Once thought to be invasive species: the bamboos of Udzungwa Scarp Forest Reserve, Tanzania

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ABSTRACT
Bamboo is one of potential Non-Timber Forest Products found in Tanzanian forests and farm lands. Its potential for different uses in Tanzania is currently rising and its contribution to improving livelihoods in rural areas is foreseen through utilising its potential as a rapidly re-growing wood substitute. Bamboo plays a great role as soil stabilizer and is potential in rehabilitation of degraded land. Bamboo as a non-timber forest product can contribute substantially towards poverty alleviation and food security. Recently however, there have been concerns on bamboo being invasive in the Eastern Arc Mountains, particularly Udzungwa Scarp Forest Reserve (USFR). This report highlights on the status, extent, and management of the bamboo species in the USFR. Circular plots with radius 5.64 m and inner plots of radius 2 m were laid out at an interval of 200m along the transect. A total of five transects each of about 2 km long, were established in the south-east direction from the edge of the forest. The level of disturbances in each plot was assessed and categorised into three disturbance levels. Specimens of the studied bamboo were taken to Lushoto Herbarium for identification. This green bamboo was identified as *Arundinaria alpina*. The *A. alpina* vegetation has been a constituent of USFR for hundreds of years and it is indigenous to Tanzania. An area of 7500 ha (75 km^2) which is approximately 0.4% of the USFR is composed of mature *A. alpina* bamboo. The density of *A. alpina* ranged from 3,030 to 11,140 culms per ha while the density of other tree species ranged from 100 to 460 stems per hectare. Highly disturbed vegetation had a highest mean density of *A. alpina* (10,002 stems/ha) of the other three disturbance levels. The density of bamboo was negatively correlated with distance from the forest edge, but the correlation was not significant ($P>0.05$). Also, there was a negative correlation (r = -0.209, N = 46, P = 0.062) between the density of regenerants of native trees and the density of bamboo, *A. alpina*. A manifestation that there is little evidence from the current study to suggest that there is an existing vegetation change from mixed hardwood forest to bamboo forest. As any possible future change needs monitoring, further investigation through the use of a series of remotely sensed data over a long period of time is mandatory. However, given available resources makes it beyond the scope of this study.

INTRODUCTION
Most of bamboo species are native to Australia, Africa, Asia and North America. Bamboos are perhaps the most primitive subfamily of grasses, which includes some 62 to 107 genera embracing some 1,200 to 1,500 species. Bamboo is one of the forest resources in the World estimated to include about 1200 species belonging to 70 genera. The total area of bamboo forest in the World is estimated to be 31.5 million hectares (FAO, 2010). There are about 15 genera and more than 20 species of bamboo in Africa. In Tanzania bamboo is naturally occurring on low altitude areas and in montane forests. Bamboo forest is estimated to cover about 127,000 ha

(Lipangile, 1985 cited by Chihongo *et al.*, 2000). This estimate is however not supported by any vegetation cover maps. The bamboo species found in Tanzania include; *Oxytenanthera braunii*, *Oreobambus buchwaldii* and *Arundinaria alpina*. The African green mountainous bamboo, *Arundinaria alpina* is found at altitudes between 2290 and 3360 m a.s.l with average density of 5000 culms/ha. It is common in Mount Meru, Mbulu (Manyara) and Mbeya Regions. It is also found in highlands of Iringa and Uluguru Mountains in Morogoro Region. *Oxytenanthera braunii* Syn. *O. abyssinica* is semi solid bamboo species in young culms and becoming solid in older culms. Commonly found in open forests often around rivers at altitude between 1100 – 2100 m a.s.l. It is also common in poor soils and dry vegetation formation in Lindi, Kigoma, Kagera, Coast Regions and Southern Highlands of Tanzania in Iringa, Mbeya and Ruvuma Regions. This species, normally used for wine is the hardiest species of the three naturally occurring East African bamboo species. *Oreobambus buchwaldii* is found inhabiting the Northern and Southern Highlands as well as East Coast zone. It is a medium sized green hollow culm bamboo found at altitude between 450 – 1000 m a.s.l. in solitary clumps in more open parts of evergreen forests of the East Usambaras (Tanga Region) and Tukuyu (Porotos) highlands in Mbeya Region. Other introduced species planted at Amani Botanical Garden include: *Bambusa vulgaris* var. *striata, B. multiplex, B. nutans, B. bambos, Gigantochloa scortechinii* and *Chimonobambusa hookeriana*. *Bambusa vulgaris* has shown high adaptability to Tanzanian ecological conditions and is now planted as ornamental in different areas (Chihongo *et al.,* 2000).

Bamboos grow principally from rhizomes, tough underground stems that produce roots, new shoots and more rhizomes. Bamboos are broadly divided into “sympodial” (clump bamboo) and “monopodial” (running bamboo) species according to their rhizomes. The two types differ in their colonisation with the later being more aggressive. The species with intermediate characteristics of the two species are known as ‘amphipodial’, with both clump and running bamboo characteristics. Running bamboo (monopodial bamboo) can be very invasive, especially in warmer climates like in the tropics. The rhizomes of running bamboo are long and adventurous like the "runners" of couch or Kikuyu grass, and in favourable conditions can continue to grow far outside the circle of culms and produce new shoots and more rhizomes for years to come. The shoots of running bamboo grow from underground rhizomes that have already grown through and past that point. These bamboos should not be grown unless there is plenty of space for their spreading habit and a clear idea of the kind of soil barriers and/or maintenance required to securely contain them. The rhizomes of clump forming species are short and new shoots appear close to the mother culms in a predictable clumped fashion. The new shoots of clumping bamboo grow at the end of each rhizome (the basal part of every shoot is a rhizome) and so the outer culms mark the limit of the rhizomes. For most species, the clump size seems to be self limiting (always dependent on growing conditions), and will not continue to increase indefinitely. They are normally not invasive. The intermediate bamboo species belong to amphypodial group, having both clump and running bamboo characteristics.

Bamboo is a fast re-growing raw material for sustainable rural industrial development and has the strategic advantage that it is economically and environmentally viable. In this way, bamboo can be the starting point for small and medium scale industries creating job opportunities with a high rate of employment for women. The economic and development potentials for bamboo as an alternate “cash” crop are numerous and could contribute as well to the fight against land degradation. Bamboo's enormous potential nevertheless remains nearly untapped in Africa for domestic processing as well as for eventual international market access:

Food and Nutrition: Bamboo shoots contain protein, fat, glucose, calcium, phosphorus, iron, thiamine, and fibre with the protein and amino acid content highest when shoots are still underground. Bamboo shoots have a bland taste and always take the colour and flavour of other foods it is combined with. It can thus be incorporated in most indigenous dishes without altering the acceptable/known taste of the dish. Adoption of bamboo shoots as a food source could contribute in enhancing the nutritional status and improving food security in the communities involved.

Wood Substitute: Bamboo has proven its potential as a wood substitute traditionally for the construction of housing, furniture and household articles like baskets and recently for the conversion into high value-added products like floor- and furniture boards. The need to transfer appropriate technology like suitable low-cost measures for bamboo preservation against insects and fungi and basic machinery and tools to improve productivity and product quality is essential to promote bamboo as a valid wood substitute.

Land Degradation: Bamboo is a natural control barrier. Because of its wide spread root system and large canopy, bamboo prevents soil erosion caused by heavy rains. Inter-planted with agricultural crops it can function as windbreaker preventing wind erosion. Unlike most trees, selective harvesting of bamboo culms and shoots does not destroy the mother plant (Boa, 1996; McNeely, 1996).

The Eastern Arc Mountains, especially the associated forests, are extremely important locally and internationally. Locally, they support the livelihoods of millions of people in and around the mountains; agricultural valleys and urban centres are served in various ways by material supplies and services accruing from the mountains. Globally, besides offering some products, the significance of Eastern Arc Mountain Forests are marked by high species richness, endemism and a large number of restricted-range species and genera. The Eastern Arc Mountains have been recognised by IUCN as one of 25 globally "hotspots" because of their biological richness and the threat to the biodiversity that they contain (Mittermeier, 1998 and Lovett, 1993). However, these forests are among the most critically threatened ecosystems from illegal activities, environmental changes and alien invasive species. Invasive species pose a significant threat to the biodiversity, ecological services and sustenance of the EAMs (Dawson *et al.,* 2008). Also research elsewhere has indicated that, spread of flora to area outside their home range has contributed to homogenization of the world biota (Cronk, 1989). In fact, alien invasive species have been ascertained to cause direct biodiversity loss and driving environmental change in many ecosystems (Binggeli, 1997). Following concerns from various institutions and organizations, the Convention of Biological Diversity in its Article 8(h) puts emphasis on the control and eradication of invasive alien species in all protected areas. The Udzungwa Scarp Forest Reserve (USFR) is one of the 13 Forest Reserves found in the Eastern Arc Mountains. Some plant species found in the USFR were noted as invasive - thus accused replacing most of the indigenous species in the USFR. In early 2005, an unidentified bamboo species was reported as one of these invasive plants species which replace native tree species (pers. com. Sabuni). This therefore called for a study to determine the status, extent and propose control measures to reduce the bamboo invasion in the Udzungwa Scarp Forest Reserve.

METHODOLOGY

Study area

The study was carried out in Kilolo District, Iringa Region in the Udzungwa Scarp Forest Reserve (currently the Uzungwa proposed Nature Reserve). The district is located at 7^o 55' to 8.3^o S and 34^o to 37^o E in western part of Udzungwa escarpment. Udzungwa Scarp Forest Reserve is among the 13 forests found in the Eastern Arc. It covers about 1,960,000 ha. The forest is about 80 km from Iringa Town through the road towards Kilolo District Council Headquarters and 40 km from Kilolo. Altitude ranges between 1,800 to 2,500 m a. s. l. The area receives rainfall seasonally ranging from 500 to 2700 mm per year starting from November to April. However, partly because of the climatic influence of the mountain range, and the proximity to the Indian Ocean, rainfall is often uninterrupted from October through to March in this area. The average annual temperature experienced in the area is 15^o C in highlands but 30^o C in lowlands. Topography of the areas is undulated hills with lowlands and highlands. Vegetation type is transitional rain forests, sub montane, montane, upper montane and extensive afro-montane grasslands (Harrison, 2006; Kato, 2007). According to 2002 census the district has a population of about 222,530 people, whereby 110,613 and 111,917 are males and females respectively (URT, 2002).

Ecological survey

Five transects of about 2 km long were established in the south-east direction from the forest boundary. The initial location of transects and the first plot was random, but subsequent plots were located systematically after every 200 m. Circular plots with radius 5.64 m (0.01 ha) and inner plots of radius 2 m (0.00125 ha) were laid out along transects. In the outer plot all bamboo culms and trees with diameter at breast height more than 10 cm were counted, identified and measured. In the inner smaller plot all regenerating woody plants were counted, identified and recorded (Annex 1), especially for the emergent dominant species. The condition of each plot was assessed in terms of dominant vegetation on the ground and percentage canopy cover. The level of disturbances in each plot was assessed and categorised into three disturbance levels (i.e. mild, moderate and high). All sample plots were positioned and the distance between them measured using a Global Positioning System (GPS- Garmin 76C S_x).

Socio-economic survey

Data were collected from four villages of Kilolo District in Iringa Region in early August 2009. The four villages were Mbawi, Masisiwe, Idegenda and Ilutila. The first three villages are administratively under Boma la Ng'ombe Ward and the other one is under Idete Ward. These villages were purposively selected because they all border with the USFR. Also, most important is that, the forest vegetation adjacent to these villages is dominated by the bamboo species under investigation, *Arundinaria alpina*. In conducting the study a cross-sectional design in which data was collected at a single point and time (Creswell, 1994) was used. About twenty respondents were selected from each village. The respondents were selected at random but representing both sexes and different age groups. Semi-structured questionnaires were used to acquire information on the utilization of bamboo and their effects on biodiversity of the USFR. The questionnaires comprised of both closed and open-ended questions, which were answered by respondents through interviews.

Data analysis

Regression analysis was done to examine the relationship between the density of bamboo and the increase in distance from the forest boundary and also with the density of all tree species. Analysis of variance (ANOVA) was performed on the densities per ha of bamboo and mature trees with dbh > 10 to investigate the effect of distance from the forest boundary and abundance of bamboo and trees across the various habitat types in the study area (Annex 3). A significant *P* value < 0.05 was assumed. All statistical analyses were done using Statistical Package for Social Science Version 12 (SPSS, Inc., 1989-2003). Garmin – Map Source Version 6.10.2 (Inc., 1999-2006) was used to estimate and calculate areas covered with bamboo species. Voucher specimens of bamboo were taken to Lushoto Herbarium where they were identified using identification keys and by matching with herbarium specimens. Descriptive statistics from socio-economic survey including frequencies, percentages and cross tabulation of some variables were used to determine the relationship between some variables.

RESULTS AND DISCUSSION

Identification of the bamboo species

Voucher specimens of the bamboo species found in Udzungwa Scarp Forest Reserve were taken to Lushoto Herbarium for identification. The bamboo species was identified to be *Arundinaria alpina*, K. Schum (Ruffo *et al*., 1996). This is the only dominant species of bamboo that was observed following an extensive field survey of the USFR. The bamboo in Udzungwa is categorized as amphypodial with running rhizomes producing shoots horizontally underground at shorter distances. The bamboo species is green in colour with internodes 50 – 100 cm apart. They grow to a height of more than 25 m in pure stands. The culms are hollow from the young stage with the diameter ranging from 7 to 12 cm for mature culms. According to Chihongo *et al.* (2000) the main species of bamboo that is found in Tanzania is *A. alpina* which is the mountainous bamboo species found in the Kilimanjaro, Arusha and Iringa Districts. Also country reports that were collated by FAO (2005) on the extent of bamboo resources at the global level show that *A. alpina* is the dominant bamboo species in the highlands of Eastern Africa. According to FAO (2010) the bamboo resources covers an areas of about 128,000 ha in the country. There are about 1,500 species of bamboo from more than sixty genera, varying in size from forest giants to tiny alpine groundcovers. Bamboo (*A. alpina*) vegetation has been a constituent of USFR for hundreds of years therefore it is indigenous to Tanzania. Discussion with key informants and aged people in the study area revealed that bamboo has been part of indigenous vegetation since time immemorial. It was observed that the same species was also found on farm, an indication that the bamboo was retained during the farm clearing. People in this area have used bamboo for generations in the construction of houses and fencing. This was also revealed after a discussion with one village elder, Mr. Stefano who has been a "lifetime" guide for visitors coming to USFR. According to this elder, *A. alpina* has been there since his young age.

The ecological distribution and abundance of bamboo species in the Udzungwa

Five villages that border the bamboo forest on the north western boundary of the reserve are Mbawi, Masisiwe, Idegenda, Ilutila and Iluti. Ground truthing survey, revealed that the bamboo forest has extended to about six kilometers southward from Masisiwe Village. However, it was noted that patches of forest with native trees have interrupted the continuity of the bamboo forest, thus forming mosaics of bamboo and natural forests. The average width of the bamboo forest is

2.5 km and the distance from one end of the area covered with bamboo to the other is about 30 km. Therefore an area of *ca* 7500 ha (75 km^2) which is approximately 0.4% of the USFR is composed of mature bamboo *Arundinaria alpina* with only less than 20% of the area of bamboo forest covered with patches of natural forest. The area that is covered by bamboo extends from Ivala to the Kivalikila River on the southern part; and from the Msimbazi to the Mkomaji River on the northern side. Other rivers such as the Mkaja, Kivenzara and Lukosi, are also flowing in the surveyed area of the forest thus the spread of bamboo is principally not limited by rivers.

Highly disturbed vegetation had a highest mean density of *Arundinaria alpina* (10,002 stems/ha) of the other three disturbance levels. The lowest density of *Arundinaria alpina*, with a mean of 3,970 stems per hectare was found in the mildly disturbed forest. There was a significant difference ($F_{2, 48} = 32.4$, $P<0.01$) in number of stems per hectare between the three disturbance levels. Disturbance commonly enhances the abundance and distribution of pioneer and weedy plants (D'Antonio *et al*., 1999). As expected, the density of *Arundinaria alpina* was higher in the vegetation that experienced high disturbance than the low disturbed vegetation. The mean density of 10,002 stems/ha exhibited by the bamboo in highly disturbed forests, could pose a threat to other existing native vegetation.

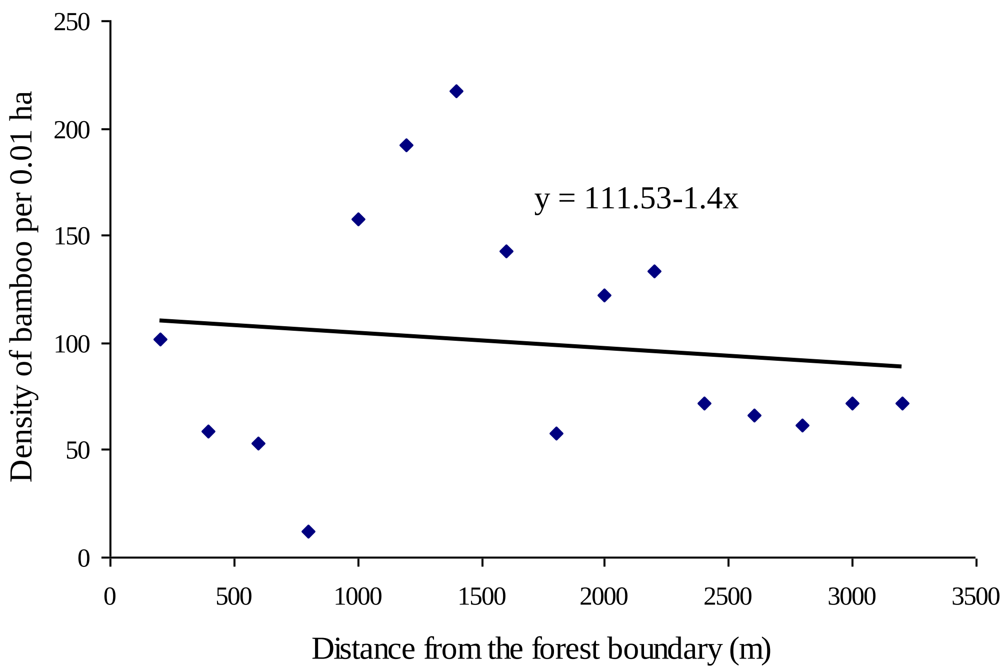

Figure 1: Relationship between density of bamboo (y) and distance from the forest boundary (x).

The analysis of variance revealed that there was no significant (P-value < 0.05, N = 48) difference between the density of bamboo close to the forest boundary, at the mid from the forest boundary and far inside from the forest boundary (at about 6 km from the forest boundary). However, the density of bamboo was negative correlated with distance from the forest edge, but the correlation was not significant (Fig 1). Invasive species could have difference in densities as the distance increases from the forest boundary where introduction is normally expected. The insignificance between densities of bamboo at the forest boundary, middle of forest and far inside the forest shows that the species history and presence in USFR go back beyond the start of unintentional and intentional introduction of plants in Tanzania.

Extent of bamboo invasion and impact on indigenous species

There is significant negative correlation (r = -0.491, N = 47, P < 0.01) between the density of bamboo and that of mature trees (Fig. 2). The density of mature bamboo ranges from 3,030 to 11, 140 culms per ha while that of indigenous tree species ranges from 100 to 460 stems per ha with higher densities recorded in forest patches. The most dominant tree species were *Macaranga kilimandscharica*, *Pseudolachnostylis maprouneifolia*, *Faurea saligna*, *Aphloia theiformis*, *Azanza garckeana* and *Syzygium guineense* (Shangali *et al.*, 1998). Under live bamboo there were very little or no regeneration of bamboo shoots at all. Regeneration of other species was observed to be poor under bamboo pure stands and profuse in dead bamboo. Regeneration of bamboo is of two types namely from rhizomes and seed. The shoot from seed is normally very small and grows to only about 1.5 m at full maturity. Subsequent shoots increase in size as they originate from the rhizome. Recorded bamboo regeneration ranged from 0 to 2,826 regenerants per hectare. Regeneration of other species was between 2,548 to 6,611 seedlings per hectare with more regeneration recorded in dead bamboo stands. Bamboos like other grasses attain full height in one year, and not surprising to find bamboo growing to a height of 25 m in one year.

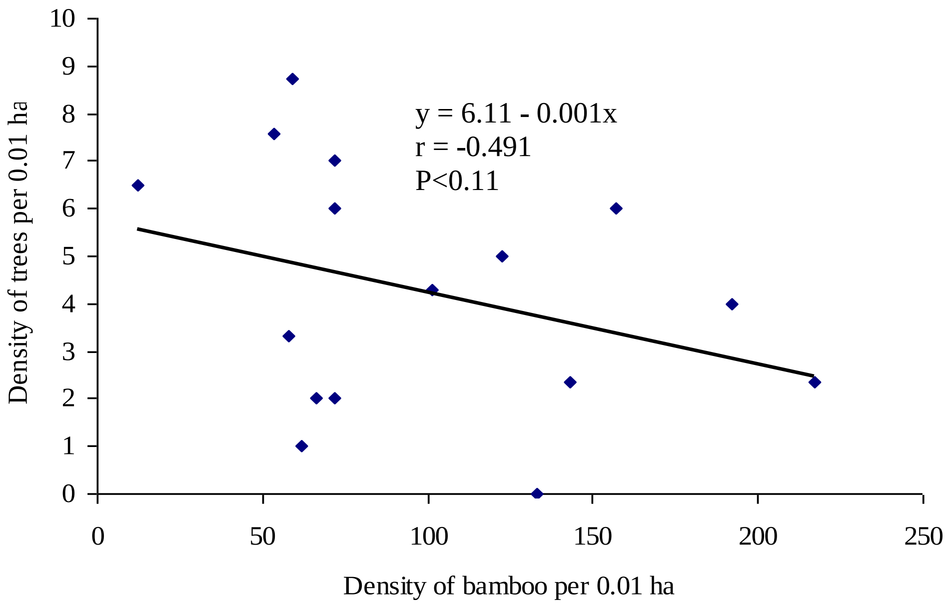

Figure 2: Relationship between density of bamboo and density of mature trees in 0.01 ha.

The density of bamboo was far higher (3,030 and 11,140 culms/ha) than the density of indigenous tree species (100 - 460 stems/ha). Therefore the averaging spacing of bamboo is less than one metre in areas with high density. Also, there was a negative correlation (r = -0.209, N = 46, P < 0.062) between the density of regenerants of native trees and the density of bamboo (Fig. 3). The density of bamboo ranged from 0 to 2,826 regenerants per hectare. Regeneration of indigenous tree species ranges from 2,548 to 6,611 regenerants per hectare with more regeneration recorded in dead bamboo stands. Regeneration of both bamboo and indigenous tree species varied substantially between areas with dead bamboo and areas with live bamboo. Under live bamboo there were very little or no regeneration at all of bamboo. Regeneration of indigenous tree species was observed to be poor under live bamboo stands and profuse in dead bamboo. Therefore, the density of regenerants (2,548 to 6,611 per ha) predicts the future vegetation of the area. Regeneration of bamboo was observed to be of two types namely from rhizomes and seed, with the former taking place in live bamboos and the later in dead bamboo stands.

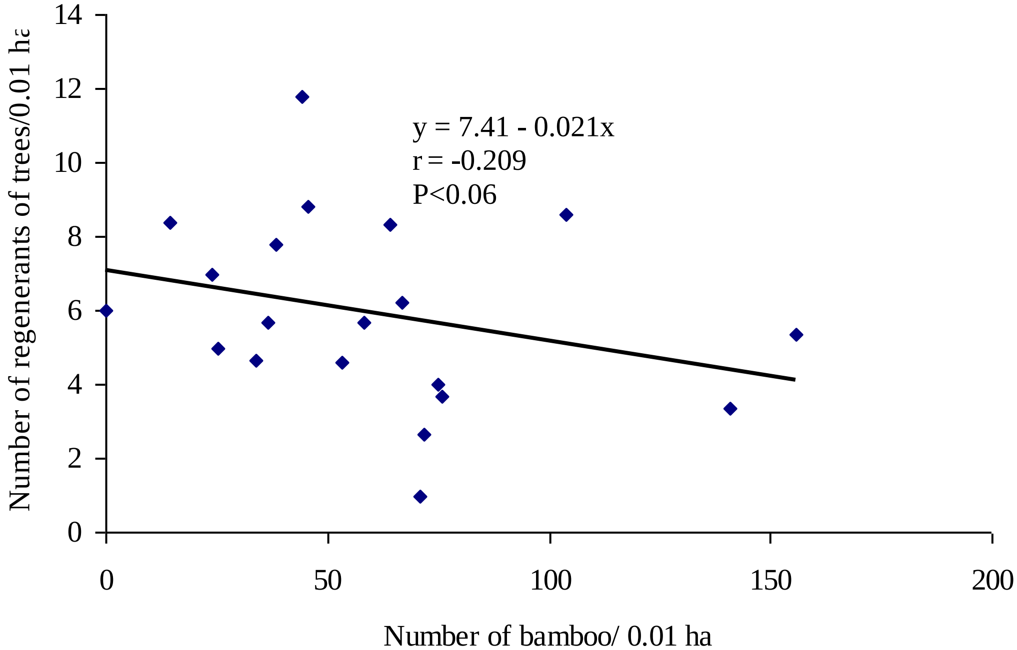

Figure 3: Relationship between density of bamboo and of regenerants of native tree species in 0.01 ha.

The relationship above (Fig. 3) reflects the reality that beneath the dense stand of bamboo there is relatively low regeneration of indigenous species. The presence of native regenerants beneath the canopy of bamboo imply possible invasion of bamboo in native tree stands. However, this is at variance with the view that the presence of bamboo suppresses the regeneration of native tree species! Observations show that profuse bamboo regeneration in the surveyed area bamboo culms are younger than the native tree regenerants. It should be remembered that bamboo shoot that grows from parent culms (which was the phenomenon for over 60 years of bamboo in USFR) grows very fast. Experienced people said that it takes less than a month for a bamboo culm to reach its full height contrary to the growth rate of many native trees which take months to be noticeable in the forest. Direct growth comparisons are therefore likely to lead to misleading conclusions.

The present concern by forest ecologists, environmentalists and the local community is that the bamboo stands are taking over the ground of other vegetation types. In a stable forest ecosystem such as that of USFR the overtaking of land by bamboo may take centuries. This is due to the fact that the massive death of bamboo culms which probably happens once in a century gives room for establishment of pioneer native trees which result in the increased patches of forest. However, no previous studies have documented this ecological change. In Echuya Forest Reserve in Uganda, the same species of bamboo *A. alpina* is reported to lose land for native trees such as *Macaranga kilimandscharica*, *Xymolas monospora*, *Nuxia congesta*, *Brillantaisia* sp., *Neoboutania macrocalyx*, *Dombeya rotundifolia*, *Psychotria* sp. and *Measa lanceolata* (Banana *et al*., 1993). Field survey in Echuya FR showed that the changes are due to colonization by hardwoods of gaps left by dead bamboo. However, the major form of gap creation in the Echuya FR is due to heavy load of climbers which resulted in falling and dead bamboo (Davenport *et al*., 1996). According to literature bamboos die once they flower like any other grass species but this depends on the variety and the growing conditions. Some bamboos species never or rarely flower. Other bamboos flower sporadically, not all at once but with old individuals randomly flowering. Most bamboo species seem to flower gregariously with all individuals of the same clump flowering at the same time across widespread populations, even across the whole planet. This was observed in the study area where bamboo individuals have selectively died in mosaics of populations. The death of the bamboo was first observed in 2004 in USFR. There after large areas of bamboo stands continued to die. The length of the flowering cycle varies considerably, with intervals up to 120 years, and others might flower almost yearly and not die back at all.

Socio-economic survey

Household and socio-economic characteristics

During the socio-economic survey, the study implored information from both female and male respondents. There was a gender balanced, thus the study acquired proper information from sex, however there high frequency of males (58%) from this interrogate (Table 1). Moreover, the age the respondents shows good distribution between age intervals. The study solicited information from youth, middle aged and elder people. Most of the respondents attained primary education (88%), therefore indicating that the achieved results were from literate people (Table 1). Three quarters (75.3%) of the respondents were observed to depend on agriculture and livestock keeping as their main income generating activities. These findings are according to Ngirwa (1997) as 84% of the Tanzanian population work in the agricultural sector producing about 60% of both domestic gross product (GDP) and mechanized export. Agricultural production is still the primary source of livelihood for about 85% of the Tanzanian population to whom it ensures economic sustenance in terms of food security, income generation and employment (Ngirwa, 1997).

Table 1: Household and socio-economic characteristic of respondents

Parameter	No. of respondents	Percentage (%)
Gender of respondents		
• Female	34	42.0
• Male	47	58.0
Age group of respondents		
• 20-30 years	13	16.0
• 31-40 years	25	30.9
• 41-50 years	19	23.5
• 51-60 years	9	11.1
• 61-70 years	10	12.3
• > 70 years	5	6.2
Marital status		
• Married	69	85.2
• Widow	6	7.4
• Single	6	7.4
Family size		
• 1-5 people	34	42.0
• 6-10 people	46	56.8
• > 10 people	1	1.2
Level of education of respondents		
• Uneducated (formal)	9	11.1
• Primary	71	87.7
• Secondary	1	1.2
Respondents' occupation		
• Agriculture	2	2.5
• Agriculture and livestock	61	75.3
• Agriculture, livestock and Petty business	11	13.6
• Agriculture, livestock and employment	2	2.5
• Agriculture, livestock and carpentry	4	4.9
• Agriculture and petty business	1	1.2

Source: Survey data, 2009

Existence and uses of bamboo (*Arundinaria alpina*)

Majority of respondents (99%) could identify or know the study bamboo species *Arundinaria alpina*. It is obvious that respondents do not identify the bamboo by its scientific name but rather its Swahili name (*Mianzi)* and also its characteristics which differentiate the species from other bamboo. Also, most of those who know this bamboo species have seen them in the USFR since their childhood. As reported in the last report, none among the respondents has witnessed the flowering of bamboo before. It is only recently (early 2000s) when flowering started which was then followed by massive death of bamboo. A few people were not aware of the massive death of bamboo in USFR (Table 2). This may be due to the fact that some of the respondents do not frequently visit the forest but some just do not want to be held responsible in case interviewers are investigating the cause of massive death of bamboo. Bamboo contributes significantly to the economy of people living adjacent USFR; this was revealed by a number of products and services that were reported as from the *A. alpina* (Plate 5 a and b). About half of the respondents (49%) use *A. alpina* for building, roofing/rafters, woodfuel and handcraft, only a small portion does not use bamboo for either purpose. More than three quarters of the respondents (77%) indicated that the massive death of bamboo has greatly affected their sources of building materials, roofing etc. Meanwhile, others reported that bamboo can be used as an alternative to many native trees, and only few were completely not in favor of bamboo as an alternative source based on the fact that, many questioned on its durability when used for constructions and its calorific value as woodfuel (Table 2). Though many claimed that they are extracting the bamboo from their farmlands, but based on the abundance of *A. alpina* in their farmlands it is obvious that large percent of bamboo is extracted from USFR.

Table 2: Knowledge on the existence of *Arundinaria alpina* and its uses

Parameter	No. of respondents	Percentage (%)
Have seen/can identify/know the bamboo		
• Yes	80	98.8
• No	1	1.2
Since when have seen the bamboo		
• Since childhood	80	98.8
• Recently	0	0.0
• Were not observing	1	1.2
Awareness of the massive death		
• Yes	77	95.1
• No	4	4.9
Uses of bamboo (*Arundinaria alpina*)		
• Building, roofing/rafters, woodfuel/heating and handcraft	40	49.4
• Building and woodfuel/heating	5	6.2
• Fences and roofing/rafters	20	24.7
• Building only	7	8.6
• Don't know/use	9	11.1
Bamboo as an alternative to native trees		
• Yes	62	76.5
• No	19	23.5
• Don't know	0	0
Planting tree in their farms		
• Yes	79	97.5
• No	2	2.5

Source: Survey data, 2009

Knowledge on the impact of bamboo to environment and biodiversity

Based on the previous information that bamboo (*A. alpina*) is replacing other native vegetation, it was important to access the knowledge of villagers on the effect of bamboo. Bamboo like and other plant species, assures its perpetuity by producing off springs. As reported earlier, before flowering (which has relatively long cycles) bamboo persists by producing rhizomes. Therefore, we accessed whether the out competing characteristic of bamboo in USFR is human assisted or natural phenomenon. The majority of the respondents (93%) said that the spread had occurred naturally and few said that it was planted by their ancestors in different areas of USFR (Table 3). More that one third indicated that there is no need of intervention to prevent its spread because natural occurrences will check its population. Some of the respondents showed the need of replacing the dead bamboo with native tree species by enrichment. It was clear that, the natural spreading of bamboo in the USFR is not considered as a threat to native vegetation since no other strategy is place.

The majority of the respondents (90%) said that bamboo does not have negative effects on environment. The assessment was narrowed down to see whether bamboo has negative effects on water sources and prohibitive characteristic on growth of native plant species. It was observed that, majority of respondents (94% and 91%) reported that bamboo has neither negative effects to either native plants nor water sources respectively. In fact, some few patches of *A. alpina* could be seen in villagers' farmlands. Due to land scarcity, it was clear that villagers do not opt to replace food crops with bamboo which at any time can easily be found from USFR.

Table 3: Knowledge on the bamboo impacts on ecosystems

Parameter	No. of respondents	Percentage (%)
Causes of bamboo spread		
• Naturally	75	92.6
• Human assisted	1	1.2
• Don't know	5	6.2
Intervention to prevent the spread		
• Doesn't need any intervention	33	40.7
• Replanting with native tree spp	16	19.8
• Do not know	32	39.5
Village Government puts strategies to prevent spread		
• Yes	7	8.6
• No any strategy	74	91.4
• Don't know	0	0.0
Any effect on environment		
• Yes	7	8.6
• No	73	90.1
• Don't know	1	1.3
Prohibitive/allelopathic on native vegetation		
• Yes	5	6.2
• No	76	93.8
• Don't know	0	0.0
Any effect on water sources		
• Yes	7	8.6
• No	74	91.4
• Don't know	0	0.0

Source: Survey data, 2009

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Management plan and control measures to reduce the bamboo invasion threat to other species

We have established that the bamboo species found in this part of Udzungwa Scarp Forest Reserve is native to Tanzania. This is a natural vegetation that need to be conserved just like any other grasslands like the Lukwangule in the Ulugurus. These are unique alpine ecosystems found in high mountain rain forests of Tanzania such as the Mount Rungwe, Livingstone, Meru and Kilimanjaro. Since bamboo can occupy gaps quickly the forest management must strive to reduce disturbance. According to these results, bamboos in this forest reserve cannot be termed as invasive plants, but it can be termed as weedy plant especially when it occupies open spaces in the forest.

CONCLUSIONS AND RECOMMENDATIONS

There is little evidence to suggest that there is an existing vegetation change from mixed hardwood forest to bamboo forest. The bamboo populations are estimated to be older than 100 years and this is supported by the observed evidence of flowering and drying of bamboo populations in a mosaic pattern. This phenomenon according to local people is being recorded for the first time. Field survey showed that there is a possibility of native trees to colonize gaps that are created by massive death of bamboo as a result of their flowering. Another major form of gap creation may be due to pressure from surrounding communities on the native forest. The surrounding villagers harvest bamboo culms and leaves for construction and roofing, this is not yet considered as illegal activity as harvesting of timber from native trees. The local people do not recognize the bamboo vegetation as part of the forest, to them the forest starts where the bamboo ends.

The majority of the respondents during socio-economic survey adhered that the spread of bamboo had occurred naturally, whereas only few said that it was planted by their ancestors in different areas. Some of the respondents argued that there is no need of intervention to prevent its spread because natural occurrences will check its population. However others showed the need of replacing the dead bamboo with native tree species by enrichment. On the other hand most of the respondents said that, the bamboos have no negative effects on either native plants or water. After this study, there is a need of carrying out further study to assess vegetation recovery following flowering and massive death of bamboo stands in the Udzungwa Scarp Forest Reserve. Furthermore, study on the side effects of bamboo on native plants and water is pertinent to be undertaken.

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