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Annual allowable cut for merchantable woody species in a community managed forest in western Kenya

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ABSTRACT

Changes in stand density, basal area, off-take and annual increment were determined from 18 permanent sample plots established in 1997 in Got Ramogi Forest in western Kenya. The plots were assessed in 2003 and 2008. A total of 824 stems $\geqslant$1.5 m in height were recorded from 43 woody species. Key merchantable woody species comprised 20% of the woody species and 67% of the overall stem density. There was a significant reduction in the overall stand density and in the stem density of key merchantable woody species, but not among other woody species between 1997 and 2008. The basal area decreased significantly among key merchantable woody species, but not for the overall forest. The basal area decreased from 22.6 to 9.7 m^2 ha^{-1} for key merchantable woody species. The stand volume of key merchantable woody species decreased from 156 m^3 ha^{-1} in 1997 to 61.7 m^3 ha^{-1} in 2008. The mean annual off-take declined from 10.3 m^3 ha^{-1} $year^{-1}$ between 1997 and 2003 to 9.1 m^3 ha^{-1} $year^{-1}$ between 2003 and 2008, while the mean annual increment increased from 2.9 to 3.3 m^3 ha^{-1} $year^{-1}$. It was predicted that forest recovery would surpass the 1997 stand volume of 156 m^3 ha^{-1} if off-take levels between 10% and 90% of the mean annual increment were adopted. We settled on an annual allowable cut of 80% of the mean annual increment as a compromise between consumptive and conservation interests. We identified over-harvesting as the main cause of the reduction in stem density among key merchantable woody species. A management plan with compartment registers indicating the diversity, abundance and distribution of each woody species was recommended to guide their utilization and monitor their population dynamics.

1. Introduction

Although the global rate of deforestation is reported to have decreased over the past decade, it continued at a steady rate in many countries in Africa and South America during the same period (FAO, 2010). Unplanned logging, over-harvesting and poor forest management practices were reported as some of the major causes of rapid decline in forest cover in these regions (Dykstra and Heinrich, 1996). Managing forests in such a way that utilization of woody resources does not compromise their ability to provide non-wood products and environmental services has been identified as one of the solutions to deforestation (Bawa and Seidler, 1998; Sist et al., 1998). However, the concept of sustained-yield utilization of woody forest resources is still met with reluctance by conservation authorities in Africa, particularly for community-managed forests (Gaugris et al., 2007). The reluctance is based perhaps on past experience, where management of such resources by local communities may have resulted in their deterioration (Bucher and Huszar, 1999). Amid the reluctance, many forests have continued to come under uncontrolled use by adjoining rural communities causing deforestation, negative impacts on biodiversity and loss of livelihood.

Unplanned logging and over-exploitation have been recognized as important causes of deforestation in many tropical forests (FAO, 2007). The situation is common in dry tropical forests, which have received little attention because of the perception that they are able to recover to mature state relatively fast when disturbed (Levesque et al., 2011). Resolving unplanned logging and over-exploitation of forest resources requires a good understanding of the dynamics of forest exploitation, degradation and recovery by forest users (Isango, 2007; Backeus et al., 2006). According to Taylor et al. (2008), Africa is more vulnerable to deforestation because of a limited number of long-term studies on stand population dynamics, the difficulties of protecting such study sites and the resources required to maintain these studies. Thus, forest degradation is often realized when it has already occurred. The challenge is even greater for community-managed forests where felling is done on a walk in – walk out basis. The situation is worse in Kenya where

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excisions and clear-felling in government forests and over-harvesting in community forests have reduced the closed canopy forest cover from about 3% to 1.7% of the country's land area over the past three decades (Matiru, 1999; Mau Forest Interim Coordinating Secretariat, 2009).

In this paper, we present findings of a study on stand dynamics carried out between 1997 and 2008 in Got Ramogi Forest in western Kenya. The forest is presently managed by a community trust under the supervision of a local council of elders. Until the late 1960s, the forest was managed primarily for biodiversity conservation and preservation of historical sacred sites (Otuoma and Odera, 2009). The local community believed that the sacred sites, which are located within the forest, were the homesteads of their ancestors. Thus, strong cultural taboos protected the forest from tree felling. Over the past three decades, however, increases in human population, economic drivers and change in religious beliefs have eroded some of the cultural taboos. Over time, the local community began to harvest trees from the forest, albeit stealthily, but this has since become a common livelihood activity. The realization that over-exploitation of woody forest resources is becoming widespread has presented the community trust with the challenge of identifying an appropriate management approach to guide sustainable use of these resources. The aim of this study was to assess changes in stand density, basal area and growth increment between 1997 and 2008, use the incremental rates of various diameter size-classes to predict a possible stand recovery pattern for the next two decades and recommend a sustainable annual allowable cut.

2. Materials and methods

2.1. Study area

An assessment of the sustainability of harvesting was carried out in Got Ramogi Forest in western Kenya in March 2008 in permanent sample plots that were established in 1997. The forest vegetation has been described as dry semi-deciduous woodland with a closed multilayered canopy (Otuoma and Odera, 2009). It lies between 00° 06′ 23″ S and 34° 04′ 10″ E near the northeastern shores of Lake Victoria in Bondo District. It ranges from an elevation of 1160–1320 m above sea level and covers an area of 374 ha. The area receives bimodal rainfall with an annual mean of 800 mm and a mean annual temperature of 28 °C. The area has shallow, dark red to brown sandy-clay loam soils, with rock outcrops in many places. The forest is registered as a trust land and belongs to Bondo County Council. The county council assigned it to the Kenya Forest Service to manage it as a trust land. However, since the forest is not gazetted as a forest reserve, the role of the Kenya Forest Service has remained minimal, effectively leaving it under the control of the local community.

2.2. Sampling design

In 1997, a total of 18 permanent sample plots were established in the forest using randomized block design to monitor trends in stand structure, basal area and stand volume. Each sample plot measured one ha. Three subplots measuring 30 m by 20 m were randomly delineated within each one-ha sample plot giving a total sample area of 0.18 ha. All woody life-forms ⩾1.5 m in height were identified by species, and their heights and diameter at breast height (DBH) measured. The trees were marked with paint to make it easy to identify them during subsequent assessment. The same parameters were measured in 2003 and 2008 from the same subplots. DBH was measured at a height of 1.3 m (or just above the buttress if present) using a metric diameter tape. Tree height was measured using ranging rods (the height of majority of trees ranged between 3.5 and 7 m, emergent trees ranged between 10 and 12 m). Mortality was recorded by counts of trees that died from non-anthropogenic causes, while recruitment was recorded by counts of new stems.

The datasets were used to compare the species diversity, evenness and stand population structure for the forest in general and for key merchantable woody species. Key merchantable woody species are tree species that were often felled from the forest. They were used for firewood, charcoal, construction poles, carving wood and timber. We estimated the mean annual increment and current off-take for the key merchantable woody species (FAO, 1998). Using the annual incremental rates of different DBH size-classes of each key merchantable wood species for the past ten years, we extrapolated the likely recovery scenarios under different annual off-take rates for the next two decades. We used the recovery scenarios to derive allowable off-take targets and their likely impact on the basal area and residual stand volume. Species diversity was determined using the Simpson diversity index (He and Hu, 2005; Mani and Parthasarathy, 2009). Stand volume was calculated using Huber's formula (Plank and Cahill, 1984; Waddell, 1989).

2.3. Mean annual increment

The mean annual increment between 1997 and 2008 was derived using equations by Shackleton (1993), FAO (1998) and Luoga et al. (2002), and expressed as follows:

$$G = \{(I_{\text{trees}} * n) - M + R\}/n$$

where, G = the mean annual increment (m^3/ha/year), I_{trees} = the sum of increments of stems that survived during the period of measurement (m^3/ha/year), M = the volume of stems that died during the period of measurement and hence no longer contributed to net forest growth (m^3/ha), R = the volume of in-growth or recruitment, during the same period (m^3/ha), n = the period of measurement in years.

2.4. Estimating current off-take and permissible off-take rates

Current off-take was estimated by accounting for the number of stems that existed in 1997, but were missing either in 2003 or 2008. Their respective basal area and heights were used to calculate the off-take volume. Permissible off-take rates were estimated by calculating off-take as a fraction of the mean annual increment on a scale of 10–90%. These off-take levels were considered permissible in the sense that they were lower than the mean annual increment of the stand volume. Each permissible off-take rate was used to extrapolate the likely residual stand volume for the next 20 years on the basis of net gains in the mean annual increment. Calculations were done at the level of DBH size-class based on DBH increments between 1997 and 2008. The intention was to illustrate the duration it would take to attain various residual stand volumes for different permissible off-take targets.

2.5. Estimating annual allowable cut

The most complex part of the study was how to arrive at an acceptable annual allowable cut. Conservation interests preferred an allowable cut that was well below the mean annual increment, while consumptive interests were not keen to see a big variation between current off-take level and the allowable off-take. We settled on a hypothetical allowable cut of 80% of the mean annual increment as a compromise between conservation and consumptive interests, but made sure that we presented all the allowable off-take scenarios and their implications for the residual stand volume.