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Fuelwood collection and its impacts on a protected tropical mountain forest in Uganda

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ABSTRACT

Local communities who live close to protected tropical forests often depend on them for woodfuel, their main source of energy. The impacts of fuelwood extraction in humid forests are rarely studied, yet the extraction of wood for fuel can impact forest structure, function and biodiversity. We assessed the effects of fuelwood collection on the forest of Mt Elgon National Park (Uganda). We interviewed 192 households about fuelwood use and surveyed dead wood in 81 plots inside the park. Forest was the most important source of fuelwood. People collected on average between 1.1 and 2.0 m^3 of fuelwood per capita per year. Other activities involving wood fuel extraction from the forest included illegal commercial fuelwood harvesting and charcoal making. Quantities of dead wood were affected by fuelwood collection up to at least 1000 m inside the boundary of the park. Depletion of dead wood inside the park was greater in the sites where the population was most dense. Nevertheless, people who planted more trees on their own land perceived land outside the park to be important and valued old growth forest less as a source of fuelwood. Highly-preferred tree species were most depleted, particularly when they were also valued timber trees, such as *Prunus africana*, *Popocarpus milianjianus*, *Allophylus abyssinicus* and *Olea* spp. Locally dominant species were less affected. Impacts varied among sites depending on the history of agricultural encroachment and locally-specific forest uses, e.g. harvesting of trees for poles or use of the forest land for grazing. Allowing the collection of dead wood in forests is double-edged as it creates opportunities for other activities that are more damaging. Demand for wood fuel from tropical forests is still likely to grow in the foreseeable future. Our results indicate that the forest may become more degraded as a result, with negative consequences for the people who depend on the forest and for conservation. Research into local ecological and cultural contexts and perceptions concerning costs and benefits can help devise more sustainable management options, including alternative sources of fuel.

1. Introduction

Fuelwood is the main source of energy for cooking and heating in large parts of the world (FAO, 2010). Sub-Saharan Africa is the region with the world's highest average per capita wood fuel consumption (0.69 m^3/year) (Iiyama et al., 2014) and more than 80% of the population rely on wood fuels – firewood and charcoal – for energy. While this percentage is expected to decline, total consumption will likely increase due to population growth (OECD/IEA, 2010). Most fuelwood comes from bush and fallow lands, but forests provide a locally important source where people lack alternatives (Arnold et al., 2003). Small land-holdings and high population densities in many humid tropical areas increase people's dependence on protected areas for wood (Naughton-Treves et al., 2007; Hartter et al., 2011). The extraction of wood for fuel by collecting dead wood or by harvesting trees or their branches, can impact forest structure, function and biodiversity (Ndangalasi et al., 2007). Woody debris plays an important role in forest ecosystems, in nutrient cycling processes and as habitat for a diversity of fauna, plants and other organisms (Duplessis, 1995). Intensive harvesting may lead to forest degradation and loss (Geist and Lambin, 2002).

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New attitudes to tropical forest management call for more devolved approaches to conservation compared with older 'fortress conservation' approaches (Wells and McShane, 2004; Lele et al., 2010). They allow access and use of forest resources by local communities living in the vicinity of protected areas, in exchange for improved forest protection (Vermeulen and Sheil, 2007). There is evidence from sub-Saharan Africa and elsewhere that where local communities participate in forest management this leads to improved environmental outcomes (Persha et al., 2011; MacKenzie et al., 2012). The management of tropical forested protected areas needs to consider both the needs of the surrounding population and the impacts of any forest use (Kaimowitz and Sheil, 2007). Yet, the implications of growing demands for food and energy on tropical forest resources are poorly characterised at local scales where outcomes can vary considerably even under a similar management regime (Sassen et al., 2013). The management of protected areas must balance conservation and human needs making it crucial to understand how various activities impact forests.

This study investigates the patterns, effects and potential management implications of fuelwood extraction on the edges of Mt Elgon National Park a mountain forest in eastern Uganda. In Uganda, more than 85% of households use fuelwood as the main cooking fuel, 98% if charcoal is included (UBOS, 2006). As in other sub-Saharan African countries, pressure on protected forests in Uganda increases due to a combination of population growth, demands for land and expanding industrial and domestic consumption of wood fuels, including charcoal. Remnant natural forests outside reserves or national parks are rapidly decreasing (Naughton-Treves et al., 2007). In this regard, Mt Elgon permits examination of the impacts of fuelwood collection in a protected area with a history of conflict between surrounding populations and conservation actors. No other forest remains in its direct vicinity and conservation outcomes vary considerably around the park boundary (Sassen et al., 2013; Sassen and Sheil, 2013).

In this paper we examine the effects of fuelwood collection and other activities on the availability and distribution of dead wood in Mt Elgon's forest. We consider their relation to historical agricultural encroachment, distance from the park boundary, forest structure and local preferences for fuelwood species. We also investigate the role of alternatives sources of fuel as we expected that many people would depend on the park for fuelwood, but people with alternative fuel sources less so. We hypothesized that preferred species would be most depleted and at greater distances inside the park and that this would impact fuelwood use.

This study is the third in a series of linked studies that examine these forests and their relationship with local people. In a first paper we described the contexts and drivers that led to local variation in forest loss and recovery over recent decades (Sassen et al., 2013). A second paper examined the nature of the resulting forests under different patterns of local use (Sassen and Sheil, 2013).

2. Study area

Mt Elgon is located on the border between Uganda and Kenya. It is a large extinct volcano (4321 m) with generally gentle slopes until 2800–3000 m down from the 8 km wide crater-rim. Below this, slopes are steeper to the south-west while characteristic sheer cliffs drop down to the plains in the north (Fig. 1). Annual precipitation between 1500 and 2000 mm falls year round but peaks in April–May and September–November. Rainfall is higher on the southern and western slopes than on the northern and eastern slopes (Dale, 1940; IUCN, 2005). Mt Elgon is an important water catchment area for several million people in the surrounding districts and for important areas such as the Nile and Victoria Basins (IUCN, 2005). The mountain is covered with a belt of bamboo and afromontane forest at on average between 2000 and 3000 m, followed by heathers and high altitude moorland (Dale, 1940; van Heist, 1994). The forests above 2000 m and the higher altitude vegetation host biodiversity characteristic of the Afromontane Region, with a number of species endemic to Mt Elgon (for details see Davenport et al., 1996; IUCN, 2005).

Mt Elgon's volcanic soils are fertile and in the south and south-west they support an intensive mixed coffee and banana based agriculture (Kayiso, 1993; ILRI, 2007). Coffee (*Coffea arabica*) is the main cash crop and is traditionally grown in combination with bananas and multi-purpose shade-trees, both indigenous and exotic species. *Eucalyptus* woodlots are often planted in stream valleys. People have been settled and cultivating the slopes since around 1500 AD. In the north and northeast, agriculture is practiced on larger plots of maize, potatoes, wheat and pasture (ILRI, 2007). In this area, people started practicing agriculture from the 1980s, when they were resettled down from the higher slopes of the mountain and from the insecure lower plains to the North.

Uganda's protected forests were widely encroached during a period of political instability that lasted from 1971 until 1986 (Hamilton, 1985; Turyahabwe and Banana, 2008). Since 1987, forest restoration activities were started in the worst affected areas on the western slopes (UWA, 2000), with mixed success. In later years new forest clearing took place in different areas of the park (Sassen et al., 2013). When Mt Elgon was gazetted a national park in 1993, local communities lost all legal access rights (Scott, 1998). Since the late 1990s park management has initiated resource use agreements with local communities living next to the park (at parish level) that allow regulated collection of a limited number of non-timber products, fallen dead wood and stems from certain shrub species (e.g. *Vernonia* spp.) to support crops like bananas and climbing beans (UWA, 2000). Cattle grazing, tree-cutting, charcoal burning and hunting are illegal but widespread (Norgrove, 2002; Sassen and Sheil, 2013). Whether or not a community living next to the park has entered into such an agreement depends strongly on the level of conflict with the park management about park boundaries and access for cattle grazing (Sassen et al., 2013). In areas without agreements some uses, including dead wood collection, are sometimes tolerated on an *ad-hoc* basis in an effort by local rangers to minimize conflicts. Dependence on forest products remains important (Katto, 2004). This is unlikely to decrease in the near future as population densities continue to grow and increase local demands for wood. No natural forests remain within 20 km around the protected area (Sassen et al., 2013). In 2002, human population densities in the parishes surrounding Mt Elgon ranged from 150 p/km^2 in the north to more than 1000 p/km^2 in the west. Average annual population growth rates ranged between 2.5% and 4.3% (UBOS, 2002a,b,c).

3. Methods

3.1. Field data

We collected data in four contrasting sites situated along the northern and western boundaries of Mt Elgon National Park, to represent different elevations, forest types and forest cover change histories (Sites 2, 9, 11 and 14, Fig. 1, Table 1). Forest cover change on Mt Elgon is strongly related to its history of recurrent agricultural encroachment (Sassen et al., 2013). Sites 2 and 9 have a long history of clearing for agriculture inside the park, with more (Site 9) or less (Site 2) successful forest restoration efforts. In Sites 11 and 14 most forest clearing for agriculture started after the establishment of the park. Each site corresponded to a sample village (Sassen and Sheil, 2013) (Table 1).