression on savanna vegetation. Village members were interviewed about historical and current practices, reasons for burning, the history of land use, and their perceptions of fire. Eight recent burn sites were selected for examination of size, ignition source, and timing of the burn. The Maasai identified eight major reasons for using fire on a landscape scale in savannas and historically used a progression of small fires throughout the dry season as grasses cured to create a fragmented burn pattern and to prevent large, catastrophic late-season fires. Currently, there is little active vegetation management using fire largely owing to federal fire suppression policies, unpredictable rainfall patterns, increasing population pressures, and a subsequent increase in the number of catastrophic accidental fires. Substantial modifications to historical fire regimes could have cascading consequences for savanna health by increasing late-season fuel loads and the occurrence of large, catastrophic fires.

Additional keywords: *Acacia–Commiphora* scrub, Maasai, semiarid savannas, Tanzania.

Introduction

Traditional management practices, such as burning, coppicing, weeding, irrigating, tilling, and rotational grazing, have been used for centuries to modify vegetation for the benefit of local communities. Many of the ecosystems once held as 'pristine' are now being recognized as highly anthropogenically modified environments (Denevan 1992; Alcorn 1995; Fairhead and Leach 1996). The development of fire as a vegetation management tool, for example, enabled people to systematically alter the natural environment on a long-term basis and a massive scale (Anderson 1999). Despite common public views of fire as a factor of degradation in many ecological systems and the formation of subsequent fire suppression policies in many countries, recent research on indigenous uses of fire in West African and Australian wooded savannas have suggested that seasonal burning not only prevents damaging late-season fires but increases plant biodiversity (Braithwaite 1996; Russell-Smith *et al*. 1997; Mbow *et al*. 2000; Laris 2002*b*).

Environmental degradation of savanna ecosystems is seen as one of the main factors leading to the increased vulnerability of African pastoral and agro-pastoral economies (Homewood and Rodgers 1991). Degradation of savanna ecosystems is a growing concern in countries such as Tanzania where tourism, particularly in savanna areas, is second only to agriculture as a gross domestic product. Savannas are arid to semiarid grasslands interspersed with a discontinuous woody overstorey of varying densities (Hudak 1999). They are inherently dynamic systems, with the ratio of woody plants to grasses determined by climate, soils, and fire and herbivore disturbance regimes (Van Langevelde *et al*. 2003). Grass fires occur in savannas because grass production in the wet season is followed by an extended dry season leading to a continuous cover of fuel and a ready source of ignitions (lightning and human) (Higgins *et al*. 2000). Today, African savannas burn more frequently and extensively than any other region on earth (Dwyer *et al*. 2000; Laris 2002*a*).

Specialized herders have occupied the savannas of northern Tanzania and southern Kenya for more than 3000 years. The Maasai, a large, loosely defined ethnic group of seminomadic pastoralists and agropastoralists, have lived in this region since ~1850 (for a detailed ethnography see Fosbrooke 1948; Beidelman 1960; Mitzlaff 1988; Spencer 1988; Homewood and Rodgers 1991; Spear and Waller 1993). Similar to other pastoralists in East Africa (Kijazi *et al*. 1999; Oba 2000; Oba and Kotile 2001), oral and pictorial traditions of the Maasai describe in rich detail both past and present management practices for local and useful plants as well as a wealth of knowledge on the ecology and environmental history of the area in which they live. Yet the balance between human occupation and wildlife concerns is continually being reassessed, resulting in increasing levels of tension and conflict between wildlife managers and resident Maasai (McCabe 1997; Coast 2002). One of the main reasons for increasing tensions has to do with the traditional burning practices employed by Maasai pastoralists.

Fire in savanna ecosystems

Fire has probably always been a major factor in Tanzanian grassland ecology, but the total area burned each year has recently

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begun to decline. Fire control programs initiated by the National Parks personnel have contributed to this decline (McNaughton 1983). Patchy grazing by migratory herds at the beginning of the dry season (McNaughton 1976) also serves to produce extensive firebreaks inimical to the widespread propagation of grass fires later in the dry season. High grazing pressure, water pond development, and the banning of fire use are believed to negatively affect range conditions in terms of botanical composition, bush encroachment, forage production, and soil erosion (Van Vegten 1984; Angassa and Baars 2000; Roques *et al*. 2001; Ghermandi *et al*. 2004). The limitation of fire use is also causing intense hardship for the Maasai, one of the world's last remaining nomadic pastoral peoples (N. Longiporo, pers. comm., 2004).

Historical analysis has revealed that when the indigenous patterns of burning were removed from these environments, a series of cascading consequences ensued (Pyne 1990, 1997; Laris 2002*a*). In the absence of periodic fires, savanna vegetation shifts from herbaceous dominance towards an increase in shrub cover (Trollope 1982; Knoop and Walker 1985; Oba *et al*. 2000; Sheuyange *et al*. 2005). Temporary protection against fire will also, in the absence of compensatory grazing, allow an accumulation of standing plant biomass of low nutritive value and an increase of fire-sensitive, often unpalatable herbaceous species (Homewood and Rodgers 1991). This makes adverse fire effects that much more serious if and when fire is deliberately or accidentally allowed to return. Stopping burning can thus lead to unwanted side effects on productivity and species composition, as shown in a comparison of burned and unburned grasslands in Maasai Mara and Nairobi National Parks, respectively (Boutton *et al*. 1988*a*, 1988*b*). Despite anthropogenic fires accounting for over 70% of the annual fires in African savannas (van Wilgen *et al*. 1990), the roles anthropogenic fires play in vegetation dynamics are poorly documented (Sheuyange *et al*. 2005).

Traditional management

Traditional ecological knowledge is an integral part of local knowledge systems for environmental classification, assessment, and management (Stevenson 1996; Bollig and Schulte 1999; Godgil *et al*. 2000; Mapinduzi 2001). It is built around human environmental perceptions and historical knowledge of resource use. Such systems are common among pastoralists worldwide (Fernandez-Gimenez 2000; Oba 2000; Oba and Kotile 2001; Mapinduzi *et al*. 2003). Anthropologists have described indigenous systems of pasture protection in Africa and shown that communal pasture management and sustainable modes of exploitation were compatible (Homewood and Rodgers 1989; Galaty and Johnson 1990; Fratkin 1997).

Almost every landscape has a complex history of human land use and natural disturbances (Aragon and Morales 2003) and the distinction between 'natural' and 'cultural' landscapes is not always obvious (Eriksson *et al*. 2002). Anthropogenic grass fires have been common throughout the world since the discovery of fire (Jacobs and Schloeder 2002). Fire has been used in traditional management systems to control disease-transmitting parasites, stimulate new growth palatable to all grazers, prevent impenetrable shrub encroachment, and encourage specific ethnobotanically important species (Belsky 1992; Angassa and Baars 2000; Cauldwell and Zieger 2000), similarly to fire management in West African savanna systems (Mbow *et al*. 2000; Laris 2002*b*). Although each of these studies has addressed the use of fire as a traditional management tool, none of them has tackled the question of vegetation change with respect to anthropogenic fires as it relates to conservation and long-term savanna management strategies.

Although there is considerable research on the ecological effects of fire in sub-Saharan Africa, research on traditional fire practices is very limited and the consequences of substantial changes to historical fire regimes have not been adequately explored. The specific dynamics surrounding anthropogenic burning and the savanna landscape remain largely understudied and poorly understood, especially in regard to the linkages among human burning practices, fire regimes, and savanna vegetation (Laris 2002*b*). The present research used a multidisciplinary approach, drawing on ecological and anthropological methods, to examine the historic and contemporary uses of fire as a land management tool and to address the following research questions:

(1) What are the historic fire management practices of the Maasai?
(2) What are the reasons for contemporary changes to traditional fire management?
(3) What are the potential impacts of changing fire management practices on savanna vegetation?

Methods

Study site

Engikareti, a Maasai village in northern Tanzania along the main road between Arusha and Nairobi, Kenya, was chosen to look at what is driving Maasai pastoralists to alter historic burning regimes. The location of the village proved ideal owing to its proximity to, but relative isolation from, the city of Arusha for transportation and supply purposes and the continued practice of traditional pastoral activities, including fire management. Engikareti is the site of long-term research and collaboration by the author. The village is located within the bounds of the Longido Game Controlled Area in Longido District, Arusha Region, in north-eastern Tanzania (03°00.9′S, 036°42.4′E) (Fig. 1). Village land is bounded by the town of Oldonyo Sambu on the south and the Maasai villages of Kiserian in the north, Emuseregi in the west, and Engarenanyuki in the east. Village land covers an area of roughly 2000 km^2 and is home to ~3000 semi-nomadic Maasai pastoralists. Within the village, residents live in *bomas*, small communities often composed of extended families and their livestock that range in size from ~20 to 200 people. In 2005 and 2006, there were ~80 *bomas* in the village.

The region is arid to semiarid with mean annual rainfall ranging from 200 to 600 mm per annum. Rainfall is bimodal and interannual variability is high. The short rains normally fall in November to December and the long rains begin as early as the month of March and terminate at the end of May or June. The short rains are highly unreliable, overall rainfall is poorly distributed, and droughts are frequent (Ngailo *et al*. 2001). A severe drought from 1999 to early 2006 resulted in a 50 to 80% reduction in livestock numbers and the starvation deaths of two children in early 2006 before the late onset of the long rains.

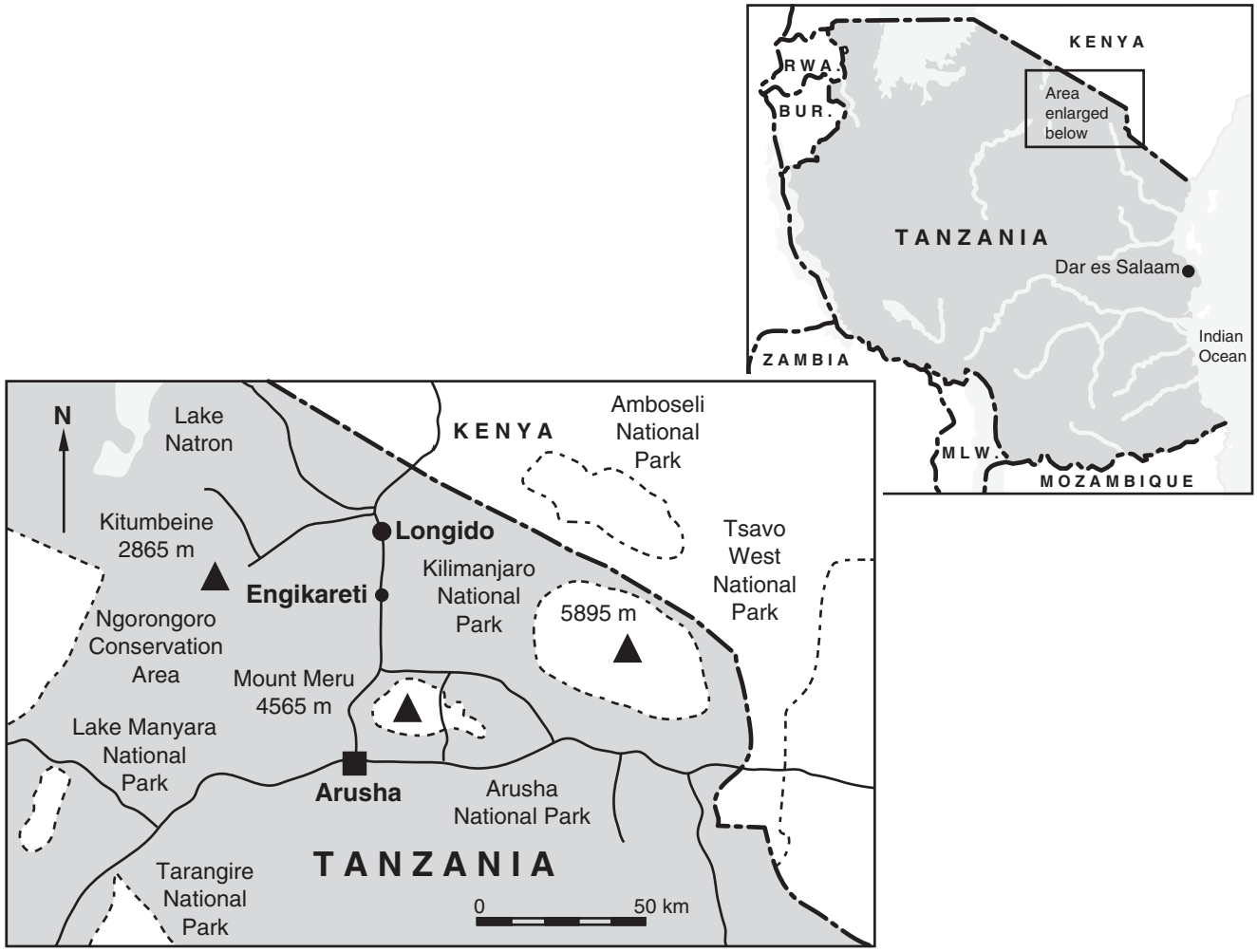

Fig. 1. Map of Engikareti, northern Tanzania (based on Homewood *et al*. 2006).

The landscape is characterized by undulating treeless short-grass savanna interspersed with *Acacia–Commiphora* scrub, and savanna woodlands dominated by umbrella acacia (*Acacia tortilis* (Forsk) Hayne) (R. Butz, unpubl. data). The village is located within the western rain-shadow of Mt Kilimanjaro and along the windward side of Mt Meru. The region has complex landforms resulting from folding, faulting, volcanic eruptions, and erosion (Oba and Kaitira 2006). Elevations generally vary from 1200 to 1700 m. There is no permanent water located on village lands. The Longido Game Controlled Area effectively forms a southern extension of the Amboseli Plains (Kenya) and is used extensively by large mammals when Amboseli is dry. It is an area of considerable importance for a large number of migratory wildlife and more than 400 species of birds have been recorded in the area (Fishpool and Evans 2001).

A public primary school, a Catholic secondary preparatory school, housing barracks for teachers, a village office, and three churches are the only infrastructure other than earthen family homes located within the village confines of Engikareti. The Maasai pastoralists living in this region engage mostly in livestock husbandry. Cattle, goats, sheep, and donkeys are grazed on communal pastures. Small garden plots have been created near a handful of *bomas* in the south-western corner of the village owing to influences from the neighboring WaArusha tribe, but no large-scale agriculture exists owing in part to the lack of available arable land. In Longido Game Controlled Area in Tanzania, all human activities are permitted except the exploitation of wildlife (Kaiza-Boshe *et al*. 1998).

Interviews on historical and contemporary fire management practices

The data on historical and contemporary fire management practices presented here were collected intensively over the course of 5 months in 2005. Owing to the sensitive nature of fire use by indigenous groups, names of *bomas* and individuals have been concealed to protect their identities and prevent retaliation from local authorities. All facets of the present research project were approved before the start of data collection by the council of village elders and local village government, and interviews were conducted with the consent of all individuals present. The author was based in the village for the duration of the study.

In-depth semi-structured interviews were conducted with the villagers both individually and in groups (Alexiades 1996;

Table 1. Individual interview questions

1. Are there fires here?
2. How do the fires start?
3. Who starts the fires?
4. How often do they occur? How many years in between fires?
5. What months are the most common for fires?
6. How do the fires stop?
7. Are there fires that are accidental?
8. How do people decide which areas to burn?
9. Who decides where to burn?
10. How big are the fires that are started on purpose?
11. How long do the fires burn?
12. What time of day are they started?
13. What is the weather like when they burn?
14. Why are the fires started? Is it important to burn?
15. What does fire do to the plants? Is it good, bad, or both?
16. Do the big trees burn? Die? How about the shrubs?
17. How does fire affect livestock?
18. How does fire affect wildlife?
19. Are there rules or laws from the government about fire? If so, what are they?
20. Is burning different now than it was in the past? If so, how and why?
21. How does burning affect food for livestock and wildlife? Other important species for food? Building materials? Medicinal plants?
22. How do you view fire? Is it good to continue using fire or should it be stopped?

Levy and Hollan 1998). In each of the three subvillages (Osinyai, Indemwa and Embalwa), nine village members were selected for a total of 27 interviewees. All three subvillages are roughly equivalent in size. Nine was chosen as the number of interviews in each subvillage for equal stratification of interviewees. Participants were selected randomly from a recent village census stratified by both gender and culturally recognized adult age class to maximize spatial extent of participants and to ensure a broad range of experience with traditional fire management was captured. Age classes were split into senior elders, junior elders and warriors for men, and senior and junior age classes for women. By sampling broadly from the adult population of the village, it is possible to assess what group or groups hold the greatest knowledge of fire practices and whether this knowledge is being transmitted to subsequent generations. All persons selected were asked whether they would be willing to participate and no one declined. Each person was interviewed individually to identify historic and existing fire management practices and perceived reasons for recent changes in management. They were asked 22 open-ended questions pertaining to the burning regime, the reasons for burning, the history of land use, and their perceptions of fire (Table 1). All interviews were conducted in the Maa and Swahili languages by the author and assisted by a well-respected and highly educated member of the community, and subsequently translated into either Swahili or English. The author speaks fluent Swahili and conversational Maa. The assistant was not related to any of the interviewees and was trained in anthropological interview techniques to minimize bias to the greatest extent possible. Each interview lasted between 45 min and 2 h and was conducted at a time and place convenient to the interviewee. Owing to the length of the interviews and the amount of information expressed, interview sessions were also tape-recorded and later transcribed to ensure that all ideas were accurately and completely captured. Interpreting indigenous ideas and concepts can be problematic especially when translating from different languages (Posey 1992), so careful documentation and cross-checking took place. Short follow-up interviews were used to clarify unclear or potentially conflicting answers and to ensure that ideas were accurately represented. Nevertheless, there were some words and concepts that were difficult to translate from Maa into Swahili, so it is inevitable that some material may have been lost. Responses were used to create a database on what, when, why, and how vegetation burns and how historic burning practices differ from present-day practices.

In addition to individual interviews, unstructured group interview techniques (Bernard 1988; Alexiades 1996) were employed during natural gatherings of age and functional groups (e.g. elders, warriors, women, village government officials) to engage a larger audience, clarify conflicting information, build rapport with the community, and keep the research process as transparent and comprehensible as possible. More than 40 group interview sessions were conducted over the course of 3 years during the author's most recent research residence in the village. Each session lasted between 30 min and 4 h, and provided extensive information about changes in traditional fire management, pastoral herd sizes and human populations over time, communal decision-making processes, enforcement of government regulations, and the transmission of traditional ecological knowledge through generations. Some, but not all, of these group interview sessions were also tape-recorded and later transcribed. For those sessions that were not recorded, extensive notes were taken during or immediately following the interviews to accurately capture the ideas presented.

In order to aid in understanding of the interview material, the author also participated with Maasai villagers in some of their fire management activities. Approximately 50 extended walks with villagers, ranging from 30 min to 9 h in duration, allowed the author to observe recent burns, historical burn areas, herding practices, wet and dry season pastures, wildlife movement corridors, charcoal production, and the environmental determinants of the landscape. Eight recent burn sites in the subvillage of Osinyai were selected for further examination and the methods and results of this work are detailed in a separate paper (R. Butz, unpubl. data). However, the characteristics of these burn sites are identified in the Results section to illustrate the timing and ignition source of recent fires.

Voucher specimens of all species mentioned during interviews and encountered during fire management activities were collected for positive identification and placed as references in the National Herbarium of Tanzania (NHT) in Arusha, and the herbarium at the Center for Plant Diversity at the University of California, Davis (DAV). Specimens were identified to species by staff at NHT. Maa names were recorded and cross-checked in the field.

Results

Historical fire management practices

Maasai pastoralists have an elaborate system of traditional fire management. Historically, men from the warrior age-class

Table 2. Eight recent fires in the subvillage of Osinyai and their ignition sources

Burn year	Accidental	Cause
October 1998	No	Purposeful burn to eliminate poor grasses
September 1999	Yes	Accidental fire that started in West Kilimanjaro
August 2000	Yes	Careless cooking fires from eating meat in the bush
August 2000	No	Purposeful burn started without permission of elders
June 2003	Yes	Careless cooking fires from eating meat in the bush
September 2003	Yes	Cigarette thrown from road
July 2004	Yes	Charcoal production
January 2005	Yes	Charcoal production

(*ilmurran*) burned before the short rainy season, with the greatest intensity of fires occurring during the months of September and October. They used a progression of small fires throughout the dry season to create a checkerboard or patch-mosaic (Parr and Brockett 1999) pattern of burns as grasses cured to prevent large, catastrophic late-season fires. These early, dry-season fires were small and contained. Maasai pastoralists used natural or constructed firebreaks, such as a dry riverbed or a constructed trench, as well as back-burns to constrain the area to be burned. Pasture areas grazed down by livestock also served to prevent fires from escaping by containing minimal fuel loads. Green branches of trees were cut and used to beat out small fires and fires that jumped a firebreak into an undesired area. Sand was also used to put out fires when careful containment was necessary. Heavily forested areas or areas near occupied *bomas* were typically not burned to prevent loss of tree cover (used as building materials and firewood by the Maasai) and to protect existing structures from accidentally escaped fires.

The decision to burn a particular area is a communal process, typically carried out by the elders of the village with input from the warrior class of men who also serve as the primary cattle herders and are therefore in prolonged, direct contact with pasture areas. The decision to burn an area is dependent on a large number of factors including: the type of vegetation present, the age of the vegetation, the amount of rainfall in the previous year or years, the amount of standing biomass, plant health, and the presence of insect pests such as ticks. Interviewees repeatedly expressed the importance of this communal process in maintaining healthy grazing lands. Punishment for accidental or non-approved fires was carried out by village elders and often consisted of a fine of livestock (i.e. a goat, sheep, or cow) commensurate with the severity of the fire.

Burning was conducted on a 1- to 8-year rotation dependent on the health of the existing vegetation, the perceived prospect of a good rain-year based on the current drought status of the village lands, and the percentage of adequate grazing land remaining were the rains to fail. Although fires varied some in size, most were small. Fires were most frequently started in the evenings when the wind was minimal or non-existent, the temperatures were cool, and the humidity was slightly higher. If the area to be burned was experiencing strong winds at night, the men would ignite the fire(s) very early in the morning and assign a team of people, often other warriors and young boys, to carefully watch the progression of the fire and keep livestock out of harm's way.

Based on results from the interviews, the Maasai identified eight major reasons for using fire on a landscape scale in savannas. The single most important reason mentioned in all individual and group interviews for the use of fire was to promote new, diverse, high-quality forage for cattle and small livestock. Other frequently mentioned reasons for fire use included the prevention of shrub encroachment, opening up landscapes to allow freer movement of livestock, killing disease-carrying ticks, eliminating cover for dangerous predators of livestock such as lions, leopards, and cheetahs, preventing late-season catastrophic fire, removing overgrown or matted grasses to more readily identify holes where livestock could be injured or killed, and creating suitable habitat for plants of edible, medicinal, or construction value.

Changing contemporary practices and attitudes towards fire

There is currently very little active management of vegetation using fire in the village. Although the villagers interviewed disagreed on the exact timing of this departure from traditional practices, they agreed that the shift has been most dramatic in the last 10 to 15 years. Out of eight recent (1998–2005) burn sites observed in the subvillage of Osinyai, only two were purposeful, and one of those was burned by a small group of warriors without permission from the village elders (Table 2). Burned sites varied drastically in size, the time of the year they burned, and the vegetation communities they encompassed.

Reasons given by interviewees for this reduction in fire management are numerous, but the most commonly stated include an increase in the number of large accidental fires, inadequate and unpredictable rainfall (including a perceived increase in the frequency and intensity of droughts), local and federal governmental policies opposing burning of any kind, and a substantial increase in human and livestock populations that has reduced the amount of land available for grazing, and therefore, for burning (Table 3).

Charcoal production, introduced into the village within the past 7 to 10 years (R. Butz, unpubl. data), is the cause of a large number of accidental fires. Other causes of accidental fires include cigarettes thrown from passing vehicles along the road that runs through the center of the village, fires used to deter bees while gathering honey, and careless campfires set by herders while eating and sleeping in the bush with their livestock. The increase in accidental fires has had reportedly devastating effects on both pasture vegetation and savanna woodlands; they often

Table 3. Top four reasons given by interviewees for the reduction in active fire management in Engikareti

Reason	Percentage of respondents ($n = 27$)
Increase in the number of accidental fires	100
Inadequate or unpredictable rainfall	89
Government policies against burning	85
Increasing human and livestock populations make burning too risky	44

burn at the driest times of the year and carry great distances because of ample dried fuel. This increase in the number and severity of accidental fires, coupled with a debilitating drought lasting from 1999 until spring 2006, has created a severe shortage of pasture grasses for both livestock and wildlife in the region.

Although everyone interviewed agreed that past fire management practices in the village, coupled with adequate rainfall, were positive, more than half of those interviewed think that burning practices should no longer be continued. Reasons for desiring to discontinue traditional fire management practices centered on perceived environmental changes, namely the increase in occurrences of warmer, drier years and a shortage of building materials. Interviewed villagers stated that they used to burn more frequently after years of plentiful rainfall, but this region has experienced warming, drying, and increased frequency of drought. Although this observation is supported by recent regional climate trends (USGS 2007), it is difficult to determine whether these observations are attributable to human-induced climate change or to natural climatic fluctuations (Nicholson 2000). One village elder stated: 'Burning was based on the assumption that the rains would come and pasture grasses would be renewed, but the rains have not been reliable and animals are starving.'

Almost all of the Maasai interviewed identified government policies against burning as one of the main reasons for decreased use of historical burning practices; however, no one knew the details of any of the government regulations pertaining to fire. More than half cited punishments of fines or jail time if caught igniting a fire. One elder declared: 'The government says that as you burn, the trees disappear, but the Maasai do not think that this is true. The government also says that when you burn, the cover [shrubs] for animals like leopards, elephants, and lions disappears and they don't want to be seen by people, so they also disappear. But this is also not true.' During another interview, a junior elder made a similar statement: 'The government makes many rules and throws our people in jail for burning because they say that fires make the rains disappear. Maybe big accidental fires cause the rains to disappear, but our traditional ways of burning do not.' Fire suppression within Tanzania, although poorly defined in government policies, is a result of widespread fear of desertification brought on by burning as well as a general sentiment by government officials that tourists 'do not want to see blackened land' when they are on safari in places like Serengeti (R. Butz, pers. obs.). Specific language of government fire suppression policies was requested by the author but was not made available for examination.

Increasing population pressure in the village due to immense growth in the past 40 years is also affecting the amount of traditional burning that is taking place because former grazing lands are currently occupied by human settlements. Engikareti became a village in 1977 and had a human population of ~600. In 2006, village leaders estimated the human population of the village to be ~3000, with approximately two-thirds of that number being children. Livestock numbers have also grown dramatically since the formation of the village. According to a village census conducted in 2002, ~8000 goats, 12 000 sheep, 3500 cattle, and 700 donkeys live within the village. The village secretary estimated in 2005 that the number of cows had increased slightly but small livestock numbers had decreased from the 2002 numbers. Greater than one-third of the villagers interviewed stated that their ability to conduct regular prescribed burns is further hampered by the increased number of *bomas* because setting fires too close to where people live is risky.

Despite strong consensus on the value and importance of fire management for the maintenance of healthy grazing lands, more than half of the Maasai interviewed during the current research were in favor of stopping most of the burning within their village lands. Although several people suggested that all fire activities should be halted based on more generalized concerns of environmental degradation, most of those who thought burning should cease stated reasons linked to federal fire suppression policies, an increase in the number of large, accidental fires late in the dry season, and a noticeable decrease in the amount and predictability of annual rainfall. Skepticism about the current value of fire by some of the pastoralists may have been affected by the long-term drought that was under way during the interview process. Long-term droughts result in less plant biomass and therefore less available forage, thereby forcing a reduction in the fire frequency. Maasai pastoralists easily distinguish between productive and unproductive fire regimes and repeatedly expressed deep concerned that the loss of their traditional burning practices will result in economic hardship and decreased savanna health.

Discussion

Indigenous practices of preventative burning have received little attention in the literature or in policy-making circles (see Laris 2002*a*, 2002*b* for exceptions). In particular, there has been little systematic research to link the reasons for burning with observed fire patterns on the ground. As a consequence, fire policies fail to distinguish between uncontrolled burning, burning for productive land-use, and burning for fire prevention. Historical Maasai patterns of burning reflect a controlled use of fire for productive land-use and late-season fire prevention.

Maasai traditional fire management practices, as outlined in the present study, share numerous similarities with traditional practices in savanna woodlands and open forests from other parts of Africa (Laris 2002*b*; A. Sheuyange and G. Oba, unpubl. data), North America (Lewis and Ferguson 1988; Anderson 1999; Boyd 1999), South America (Mistry *et al*. 2005), and Australia (Russell-Smith *et al*. 1997; Andersen *et al*. 1998; Bowman *et al*. 2004). In all of these systems, mosaic patterns of burning are used, often early in the dry season, to help prevent large, catastrophic fires later in the dry season. They are of low to

moderate intensity and rarely, if ever, enter the canopy. It has been suggested that a regime of small, fragmented or patch-mosaic fires, which divides the landscape into patches of burned and unburned vegetation, produces different vegetation formations than a regime of large, contiguous fires (Parr and Brockett 1999). Such a regime is associated with two key ecological benefits: increased ecosystem biodiversity from edge habitat and decrease potential for large, destructive, uncontrolled fires later in the dry season (Braithwaite 1996; Russell-Smith *et al*. 1997; Boyd 1999; Parr and Brockett 1999; Laris 2002*a*). The reasons local Maasai pastoralists give for their burning practices agree with these ecological arguments; they burn both to increase diversity and productivity of the vegetation and to prevent damaging late-season fires.

The almost complete cessation in traditional Maasai fire management in the past 10 to 15 years due mainly to land-use change, population pressures, government fire suppression, and a current cycle of severe drought has led to an increase in these late-season catastrophic fires. Fire suppression or substantial modifications to historical fire regimes could have cascading consequences for savanna health. As grasses cure with progression of the season, fires increase in size and intensity. In wooded savanna environments, such as those of northern Tanzania, the amount of vegetation consumed by a savanna fire is directly related to the combustion efficiency, which is largely a function of vegetation moisture content (Laris 2002*a*). As moisture content progressively decreases during the dry season, the combustion efficiency will increase as the season advances. A regular regime of hot, late dry-season fires will result in a landscape dominated by grasses (Cole 1986; Walker 1987; Louppe *et al*. 1995; Menault *et al*. 1995) and prevent the formation of dense patches of woodland (Laris 2002*a*) that are necessary to maintain diversity and supply local pastoralists with building materials. Late-season damaging fires are, at least in part, a product of federal fire suppression policies because fire suppression effectively removes early dry-season burning, thereby increasing late-season fuel loads and the occurrence of these catastrophic, accidental fires.

Although the existing scientific literature on the effects of fire suppression or other dramatic shifts in fire management is relatively rich on a global scale (Baker 1992; Mistry 1998; Keeley *et al*. 1999; Yibarbuk *et al*. 2001), the general lack of published research on historically practiced fire management in sub-Saharan Africa precludes any understanding of how shifts in these practices may affect ecological communities at local and regional scales. There is a pressing need for further research focusing on the ecological significance of altering historical fire regimes, particularly in areas where traditional practices continue or have only recently begun to change, as exemplified here by the Maasai.

The implications of these findings are clear in terms of recommendations for fire management policy. Early burning regimes are not only less damaging to woodlands, but they also serve to prevent large, accidental late-season fires from sweeping through the landscape. These small, early fires fragment the landscape by burning themselves out when they reach the border of moister patches of vegetation, creating microhabitats and promoting tree regrowth. Given the political sensitivity of fire policy worldwide, it is imperative that scientists, land managers, and policy-makers work together with local inhabitants to develop region-specific fire plans that maintain a healthy savanna landscape capable of supporting local livelihoods and a diverse flora and fauna.

Conclusion

Multidisciplinary approaches that draw on both ecological and anthropological methods can be used to effectively study historic and contemporary uses of fire as a land management tool and explore the potential impacts of changing fire management and fire suppression on vegetation communities. Indigenous practices of preventative burning have received little attention in the literature or in policy-making circles, yet these practices have represented, and in some regions of the world continue to represent, disturbance regimes in large part responsible for the maintenance of savannas. Substantial modifications to historical fire regimes could have cascading consequences for ecosystem health in savanna systems by increasing late-season fuel loads and the occurrence of large, catastrophic fires. These changes have multiple implications for the conservation and management of savannas.

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