Anthropogenic disturbance of forests, its effects on primates, and conservation in West Usambara, Tanzania

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Abstract

Forest utilization by humans is widespread and often results in environmental degradation. This dissertation aimed to help provide the understanding necessary to achieve the sustainable utilization of 13 forests in West Usambara, Tanzania. First, I examined forest disturbance by local people (Chapter 2), then determined if the disturbance was harmful to wildlife (Chapter 3), and finally, investigated if participatory forest management was an appropriate conservation strategy in West Usambara (Chapter 4). Disturbance was ubiquitous, but variable in West Usambara and I found that utilization was highest in areas of high population pressure. In terms of wildlife, *Colobus angolensis palliatus* monkeys appeared to have become extinct in three small forests with intense removal of poles (i.e. small trees), which implied that utilization may be unsustainable. However, the effects of pole removal may be different than the effects of tree removal as I recorded high encounter rates with the monkeys in areas of intense tree removal. The results from Chapter 2 and 3 suggested that conservation efforts were necessary in West Usambara, and therefore I examined if participatory forest management was an appropriate conservation strategy. I found that most local people knew that forest utilization was detrimental to the forest, and many supported the conservation of forests, which together indicated that local people may be able to manage forests effectively and sustainably. I also found that large farms were associated with

high support for conservation. The mechanisms that connect farm size to support for conservation are not clear but the results implied that increasing access to non-forest resources may lead to increased support for conservation. In conclusion, I found that the forests of West Usambara were highly utilized by local people, a focal wildlife species was negatively affected by forest disturbance, and participatory forest management was a sensible conservation approach.

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colobus monkeys (N=156 interviewees in 20 villages), and Sykes monkeys (N=235 interviewees in 26 villages). Error bars indicate the quartiles (25% and 75%).

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Chapter 1. Introduction to the dissertation

CHAPTER 1. INTRODUCTION TO THE DISSERTATION

INTRODUCTION

The debate over how to achieve sustainable use of natural resources has been long-standing and on-going (Borgerhoff Mulder and Coppolillo 2005). Forests provide an informative case study of the debate due to the long and well-documented histories of both forest utilization and forest conservation (Bowles et al. 1998; Lugo 1999).

FOREST UTILIZATION

Forest utilization by humans has a long history (at least 9000 years: Yasuda et al. 2000) and creates disturbance that has shaped and continues to shape forest ecosystems across much of the world. Utilization can take the shape of large-scale harvesting of timber (Geist and Lambin 2002) or clear cutting of forests for agriculture (Fitzherbert et al. 2008). A variety of public and private actors regularly utilize forests, including the United States government which created "forest reserves" in the 19^{th} century for seemingly economic reasons (Borgerhoff Mulder and Coppolillo 2005; Geist and Lambin 2002). Forest utilization also involves the small-scale collection of forest products by local people (Ndanyalasi et al. 2007). In fact, across much of the world, local livelihoods and sustenance are derived from extraction of forest products (Lugo 1999; Pimentel et al. 1997).

Many studies have shown that the utilization of forests has negative impacts on forest wildlife (globally: Brooks et al. 2002; Indian Himalaya: Pandit et al. 2007; Southeast Asia: Sodhi et al. 2004) and even on humans (e.g. loss of water sources: Tinker et al. 1996). On the other hand, some species may be able to survive within utilized forests, including several primate species (e.g. Pongo pygmaeus: Husson et al. 2009; Marshall et al. 2006; Colobus guereza, Cercopithecus mitis, Cercopithecus ascanius: Plumptre and Reynolds 1994).

FOREST CONSERVATION

In contrast to forest utilization, the creation of specific areas (e.g. national parks and reserves) for forest conservation is a more recent concept (~250 years: Borgerhoff Mulder and Coppolillo 2005; Grove 1995). Broadly, forest conservation aims to provide areas for the environment to exist without much interference by human activities. Conservationists argue that forests should be protected from human utilization in order to be able to continue to function in their roles as important constituents of local and global ecological systems. For example, forests are well-known for high levels of biodiversity (Myers et al. 2000; Rohde 1992; Turner 1996), water catchment functions (Dudley and Stolton 2003; Tinker et al. 1996), and carbon sequestration (DeFries et al. 2002).

COMPROMISING

The practices of forest utilization and forest conservation appear to be at odds with each other. The inherent challenges of this potential conflict are nicely summarized by a conversation I had with a forest manager in West Usambara, Tanzania. The manager described how the utilization of the local forests was crucial for the survival of the local people, as they depended on the forest’s resources for fuel wood and building materials. At the same time, it was evidently clear that if the local people continued to utilize the forest at the current rates, the forest would be gone in the near future. Neither unrestrained utilization nor strict protection was sensible; a compromise was necessary.

The realization that both utilization and conservation were important helped spur the creation of modern conservation models that attempt to balance utilization and conservation via the sustainable use of natural resources; this effort most notably began with the launch of the 'Man and the Biosphere' project by the United Nations in the late 1960s (Batisse 1982; Borgerhoff Mulder and Coppolillo 2005). This project established the concept of protected areas that allowed for both the utilization and conservation of resources (Batisse 1982). While this concept has been added to and modified over the years (e.g. participatory forest management, community-based conservation, integrated conservation and development), the goal has remained essentially the same: finding a balance that allows for the survival of both humans and the environment.

OBJECTIVES OF THE STUDY

A recent report showed that utilization of natural forest is extensive, with about 13 million hectares of the world's forests lost each year (Food and Agriculture Organization 2010). As a result, it is often the case that to ensure the sustainable use of natural resources, efforts are needed to limit utilization and promote conservation. Broadly, this study aimed to do just that in the forests of West Usambara, Tanzania: to help determine where disturbance was too high, and in those areas identify what actions can be done to restrict utilization and bolster conservation.

More specifically, I addressed three main questions:

First, where is forest disturbance most severe and what part of the local population is associated with utilization (Chapter 2)? We need to understand where utilization needs to be restricted and conservation needs to be bolstered. Further, identifying what aspects of the local human population are most associated with utilization is critical to finding potential management strategies that will help reduce utilization.

Second, how is forest disturbance affecting wildlife (Chapter 3)? The answer to this question will give insight into the sustainability of the utilization. If wildlife is found to be suffering, then clearly less utilization is necessary. However, if wildlife is found to be surviving, then potentially the amount of utilization is sustainable.

Third, how do we engage local people in conservation (Chapter 4)? The conservation literature is clear that solutions that come from the local level can be successful (Borgerhoff Mulder and Coppolillo 2005; Gadgil 1992; Pimbert and Pretty 1997). Participatory forest management is a commonly-used engagement technique, where local people become the primary actors in forest management (Blomley et al. 2008; Saxena 1997). Yet for participatory management to be successful in terms of conservation, a few questions need to be asked prior to initiating a participatory approach. Are local people aware of conservation problems? Do local people support conservation? If so, what influences support for conservation? The answers to these questions will help conservationists know if and how to engage the local population in sustainable management of the forest (Chapter 4).

Together, these three topics comprise the body of this study. Each topic is addressed in a stand-alone chapter; and each chapter is written in the style of a scientific article.

STUDY SITE

This study aims to help alleviate the struggle between forest conservation and utilization in the Eastern Arc Mountains of Tanzania and Kenya (Figure 1.1). The Eastern Arcs comprise 13 separate mountain blocks that stretch from south-eastern Kenya to south-central Tanzania and include about 3530 km^2 of forest (Burgess et al. 2007; Mbilinyi et al. 2006). Mountain blocks are differentiated geographically and each block contains numerous forests.

The Eastern Arc Mountains have been identified as one of the 25 global hotspots of biodiversity, which are areas that have been empirically determined to have high species richness, yet are highly threatened (Myers et al. 2000). The Eastern Arcs are the geographically-smallest of these areas and recent discoveries of mammals, such as a new species of primate (Jones et al. 2005) and a new species of elephant shrew (Rovero et al. 2008), highlight the area's biodiversity and suggest that many species are still yet to be identified. At the same time, over-utilization of the forests has been repeatedly shown (Hall et al. 2009; Madoffe and Munishi 2005). Indeed, at least 77% of the forested area in the Eastern Arcs has been cleared over the past 2000 years (Newmark 1998). Most households of the local human populace practice shifting cultivation at a subsistence level in the Eastern Arcs (Conte 2004; Mwampamba 2009), and many depend on the forest for firewood, charcoal, building timber, etc. (Halperin 2002; Ndanyalasi et al. 2007). In this area, the forest is mainly utilized by local people, as commercial logging of these forests was banned in the 1980s (Persha and Blomley 2009).

This study primarily focused on the West Usambara mountain block in north-eastern Tanzania. This block was once a large, single forest, but a 2000 year history of utilization has resulted in a loss of 84% of the forest (Newmark 1998). Heavy utilization continues presently as shown by a 10% loss in forest area between 1970 and 2000 (Mbilinyi et al. 2006). Only 320 km^2 of forest remain in West Usambara, which is divided between several isolated patches (Mbilinyi et al. 2006). Clearly, the persistence of these forests requires that high levels of forest utilization are balanced with conservation in order to achieve sustainable use. This study aimed to provide information needed to achieve that balance.

Chapter 2. Quantifying and understanding anthropogenic disturbance of forests in a biodiversity hotspot in Tanzania

CHAPTER 2. QUANTIFYING AND UNDERSTANDING ANTHROPOGENIC DISTURBANCE OF FORESTS IN A BIODIVERSITY HOTSPOT IN TANZANIA

ABSTRACT

Anthropogenic disturbance of tropical forests is troublesome to conservationists as these forests are known for high levels of biodiversity, water catchment functions, and carbon sequestration. Understanding the distribution and causes of anthropogenic disturbance is a necessary step towards conserving these forests. Unfortunately, these types of data are often lacking at a local level. This study quantified and then examined potential influences on anthropogenic disturbance inside the forests of 11 mountain blocks in the Eastern Arc Mountains of Kenya and Tanzania. Anthropogenic disturbance was defined by the number and basal area (m^2) per hectare of pole stumps (5-15 cm diameter) and tree stumps (>15 cm diameter). Forests in every mountain block were disturbed, and the blocks differed significantly in the number of pole stumps and tree stumps. These results helped to identify the mountain blocks most in need of conservation. In the study's second part, I estimated the influences on disturbance in one of the mountain blocks, West Usambara. Explanatory variables included six variables about the local human population size and behavior as assessed by structured interview, the Tanzanian census, and GIS analysis. I found that population pressure (village population size / forest size (km^2)) was positively related to the basal area of pole stumps per hectare. This result is supported by a substantial body of literature that links human population density to environmental degradation. I found no clear influences on the density of tree stumps. Together, these two results suggest that pole removal and tree removal are driven by

fundamentally different processes. For conservation, managers may want to focus efforts on reducing forest utilization in large villages, and especially large villages near to small forests. The next step in this research program is to examine how population pressure and forest disturbance interact with forest governance strategies in West Usambara.

KEY WORDS

anthropogenic disturbance, conservation, Eastern Arc, forests, Tanzania, West Usambara

INTRODUCTION

Humans alter landscapes across the world through over-utilization of natural resources, and forested habitats have not been spared (Barnes 1990; Vitousek et al. 1997). Indeed, forests have been and continue to be utilized and disturbed by humans in many ways, ranging from outright forest clearing for agriculture and other purposes (Carr 2004; Geist and Lambin 2001) to subsistence level harvesting of forest products (Ndanyalasi et al. 2007). The disturbance of tropical forests is especially troublesome to conservationists as these forests contain high levels of biodiversity (Myers et al. 2000; Rohde 1992; Turner 1996), serve water catchment functions (Dudley and Stolton 2003; Tinker et al. 1996), and sequester carbon (DeFries et al. 2002).

To better target limited resources to areas of greatest biological value, some species-rich yet highly threatened forests have been included in the list of "biodiversity hotspots" (Myers et al. 2000). The hotspot concept is useful for focusing conservation efforts on important habitats in a realistic economic climate of limited resources. However, these global hotspot analyses do not incorporate the detailed and localized information that is necessary to actually implement conservation. That is, global hotspots cover such large areas (from 3530 km2 – 356,630 km2: Mbilinyi et al. 2006; Myers et al. 2000) that they veil potentially important variation in land use within a particular hotspot. Understanding the distribution of anthropogenic disturbance within a hotspot is therefore a good step in further focusing conservation efforts. We need to know which parts of the hotspot are disturbed, and of those, which parts are the most disturbed. Unfortunately, such localized data about land use are often lacking. Therefore, in the first part of this study, to improve our weak understanding of the spatial dynamics of land use in biodiversity hotspots, I documented anthropogenic disturbance in the smallest of these hotspots, the tropical forests of the Eastern Arc Mountains of Kenya and Tanzania.

Once disturbance is quantified, it is then important to identify what drives disturbance within a hotspot. Identifying the influences on disturbance in localized areas can be useful in developing conservation plans, as these types of analyses are able to determine the factors that influence human behavior towards forests in the area of focus (Agrawal and Yadama 1997). Once these factors are known, conservation managers can adopt appropriate strategies. Therefore, in the second part of this study, I examined the influence of six measures of local human population size and behavior on disturbance in 13 forests of the West Usambara mountain block in the Eastern Arcs. Table 2.1 lists and describes the six explanatory variables. A variety of other aspects likely play a role in forest disturbance (e.g. forest governance: Gibson et al. 2000; Persha and Blomley 2009); this study however is limited to these six due to time and resource limitations.

METHODS

STUDY SITE

This study took place in the Eastern Arcs Mountains of Kenya and Tanzania (Figure 1.1). At about 3,530 km^2, the Eastern Arc Mountains are the smallest biodiversity hotspot (Mbilinyi et al. 2006; Myers et al. 2000), and comprise 13 separate mountain blocks that stretch from south-eastern Kenya to south-central Tanzania (Burgess et al. 2007). Numerous forests exist in each of these mountain blocks. Most households of the local human populace practice shifting cultivation at a subsistence level in the Eastern Arcs (Conte 2004; Mwampamba 2009), and many harvest firewood, charcoal, building timber, etc. from the forests (Halperin 2002; Ndanyalasi et al. 2007). In this area, the forest is mainly utilized by local people, as commercial logging of these forests was officially banned in the 1980s (Persha and Blomley 2009).

DEFINING ANTHROPOGENIC FOREST DISTURBANCE

For this study, I focused on disturbance associated with extraction within forests rather than larger isolation or edge effects. I used the locally-common method of estimating extraction by calculating the number and basal area of pole stumps and tree stumps per hectare (Doggart 2006; Madoffe and Munishi 2005; Marshall et al. 2005). I defined stumps as the base of woody plants that remained after the removal of the majority of the plant by humans, usually after cutting with a bush knife. I classified stumps with a diameter of 5 – 15 cm at the point of removal as ‘poles’, and stumps with a diameter of > 15 cm at the point of removal as ‘trees’. I included every cut (≥ 5 cm) on free-standing stems within the plots (e.g. I did not include stumps on fallen logs, or lianas).

QUANTIFYING ANTHROPOGENIC DISTURBANCE

I quantified anthropogenic disturbance by estimating the number of pole and tree stumps per hectare in 11 of the 13 mountain blocks in the Eastern Arc Mountains. I estimated the number of pole and tree stumps per hectare along a combined total of 346 transects in 59 forests within the 11 mountain blocks (Table 2.2; Appendix 2.1). I collected data from transect surveys using two methods: field data collection and a review of the literature.

Field data collection (N=26 transects in 13 forests in a single mountain block). I collected data in the field in the forests of the West Usambara mountain block from June 2008 through March 2009. In each forest I placed between one and seven transects. The number of transects varied based on the size of the forest and if the forest had been sectioned into areas which were managed by different authorities (Table 2.3). When transformed by natural logarithm, I found a significant and positive association between the number of transects per forest and forest size (coefficient estimate=1.73; standard error=0.64; p=0.021). I conducted this analysis using a general linear model in R (R Development Core Team 2010).

Each transect started at either the edge of a forest or the edge of a forest section. The starting points and directions of each transect were chosen to maximize the length of the transect, which in most cases meant aligning the transect with the longest axis of the forest. I consulted maps to determine the direction of the forest's longest axis. Transects continued for 3000 m, unless the end of the forest was reached first (range: 554 m to 3000 m). In forests with more than one transect, I spaced the transects a minimum of 750 meters apart. I had no prior knowledge of the forests and therefore the placement of the transects was not influenced by anything but an attempt to have the longest transect. A team of two or three observers walked each transect at a pace of ~200 m/hour. This team searched for all pole and tree stumps within a five meter width (2.5 meters on each side of the transect). The team recorded the diameter of each cut, from which I calculated the basal area (m^2).

A bias may have been introduced by the method of transect placement, in that the transects may contain a higher proportion of center to edge forest than does the forest as a whole. To assess the magnitude of this bias I examined the strength of the edge effect. A stronger edge effect would indicate a stronger bias. For each transect, distance was bracketed into 50 meter sections, and the basal area of pole and tree stumps in that section was summed. I plotted the basal area of pole and tree stumps as a function of distance from the start of the transect and then assessed the strength of either the linear or quadratic relationship between the variables. I examined linear fits for transects that went from forest edge to the forest center and I examined quadratic fits for transect that went from forest edge to forest edge. In all cases, there was no apparent effect of distance on disturbance (Appendix 2.2). This outcome may be a result of disturbance being widespread throughout the forest and suggests that any distinction between edge and center is weak in this forest. Therefore, I considered this bias to be of only minimal concern. I conducted these analyses in JMP 8.0.2 (SAS Institute Inc. 2009).

Literature review (N=320 transects in 46 forests in 10 mountain blocks). I searched the literature for reports of anthropogenic disturbance in forests in all of the other mountain blocks of the Eastern Arcs. I included reports that used similar methods to those described above (i.e. transects), and that presented data in a manner that permitted re-analysis (the number of transects and forests in each mountain block for which I found data varied and is reported in Table 2.2). For example, many reports included raw data on the number of pole and tree stumps on transects in the forests. Appendix 2.1 lists all of the reports used.

Statistical Analysis

I conducted an analysis of variance (ANOVA) to determine if the number of pole and tree stumps per hectare differed significantly among mountain blocks. I used each transect (N=346) in the 59 forests within the 11 mountain blocks as the datum for statistical analysis. I treated forest as a random effect nested within mountain block. I transformed by natural logarithm (plus a constant=1) both pole stumps and tree stumps per hectare in order to more closely satisfy the assumptions of normality, linearity, and homoscedasticity. I added the constant in order to avoid undefined values (i.e. natural logarithm of zero). I conducted the analysis in R using the ‘nlme’ package (Pinheiro et al. 2010; R Development Core Team 2010).

To determine the most and least disturbed mountain blocks, I calculated the median number of pole and tree stumps per hectare for each mountain block (Table 2.2). Subsequently, in Table 2.4, I ranked mountain blocks according to each measure of disturbance (1 = most disturbed, 11 = least disturbed). I also ranked the mountain blocks based on the remaining size of forests in the blocks (1 = smallest, 11 = largest), which Mbilinyi et al. (2006) estimated from satellite image analysis and is reported in Table 2.2. Finally, I calculated the mean of the three rankings for each mountain block (Table 2.4).

FACTORS INFLUENCING ANTHROPOGENIC DISTURBANCE

To identify the factors that influence anthropogenic forest disturbance, I examined how six measures of local human population size and behavior were related to forest disturbance in 13 forests of the West Usambara mountain block of the Eastern Arc Mountains (Figure 1.1).

Forest Disturbance

For this analysis, I defined forest disturbance as the basal area of pole and tree stumps per hectare. In this part of the study, I focused on the basal area of the stumps, rather than the number of stumps, because basal area provided a clearer picture of the amount of wood removed from the forest. I estimated disturbance in the field along 26 transects in a total of 13 forests within the West Usambara mountain block (Table 2.3). I described above the transect methods for field data collection.

Explanatory Variables

I identified six measures of local human population size and behavior that may influence disturbance, which I described in Table 2.1 and summarized in Table 2.5. I collected most of the data for these six measures from structured interviews of local people. I also collected data from the 2002 Tanzanian census (United Republic of Tanzania 2005) and I re-analyzed Geographic Information System (GIS) data using Quantam GIS 1.0.2 (data provided by Mbilinyi et al (2006)). A Tanzanian project assistant conducted the interviews in Kiswahili, though I was present for all interviews. Before beginning the interview, we read to the interviewee an explanation in which we described our scientific purpose and told them that their responses were confidential and anonymous. We also described how they were not required to participate nor required to answer any questions and that they would not be punished for any of their responses. I included a copy of this explanation in Appendix 2.3. We asked either multiple choice or short answer questions. The questions for this study were a subset of the questions for the entire survey; we asked other questions for the purposes of another research project (Appendix 2.3; questions for this study: 3, 7, 10, 14, and 15).

We conducted interviews in October 2009 in 10 households in each of two villages neighboring each of the 13 forests (10 households * 2 villages * 13 forests = 260 interviews). One respondent made conflicting responses on relevant questions and was excluded from data analysis for this study, which resulted in N=259. We chose villages that were closest to the forest edge, as it was suspected that individuals in these villages would have the most interactions with the forest. In the case that one large village was near to two forests, we conducted interviews in only the sub-village closest to each forest. In both cases where this occurred, the sub-villages were at least three kilometers apart. For the purposes of this study, these sub-villages were considered separate villages. In each of the villages, we consulted with the local government and an appropriate local guide was assigned to assist in our interviews. We selected households systematically by choosing either every third or every fifth household, depending on the perceived household density, irrespective of proximity to roads or village centers. Within a household, we interviewed either one adult male or one adult female (determined by who we encountered first). If no individuals from the selected household were home or agreed to participate, we selected the next household. We did not systematically collect data on the number of people who declined to participate; however, in most villages everyone agreed to participate and never more than two people per village declined.

1) Population pressure. To calculate population pressure, I divided each village's population size by size of the nearby forest (km^2). The census reported village population size and I calculated forest size from GIS analysis. I used each village as the datum for statistical analysis (N=26).

2) Median age of local people. The census reported the median age of local people in each village. I used each village as the datum for statistical analysis (N=26).

3) Hours per year in the forest. We asked each interviewee to report the time (in hours) they spend in forest per entry. We also asked each interviewee how often they go to the forest. Interviewees could respond by choosing one of the following: every day of the week; few days per week; few days per month; few days per year; or, never. I translated these categories into number of days in the forest per year (every day of the week=365, few days per week=156, few days per month=36, few days per year=10, or never=0). I multiplied the two responses (time in hours per entry * days of entry per year). I used each interviewee as the datum for statistical analysis (N=259).

4) Number of children. We asked each interviewee how many children they had. I used each interviewee as the datum for statistical analysis (N=259).

5) Farm size (acres). We asked each interviewee the total size of their farms. I used each interviewee as the datum for statistical analysis (N=259).

6) Support for conservation of the forest. We asked each interviewee if members of their village thought it was important to protect the forest. Interviewees could respond by choosing one of the following: yes, everyone; yes, many people; yes, but few people;

no; or, I don't know. I treated this variable as a binary response (high support or low/no support). I defined high support as a response of "everyone" or "many people". All other responses were considered low/no support. I used each interviewee as the datum for statistical analysis (N=259).

Statistical Analysis

I conducted two analyses, one for each measure of disturbance (basal area of pole stumps and basal area of tree stumps). For these analyses the sample size was a result of data sets with both nested and partially-crossed effects, as described below (N=319). Interviews (N=259) were nested within villages (N=26), which were nested within forests (N=13). Disturbance transects (N=26) were also nested within forests. Transects and villages were partially crossed. That is, I associated each village with at least one disturbance transect. In forests with two transects, I associated a single transect with a single village, which I determined by geographic proximity. I followed a similar procedure for forests with more than two transects, except that in this case, I associated multiple transects with a single village. For forests with only one transect, I associated both villages with the same transect.

I constructed linear mixed models to assess the relationship between the six explanatory variables (e.g. population pressure, support for conservation of the forest) and each response variable (e.g. basal area of pole stumps). I transformed all variables by natural logarithm in order to more closely satisfy the assumptions of normality, linearity, and homoscedasticity (except for the binary variable: support for conservation of the forest). Before transforming by natural logarithm, I added a constant (1) to the basal area of tree stumps, hours per year in the forest, number of children, and farm size in order to avoid undefined values (i.e. natural logarithm of zero).

For both analyses (pole stumps and tree stumps), I treated forest, village, and transect as random effects. However, the inclusion of transect caused the model to fail to achieve convergence. Due to the lack of convergence, and the limited variance explained by transect, I excluded it from both models. Subsequently, I ran the global model including all six explanatory variables. With little a priori reasoning to include specific interactions between explanatory variables, I followed the practice of Gelman and Hill (2007) and included interaction effects between the explanatory variables that had large effects. I analyzed all possible combinations of fixed effects and compared models using the second-order Akaike's information criterion (AICc; Burnham and Anderson 2002). I selected models within two AICc values of the model with the lowest AICc value, as I considered all of these models to have substantial empirical support, according to the guidelines provided by Burnham and Anderson (2002). Using Akaike weights, I averaged the parameters of the selected models (Burnham and Anderson 2002). I conducted these analyses in R using the ‘lme4’ and ‘MuMIn’ packages (Barton 2010; Bates and Maechler 2010; R Development Core Team 2010). I instructed ‘lme4’ to calculate estimates via the maximum likelihood method.

RESULTS

QUANTIFYING ANTHROPOGENIC DISTURBANCE

I found that there was nearly a 70-fold difference in the median density of pole stumps and about a 50-fold difference in the median density of tree stumps between the mountain blocks ($F_{10,48}$=3.79; p<0.001 and $F_{10,48}$=2.30; p=0.027, respectively; Table 2.2). An averaging of disturbance ranks across mountain blocks revealed that South Pare and Ukaguru were the most disturbed mountain blocks, whereas Nguu and Uluguru were the least disturbed (Table 2.4).

FACTORS INFLUENCING ANTHROPOGENIC DISTURBANCE

I used six explanatory variables, plus an interaction (between population pressure and median age of local people) to explain the basal area of pole stumps per hectare. After model selection and model averaging, I identified a model that included population pressure (positive effect) and median age of local people (positive effect, but wide 95% confidence interval) as explanatory variables. The interaction term was not included in the model after selection and averaging (Table 2.6a; Figure 2.1). I used the same six explanatory variables to explain the basal area of tree stumps per hectare (no interactions were included). After model selection and model averaging, I identified a model that included only the median age of local people (slightly positive effect, but wide 95% confidence interval) as the explanatory variable (Table 2.6b).

DISCUSSION

QUANTIFYING ANTHROPOGENIC DISTURBANCE

Anthropogenic disturbance varied in the mountain blocks of the Eastern Arcs and the block that is the focus of the second part of this study, West Usambara, was one of the more disturbed. Burgess et al. (2007) describe West Usambara to be a biologically important mountain block in terms of the biodiversity of tree species, which is troubling due to the high density of pole stumps (second highest density of the 13 blocks) and tree stumps found in this block (fourth highest density of the 13 blocks). These findings indicated that West Usambara was an appropriate mountain block for studies of the effects of humans on forest disturbance (next section), and of forest disturbance on primate populations (Chapter 3).

FACTORS INFLUENCING ANTHROPOGENIC DISTURBANCE

BASAL AREA OF POLE STUMPS PER HECTARE

I found that in areas of high population pressure in West Usambara there was also high basal area of pole stumps per hectare. This result is supported by the recent work of Persha and Blomley (2009), who studied two of the same forests that I examined. Persha and Blomley present data that show that the forest with the highest population pressure also had the highest frequency of pole stumps. Though our definition of pole stumps differed, and the authors did not explicitly test the relationship between these variables, their results accord with the results from this study.

The apparent strong effect of population pressure on forest disturbance in West Usambara is supported by a substantial body of literature that suggests that high human population density is associated with environmental degradation (Ehrlich 1968; Laurance 1999). For instance, in India a few studies have associated high population density with degraded forests (Agrawal and Yadama 1997; Karanth et al. 2006). Similarly, Becker and León (2000) show that in areas of high population density in Bolivia, there were declines in the density of 11 out of 28 studies tree species that local people used traditionally; this result also suggests that while population pressure affects the condition of the forest, it is not necessarily an indiscriminate effect.

Nevertheless, not all studies have found a relationship between population pressure and environmental degradation. For example, Varughese (2000) found that high human density occurred near to forests in both good and bad condition in Nepal. Instead of population as an influence on forest disturbance, he found that forests were less disturbed in areas where there was a more developed forest-related institution. This latter finding, which is only one example of many possible, indicates that other variables besides population certainly influence forest disturbance. Indeed a strong literature has developed that examines the influence of forest governance systems on forest quality (Agrawal and Yadama 1997; Gibson et al. 2000), including research from Tanzania (Blomley et al. 2008; Persha and Blomley 2009).

Basal area of tree stumps per hectare

None of the explanatory variables included in this study had a clear effect on the basal area of tree stumps per hectare in the forests of West Usambara. Due to the wide confidence intervals associated with the lone fixed effect, we cannot be confident in either the direction or the magnitude of the effect. The finding that population pressure did not influence tree removal, even though it seems to strongly influence pole removal suggests that there are fundamental differences between removing poles and removing trees. Further research is needed to understand these differences.

Additionally, the fact that no explanatory variable was strongly related to tree removal suggests that factors other than the included variables influence tree removal.

One important factor that was not included in the present analysis was the effect of forest governance, as also mentioned above regarding pole stumps. For instance, Persha and Blomley (2009) found that in West Usambara there was significantly more logging of large trees in co-managed forests (which are forests where local people and the government share management responsibility) as compared to communal and centralized forests, suggesting a strong role for governance in influencing forest disturbance. Similarly, Bleher et al. (2006) also found that governance type had a significant effect on forest disturbance, by showing that forest disturbance was greater in Forest Reserves as compared to National Reserves in Kenya. Other sensible factors to examine might include, for example, distance from village to forest (Karanth et al. 2006), distance of village and forests from roads, trains, or urban centers (Agrawal and Yadama 1997; Sauvajot et al. 1998), income or wealth of local people (Angelsen and Kaimowitz 1999; Brooks 2010; Godoy et al. 1997), and the education level of local people (Godoy and Contreras 2001). Finally, it may be that those people who remove trees from the forest are not members of the local population and therefore characteristics of the local population would not be expected to be related to tree removal.

CONCLUSION

Due to the widespread disturbance I documented in all mountain blocks, and the fact that there is a nearly complete lack of effective government regulation (personal observation; Persha and Blomley 2009), I suggest that most of the forests in the Eastern Arcs are utilized more or less without restriction by local people. This scenario is especially likely in the mountain blocks with the most forest disturbance. Therefore to achieve sustainable use of forest resources, systems are likely needed that restrict utilization.

The second part of the study provided both methodological and conservation insights. Methodologically, I presented evidence that showed how pole removal was fundamentally different than tree removal, in that population pressure influenced pole removal but not tree removal. While further research is necessary to understand the difference between pole and tree removal, researchers may want to account for this difference when examining forest disturbance. For conservation, results from this study suggest that conservation managers may want to focus resources and efforts on reducing forest utilization in large villages, and especially large villages near to small forests. In these areas of high human population pressure, managers may want to identify the specific uses of poles and trees by local communities and facilitate the provisioning of inexpensive alternatives that might take harvest pressure off local forests.

The next step in this research program is to examine how population pressure and forest disturbance interact with forest governance strategies in West Usambara, building upon the work of Persha and Blomley (2009). This next step is especially appropriate due to the emergence of a large body of research in Tanzania on forest governance (Blomley et al. 2008; Sumbi 2004; Woodcock et al. 2006), which is in large part due to a fairly recent policy adjustment at the national level which allows for increased local participation in forest management (Forestry and Beekeeping Division 2008).

Yet, while focusing on areas of high population pressure and examining the effectiveness of forest governance institutions may be fruitful approaches to eventually reducing forest degradation, many local people will continue to need to use local forest resources to meet daily needs regardless of the amount of control they have over the management of the forest. To ensure the survival of the forests, it is necessary to determine the levels at which forest utilization is either sustainable or destructive. A good measure of this threshold is to monitor the effects of forest disturbance on wildlife populations.

Chapter 3. The effects of disturbance on black-and-white colobus monkeys (*Colobus angolensis palliatus*) in the forests of West Usambara, Tanzania

CHAPTER 3. THE EFFECTS OF DISTURBANCE ON BLACK-AND-WHITE COLOBUS MONKEYS (*Colobus angolensis palliatus*) IN THE FORESTS OF WEST USAMBARA, TANZANIA

ABSTRACT

Determining the fate of species in disturbed areas is crucial for determining the sustainability of resource utilization. The present study examined how populations of *Colobus angolensis palliatus* monkeys fared in 13 anthropogenically disturbed forests in West Usambara, Tanzania. I documented the current and historic distribution of *C. a. palliatus*, and also examined the influence of forest disturbance on encounter rate with the monkeys and group size. I measured disturbance via transect surveys and estimated forest size via GIS analysis. I estimated the monkey's distribution and encounter rate via repeated transect surveys (range: 8-96 surveys per forest) and structured interviews of local people (N=260). I estimated *Colobus* group size during all group encounters. *C. a. palliatus* monkeys were absent and likely have become extinct in three forests, which were significantly smaller and had significantly higher basal area of pole stumps per hectare than forests where the monkeys were present. Further research is needed to determine if forest size and pole removal were causal factors in these local extinctions. I also found that in forests with a high basal area of tree stumps per hectare there was also a high encounter rate with *C. a. palliatus*. The finding that the monkey's population size may be high in forests with relatively high levels of tree removal (but not pole removal) suggests that the effects of removing poles and trees differ. Additionally, a clear relationship between the proportion of interviewees that reported *C. a. palliatus* were

present and the encounter rate calculated from transect surveys revealed that local knowledge may be useful when estimating the relative size of primate populations. Finally, the identification of localized primate extinctions suggests that forest utilization might be too severe (i.e. pole removal and forest loss), though the effects of different types of utilization need to be further examined.

KEY WORDS

anthropogenic disturbance, *Colobus angolensis*, conservation, distribution, Eastern Arc, encounter rate, extinction, forests, group size, Tanzania, West Usambara

INTRODUCTION

Although many primate species do not survive in anthropogenically disturbed areas, others do (Bierregaard et al. 1992; Harcourt 1998; Isaac and Cowlishaw 2004; Johns and Skorupa 1987). For instance, spider monkeys (*Ateles* spp.) in the Amazon National Park, Brazil were absent from anthropogenically disturbed areas, while at least five other primate species seemed to at least tolerate disturbance (Branch 1983). Along the same lines, ruffed lemurs (*Varecia variegata*) were absent from the most disturbed site in Ranomafana National Park, Madagascar, while other lemurs persisted amidst the disturbance (White et al. 1995). On the other extreme are those species that are not threatened by human disturbance. The most prominent example is that of the "weedy" macaques (*Macaca* spp.) that are so well-adapted to life with humans that they sometimes even thrive in city environments (Richard et al. 1989). Similarly, Johns (1991) described how many primates species in the Amazon had higher abundance in disturbed as compared to pristine habitats.

Determining the species that either become extinct or are able to persist in disturbed areas is crucial to developing conservation management strategies. That is, if species become extinct in disturbed forests, then it is likely that management strategies must change or that we must accept the loss of local biodiversity. On the other hand, if wildlife is able to survive or even thrive in disturbed forests, the current level of natural resource utilization is potentially acceptable, at least for the focal species. Of course, the latter scenario depends on monitoring the wildlife population for a long enough time period to ensure that any time-delayed effects of disturbance have had sufficient time to manifest (cf. extinction debt: Tilman et al. 1994).

This study examined the fate of populations of black-and-white colobus monkeys (*Colobus angolensis palliatus*) in the disturbed forests of West Usambara, Tanzania. In doing so, this study helped to determine the need, or lack thereof, to implement restrictions on forest use in West Usambara and, more generally, added to the literature on the fate of primates and of black-and-white colobus monkeys in disturbed areas.

BLACK-AND-WHITE COLOBUS MONKEYS IN DISTURBED FORESTS

The most prominent studies of black-and-white colobus monkeys have been of one species, *C. guereza* (Chapman et al. 2000; Oates 1977; Plumptre and Reynolds 1994; Skorupa 1986). The results from these studies have allowed researchers to generalize that black-and-white colobus monkeys can thrive in disturbed forests. For instance, Skorupa (1986) found that the abundance of *C. guereza* was highest in a heavily logged section of

Kibale National Park, Uganda. The results from Kibale are supported by studies of *C. guereza* in both the Ituri Forest, Democratic Republic of Congo and in Budongo Forest, Uganda (Plumptre and Reynolds 1994; Thomas 1991). In fact, Isaac and Cowlishaw (2004) show how *C. guereza* are on average nearly three times more abundant in logged forests than they are in unlogged forests.

Nevertheless, other evidence suggests that black-and-white colobus monkeys might not always thrive in disturbed forests. In the Udzungwa Mountains, Tanzania, Marshall et al. (2005) describe how black-and-white colobus monkeys (*C. angolensis*) had a lower abundance in the most disturbed forest. Similarly, in both Ituri and Lomako Forest, populations of *C. angolensis* were rare in disturbed forests (McGraw 1994; Thomas 1991). These types of findings are not limited to *C. angolensis*. Disturbance from local use in western Kenya and in forest fragments outside of Kibale may have led to a decline in the population of *C. guereza* (Chapman et al. 2007; von Hippel et al. 2000).

It is unknown how *C. a. palliatus* monkeys in West Usambara respond to disturbance, as this study is the first to systematically examine the populations (Rodgers 1981). To increase understanding, I first documented the current and historic distribution of *C. a. palliatus* in West Usambara, and determined if any cases of local extinction had occurred. Within this section, I also compared two methods that assessed the current distribution. Second, I examined the influence of anthropogenic forest disturbance on the encounter rate and group size of *C. a. palliatus*.

METHODS

STUDY SITE

I studied 13 forest fragments in the West Usambara mountain block of the Eastern Arcs Mountains in Tanzania (Figure 1.1). The Eastern Arc Mountains are a biodiversity hotspot with the troubling combination of a high number of endemic species and high levels of forest disturbance (Chapter 2; Burgess et al. 2007; Myers et al. 2000). Most households of the local human populace practice shifting cultivation at a subsistence level (e.g. Conte 2004; Mwampamba 2009), and many meet their daily needs by harvesting forest products (Halperin 2002; Ndanyalasi et al. 2007). The forests of West Usambara are some of the most disturbed in the entire hotspot (Chapter 2). Two primate species regularly inhabit the forests of West Usambara: black-and-white colobus monkeys (*C. angolensis palliatus*) and Sykes monkeys (*Cercopithecus mitis*).

STUDY SPECIES

I focused on the black-and-white colobus monkey (*C. a. palliatus*), an IUCN 'least concern' sub-species (Kingdon et al. 2008). *C. a. palliatus* mainly inhabits Tanzania, but also occupies small portions of Kenya, Malawi, and Zambia (Anderson et al. 2007; Kingdon et al. 2008; Rodgers 1981). Other species of *C. angolensis* inhabit countries across much of Central Africa (Fashing et al. 2007; Fimbel et al. 2001; Kingdon et al. 2008; Thomas 1991). More broadly, Grubb et al. (2003) recognize five species of black-and-white colobus. Researchers have tended to focus on *C. guereza* (Chapman et al. 2000; Chapman et al. 2007; Fashing 2001; Harris and Chapman 2007; Oates 1977; Thomas 1991), but many also study *C. polykomos*, *C. satanas*, and *C. vellerosus* (Dasilva 1994; Korstjens et al. 2005; McKey and Waterman 1982; Wong et al. 2006).

CURRENT DISTRIBUTION, HISTORIC DISTRIBUTION, AND LOCAL EXTINCTIONS

CURRENT DISTRIBUTION

I assessed the current distribution of *C. a. palliatus* in West Usambara, Tanzania by two methods: transect surveys and structured interviews.

Transect surveys: placement of transects. In each forest I placed between one and six transects (total transects = 25). The number of transects varied based on the size of the forest and if the forest had been sectioned into areas that were managed by different authorities (Table 3.1). When transformed by natural logarithm, I found a significant and positive association between the number of transects per forest and forest size (coefficient estimate=1.87; standard error=0.66; p=0.017). I conducted this analysis with a general linear model in R (R Development Core Team 2010).

Each transect started at either the edge of a forest or the edge of a forest section. The starting points and directions of each transect were chosen to maximize the length of the transect, which in most cases meant aligning the transect with the longest axis of the forest. I consulted maps to determine the direction of the forest's longest axis. Transects continued for 3000 m, unless the end of the forest was reached first (range: 667 m to 3000 m). In forests with more than one transect, I spaced the transects a minimum of 750 meters apart. I had no prior knowledge of the forests and therefore the placement of the transects was not influenced by anything but an attempt to have the longest possible transect.

A bias may have been introduced by the method of transect placement, in that the transects may contain a higher proportion of center to edge forest than does the forest as a whole. To assess the magnitude of this bias I examined the strength of the edge effect. A stronger edge effect would indicate a stronger bias. For each transect, distance was bracketed into 50 meter sections, and the basal area of pole and tree stumps in that section was summed (I describe below the details on data collection for the basal area of pole and tree stumps). I plotted the basal area of pole and tree stumps as a function of distance from the start of the transect and then assessed the strength of either the linear or quadratic relationship between the variables. I examined linear fits for transects that went from forest edge to the forest center and I examined quadratic fits for transect that went from forest edge to forest edge. In all cases, there was no apparent effect of distance on disturbance (Appendix 2.2). This outcome may be a result of disturbance being widespread throughout the forest and suggests that any distinction between edge and center is weak in this forest. Therefore, I considered this bias to be of only minimal concern. I conducted these analyses in JMP 8.0.2 (SAS Institute Inc. 2009).

Transect surveys: collection of data. A team of two or three observers walked each transect in one direction in search of primate groups roughly once every six weeks at a pace of ~1 km/hour between June 2008 and May 2010 (Table 3.1). Surveys started in the early morning, unless rain or fog was too dense. The team spent ≤10 minutes with each group in order to measure horizontal distance to the group (with a Nikon Forestry 550 laser rangefinder) and sighting angle (with a compass). We spent only 10 minutes with each group to ensure that the researchers moved along the transect faster than the primate groups to avoid duplicate encounters (Marshall et al. 2008). I later converted horizontal distance and sighting angle to the group's perpendicular distance from the transect. The team measured distance and sighting angle to four points: first individual sighted, nearest individual, visible group center, and estimated group center. If time permitted, the researchers also estimated group size and spread. Two observers assumed the role of lead researcher; these individuals trained together and often conducted surveys together; therefore I assumed that inter-observer variability was low, though data was not collected specifically on inter-observer differences.

One encounter was sufficient to determine that the monkey species was present in the forest, however I also calculated encounter rate (# of groups sighted divided by length of transect (km); Table 3.2), which is a commonly used statistic by primate researchers (Marshall et al. 2005; Mitani et al. 2000; Skorupa 1986; Struhsaker 1997). I had intended to calculate abundance in a manner that accounted for errors in detecting groups (e.g. Distance Analysis: Thomas et al. 2010); however, I encountered groups too infrequently to meet the requirements for this kind of robust density estimation (which generally require >40 observations per site; Peres 1999). To test the severity of the bias created by not controlling for detectability, I conducted an analysis of variance (ANOVA) to compare the perpendicular distances of observations (from observer to estimated group center) in this study between forests (N=231 observations from repeated transect surveys). If detection distances were similar, it would imply that detection probability was similar, and this bias would be minimized. I transformed perpendicular detection distance by natural logarithm (plus a constant=1) in order to more closely satisfy the assumptions of normality, linearity, and homoscedasticity. I added the constant in order to avoid undefined values (i.e. natural logarithm of zero). Transects were nested within forest and treated as a random effect. Forests did not differ significantly in perpendicular detection distance ($F_{9,10}$=1.25; p=0.366). I conducted this analysis in R using the ‘nlme’ package (Pinheiro et al. 2010; R Development Core Team 2010). As detection distances did not vary significantly, failing to control for detectability is of only limited concern.

Structured interviews. I supplemented transect surveys with structured interviews of local people. I asked interviewees if *C. a. palliatus* lived in the forest currently. I showed each interviewee a color picture of *C. a. palliatus* to ensure that the interviewee understood which animal was under consideration. There were three possible responses: yes; no; or I don't know. I calculated the proportion of the responses, for each possible response, for all 20 interviewees around each forest (Table 3.3).

A Tanzanian project assistant conducted the interviews in Kiswahili, though I was present for all interviews. Before beginning the interview, we read to the interviewee an explanation in which we described our scientific purpose and told them that their responses were confidential and anonymous. We also described how they were not required to participate nor required to answer any questions and that they would not be punished for any of their responses. I included a copy of this explanation in Appendix 2.3. We asked either multiple choice or short answer questions. The questions for this study were a subset of the questions for the entire survey; we asked other questions for the purposes of another research project (Appendix 2.3; question for this study: 30).

We conducted interviews in October 2009 in 10 households in each of two villages neighboring each of the 13 forests (10 households * 2 villages * 13 forests = 260 interviews). We chose villages that were closest to the forest edge, as it was suspected that individuals in these villages would have the most interactions with the forest. In the case that one large village was near to two forests, we conducted interviews in only the sub-village closest to each forest. In both cases where this occurred, the sub-villages were at least three kilometers apart. For the purposes of this study, these sub-villages were considered separate villages. In each of the villages, we consulted with the local government and an appropriate local guide was assigned to assist in our interviews. We selected households systematically by choosing either every third or every fifth household, depending on the perceived household density, irrespective of proximity to roads or village centers. Within a household, we interviewed either one adult male or one adult female (determined by who we encountered first). If no individuals from the selected household were home or agreed to participate, we selected the next household. We did not systematically collected data on the number of people who declined to participate; however, in most villages everyone agreed to participate and never more than two people per village declined.

Relationship between results from transect surveys and structured interviews. I considered the results from transect surveys as the definitive source for the monkey's presence or absence. However, I also assessed the relationship between the results from transect surveys (i.e. encounter rate) and the structured interviews (i.e. interviewees reporting that the monkeys were present) to determine if the two methods produced related results. For this analysis the sample size was a result of a data set with both nested and partially-crossed effects, as described below (N=374). I calculated encounter rate for each transect survey (N=310) and I calculated the proportion of interviewees per village who reported that the monkeys were present (N=26). Village and encounter rate per transect were both nested within forests (N=13). I treated forest, village, and transect as random effects. Transects and villages were partially crossed. That is, I associated each village with at least one disturbance transect. In forests with two transects, I associated a single transect with a single village, which I determined by geographic proximity. I followed a similar procedure for forests with more than two transects, except that in this case, I associated multiple transects with a single village. For forests with only one transect, I associated both villages with the same transect.

I constructed a linear mixed model to assess the relationship between the two variables (encounter rate and proportion of interviewees reporting that the monkeys were present). I transformed encounter rate by natural logarithm plus a constant (1) in order to more closely satisfy the assumptions of normality, linearity, and homoscedasticity. I added a constant in order to avoid undefined values (i.e. natural logarithm of zero). I conducted this analysis in R using the 'nlme' package (Pinheiro et al. 2010; R Development Core Team 2010).

Historic Distribution

I determined historic distribution from structured interviews of local people in the same interviews as described above. We asked interviewees if *C. a. palliatus* lived in the forest in the past. Again, I showed each interviewee a color picture of *C. a. palliatus* to ensure that the interviewee understood which animal was under consideration. There were three possible responses: yes; no; or I don't know. I calculated the proportion of the responses, for each possible response, for all 20 interviewees around each forest (Table 3.3). The strength of evidence for historical presence was determined by the proportions of interviewees that confirmed a historical presence (strong evidence: >50% of interviewees confirmed; moderate evidence: 25-50% of interviewees confirmed; weak evidence: 5-25% of interviewees confirmed).

As it may be expected that younger people would have different knowledge about the historic presence of primates than older people, I examined how an interviewee's age was related to reporting that primates were historically present. I conducted this analysis first for all interviewees (N=260), and then for only interviewees that were at least 40 years old (N=136). I examined both data sets by constructing generalized linear mixed models with binomial distributions, and included both forest and village as random effects. When including all interviewees, I found that age was positively associated with reporting that the monkeys were historically present in the forest (coefficient estimate=0.03; standard error=0.01; p=0.007). However, when I restricted data to interviewees at least 40 years old, the relationship ceased to exist (coefficient estimate=0.00; standard error=0.02; p=0.914). Therefore, I chose to limit the data set in this part of the study to only interviewees that were at least 40 years old in order to reduce the bias caused by age in reporting historical presence. I conducted analyses in R using the 'lme4' package (Bates and Maechler 2010; R Development Core Team 2010).

Local Extinctions

I considered that local extinction occurred when the transect surveys failed to find the primate, but interviewees reported that the primate historically inhabited the forest (Table 3.3). The strength of evidence for local extinction was determined by the proportions of interviewees that confirmed a historical presence (strong evidence: >50% of interviewees confirmed; moderate evidence: 25-50% of interviewees confirmed; weak evidence: 5-25% of interviewees confirmed).

THE INFLUENCE OF ANTHROPOGENIC FOREST DISTURBANCE

ANTHROPOGENIC FOREST DISTURBANCE

I defined anthropogenic forest disturbance by three variables: forest size (km^2) and the basal area (m^2) of poles and trees stumps in each forest. I examined the influences on forest disturbance in West Usambara in detail in Chapter 2.

Forest size (km^2). The entire West Usambara mountain block was once a large, single forest (Newmark 1998), and therefore forest size is the result of forest loss, and a measure of it. I calculated the size of each forest in West Usambara examined in this study by further analyzing GIS data created by Mbilinyi et al. (2006), using Quantam GIS 1.0.2, an open-source GIS software package (N=13; Table 3.1).

Basal area of pole stumps and tree stumps per hectare. I defined stumps as the base of woody plants that remained after the removal of the majority of the plant by humans, usually after cutting with a bush knife. I classified stumps with a diameter of 5 – 15 cm at the point of removal as poles, and stumps with a diameter of > 15 cm at the point of removal as trees. I included every cut (≥ 5 cm) on free-standing stems within the plots (e.g. I did not include stumps on fallen logs, or lianas).

The basal area of pole and tree stumps in each forest was determined based on data collected from transect surveys that started in June 2008 and ended in March 2009 (N=25). Above, I have described the placement of transects in the forest. Each transect was walked one time by a team of two or three observers at a pace of ~200 m/hour. This team searched for all pole and tree stumps within a five meter width (2.5 meters on each side of the transect). The team recorded the diameter of each cut, from which I calculated the basal area (m^2). Finally, I calculated the basal area of stumps per hectare for each transect (N=25; Table 3.2).

POPULATION PARAMETERS

I defined the population of black-and-white colobus monkeys by two variables: encounter rate and group size.

Encounter rate. I described above the methods for the calculation of encounter rate.

Group Size. The research team measured group size when encountering groups during transect surveys (if time allowed), and when encountering groups opportunistically. In analysis, I included only reliable group counts (i.e. when we were confident of the count within about one individual). In all cases, I used the actual counted group size as the datum, and as a result I considered group sizes to be minima (Table 3.4).

STATISTICAL ANALYSIS

First, as I found that the monkeys were absent from three of the 13 forests (see below: CURRENT DISTRIBUTION), I compared anthropogenic disturbance in the forests where the monkeys were absent to the disturbance in the forest where the monkeys were present by conducting an analysis of variance (ANOVA). I also examined the relationships between the three measures of disturbance by constructing linear mixed models in order to determine if the different types of disturbance acted synergistically. For these analyses, I transformed all three measures of disturbance by natural logarithm in order to more closely satisfy the assumptions of normality, linearity, and homoscedasticity. Before transforming by natural logarithm, I added a constant (1) to the basal area of tree stumps per hectare in order to avoid undefined values (i.e. natural logarithm of zero). For the ANOVA test for forest size, I used forest as the datum (N=13). For all of the other analyses, I used each transect as the datum for statistical analyses (N=25); transects were nested within forest (N=13). I treated forest as a random effect.

Second, I constructed a linear mixed model to assess the relationship between the measures of disturbance (i.e. forest size, basal area of pole stumps, and basal area of tree stumps) and encounter rate in forests where the monkeys were present. For this analysis, I used the encounter rate for each transect walk as the datum (N=284). I recorded multiple observations along each transect due to repeated walks of the transects. Transects (N=22) were nested with forests (N=10) and I treated both as random effects. I transformed all variables by natural logarithm in order to more closely satisfy the assumptions of normality, linearity, and homoscedasticity. Before transforming by natural logarithm, I added a constant (1) to the encounter rate and the basal area of tree stumps per hectare in order to avoid undefined values (i.e. natural logarithm of zero).

I also constructed a generalized linear mixed model with Poisson distributions to assess the relationship between the measures of disturbance (i.e. forest size, basal area of pole stumps, and basal area of tree stumps) and group size in forests where the monkeys were present. I used each reliable group count as the datum (N=109). I treated forest (N=10) as a random effect. I transformed the basal area of pole and trees stumps by dividing each value by 10 in order to ensure convergence of the models.

For both analyses (to explain the encounter rate and group size), I ran the global model including all three explanatory variables. With little a priori reasoning to include specific interactions between explanatory variables, I followed the practice of Gelman and Hill (2007) and included interaction effects between the explanatory variables that had large effects. I analyzed all possible combinations of fixed effects and compared models using the second-order Akaike's information criterion (AICc; Burnham and Anderson 2002). I selected models within two AICc values of the model with the lowest AICc value, as I considered all of these models to have substantial empirical support, according to the guidelines provided by Burnham and Anderson (2002). Using Akaike weights, I averaged the parameters of the selected models (Burnham and Anderson 2002). I conducted analyses in R using the 'nlme', 'lme4' and 'MuMIn' packages (Barton 2010; Bates and Maechler 2010; Pinheiro et al. 2010; R Development Core Team 2010). I instructed 'lme4' to calculate estimates via the maximum likelihood method.

RESULTS

CURRENT DISTRIBUTION, HISTORIC DISTRIBUTION, AND LOCAL EXTINCTIONS

Current Distribution

The research team encountered black-and-white colobus monkeys during transect surveys in all but three of the forests in West Usambara, Tanzania (Table 3.2 and 3.3). The absence of black-and-white colobus monkeys in these forests (Lutindi, Mtumbi, and Shambalai) was supported by the finding that only 5-10% of interviewees reported that black-and-white colobus monkeys currently lived in the forests (Table 3.3). In only one forest (Ambangulu / Vugiri) did the results between transect surveys and structured interviewees differ drastically (Table 3.3). The team encountered black-and-white colobus monkeys during transect surveys; however, only 35% of interviewees reported that the monkeys were present. The discrepancy is likely due to the extremely low encounter rate of black-and-white colobus in this forest (Table 3.2). Indeed, across the study site, the proportion of interviewees per village that reported that black-and-white colobus monkeys were present had a positive relationship with the encounter rate as calculated by transect surveys (Figure 3.1; Table 3.5).

HISTORIC DISTRIBUTION

As West Usambara was historically one large forest that was subsequently fragmented into isolated forests (Newmark 1998), we can safely assume that black-and-white colobus monkey were historically present in all of the forests. This assumption was mostly supported by the results of the structured interviews. In 12 of the 13 forests, there was strong evidence that black-and-white colobus inhabited the forests in the recent past (≥50% of the interviewees confirmed; Table 3.3). In one forest there was only weak evidence of historical presence (5-25% of the interviewees confirmed; Table 3.3).

LOCAL EXTINCTIONS

In the three forests (Lutindi, Mtumbi, and Shambalai) where black-and-white colobus were currently absent, evidence of historical presence varied. In two of the three forests (Lutindi and Mtumbi), evidence of historical presence was moderate with 55% and 56% of interviewees reporting that the monkeys were present in the past (Table 3.3). In the third forest (Shambalai), evidence of historical presence was weak, with only 9% of interviewees reporting that the monkeys were present in the past (Table 3.3).

THE INFLUENCE OF ANTHROPOGENIC FOREST DISTURBANCE

COMPARISON OF DISTURBANCE IN FORESTS WITH AND WITHOUT *C. A. PALLIATUS*

I found that the forests where black-and-white colobus monkeys were absent were significantly smaller than the forests where they were present ($F_{1,11}$=13.23; p=0.004; Figure 3.2). Also, I found that the basal area of pole stumps per hectare was significantly higher in forests where the monkeys were absent than in the forests where they were present ($F_{1,11}$=10.56; p=0.008; Figure 3.2). I did not find a significant difference in the basal area of tree stumps per hectare ($F_{1,11}$=0.28; p=0.609; Figure 3.2).

RELATIONSHIPS BETWEEN DISTURBANCE MEASURES

Also, I found that forest size and the density of pole stumps had a strong negative relationship (coefficient estimate=-0.45; standard error=0.13; p=0.007). That is, smaller forests had higher densities of pole stumps. The relationships between forest size and the density of tree stumps (coefficient estimate=0.08; standard error=0.14; p=0.596), and the density of tree stumps and the density of pole stumps (coefficient estimate=0.23; standard error=0.23; p=0.340) did not achieve significance.

THE INFLUENCE OF ANTHROPOGENIC FOREST DISTURBANCE ON POPULATION PARAMETERS

I used three explanatory variables (no interactions were included) to explain the encounter rate of black-and-white colobus monkeys. After model selection and model averaging, I identified a model that included the basal area of tree stumps per hectare (positive effect and a wide 95% confidence interval; Figure 3.3), the basal area of pole stumps per hectare (nearly no effect and a wide 95% confidence interval), and forest size (nearly no effect and a wide 95% confidence interval) as explanatory variables (Table 3.6a). I used the same three explanatory variables (no interactions were included) to explain group size of black-and-white colobus monkeys. After model selection and model averaging, I identified a model that included the basal area of tree stumps per hectare (nearly no effect and a wide 95% confidence interval), the basal area of pole stumps per hectare (slightly positive effect, but wide 95% confidence interval), and forest size (nearly no effect and a wide 95% confidence interval) as explanatory variables (Table 3.6b).

DISCUSSION

LOCAL EXTINCTIONS

Black-and-white colobus monkeys were absent from three forests in West Usambara, and have likely become locally extinct in at least two of the cases (Table 3.3). I found that the forests where the monkeys were absent were smaller and had more pole stumps than the forest where they were present, and that forest size and the density of pole stumps may act synergistically. These findings suggest that black-and-white colobus monkeys fail to survive in forests that are too small and where pole removal is too intense. The current data set does not allow for an examination to determine if extinctions would also occur in small forests without pole removal, or in large forests with high pole removal.

Anderson et al. (2007) also found that small forests were related to the absence of *C. angolensis palliatus*. The effect of species-area relationships may be the best explanation for these findings (MacArthur and Wilson 1967; Marshall et al. 2010). In terms of pole removal, the removal of plants from a forest will likely reduce available food (Johns 1988; Kinnaird 1992; Rode et al. 2006) and could have consequences for survival, however it is not entirely clear why pole removal would be associated with local extinction, but not tree removal. One scenario is that pole removal may result in a loss of food as mentioned, while tree removal may result in the growth of dense secondary forest and an increase in food (described below). Or, it may be the case that extinction is simply due to small forest size, and dense pole removal in small forests is unrelated to extinction.

Yet another scenario is that dense pole removal may equate with frequent entry by humans into the forest (i.e. daily collection of firewood by many local people) and increased human presence in the forest might be related to increased hunting frequency. Dense tree removal would not cause a similar increase in hunting because tree removal is not necessarily associated with frequent human entry into the forest (i.e. a small team of loggers cutting down many trees). This final scenario is plausible due to the well-documented and strong negative effects of hunting on primates (Isaac and Cowlishaw 2004). For instance, *C. angolensis* seem to do poorly in hunted areas, at least in Ituri Forest (Isaac and Cowlishaw 2004; Thomas 1991). More broadly, Peres (2001) describes how hunting in small forests in the Amazon can lead to the extinction of mid- to large-sized vertebrates. In West Usambara, I have observed both direct and indirect evidence of hunting; however I have yet to be able to quantify hunting intensity. While I asked interviewees about hunting in the forests, most of them appeared too shy to report the occurrence of activity that I suspect most of them know is illegal. Further study of hunting pressure in West Usambara is clearly necessary.

Regardless of the causal factors involved, the identification of local extinctions amidst disturbance is supported by many other studies on primates. For example, Skorupa (1986) present evidence of several primates species having lower abundance in logged forests in Kibale. In a more recent study in Kibale, red-tail guenons (*Cercopithecus ascanius*) were shown to have both lower food availability and lower population density in logged forests than in unlogged forests (Rode et al. 2006). Both the Tana River red colobus (*Procolobus rufomitratus*) and the crested mangabey (*Cercocebus galeritus galeritus*) seem to have lower group density in smaller forests (Medley 1993; Wahungu et al. 2005). For *C. angolensis*, both McGraw (1994) and Thomas (1991) found lower abundances in internally disturbed sections, as compared to pristine sections of two separate forests in the Democratic Republic of Congo, and Marshall et al. (2005) found similar results in southern Tanzania. While many populations of *C. guereza* have been shown to do well in disturbed areas (see citations in the Introduction and discussed below), populations have also been shown to survive poorly in disturbed forests in both the fragments outside of Kibale (Chapman et al. 2007) and in Kakamega Forest in western Kenya (von Hippel et al. 2000).

If pole removal and forest size do indeed influence local extinction of *C. angolensis palliatus* in West Usambara, it would be expected that these variables would also have negative relationships with the monkey's encounter rate. However, in contrast, both pole removal and forest size lacked an effect on the encounter rate of black-and-white colobus monkeys (Table 3.6a). Among other possibilities to explain the apparently anomalous results, it might be that as forests become smaller and/or pole removal becomes more dense, primate population size does decrease. However, this decrease may be disguised by the temporary effects of a compressed population (Decker 1994).

ENCOUNTER RATE

I also found that in forests in West Usambara with a high basal area of tree stumps per hectare there was also a high rate of encounter with black-and-white colobus monkeys, though this effect was slight and the 95% confidence interval was wide (Table 3.6a; Figure 3.3). If further examination supports this tentative finding, it suggests that the removal of trees does not harm these primates, and may even (slightly) help them. One explanation for this scenario is that as disturbance continues and more trees are removed, other trees gain more exposure to sunlight, and subsequently are able to produce more new leaves with higher protein-to-fiber ratios (Ganzhorn 1995; Johns 1988). Leaves with high protein-to-fiber ratios are a preferred food source for black-and-white colobus monkeys (Chapman et al. 2004) and increased amounts of preferred food may have a positive effect on a population, though this is not always the case (e.g. *Hylobates albibarbis*: Marshall and Leighton 2006).

The finding that *C. angolensis palliatus* might do well in areas with more trees removed is supported by many other studies of primates and by most studies of *C. guereza*. For instance, Thomas (1991) reports that three *Cercopithecus* monkeys in Ituri had higher population densities in areas that were previously agricultural plots than in primary forest. This finding also supports the idea that disturbed forests might have more food, as Thomas suggests that the high density of monkeys in the disturbed areas may be a result of the continuous fruit availability from a pioneer species (*Musanga cecropioides*). In Budongo, Plumptre and Reynolds (1994) show how *C. guereza*, blue monkeys (*Cercopithecus mitis*), and red-tail guenons all benefit from selective logging. Skorupa (1986) also describes how the *C. guereza* do well in disturbed areas of Kibale, as do gorillas (*Gorilla gorilla beringei*) in Rwanda (e.g. Schaller 1963).

Previous studies of *C. angolensis* in disturbed forests have tended to show that they do poorly (Anderson et al. 2007; Marshall et al. 2005; McGraw 1994; Thomas 1991), which runs contrary to the tentative results from this part of this study. It may be that by refining the classification of disturbance (i.e. poles vs. trees), I was able to better distinguish the effects of disturbance on this species. That is, I found that pole removal may contribute to the local extinction of these monkeys while tree removal seems to actually provide slight benefits. Results from Chapter 2 also suggested that pole removal was fundamentally different than tree removal. As the findings of these studies are preliminary, further research is necessary to help understand differences in the effects of pole and tree removal.

METHODS FOR ESTIMATING ABUNDANCE

Line transect surveys are a widespread method used to estimate the abundance of primate populations (Buckland et al. 2010b; Ferrari et al. 2010; Plumptre 2000; Thomas et al. 2010). Yet, transect surveys are wrought with challenges. For example, line transect surveys can be burdensome for projects logistically and financially (Marshall and Meijaard 2009; Peres 1999). Additionally, researchers have engaged in substantial debate over data collection and analysis procedures (Buckland et al. 2010a; Marshall and

Meijaard 2009; Marshall et al. 2008). These debates illustrate the questionable accuracy of some estimates (Brugiere and Fleury 2000; Hassel-Finnegan et al. 2008). Finally, to construct line transects, researchers often cut new trails into seldom-accessed sections of forests (Peres 1999). These new trails make the forest accessible to more people and attract even more forest disturbance (personal observation). Clearly, we need suitable alternatives for estimating primate density (Marshall and Meijaard 2009).

The results from this study suggest that structured interviews might be a viable alternative to transect surveys and avoid many of their challenges. I found that the proportion of interviewees per village that reported that black-and-white colobus monkeys were present was positively related to the encounter rate I calculated from transect surveys (Figure 3.1), suggesting that structured interviews may provide useful estimates of the relative size of *C. angolensis* populations. Additionally, interviews can be conducted quite rapidly on small budgets. For example, the interviews for this study took only one month to complete (as compared to two years for the transect surveys) and the financial cost of the interviews were only a small percentage of the cost of the transect surveys. Structured interviews also avoid the problem of increasing access to forests. Of course, to confirm the present findings, we need more studies that compare results of interviews with the results of line transect surveys and with primate populations with known sizes.

CONCLUSION

C. angolensis palliatus has likely gone extinct in three small forests with intense pole removal in West Usambara, which suggests that forest utilization might be too severe.

However, the evidence that forest and/or pole removal were influential factors was not entirely clear and suggested that an additional and unmeasured variable might be involved in the local extinction of these monkeys, such as hunting. The understanding here would benefit from research on hunting pressure in West Usambara. Additionally, that these monkeys may thrive in forests with intense tree removal runs contrary to both the first part of the study, and to the literature on *C. angolensis* in disturbed forests. This result suggests that it may be beneficial to distinguish the effects of pole removal from the effects of tree removal when examining how populations survive in disturbed forests. That is, we need to examine not only the intensity, but also the types of disturbance that have (either negative or positive) effects on *Colobus* populations.

This study also found that structured interviews with local humans might provide valuable information about the current distribution of monkeys in local forests. In this study, structured interviews were much more efficient in terms of time spent and financial cost than transect surveys. Interviews with local people may be a suitable method under some circumstances for determining the distribution of primates. Marshall and Meijaard (2009) have also suggested that structured interviews with local people may be a sensible approach to estimating the (relative) parameters of primate populations.

As these results are preliminary, it is too early to know if utilization is too severe. Nevertheless, as local extinctions have indeed occurred, it may be the case the conservation managers need to attempt to limit utilization in at least some of the forests in West Usambara.

Chapter 4. Preparing for participatory management: local awareness and support for conservation in West Usambara, Tanzania

CHAPTER 4. PREPARING FOR PARTICIPATORY MANAGEMENT: LOCAL AWARENESS AND SUPPORT FOR CONSERVATION IN WEST USAMBARA, TANZANIA

ABSTRACT

Local communities ultimately determine whether forest utilization is sustainable in many areas of the world and, thus, their engagement is essential to conservation efforts. Much research has been conducted on engaging people in conservation via participatory management. While a valuable approach, efforts to initiate participatory management could benefit from prior understanding of local circumstances. At minimum, three actions are needed: ensuring that local people understand their effects on the environment, identifying local support for conservation, and understanding the factors that influence support for conservation. I examined these three issues for the conservation of forests and primates in West Usambara, Tanzania by conducting 10 structured interviews in each of two villages surrounding each of 13 forests (N=260 interviews). I found that local people had a near unanimous awareness that removing poles and trees from the forest and clearing forests for farms was bad for forests and primates. Additionally, local people had high support for conservation of forests, especially as compared to support for conservation of primates. Widespread awareness of effects on the environment indicates that local people may be able to develop sensible management strategies, and high support for conservation of the forests suggests that local people may sustainably manage the forest. Also, I found that large farms were associated with high support for the conservation of forests. This may be a result of low dependence on forests for families

with large farms, which results in a willingness to forgo open-access to the forest in return for the long-term benefits of forest conservation. This result suggests that support for conservation could be bolstered by increasing access to non-forest resources. Finally, this study points to both the necessity and ease of gaining knowledge from the community prior to initiating participatory management.

KEY WORDS

awareness, *Cercopithecus mitis*, *Colobus angolensis*, conservation, Eastern Arc, farm size, forests, local communities, participatory management, Tanzania, West Usambara

INTRODUTION

Local communities can strongly influence either the destruction or conservation of natural habitats (Borgerhoff Mulder and Coppolillo 2005; Gadgil 1992; Pimbert and Pretty 1997). If ignored by a conservation project, local people may even deliberately increase destruction. For instance, in Sagarmatha National Park, Nepal local people increased timber extraction when traditional systems of conservation were replaced by state-run systems (Stevens 1997). However if local people are actively engaged, conservation can succeed. A nice example of this comes from San Salvador Island, Philippines, where the local people were engaged in and became the driving forces behind the successful protection of a coral reef (Katon et al. 1999). Outside influences spurred and initially helped organize the conservation effort in San Salvador, yet at the core of the project was the engagement of the local community.

Much effort has been applied to the engagement of local communities in conservation, often via the promotion of participatory management, in which local communities gain formal rights to manage the natural resource (Lund et al. 2009; Saxena 1997). The premise is that users of the resources may be the ones that are most apt to develop guidelines for sustainable use, and are also the ones that are able to monitor use, all of which will result in improved conservation (i.e. common-pool resource use: Ostrom 1999). When implemented, the participatory management approach appears to have been successful in terms of conservation, at least in some areas. For example, Blomley et al. (2008) describe three cases from Tanzania where forests were in better condition under participatory management as compared to forests not under participatory management. However, the installation of participatory management has proven to be a long and challenging process that is both costly to organizations that are helping communities establish participatory management and to the members of the communities themselves (Meshack et al. 2006; Woodcock et al. 2006). It may that be that a better understanding of local circumstances prior to engaging in the decentralization of management may help to alleviate some of the challenges. At minimum, the following three questions about local circumstances should be asked prior to the initiation of a participatory management approach. The answers to these questions will help managers better know if and how to engage the local population in sustainable management of the forest.

1) Do local people understand how their actions affect the environment? In many areas, local people are a driving force in the destruction of natural habitats (Chapter 2; Geist and Lambin 2001). If these same people are to participate in the management of the habitat, it is necessary for them to understand the effects of their actions on the habitat in

order for them to be able to create sensible management strategies. Historical accounts of the Cree people in Canada illustrate this point. The Cree's detailed understanding of the effects of hunting on beaver populations led them to develop and refine systems and institutions over decades that ensured sustainability (Berkes 1998). Only by understanding one's affect on the environment can one be able to develop sustainable systems. If awareness does not yet exist, creating this awareness may be a necessary first step before engaging the local people as resource managers.

2) Do local people support conservation? Local people who support conservation may be most interested in taking part in participatory forest management. For instance, in Uganda, local people's desire for conservation of the forest was a factor in the decision of local organizations to take part in participatory forest management (Turyahabwe et al. 2007). Furthermore, local people with support for conservation may also be people that will most effectively and sustainably manage habitats. This is best illustrated by the self-initiated community management of forests in Orissa, India (Conroy et al. 2002). People in these communities initiated local protection of the forests after recognizing the need for conservation due to the degradation of neighboring forests. Their support for conservation was transformed into local management of the forest, which in turn has seemed to benefit the ecological condition of the forest. In contrast, users without conservation interests may seek to gain management control of a habitat to ensure access to the habitat's resource, rather than to responsibly manage the forest, as was shown to be the intention of users in the iGxalingenwa forest in South Africa (Robertson and Lawes 2005).

3) What influences support for conservation? Support for conservation may positively influence participatory management (see above; Conroy et al. 2002). The next step in preparing for participatory management is to identify the factors that influence support, as these factors can be built upon to garner widespread support for conservation. Widespread support of conservation is important in that it may help minimize conflict during the set-up and activities of participatory management. For instance, some community members may have differing opinions over the amount of utilization that should be allowed in a forest (Conroy et al. 2002; Woodcock et al. 2006). If support for conservation is widespread, this type of conflict may be minimized.

I answered these three questions in regards to the conservation of forests and primates in communities in the West Usambara Mountains of Tanzania. First, I examined if local people were aware of their effects on forests and primates. Second, I estimated the local support for conservation, using three focal points (the forest and two primate species). I examined the support for the three focal points to determine if local people's support varied. If support does vary, engaging local people in participatory management may be most successful if the focus is on the factor with the highest level of support. Finally, to determine strategies that might help bolster support for conservation, I examined the influence of five factors on the support for conservation of forests and primates, and an additional sixth factor that might influence support for conservation of only primates (Table 4.1).

This chapter examines only one aspect (i.e. engaging local people) of the complex pursuit of sustainable use. Even if local people understand the environmental impacts of their actions, support conservation, and engage in forest management, it does not necessarily mean that the sustainable use of forests will follow. Local people must also be able and willing to reduce their current harvest rates, which would require that alternative resources are available and economically-sensible. Previously, I have identified at least one social factor that influences harvest rates (Chapter 2); an understanding of the social factors that drive harvest rates is one step towards reducing harvest rates. Another step towards reducing harvest rates, which has yet to investigated in West Usambara, is a close examination of the availability and economics of alternative resources.

METHODS

STUDY SITE

This study took place around 13 forests in the West Usambara mountain block of the Eastern Arcs Mountains in Tanzania (Figure 1.1). The forests in the mountain blocks of the Eastern Arc Mountains are a biodiversity hotspot with the troubling combination of high levels of endemic species and high levels of forest disturbance (Chapter 2; Burgess et al. 2007; Myers et al. 2000). In fact, the forests of West Usambara are some of the most disturbed in the entire hotspot (Chapter 2). Two diurnal primate species regularly inhabit forests in West Usambara, the black-and-white colobus monkey (*Colobus angolensis*) and the Sykes monkey (*Cercopithecus mitis*). Both were in 10 of the 13 forests in this study; the black-and-white colobus was absent from three (Chapter 3). Most households of the local human populace practice shifting cultivation at a subsistence level in the Eastern Arcs (e.g. Conte 2004; Mwampamba 2009), and many meet their daily needs by harvesting forest products (Halperin 2002; Ndanyalasi et al. 2007).

The Tanzanian government has actively promoted participatory forest management over the last ~20 years, and its implementation is now widespread (Blomley et al. 2008; Forestry and Beekeeping Division 2008). In West Usambara, great effort that has been put into participatory forest management in West Usambara (e.g. by the Tanzania Forest Conservation Group: Woodcock et al. 2006), and these efforts could be aided by increased understanding of local circumstances.

DATA COLLECTION

I collected data for this study based on structured interviews of local people that asked questions on three topics: first, the awareness of the effects of human activities on forests and primates; second, local peoples' support for conservation of forests and primates; and third, the factors that influence local peoples' support for conservation of forests and primates. A Tanzanian project assistant conducted the interviews in Kiswahili, though I was present for all interviews. Before beginning the interview, we read to the interviewee an explanation in which we described our scientific purpose and told them that their responses were confidential and anonymous. We also described how they were not required to participate nor required to answer any questions and that they would not be punished for any of their responses. I included a copy of this explanation in Appendix 2.3. We asked either multiple choice or short answer questions. The questions for this study were a subset of the questions for the entire survey; we asked other questions for the purposes of another research project (Appendix 2.3; questions for this study: 3, 7, 10, 13, 14, 15, 16, 19, 26, 28, 29, 31, 39, 41, and 42.).

We conducted interviews in October 2009 in 10 households in each of two villages neighboring each of the 13 forests (10 households * 2 villages * 13 forests = 260 interviews). Some interviewees did not respond to questions regarding the primates because they lacked knowledge that the primates existed in the local forest or due to the local absence of the primates (black-and-white colobus monkeys were absent from three forest and therefore six villages; Chapter 3). As a result, sample size was highest for questions regarding forests (N=260), lower for questions regarding black-and-white colobus (N=156), and moderate for questions regarding Sykes monkeys (N=235). By interviewees not responding to some questions, a bias was created and the results from this study are therefore only indicative of people who recognize the presence of the primates in the local forest.

We chose villages that were closest to the forest edge, as it was suspected that individuals in these villages would have the most interactions with the forest. In the case that one large village was near to two forests, we conducted interviews in only the sub-village closest to each forest. In both cases where this occurred, the sub-villages were at least three kilometers apart. For the purposes of this study, these sub-villages were considered separate villages. In each of the villages, we consulted with the local government and an appropriate local guide was assigned to assist in our interviews. We selected households systematically by choosing either every third or every fifth household, depending on the perceived household density, irrespective of proximity to roads or village centers. Within a household, we interviewed either one adult male or one adult female (determined by who we encountered first). If no individuals from the selected household were home or agreed to participate, we selected the next household.

We did not systematically collected data on the number of people who declined to participate; however, in most villages everyone agreed to participate and never more than two people per village declined.

Awareness of Effects

Data Collection

To determine the awareness of local people about the effects of human activities on forests and primates, we asked interviewees if certain activities were good or bad for the forest, for black-and-white colobus monkeys, and for Sykes monkeys (we showed pictures of the monkeys to the interviewees). For the purpose of this study, I limited human activities to removing poles from the forest (‘poles’ are woody stems that are less than or equal to 15 cm in diameter at the point of removal), removing trees from the forest (‘trees’ are woody stems that are greater than 15cm in diameter at the point of removal), and clearing the forest for farms. I calculated the proportion of interviewees in each village around each forest that viewed the human activities as bad for forests, for black-and-white colobus monkeys, and for Sykes monkeys (N=26). I then calculated the median response from all of the villages (Table 4.2).

Identifying Support for Conservation

Data Collection

We asked each interviewee if members of their village thought it was important to protect the forest, black-and-white colobus monkeys, and Sykes monkeys (we showed pictures of the monkeys to the interviewees). We used the term “protection” in a practical sense (e.g.

guarding). Interviewees could respond by choosing one of the following: yes, everyone; yes, many people; yes, but few people; no; or, I don't know. I treated this variable as a binary response (high support or low/no support). I defined high support as a response of "everyone" or "many people". All other responses were considered low/no support. (Table 4.3).

Statistical Analysis

I conducted an analysis of variance (ANOVA) to determine if support for conservation of forests, black-and-white colobus monkeys, and Sykes monkeys significantly differed. I used the proportion of interviewees per village that had high support for conservation as the datum (N=26 for forests and Sykes monkeys; N=20 for black-and-white colobus monkeys). Village was nested within forests (N=13 for forests and Sykes monkeys; N=10 for black-and-white colobus monkeys). I treat forest as a random effect. I conducted the analysis in R using the 'nlme' package (Pinheiro et al. 2010; R Development Core Team 2010).

INFLUENCES ON SUPPORT FOR CONSERVATION

Data Collection

I examined the potential influence of five factors on the support for conservation of forests and primates, and an additional sixth factor that might influence only support for conservation of primates. I described these factors in Table 4.1 and summarized the data in Table 4.4.

I described above the survey methods and sample size, in addition to data collection on the support for conservation. One respondent made conflicting responses on relevant questions and was excluded from data analysis for this part of the study, which resulted in smaller sample sizes (N=259 for forests, N=155 for black-and-white colobus monkeys, and N= 234 for Sykes monkeys). For this part of the study, in addition to the structured interviews, I also collected data from the 2002 Tanzanian census (United Republic of Tanzania 2005) and I re-analyzed Geographic Information System (GIS) data using Quantam GIS 1.0.2 (data provided by Mbilinyi et al (2006)).

1) Population pressure. To calculate population pressure, I divided each village's population size by size of the nearby forest (km^2). The census reported village population size and I calculated forest size from GIS analysis. I used each village as the datum for statistical analysis (N=26 for forests and Sykes monkeys; N=20 for black-and-white colobus monkeys).

2) Median age of local people. The census reported the median age of local people in each village. I used each village as the datum for statistical analysis (N=26 for forests and Sykes monkeys; N=20 for black-and-white colobus monkeys).

3) Hours per year in the forest. We asked each interviewee to report the time (in hours) they spend in forest per entry. We also asked each interviewee how often they go to the forest. Interviewees could respond by choosing one of the following: every day of the week; few days per week; few days per month; few days per year; or, never. I translated these categories into number of days in the forest per year (every day of the week=365, few days per week=156, few days per month=36, few days per year=10, or never=0). I multiplied the two responses (time in hours per entry * days of entry per year). I used each interviewee as the datum for statistical analysis (N=259 for forests, N=155 for black-and-white colobus monkeys, and N= 234 for Sykes monkeys).

4) Number of children. We asked each interviewee how many children they had. I used each interviewee as the datum for statistical analysis (N=259 for forests, N=155 for black-and-white colobus monkeys, and N= 234 for Sykes monkeys).

5) Farm size (acres). We asked each interviewee the total size of their farms. I used each interviewee as the datum for statistical analysis (N=259 for forests, N=155 for black-and-white colobus monkeys, and N= 234 for Sykes monkeys).

6) Crop-raiding frequency (for primates only). We asked each interviewee if they had seen each primate species in farms outside of the forest (we showed pictures of the monkeys to the interviewees). We made the assumption that monkeys in farms were crop-raiding. If interviewees had seen the monkeys on farms, we asked the frequency of their sightings for each species, out of four possible responses: every day; many times; few times; or very few times. I quantified the responses (every day=4, many times=3, few times=2, and very few times=1). I used each interviewee as the datum for statistical analysis (N=155 for black-and-white colobus monkeys and N= 234 for Sykes monkeys).

Statistical Analysis

I conducted three sets of analyses, one for each of forests, black-and-white colobus monkeys, and Sykes monkeys. For these analyses the sample size varied. Interviews (N=259 for forests, N=155 for black-and-white colobus monkeys, and N= 234 for Sykes monkeys) were nested within villages (N=26 for forests and Sykes monkeys; N=20 for black-and-white colobus monkeys) which were nested within forests (N=13 for forests and Sykes monkeys; N=10 for black-and-white colobus monkeys).

I constructed generalized linear mixed models with binomial distributions to assess the relationship between the five or six explanatory variables (e.g. population pressure, farm size) and each response variable (e.g. support for conservation of the forest). I transformed population pressure by dividing by 10 in order to rectify convergence problems with the models. For all three analyses, I treated forest and village as random effects. Subsequently, I ran the global model including all explanatory variables. With little a priori reasoning to include specific interactions between explanatory variables, I followed the practice of Gelman and Hill (2007) and included interaction effects between the explanatory variables that had large effects. I analyzed all possible combinations of fixed effects and compared models using the second-order Akaike's information criterion (AICc; Burnham and Anderson 2002). I selected models within two AICc values of the model with the lowest AICc value, as I considered all of these models to have substantial empirical support, according to the guidelines provided by Burnham and Anderson (2002). Using Akaike weights, I averaged the parameters of the selected models (Burnham and Anderson 2002). I conducted these analyses in R using the 'lme4' and 'MuMIn' packages (Barton 2010; Bates and Maechler 2010; R Development Core Team 2010). I instructed 'lme4' to calculate estimates via the maximum likelihood method.

RESULTS

AWARENESS OF EFFECTS

A nearly unanimous awareness existed among local people that removing poles and trees from the forest, and clearing forests for farms was bad for forests, black-and-white colobus monkeys, and Sykes monkeys (Table 4.2).

IDENTIFYING SUPPORT FOR CONSERVATION

Support for conservation differed significantly between forests, black-and-white colobus monkeys, and Sykes monkeys ($F_{2,57}$=12.39; p<0.001). Support for conservation of forest was higher than support for black-and-white colobus monkeys, which was in turn higher than support for Sykes monkeys (Figure 4.1; Table 4.3).

INFLUENCES ON SUPPORT FOR CONSERVATION

I used five explanatory variables to explain the support for conservation of the forest (no interactions were included). After model selection and model averaging, I identified a model that included four explanatory variables, yet only farm size had a noticeable effect (slightly positive; Table 4.5a). I used six explanatory variables to explain the support for conservation of black-and-white colobus monkeys (no interactions were included). After model selection and model averaging, I identified a model that included five explanatory variables, yet only farm size and crop-raiding frequency had a noticeable effect (slightly positive, but wide 95% confidence intervals; Table 4.5b). I used six explanatory variables to explain the support for conservation of Sykes monkeys (no interactions were included). After model selection and model averaging, I identified a model that included all six explanatory variables, yet only farm size had a noticeable effect (slightly positive; Table 4.5c).

DISCUSSION

I found that local people had a nearly unanimous understanding of the negative effects of human activities on forests and primates. While I did not examine the source of this knowledge, it may be a result of the substantial effort by conservation and development projects in West Usambara to teach local people about their effects on the environment (Johansson 2001). Regardless of the source, understanding the effects of forest use is clearly not sufficient in encouraging people to cease utilization, as forest disturbance remains widespread in the forests of West Usambara (Chapter 2). Nevertheless, by expressing a nearly unanimous understanding of the effects of their actions on the environment, the people of West Usambara seem likely to be able to act as sensible forest managers.

I also identified strong support among local people for the conservation of forests, more so than for either of the primate species (Figure 4.1). In terms of participatory forest management, the finding of high support for conservation of forests suggests that local people in West Usambara may be interested in participating in forest management, as was found to be the case in Uganda (Turyahabwe et al. 2007). High support for conservation of forests also suggests that local people in West Usambara may have potential to manage forests effectively and sustainably, as was shown in areas of participatory management in India (Conroy et al. 2002).

Support for conservation may differ between forests and primates due to the role that personal benefits play in influencing support for conservation. For example, results from both Kenya and Tanzania show that people who receive direct benefits from conservation have positive attitudes toward conservation (e.g. payments from tourism: Gadd 2005; receiving meat quotas: Gillingham and Lee 1999). In West Usambara, many local people depend directly on the forest for sustenance (Halperin 2002; Ndanyalasi et al. 2007) and therefore the conservation of forests would provide personal benefit. On the other hand, from the perspective of the general public, primates may not seem to provide much benefit to local people. This point is supported by the finding that Sykes monkey had the lowest support for conservation. Sykes monkeys are thought of as crop-raiders in Tanzania much more than are colobus monkeys (personal observation; Table 4.4; Siex and Struhsaker 1999) and therefore not only do Sykes monkeys not benefit the local people, but they may actually cause harm (or at least be perceived to cause harm). Even socially, the conservation of primates in West Usambara provide little benefit, as there are no known social customs regarding the protection of primates, as have been found to exist in other places (Ghana: Saj et al. 2006). It may be that some local people may not understand the important role that primates play in the forest ecosystem (e.g. as seed dispersers: Chapman 1995). An education program that teaches about the importance of wildlife to the functioning of forests may be an appropriate conservation program.

In terms of the influences on the support for conservation, I found that large farms were associated with high support for the conservation of forests and primates. As confidence in the relationships was fairly low, it seems that there are other unmeasured variables that influence the support for conservation (e.g. wealth, education level, access to alternatives, forest governance system, etc.). Nevertheless, families with larger farms may have more non-forest resources available to them and therefore be able to decrease their use of the forest. For example, larger farms tend to have more trees planted (in

Nepal: Gautam et al. 2000; in Kenya: Patel et al. 1995) and if more trees are planted on farms there is less need for removing trees from the forest. In the same way, people with the smallest farms may not have the space to plant more crops, and therefore may be the most dependent on the forest, as illustrated by a cardamom (*Elettaria cardamomum*) planting project in East Usambara, Tanzania (Stocking et al. 1995). Also, farms have been associated with wealth (Bhalotra and Heady 2003; Polson and Spencer 1991) and in some circumstances wealth can help reduce forest disturbance. For example, Brooks (2010) shows how in Bhutan wealth is associated with lower firewood use and more tree planting. I did not find an effect of farm size on pole and tree removal in West Usambara as would be expected under this scenario (Chapter 2), and I did not record information about trees planted on farms or wealth of interviewees, which indicates that further research is necessary.

If further studies find that families with large farms in West Usambara do indeed have reduced dependence on forests, it may be that this reduced dependence allows for increased support for conservation of both forest and primates. That is, people who do not depend on the forest should support actions that promote healthy forests, as healthy forests provide long term benefits such as reduced soil erosion, increased water catchment, and a continued supply of non-timber forest products (West Usambara: Lundgren 1980; Lundgren and Lundgren 1979; Meshack et al. 2006; Msuya et al. 2010). As primates are important actors in the forest ecosystem, supporting primate conservation could help to promote healthy forests. Furthermore, an intact population of primates in the forests might lead to potential financial benefits from the tourism sector. Indeed, primate and forest tourism is a visibly growing sector in West Usambara (personal observation). However, more research is needed to further understand the relationships between farm size, forest dependence, and support for conservation.

CONCLUSION

Due to the nearly unanimous awareness by local people of the negative effects of human activities on forest and primates, conservation managers in this area do not need to spend time and energy in educating local people about their effects on the environment. This result also suggests that a participatory approach to conservation may be appropriate in West Usambara, as it is clear that local people recognize the effects of their actions on the environment. Decentralizing forest management in West Usambara is further supported by the finding that a high level of support existed among local people to conserve forests. High local support for conservation suggests that local people would manage the forest in way as to promote conservation (i.e. as opposed to a management style that included reckless utilization).

The results from the third section of this study suggested that increasing access to non-forest resources could result in increased support for conservation. If non-forest resource availability is indeed the mechanism that connects larger farms to high support for conservation, then efforts to provide access to non-forest products (e.g. via a tree planting campaign) may go along ways towards increasing support of conservation. However, to ensure the success of a tree planting campaign it may be necessary to find and use communal land, as people with small farms may not have the space for tree planting and are also the ones that may have the lowest support for conservation due to high dependence on the forest. Of course, more data are needed to support these conclusions, and the recommendation would need to be tested by, for example, implementation in only half of the forests.

Finally, this study points to both the necessity and the ease of gaining knowledge from and about the community prior to initiating participatory management of resources. The data for this study were collected on a small budget over the course of only one month, but the results provide managers with valuable information that can be used in the process of initiating participatory management. However, verification of these results is necessary and could be achieved via another study in different villages and without the presence of a foreign researcher.

Chapter 5. Conclusion to the Dissertation

CHAPTER 5. CONCLUSION TO THE DISSERTATION

INTRODUCTION

A debate over either utilizing or conserving forests has been long-standing and on-going (Borgerhoff Mulder and Coppolillo 2005). The utilization of forests by humans is widespread and has often resulted in deforestation (Fitzherbert et al. 2008; Geist and Lambin 2002). In many cases overutilization of forests has been shown to have negative effects on animals (globally: Brooks et al. 2002; Indian Himalaya: Pandit et al. 2007; Southeast Asia: Sodhi et al. 2004) and even humans (e.g. loss of water sources: Tinker et al. 1996). On the other hand, strict protection of natural resources, while beneficial for wildlife, prevents humans from utilizing these resources (Borgerhoff Mulder and Coppolillo 2005; Lugo 1999), and in some cases limits the abilities of local people to survive (Ndanyalasi et al. 2007; Pimentel et al. 1997). As both allowing humans to use some forest resources and protecting those resources are important, finding a balance between utilization and strict protection is crucial to effective conservation management. This dissertation provided knowledge necessary to begin to balance utilization and conservation in the forests of the Eastern Arc Mountains of Tanzania, with a focus on the West Usambara mountain block.

OVERVIEW OF FINDINGS AND FUTURE DIRECTIONS

CHAPTER 2

As utilization seems to be the dominant model for humans (Food and Agriculture Organization 2009; Geist and Lambin 2002; Yasuda et al. 2000), a first step towards achieving sustainable use of natural resources is to determine where utilization is most severe (Chapter 2). In the Eastern Arcs, I found that all the mountain blocks were disturbed, some much more than others. Managers can use these results to help focus their efforts, potentially in combination with knowledge of the distribution of biodiversity (Burgess et al. 2007).

Also, in Chapter 2, I examined the influence of the local human population size and behavior on disturbance in West Usambara. This section of the study was used to inform managers of what kinds of human populations and behavior were associated with utilization, in an effort to identify potential conservation approaches. I found that in areas of high population pressure (village population size / forest size (km^2)) there was also high basal area of pole stumps per hectare. I found no strong predictors of the basal area of tree stumps per hectare. That only pole removal was influenced by population pressure and not tree removal suggests that these two types of disturbance are fundamentally different. Further research is needed to understand these differences.

The apparent strong effect of population pressure on pole removal in West Usambara is supported by the recent work of Persha and Blomley (2009), who studied two of the same forests that I examined. Persha and Blomley present data that show that the forest with the highest population pressure also had the highest frequency of pole stumps. Additional support for this results comes from a substantial body of literature that suggests that human population pressure is associated with environmental degradation (Ehrlich 1968; Laurance 1999). For instance, in India a few studies have associated high population pressure with degraded forests (Agrawal and Yadama 1997; Karanth et al. 2006). Similarly, Becker and León (2000) show that in areas of high population density in Bolivia, there were declines in the density of 11 out of 28 studied tree species that local people used traditionally; this result also suggests that while population pressure affects the condition of the forest, it is not necessarily an indiscriminate effect.

Nevertheless, not all studies have found a relationship between population pressure and environmental degradation. For example, Varughese (2000) found that high human population density occurred near to both forests in good and bad condition in Nepal. Instead of population as an influence on forest disturbance, he found that forests were less disturbed in areas where there was a more developed forest-related institution. This latter finding, which is only one example of many possible, indicates that other variables besides population certainly influence forest disturbance. Indeed a strong literature has developed that examines the influence of forest governance systems on forest quality (Agrawal and Yadama 1997; Gibson et al. 2000), including much work in Tanzania (Blomley et al. 2008; Persha and Blomley 2009; Sumbi 2004; Woodcock et al. 2006).

The next step in this research program is to examine how population pressure and forest disturbance interact with forest governance strategies in West Usambara, building upon the work of Persha and Blomley (2009). This next step is especially appropriate due to a fairly recent policy adjustment at the national level in Tanzania which allows for increased local participation in forest management (Forestry and Beekeeping Division 2008). While many questions remain unanswered, the results from this chapter provide managers with a starting point for reducing utilization in that they now know where conservation is most needed.

CHAPTER 3

While understanding the distribution of and influences on forest disturbance was an important step (Chapter 2), it did not provide information on the sustainability of forest utilization. That is, simply knowing the intensity of utilization does not provide indication of the ability of the forests or its inhabitants to survive. Potentially even high densities of utilization found in Chapter 2 may have had no measurable effects on the forest ecosystem. Alternatively, it was possible that even the lowest densities of utilization found in Chapter 2 had severely negative effects on these ecosystems. One way to gain better understanding of the sustainability of forest utilization is to examine how wildlife populations are affected. To do so, I examined how forest disturbance affected black-and-white colobus monkeys (*Colobus angolensis palliatus*) in 13 forests in West Usambara.

I found that *C. a. palliatus* monkeys were absent and likely went extinct in three forests. The forests in which they had gone extinct were significantly smaller and had significantly more pole removal than forests in which they had persisted, suggesting that *C. a. palliatus* populations may be unable to survive in small forests or areas of intense pole removal. If forest size and pole removal do indeed influence the survival of *C. angolensis palliatus* in West Usambara, it would be expected that these variables would also have negative effects on the monkey's encounter rates. However, in contrast, both pole removal and forest size lacked an effect on the encounter rate of black-and-white colobus monkeys. It may be the case that an unmeasured variable, such as hunting pressure, may be an influential in the extinction of black-and-white colobus monkey populations, and may also be related to pole removal and forest size. Future studies that examine hunting pressure in addition to disturbance would help to clarify these results.

Additionally, I found that in forests with a high basal area of tree stumps per hectare there was also a high rate of encounter with black-and-white colobus monkeys, though this effect was slight. This latter finding suggests that the removal of trees may (slightly) help the monkeys to survive. One explanation for this scenario is that as disturbance continues and more trees are removed, other trees gain more exposure to sunlight, and subsequently are able to produce more new leaves with higher protein-to-fiber ratios (Ganzhorn 1995; Johns 1988). This result was unique as previous studies of *C. angolensis* in disturbed forests have tended to show that they do poorly (Anderson et al. 2007; Marshall et al. 2005; McGraw 1994; Thomas 1991). It may be that by refining the classification of disturbance (i.e. pole removal vs. tree removal) I was able to better distinguish the effects of disturbance on this species. As the findings of this study are preliminary, further studies are necessary to help elucidate differences in the effects of pole and tree removal.

The results from this study suggest that structured interviews might be a viable alternative to transect surveys for estimating the relative size of primate populations, which accords well with the suggestions of Marshall and Meijaard (2009). I found that the proportion of interviewees per village that reported that black-and-white colobus monkeys were present was positively related to the encounter rate I calculated from transect surveys, suggesting that structured interviews may provide at least comparable estimates. Additionally, interviews can be conducted quite rapidly on small budgets when compared to transect surveys (in this study: one month vs. two years). Of course, to confirm the present findings, we need more studies that compare results of interviews with the results of line transect surveys and with primate populations with known sizes.

Finally, as these results are preliminary, it is too early to know if utilization is too severe in these forests. Nevertheless, as local extinctions have indeed occurred, it may be the case the conservation managers need to attempt to limit use of the forest in some areas.

CHAPTER 4

Based on the results of Chapter 2 and 3, it was clear that conservation was necessary in West Usambara, Tanzania. The conservation literature is fairly clear that solutions that come from the local level can be successful (Borgerhoff Mulder and Coppolillo 2005; Gadgil 1992; Pimbert and Pretty 1997). Much effort has been applied to the engagement of local communities in conservation, often via the promotion of participatory management (Lund et al. 2009; Saxena 1997). When implemented, this approach appears to have been successful in terms of conservation, at least in some areas (Blomley et al. 2008). However, considering the challenges that have often been faced during the installation of participatory management (Meshack et al. 2006; Woodcock et al. 2006), a better understanding of local circumstances prior to engaging in the decentralization process may be appropriate. At minimum, the following three questions about local circumstances should be asked: Are local people aware of their effects on the environment? Do local people support conservation? If so, what influences support for conservation? The answers to these questions will help managers better know if and how to engage the local population in sustainable management of the forest. This chapter aimed to answer these questions regarding the local people in West Usambara, Tanzania.

I found that nearly every interviewed person had an understanding of the negative effects of human activities on forests and primates. This finding suggests that conservation managers can forgo intensive education about the effects of local humans on the environment at this location. Also, by expressing a nearly unanimous understanding of the effects of their actions on the environment, the people of West Usambara seem likely to be able to act as sensible forest managers. I also identified strong support among local people for the conservation of forests. In terms of participatory forest management, this finding suggests that local people in West Usambara may be interested in participating in forest management, and also may also have potential to manage forests effectively and sustainably. However, verification of these results is necessary and could be achieved via study in different villages and without the presence of a foreign researcher.

In terms of the influences on the support for conservation, I found that large farms were associated with high support for the conservation of forests and primates. Families with large farms may have more non-forest resources available to them and therefore be able to decrease their dependence on the forest. For example, larger farms tend to have more trees planted (in Nepal: Gautam et al. 2000; in Kenya: Patel et al. 1995) and if more trees are planted on farms there is less need for removing trees from the forest. However, I did not find an effect of farm size on pole and tree removal in West Usambara as would be expected under this scenario (Chapter 2), and I did not record information about trees planted on farms.

If further studies find that families with large farms in West Usambara do indeed have reduced dependence on forests, it may be that this reduced dependence allows for increased support for conservation. That is, people who do not depend on the forest should support actions that promote healthy forests, as healthy forests provide long term benefits such as reduced soil erosion, increased water catchment, and a continued supply of non-timber forest products (West Usambara: Lundgren 1980; Lundgren and Lundgren 1979; Meshack et al. 2006; Msuya et al. 2010). These results suggest that increasing access to non-forest resources could result in increased support for conservation. Of course, more research is needed to further understand the relationships between farm size, forest dependence, and support for conservation.

In conclusion, the preliminary results from this chapter suggest that West Usambara is an appropriate area to initiate participatory forest management. Additionally, these results point to both the necessity and the ease of gaining knowledge from and about the community prior to initiating participatory management of resources.

CONCLUSION

The forests of West Usambara are highly utilized, some more than others, and at least one species of wildlife seems to suffer due to the intense utilization. As a result, conservation efforts are necessary in order to prevent further disturbance of the forest ecosystem. Strict protection is not sensible, as many of the local people depend on the forest for their livelihood (personal observation; Ndanyalasi et al. 2007). However, helping to limit forest utilization is advisable, and the results from this dissertation can help to design such efforts. Indeed, imagine the (not so fictional) scenario where there was no more time or money for further studies, and conservation efforts had to start immediately. Based on the results from this dissertation, I would suggest to conservation managers the following strategies:

Within the Eastern Arcs,

- Focus efforts on the most disturbed mountain blocks, but also consider the biological richness of the those blocks (Burgess et al. 2007). For instance, it may be appropriate to create a ranking that prioritizes conservation efforts for the blocks that have both high disturbance and high species richness.

Within West Usambara,

- Focus efforts on areas of high population pressure;
- Attempt to reduce pole removal and forest loss, more so than tree removal (though reducing tree removal is likely also to be important);
- Forgo educating local people about their effects on the environment, as local people already know about their effects on the environment;
- Focus discussion with local people on the conservation of forests, rather than, for example, on protecting a charismatic species;
- Build support for conservation by increasing access to non-forest products, such as trees planted on farms and other non-forested (communal) land;
- Initiate participatory forest management.

Together, these strategies could form the basis of a conservation plan that effectively balances utilization and conservation of the forests in the Eastern Arc Mountains of Tanzania.

Tables and Figures

Table 2.1. Descriptions of the six explanatory variables used to explain forest disturbance.

Population pressure	Population pressure is a measure of population size in relation to the local resource base (e.g. forests). Smalls forests surrounded by large populations experience high population pressure, and large forests surrounded by small populations experience low population pressure. High population pressure often leads to more environmental degradation (Laurance 1999). For instance, forests in India under higher population pressure have been shown to be more degraded (Agrawal and Yadama 1997; Karanth et al. 2006). However, the associations are not inevitable, especially in the case of high institutional effectiveness (Agrawal 1995; Southgate et al. 1990).
Median age of local people	Different aged populations may use forest resources differently. For example, age has been found to have an inverted U relationship with forest clearing in Honduras (Godoy et al. 1997). The youngest and oldest households cleared the least amount of forest, while middle-age households cleared the most. Potentially, middle-aged households had the most children to support and therefore were in the most need of land for larger farms. While Godoy et al (1997) looked at only forest clearing, this same rationale could also apply to extracting resources from within the forest.
Hours per year in the forest	The amount of time spent in the forest is a measure of forest use. More time in the forest presumably means more intensive use of forest resources (e.g. more time for collection of forest resources).
Number of children	Families with more children are able to gather more resources, but also need more resources for survival (Bhalotra and Heady 2003; Caldwell and Caldwell 1987; Dasgupta 1998). To meet this need, some families may increase collection within a forest. For instance, in Tanzania it was found that large families collected the most firewood in the forest (Fleuret and Fleuret 1978), even though large families tend to use firewood more efficiently (Biran et al. 2004).
Farm size (acres)	Farm land often comes at the expense of forests, and may be responsible for 63% of forest area change in tropical Africa (Carr 2004; Food and Agriculture Organization 2009; Geist and Lambin 2002). However, large farms may also allow for less extraction from the forests. Farms are associated with wealth (Bhalotra and Heady 2003; Polson and Spencer 1991) and wealth may help reduce forest disturbance. For example, wealth in Bhutan is associated with lower firewood use and more tree planting (Brooks 2010). Moreover, households with more land may also plant more trees, which should help reduce dependence on forests (in Nepal: Gautam et al. 2000; in Kenya: Patel et al. 1995).
Support for conservation of the forest	In general, those who support conservation can often be assumed to practice conservation-orientated behavior. Indeed, Kaiser et al (1999) show that ecologically-minded desires are strong predicators of conservation-orientated behavior. However, the connection between attitude and behavior is not always present (Hines et al. 1986/1987). The influences on the support for conservation are treated in detail in Chapter 4.

Table 2.2. Data on anthropogenic disturbance and research effort in the mountain blocks of the Eastern Arc Mountains. *Applicable data was not found in the literature, and therefore these blocks were not included in the analyses. ** I calculated the median and quartiles with respect to the nesting of transects within forests, and forests within mountain blocks. ***Data from Mbilinyi et al (2006).

Mountain block	Total forest size (km^2) in the mountain block ***	N= total # of transects	N= total # of forests	Median # of pole stumps / ha *(quartiles 25% - 75%)* **	Median # of tree stumps / ha *(quartiles 25% - 75%)* **
East Usambara	262.7	127	12	22.1 *(12.5 - 52.1)*	5.1 *(2.7 - 10.1)*
Mahenge	19.4	25	4	19.1 *(3.5 - 36.5)*	15.3 *(2.9 - 22.7)*
Malundwe *	13.3	-	-	-	-
Nguru	296.8	6	1	26.7 *(-)*	25.2 *(-)*
Nguu	187.6	18	2	2.2 *(2.2 - 2.3)*	1.5 *(0.8 - 2.2)*
North Pare	27.2	13	4	27.9 *(12.5 - 54.7)*	7.9 *(6.4 - 44.6)*
Rubeho	464.5	20	3	28.5 *(2.1 - 40.0)*	16.1 *(6.4 - 21.3)*
South Pare	138.5	7	2	115.1 *(62.9 - 167.3)*	88.0 *(74.7 - 101.3)*
Taita Hills *	3.0	-	-	-	-
Udzungwa	1352.8	49	15	22.0 *(2.8 - 70.3)*	16.0 *(6.7 - 60.4)*
Ukaguru	172.0	6	1	30.0 *(-)*	31.3 *(-)*
Uluguru	278.1	49	2	1.7 *(0.0 - 3.3)*	1.7 *(1.1 - 2.2)*
West Usambara	318.9	26	13	79.6 *(66.4 - 208.5)*	20.3 *(13.4 - 38.2)*
Median ** *(quartiles 25% - 75%)*	187.6 *(23.3 – 307.9)*	20 *(7 – 49)*	3 *(2 - 12)*	26.7 *(19.1 – 30.0)*	16 *(5.0 – 25.2)*

Table 2.3. Anthropogenic disturbance along transects in West Usambara forests. I differentiated pole stumps (5 – 15 cm diameter) and trees stumps (> 15 cm diameter) by size. *I calculated the median and quartiles with respect to the nesting of transects within forests.

Forest	Transect #	Transect area (ha)	Basal area (m^2) of pole stumps / ha	Basal area (m^2) of tree stumps / ha
Ambangulu / Vugiri	9	1.46	0.31	3.79
Ambangulu / Vugiri	10	0.82	0.39	0.00
Ambangulu / Vugiri	11	0.70	0.49	2.97
Baga / Mazumbai / Sagara	1	1.32	0.02	0.07
Baga / Mazumbai / Sagara	2	1.18	0.11	0.15
Baga / Mazumbai / Sagara	3	1.50	0.18	6.41
Baga / Mazumbai / Sagara	4	1.47	0.19	0.82
Baga / Mazumbai / Sagara	5.1	0.54	0.17	6.73
Baga / Mazumbai / Sagara	5.2	0.28	0.02	0.07
Baga / Mazumbai / Sagara	6	0.57	0.50	0.61
Balangai	14	1.50	0.62	11.17
Balangai	15	1.50	0.22	5.90
Kisima Gonja	7	1.24	0.37	0.98
Kisima Gonja	8	1.50	0.32	0.89
Lutindi	24	1.04	1.38	1.61
Magamba	21	1.50	0.52	7.18
Magamba	22	1.50	0.43	3.60
Mahazengulu	18	0.99	0.31	1.19
Mkussu	19	1.14	0.56	26.87
Mkussu	20	1.50	1.56	4.82
Mtumbi	25	0.62	1.20	1.14
Mzinga	12	1.01	0.69	1.83
Ndelemai	13	1.17	0.43	10.96
Shagayu	16	1.50	0.25	6.31
Shagayu	17	1.50	0.13	2.90
Shambalai	23	0.33	4.13	5.04
Median * *(quartiles 25% - 75%)*	-	1.17 *(0.91 – 1.44)*	0.43 *(0.33 - 1.13)*	2.97 *(1.17 - 6.96)*

Table 2.4. Ranking of the total forest size (ha) in the mountain block (1 = smallest; 11 = largest), and median disturbance (1 = most disturbed, 11 = least disturbed). Ranks were averaged by mountain block.

Mountain block	Rank – Total forest size (ha) in the mountain block	Rank - Median # of pole stumps / ha	Rank - Median # of tree stumps / ha	Average rank
South Pare	3	1	1	1.7
Ukaguru	4	3	2	3.0
North Pare	2	5	8	5.0
West Usambara	9	2	4	5.0
Mahenge	1	9	7	5.7
Nguru	8	6	3	5.7
Rubeho	10	4	5	6.3
East Usambara	6	7	9	7.3
Udzungwa	11	8	6	8.3
Nguu	5	10	11	8.7
Uluguru	7	11	10	9.3

Table 2.5. Summary statistics for the six explanatory variables used to explain the basal area of pole and tree stumps per hectare. *I calculated the median and quartiles with respect to the nesting of interviews within villages, and villages within forests. **Data provided by the 2002 Tanzanian census; the census did not report quartiles (United Republic of Tanzania 2005).

Forest	Village	Population pressure *(village population size / forest size (km^2))*	Median age of local people **	Hours per year in the forest	
				N=	Median *(quartiles)* *
Ambangulu / Vugiri	Bagamoyo	100.9	18.1	10	234.0 *(9.8 - 409.5)*
Ambangulu / Vugiri	Old Ambangulu	91.9	14.4	10	20.0 *(7.5 - 195.0)*
Baga / Mazumbai / Sagara	Kizanda	73.8	17.2	10	126.0 *(0.0 - 448.5)*
Baga / Mazumbai / Sagara	Malomboi	60.8	13.2	10	72.0 *(31.5 - 132.8)*
Balangai	Balangai	260.5	17.5	10	0.0 *(0.0 - 351.0)*
Balangai	Kweminyasa A	500.5	16.7	10	46.0 *(14.1 - 87.8)*
Kisima Gonja	Kwabosa	139.5	15.5	10	36.0 *(0.0 - 279.0)*
Kisima Gonja	Mavumbi	97.1	15.0	9	20.0 *(0.0 - 60.0)*
Lutindi	Lutindi	29.0	37.8	10	54.0 *(3.8 - 162.6)*
Lutindi	Masange 2	136.9	16.3	10	150.0 *(78.0 - 331.5)*
Magamba	Kwesimu	17.2	18.4	10	66.0 *(31.5 - 175.5)*
Magamba	Magamba-Cost B	61.5	16.7	10	36.0 *(8.8 - 56.6)*
Mahazengulu	Mahazengulu	675.3	15.4	10	22.5 *(6.8 - 108.0)*
Mahazengulu	Tamota	336.0	17.6	10	117.0 *(0.0 - 331.5)*
Mkussu	Magamba-Cost A	132.0	16.7	10	20.5 *(0.0 - 79.5)*
Mkussu	Masange 1	74.1	14.8	10	87.0 *(1.3 - 533.5)*
Mtumbi	Kwekifinyu	888.0	14.5	10	7.5 *(0.0 - 24.0)*
Mtumbi	Mnandani	2807.1	14.8	10	28.0 *(0.0 - 85.5)*
Mzinga	Baga	858.9	15.0	10	4.2 *(0.0 - 45.0)*
Mzinga	Wanga	811.2	14.3	10	156.0 *(0.0 - 312.0)*
Ndelemai	Kweminyasa B	411.7	16.7	10	81.0 *(32.0 - 253.5)*
Ndelemai	Magila	211.9	16.6	10	17.0 *(0.0 - 99.0)*
Shagayu	Goka	29.5	14.5	10	114.0 *(16.0 - 259.5)*
Shagayu	Mpanga	28.4	15.3	10	546.0 *(292.5 - 799.5)*
Shambalai	ChakeChake	10004.6	21.0	10	0.0 *(0.0 - 1.6)*
Shambalai	Dolci	17077.3	18.4	10	0.0 *(0.0 - 93.0)*
Median *(quartiles)* *	-	118.3 *(75.1 - 670.3)*	16.3 *(15.1 - 17.3)*	10 *(10 – 10)*	53.8 *(25.5 - 100.5)*

Table 2.5. (cont.)

Forest	Village	Number of children		Farm size (acres)		Support for forest conserv.	
		N=	Median *(quartiles)* *	N=	Median *(quartiles)* *	N=	Median *(quartiles)* *
Ambangulu / Vugiri	Bagamoyo	10	5.0 *(3.5 - 7.0)*	10	2.5 *(1.9 - 4.3)*	10	0.6
Ambangulu / Vugiri	Old Ambangulu	10	6.0 *(1.8 - 8.3)*	10	4.0 *(2.0 - 5.3)*	10	0.6
Baga / Mazumbai / Sagara	Kizanda	10	4.0 *(2.3 - 6.0)*	10	3.0 *(2.8 - 5.0)*	10	0.7
Baga / Mazumbai / Sagara	Malomboi	10	7.5 *(4.8 - 9.8)*	10	4.5 *(2.0 - 7.0)*	10	0.9
Balangai	Balangai	10	4.5 *(1.0 - 6.3)*	10	3.5 *(1.0 - 5.6)*	10	0.8
Balangai	Kweminyasa A	10	3.0 *(1.5 - 5.0)*	10	1.9 *(0.8 - 3.1)*	10	0.7
Kisima Gonja	Kwabosa	10	4.5 *(2.8 - 8.0)*	10	3.3 *(2.4 - 4.3)*	10	0.8
Kisima Gonja	Mavumbi	9	3.0 *(0.5 - 4.0)*	9	1.0 *(0.8 - 2.0)*	9	0.8
Lutindi	Lutindi	10	6.0 *(2.3 - 8.5)*	10	3.3 *(2.9 - 4.0)*	10	0.7
Lutindi	Masange 2	10	4.5 *(1.5 - 6.5)*	10	2.5 *(1.8 - 5.3)*	10	0.7
Magamba	Kwesimu	10	3.0 *(2.0 - 5.0)*	10	2.0 *(0.5 - 4.0)*	10	0.5
Magamba	Magamba-Cost B	10	3.0 *(1.0 - 3.3)*	10	2.0 *(1.8 - 3.3)*	10	0.7
Mahazengulu	Mahazengulu	10	5.0 *(3.0 - 9.0)*	10	4.5 *(1.8 - 6.3)*	10	0.6
Mahazengulu	Tamota	10	4.5 *(1.5 - 5.3)*	10	2.0 *(1.5 - 2.3)*	10	0.7
Mkussu	Magamba-Cost A	10	4.5 *(2.0 - 6.3)*	10	1.3 *(1.0 - 2.0)*	10	0.4
Mkussu	Masange 1	10	3.5 *(1.5 - 7.3)*	10	2.0 *(0.4 - 3.3)*	10	0.6
Mtumbi	Kwekifinyu	10	5.0 *(4.8 - 7.0)*	10	2.5 *(1.8 - 3.0)*	10	0.9
Mtumbi	Mnandani	10	3.5 *(2.0 - 8.3)*	10	3.0 *(2.0 - 4.8)*	10	0.8
Mzinga	Baga	10	5.0 *(3.0 - 5.3)*	10	3.5 *(2.0 - 4.3)*	10	0.6
Mzinga	Wanga	10	4.5 *(1.8 - 7.0)*	10	3.0 *(2.0 - 4.3)*	10	0.7
Ndelemai	Kweminyasa B	10	3.0 *(1.0 - 6.0)*	10	2.5 *(0.8 - 4.5)*	10	0.5
Ndelemai	Magila	10	4.0 *(0.0 - 6.3)*	10	2.0 *(0.9 - 3.0)*	10	0.4
Shagayu	Goka	10	5.5 *(2.8 - 6.8)*	10	2.5 *(1.4 - 5.0)*	10	0.7
Shagayu	Mpanga	10	3.5 *(2.0 - 6.0)*	10	2.8 *(1.0 - 4.3)*	10	0.9
Shambalai	ChakeChake	10	3.0 *(2.0 - 4.0)*	10	1.0 *(0.0 - 5.3)*	10	0.2
Shambalai	Dolci	10	5.5 *(3.0 - 6.0)*	10	1.8 *(0.6 - 3.5)*	10	0.7
Median * *(quartiles 25% - 75%)*	-	10 *(10 – 10)*	4.3 *(3.8 - 5.0)*	10 *(10 – 10)*	2.7 *(2.1 - 3.3)*	10 *(10 – 10)*	0.7 *(0.6 - 0.8)*

Table 2.6a. Results following model selection and averaging of a linear mixed model that included six explanatory variables (five transformed by natural logarithm, one binary) to explain the basal area of pole stumps (m^2) per hectare (transformed by natural logarithm). I treated both forest and village as random effects. I defined population pressure as village population size divided by forest size (km^2).

Fixed effect	Coefficient	Standard error	Lower 95% confidence interval	Upper 95% confidence interval
Intercept	-2.76	1.39	-5.49	-0.04
Ln (median age of local people)	0.23	0.40	-0.55	1.02
Ln (population pressure)	0.28	0.10	0.08	0.47

Table 2.6b. Results following model selection and averaging of a linear mixed model that included six explanatory variables (five transformed by natural logarithm, one binary) to explain the basal area of tree stumps (m^2) per hectare (transformed by natural logarithm plus a constant). I treated both forest and village as random effects.

Fixed effect	Coefficient	Standard error	Lower 95% confidence interval	Upper 95% confidence interval
Intercept	1.30	0.58	0.16	2.44
Ln (median age of local people)	0.04	0.18	-0.31	0.40

Table 3.1. Survey effort in the forests of West Usambara.

Forest name	Forest size (ha)	# of transects	Total # of transect surveys	Total distance surveyed (km)	Median # of days between surveys *(quartiles 25% - 75%)*
Ambangulu / Vugiri	1339	3	39	77.32	45.00 *(36.00 - 64.00)*
Baga / Mazumbai / Sagara	3719	6	96	210.30	39.00 *(30.00 - 47.25)*
Balangai	1076	2	22	66.00	42.50 *(33.75 - 52.75)*
Kisima Gonja	1545	2	30	82.05	39.00 *(33.50 - 51.25)*
Lutindi	404	1	9	18.74	47.00 *(43.00 - 63.75)*
Magamba	7097	2	18	54.00	51.00 *(40.25 - 55.75)*
Mahazengulu	445	1	12	23.76	47.00 *(35.00 - 67.00)*
Mkussu	3306	2	17	45.16	55.00 *(37.00 - 71.00)*
Mtumbi	183	1	8	9.93	47.00 *(43.00 - 76.00)*
Mzinga	365	1	15	30.20	38.00 *(33.00 - 50.25)*
Ndelemai	1308	1	11	25.71	42.00 *(36.75 - 57.50)*
Shagayu	6777	2	24	72.00	44.00 *(34.00 - 71.25)*
Shambalai	22	1	9	6.00	48.50 *(39.75 - 61.00)*
Median *(quartiles 25% - 75%)*	1308 *(385 - 3513)*	2 *(1 - 2)*	17 *(10 – 27)*	45.16 *(21.25 - 74.66)*	45.00 *(40.50 - 47.75)*

Table 3.2. Encounter rate and anthropogenic disturbance along transects. I differentiated pole (5 – 15 cm diameter) and trees stumps (> 15 cm diameter) by size. *I calculated the median and quartiles with respect to the nesting of transects within forests.

Forest	Transect #	# of groups sighted	Encounter rate (groups / km)	Transect area (ha)	Basal area (m^2) of pole stumps / ha	Basal area (m^2) of tree stumps / ha
Ambangulu / Vugiri	9	2	0.05	1.46	0.31	3.79
Ambangulu / Vugiri	10	0	0.00	0.82	0.39	0.00
Ambangulu / Vugiri	11	0	0.00	0.70	0.49	2.97
Baga / Mazumbai / Sagara	1	7	0.17	1.32	0.02	0.07
Baga / Mazumbai / Sagara	2	9	0.24	1.18	0.11	0.15
Baga / Mazumbai / Sagara	3	13	0.27	1.50	0.18	6.41
Baga / Mazumbai / Sagara	4	9	0.19	1.47	0.19	0.82
Baga / Mazumbai / Sagara	5.1	9	0.52	0.54	0.17	6.73
Baga / Mazumbai / Sagara	6	6	0.33	0.57	0.50	0.61
Balangai	14	2	0.06	1.50	0.62	11.17
Balangai	15	5	0.15	1.50	0.22	5.90
Kisima Gonja	7	19	0.51	1.24	0.37	0.98
Kisima Gonja	8	15	0.33	1.50	0.32	0.89
Lutindi	24	0	0.00	1.04	1.38	1.61
Magamba	21	8	0.30	1.50	0.52	7.18
Magamba	22	19	0.70	1.50	0.43	3.60
Mahazengulu	18	7	0.29	0.99	0.31	1.19
Mkussu	19	24	1.32	1.14	0.56	26.87
Mkussu	20	12	0.44	1.50	1.56	4.82
Mtumbi	25	0	0.00	0.62	1.20	1.14
Mzinga	12	30	0.99	1.01	0.69	1.83
Ndelemai	13	5	0.19	1.17	0.43	10.96
Shagayu	16	17	0.47	1.50	0.25	6.31
Shagayu	17	13	0.36	1.50	0.13	2.90
Shambalai	23	0	0.00	0.33	4.13	5.04
Median * *(quartiles 25% - 75%)*	-	7 *(0 – 16)*	0.26 *(0 - 0.46)*	1.17 *(0.91 – 1.44)*	0.43 *(0.33 - 1.13)*	2.97 *(1.17 - 6.96)*

Table 3.3. Current and historic distribution of black-and-white colobus monkeys in the forests of West Usambara, Tanzania, based on the results from transects surveys and structured interviews with local people. Survey effort for transect surveys is reported in Table 3.1. **Bold** indicates a potential extinction. *Moderate evidence exists that black-and-white colobus monkeys have gone extinct in these forests. **Weak evidence exists that black-and-white colobus monkeys have gone extinct in this forest.

	CURRENT DISTRIBUTION (from transect surveys)	CURRENT DISTRIBUTION (from interviews)				HISTORIC DISTRIBUTION (from interviews of local people ≥ 40 years old)			
Forest name	Present or Absent	N=	Proportion reporting present	Proportion reporting absent	Proportion reporting "don't know"	N=	Proportion reporting present	Proportion reporting absent	Proportion reporting "don't know"
Ambangulu / Vugiri	Present	20	0.35	0.65	0.00	12	0.50	0.50	0.00
Baga / Mazumbai / Sagara	Present	20	1.00	0.00	0.00	15	1.00	0.00	0.00
Balangai	Present	20	0.75	0.25	0.00	10	0.80	0.10	0.10
Kisima Gonja	Present	20	0.90	0.10	0.00	7	0.86	0.14	0.00
Lutindi *	**Absent**	**20**	**0.10**	**0.85**	**0.05**	**11**	**0.55**	**0.36**	**0.09**
Magamba	Present	20	0.90	0.10	0.00	8	1.00	0.00	0.00
Mahazengulu	Present	20	0.90	0.05	0.05	11	0.91	0.00	0.09
Mkussu	Present	20	0.85	0.05	0.10	13	1.00	0.00	0.00
Mtumbi *	**Absent**	**20**	**0.05**	**0.95**	**0.00**	**9**	**0.56**	**0.44**	**0.00**
Mzinga	Present	20	0.85	0.10	0.05	11	0.91	0.00	0.09
Ndelemai	Present	20	0.50	0.45	0.05	9	0.89	0.11	0.00
Shagayu	Present	20	0.80	0.20	0.00	9	0.89	0.11	0.00
Shambalai **	**Absent**	**20**	**0.05**	**0.95**	**0.00**	**11**	**0.09**	**0.91**	**0.00**

Table 3.4. Summary of data on group size of black-and-white colobus monkeys in the forests of West Usambara.

Forest name	GROUP SIZE	
	# of groups with reliable group size	Median group size *(quartiles 25% - 75%)*
Ambangulu / Vugiri	3	7.00 *(6.00 - 8.00)*
Baga / Mazumbai / Sagara	42	6.00 *(5.75 - 9.00)*
Balangai	2	8.50 *(6.00 - 11.00)*
Kisima Gonja	13	7.00 *(6.00 - 8.00)*
Lutindi	-	-
Magamba	7	8.00 *(5.00 - 12.00)*
Mahazengulu	3	5.00 *(5.00 - 6.00)*
Mkussu	13	7.00 *(5.00 - 8.00)*
Mtumbi	-	-
Mzinga	15	6.00 *(5.00 - 9.00)*
Ndelemai	1	6.00 *(-)*
Shagayu	10	8.50 *(5.00 - 12.00)*
Shambalai	-	-
Median *(quartiles 25% - 75%)*	8.50 *(2.75 - 13.50)*	7.00 *(6.00 - 8.13)*

Table 3.5. Results of the linear mixed model that assessed the relationship between the proportion of interviewees per village that reported that the black-and-white colobus monkeys were present in the forest and the encounter rate (transformed by natural logarithm plus one) as calculated from transect surveys in the forest. I treated forest, village, and transect as random effects.

Fixed effect	Coefficient	Standard error	Lower 95% confidence interval	Upper 95% confidence interval
Intercept	0.11	0.08	-0.05	0.27
Proportion of interviewees per village the reported the monkeys present	0.19	0.10	-0.04	0.41

Table 3.6a. Results following model selection and averaging of linear mixed model that included three explanatory variables to explain the encounter rate of black-and-white colobus monkeys in the forests of West Usambara (all variables transformed by natural logarithm; I added a constant (1) to the basal area of tree stumps per hectare and the encounter rate before transformation). I treated both forest and village as random effects.

Fixed effect	Coefficient	Standard error	Lower 95% confidence interval	Upper 95% confidence interval
Intercept	0.22	0.11	0.01	0.44
Ln (1 + basal area of tree cuts per hectare)	0.05	0.04	-0.03	0.13
Ln (basal area of pole cuts per hectare)	0.00	0.01	-0.02	0.02
Ln (forest size (km^2))	0.00	0.01	-0.03	0.03

Table 3.6b. Results following model selection and averaging of generalized linear mixed model that included three explanatory variables to explain the group size of black-and-white colobus monkeys in the forests of West Usambara. I treated both forest and village as random effects.

Fixed effect	Coefficient	Standard error	Lower 95% confidence interval	Upper 95% confidence interval
Intercept	1.89	0.09	1.72	2.06
(Basal area of tree cuts per hectare) / 10	0.00	0.02	-0.03	0.04
(Basal area of pole cuts per hectare) / 10	0.03	0.29	-0.55	0.61
Forest size (km^2)	0.00	0.00	0.00	0.01

Table 4.1. Descriptions of the six explanatory variables used to explain support for conservation.

Population pressure	Population pressure is a measure of population size in relation to the local resource base. High population pressure often leads to more environmental degradation (Laurance 1999). For instance, forests under high population pressure in India have been shown to be more degraded (Karanth et al. 2006). However, the associations are not inevitable, especially in the case of high institutional effectiveness (Agrawal 1995; Southgate et al. 1990). If population pressure leads to environmental degradation, it is indicative of the failure of local people to practice conservation-orientated behaviors. Nevertheless, these people may still have high support for conservation as an intact forest may be necessary for their sustenance. Harcourt (2000) demonstrates these principles with the story of an Ugandan farmer who knows that clearing the forest is detrimental, and presumably supports conservation of the forest in the long run, but has to clear the forest in order to feed his family in the short-term.
Median age of local people	Different aged populations may vary in use of forest resources (Godoy et al. 1997). Those age groups that more intensely use forests may be more dependent on forest resources. People more dependent on forest resources may be less likely to personally conserve forest resources. However, as described above, these same people may have high support for the conservation of the forest.
Hours per year in the forest	The amount of time spent in the forest is a measure of forest use. More time in the forest presumably means more dependence of forest resources (Byron and Arnold 1999). Again, dependence on forests should reduce interest in personally participating in conservation, but may increase overall support for conservation.
Number of children	Unless the resources are available for agricultural intensification (Kenya: Tiffen 1993), more children may lead to increased forest dependence, as additional resources to support larger families may come from increased gathering in the forest (Dasgupta 1998; Geist and Lambin 2001). As described above, dependence on forests may reduce interest in personally participating in conservation, but may increase general interest in conservation.
Farm size (acres)	Local people that already have large farms are often wealthy (e.g. Bhalotra and Heady 2003; Polson and Spencer 1991), and therefore may not be very dependent on forest resources (Bhutan: Brooks 2010), though they may have interest in profit-driven harvesting (Tanzania: Holmes 2003). If dependence on forest resources is decreased, local people may support conservation as few short-term benefits would be lost, but the long-term benefits of conservation would be gained, such as reduced soil erosion and continued water catchment (West Usambara: Lundgren 1980; Lundgren and Lundgren 1979).
Crop-raiding frequency (for primates only)	Those species that raid crops are often despised by local people and therefore support for conservation would be absent, as shown by strong negative attitudes of local people toward baboons (*Papio anubis*) in Uganda (Hill and Webber 2010). Though, on the other hand, some farmers in Sulawesi were quite tolerant of macaques, even though crop-raiding was frequent; the authors attribute this to the prominent and positive place for the monkeys in local folklore and culture (Riley and Priston 2010).

Table 4.2. The proportion of interviewees that reported that the activities were bad for forests and primates. *Black-and-white colobus monkeys were absent from these forests. ** I calculated the median and quartiles with respect to the nesting of villages within forests.

Forest	Village	Forests			
		N=	Removing poles	Removing trees	Clearing forest
Ambangulu / Vugiri	Bagamoyo	10	1.00	1.00	1.00
Ambangulu / Vugiri	Old Ambangulu	10	0.90	1.00	1.00
Baga / Mazumbai / Sagara	Kizanda	10	1.00	1.00	1.00
Baga / Mazumbai / Sagara	Malomboi	10	1.00	1.00	1.00
Balangai	Balangai	10	1.00	1.00	1.00
Balangai	Kweminyasa A	10	1.00	1.00	0.90
Kisima Gonja	Kwabosa	10	1.00	1.00	1.00
Kisima Gonja	Mavumbi	10	1.00	1.00	1.00
Lutindi *	Lutindi	10	0.90	0.80	0.70
Lutindi *	Masange 2	10	0.80	1.00	0.70
Magamba	Kwesimu	10	1.00	1.00	1.00
Magamba	Magamba-Cost B	10	1.00	1.00	1.00
Mahazengulu	Mahazengulu	10	1.00	1.00	1.00
Mahazengulu	Tamota	10	1.00	1.00	1.00
Mkussu	Magamba-Cost A	10	1.00	1.00	0.90
Mkussu	Masange 1	10	1.00	1.00	1.00
Mtumbi *	Kwekifinyu	10	1.00	1.00	1.00
Mtumbi *	Mnandani	10	1.00	1.00	1.00
Mzinga	Baga	10	1.00	1.00	1.00
Mzinga	Wanga	10	1.00	1.00	1.00
Ndelemai	Kweminyasa B	10	1.00	1.00	1.00
Ndelemai	Magila	10	1.00	1.00	1.00
Shagayu	Goka	10	1.00	1.00	1.00
Shagayu	Mpanga	10	1.00	1.00	1.00
Shambalai *	ChakeChake	10	1.00	1.00	1.00
Shambalai *	Dolci	10	1.00	1.00	1.00
Median *(quartiles 25% - 75%) ***		10 *(10 - 10)*	1.00 *(1.00 - 1.00)*	1.00 *(1.00 - 1.00)*	1.00 *(0.98 - 1.00)*

Table 4.2. (cont.)

Forest	Village	Black-and-white colobus monkeys				Sykes monkeys			
		N=	Removing poles	Removing trees	Clearing forest	N=	Removing poles	Removing trees	Clearing forest
Ambangulu / Vugiri	Bagamoyo	2	1.00	1.00	1.00	7	1.00	1.00	1.00
Ambangulu / Vugiri	Old Ambangulu	5	1.00	1.00	1.00	6	1.00	1.00	1.00
Baga / Mazumbai / Sagara	Kizanda	10	1.00	1.00	1.00	10	1.00	1.00	1.00
Baga / Mazumbai / Sagara	Malomboi	10	1.00	1.00	1.00	10	1.00	1.00	1.00
Balangai	Balangai	6	1.00	1.00	1.00	9	1.00	1.00	1.00
Balangai	Kweminyasa A	9	1.00	1.00	1.00	10	1.00	1.00	1.00
Kisima Gonja	Kwabosa	8	1.00	1.00	1.00	9	1.00	1.00	1.00
Kisima Gonja	Mavumbi	10	1.00	1.00	1.00	9	1.00	1.00	1.00
Lutindi *	Lutindi	-	-	-	-	7	1.00	1.00	0.71
Lutindi *	Masange 2	-	-	-	-	5	1.00	1.00	1.00
Magamba	Kwesimu	8	1.00	1.00	1.00	10	1.00	1.00	1.00
Magamba	Magamba-Cost B	10	0.90	1.00	1.00	9	0.89	1.00	1.00
Mahazengulu	Mahazengulu	10	1.00	1.00	1.00	9	1.00	1.00	1.00
Mahazengulu	Tamota	8	1.00	1.00	1.00	10	1.00	1.00	1.00
Mkussu	Magamba-Cost A	8	1.00	1.00	0.88	10	1.00	1.00	0.90
Mkussu	Masange 1	9	1.00	1.00	1.00	10	1.00	1.00	1.00
Mtumbi *	Kwekifinyu	-	-	-	-	10	1.00	1.00	1.00
Mtumbi *	Mnandani	-	-	-	-	9	1.00	1.00	1.00
Mzinga	Baga	7	1.00	1.00	1.00	8	1.00	1.00	1.00
Mzinga	Wanga	10	1.00	1.00	1.00	10	1.00	1.00	1.00
Ndelemai	Kweminyasa B	1	1.00	1.00	1.00	8	1.00	1.00	1.00
Ndelemai	Magila	9	1.00	1.00	1.00	10	1.00	1.00	1.00
Shagayu	Goka	7	1.00	1.00	1.00	10	1.00	1.00	1.00
Shagayu	Mpanga	9	1.00	1.00	1.00	10	1.00	1.00	1.00
Shambalai *	ChakeChake	-	-	-	-	10	1.00	1.00	1.00
Shambalai *	Dolci	-	-	-	-	10	1.00	1.00	1.00
	Median *(quartiles 25% - 75%)* **	8.5 *(6.9 - 9.0)*	1.00 *(1.00 - 1.00)*	1.00 *(1.00 - 1.00)*	1.00 *(1.00 - 1.00)*	9.5 *(9.0 - 10.0)*	1.00 *(1.00 - 1.00)*	1.00 *(1.00 - 1.00)*	1.00 *(1.00 - 1.00)*

Table 4.3. The proportion of interviewees that reported high support for conservation. *Black-and-white colobus monkeys were absent from these forests. ** I calculated the median and quartiles with respect to the nesting of villages within forests.

Forest	Village	Forests		Black-and-white colobus monkeys		Sykes monkeys	
		N=	Proportion	N=	Proportion	N=	Proportion
Ambangulu / Vugiri	Bagamoyo	10	0.60	2	0.50	7	0.00
Ambangulu / Vugiri	Old Ambangulu	10	0.60	5	0.40	6	0.67
Baga / Mazumbai / Sagara	Kizanda	10	0.70	10	0.70	10	0.50
Baga / Mazumbai / Sagara	Malomboi	10	0.90	10	0.80	10	0.60
Balangai	Balangai	10	0.80	6	0.50	9	0.22
Balangai	Kweminyasa A	10	0.70	9	0.33	10	0.20
Kisima Gonja	Kwabosa	10	0.80	8	0.88	9	0.78
Kisima Gonja	Mavumbi	10	0.70	10	0.60	9	0.67
Lutindi *	Lutindi	10	0.70	-	-	7	0.43
Lutindi *	Masange 2	10	0.70	-	-	5	0.80
Magamba	Kwesimu	10	0.50	8	0.63	10	0.10
Magamba	Magamba-Cost B	10	0.70	10	0.50	9	0.56
Mahazengulu	Mahazengulu	10	0.60	10	0.40	9	0.33
Mahazengulu	Tamota	10	0.70	8	0.63	10	0.40
Mkussu	Magamba-Cost A	10	0.40	8	0.63	10	0.30
Mkussu	Masange 1	10	0.60	9	0.33	10	0.00
Mtumbi *	Kwekifinyu	10	0.90	-	-	10	0.50
Mtumbi *	Mnandani	10	0.80	-	-	9	0.56
Mzinga	Baga	10	0.60	7	0.71	8	0.38
Mzinga	Wanga	10	0.70	10	0.80	10	0.90
Ndelemai	Kweminyasa B	10	0.50	1	0.00	8	0.13
Ndelemai	Magila	10	0.40	9	0.67	10	0.60
Shagayu	Goka	10	0.70	7	0.43	10	0.20
Shagayu	Mpanga	10	0.90	9	0.67	10	0.60
Shambalai *	ChakeChake	10	0.20	-	-	10	0.30
Shambalai *	Dolci	10	0.70	-	-	10	0.00
	Median *(quartiles 25% - 75%) ** *	10.0 *(10.0 - 10.0)*	0.65 *(0.55 - 0.78)*	8.5 *(6.9 - 9.0)*	0.53 *(0.44 - 0.74)*	9.5 *(9.0 - 10.0)*	0.37 *(0.27 - 0.58)*

Table 4.4. Summary statistics for the explanatory variables that may influence support for conservation. *I calculated the median and quartiles with respect to the nesting of interviews within villages, and villages within forests. **Data provided by the 2002 Tanzanian census; the census did not report quartiles (United Republic of Tanzania 2005). ***Black-and-white colobus monkeys were absent from these forests.

Forest	Village	Population pressure *(village population size / forest size (km^2))*	Median age of local people **	Hours per year in the forest	
				N=	Median *(quartiles)* *
Ambangulu / Vugiri	Bagamoyo	100.9	18.1	10	234.0 *(9.8 - 409.5)*
Ambangulu / Vugiri	Old Ambangulu	91.9	14.4	10	20.0 *(7.5 - 195.0)*
Baga / Mazumbai / Sagara	Kizanda	73.8	17.2	10	126.0 *(0.0 - 448.5)*
Baga / Mazumbai / Sagara	Malomboi	60.8	13.2	10	72.0 *(31.5 - 132.8)*
Balangai	Balangai	260.5	17.5	10	0.0 *(0.0 - 351.0)*
Balangai	Kweminyasa A	500.5	16.7	10	46.0 *(14.1 - 87.8)*
Kisima Gonja	Kwabosa	139.5	15.5	10	36.0 *(0.0 - 279.0)*
Kisima Gonja	Mavumbi	97.1	15.0	9	20.0 *(0.0 - 60.0)*
Lutindi***	Lutindi	29.0	37.8	10	54.0 *(3.8 - 162.6)*
Lutindi***	Masange 2	136.9	16.3	10	150.0 *(78.0 - 331.5)*
Magamba	Kwesimu	17.2	18.4	10	66.0 *(31.5 - 175.5)*
Magamba	Magamba-Cost B	61.5	16.7	10	36.0 *(8.8 - 56.6)*
Mahazengulu	Mahazengulu	675.3	15.4	10	22.5 *(6.8 - 108.0)*
Mahazengulu	Tamota	336.0	17.6	10	117.0 *(0.0 - 331.5)*
Mkussu	Magamba-Cost A	132.0	16.7	10	20.5 *(0.0 - 79.5)*
Mkussu	Masange 1	74.1	14.8	10	87.0 *(1.3 - 533.5)*
Mtumbi***	Kwekifinyu	888.0	14.5	10	7.5 *(0.0 - 24.0)*
Mtumbi***	Mnandani	2807.1	14.8	10	28.0 *(0.0 - 85.5)*
Mzinga	Baga	858.9	15.0	10	4.2 *(0.0 - 45.0)*
Mzinga	Wanga	811.2	14.3	10	156.0 *(0.0 - 312.0)*
Ndelemai	Kweminyasa B	411.7	16.7	10	81.0 *(32.0 - 253.5)*
Ndelemai	Magila	211.9	16.6	10	17.0 *(0.0 - 99.0)*
Shagayu	Goka	29.5	14.5	10	114.0 *(16.0 - 259.5)*
Shagayu	Mpanga	28.4	15.3	10	546.0 *(292.5 - 799.5)*
Shambalai***	ChakeChake	10004.6	21.0	10	0.0 *(0.0 - 1.6)*
Shambalai***	Dolci	17077.3	18.4	10	0.0 *(0.0 - 93.0)*
Median *(quartiles)* *	-	118.3 *(75.1 - 670.3)*	16.3 *(15.1 - 17.3)*	10 *(10 – 10)*	53.8 *(25.5 - 100.5)*

Table 4.4. (cont.)

Forest	Village	Number of children N=	Number of children Median *(quartiles)* *	Farm size (acres) N=	Farm size (acres) Median *(quartiles)* *
Ambangulu / Vugiri	Bagamoyo	10	5.0 *(3.5 - 7.0)*	10	2.5 *(1.9 - 4.3)*
Ambangulu / Vugiri	Old Ambangulu	10	6.0 *(1.8 - 8.3)*	10	4.0 *(2.0 - 5.3)*
Baga / Mazumbai / Sagara	Kizanda	10	4.0 *(2.3 - 6.0)*	10	3.0 *(2.8 - 5.0)*
Baga / Mazumbai / Sagara	Malomboi	10	7.5 *(4.8 - 9.8)*	10	4.5 *(2.0 - 7.0)*
Balangai	Balangai	10	4.5 *(1.0 - 6.3)*	10	3.5 *(1.0 - 5.6)*
Balangai	Kweminyasa A	10	3.0 *(1.5 - 5.0)*	10	1.9 *(0.8 - 3.1)*
Kisima Gonja	Kwabosa	10	4.5 *(2.8 - 8.0)*	10	3.3 *(2.4 - 4.3)*
Kisima Gonja	Mavumbi	9	3.0 *(0.5 - 4.0)*	9	1.0 *(0.8 - 2.0)*
Lutindi***	Lutindi	10	6.0 *(2.3 - 8.5)*	10	3.3 *(2.9 - 4.0)*
Lutindi***	Masange 2	10	4.5 *(1.5 - 6.5)*	10	2.5 *(1.8 - 5.3)*
Magamba	Kwesimu	10	3.0 *(2.0 - 5.0)*	10	2.0 *(0.5 - 4.0)*
Magamba	Magamba-Cost B	10	3.0 *(1.0 - 3.3)*	10	2.0 *(1.8 - 3.3)*
Mahazengulu	Mahazengulu	10	5.0 *(3.0 - 9.0)*	10	4.5 *(1.8 - 6.3)*
Mahazengulu	Tamota	10	4.5 *(1.5 - 5.3)*	10	2.0 *(1.5 - 2.3)*
Mkussu	Magamba-Cost A	10	4.5 *(2.0 - 6.3)*	10	1.3 *(1.0 - 2.0)*
Mkussu	Masange 1	10	3.5 *(1.5 - 7.3)*	10	2.0 *(0.4 - 3.3)*
Mtumbi***	Kwekifinyu	10	5.0 *(4.8 - 7.0)*	10	2.5 *(1.8 - 3.0)*
Mtumbi***	Mnandani	10	3.5 *(2.0 - 8.3)*	10	3.0 *(2.0 - 4.8)*
Mzinga	Baga	10	5.0 *(3.0 - 5.3)*	10	3.5 *(2.0 - 4.3)*
Mzinga	Wanga	10	4.5 *(1.8 - 7.0)*	10	3.0 *(2.0 - 4.3)*
Ndelemai	Kweminyasa B	10	3.0 *(1.0 - 6.0)*	10	2.5 *(0.8 - 4.5)*
Ndelemai	Magila	10	4.0 *(0.0 - 6.3)*	10	2.0 *(0.9 - 3.0)*
Shagayu	Goka	10	5.5 *(2.8 - 6.8)*	10	2.5 *(1.4 - 5.0)*
Shagayu	Mpanga	10	3.5 *(2.0 - 6.0)*	10	2.8 *(1.0 - 4.3)*
Shambalai***	ChakeChake	10	3.0 *(2.0 - 4.0)*	10	1.0 *(0.0 - 5.3)*
Shambalai***	Dolci	10	5.5 *(3.0 - 6.0)*	10	1.8 *(0.6 - 3.5)*
Median * *(quartiles 25% - 75%)*	-	10 *(10 – 10)*	4.3 *(3.8 - 5.0)*	10 *(10 – 10)*	2.7 *(2.1 - 3.3)*

Table 4.4. (cont.)

		Crop-raiding: Black-and-white colobus monkeys		Crop-raiding: Sykes monkeys	
Forest	Village	N=	Median *(quartiles)* *	N=	Median *(quartiles)* *
Ambangulu / Vugiri	Bagamoyo	2	0.0 *(0.0 - 0.0)*	7	0.0 *(0.0 - 0.0)*
Ambangulu / Vugiri	Old Ambangulu	5	0.0 *(0.0 - 4.0)*	6	0.0 *(0.0 - 0.8)*
Baga / Mazumbai / Sagara	Kizanda	10	0.0 *(0.0 - 0.0)*	10	0.0 *(0.0 - 0.5)*
Baga / Mazumbai / Sagara	Malomboi	10	0.0 *(0.0 - 0.0)*	10	1.0 *(0.0 - 2.0)*
Balangai	Balangai	6	0.0 *(0.0 - 0.5)*	9	2.0 *(0.5 - 3.5)*
Balangai	Kweminyasa A	9	0.0 *(0.0 - 0.0)*	10	2.0 *(0.0 - 2.0)*
Kisima Gonja	Kwabosa	8	0.0 *(0.0 - 0.0)*	9	0.0 *(0.0 - 2.5)*
Kisima Gonja	Mavumbi	9	0.0 *(0.0 - 0.0)*	8	1.0 *(1.0 - 2.8)*
Lutindi***	Lutindi	-	-	7	1.0 *(0.0 - 1.0)*
Lutindi***	Masange 2	-	-	5	0.0 *(0.0 - 2.5)*
Magamba	Kwesimu	8	0.0 *(0.0 - 0.0)*	10	0.0 *(0.0 - 2.0)*
Magamba	Magamba-Cost B	10	0.0 *(0.0 - 0.0)*	9	0.0 *(0.0 - 3.0)*
Mahazengulu	Mahazengulu	10	0.0 *(0.0 - 0.0)*	9	2.0 *(1.0 - 3.0)*
Mahazengulu	Tamota	8	0.0 *(0.0 - 2.3)*	10	1.0 *(0.0 - 3.0)*
Mkussu	Magamba-Cost A	8	0.0 *(0.0 - 0.0)*	10	0.0 *(0.0 - 1.3)*
Mkussu	Masange 1	9	0.0 *(0.0 - 0.0)*	10	0.0 *(0.0 - 0.0)*
Mtumbi***	Kwekifinyu	-	-	10	0.0 *(0.0 - 2.0)*
Mtumbi***	Mnandani	-	-	9	0.0 *(0.0 - 1.5)*
Mzinga	Baga	7	0.0 *(0.0 - 0.0)*	8	0.0 *(0.0 - 1.8)*
Mzinga	Wanga	10	0.0 *(0.0 - 0.0)*	10	0.0 *(0.0 - 1.3)*
Ndelemai	Kweminyasa B	1	0.0 *(0.0 - 0.0)*	8	0.0 *(0.0 - 0.8)*
Ndelemai	Magila	9	0.0 *(0.0 - 0.0)*	10	0.5 *(0.0 - 2.0)*
Shagayu	Goka	7	0.0 *(0.0 - 0.0)*	10	1.0 *(0.0 - 2.3)*
Shagayu	Mpanga	9	0.0 *(0.0 - 0.0)*	10	0.0 *(0.0 - 0.3)*
Shambalai***	ChakeChake	-	-	10	0.0 *(0.0 - 3.0)*
Shambalai***	Dolci	-	-	10	0.0 *(0.0 - 0.3)*
Median * *(quartiles 25% - 75%)*	-	8.5 *(6.9 - 9.0)*	0.0 *(0.0 - 0.0)*	9.5 *(8.8 - 10.0)*	0.3 *(0.0 - 0.5)*

Table 4.5a. Results following model selection and averaging of a generalized linear mixed model that included five explanatory variables to explain the support for conservation of the forest. I treated both forest and village as random effects. I defined population pressure as village population size divided by forest size (km^2).

Fixed effect	Coefficient	Standard error	Lower 95% confidence interval	Upper 95% confidence interval
Intercept	0.65	0.34	-0.01	1.30
Median age of local people	-0.01	0.01	-0.03	0.02
Number of children	0.00	0.01	-0.02	0.01
Farm size (acres)	0.05	0.06	-0.07	0.17
Population pressure / 10	0.00	0.00	0.00	0.00

Table 4.5b. Results following model selection and averaging of a generalized linear mixed model that included six explanatory variables to explain the support for conservation of black-and-white colobus monkeys. I treated both forest and village as random effects.

Fixed effect	Coefficient	Standard error	Lower 95% confidence interval	Upper 95% confidence interval
Intercept	0.37	0.52	-0.65	1.39
Median age of local people	-0.01	0.02	-0.05	0.03
Number of children	0.01	0.02	-0.03	0.05
Crop-raiding frequency	0.04	0.09	-0.14	0.22
Farm size (acres)	0.05	0.07	-0.10	0.19
Hours per year in the forest	0.00	0.00	0.00	0.00

Table 4.5c. Results following model selection and averaging of a generalized linear mixed model that included six explanatory variables to explain the support for conservation of Sykes monkey. I treated both forest and village as random effects. I defined population pressure as village population size divided by forest size (km^2).

Fixed effect	Coefficient	Standard error	Lower 95% confidence interval	Upper 95% confidence interval
Intercept	-0.46	0.45	-1.35	0.42
Median age of local people	0.00	0.01	-0.02	0.02
Number of children	0.01	0.03	-0.04	0.07
Crop-raiding frequency	0.00	0.01	-0.02	0.02
Farm size (acres)	0.08	0.08	-0.08	0.23
Hours per year in the forest	0.00	0.00	0.00	0.00
Population pressure / 10	0.00	0.00	0.00	0.00

Figure 1.1. Map of the Eastern Arc Mountains of Kenya and Tanzania and the forests of the West Usambara mountain block.

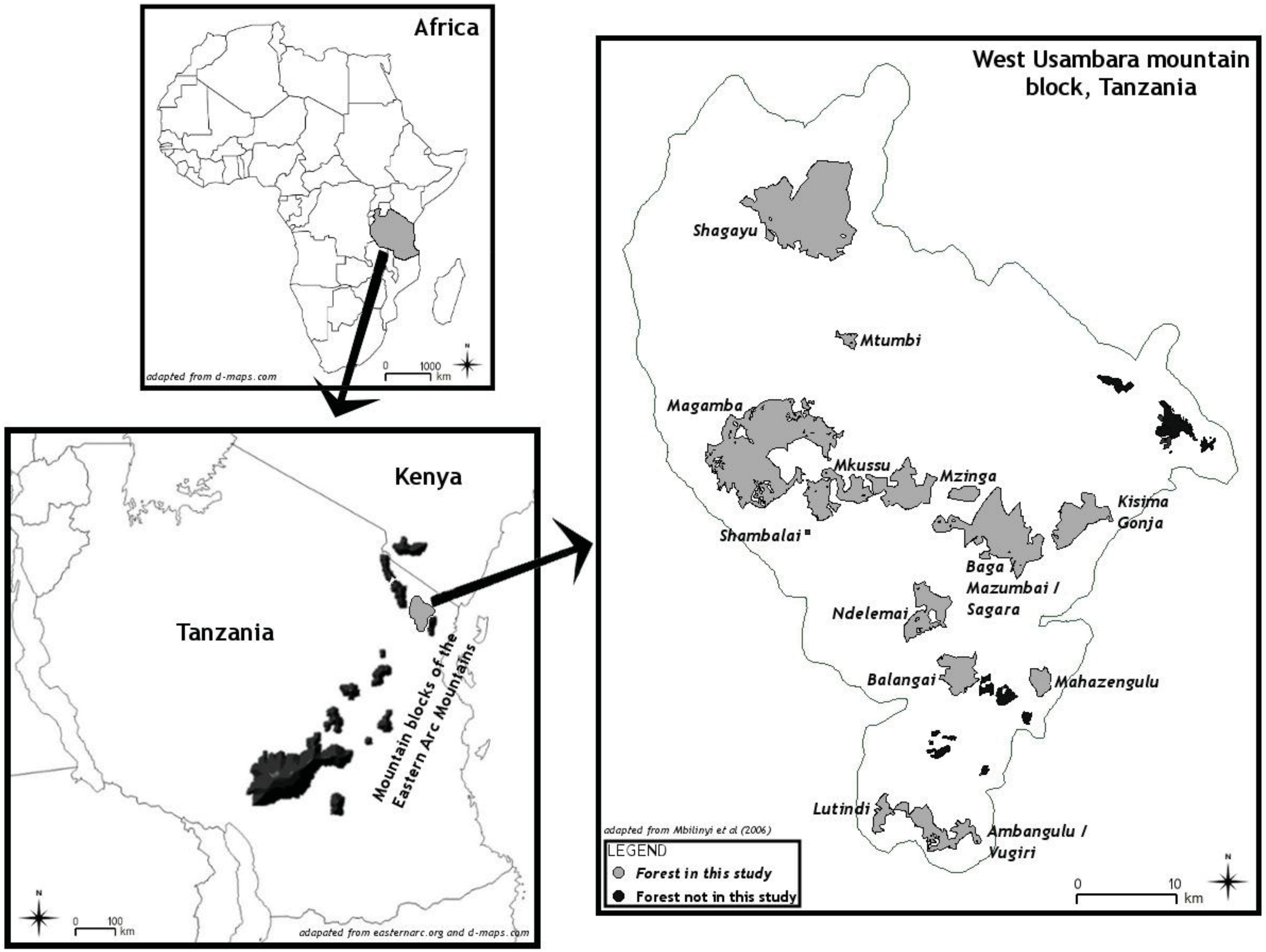


Figure 2.1. Plot of the relationship (coefficient estimate=0.28; standard error=0.10, lower 95% CI=0.08; upper 95% CI=0.47) between population pressure (transformed by natural logarithm) and the basal area of pole stumps (m^2) per hectare (transformed by natural logarithm). I defined population pressure as village population size divided by forest size (km^2).

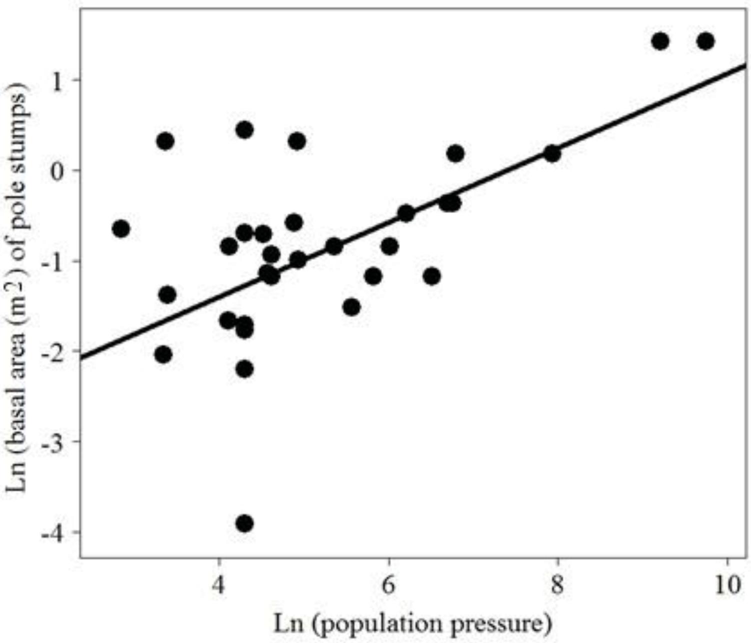


Figure 3.1. Plot of the relationship (coefficient estimate=0.19, standard error=0.10, lower 95% CI=-0.04, upper 95% CI=0.41) between the proportion of interviewees reporting that the black-and-white colobus monkeys were present and the encounter rate with the monkeys in the forests of West Usambara (transformed by natural logarithm plus one). I defined encounter rate at the number of groups sighted per transect walk divided by the length of the transect (km).

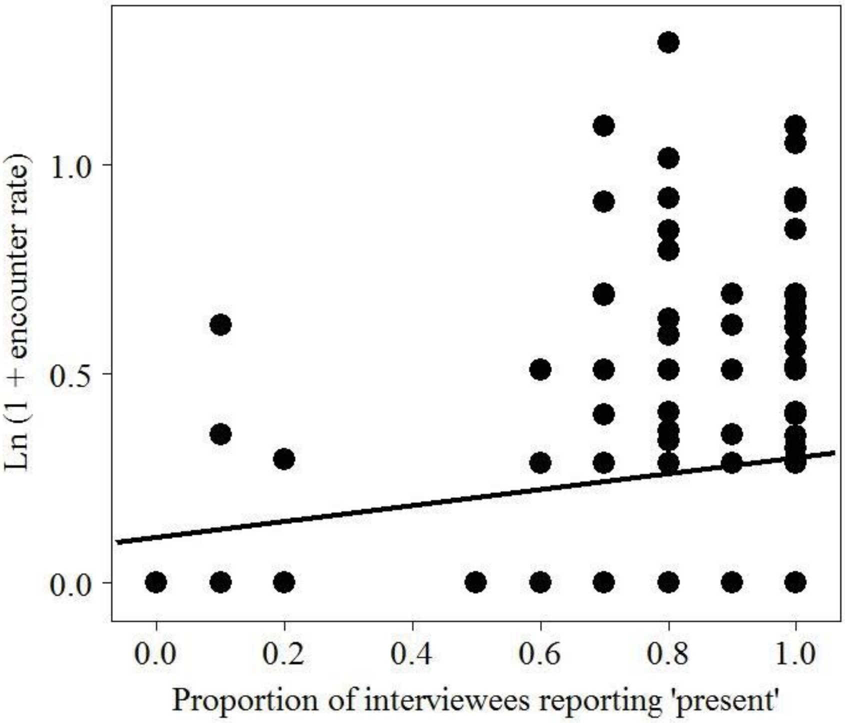


Figure 3.2. Anthropogenic forest disturbance in West Usambara as compared between forests where black-and-white colobus are absent (N=3) and forests where they are present (N=10). Points indicate the medians and hash marks show the quartiles (25-75%). '*' indicates a significant difference as determined by an ANOVA test (see text for details). Black = median basal area (m^2) of tree stumps / ha ($F_{1,11}$=0.28; p=0.609). Dark grey = median basal area (m^2) of pole stumps / ha ($F_{1,11}$=10.56; p=0.008). Light grey = forest size (km^2) ($F_{1,11}$=13.23; p=0.004).

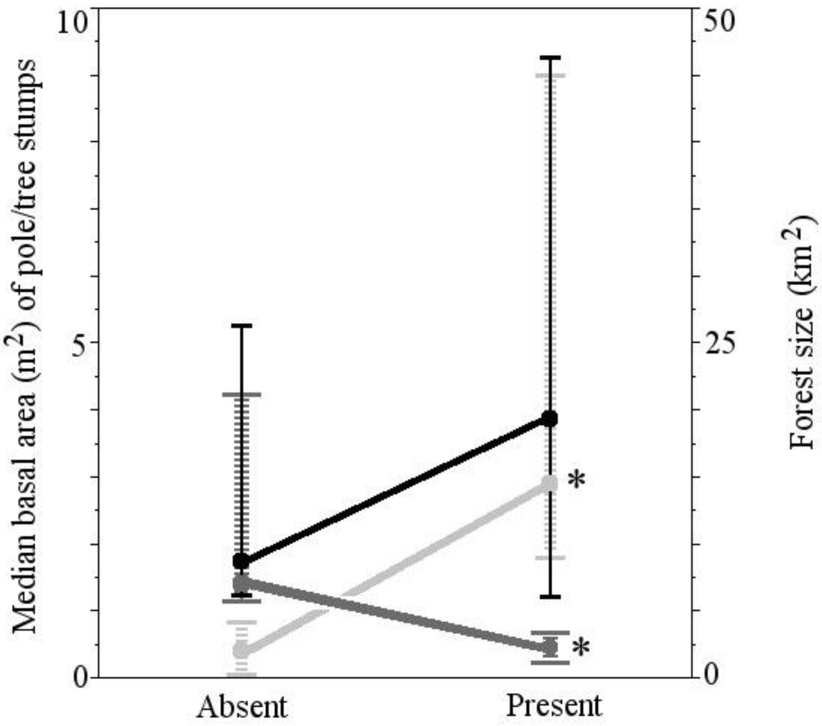


Figure 3.3. Plot of the relationship (coefficient estimate=0.05, standard error=0.04, lower 95% CI=-0.03, upper 95% CI=0.13) between the basal area (m^2) of tree stumps per hectare (transformed by natural logarithm plus one) and the encounter rate of black-and-white colobus monkeys in the forests of West Usambara (transformed by natural logarithm plus one). I defined encounter rate at the number of groups sighted per transect walk divided by the length of the transect (km).

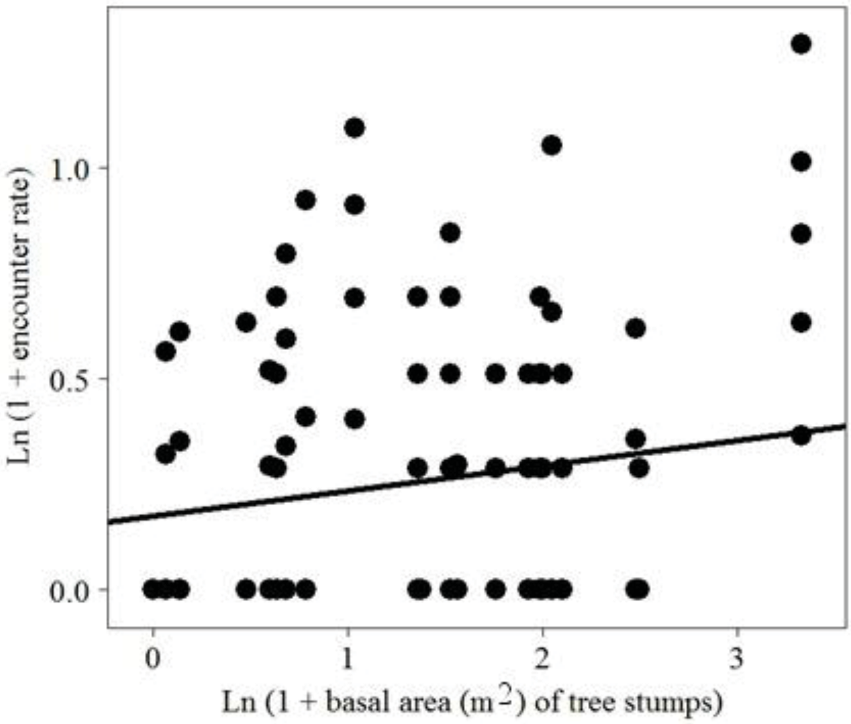
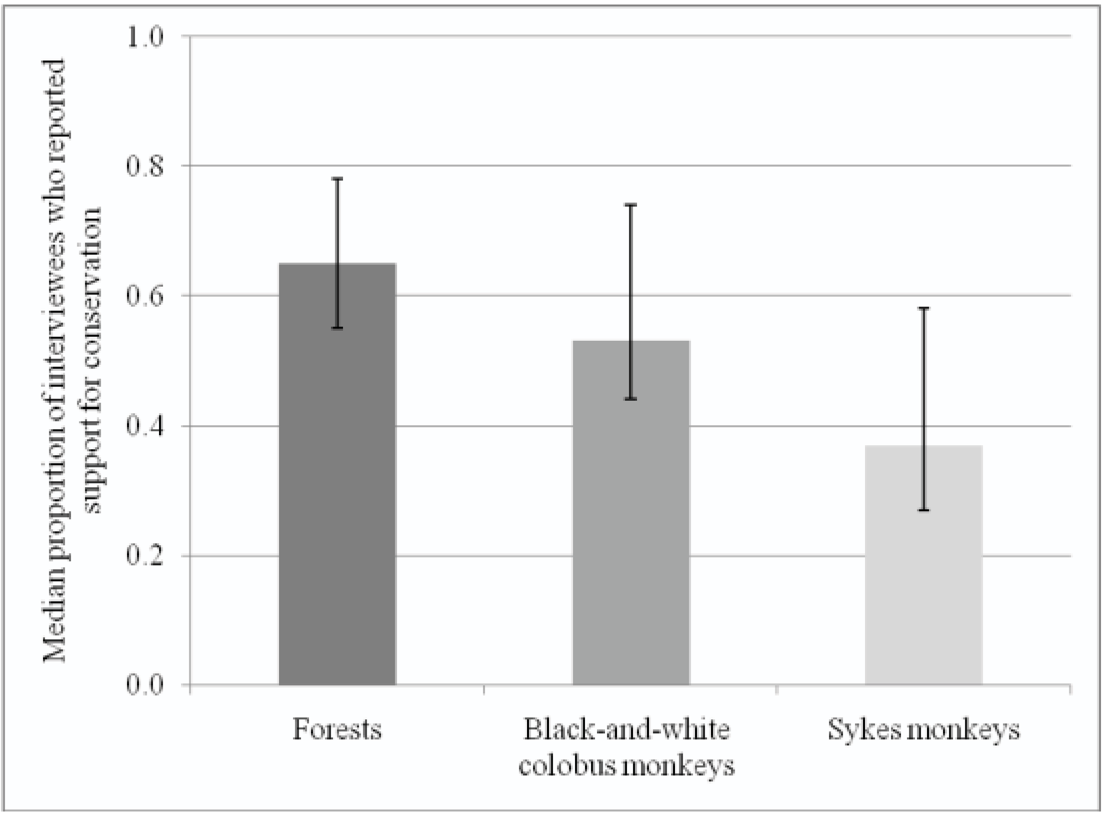


Figure 4.1. The median proportion of interviewees who reported high support for conservation of forests (N=260 interviewees in 26 villages), black-and-white colobus monkeys (N=156 interviewees in 20 villages), and Sykes monkeys (N=235 interviewees in 26 villages). Error bars indicate the quartiles (25% and 75%). Support for conservation differed significantly between forests, black-and-white colobus monkeys, and Sykes monkeys ($F_{2,57}$=12.39; p<0.001).



Appendices

Appendix 2.1. A list of the number of pole and tree stumps per hectare, and the source of the data, in a combined total of 346 transects in 59 forests within 11 mountain blocks in the Eastern Arc Mountains of Tanzania.

Mountain Block	Forest	Tran #	# of pole stumps / ha	# of tree stumps / ha	Source
East Usambara	Amani N.R.	1	47.3	16.4	(Doody et al. 2001b)
East Usambara	Amani N.R.	2	29.0	3.2	(Doody et al. 2001b)
East Usambara	Amani N.R.	3	72.8	19.3	(Doody et al. 2001b)
East Usambara	Amani N.R.	4	29.6	11.9	(Doody et al. 2001b)
East Usambara	Amani N.R.	5	38.7	7.0	(Doody et al. 2001b)
East Usambara	Amani N.R.	6	23.3	3.7	(Doody et al. 2001b)
East Usambara	Amani N.R.	7	21.6	6.4	(Doody et al. 2001b)
East Usambara	Amani N.R.	8	22.5	5.2	(Doody et al. 2001b)
East Usambara	Amani N.R.	9	20.4	8.5	(Doody et al. 2001b)
East Usambara	Amani N.R.	10	3.8	5.0	(Doody et al. 2001b)
East Usambara	Amani N.R.	11	6.6	4.7	(Doody et al. 2001b)
East Usambara	Amani N.R.	12	8.4	4.3	(Doody et al. 2001b)
East Usambara	Amani N.R.	13	11.6	4.2	(Doody et al. 2001b)
East Usambara	Amani N.R.	14	4.4	3.8	(Doody et al. 2001b)
East Usambara	Amani N.R.	15	12.7	0.0	(Doody et al. 2001b)
East Usambara	Amani N.R.	16	23.6	10.9	(Doody et al. 2001b)
East Usambara	Amani N.R.	17	27.9	8.8	(Doody et al. 2001b)
East Usambara	Bombo East I	18	13.8	30.6	(Staddon et al. 2002a)
East Usambara	Bombo East I	19	25.7	16.3	(Staddon et al. 2002a)
East Usambara	Bombo East I	20	51.0	12.4	(Staddon et al. 2002a)
East Usambara	Bombo East I	21	5.9	0.0	(Staddon et al. 2002a)
East Usambara	Bombo East I	22	0.0	0.0	(Staddon et al. 2002a)
East Usambara	Bombo East I	23	22.7	3.1	(Staddon et al. 2002a)
East Usambara	Bombo East I	24	9.5	0.5	(Staddon et al. 2002a)
East Usambara	Bombo East I	25	8.0	0.0	(Staddon et al. 2002a)
East Usambara	Bombo East I	26	104.0	0.0	(Staddon et al. 2002a)
East Usambara	Bombo East II	27	16.0	6.0	(Staddon et al. 2002b)
East Usambara	Bombo East II	28	4.2	2.8	(Staddon et al. 2002b)
East Usambara	Bombo East II	29	18.4	0.8	(Staddon et al. 2002b)
East Usambara	Bombo East II	30	12.1	5.7	(Staddon et al. 2002b)
East Usambara	Bombo West	31	102.9	151.4	(Madoffe and Munishi 2005)
East Usambara	Bombo West	32	46.9	128.0	(Madoffe and Munishi 2005)
East Usambara	Kwamgumi / Segoma	33	36.2	7.6	(Doggart et al. 1999a; Doody et al. 2001d)

East Usambara	Kwamgumi / Segoma	34	37.5	10.7	(Doggart et al. 1999a; Doody et al. 2001d)
East Usambara	Kwamgumi / Segoma	35	32.1	4.9	(Doggart et al. 1999a; Doody et al. 2001d)
East Usambara	Kwamgumi / Segoma	36	9.7	4.4	(Doggart et al. 1999a; Doody et al. 2001d)
East Usambara	Kwamgumi / Segoma	37	6.9	3.6	(Doggart et al. 1999a; Doody et al. 2001d)
East Usambara	Kwamgumi / Segoma	38	4.3	1.3	(Doggart et al. 1999a; Doody et al. 2001d)
East Usambara	Kwamgumi / Segoma	39	1.4	2.5	(Doggart et al. 1999a; Doody et al. 2001d)
East Usambara	Kwamgumi / Segoma	40	8.6	10.5	(Doggart et al. 1999a; Doody et al. 2001d)
East Usambara	Kwamgumi / Segoma	41	0.9	6.2	(Doggart et al. 1999a; Doody et al. 2001d)
East Usambara	Kwamgumi / Segoma	42	9.4	11.4	(Doggart et al. 1999a; Doody et al. 2001d)
East Usambara	Kwamgumi / Segoma	43	3.7	9.9	(Doggart et al. 1999a; Doody et al. 2001d)
East Usambara	Kwamgumi / Segoma	44	2.4	1.8	(Doggart et al. 1999a; Doody et al. 2001d)
East Usambara	Kwamgumi / Segoma	45	3.2	0.6	(Doggart et al. 1999a; Doody et al. 2001d)
East Usambara	Manga	46	10.0	0.0	(Doggart et al. 1999c)
East Usambara	Manga	47	9.3	0.3	(Doggart et al. 1999c)
East Usambara	Manga	48	7.5	6.0	(Doggart et al. 1999c)
East Usambara	Manga	49	18.0	12.8	(Doggart et al. 1999c)
East Usambara	Manga	50	14.2	10.5	(Doggart et al. 1999c)
East Usambara	Manga	51	38.5	21.5	(Doggart et al. 1999c)
East Usambara	Mgambo	52	26.7	0.0	(Oliver et al. 2002)
East Usambara	Mgambo	53	57.6	4.7	(Oliver et al. 2002)
East Usambara	Mgambo	54	25.8	0.8	(Oliver et al. 2002)
East Usambara	Mgambo	55	35.9	9.5	(Oliver et al. 2002)
East Usambara	Mgambo	56	18.9	1.7	(Oliver et al. 2002)
East Usambara	Mgambo	57	17.6	2.1	(Oliver et al. 2002)
East Usambara	Mgambo	58	15.2	2.4	(Oliver et al. 2002)
East Usambara	Mlinga	59	15.2	1.0	(Hall et al. 2002)
East Usambara	Mlinga	60	25.0	5.0	(Hall et al. 2002)
East Usambara	Mlinga	61	3.4	3.4	(Hall et al. 2002)
East Usambara	Mlinga	62	23.3	8.6	(Hall et al. 2002)
East Usambara	Mlinga	63	2.5	0.0	(Hall et al. 2002)
East Usambara	Mlinga	64	5.8	6.1	(Hall et al. 2002)
East Usambara	Mlinga	65	7.4	2.1	(Hall et al. 2002)
East Usambara	Mlinga	66	0.0	0.0	(Hall et al. 2002)
East Usambara	Mpanga	67	181.8	18.2	(Doody et al. 2001a)

East Usambara	Mpanga	68	136.5	32.9	(Doody et al. 2001a)
East Usambara	Mpanga	69	79.4	26.5	(Doody et al. 2001a)
East Usambara	Mpanga	70	92.9	7.1	(Doody et al. 2001a)
East Usambara	Mtai	71	44.0	25.3	(Doggart et al. 1999b; Madoffe and Munishi 2005)
East Usambara	Mtai	72	47.0	40.0	(Doggart et al. 1999b; Madoffe and Munishi 2005)
East Usambara	Mtai	73	66.7	21.7	(Doggart et al. 1999b; Madoffe and Munishi 2005)
East Usambara	Mtai	74	20.0	47.1	(Doggart et al. 1999b; Madoffe and Munishi 2005)
East Usambara	Mtai	75	77.7	7.1	(Doggart et al. 1999b; Madoffe and Munishi 2005)
East Usambara	Mtai	76	83.2	5.8	(Doggart et al. 1999b; Madoffe and Munishi 2005)
East Usambara	Mtai	77	114.1	8.3	(Doggart et al. 1999b; Madoffe and Munishi 2005)
East Usambara	Mtai	78	113.3	6.7	(Doggart et al. 1999b; Madoffe and Munishi 2005)
East Usambara	Mtai	79	65.4	6.2	(Doggart et al. 1999b; Madoffe and Munishi 2005)
East Usambara	Mtai	80	38.1	10.6	(Doggart et al. 1999b; Madoffe and Munishi 2005)
East Usambara	Mtai	81	58.2	10.3	(Doggart et al. 1999b; Madoffe and Munishi 2005)
East Usambara	Mtai	82	68.1	8.9	(Doggart et al. 1999b; Madoffe and Munishi 2005)
East Usambara	Mtai	83	116.2	20.7	(Doggart et al. 1999b; Madoffe and Munishi 2005)
East Usambara	Mtai	84	65.3	20.0	(Doggart et al. 1999b; Madoffe and Munishi 2005)
East Usambara	Mtai	85	59.9	31.4	(Doggart et al. 1999b; Madoffe and Munishi 2005)
East Usambara	Mtai	86	77.2	18.6	(Doggart et al. 1999b; Madoffe and Munishi 2005)
East Usambara	Mtai	87	42.1	7.6	(Doggart et al. 1999b; Madoffe and Munishi 2005)
East Usambara	Mtai	88	51.6	6.3	(Doggart et al. 1999b; Madoffe and Munishi 2005)
East Usambara	Mtai	89	16.4	2.3	(Doggart et al. 1999b; Madoffe and Munishi 2005)
East Usambara	Mtai	90	24.8	3.4	(Doggart et al. 1999b; Madoffe and Munishi 2005)
East Usambara	Mtai	91	56.3	25.2	(Doggart et al. 1999b; Madoffe and Munishi 2005)
East Usambara	Mtai	92	63.5	7.0	(Doggart et al. 1999b; Madoffe and Munishi 2005)
East Usambara	Mtai	93	171.8	5.9	(Doggart et al. 1999b; Madoffe and Munishi 2005)
East Usambara	Mtai	94	92.8	24.5	(Doggart et al. 1999b; Madoffe and Munishi 2005)
East Usambara	Mtai	95	5.5	3.4	(Doggart et al. 1999b; Madoffe and Munishi 2005)

East Usambara	Mtai	96	36.9	13.3	(Doggart et al. 1999b; Madoffe and Munishi 2005)
East Usambara	Mtai	97	29.0	7.6	(Doggart et al. 1999b; Madoffe and Munishi 2005)
East Usambara	Mtai	98	21.2	13.9	(Doggart et al. 1999b; Madoffe and Munishi 2005)
East Usambara	Mtai	99	132.4	18.2	(Doggart et al. 1999b; Madoffe and Munishi 2005)
East Usambara	Nilo	100	20.0	2.4	(Beharrell et al. 2002; Madoffe and Munishi 2005)
East Usambara	Nilo	101	13.6	4.8	(Beharrell et al. 2002; Madoffe and Munishi 2005)
East Usambara	Nilo	102	39.6	9.8	(Beharrell et al. 2002; Madoffe and Munishi 2005)
East Usambara	Nilo	103	30.0	4.3	(Beharrell et al. 2002; Madoffe and Munishi 2005)
East Usambara	Nilo	104	42.2	20.0	(Beharrell et al. 2002; Madoffe and Munishi 2005)
East Usambara	Nilo	105	26.6	11.1	(Beharrell et al. 2002; Madoffe and Munishi 2005)
East Usambara	Nilo	106	26.1	12.1	(Beharrell et al. 2002; Madoffe and Munishi 2005)
East Usambara	Nilo	107	50.4	7.7	(Beharrell et al. 2002; Madoffe and Munishi 2005)
East Usambara	Nilo	108	23.8	8.3	(Beharrell et al. 2002; Madoffe and Munishi 2005)
East Usambara	Nilo	109	57.6	34.7	(Beharrell et al. 2002; Madoffe and Munishi 2005)
East Usambara	Nilo	110	32.3	8.4	(Beharrell et al. 2002; Madoffe and Munishi 2005)
East Usambara	Nilo	111	56.8	31.2	(Beharrell et al. 2002; Madoffe and Munishi 2005)
East Usambara	Nilo	112	17.7	8.8	(Beharrell et al. 2002; Madoffe and Munishi 2005)
East Usambara	Nilo	113	42.7	31.3	(Beharrell et al. 2002; Madoffe and Munishi 2005)
East Usambara	Nilo	114	16.3	5.8	(Beharrell et al. 2002; Madoffe and Munishi 2005)
East Usambara	Nilo	115	43.0	21.5	(Beharrell et al. 2002; Madoffe and Munishi 2005)
East Usambara	Nilo	116	16.7	10.0	(Beharrell et al. 2002; Madoffe and Munishi 2005)
East Usambara	Nilo	117	37.7	8.6	(Beharrell et al. 2002; Madoffe and Munishi 2005)
East Usambara	Nilo	118	14.5	4.5	(Beharrell et al. 2002; Madoffe and Munishi 2005)
East Usambara	Nilo	119	43.7	22.2	(Beharrell et al. 2002; Madoffe and Munishi 2005)
East Usambara	Nilo	120	27.6	24.7	(Beharrell et al. 2002; Madoffe and Munishi 2005)
East Usambara	Nilo	121	15.0	25.0	(Beharrell et al. 2002; Madoffe and Munishi 2005)
East Usambara	Nilo	122	13.3	1.3	(Beharrell et al. 2002; Madoffe and Munishi 2005)

East Usambara	Nilo	123	60.0	0.0	(Beharrell et al. 2002; Madoffe and Munishi 2005)
East Usambara	Semdoe	124	23.9	2.0	(Doggart et al. 2001)
East Usambara	Semdoe	125	19.3	3.3	(Doggart et al. 2001)
East Usambara	Semdoe	126	24.8	8.3	(Doggart et al. 2001)
East Usambara	Semdoe	127	7.7	1.3	(Doggart et al. 2001)
Mahenge	Mahenge Scarp	128	25.9	18.8	(Bracebridge et al. 2004a)
Mahenge	Mselezi	129	7.0	10.0	(Owen et al. 2007)
Mahenge	Mselezi	130	16.0	8.0	(Owen et al. 2007)
Mahenge	Mselezi	131	12.5	32.5	(Owen et al. 2007)
Mahenge	Mselezi	132	467.0	22.0	(Owen et al. 2007)
Mahenge	Mselezi	133	53.3	6.7	(Owen et al. 2007)
Mahenge	Mselezi	134	98.0	39.0	(Owen et al. 2007)
Mahenge	Mselezi	135	28.0	24.0	(Owen et al. 2007)
Mahenge	Mselezi	136	98.0	24.0	(Owen et al. 2007)
Mahenge	Mselezi	137	0.0	31.1	(Owen et al. 2007)
Mahenge	Mselezi	138	126.7	60.0	(Owen et al. 2007)
Mahenge	Mselezi	139	40.0	40.0	(Owen et al. 2007)
Mahenge	Nawenge	140	43.6	27.3	(Bracebridge et al. 2004b)
Mahenge	Nawenge	141	18.3	17.5	(Bracebridge et al. 2004b)
Mahenge	Nawenge	142	10.0	11.8	(Bracebridge et al. 2004b)
Mahenge	Nawenge	143	12.4	7.1	(Bracebridge et al. 2004b)
Mahenge	Nawenge	144	4.0	2.7	(Bracebridge et al. 2004b)
Mahenge	Sali	145	3.0	0.0	(Owen et al. 2007)
Mahenge	Sali	146	0.0	0.0	(Owen et al. 2007)
Mahenge	Sali	147	0.0	0.0	(Owen et al. 2007)
Mahenge	Sali	148	0.0	0.0	(Owen et al. 2007)
Mahenge	Sali	149	0.0	0.0	(Owen et al. 2007)
Mahenge	Sali	150	1.0	0.0	(Owen et al. 2007)
Mahenge	Sali	151	1.0	0.0	(Owen et al. 2007)
Mahenge	Sali	152	1.0	0.0	(Owen et al. 2007)
Nguru	Kanga	153	21.4	57.1	(Madoffe and Munishi 2005)
Nguru	Kanga	154	20.0	12.9	(Madoffe and Munishi 2005)
Nguru	Kanga	155	41.3	80.0	(Madoffe and Munishi 2005)
Nguru	Kanga	156	10.8	18.5	(Madoffe and Munishi 2005)
Nguru	Kanga	157	32.0	12.0	(Madoffe and Munishi 2005)
Nguru	Kanga	158	44.0	32.0	(Madoffe and Munishi 2005)
Nguu	Kilindi	159	1.3	0.0	(Madoffe and Munishi 2005)
Nguu	Kilindi	160	3.1	4.4	(Madoffe and Munishi 2005)
Nguu	Kilindi	161	3.3	0.0	(Madoffe and Munishi 2005)

Nguu	Kilindi	162	0.0	1.5	(Madoffe and Munishi 2005)
Nguu	Nguru North	163	0.0	0.0	(Madoffe and Munishi 2005)
Nguu	Nguru North	164	1.2	2.4	(Madoffe and Munishi 2005)
Nguu	Nguru North	165	8.0	18.0	(Madoffe and Munishi 2005)
Nguu	Nguru North	166	6.7	3.3	(Madoffe and Munishi 2005)
Nguu	Nguru North	167	8.6	0.0	(Madoffe and Munishi 2005)
Nguu	Nguru North	168	0.0	0.0	(Madoffe and Munishi 2005)
Nguu	Nguru North	169	13.3	20.0	(Madoffe and Munishi 2005)
Nguu	Nguru North	170	3.0	2.0	(Madoffe and Munishi 2005)
Nguu	Nguru North	171	3.3	4.7	(Madoffe and Munishi 2005)
Nguu	Nguru North	172	0.0	0.0	(Madoffe and Munishi 2005)
Nguu	Nguru North	173	1.0	1.0	(Madoffe and Munishi 2005)
Nguu	Nguru North	174	0.0	8.9	(Madoffe and Munishi 2005)
Nguu	Nguru North	175	8.6	0.0	(Madoffe and Munishi 2005)
Nguu	Nguru North	176	1.5	4.6	(Madoffe and Munishi 2005)
North Pare	Kindoroko	177	106.0	10.0	(Doggart et al. 2008a)
North Pare	Kindoroko	178	2.0	6.0	(Doggart et al. 2008a)
North Pare	Kindoroko	179	28.2	5.9	(Doggart et al. 2008a)
North Pare	Kiverenge	180	82.2	43.0	(Madoffe and Munishi 2005)
North Pare	Kiverenge	181	44.8	70.5	(Madoffe and Munishi 2005)
North Pare	Minja	182	14.0	4.0	(Doggart et al. 2008a)
North Pare	Minja	183	1.0	11.0	(Doggart et al. 2008a)
North Pare	Mramba	184	6.0	4.0	(Doggart et al. 2008a; Madoffe and Munishi 2005)
North Pare	Mramba	185	9.0	1.0	(Doggart et al. 2008a; Madoffe and Munishi 2005)
North Pare	Mramba	186	32.0	12.0	(Doggart et al. 2008a; Madoffe and Munishi 2005)
North Pare	Mramba	187	114.0	20.0	(Doggart et al. 2008a; Madoffe and Munishi 2005)
North Pare	Mramba	188	64.4	4.4	(Doggart et al. 2008a; Madoffe and Munishi 2005)
North Pare	Mramba	189	23.0	13.0	(Doggart et al. 2008a; Madoffe and Munishi 2005)
Rubeho	Mafwomera	190	40.0	16.4	(Madoffe and Munishi 2005)
Rubeho	Mafwomera	191	0.0	6.0	(Madoffe and Munishi 2005)
Rubeho	Mafwomera	192	64.3	48.7	(Madoffe and Munishi 2005)
Rubeho	Mafwomera	193	63.8	21.3	(Madoffe and Munishi 2005)
Rubeho	Mafwomera	194	16.7	26.7	(Madoffe and Munishi 2005)
Rubeho	Mang'alisa	195	25.0	28.0	(Madoffe and Munishi 2005)
Rubeho	Mang'alisa	196	37.6	16.8	(Madoffe and Munishi 2005)
Rubeho	Mang'alisa	197	19.3	17.9	(Madoffe and Munishi 2005)
Rubeho	Mang'alisa	198	41.5	15.4	(Madoffe and Munishi 2005)

Rubeho	Mang'alisa	199	32.0	10.0	(Madoffe and Munishi 2005)
Rubeho	Mang'alisa	200	25.0	15.0	(Madoffe and Munishi 2005)
Rubeho	Ukwiva	201	0.0	5.7	(Madoffe and Munishi 2005)
Rubeho	Ukwiva	202	0.0	2.2	(Madoffe and Munishi 2005)
Rubeho	Ukwiva	203	12.0	14.0	(Madoffe and Munishi 2005)
Rubeho	Ukwiva	204	2.1	6.4	(Madoffe and Munishi 2005)
Rubeho	Ukwiva	205	1.0	18.0	(Madoffe and Munishi 2005)
Rubeho	Ukwiva	206	8.0	4.8	(Madoffe and Munishi 2005)
Rubeho	Ukwiva	207	5.2	10.4	(Madoffe and Munishi 2005)
Rubeho	Ukwiva	208	0.0	8.2	(Madoffe and Munishi 2005)
Rubeho	Ukwiva	209	2.1	1.4	(Madoffe and Munishi 2005)
South Pare	Chambogo	210	126.7	106.3	(Madoffe and Munishi 2005)
South Pare	Chambogo	211	178.9	74.7	(Madoffe and Munishi 2005)
South Pare	Chambogo	212	167.3	29.1	(Madoffe and Munishi 2005)
South Pare	Vumari	213	45.7	85.7	(Madoffe and Munishi 2005)
South Pare	Vumari	214	85.7	152.9	(Madoffe and Munishi 2005)
South Pare	Vumari	215	40.0	27.0	(Madoffe and Munishi 2005)
South Pare	Vumari	216	80.0	116.9	(Madoffe and Munishi 2005)
Udzungwa	Idewa	217	275.6	157.8	(Madoffe and Munishi 2005)
Udzungwa	Ihang’ana	218	76.0	22.7	(Madoffe and Munishi 2005)
Udzungwa	Ihang’ana	219	157.9	142.1	(Madoffe and Munishi 2005)
Udzungwa	Ihang’ana	220	173.0	158.0	(Madoffe and Munishi 2005)
Udzungwa	Ihanga	221	500.0	610.0	(Madoffe and Munishi 2005)
Udzungwa	Ihanga	222	97.6	49.6	(Madoffe and Munishi 2005)
Udzungwa	Ihanga	223	48.8	55.0	(Madoffe and Munishi 2005)
Udzungwa	Ihanga	224	154.3	65.7	(Madoffe and Munishi 2005)
Udzungwa	Ipafu	225	2.0	1.0	(Doggart et al. 2008b)
Udzungwa	Iyondo	226	9.0	23.0	(Madoffe and Munishi 2005; Rovero 2007)
Udzungwa	Iyondo	227	31.7	20.7	(Madoffe and Munishi 2005; Rovero 2007)
Udzungwa	Iyondo	228	1.6	22.4	(Madoffe and Munishi 2005; Rovero 2007)
Udzungwa	Iyondo	229	2.8	0.7	(Madoffe and Munishi 2005; Rovero 2007)
Udzungwa	Iyondo	230	9.0	13.0	(Madoffe and Munishi 2005; Rovero 2007)
Udzungwa	Iyondo	231	0.8	5.6	(Madoffe and Munishi 2005; Rovero 2007)
Udzungwa	Iyondo	232	0.0	1.1	(Madoffe and Munishi 2005; Rovero 2007)
Udzungwa	Iyondo	233	2.4	2.4	(Madoffe and Munishi 2005; Rovero 2007)
Udzungwa	Iyondo	234	37.8	21.8	(Madoffe and Munishi 2005; Rovero

					2007)
Udzungwa	Kisinga-Rugaro	235	22.3	18.5	(Madoffe and Munishi 2005)
Udzungwa	Kisinga-Rugaro	236	17.9	12.1	(Madoffe and Munishi 2005)
Udzungwa	Kisinga-Rugaro	237	10.5	8.6	(Madoffe and Munishi 2005)
Udzungwa	Kisinga-Rugaro	238	12.2	8.9	(Madoffe and Munishi 2005)
Udzungwa	Kisinga-Rugaro	239	25.6	11.1	(Madoffe and Munishi 2005)
Udzungwa	Kisinga-Rugaro	240	53.3	76.7	(Madoffe and Munishi 2005)
Udzungwa	Kisinga-Rugaro	241	80.0	20.0	(Madoffe and Munishi 2005)
Udzungwa	Kisinga-Rugaro	242	15.0	10.0	(Madoffe and Munishi 2005)
Udzungwa	Kisinga-Rugaro	243	22.0	4.0	(Madoffe and Munishi 2005)
Udzungwa	Kitonga	244	121.9	203.2	(Madoffe and Munishi 2005)
Udzungwa	Kitonga	245	18.7	21.3	(Madoffe and Munishi 2005)
Udzungwa	Lulanda	246	9.0	16.0	(Doggart et al. 2008b)
Udzungwa	Matundu	247	13.1	6.7	(Rovero 2007)
Udzungwa	Mufindi	248	0.0	0.0	(Doggart et al. 2008b)
Udzungwa	Mufindi	249	6.0	0.0	(Doggart et al. 2008b)
Udzungwa	Mufindi	250	2.0	3.0	(Doggart et al. 2008b)
Udzungwa	Mufindi	251	4.0	5.0	(Doggart et al. 2008b)
Udzungwa	Mufindi	252	0.0	0.0	(Doggart et al. 2008b)
Udzungwa	Mufindi	253	1.0	2.0	(Doggart et al. 2008b)
Udzungwa	Mufindi	254	231.0	30.0	(Doggart et al. 2008b)
Udzungwa	Mufindi	255	6.0	0.0	(Doggart et al. 2008b)
Udzungwa	Mufindi	256	2.0	3.0	(Doggart et al. 2008b)
Udzungwa	Mufindi	257	0.0	2.0	(Doggart et al. 2008b)
Udzungwa	Mufindi	258	0.0	0.0	(Doggart et al. 2008b)
Udzungwa	Mufindi	259	2.0	0.0	(Doggart et al. 2008b)
Udzungwa	Mufindi	260	1.0	2.0	(Doggart et al. 2008b)
Udzungwa	Mwanihana	261	27.4	10.6	(Rovero 2007)
Udzungwa	N.Dabaga / Ula.	262	16.0	18.5	(Doody et al. 2001c)
Udzungwa	Nyanganje	263	23.9	16.6	(Rovero 2007)
Udzungwa	Uzungwa Scarp	264	66.2	46.6	(Rovero 2007)
Udzungwa	W. Kilo. Scarp	265	0.5	0.3	(Doody et al. 2001e)
Ukaguru	North Mamiwa Kisara	266	84.0	54.0	(Madoffe and Munishi 2005)
Ukaguru	N. M. Kisara	267	10.0	10.0	(Madoffe and Munishi 2005)
Ukaguru	N. M. Kisara	268	26.7	55.0	(Madoffe and Munishi 2005)
Ukaguru	N. M. Kisara	269	62.6	22.6	(Madoffe and Munishi 2005)
Ukaguru	N. M. Kisara	270	17.9	8.4	(Madoffe and Munishi 2005)
Ukaguru	N. M. Kisara	271	33.3	40.0	(Madoffe and Munishi 2005)
Uluguru	Uluguru North	272	68.9	16.7	(Bracebridge et al. 2005b)

Uluguru	Uluguru North	273	0.0	0.0	(Bracebridge et al. 2005b)
Uluguru	Uluguru North	274	14.4	3.3	(Bracebridge et al. 2005b)
Uluguru	Uluguru North	275	0.0	0.0	(Bracebridge et al. 2005b)
Uluguru	Uluguru North	276	7.8	15.6	(Bracebridge et al. 2005b)
Uluguru	Uluguru North	277	12.2	2.2	(Bracebridge et al. 2005b)
Uluguru	Uluguru North	278	2.2	0.0	(Bracebridge et al. 2005b)
Uluguru	Uluguru North	279	0.0	0.0	(Bracebridge et al. 2005b)
Uluguru	Uluguru North	280	22.2	2.2	(Bracebridge et al. 2005b)
Uluguru	Uluguru North	281	0.0	0.0	(Bracebridge et al. 2005b)
Uluguru	Uluguru North	282	0.0	2.2	(Bracebridge et al. 2005b)
Uluguru	Uluguru North	283	0.0	0.0	(Bracebridge et al. 2005b)
Uluguru	Uluguru North	284	101.1	53.3	(Bracebridge et al. 2005b)
Uluguru	Uluguru North	285	3.3	1.1	(Bracebridge et al. 2005b)
Uluguru	Uluguru North	286	15.6	3.3	(Bracebridge et al. 2005b)
Uluguru	Uluguru North	287	2.2	0.0	(Bracebridge et al. 2005b)
Uluguru	Uluguru North	288	15.6	2.2	(Bracebridge et al. 2005b)
Uluguru	Uluguru South	289	0.0	5.6	(Bracebridge et al. 2005a)
Uluguru	Uluguru South	290	0.0	0.0	(Bracebridge et al. 2005a)
Uluguru	Uluguru South	291	10.0	4.4	(Bracebridge et al. 2005a)
Uluguru	Uluguru South	292	24.4	17.8	(Bracebridge et al. 2005a)
Uluguru	Uluguru South	293	3.3	7.8	(Bracebridge et al. 2005a)
Uluguru	Uluguru South	294	0.0	0.0	(Bracebridge et al. 2005a)
Uluguru	Uluguru South	295	1.1	0.0	(Bracebridge et al. 2005a)
Uluguru	Uluguru South	296	0.0	0.0	(Bracebridge et al. 2005a)
Uluguru	Uluguru South	297	0.0	0.0	(Bracebridge et al. 2005a)
Uluguru	Uluguru South	298	0.0	0.0	(Bracebridge et al. 2005a)
Uluguru	Uluguru South	299	0.0	0.0	(Bracebridge et al. 2005a)
Uluguru	Uluguru South	300	0.0	3.3	(Bracebridge et al. 2005a)
Uluguru	Uluguru South	301	0.0	0.0	(Bracebridge et al. 2005a)
Uluguru	Uluguru South	302	0.0	1.1	(Bracebridge et al. 2005a)
Uluguru	Uluguru South	303	16.7	16.7	(Bracebridge et al. 2005a)
Uluguru	Uluguru South	304	3.3	3.3	(Bracebridge et al. 2005a)
Uluguru	Uluguru South	305	0.0	0.0	(Bracebridge et al. 2005a)
Uluguru	Uluguru South	306	0.0	0.0	(Bracebridge et al. 2005a)
Uluguru	Uluguru South	307	0.0	0.0	(Bracebridge et al. 2005a)
Uluguru	Uluguru South	308	0.0	0.0	(Bracebridge et al. 2005a)
Uluguru	Uluguru South	309	50.0	27.8	(Bracebridge et al. 2005a)
Uluguru	Uluguru South	310	0.0	1.1	(Bracebridge et al. 2005a)
Uluguru	Uluguru South	311	12.5	28.8	(Bracebridge et al. 2005a)

Uluguru	Uluguru South	312	0.0	0.0	(Bracebridge et al. 2005a)
Uluguru	Uluguru South	313	0.0	0.0	(Bracebridge et al. 2005a)
Uluguru	Uluguru South	314	21.1	10.0	(Bracebridge et al. 2005a)
Uluguru	Uluguru South	315	0.0	0.0	(Bracebridge et al. 2005a)
Uluguru	Uluguru South	316	4.4	18.9	(Bracebridge et al. 2005a)
Uluguru	Uluguru South	317	7.8	3.3	(Bracebridge et al. 2005a)
Uluguru	Uluguru South	318	8.9	10.0	(Bracebridge et al. 2005a)
Uluguru	Uluguru South	319	23.3	20.0	(Bracebridge et al. 2005a)
Uluguru	Uluguru South	320	11.1	1.1	(Bracebridge et al. 2005a)
West Usambara	Amba. / Vugiri	321	65.2	9.6	this study
West Usambara	Amba. / Vugiri	322	79.6	0.0	this study
West Usambara	Amba. / Vugiri	323	105.6	8.6	this study
West Usambara	Baga/Maz/Sag	324	5.3	1.5	this study
West Usambara	Baga/Maz/Sag	325	22.0	3.4	this study
West Usambara	Baga/Maz/Sag	326	34.7	8.7	this study
West Usambara	Baga/Maz/Sag	327	32.0	2.0	this study
West Usambara	Baga/Maz/Sag	328	41.0	24.2	this study
West Usambara	Baga/Maz/Sag	329	3.6	3.6	this study
West Usambara	Baga/Maz/Sag	330	93.8	10.6	this study
West Usambara	Balangai	331	126.0	32.0	this study
West Usambara	Balangai	332	46.0	8.7	this study
West Usambara	Kisima Gonja	333	61.5	16.2	this study
West Usambara	Kisima Gonja	334	60.7	13.3	this study
West Usambara	Lutindi	335	267.1	18.3	this study
West Usambara	Magamba	336	84.7	40.0	this study
West Usambara	Magamba	337	72.7	27.3	this study
West Usambara	Mahazengulu	338	71.7	14.1	this study
West Usambara	Mkussu	339	89.9	106.6	this study
West Usambara	Mkussu	340	273.3	55.3	this study
West Usambara	Mtumbi	341	235.3	21.0	this study
West Usambara	Mzinga	342	114.3	38.7	this study
West Usambara	Ndelemai	343	76.2	37.7	this study
West Usambara	Shagayu	344	52.7	12.7	this study
West Usambara	Shagayu	345	30.7	12.7	this study
West Usambara	Shambalai	346	887.6	42.0	this study

Appendix 2.2. Results from analyses of the relationship between distance from the start of the transect and the basal area of pole and tree stumps. I conducted these analyses in order to assess the strength of the edge effect. * This transect had no tree stumps.

			Pole stumps			Tree stumps		
Forest	Tran #	Linear or Quadratic	Coef.	Standard error	P-value	Coef.	Standard error	P-value
Ambangulu/Vugiri	9	Linear	0.00	0.00	0.30	0.00	0.00	0.55
Ambangulu/Vugiri *	10	Quadratic	0.00	0.00	0.06			
Ambangulu/Vugiri	11	Quadratic	0.00	0.00	0.06	0.00	0.00	0.12
Baga/Mazumbai/Sagara	1	Quadratic	0.00	0.00	0.02	0.00	0.00	0.22
Baga/Mazumbai/Sagara	2	Quadratic	0.00	0.00	0.00	0.00	0.00	0.00
Baga/Mazumbai/Sagara	3	Linear	0.00	0.00	0.00	0.00	0.00	0.08
Baga/Mazumbai/Sagara	4	Linear	0.00	0.00	0.00	0.00	0.00	0.03
Baga/Mazumbai/Sagara	5.1	Linear	0.00	0.00	0.62	0.00	0.00	0.57
Baga/Mazumbai/Sagara	5.2	Linear	0.00	0.00	0.33	0.00	0.00	0.89
Baga/Mazumbai/Sagara	6	Quadratic	0.00	0.00	0.95	0.00	0.00	0.22
Balangai	14	Linear	0.00	0.00	0.22	0.00	0.00	0.90
Balangai	15	Linear	0.00	0.00	0.04	0.00	0.00	0.41
Kisima Gonja	7	Quadratic	0.00	0.00	0.84	0.00	0.00	0.43
Kisima Gonja	8	Linear	0.00	0.00	0.37	0.00	0.00	0.26
Lutindi	24	Quadratic	0.00	0.00	0.33	0.00	0.00	0.59
Magamba	21	Linear	0.00	0.00	0.81	0.00	0.00	0.70
Magamba	22	Linear	0.00	0.00	0.00	0.00	0.00	0.03
Mahazengulu	18	Quadratic	0.00	0.00	0.00	0.00	0.00	0.00
Mkussu	19	Quadratic	0.00	0.00	0.26	0.00	0.00	0.40
Mkussu	20	Linear	0.00	0.00	0.05	0.00	0.00	0.88
Mtumbi	25	Quadratic	0.00	0.00	0.46	0.00	0.00	0.65
Mzinga	12	Quadratic	0.00	0.00	0.79	0.00	0.00	0.80
Ndelemai	13	Quadratic	0.00	0.00	0.08	0.00	0.00	0.34
Shagayu	16	Linear	0.00	0.00	0.01	0.00	0.00	0.63
Shagayu	17	Linear	0.00	0.00	0.00	0.00	0.00	0.28
Shambalai	23	Quadratic	0.00	0.00	0.66	0.00	0.00	0.51

Appendix 2.3. A copy of the interview questions used to collect data on local humans' characteristics.

READ TO INTERVIEWEE:

Thank you for talking with us. Our names are ___________. We have important questions to ask about human uses of the forest and about the life of monkeys. We are asking many people in Lushoto and Korogowe as part of our research. This information will help us to understand about the quality of the forest.

There is no punishment if you do not want to participate. If you are not able to answer any questions and if you do not want to answer the questions you are able to stop at any time. You are able to ask us questions at any time. We will not pay anything for answering our questions.

We are not police man and we can bring any trouble from the law. We only want scientific information. We do not need to write your name.

Do you want to participate?

INTERVIEW DETAILS

Forest: ____________________ Date: ________________________

Village: ____________________ Time: ________________________

Interview #: _________________ Interviewer (choose one): a. Matt b. Hassan c. Other: _______

Area in the village (circle one)? a. House d. Dispensary
b. School e. Forest
c. Market f. Other area: ___________

How far from the forest (circle one)? a. In the forest c. Not far from the forest
b. Near the forest d. Far from the forest

How selected interviewee (circle one)? a. Random c. Volunteered
b. Looked for them d. Other: ___________

Gender of interviewee: __________________

INTERVIEWEE DETAILS

1) Age: _________
2) Number of wifes/husbands: ______________
3) Number of children: ______________
4) Religion: _________________
5) What is your main source of income? ___________________________
6) And other sources of incomes? ___________________________
7) How many acres is your farm? _______ acres
8) How did you receive your farm? _________________________________

FOREST USE

9) Do you know ______________________ forest (choose one)?

a. Yes   b. No

10) Do villagers think it is important to protect the forest (choose one)?

a. Yes, everyone
b. Yes, many people
c. Yes, but few people
d. No
e. I don't know

11) Do villagers try to protect the forest (choose one)?

a. Yes, everyone
b. Yes, many people
c. Yes, but few people
d. No
e. I don't know

12) Is this forest protected by Tanzanian law (choose one)? Do you think it is good if this forest is protect by Tanzanian law (choose one)?

a. Yes c. I don't know	a. Yes c. I don't know
b. No	b. No

13) How important is the forest for your life (choose one)?

a. Very important
b. Somewhat important
c. Not important
d. I don't know

14) How often do you go to the forest (choose one)? Do you go to the forest __________ (yes or no)?

a. Every day of the week	a. to fetch water ___	j. to gather food for livestock ___
b. Few times per week	b. to walk ___	k. to gather food for people ___
c. Few times per month	c. to collect firewood ___	l. to cut plants for weaving ___
d. Few times per year	d. to make charcoal ___	m. to dig up soil ___
e. Never *(go to #16)*	e. to cut poles ___	n. to collect medicine ___
	f. to cut timber ___	o. to clear the forest for farms ___
	g. to hunt ___	p. to burn the forest ___
	h. to dig for minerals ___	q. to plant trees outside of the forest ___
	i. to graze livestock ___	r. to protect the forest ___
		s. for other reasons: _________

15) When you go the forest, how much time do you spend? Ten years ago, when you went to the forest, how much time did you spend?

# of hours _____________	# of hours _____________

16) __________ inside the forest is good or bad for the forest?

a. To fetch water _______
b. To walk ________
c. To collect firewood _______
d. To make charcoal _______
e. To cut poles _______
f. To cut timber _______
g. To hunt _______
h. To dig for minerals _______
i. To graze livestock ________
j. To gather food for livestock _______
k. To gather food for people _______
l. To cut plants for weaving ______
m. To dig up soil _______
n. To collect medicine _______
o. To clear the forest for farms _______
p. To burn the forest _______
q. To plant trees outside of the forest _______

17) How will the forest be in ten years?

a. Same as now
b. Bigger than now
c. Smaller than now
d. It will be finished

SYKES MONKEY POPULATIONS (SHOW PICTURE OF SYKES)

18) Do Sykes live in the forest (choose one)? Did Sykes live in the forest in the past (choose one)?

a. Yes
b. No *(after part b, go to #30)*
c. I don't know *(after part b, go to #30)*

a. Yes
b. No
c. I don't know

(IF NO for PART A, and YES for PART B: Why are there no Sykes now? ____________________)

19) Do villagers think it is important to protect Sykes (choose one)?

a. Yes, everyone
b. Yes, many people
c. Yes, but few people
d. No
e. I don't know

20) Do villagers try to protect Sykes (choose one)?

a. Yes, everyone
b. Yes, many people
c. Yes, but few people
d. No
e. I don't know

21) Are Sykes protected by Tanzanian law (choose one)? Do you think it is good if Sykes are protected by Tanzanian law (choose one)?

a. Yes
b. No
c. I don't know

a. Yes
b. No
c. I don't know

22) A. How many Sykes do you think live in the forest (choose one)?

B. How many Sykes do you think lived in the forest 10 years ago (choose one)?

C. How many Sykes do you think will live in the forest 10 years from now (choose one)?

a. Very many	a. Very many	a. Very many
b. Many	b. Many	b. Many
c. Few	c. Few	c. Few
d. Very few	d. Very few	d. Very few
e. None	e. None	e. None

23) When you go to the forest, how often do you see Sykes (choose one)?

a. Every time
b. Many times
c. Few times
d. Very few times
e. Never *(go to #26)*

24) When was the last day you saw Sykes in the forest (choose one)?

a. This week
b. This month
c. 6 months have passed
d. 1 year has passed
e. Many years have passed

25) How many groups of Sykes did you see that day?

\# of groups: _______________

26) A. Have you seen Sykes outside of the forest (choose one)?

B. (If yes for part A): How often do you see Sykes outside of the forest (choose one)?

C. (If yes for part A): Where have you seen Sykes outside of the forest (choose any)?

a. Yes	a. Every day	a. From the road (outside of the forest)
b. No	b. Many times	b. Farm
	c. Few times	c. Tree farm
	d. Very few times	d. Other area: ____________

27) A. Do villagers hunt Sykes (choose one)?

B. (Kama yes part A): How often have you seen dead Sykes (choose one)?

C. (Kama yes part A): Why do they hunt Sykes ___________ (yes or no)?

a. Yes	a. Every day	a. They eat meat
b. No	b. Few times per week	b. They sell meat
c. I don't know	c. Few times per month	c. They get medicine
d. I don't want to say	d. Few times per year	d. They sell medicine
	e. Never	e. They collect furs
		f. They sell fur
		g. Damage to crops
		h. Danger to humans
		i. Other: _________

28) __________ inside the forest is good or bad for Sykes?

a. To fetch water _______
b. To walk ________
c. To collect firewood _______
d. To make charcoal _______
e. To cut poles _______
f. To cut timber _______
g. To hunt _______
h. To dig for minerals _______
i. To graze livestock ________
j. To gather food for livestock _______
k. To gather food for people _______
l. To cut plants for weaving ______
m. To dig up soil _______
n. To collect medicine _______
o. To clear the forest for farms _______
p. To burn the forest _______
q. To plant trees outside of the forest _______

29) Is it good or bad to live near to Sykes (choose one)? Why?

a. Good ____
b. Bad ____
c. I don't know ____

<u>BLACK AND WHITE COLOBUS POPULATIONS</u> (SHOW PICTURE OF THIS B/W Colobus)

30) Do B/W Colobus live in the forest (choose one)? Did B/W Colobus live in the forest in the past (choose one)?

a. Yes	c. I don't know *(after part b, go to #43)*	a. Yes	c. I don't know
b. No *(after part b, go to #43)*		b. No	

(IF NO for PART A, and YES for PART B: Why are there no B/W Colobus now? ______________________)

31) Do villagers think it is important to protect B/W Colobus (choose one)?

a. Yes, everyone
b. Yes, many people
c. Yes, but few people
d. No
e. I don't know

32) Do villagers try to protect B/W Colobus (choose one)?

a. Yes, everyone
b. Yes, many people
c. Yes, but few people
d. No
e. I don't know

33) Are B/W Colobus protected by Tanzanian law (choose one)? Do you think it is good if B/W Colobus are protected by Tanzanian law (choose one)?

a. Yes	c. I don't know	a. Yes	c. I don't know
b. No		b. No	

34) A. How many B/W Colobus do you think live in the forest (choose one)?

B. How many B/W Colobus do you think lived in the forest 10 years ago (choose one)?

C. How many B/W Colobus do you think will live in the forest 10 years from now (choose one)?

A	B	C
a. Very many	a. Very many	a. Very many
b. Many	b. Many	b. Many
c. Few	c. Few	c. Few
d. Very few	d. Very few	d. Very few
e. None	e. None	e. None

35) When you go to the forest, how often do you see B/W Colobus (choose one)?

a. Every time
b. Many times
c. Few times
d. Very few times
e. Never *(go to #38)*

36) When was the last day you saw B/W Colobus in the forest (choose one)?

a. This week
b. This month
c. 6 months have passed
d. 1 year has passed
e. Many years have passed

37) How many groups of B/W Colobus did you see that day?

\# of groups: _______________

38) How many B/W Colobus did you see inside the group that day?

Group 1: # of B/W Colobus: ________
Group 2: # of B/W Colobus: ________
Group 3: # of B/W Colobus: ________
Group 4: # of B/W Colobus: ________
Group 5: # of B/W Colobus: ________
Group 6: # of B/W Colobus: ________
Group 7: # of B/W Colobus: ________
Group 8: # of B/W Colobus: ________

39) A. Have you seen outside of the forest (choose one)?

B. (If yes for part A): How often do you see B/W Colobus outside of the forest (choose one)?

C. (If yes for part A): Where have you seen B/W Colobus outside of the forest (choose any)?

A	B	C
a. Yes	a. Every day	a. From the road (outside of the forest) c. Tree farm
b. No	b. Many times	b. Farm d. Other area: ____________
	c. Few times	
	d. Very few times	

40) A. Do villagers hunt B/W Colobus (choose one)?

B. (Kama yes part A): How often have you seen dead B/W Colobus (choose one)?

C. (Kama yes part A): Why do they hunt B/W Colobus ___________ (yes or no)?

a. Yes	a. Every day	a. They eat meat	f. They sell fur
b. No	b. Few times per week	b. They sell meat	g. Damage to crops
c. I don't know	c. Few times per month	c. They get medicine	h. Danger to humans
d. I don't want to say	d. Few times per year	d. They sell medicine	i. Other: _________
	e. Never	e. They collect furs	

41) __________ inside the forest is good or bad for B/W Colobus?

a. To fetch water _______
b. To walk ________
c. To collect firewood _______
d. To make charcoal _______
e. To cut poles _______
f. To cut timber _______
g. To hunt _______
h. To dig for minerals _______
i. To graze livestock ________
j. To gather food for livestock _______
k. To gather food for people _______
l. To cut plants for weaving ______
m. To dig up soil _______
n. To collect medicine _______
o. To clear the forest for farms _______
p. To burn the forest _______
q. To plant trees outside of the forest _______

42) Is it good or bad to live near to B/W Colobus (choose one)? Why?

a. Good ____
b. Bad ____
c. I don't know ____

OTHER MONKEY POPULATIONS

43) (SHOW PICTURE) Do red colobus live in the forest (choose one)? Did red colobus live in the forest in the past (choose one)?

a. Yes	c. I Don't Know	a. Yes	c. I Don't Know
b. No		b. No	

44) (SHOW PICTURE) Do baboons live in the forest (choose one)? Did baboons live in the forest in the past (choose one)?

a. Yes	c. I Don't Know	a. Yes	c. I Don't Know
b. No		b. No	

45) (SHOW PICTURE) Do vervet monkeys live in the forest (choose one)? Did vervet monkeys live in the forest in the past (choose one)?

a. Yes	c. I Don't Know	a. Yes	c. I Don't Know
b. No		b. No	

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