Monitoring the health of selected eastern arc forests in Tanzania

Seif Madoffe[1]*, Gerard D. Hertel[2], Paul Rodgers[3], Barbra O'Connell[3] and Raymond Killenga[4]

[1]*Sokoine University of Agriculture, PO Box 3010, Morogoro, Tanzania,* [2]*Department of Biology, West Chester University, West Chester, PA 19383-2112, U.S.A.,* [3]*Rocky Mountain Research Station, 507 25th St., Ogden, UT 84401, U.S.A. and* [4]*East Usambara Forest Project, PO Box 1449, Tanga, Tanzania*

Abstract

The eastern arc mountains (EAMs) are a chain of isolated mountains (534,000 ha) in Kenya and Tanzania surrounded by arid woodlands and influenced by the Indian Ocean. In 1900 there was three times the amount of forest cover there is today. Much of the original forests have been converted into agricultural crops. These mountains are recognized as a globally important 'hot spot' by World Wide Fund for Nature (WWF) and World Conservation of Union (IUCN) for forest biodiversity and are major national, regional and local sources of hydropower, water and wide array of forest-based benefits and agricultural production. In February 2000 we began a 3-year evaluation of forest health, land-use change and information sharing in the EAMs. Permanent sample plots were used to evaluate forest health. This paper summarizes the baseline data from eighteen permanent sample plots in the east Usambara's and nine in Ulugurus. The eastern arc web site (http://www.easternarc.org) was established, continues to expand and contains some detailed information on the project. Information gathered will assist land managers, planners, policy makers, interested communities (villages) and individuals in decision-making. These data can also provide an early warning system of stresses on forest catchments.

[1]Tree variables measured: tree: >12.7 cm diameter at breast height (DBH); sapling: <12.7 cm and >2.54 cm DBH; seedling: <2.54 cm DBH and >0.3 m tall; foliage transparency: the amount of light visible through the live crown. Severe transparency can result from defoliation, disease, or stress; crown density: the amount of branches and foliage that blocks light visibility through the crown; crown dieback: recent mortality of fine branches and twigs.

**Correspondence:* E-mail: madoffe@suanet.ac.tz

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Résumé

Les montagnes de l'arc oriental (les MAOs) forment une chaîne de montagnes isolée au Kenya et en Tanzanie entourée par des bois arides et influencée par la mer d'Inde. En 1900 l'entendu de la couverture forestière était trois fois plus important qu'il ne l'est aujourd'hui. Une grande parti des forêts originales ont été transformés en cultures agricoles. Ces montagnes représentent un 'point chaud' d'importance mondiale selon le WWF et l'IUCN vis-à-vis la biodiversité forestière, et sont une source majeure nationale, régionale et locale d'énergie hydroèlectrique, de l'eau, et de toute une gamme de bénéfices émanant de la forêt ainsi que la production agricole. En février 2000 nous avons commencés une évaluation de trois ans de la santé forestière, les changements dans l'usage de la terre et le partage d'informations dans les MAOs. Des placettes d'échantillonnage permanentes furent utilisées afin d'évaluer la santé forestière. Cette ètude résume les données de base provenant de 18 placettes d'échantillonnage dans les monts Usambara occidentaux, et 9 dans les Ulugurus. Le site web des montagnes de l'arc oriental (http://www.easternarc.org) fut établi, et continue de s'agrandir, avec des informations approfondies sur le projet. Des informations amassées aideront les gérants de la terre, les responsables politiques, les communautés touchées, et les individus à prendre des décisions. Les données peuvent aussi servir comme système de première alerte par rapport aux stresses sur les bassins forestiers.

Introduction

In recent years, forest sustainability and biodiversity conservation have become major concern worldwide

(Constaza, 1991). Conservation objectives can however, be compromised by biotic and abiotic influences such as weather, air pollution, fire, exotics invasive species, forest insects and diseases (Schmidt, 1989). This places a premium on monitoring the changes in forest condition to facilitate decision-making.

The United States Department of Agriculture, Forest Service (USDA-FS) and the National Association of State Foresters have developed a programme of forest health monitoring. This method utilizes a combination of remote sensing, permanent sample plots and special aerial and ground survey techniques to account for changes in forest condition (Brooks *et al.*, 1991). This programme provides land managers, planners, policy makers, environmental groups and interested communities and individuals with the status and trend information needed for making decisions. The monitoring system also provides an early warning system of stresses on the forest ecosystem. One area that desperately needs quality information on forest condition is the eastern arc mountains (EAMs) of Tanzania (Rodgers, 1993).

The EAM's are a chain of ancient crystalline mountains (534,000 ha), which run from the Taita hills in southeast Kenya to the Makambako gap just to the southwest of the Udzungwa mountains in Tanzania (Fig. 1). The mountain chain is a series of isolated mountains, which were once heavily covered by forests. Much of the original forest has however, been converted to agricultural crop production (Mrema & Nummelin, 1998; Zilihona *et al.*, 1998). There are serious conflicts between the use of the ecosystem by the local people to meet their requirements for income and food production and the sustainability of the forest resource with its unique biodiversity of flora and fauna.

The EAM's have been recognized by World Wide Fund for Conservation and Nature (WWF) and International Union for Conservtion and Nature (IUCN) as one of 25 globally 'hotspots' because of their biological richness and the threat to the biodiversity that they contain (Mittermeier *et al.*, 1998; Myers *et al.*, 2000). Over 25% (800 species) of the eastern arc plant species are endemic while 60% of all Tanzania endemic plants occur in the EAM's (Rodgers, 1993). These mountains are major national, regional and local sources of hydropower, water, a wide array of forest products and agricultural production. In November 1997, the second international conference on the EAM's concluded that this unique ecosystem was

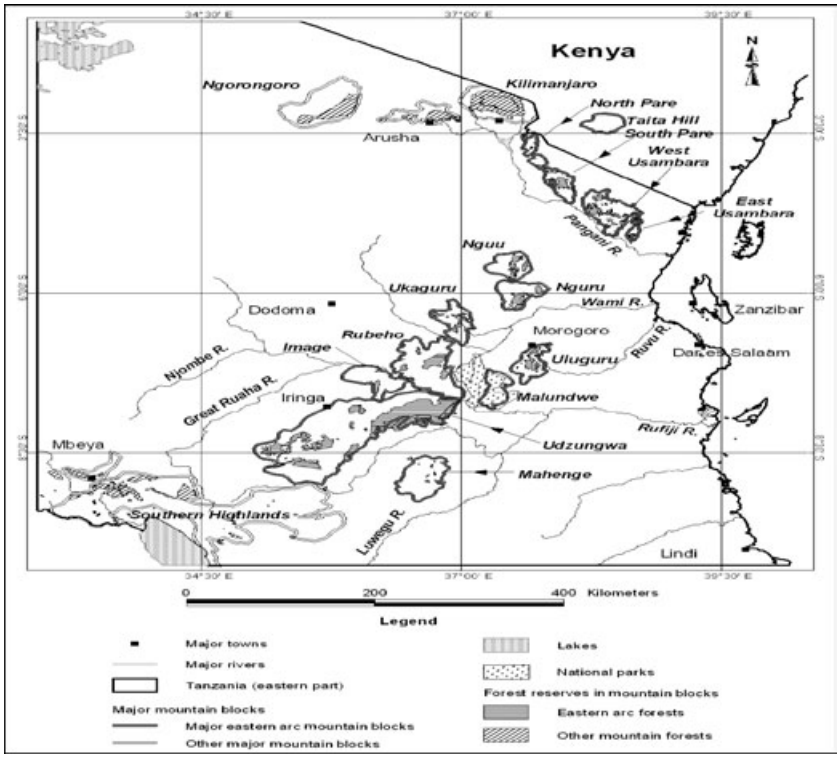

Fig 1 Location of eastern arc mountain forests of Tanzania.

undergoing an accelerated rate of destruction and that there was an urgent need for documentation of the problem if changes were to be made to reverse or slow the process (Burgess *et al.*, 1998). It is through this reflection that the current work on forest health monitoring in the EAMs is proposed. The aim of this study was to show the use of forest health monitoring techniques and to asses current status and trend in forest condition of the EAM's. The specific objectives are:

- To establish a baseline data to compare with future surveys and make this information available to Tanzania for planning and policy purposes.
- Train local people in the use of forest health monitoring technology.
- To show how these data can be used to strengthen the co-ordination and co-operation between government agencies, regional institutions, NGOs and the local communities.

Methodology

Location

The study was conducted in east Usambara (Amani nature reserve), Teacher's college riverine forest (Uluguru mountains) and Kimboza forest reserve. These forests have very high biological diversity of both flora and fauna.

The east Usambara mountains are located on the northeast coast of Tanzania between 4°48′–5°13′S and 38°32′–38°48′E, and the altitude between 800 and 1250 m a.s.l. It has bimodal rainfall averaging to 1500 mm per year. The forests are rich in flora and fauna and the number of endemic species is high (Rodgers & Homewood, 1982). Commercial logging was undertaken until the mid-1980s, while pit sawing continued up to the 1990s, conditions which have made the forests becoming fragmented. Logging was very intensive in forest guard and Amani west blocks, mild in the upper reaches of Sigi falls and the Toraco trail was not logged. Kimboza forest reserve is located on the eastern foothills of the Uluguru mountains in Morogoro, astride the Ruvu river at 7°00′S and 37°48′E at about 350 m a.s.l. (Rodgers *et al.*, 1983). It has bimodal rainfall pattern averaging 1700 mm per year. The vegetation is typically of lowland rain forest and human activities such as logging, poles and withes cutting are strictly prohibited since 1982.

Kimboza forest was considered in this study because it has very high biodiversity, shares some species with the EAM's and administratively they are regarded as Catchment Forest Reserve along with other EAM forests (Lovett & Pocs, 1993). The Teacher's college riverine forest reserve lies in the eastern slope of Uluguru Mountains (7°S, 38°E, maximum height 2646 m) at about 700 m a.s.l. and has bimodal rainfall averaging to 1200 mm per year. In spite human activities being prohibited like other forests of the eastern arc it has very intense human pressure.

Data collection

Forest health monitoring plots. Between February 2000 and January 2002 eighteen permanent forest health plots were established in Amani nature reserve, and three each in Teacher's college and Kimboza forest reserves. These plots were distributed throughout the forest in order to cover most ecological zones. Each plot is made up of four 1/60 ha circular subplots in which the following tree variables[1] were measured: tree species, diameter (dbh), height, foliage transparency, crown density and crown dieback. Each subplot contained one micro-plot where seedlings and saplings were tallied (Dunn, 1999). To attain the objective of long-term, comprehensive assessment of forest health in each of these blocks, the original plots will be monitored constantly.

Results

East Usambara mountains

Tree saplings and seedlings distribution is given in Table 1. In these plots we observed 149 trees, 32 saplings, 392 seedlings and seven standing dead trees. Of the fifteen commonest tree species, only six species were found as common trees, saplings and seedlings. *Newtonia buchananii* was found only in the seedlings class while *Maesopsis eminii* and *Mesogyne insignis* were only found in the trees class.

Fifty-one per cent of the trees were in the pole-size class (dbh 12.7–27.9 cm) and 11% in sawn timber size (dbh >50 cm; Fig. 2). Most of the trees (42%) were in the mid-height class (15–25 m; Fig. 3). Of the 149 trees measured, 82% were observed to have average to good crown (Fig. 4). Based on crown condition, the trees are healthy but a little less so than those in Kimboza. Sixty-eight per cent of the measured trees had no observable damage, 23% had one damage and 9% had two damages. Decay and vines in crown are the most serious damaging agents.

Table 1 Commonest trees, saplings and seedlings distribution in East Usambara mountains forest reserve

	Frequency (%)		
Species	Trees	Saplings	Seedlings
Allanblackia stuhlmannii	13	14	–
Cephalosphaera usambarensis	9	16	37
Funtumia Africana	15	17	4
Greenwayodendron suaveolens	12	9	–
Isoberlinia scheffleri	–	12	4
Leptonychia usambarensis	23	31	5
Macaranga kilimandscharica	10	7	–
Maesopsis eminii	16	–	–
Mesogyne insignis	35	6	–
Myrianthus holstii	8	–	–
Newtonia buchananii	–	–	11
Pycnocoma littoralis	–	16	26
Rawsonia lucida	8	5	3
Sorindeia madagascariensis	5	5	16
Strombosia scheffleri	6	8	3

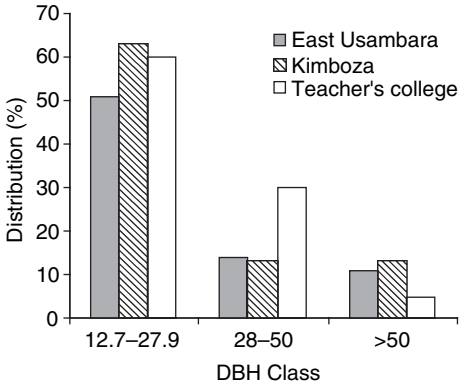

Fig 2 The DBH (cm) distribution in East Usambara, Kimboza and Teacher's college forest reserves

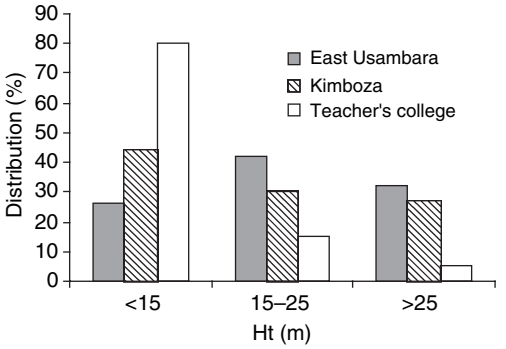

Fig 3 Height (m) distribution in East Usambara, Kimboza and Teacher's college forest reserves

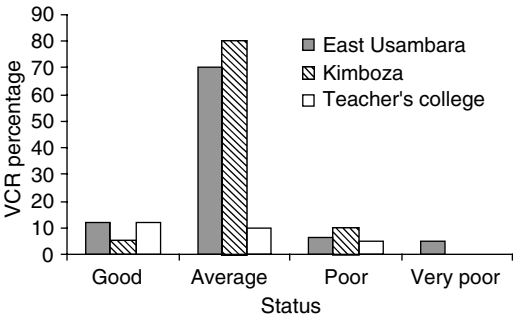

Fig 4 Visual crown rating (foliage transparency, crown density and dieback) in East Usambara, Kimboza and Teacher's college forest reserves

Kimboza forest reserve

In Kimboza we measured 57 trees, 28 saplings, 330 seedlings and one standing dead tree. Seventy per cent of all the trees measured consisted of eight species. *Engalerophytum natalense*, *Lepronychia usambarensis* and *Sorindeia madagascariensis* shared trees, saplings and seedlings (Table 2). Six and four species had only saplings and trees class respectively, while *Cola clavata* had only the seedlings class. Sixty-three per cent of the measured trees were in the pole-size class (dbh 12.7–27.9 cm) while 13% were both in sawn timber (28–50 cm) and large sawn timber class (50 cm; Figs 2 and 3). Of the trees measured, 85% had average to good crown. Only 65% of the trees had no damage, 32% had one damage and 3% had two damages. Decay and vines in the crown were the commonest damages.

Teacher's college forest reserve

In this locality 45 trees, 18 saplings and 100 seedlings were observed. Trees, saplings and seedlings shared only two species, *S. madagascariensis* and *Synsepalum msolo* (Table 3). *Grewia goetzeana* and *Psychotria megalopus* had only the trees class while *Clausena anisata* and *Oxyanthus speciosus* had only the seedlings class. Sixty per cent of the measured trees were in the pole-size class and only 5% had dbh >50 cm (Fig. 2). Likewise, majority of the trees (80%) were in the small height class (<15 m) and only 5% were >25 m (Fig. 3). Of the 45 trees measured, 82% were

Table 2 Commonest trees, saplings and seedlings distribution in Kimboza forest reserve

	Frequency (%)		
Species	Trees	Saplings	Seedlings
Albizia glaberrima	5		
Allophylus melliodorus	–	7	–
Alsodeiopsis schumannii	–	7	–
Cola clavata	–	–	8
Cola scheffleri	–	7	–
Cedrela mexicana	17	–	–
Englerophytum natalense	4	7	14
Khaya anthotheca	5	–	–
Leptonychia usambarensis	5	11	16
Pandanus rabaiensi	9	–	–
Quassia undulata	–	7	–
Scorodophloeus fischeri	11	–	17
Sorindeia madagascariensis	7	7	3
Trilepisium madagascariensis	–	11	–
Turraea floribunda	–	7	–

Table 3 Commonest trees, saplings and seedlings distribution in Teacher's college forest reserve

	Frequency (%)		
Species	Trees	Saplings	Seedlings
Albizia gummifera	–	5	–
Blighia unijungata	–	5	–
Carpolobia goetzei	–	5	–
Clausena anisata	–	–	5
Deinbollia kilimandscharica	–	5	5
Diospyros whyteana	–	5	5
Englerophytum natalense	–	54	80
Grewia goetzeana	6	–	–
Obetia radula	17	5	–
Oxyanthus speciosus	–	–	5
Psychotria mahonii	6	–	5
Psychotria megalopus	16	–	–
Sorindeia madagascariensis	24	5	5
Synsepalum msolo	5	5	5

observed to have average to good crown (Fig. 4). Only 18% of the trees had no damage. Fifty-three per cent had one-damage and 29% had two damages. Decay and vines in the crown were the commonest damages.

Discussion

The EAMs have suffered extreme forest loss and fragmentation because of human caused impacts and by 1987 about 77% of the forests have been lost (Schmidt, 1989). In East Usambara, disturbed forest blocks like Amani west and Forest guard had fewer tree species than undisturbed areas like Toraco trail. Forest loss suggests that approximately 30% of the species have become extinct or are in danger of extinction (Zilihona *et al.*, 1998). In order to reduce further losses of biodiversity and fragmentation logging was banned in the EAMs in mid-1980s and 1990s and forest boundaries restored in most reserves. Other human activities like agriculture development and withes collection were also prohibited. Amani and Udzungwa were declared Nature reserve and National park, respectively, in order to give them more protection. The National forest policy (MNRT, 1998) has also put more emphasis on forest management and conservation. In spite of all these efforts, agriculture development, illegal logging and fire are still threatening some parts of the EAMs. These activities could lead to further fragmentation of this important ecosystem. Forest fragmentation is considered to be one of the major sources of biodiversity loss (Newmark, 1998). The new eastern arc conservation programme is expected to further reduce the problems.

In this study, all sites were dominated by between five and nine tree species, while saplings and seedlings were dominated by either one or two species. The inconsistent occurrence of large tree species and saplings and/or seedlings of similar species and the threat of decay to large trees could probably contribute to further loss of species in this ecosystem. Nsolomo & Venn (1994) recorded some fungal attack in large trees in the Usambara mountains. Furthermore, studies in west Usambara have shown that about 32% of *N. buchananii* growing in the reserve and >50% of those in disturbed forests had stem cranks and/or decay mainly as butt rot (Mrema & Nummelin, 1998). In this study we did not sample large *N. buchananii* despite sampling about 11% of all the seedlings in east Usambara. The outcome of the death of some large trees would lead to gap formation, which could eliminate restricted-range plant species (Wilson, 1988). Gaps could also allow too much light to the undestory vegetation, which could lead to vines or invasive species explosion, consequently reducing the diversity of tree species. Undergrowth and invasive *M. eminii* was a common phenomena in Amani west and Forest guard block, which had undergone heavy logging in 1960s and 1970s (Binggeli, 1989). Conversely, Toroco trail and Sigi falls, which have some primary forests with least disturbance, had less gaps and invasive species (Hamilton, 1989). *Maesopsis eminii* has some negative

ecological impact on the natural vegetation (Mugasha, Mugangangamundo & Zahabu, 2000). Similarly in Kimboza, *Cedrela mxicana*, which was introduced in the reserve in early 1970s, has spread to almost the whole reserve and it could have some effects on the natural vegetation. However, the invasive impact of *M. eminii* and *C. mexicana* in the forest reserves may be declining as forest cutting and disturbance has greatly decreased, thereby reducing the opportunity for this pioneer species to invade.

Most trees were in pole-size class 12.7–27.9 cm and <15 m height class particularly in Teacher's college forest as a result of previous and/or continuous cutting of large trees. Altitudinal effect could also contribute particularly in some parts of east Usambara mountain forests (Lovett, 1996).

One of the primary indicators of tree health is the condition of the tree crown (visual crown rating; Dunn, 1999). In this study the tree crown, saplings and seedlings have indicated an overall good health of the forests. However, the loss of biodiversity as a result of fragmentation, gaps and other human impact could reduce the healthiness of the forest (Stoyeno, Witter & Leutscher, 1997).

From this study, one could not overlook the role of human being in forest degradation and therefore the need for involvement of the rural community in natural resources management. As poverty and population growth are the main force behind these degradation, people's participation could be an important tool in the reduction of the losses.

Conclusions

Most of the local communities living around the EAM forests depend on the forests for their livelihood. This has resulted in loss of forest cover in most areas as a result of land clearing for agricultural activities, illegal logging and fire. Furthermore, decay and vines in the crown was the commonest tree damaging agents and the former appears to be a big threat in east Usambara.

This study has demonstrated that the remaining indigenous forests in our study locations are in good health and our plot system provides an excellent indicator of the health of the remaining forest. The work has promoted cooperation between national specialists and other investigators with government officials responsible for formulating policies for protection of natural resources of the respective countries. The eastern arc website (http://www.easternarc.org) was established and continues to be modified and added to as the list of partners and co-operating institutions and individuals expands. For sustainable data collection and management, six people were trained and certified in forest health monitoring techniques in 2001.

Findings from this study and/or any valuable scientific information could help policy makers and managers to improve their conservation/management decisions. The policy statement should emphasize on the need to maintain 'healthy forests'. It is emphasized that any conservation measure should go hand in hand with poverty alleviation and therefore should seek for alternative sources of income or resources for the surrounding communities. It is further recommended on the need to disseminate the findings to the local communities for the preparation and implementation of locally adaptive management plans that integrate an understanding of human resource needs and the ecology of these forests. Further, both formal and indigenous conservation methods should be used as appropriate. This work should be extended to other parts of the EAMs and studies on the most damaging agents (decay and vines) and other health indicators e.g. soil conditions, should be initiated.

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