INSTITUTIONS AND THE CONDITION OF TROPICAL MOIST FORESTS OF CENTRAL UGANDA

JOSEPH BAHATI
ESTHER MWANGI

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Introduction

Forests cover about 25% of Uganda's total land area. These forests are rapidly declining at an estimated rate of about 650 square kilometers per annum. This paper focuses on the condition of tropical moist forests in Mpigi district of central Uganda (Figure 1 of Appendix 1). A high population density and the rapid rate of urbanization combine to make deforestation rates highest in Mpigi district relative to other districts in Uganda (Gombya-Ssembajjwe, 1996). Yet, a large portion of the population is dependent on these forests for timber, energy supply and food. The forests are also important for the conservation of biological diversity, and as a source of national income through tourism. It is crucial that the rapid deforestation rates be halted, or even reversed. For this to happen, an understanding of the processes causing and mediating deforestation is important.

Recent work on deforestation indicates that there are many intertwined causes of deforestation. Turner (1995), for example, identifies demographic factors, agricultural factors, and timber production as important underlying causes of deforestation. In addition to these, political economy (systems of exchange, ownership and control), political structure (institutions and organization of governance, security of property rights) and attitudes and values of individuals and groups are equally important (Ostrom, 1995). Ostrom (1995) observes that these institutional systems affect the incentives that individuals face and may enable individuals at a microlevel to make more sustainable uses of land resources.

In this paper, we investigate relationships between forest condition on the one hand and environmental variables, on the other. By using ecological and institutional theory within the context of the IAD framework, we construct a model that will facilitate our inquiry. We focus our study on the tropical moist forests of Mpigi District in Uganda where the uniformity of bedrock, microclimate, and forest vegetation as well as the diversity of forest tenure regimes combine to make it a particularly good area for investigating institutional effects on forest, structure. We anticipate that,- given the homogeneity of the biophysical environment within the area of study, any variation in forest structure as represented by DBH[1] is likely the influence of institutional factors. Our first set of institutional factors divides the forests into four tenure regimes: government-owned nature reserves; govemment-owned production forests; communally owned forests; and individually owned forests. With regard to tenure regimes, we anticipate that forest condition will be better (i.e., trees will be larger, and have larger diameters) where tenure regimes are either private or communal. Under private and communal tenure, forest ownership is not ambiguous, and incentive structures are. clearly defined (Ostrom, 1996). Benefits from forest products accrue directly to owners, hence they have stronger incentive to undertake forest conservation. Our second set of institutional factors relates to rules, and how rules order people-forest interactions. We consider two types of rules: monitoring and enforcement rules and use rules. We specifically determine whether these rules are present or absent; and further, where present, whether they are respected or ignored. Thus we also anticipate that where use rules and monitoring rules are present and respected, forest structure is likely better than where rules are absent.

[1] **DBH=diameter at breast height; used as a measure of forest condition**

Our study builds on previous investigations that underscore the centrality of institutions in enhancing forest sustainability (Becker, et al, 1995 and Gombya-Ssembajjwe, 1996). Becker, et al., revealed that forest condition (e.g., tree sizes, tree density and tree species diversity) is better in a private forest than in a government forest. The private forest had better monitoring and rule enforcement, and local users actively participated in rule making.. In contrast, the government forest was poorly monitored, lacked clear sanctions, had lax enforcement, and did not involve local users in rule making. Gombya-Ssembajjwe's extensive study of 14 of the tropical moist forests of -Uganda managed under four institutional regimes (government nature, government production, private and communal) shows that forest tree attributes such as species diversity, basal area and heights are significantly different across institutional regimes: For instance, government nature forests ranked higher in forest health than government exploitation forests. To these two valuable studies we add the following:

- We consciously incorporate biophysical variables such as soil texture and slope inclination into our investigative structure;
- We divide our institutional variables into two types: those dealing with tenure regimes, and those directly related to rules constraining forest use and maintenance; and
- We use a multiple regression procedure.

Given knowledge of the assumptions underlying multiple regression, practical field experience, and knowledge of the processes influencing forest condition, we believe that multiple regression is an excellent technique for the purpose of our study. Multiple regression takes into account any correlation between independent variables, so that a multiple regression equation will be satisfactory as an empirical predictor. It also provides good means for testing hypotheses for exploring the importance of a wide range of environmental variables on forest condition. Most importantly, multiple regression enables us to use dummy variables to quantify the effects of qualitative variables such as soil texture, tenure regimes and rules structure, on forest condition.

We first present a generalized description of each of the forests under investigation. The description includes an account of the socio-economic environment, and botanical composition of each forest according to the ten most dominant tree species. We also take a quick look at the sapling species composition to provide an indication of forest regeneration is also provided. The second part of our paper discusses the model we adopt, the regression procedure, our results, and our conclusion from these results.

PART I : Forest descriptions

Data were collected by the Uganda.Forest Resources and Institutions Center (UFRIC) (http://www.indiana.edu/~ifri/crc/uganda/kamp crc.html) between 1992 and 1998, using the International Forest Resources and Institutions (IFRI) protocol (<http://www.indiana.edu/~ifri/research/ifrirestrat.htm>): 30 plots per forest were randomly sampled in each of the 14 forests. In each plot biophysical information was collected using nested concentric circles of 1-3-10 meter radii. Tree and sapling measurements of diameter at breast height (DBH) were taken in the 3 and 10 m plots. DBH is our dependent variable. We selected DBH because it is an empirically determined measurement that represents tree size, from which other measures such as biomass are derived via specified formulae. DBH is straightforward and does not involve any hidden assumptions;

Socio-economic information was gathered using Participatory Rural Appraisal (PRA) techniques. Such information includes' local community forest use, informal and formal rules for forest access and use, forest-related and non-forest related income and population size and distribution. Special emphasis is given to forest-adjacent communities. A key assumption of IFRI methodology is that relationships between the forest resource and adjacent communities are mediated by the institutional arrangements, both formal and informal, that are designed to control access to forest resources.

.Most of the forests range in age between 300-500 years. Four of the forests are very young, varying in age between 50 to 100 years. The information on forest age is however based on estimates made by the local communities, and there may be some important inconsistencies regarding the criteria upon which these estimates are based. These forests represent four different tenure regimes: government production; -government nature; communal forests; and individually owned forests. Government forests are owned and managed by the government. Production forests are managed for timber production, while nature reserves are strict preservation areas that discourage consumptive use. Table 1 (Appendix II) provides a summary of key attributes for each forest. A11 forest stand inventory tables showing the ten most dominant tree species in each forest, are presented in Appendix III.

Namungo's forest:

This is a privately owned lowland tropical rainforest, 40 hectares in size, about - 300 years old, and surrounded by the large, government-owned Lwamunda forest. Dominant trees in the forest include *Pseudospondias macrocarpa, Bosquiea phoberos,* and *Trichilia prieuriana.* Tree density is about 355 tree per hectare, with mean dbh of 24.48 cm, and height of 17.60m. A total of 63 tree species were found in the sample area of this forest. The sapling population is representative of the tree population, and regeneration does not appear to be a problem.

50 people live less than 5Km from the forest edge. The main user group is Nanuingo's family/Kawombo dairy. All users in the group are agricultural laborers on Namungo's farm, none of who own land apart from Namungo. Namungo allows user rights to workers on his farm for fuelwood and non-wood products. However none have rights to charcoaland timber and there is evidence of illegal timber extraction and charcoal burning. Mr. Namungo conducts selective harvesting of timber, but also attempts to maintain a balance between conservation and exploitation. He has converted a small (5 hectares) portion of his property'into a *Eucalyptus* woodlot. Users see the condition of the forest as good.and feel that the level of conservation is adequate. However both managers and users are concerned about tree poaching for charcoal and timber.

Lwamunda forest:

Lwamunda is officially designated as a government forest reserve. It is 1000 hectares large, and about 400 years old. Tree dominants here include *Celtis durandii, Celtis mildebraedii,* and *Macaranga monandra.* Tree density is about 404 stems per hectare, with a mean dbh of 22.61 cm and height of 14.06 m. A total of 101 tree species were found within the sampling area. There does riot appear to be a regeneration problem, and the main tree dominants appear to be well represented within the sapling population.

Approximately 75 people live less than 5Km from this forest. Individuals or groups are permitted to extract non-reserved tree species or other products in reasonable amounts such as firewood, medicinal plants, craft material, and poles. On average most users live within **1-5** kilometers of the forest and harvest such products as trees, water and wildlife. The forest is particularly important for firewood, charcoal and timber. It supplies approximately 90% of timber needs and 90% of fuelwood needs. Tree densities and forest area are decreasing due to timber cutting, charcoal making, and firewood collection. Most users rank the forest's condition as low and are concerned that poor rule enforcement and high harvesting rates will compromise the capacity of the forest to meet future needs. High demands for forest products, lack of affordable substitutes and limited capacity of the forest department to regulate harvesting are seen as critical problems likely to hasten the decline in forest quality and extent. It is thought that future opportunities lie in improving monitoring and control of harvesting. Also as trees get depleted on government land great opportunity exists for private forests to meet the population's demand for wood products.

Buttobuvuma forest:

Buttobuvuma is a government nature reserve 1096 hectares large. It is approxiamtely 300 years old. Most important tree species in this forest are *Maesopsis eminii* and *Celtis, Mildebraedii.* A total of 64 tree species were encountered, with a density of about 104 trees per hectare; mean tree height of 13.39 meters, and mean dbh of 22.7 cm. The sapling composition of this forest appears slightly different from the dominant tree species, because none of the dominant trees are represented among the ten most dominant saplings. However, all dominant trees are represented amongst the list of saplings in this forest. Thus regeneration may not be a problem, and this pattern may be a feature of the forest's regeneration dynamics.

The forest has an irregular boundary line and is surrounded by 12 villages, some of which are enclosed within the forest. About 120 people live less than 5Km from the forest edge. The forest has low species diversity, low tree density/low commercial value, and a somewhat normal subsistence value. Tree densities have been noted to be decreasing due to commercial fuel wood harvesting, charcoal burning and pitsawing. Majority of the users feel that forest protection and law enforcement are low, and are concerned that if current harvesting levels are sustained the forest will soon be depleted. Some serious problems include overexploitation by illegal harvesters, limited enforcement capacity by the forest department and the need to create alternative income generating activities within the surrounding community. The greatest opportunity is for the development and experimentation of joint management between the forest department and user groups/community, as a first step towards solving the problems.

Mpanga Nature Reserve:

This is a government nature reserve 453 hectares in size, and about 50 years old. Dominant tree species are *Celtis mildbraedii* and *Bosquieia phoberbs.* A total of 68 tree species were present in the sample area. About 378 individual trees were sampled, making up a density of about 394 trees per hectare. Sapling composition is similar to that - of the dominant trees, and regeneration appears not to **be** a problem. However, the ' dominance of Euphorbia teke (a shrub) in the understorey may present a problem to the natural regeneration dynamic of the forest. In sum, The forest is in good condition, with high vegetation density and species diversity.

About 300 people live less than 5Km from the forest edge. Although no commercial harvesting is allowed, the forest has a normal commercial value, and an above normal subsistence value. Main users of forest products include traditional drum makers as well as women.who use the forest on a subsistence level. The most serious challenge faced by the forest is with regard to how government employees pursue their duty of law enforcement. For the most part this causes enmity between the users and the managers of the forest. In addition tree densities are decreasing due to illegal tree felling and natural causes. The users feel that the government is too restrictive. The greatest future opportunity for Mpanga nature reserve is that it may support a lucrative handicraft industry. This is important both for income generation and as an entry point for initiating joint forest management activities between the community and the forest department.

Mugalu forest:

Mugalu forest is a private forest that is owned by the Mugalu family. It is 150 hectares, and roughly 500 years old. Main tree dominants include *Bosquiea phoberos* and *Pseudospondias macrocarpa* (Table 5a., Appendix II). A total of 50 different **tree** species were encountered **in the** sampled area of this forest, **with an** average dbh of 25.51 cm **and** mean height of 10.33 meters. Tree density is about 99 **trees** per hectare. Although **not all** dominant trees **are not** dominant as saplings, they **are still** well-represented among **the** sapling community indicating fairly decent recruitment. The only exception is *Prunus* *africana,* a rare arid valuable hardwood species, which is completely absent among the sapling population. This species is however well known for its poor regeneration capacity.

The main forest-related activities include commercial fuelwood harvesting, charcoal burning and pitsawirig. About 53 people live within'5Km of the forest. Tree density and species diversity are low; the forests' commercial value is low, but its subsistence value is high. Tree densities within the forest are decreasing due to clearing for cultivation, pitsawing, charcoal burning and commercial fuelwood harvesting. The forest area has also decreased in size. Users feel that forest condition is poor and that the level of forest protection and regulation is too low. Generally the forest is under enormous threat.from clearing for cultivation and through intensified harvesting for commercial fuelwood.

Kizzikibi forest:

This is a 560-hectare forest, about 500 years old, and dominated by *Bosquieia phoberos, Celtis durandii,* and *Pseudospondias macrocarpa* tree species. 54 different tree species were found in the area sampled, with mean dbh and tree heights of 26.3 cm and 12.9 meters, respectively. Tree density is about 122 trees per hectare. Regeneration within the forest is good, with up to five of the ten dominant tree species represented among the ten most dominant saplings. A11 other trees are also well represented among the sapling population..

Approximately 268 people live less than five kilometers from the forest boundary. The forest vegetation density is low and species diversity is low. It has a very low commercial value and an above normal subsistence value. Tree densities are further decreasing due to pitsawing activities. The greatest challenge to forest conservation is the illegal harvesting of under-sized trees, which is likely to reduce the forests' ability to meet future timber requirements. Although there is no charcoal burning-or commercial fuelwood harvesting currently, it is envisioned that these activities are likely to increase in future as forests closer to Kampala city get depleted and charcoal demands increase.

Najjakulya forest:

This forest is 50 hectares and is located on private land under the mailoland tenure system. The main tree dominants are *Antiaris toxicaria, Sapium ellipticum, and Lovoa brownii.* Tree density in this forest is about 248 stems per hectare, mean dbh is 19.98cm, and a mean height of 8.85m. A total of 43 different species were encountered in the sampling area. The sapling population seems to be representative of the tree population.

It is situated on land that was previously committed to cotton growing but later abandoned due to unprofitability of the cotton. The forest does not generate income for other community members apart from its owner who sells trees to pitsawyers from other communities. All people reside at a distance greater than 5Km from the forest. Users rank the condition of this forest as poor, the level of enforcement as lax and are concerned that current levels of extraction are unsustainable. The property owner is too old to effectively monitor and manage the forest; as such illegal harvesting is on the increase. An even greater challenge is the fact that the banning of pitsawing in government forests is placing greater pressure on private forest owners to increase harvesting to fill in the deficits.

Kyambogo forest:

Kyambogo forest reserve is 760 hectares in size, about 500 years old, with *Bosqueia phoberos* and *Teclea nobilis* as the main tree dominants. The forest area sampled comprised 68 different tree species. Trees have a density of about 477 stems per hectare, a mean dbh of 24.26 cm, and an average height of 12.98 cm. The sapling population is a good representation of the tree population, and regeneration appears to be proceeding normally.

Kyambogo forest has a total of 180 people living within 5Km of the forest boundary. Coffee farms, abandoned due to low profitability, surround the forest. Young men have thus taken up pitsawing in the forest as a source of cash income. Vegetation density is high, species diversity is high, but commercial value of forest is low. The forest's subsistence value is however normal. The area of the forest is decreasing, as well as tree density due to pitsawing. The greatest challenge is the deficiency of harvestable timber sizes in the forest, and the subsequent harvesting of undersized trees. There have been no incidences of charcoal burning.

Magezigoomu cultural forest:

The forest is located on the shores of Lake Victoria, and is 20 hectares in size. The main tree dominants are *Maesopsis eminii, Lovoa brownii,* and *Piptadeniastrum africanum.* A total of 41 different tree species, having a density of about 309 trees per hectare, were encountered within this small area of forest. Mean tree dbh and height are 21 cm and 10.8m, respectively. The sapling community appears to be representative of the tree population, indicating the likelihood of a normal regeneration procedure.

Forestor's appraisal indicates that vegetation density is normal, species diversity is normal, commercial value of forest is below normal, and the subsistence value is substantially above normal. The tree density is rapidly on the decline due to selective harvesting. The greatest challenge to forest conservation is the rapid rate of land fragmentation, and the selling of trees from individuals' lands.

Rules structure in the forests:

In Lwamunda and Namungo's forest, rules for forest maintenance, monitoring and management are present. Such rules include those pertaining to type of seedling planted, fire management and infrastructure development. Buttobuvuma has some of the rules in place, particularly those regarding forest improvement such as seedling planting and infrastructure development, but none for forest maintenance such as for fire management. Mpanga nature reserve has no maintenance/forest improvement rules, but has rules for infrastructure development, seedling and fire management. Mugalu, Najjakulya, Kizzikibi, Kyambogo, and Magezigoomu do not have specific rules restricting maintenance and monitoring activities within them. For example, they do not have specific rules relating to infrastructure development, selection of seedling type for planting, when or where fires may be started, or weeding methods in relation to specific products.

PART II: Effects of institutions on forest condition: A regression analysis

The regression model:

The Institutional Analysis and Development framework (IAD) *(Appendix I)* has been used to develop grounded theory concerning how institutions affect human incentives and behavior, as these impact on the governance and management of natural resource systems (Ostrom, 1996). At the core of the IAD framework are individuals who hold different positions (e.g. member of a forest user group, forest official, local forest user group official, landowner, elected local, regional and/or national official) who must decide upon actions (e.g., what to plant, protect, harvest, monitor, or sanction) that cumulatively affect outcomes in the world (e.g., a forest ecosystem and the distribution of forest benefits and costs).

The correlative approach in ecological theory relies on an assumed correlation of measurable habitat/environmental factors with those of direct, effective physiological importance to plants. The environmental factors can be defined as independent and the plant responses as dependent (Major, 1951 and Billings, 1952). Treating the factors as independent variables, the total derivative can be obtained as a group of partial derivatives of the independent variables. Thus, one can consider vegetation in terms of one factor with all the others held constant. Environmental variables are often listed under the headings of climatic edaphic, biotic, pyric and topographic. The major topographic features, for example elevation, aspect and slope inclination, are known to play a significant role in determining structural characteristics of vegetation. (Whittaker, 1956, 1960, Whittaker and Niering, 1965). Also differences in soil structure and texture strongly influence the water retention capacity of soils.

Given the above theoretical framework, we began our inquiry with the following model:

Dbh = f (forest age + soil texture + slope steepness + tenure + rules)

Where:

- Forest age;

- Soil texture is a categorical variable with 6 categories: clay, clay loam, sandy, sandy loam, sandy-clay-loam and sandy-clay;
- Slope steepness, measured in degrees, is a continuous variable;
- Tenure is a categorical variable with four categories: government production, government nature, communal and individual.
- We have two sets of rules:

  Maintenance rules, which fall under two categories, whether followed or not and;
  Use rules. We consider whether use rules are present or absent, and further, whether where use rules are present, they are followed.

For the specification of our regression model, we have attempted to include what theory deems as the most salient variables associated with forest condition at the local level. However, we acknowledge that other variables that we did not include may be relevant to the model. For example the **degree** of forest dependence by local households (both subsistence **and** commercial). This **was** difficult to determine from our **data.**

Regression analysis results

$$PCIRCUM = 17.564 + 131.17PCIDM + 0.0112FAGE\ 0.2937SLOPE + 2.054COMM + 2.3762MRULE + u,$$

VARIABLE	PARAMETER	S.E	T-STAT	PROB-T
Intercept	17.564	2.1053	8.343	0.0001
PCIDM	131.17	3.006	43.637	0.0001
Fage	0.0112	0.0048	2.322	0.0203
Slope	0.2937	0.5097	0.576	0.5646
Comm	2.054	1.9651	1.045	0.296
Mrule	2.3762	0.8887	2.674	0.0075
R-square	**0.5939**			
Adjusted-R	**0.5935**			
F-stat	**1213.744**			
Prob-F	**0.0001**			

Where:

PCIRCUM	– Diameter at breast height (cm)
PCIDM	= Jacknife
FAGE	= Forest Age (years)
SLOPE	= Slope steepness (degrees)
COMM	1=Community forest
	0=Not Community forest
MRULE	1=Maintenance rules present
	0=Maintenance rules not present

Our final regression model is derived- from a model that has been re-specified to include a dummy variable that represents a jack-knife component that is not present in our theoretical model. We introduced the jack-knife into our model due to the presence of a marked discontinuity along the slope-dbh gradient. Slope steepness for 12 forests averages 1.875°, ranging between 0.5° to 5°. Average dbh for these 12 forests is 20cm. While slope steepness for the excluded forest (Najjakulya forest) is 15°, with an average dbh of 23cm. This sharp discontinuity in slope coincided with an increase in tree size, a source of variation that has been captured by the jack-knife component. The absence of the jack-knife in initial models served to obscure the effects of the rest of the independent variables in the model. We conducted tests for spatial autocorrelation (Durbin-Watson); multicollinearity (R_{aux}, Condition Index, pairwise correlation); and heteroscedasticity (White's test). Our tests indicate-that our data do not have spatial autocorrelation or multicollinearity problems, however heteroscedasticity was present. We attributed heteroscedasticity to the slope variable because our initial plot of residuals against slope indicated a fan-shaped pattern, other similar plots did not show such a pattern. We corrected for heteroscedasticity using the weighted least squares procedure. A further heteroscedasticity check indicated that we had not completely removed the problem, and that in fact, a dummy variable now accounted for the little that could be observed. We were thus unable to conduct a correction, hence our final results should be interpreted with caution. Heteroscedasticity is known to bias the OLS estimators, and to inflate the variance, hence affecting the t and f statistics.

Our results indicate that there is a significant linear relationship (F=1213.744; Prob-F=0.0001) between forest condition and environmental/institutional factors. These factors include weighted forest age (t=2.3-22; prob-t=0.0203); weighted[2] slope (t=0.576; prob-t=0.5646); communal tenure (t=l .045; prob-t=0.2960); maintenance rules (t=2.674; prob-t=0.0075); and a jack-knife component (t=43.467; prob-t=0.0001). 59.35% of the variation in forest condition can be associated with the mentioned factors.

Slope steepness does not significantly affect forest condition (t=0.576; prob-t=0.5646). For 10 forests (out of a total of 13) slope steepness ranges between 0.5° and 3°, and an. average of 1.875° for 12 forests. The only exception is the outlier forest (Najjakulya) which has a slope of 15°. This result is consistent with our expectation, since we had purposely designed the model to investigate the impacts of varying institutions on forest condition within a relatively homogeneous environment.

Forest age is significant. We find that, as expected, younger forests have smaller sized trees than older, more mature forests. This is consistent with ecological theory, where larger forests have had a longer period of biomass accumulation that is directly observed in tree dbh (Barnes, et., al., 1998). We acknowledge that our forest age estimates are-crude, and recommend that this result be interpreted with caution. Indeed, we did attempt to treat forest age as a categorical variable comprising three categories: 300-500 years, 50-100 years, and 30 years. This resulted in the forest age variable having a 100% correlation with the intercept term, indicating that this format may not have been suitable. The forest age variable requires further consideration; it may well be that it is best excluded out of future models, although it plays a useful indicator as a rough estimate of forest age.

Communal tenure is significant; forests found within areas under communal tenure are on average larger than those managed under individual, government production or government natural forests. This is-an expected result. Communal tenure means that communities manage forests. According to the institutional arguments within our theoretical framework, such communities have strong incentives to use the forests sustainably since they are the direct beneficiaries of forest products. In our particular case, a greater incentive to conserve may have been provided by cultural and religious factors since all three communal forests appear to have cultural and religious significance to the local communities.

Maintenance rules are significant and important. This is an expected result, because maintenance involves such activities as weeding and tending tree seedlings, and fire protection. Such activities enhance the chances of a seedling thriving and ensure that those thriving may survive to become large trees. We find extremely puzzling the fact that the presence or absence of use rules, or the following or not of use rules where they are present, is not significant. Use rules represent a direct constraint to unlimited harvesting that would otherwise result in forest degradation. Up to six forests have'use rules that are respected; we would thus" have expected a positive and significant relationship. This result merits further investigation.

[2] **Weighted because these variables were divided by slope during the WLS procedure**

Conclusion

The incentive structures facing individuals are shaped and mediated by the institutions to which the individuals are exposed. These incentives are reflected in the actions and behaviors that individuals select, which in our study have direct implications for forest conservation. In the tropical moist forests of central Uganda, we find that institutions are important constraints that regulate people-forest interactions. This is consistent with our hypotheses. Our results are also consistent with previous findings in this region of Uganda, which indicate that institutions are central to forest sustainability (Becker, et al, 1995 and Gombya-Ssembajjwe, 1996). By desegregating institutions into , tenure, arrangements and rules structures, we find that maintenance rules are particularly significant determiners of forest condition. We also find that communal arrangements, particularly those that are linked to cultural or religious beliefs are valuable predictors of forest sustainability. The implications for forest policy are clear: tenure arrangements that feature strong government control are unlikely to yield forest sustainability. Incentive structures at the forest-people interface must be modified if the goals of forest conservation are to be achieved. Joint or cooperative management initiatives between local communities and government are a possibility that Uganda's Forest Department could explore. We suggest that future research focus more narrowly at establishing why use rules are not significant determinants of forest condition in our study area. Also future research should investigate more closely the incentive structures that confront the entire range of government forest management regimes. We also believe that an extension of our current analysis to include variables that represent population density of forest-adjacent communities, and their degree of forest dependence, may yield information pertinent both to forest condition and forest policy.

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APPENDIX I

A Schematic of the IAD framework:

Attributes of the physical World

Action Arena

Patterns of Interactions

Attributes of the Community

Action Situations

Actors

Outcomes

Rules-in-use

Evaluative Criteria

(Source: Ostrom, 1996)

APPENDIX II

TABLE SHOWING FOREST, TENURE REGIME AND RULE STRUCTURE:

FNAME	SLOPE	FAGE	GPROD	GNAT	COMM	MRULE	URULE	URULFO
Butto-buvuma	5	300	0	1	0	1	0	0
Kizzikibi Forest Reserve	4	500	1	0	0	0	1	0
Kyambogo Forest Reserve	1	500	1	0	0	0	0	0
Lukambagire forest	0.5	500	0	0	0	0	0	0
Lwamunda Forest Reserve	0.5	400	1	0	0	0	1	1
Magezigoomu Cultural Forest	0.5	60	0	0	1	0	1	1
MPANGA NATURE RESERVE	1	50	0	1	0	1	0	0
Mugalu Forest	3	500	0	0	0	0	1	1
Mugomba.	0.5	500	1	0	0	0	0	0
Mukasa Cultural Forest	3	300	0	0	1	0	1	1
Mukasa-mu-nzo Cultural Forest	3	100	0	0	1	0	1	1
Najjakulya forest	15	60	0	0	0	0	0	0
Namungo's Forest	0.5	300	0	0	0	1	1	1

1=presence of attribute at top of column
0=absence of attribute at top of column

APPENDIX III

Tree stand inventory for Namungo's forest:

	Stem count	Mean Ht.	Mean dbh	Rel. freq.	Rel. dens	Rel domin	IV
Pseudospondia macrocarpa	19	21.4	47.4	0.0507	0.0554	0.02194	0.1085
Bosqueia phoberos	31	17.1	0.076	0.0904	0.01511	0.0725	0.0725
Trichilia prieureana	23	17.3	26.7	0.022	0.0671	0.0678	0.069
Macaranga monandra	23	18.2	23.2	0.0507	0.0671	0.0501	0.056
Antiaris toxicaria	11	23.4	38.9	0.038	0.0321	0.0934	0.0545
Tabernaemontana holstii	23	10.7	15.1	0.0634	0.0671	0.0174	0.0493
Piptadeniastrum africanum	7	29.3	51.7	0.0292	0.0204	0.0776	0.0424
Celtis mildaebridii	8	23.8	34.8	0.0292	0.0233	0.0343	0.0289
Funtumia elastica	12	15.8	14.4	0.038	0.035	0.0088	0.0273
Albizia gummifera	10	22.7	21.7	0.0292	0.0292	0.022	0.068

Sapling inventory table for Namungo's forest:

	Stem count	Mean Ht.	Mean dbh	Rel. freq.	Rel. dens	Rel domin	IV
Tabernaemontana holstii	12	5.4	5.3	0.1395	0.15	0.1752	0.1549
Coffea canephora	8	4.6	4.4	0.0791	0.1	0.0768	0.0853
Blighia unijugata	5	4.4	4.1	0.0605	0.0625	0.0398	0.0543
Teclea nobilis	4	4.5	4.9	0.0465	0.05	0.0476	0.048
Funtumia africana	3	8	6	0.0326	0.0375	0.0544	0.0415
Chaetacme aristata	3	6.3	5.7	0.0326	0.0375	0.0453	0.0385
Symphonia globulifera	3	4.5	4.3	0.0465	0.0375	0.0246	0.062
Albizia zygia	3	7	4	0.0465	0.0375	0.0235	0.0358
Albizia gummifera	2	6.5	7	0.0326	0.025	0.0442	0.0339
Funtumia elastica	2	7	5	0.0326	0.025	0.025	0.0275

Tree stand inventory for Lwamunda forest:

	Stem count	Mean Ht.	Mean dbh	Rel. freq.	Rel. dens	Rel domin	IV
Celtis durandii	52	13.9	21.9	0.0461	0.0713	0.0997	0.0724
Celtis mildebraedii	47	19.5	30.1	0.0553	0.0645	0.0894	0.0697
Macaranga monandra	49	14.5	21.9	0.0461	0.0672	0.0467	0.0533
Antiaris toxicaria	29	20.3	32.6	0.038	0.0398	0.0684	0.0487
Tabernaemontana holstii	46	7.5	12.8	0.0495	0.0631	0.0129	0.0418
Parinari excelsia	3	41.7	150	0.0035	0.0041	0.1159	0.0412
Pseudospondia macrocarpa	21	12.3	21.5	0.0288	0.0288	0.0212	0.0263
Bosquiea phoberos	21	13.5	18.2	0.0346	0.0288	0.0131	0.0255
Funtumia elastica	22	11.7	15	0.0311	0.0302	0.009	0.0234
Maesopsis eminii	18	13.4	19	0.0311	0.0247	0.0133	0.023

Sapling inventory table for Lwamunda forest:

	Stem count	Mean Ht.	Mean dbh	Rel. freq.	Rel. dens	Rel domin	IV
Cedrela odorata	38	4.1	3.8	0.008	0.1638	0.1114	0.0944
Solanum giganteum	23	4.2	4	0.052	0.0991	0.0779	0.0763
Blighia unijugata	10	3.6	4.7	0.06	0.0431	0.0492	0.0508
Teclea nobilis	9	4.4	4.6	0.052	0.0388	0.0411	0.044
Antiaris toxicaria	6	6.2	5.5	0.04	0.0259	0.04	0.0353
Bosquiea phoberos	6	5.1	5.6	0.032	0.0259	0.042	0.0333
Funtumia elastica	6	5.5	5.5	0.032	0.0259	0.0382	0.032
Trichilia prieureana	5	4.2	5.5	0.032	0.0216	0.0333	0.029
Croton sylvaticus	5	4.8	5.1	0.028	0.0216	0.0246	0.0247
Dictyandra aborescens	5	4.9	4.2	0.028	0.0216	0.0192	0.0229

Tree stand inventory table for Buttobuvuma forest:

	Stem count	Mean ht.	Mean dbh	Rel freq	Rel. dens	Rel domin	IV
Maesopsis eminii	24	21.3	34.8	0.0534	0.0767	0.1438	0.0913
Celtis mildbraedii	16	19.8	36.3	0.0577	0.0511	0.1348	0.0812
Celtis durandii	36	10	16.6	0.0722	0.115	0.0534	0.0802
Antiaris toxicaria	16	15.3	24.8	0.0476	0.0511	0.0608	0.0532
Macaranga monandra	18	13.3	32.2	0.0433	0.0575	0.0474	0.0494
Ficus exasperata	19	12.5	17.2	0.0476	0.0607	0.0278	0.0454
Ficus capensis	17	11.8	19.2	0.039	0.0543	0.0347	0.0427
Psuedospondias macrocarpa	9	13.9	29.8	0.0332	0.0288	0.056	0.0393
Trichilia dregeana	8	18.4	31	0.039	0.0256	0.0403	0.0350
Phyllanthus discoideus	10	11.7	10.5	0.0289	0.0319	0.0267	0.0292

Sapling inventory for Buttobuvuma forest:

	Stem count	Mean ht.	Mean dbh	Rel freq	Rel. dens	Rel domin	IV
Solanum gigantea	18	3.3	3.5	0.0866	0.1748	0.1181	0.1265
Tabernaemontana holstii	6	4.2	5.6	0.0866	0.0583	0.1089	0.0846
Celtis durandii	5	4.8	5.8	0.0563	0.0485	0.0849	0.0632
Funtumia elastica	7	3.9	3.7	0.0736	0.0680	0.0469	0.0628
Macaranga lancifolia	7	3.4	3.9	0.0303	0.0680	0.0616	0.0533
Trichilia prieureana	4	4.5	5.3	0.0563	0.0388	0.0576	0.0509
Croton sylvaticus	7	3	3.4	0.013	0.0680	0.0391	0.0400
Chaetacme aristata	4	4.5	4.6	0.0303	0.0388	0.0495	0.0395
Ficus vallis-choudae	3	4.7	5.5	0.0433	0.0291	0.0453	0.0392
Ficus exasperata	3	5	5.2	0.0433	0.0291	0.0374	0.0366

Tree stand inventory for Mpanga forest:

	Stem count	Mean ht.	Mean dbh	Rel freq	Rel. dens	Rel domin	IV
Celtis mildbraedii	37	24.3	30.7	0.0778	0.0979	0.2066	0.1274
Bosqueia phoberos	38	15.2	19.5	0.0889	0.1005	0.0456	0.0783
Trichilia prieureana	34	14.5	20.6	0.0667	0.0899	0.0578	0.0715
Celtis zenkeri	21	21.0	37.7	0.0522	0.0556	0.1043	0.0707
Antiaris toxicaria	13	21.5	39.0	0.0367	0.0344	0.0888	0.0533
Teclea nobilis	24	13.0	21.2	0.0522	0.0635	0.0326	0.0494
Aningeria altissima	15	20.0	30.8	0.0367	0.0397	0.0587	0.0450
Celtis durandii	15	18.1	28.5	0.0333	0.0397	0.0416	0.0382
Mimusops bagswawei	11	19.0	28.7	0.0411	0.0291	0.0354	0.0352
Morus lactea	14	16.0	22.3	0.0367	0.037	0.0283	0.0340

Sapling inventory table for Mpanga forest:

	Stem count	Mean ht.	Mean dbh	Rel freq	Rel. dens	Rel domin	IV
Euphorbia teke	10	3.1	4.5	0.1164	0.0122	0.1370	0.1251
Trichilia prieureana	7	3.4	4.1	0.0862	0.0854	0.0695	0.0804
Bosqueia phoberos	6	4.2	4.9	0.0560	0.0732	0.0895	0.0729
Blighia unijugata	5	5.2	5.3	0.0560	0.0610	0.0845	0.0672
Entandophragma cylindricum	4	5.0	6.0	0.0560	0.0488	0.0825	0.0624
Antiaris toxicaria	4	6.0	4.5	0.0560	0.0488	0.0562	0.0537
Belonophora glomerata	4	3.5	3.6	0.0560	0.0488	0.0308	0.0452
Oxyanthus speciosus	4	3.0	4.0	0.0302	0.0488	0.0419	0.0403
Celtis mildbraedii	3	3.8	4.3	0.0431	0.0366	0.0323	0.0373
Lovoa brownii	2	5.5	5.3	0.0302	0.0244	0.0385	0.0310

Tree stand inventory table for Mugalu forest:

	Stem count	Mean ht.	Mean dbh	Rel freq	Rel. dens	Rel domin	IV
Bosqueia phoberos	42	0	25.1	0.09200	0.14050	0.23800	0.15690
Pseudospondias macrocarpa	33	10.5	37.6	0.09660	0.11040	0.20030	0.13580
Funtumia elastica	19	8.7	17	0.06130	0.06350	0.02160	0.04880
Sapium ellipticum	8	15.6	51.5	0.03070	0.02680	0.06970	0.04240
Ficus capensis	7	13.3	38.6	0.03530	0.02340	0.03920	0.03260
Antiaris toxicaria	9	16	26.9	0.03530	0.03010	0.02840	0.03130
Macaranga schweinfurthii	13	8.7	22.7	0.02610	0.04350	0.02360	0.03110
Prunus africana	7	18.1	42.9	0.01530	0.02340	0.05310	0.03060
Trichilia rubescens	14	6.6	15.9	0.03070	0.04680	0.01180	0.02980
Celtis durandii	8	11.5	28.9	0.03070	0.02680	0.02380	0.02710

Sapling inventory table for Mugalu forest:

	Stem count	Mean ht.	Mean dbh	Rel freq	Rel. dens	Rel domin	IV
Coffea canephora	25	3.9	5.4	0.07710	0.12950	0.16870	0.12510
Bosqueia phoberos	16	3.5	4.6	0.06570	0.08290	0.08160	0.07670
Oxyanthus speciosus	12	5.0	5.0	0.06570	0.06220	0.07460	0.06750
Solanum gigantea	19	2.9	3.7	0.03710	0.09840	0.05680	0.06410
Trichilia prieureana	15	3.2	3.9	0.05710	0.07770	0.05190	0.06220
Funtumia elastica	14	3.0	3.7	0.06570	0.07250	0.04400	0.06070
Trichilia rubescens	10	3.3	4.5	0.04860	0.05180	0.04910	0.04980
Glyphaea brevis	8	3.8	6.5	0.00860	0.04150	0.07580	0.04200
Tabernaemontana holstii	6	3.2	4.9	0.04860	0.03110	0.03800	0.03920
Phyllanthus discoideus	6	4.7	5.1	0.02860	0.03110	0.03710	0.03230

Tree stand inventory table for Kizzikibi forest:

	Stem count	Mean ht.	Mean dbh	Rel freq	Rel. dens	Rel domin	IV
Bosqueia phoberos	74	12.7	20.9	0.11130	0.20220	0.13220	0.148
Celtis durandii	35	9.0	26.8	0.07930	0.09560	0.11520	0.096
Pseudospondias macrocarpa	26	13.5	36.2	0.05560	0.07100	0.15620	0.094
Antiaris toxicaria	21	15.0	26.5	0.05150	0.05740	0.05980	0.056
Teclea nobilis	24	9.0	18.6	0.05560	0.06560	0.03170	0.051
Chaetacme aristata	22	8.1	19.7	0.05980	0.06010	0.03260	0.050
Lovoa brownii	19	12.4	18.8	0.05980	0.05190	0.02700	0.046
Funtumia elastica	14	14.8	22.2	0.04170	0.03830	0.02550	0.035
Blighia unijugata	12	10.6	18.7	0.04170	0.03280	0.01870	0.031
Piptadeniastrum africanum	5	22.0	49.8	0.02360	0.01370	0.05410	0.030

Sapling inventory table for Kizzikibi forest:

	Stem count	Mean ht.	Mean dbh	Rel freq	Rel. dens	Rel domin	IV
Bosqueia phoberos	43	3.8	4.4	0.15250	0.22400	0.20980	0.195
Teclea nobilis	19	4.7	5.3	0.06540	0.09900	0.13760	0.100
Blighia unijugata	15	3.6	3.9	0.07990	0.07810	0.06860	0.075
Lovoa brownii	12	3.9	3.7	0.04840	0.06250	0.03890	0.049
Trichilia dregeana	9	3.2	3.7	0.07260	0.04690	0.02940	0.049
Coffea canephora	12	4.0	3.6	0.03150	0.06250	0.03660	0.043
Xymalos monospora	7	3.0	5.4	0.0315	0.0365	0.0539	0.04
Rothmannia urcelliformis	4	7.3	8.1	0.02420	0.02080	0.06050	0.035
Entandophragma angolense	6	3.3	4.0	0.04120	0.03130	0.02310	0.031
Antiaris toxicaria	5	4.7	4.3	0.04120	0.02600	0.02120	0.029

Tree stand inventory table for Najjakulya forest:

	Stem count	Mean ht.	Mean dbh	Rel freq	Rel. dens	Rel domin	IV
Antiaris toxicaria	25	13.7	32.4	0.08470	0.10550	0.28710	0.15910
Sapium ellipticum	44	9.0	20.6	0.099600	0.185700	0.176900	0.154100
Lovoa brownii	35	9.2	17.7	0.099600	0.147700	0.100800	0.116000
Maerua duchesnei	19	5.5	16.0	0.078400	0.080200	0.043900	0.067500
Chaetacme aristata	13	6.5	20.1	0.06990	0.05490	0.04650	0.05710
Bosqueia phoberos	11	9.4	17.4	0.04870	0.04640	0.02930	0.04150
Maesopsis eminii	10	11.1	20.6	0.042400	0.004200	0.038600	0.041100
Piptadeniastrum africanum	2	19	48.5	0.014800	0.008400	0.0588	0.0273
Celtis africana	7	8.4	14.9	0.03600	0.02950	0.01290	0.02610
Rothmannia urcelliformis	6	6.2	16.7	0.036000	0.025300	0.014000	0.025100

Sapling inventory table for Najjakulya forest:

	Stem count	Mean ht.	Mean dbh	Rel freq	Rel. dens	Rel domin	IV
Maerua duchesnei	33	3	4.8	0.010580	0.191900	0.222700	0.173700
Lovoa brownii	26	3.9	4.0	0.0737000	0.1512000	0.1265000	0.1171000
Chaetacme aristata	11	4.3	5.6	0.0737000	0.0640000	0.1062000	0.0813000
Coffea canephora	16	3.9	3.9	0.0545000	0.0930000	0.0706000	0.0729000
Pittosporum mannii	7	4.4	4.8	0.041700	0.040700	0.051400	0.044600
Celtis africana	6	5.0	34.2	0.0545000	0.0349000	0.0312000	0.0402000
Bosqueia phoberos	6	3.7	3.8	0.0545000	0.0349000	0.0271000	0.0388000
Sapium ellipticum	6	4.5	4.7	0.041700	0.034900	0.039400	0.038700
Antiaris toxicaria	5	2.5	4.1	0.0545000	0.0291000	0.0248000	0.0361000
Sacurinega virosa	7	4.6	4.2	0.022400	0.040700	0.037100	0.033400

Tree stand inventory table for Kyambogo forest:

	Stem count	Mean ht.	Mean dbh	Rel freq	Rel. dens	Rel domin	IV
Bosqueia phoberos	63	12.3	18.7	0.0921	0.1388	0.0618	0.0976
Teclea nobilis	49	9.7	18.7	0.0699	0.0107	0.0471	0.0750
Pseudospondias macrocarpa	25	15.6	34.1	0.0555	0.0551	0.0913	0.0673
Funtumia elastica	25	14.9	20.0	0.0411	0.0551	0.0273	0.0412
Ficus exasperata	12	14.7	32.9	0.0333	0.0264	0.0403	0.0333
Celtis durandii	20	12.2	16.6	0.0366	0.0441	0.0158	0.0322
Antiaris toxicaria	15	9.9	21.1	0.0411	0.0330	0.0177	0.0306
Oxyanthus speciosus	16	6.7	16.1	0.0411	0.0352	0.0152	0.0305
Celtis mildbraedii	14	17.2	23.4	0.0333	0.0308	0.0227	0.0289

Sapling inventory table for Kyambogo forest:

	Stem count	Mean ht.	Mean dbh	Rel freq	Rel. dens	Rel domin	IV
Bosqueia phoberos	33	4.2	5.2	0.1348	0.1521	0.2257	0.1709
Oxyanthus speciosus	19	3.9	5.0	0.0664	0.0876	0.1198	0.0913
Teclea nobilis	16	3.4	3.8	0.0664	0.0737	0.0614	0.0672
Blighia unijugata	11	3.7	4.4	0.0543	0.0507	0.0542	0.0531
Trichilia prieureana	13	3.7	3.8	0.0463	0.0599	0.0452	0.0505
Celtis mildbraedii	7	4.8	5.4	0.0463	0.0323	0.0545	0.0444
Lovoa brownii	10	3.7	3.8	0.0463	0.0461	0.0368	0.0431
Funtumia elastica	9	4.2	4.3	0.0402	0.0415	0.0418	0.0412
Celtis durandii	8	4.9	4.9	0.0342	0.0369	0.0478	0.0396
Coffea canephora	9	3.8	3.1	0.0463	0.0415	0.0192	0.0357

Tree stand inventory table for Magezigoomu forest:

	Stem count	Mean ht.	Mean dbh	Rel freq	Rel. dens	Rel domin	IV
Maesopsis eminii	28	15.6	27.7	0.08640	0.09560	0.11100	0.09770
Lovoa brownii	31	10.7	16.9	0.09840	0.10580	0.04540	0.08320
Piptadeniastrum africanum	9	16.2	45.0	0.04660	0.03070	0.17010	0.08250
Canarium schweinfurthii	4	20.5	77.8	0.01730	0.01370	0.18410	0.07170
Cassipourea congensis	24	9.8	21.3	0.06390	0.08190	0.05700	0.06760
Antiaris toxicaria	16	11.8	24.9	0.06390	0.05460	0.06170	0.06010
Phyllanthus discoideus	22	9.7	18.1	0.06390	0.07510	0.03670	0.05860
Fagara angolensis	17	9.6	19.0	0.05700	0.05800	0.03240	0.04910
Pseudospondias macrocarpa	15	9.7	20.0	0.04660	0.05120	0.03310	0.04360
Sapium ellipticum	10	13.2	26.5	0.03970	0.01340	0.04400	0.03930

Sapling inventory for Magezigoomu forest:

	Stem count	Mean ht.	Mean dbh	Rel freq	Rel. dens	Rel domin	IV
Lovoa brownii	32	3.9	3.9	0.13770	0.17780	0.17850	0.16470
Blighia unijugata	30	3.3	3.7	0.14600	0.16670	0.14850	0.15370
Antiaris toxicaria	16	3.8	4.2	0.08260	0.08890	0.10420	0.09190
Bosqueia phoberos	12	3.3	3.2	0.08260	0.16670	0.04660	0.06530
Teclea nobilis	11	4.0	3.6	0.08260	0.06110	0.05150	0.06510
Coffea canephore	10	3.0	3.4	0.02750	0.05560	0.04210	0.04170
Cassipourea congensis	6	4.3	4.9	0.03580	0.03330	0.05050	0.03990
Oxyanthus speciosus	7	3.3	3.4	0.03580	0.03890	0.02830	0.03430
Pittosporum mannii	3	4.0	6.3	0.02750	0.01670	0.04470	0.02960
Scolopia rhamnophylla	5	3.7	3.4	0.03580	0.02780	0.01900	0.02750

Tree stand inventory table for Lukambagire forest:

	Stem count	Mean Ht.	Mean dbh	Rel. freq.	Rel. dens	Rel domin	IV
Macaranga schweinfurthii	50	9.2	21.8	0.1147	0.2024	0.177	0.1647
Pseudospondia macrocarpa	35	11.5	27.1	0.1469	0.1417	0.1918	0.1601
Voacanga thouarsii	26	9.4	15.5	0.664	0.1053	0.0443	0.07
Phoenix reclinata	17	9.4	16	0.664	0.688	0.0291	0.548
Sapium ellipticum	8	13.9	35.2	0.0402	0.0324	0.0827	0.0518
Phyllanthus discoideus	10	11.6	27.5	0.0402	0.0405	0.0642	0.0483
Erythrina excelsa	7	15.4	35.4	0.0402	0.0283	0.0717	0.0467
Ficus thoningii	7	11.4	24.5	0.0201	0.0283	0.0398	0.0294
Belschmeidia ugandensis	7	10.6	16	0.0402	0.0283	0.0118	0.0268
Ficus capensis	6	12.8	23	0.0262	0.0243	0.0229	0.0245

Sapling inventory table for Lukambagire forest:

	Stem count	Mean Ht.	Mean dbh	Rel. freq.	Rel. dens	Rel domin	IV
Macaranga scweinfurthii	36	4.6	5	0.1276	0.2647	0.3259	0.2394
Xymalos monospora	12	3.4	4.1	0.0793	0.0882	0.0698	0.0791
Funtumia elastica	9	3.5	3.9	0.0793	0.0662	0.0548	0.0668
Pseudospondia macrocarpa	9	3.4	3.9	0.0793	0.0662	0.0548	0.0668
Belschmeidia ugandensis	6	3.8	5.5	0.0586	0.0441	0.068	0.0569
Voacanga thouarsii	6	4.8	5.7	0.0448	0.0441	0.0702	0.053
Bosqueia phoberos	4	4.6	5	0.0345	0.0294	0.0372	0.0337
Coffea canephora	4	3.5	4	0.0345	0.0294	0.0251	0.0297
Pittosporum mannii	4	2.6	4.2	0.0345	0.0294	0.0247	0.0295
Alchornea cordifolia	4	4.5	4.3	0.0241	0.0294	0.0265	0.0267

Tree stand inventory for Mukasa forest:

	Stem count	Mean Ht.	Mean dbh	Rel. freq.	Rel. dens	Rel domin	IV
Pseudospondia macrocarpa	13	15.9	47.7	0.1313	0.1287	0.03462	0.2021
Bosqueia phoberos	17	11.6	21.8	0.0746	0.1683	0.1683	0.1099
Antiaris toxicaria	6	22.7	50.9	0.094	0.0594	0.0594	0.1086
Phoenix reclinata	13	14.5	21.2	0.0194	0.1287	0.0548	0.0676
Markhamia platycalyx	8	18	24.2	0.0746	0.0792	0.0465	0.0668
Trichilia dregeana	5	18.8	37.3	0.0746	0.0495	0.0726	0.0656
Pittosporum mannii	4	6.5	16.3	0.0567	0.0396	0.0103	0.0355
Cassipourea congensis	5	9.6	18.5	0.0373	0.0495	0.0164	0.0344
Canarium schweinfurthii	3	11.3	21	0.0567	0.0297	0.0121	0.0328
Maesopsis eminii	3	14.7	26	0.0373	0.0297	0.0227	0.0299

Sapling inventory table for Mukasa forest:

	Stem count	Mean Ht.	Mean dbh	Rel. freq.	Rel. dens	Rel domin	IV
Bosqueia phoberos	13	2.8	4.2	0.2591	0.4643	0.4941	0.4051
Pseudospondia macrocarpa	2	1	6.8	0.0674	0.0714	0.1978	0.1122
Pittosporum mannii	3	4.5	3.3	0.0674	0.1071	0.0711	0.0819
Pycnanthus angolensis	2	3.8	3.5	0.0674	0.0714	0.0501	0.063
Trichilia dregeana	1	5	5	0.0674	0.0357	0.0501	0.0511
Funtumia elastica	1	3	4	0.0674	0.0357	0.0321	0.0451
Garcinia huillensis	1	1.5	3.2	0.0674	0.0357	0.0205	0.0412
Teclea nobilis	1	2	2.6	0.0674	0.0357	0.0135	0.0389
Cassipourea congensis	1	2	2.5	0.0674	0.0357	0.0125	0.0385
Rothmannia urcelliformis	1	2	2.5	0.0674	0.0357	0.0125	0.0385

Tree stand inventory table for Mugomba forest:

	Stem count	Mean Ht.	Mean dbh	Rel. freq.	Rel. dens	Rel domin	IV
Raphia farinifera	22	8.2	37.1	0.1179	0.176	0.2729	0.1889
Musanga cecropiodes	17	12.3	32.6	0.0875	0.136	0.1956	0.1397
Battidevia nyaska*	11	12.1	24.3	0.0722	0.088	0.0574	0.0725
Terminalia ivorensis*	11	17.4	24	0.0456	0.088	0.0615	0.065
Mitragyna stipulosa	1	18	120	0.0152	0.008	0.1189	0.0474
Maesopsis eminii	7	7.3	13.4	0.0722	0.056	0.0108	0.0463
Erthrophyleum guineense	1	28	110	0.0152	0.008	0.0999	0.041
Eucalyptus deglapta*	10	11.1	16.3	0.0152	0.08	0.225	0.0392
Pseudospondias macrocarpa	5	6.4	18.1	0.0456	0.04	0.0148	0.0335
Voacanga thouarsii	5	9	23.2	0.0304	0.04	0.0295	0.0333

Sapling inventory table for Mugomba forest:

	Stem count	Mean Ht.	Mean dbh	Rel. freq.	Rel. dens	Rel domin	IV
Mitragyna stipulosa	21	3.8	5.1	0.0326	0.116	0.1345	0.0944
Pseudospondias macrocarpa	11	3.3	4.9	0.0625	0.0608	0.0651	0.0628
Euphorbia teke	14	2.5	4.1	0.0326	0.0773	0.0565	0.0555
Bosquiea phoberos	8	4.4	6.6	0.0408	0.0442	0.0811	0.0554
Artocarpus heterophyllus	10	5.2	6	0.0217	0.0552	0.0877	0.0549
Spondianthus preusii	8	4.1	3.7	0.0625	0.0442	0.0257	0.0441
Canarium schweinfurthii	6	4.2	5.5	0.0516	0.0331	0.0458	0.0435
Macaranga schweinfurthii	6	6	6.8	0.0217	0.0331	0.068	0.0409
Craterispermum laurianum	7	2.4	4.3	0.0217	0.0387	0.0305	0.0303
Trichilia martineaui	5	2.8	4.6	0.0326	0.0276	0.0244	0.0282

APPENDIX IV

ORIGINAL SAMPLE REGRESSION FUNCTION:

$$PCIRCUM = 16.389275 + 0.0106\ (FAGE) + 0.2391\ (SLOPE) + 0.8881\ (GPROD) + 0.4694\ (GNAT) + 3.9558\ (COMM) + 3.3301\ (MRULE) + 0.1950\ (URULE) + 1.2102\ (URULFO) + 0.9088\ (CLAY) + 0.3572\ (CLOAM) + 0.5318\ (SANDY) - 0.4998(\ SLC) + 4.5442\ (SCLAY) + u_i$$

Adjusted-R^2=0.0025

Where:

PCIRCUM	= Diameter at breast height (cm)
FAGE	= Forest age (years)
SLOPE	= Slope steepness (degrees)
GPROD	1 = Government Product forest 0=Not government production forest
GNAT	1 = Government nature forest 0=Not government nature forest
COMM	1 = Community forest 0=Not community forest
INDIVIDUAL	=Individual/private tenure= BASE CASE
MRULE	1 = Maintenance rules present 0=Maintenance rules not present
URULE	1 = Use rules present 0=Use rules not present
URULFO	1= Use rules present and followed 0= Use rules present and not followed
CLAY	1= Clay 0=Not clay
CLOAM	1= Clay-loam 0=Not clay- loam
SANDY	1= Sandy 0=Not sandy
SLC	1= Sandy -clay -loam 0=Not sandy –clay- loam
SCLAY	1= Sandy- Clay 0=Not sandy-clay
SLOAM	=Sandy-loam = BASE CASE

Results of first/original regression

VARIABLE	PARAMETER	S.E	T-STAT	PROB-T
Intercept	16.3892	1.8341	8.936	0.0001***
Fage	0.0107	0.0026	4.058	0.0001***
Slope	0.2391	0.9222	2.593	0.0095***
Gprod	0.8882	1.0524	0.844	0.3987
Gnat	0.4694	1.3871	0.338	0.7351
Comm	3.9558	1.4446	2.738	0.0062***
Mrule	3.3301	1.427	2.334	0.0197**
Urule	0.195	1.1441	0.17	0.8647
Urulfo	1.2102	1.3158	0.92	0.3578
Clay	0.9088	1.2618	0.72	0.4714
Cloam	0.3572	0.8329	0.429	0.668
Sandy	0.5318	3.3559	0.158	0.8741
Slc	-0.4998	1.7047	-0.293	0.7694
Sclay	4.5442	5.1469	0.883	0.3773
R-square	**0.0056**			
Adjusted-R	**0.0025**			
F-stat	**1.807**			
Prob-F	**0.0365**			

*significant at 0.10 level
**significant at 0.05 level
***significant at 0.01 level