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EXPLAINING DEFORESTATION: THE ROLE OF FOREST INSTITUTIONS IN UGANDAN FORESTS

by

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Abstract

At the beginning of the nineteenth century, forests and woodlands covered 45% of the total land area of Uganda. At present, forest cover has been reduced to 20% of the total land area. Variations of the condition of forests in Uganda are best explained by examining the effectiveness of local branches of national forest institutions—district forest offices—to monitor and enforce rules.

The results of the regression analysis indicated that, as the distance from the administrative center increased, the probability of the forest plot showing evidence of timber harvesting increased significantly. The regression results also predicted that as the forest size increased, the probability of the forest plot showing evidence of timber harvesting would increase significantly.

Given limited budgets and staff, it is not surprising that forest degradation in Uganda continues. Strengthening forest institutions at the forest level is key to reducing the rate of deforestation.

Keywords: Local forest institutions, local communities, effective monitoring, rule enforcement, forest degradation, decentralization of forest resources

Introduction

Uganda's forest resources are characterized by very high levels of biodiversity. These forests are an essential foundation for the country's current and future livelihood and growth. Sustainable management of these forests, however, is a great challenge not only to forest managers but also to policy makers given that the population is heavily dependent on them for timber, agriculture, and energy production (Hamilton, 1987), resulting in deforestation. At the beginning of the nineteenth century, forests and woodlands covered approximately 45% of the total land area of Uganda. At present, forest cover has been reduced to approximately 4.9 million hectares or about 20% of the total land area (MWLE, 2001). About 30% of the tropical high forests is degraded and the degradation trend continues. Without effective institutions to limit and regulate harvesting levels and management practices, forest resources can be overharvested and even irreversibly destroyed, as is often the case in "open access" forests (Hardin, 1968; Ascher, 1995; Ostrom, 1998, 2000, 2001; Tucker 1999; Gibson, McKean, and Ostrom, 2000).

National government forest departments in many developed and developing countries have been notably unsuccessful in their efforts to design an effective and uniform set of rules to regulate forestry resource use across a broad domain (Ostrom, 1999a, 2001). If we wish to halt loss of forest cover, we need to better understand how to effectively regulate use of forest resources. We contribute to this goal with a close examination of sources of variation in the effectiveness of rules for forestry management in Uganda.

Following the centralization of the management of forest resources in Uganda in 1967, institutions that local people had devised to limit entry and harvesting forest resources lost their legal standing (Banana and Gombya-Ssembajjwe, 2000). The government appoints forest guards to look after state-owned forest reserves. However, it lacks both the financial and human resources to monitor the effective use of these resources. It has proven economically unfeasible for the government to effectively monitor forests in Uganda, as forest patches are scattered over very large areas; thereby resulting in an extremely large number of guards required to police them. Additionally, forest guards have no personal investment or stake in the forests, a fact that has contributed to lack of motivation in effective forest policing. The result, subsequently, has been largely unimpressive forest management in Uganda over the past thirty years.

In this paper, we argue that institutions play a key role in determining the condition of the forestry resources by indirectly mediating the effects of social and cultural norms, state policies, technological variables, level of market pressures and demographic pressures. Institutions can be defined as the "humanly devised constraints that structure human interactions" (Crawford and Ostrom, 1995; North, 1990). It is the absence of effective institutions to regulate resource use that allows deterioration of the condition of the forest (Agrawal, 1994, 1996; Varughese, 2000; Gibson, 2001). If rules about the use of a resource exist and are in use, one would expect that evidence of harvesting of restricted resource units would be minimal. This should be reflected, in turn, in the population structure of that resource. If, for example, there are restrictions on harvesting timber tree species and these rules are enforced, one would expect to find a normal distribution of the different diameter classes of those species in the forest (Peters, 1994; Becker and Ostrom, 1995). On the other hand, if the rules regulating harvesting of timber species are not enforced, we would expect to find a pattern of use close to "open-access" exploitation (Ostrom, Gardner, and Walker, 1994; Ostrom, 1999b; McKean, 2000). In such a situation, resource use would be predicted by the optimal foraging theory of maximizing economic returns while minimizing costs (Schweik, 2000; Gibson, 2001; Stephens and Krebs, 1986).

In this paper, we contribute to the analysis of forest governance in Uganda by identifying (1) the effects national forest institutions have on incentives facing forest users and (2) the ways in which these incentives encourage forest users to engage in sustainable or unsustainable development of forests. We evaluate the relative importance of tenure arrangements, population pressure, and distance from administrative centers and markets on the effectiveness of monitoring and forest rule enforcement by the District Forest Offices. Given limited budgets and staff, and a legacy of ineffective regulations and local communities that have been stripped of their powers to control their own forests, we hypothesize that the effectiveness of monitoring and enforcement of forest rules by local branches of national forest institutions is poor. In the paper, we provide evidence that leads us to conclude that poor monitoring and rule enforcement by the District Forest Office coupled with lack of participation of local communities in forest management best explains the continued degradation of Uganda's forestry resources.

Empirical evidence from studies carried out in Uganda has shown that effective monitoring and rule enforcement and not form of tenure is a good predictor of sustainable management (Becker, Banana, and Gombya-Ssembajjwe, 1995; Banana and Gombya-Ssembajjwe, 2000). These findings are consistent with other studies by Tucker (1999), Agrawal and Yadama (1997), Barrows and Roth (1990), Bruce and Migot-Adholla (1994), Lawry (1989) and Little and Brokensha (1987). Instead, the more critical factors are whether the owner(s) of the forest resources have decided to limit levels of exploitation, and are able to achieve their goals through monitoring and rule enforcement.

Tenure systems address the management problem by defining the rights resource owners and local communities have to the resource. However, clearly defined tenure is not enough to ensure sustainable management of renewable resources. The study by Agrawal and Yadama (1997) showed that the willingness of a user-group to monitor rule compliance by hiring designated and paid guards was a major factor in the difference between a forest in good condition and one that has become degraded. The study also showed that the number of months for which a guard was hired was the most important variable affecting forest conditions. An earlier study by Agrawal (1992) also found that communities in Uttar Pradesh who had healthy forests were those that recycled the fines and penalties they collected into providing for more guards. The communities with degraded forests were those who collected less in fines, and put the fines into a general village budget.

Changes in Forest Institutions in Uganda in the Last Century

Forest policy in Uganda is characterized by the many changes that have occurred during the course of the country's political development (Kamugisha, 1993). The British Colonial Government initiated scientific management of Uganda's forestry resources in 1898. The first national Forest Policy of 1929 stressed the environmental role that forests play, both in direct economic ways and indirectly by modifying the climate, protecting water supplies and preventing excessive soil erosion. The subsequent policies of 1939 and 1948 laid greater emphasis on conservation, strengthening local forest institutions, extension, and training. Local authorities initiated major afforestation schemes at this time (Uganda Forest Department, 1951). However, the 1970 Forest Policy stressed timber production, harvesting, and utilization. It downplayed the role forests play in the protection of the environment and the role of local institutions in forest management. The 1988 Forest Policy recognized the need for biodiversity conservation, regular research, and the importance of non-consumptive uses of forests such as ecotourism. The policy was silent about empowerment of local authorities to manage forest resources. However, the new policy formulated in 2001 emphasizes community participation in forest management.

Currently, the Forest Department manages approximately 417,000 ha of tropical high forests and montane forests, and 720,000 ha of savanna woodlands, while the Wildlife Authority manages about 321,000 ha of forested land (MLWE, 2001). The two organizations manage a protected forest area system that accounts for 6.7% of the total land area of Uganda. Over 50% of the forests are, however, located outside the protected area network on private and customary land. Individuals, private firms, or communities hold rights to forests not under government protection. In addition to forests managed by communities through social forestry programs, some communities continue to respect traditional sacred groves.

Boundaries of the present forest estate were established in the 1930s and 1940s. Legislation establishing forest reserves under the local governments was enacted in 1938 and 1947. Numerous small "Local Forest Reserves" were gazetted to cater to local demands while "Central Forest Reserves," which were usually larger, were established at the same time to serve regional needs (Hamilton, 1987).

The present Forest Act was passed in 1964. Of the several subsequent statutory instruments, the most important transferred the administration of the "Local Forest Reserves" to the Central Government in1967. This meant that the forest services run by local administrations were absorbed into a centrally organized Forest Department. The institutional arrangements that local authorities and forest users had devised to limit entry and harvesting levels lost their legal standing. This was not based on the failure of local institutions to manage forest resources; rather, it was as part of a general political move towards centralization based on the belief that it would be more rational and efficient.

The 1964 Forest Act established the boundary, authority, and payoff rules to limit entry and harvesting levels in forest reserves, private forests, and communal forests (Government of Uganda, 1964). The 1964 Act reserved authority over entry to the Forest Department and its officers. No one may reside, cultivate, or graze livestock in a reserve without the written permission of a Senior Forest Officer; and certain species are reserved as forest produce and may only be cut with Forest Department approval both within the forest reserve and on other private or communal land. Local communities may enjoy special privileges in the use of unreserved forest produce. They may extract "minor forest products" in reasonable quantities for their own domestic use without a permit or the payment of fees. Any other form of forest resource use requires issuance of a permit from a Senior Forest Officer and usually requires payment of a stipulated fee.

No doubt these provisions weakened the local institutions involved in the management of forest resources. Worse still, the provisions curtailed the benefits local communities obtained from the forests since most economically viable timber species were classified as "reserved" forest produce (Banana, 2000). The rich members of the community who owned sawmills and could afford to pay for the permits harvested these tree species. The provisions also acted as a disincentive for individuals to plant and manage economically viable tree species such as mvule (*Milicia excelsa*) and the mahoganies (*Khaya anthotheca* and *Entandrapragma utile*) on their property. The Central Government posted forest officers in each district of the country, forest rangers at the counties, and forest guards at the sub-counties to monitor and enforce the provisions of the Forest Act. In the 1970s and 1980s, however, the overcentralized government institutions were notably unsuccessful in their efforts to implement the provisions of the 1964 Forest Act. Their failure could be attributed to the prevailing political and economic instability caused by the military dictatorship from 1971-1985. The government lacked funds and personnel to monitor the use of forest resources as the economy collapsed and trained manpower left the country because of persecution. Thus, common pool resources became *de facto* open access regimes and were severely degraded in quality and reduced in size. With the ouster of the military dictatorship in 1986, law and order were re-established and the forest estate was rehabilitated by the central government. In 1987, the government embarked on a process of devolution of power to districts and local councils including environmental management and natural resource utilization.

The history of forest management in Uganda has thus gone through four distinct periods:

- The colonial period (1898-1961), whereby the government established a network of Central Forest Reserves and Local Forest Reserves that were well managed using rigorous scientific methods and elaborate management plans.
- The post-independence era (1962-71), whereby the government centralized forest resources but was able to maintain the forest estate in reasonably good condition through a process of command and control.
- The military dictatorship era (1972-1986), when there was no effective forest management by the state due to the prevailing political and economic instability. During this period, the forest estate was severely degraded.
- The decentralization period (1987 to present), whereby the government embarked on a process of devolution of power to Districts and Local Councils including the management of natural resources.

Decentralization of Environment Management in Uganda Since 1987

The current Local Administrative system is a five-tiered system of elected Local councils (LCs) and executive committees—LC1 (village), LC2 (parish), LC3 (sub-county), LC4 (municipality, if it exists), and LC5 (district). Each local council at every level includes an executive committee of nine members who have specific responsibilities (e.g. secretary for environment). The LC1 includes all residents of the village. The higher-level LCs include all executive committee members from the LC at the level immediately below them. The LC3, LC4, and LC5 executive committee members are paid; LC2 and LC1 committee members are volunteers.

Following the enactment of the Resistance Councils and Committees Statute of 1987, ten pilot districts were selected to implement the statute. Delivery of services in the pilot districts was decentralized to the Districts and Local councils. However, this attempt to decentralize forest management was highly unsuccessful. The new jurisdictional lines between the District Forest Officer—an employee of the central government—and the Local Councils were not clear. In addition, Local Councils lacked both the human and financial resources to manage the forest estate in the districts. Revenue from the sale of forest products was used to run other services, and was not invested in the forest sector. Management of forest resources was re-centralized after one year of experimentation. Failure of the experiment was attributed to the rapid devolution of formal power to the local authorities (Okedi, 2000). Local forest institutions needed to be re-established after decades of disuse and empowered by putting in place appropriate legal frameworks.

Since then, the Government has passed the National Environment Statute (1995) and the Local Government Act of 1997—also called the Decentralization statute. Both of these statutes empower and support devolution of power to Districts and Local councils. Decentralization aims at ensuring good democratic governance, ensuring people's participation in decision making, and ensuring accountability. It is hoped that decentralization will permit development of programs tailored to local conditions, reduction of costs, and also opportunities for new local authorities to gain skills in planning, management, and delivery of services.

Through both the Environmental statute and the Local Government Act, institutional mechanisms have been put in place at district and local government levels to transfer power from the center to the local councils. In the environment sector, these structures include the establishment of Environment Committees within the councils from LC1-LC5. These committees formulate by-laws for proper management of natural resources while the District Council hires staff to manage and enforce the by-laws.

At present, all sectors of the government except Forestry have fully decentralized the delivery of services to the District and Local councils. The Forest Department has been more cautious in implementing the Decentralization Statute given the failure of its decentralization experiment in the early 1990s. Only small forests, gazetted in the 1940s as "Local Forest Reserves," have been transferred to the Districts and Local Councils to be managed. The large forests gazetted in the 1940s as "Central Government Forest Reserves" have been retained at the center. These large, economically viable forest reserves are, however, to be transferred to the proposed National Forest Authority—a semi-autonomous, profit-oriented body to be established by an Act of Parliament. The long process of restructuring the Forest Department into an Authority, which started in 1997, has also contributed to the slow implementation of the decentralization statute and other forest-related initiatives. Once again, local communities, as in the 1960s, have been denied the chance to manage the economically viable forest resources and have been entrusted with only the small, degraded, and economically unviable forest areas.

The Impact of Partial Decentralization on Forest Governance and Use

Failure to fully decentralize the management of forest resources has led to confusion within the forestry sector. This confusion arises from the unclear chain of command for forestry personnel and contributes to an unwillingness to take budgetary responsibility for forest protection activities.

The District Local Councils receive 40% of all revenue collected from Central Forest Reserves located in the district and 100% of all revenue collected from the Local Forest Reserves. The revenue collected in the district from forestry resources is not, however, plowed back into forestry activities. Instead of providing for more forest guards and forest rangers, these funds go to the general district budget. Due to lack of both human and financial resources, the District Councils have delegated the management of Local Forest Reserves to the District Forest Officers. At the same time, the District Forest Officers do not receive adequate budgetary support from the Central Government, since it (the government) considers forest resources to be decentralized. While District Forest Officers are employees of the Central Government, the District Local Councils supervise them. On the other hand, the technical staff that support the District Forest Officer (the Forest Rangers and the Forest Guards) are employees of the District Local Councils.

The consequences of this policy indecision have been disastrous. Common-pool forest resources appear to be reverting to *de facto* open-access regimes as was the case in the 1970s and early 1980s. Overall, about 40% of 1216 sample plots located in 43 forests of Uganda show evidence of illegal consumptive utilization of one form or another (see Table 1). Many of the forests show serious signs of open-access utilization that, if left unabated, could lead to a serious shortage of forest products, substantial forest degradation, and loss of useful biotic resources and amenities.

[Table 1 about here]

The high level of illegal consumption of forest resources raises questions regarding the level and effectiveness of monitoring, enforcement, and sanctioning. At the sub-county level, the Forest Guard, working together with the Local Council officials, enforces forest rules. Local Council officials give graduated sanctions to the offenders. A verbal warning is given to first time offenders, while tools and illegally harvested products are confiscated on the second offense.

When an individual violates forest rules several times, the case is referred to the District Forest Officer who prosecutes the offender at the District Magistrate's court. The rarity with which prosecution occurs is evident from the court and LC records from the Mpigi district near Kampala. Of the 372 forest plots located in Mpigi district about 61% of them showed evidence of illegal harvesting. However, in 2000, only 14 people were prosecuted in this District for illegal harvesting of firewood, charcoal, and timber. Ten people admitted the offense and were lightly fined (Uganda Sh. 2000—equivalent to about US $1.20).

Confiscated timber is transferred to the Forest Department Headquarters where it is auctioned. Impounded firewood and charcoal are donated to the Army. Funds raised from the auctioning of impounded forest products are considered Central Government revenue. This frustrates the Forest guards and the Local Council officials, reducing their motivation to monitor and enforce forest rules at the local level.

The quantitative evidence presented above suggests that the high level of illegal consumptive utilization of forest products may be attributed to the low level of enforcement of rules and inadequate sanctioning. Institutional analysis scholars argue that forest resources are more likely to be sustainably utilized if an effective structure of institutional arrangements exists that gives rise to an authority system which is meaningful at the local level (Bromley, 1991/92). Regardless of the *de jure* property regime, all forests can be *de facto* open-access regimes if there are no effective institutions and mechanisms to enforce the rules. This argument is supported by data collected from 43 forests located in various districts of the country since 1994 (see Table 2). Consumptive disturbance was not universally high in all the forests. For example, the Mpanga government forest reserve had only one plot showing evidence of human disturbance. About 25% of the government forest reserves showed a very high level of exclusion of illegal harvesters. On the other hand 50% of the privately owned forests were well managed while the other half was *de facto* open access. About 60% of the communal forests were moderately well managed. We therefore argue that other factors at the local/forest level, rather than formal property rights, are important in determining forest use and the condition of forest resources in the country. We also argue that the local branches of the national forest institutions are not effective in monitoring and enforcing of rules at the forest level.

[Table 2 about here]

<u>Sampling Techniques and Data Collection</u>

Empirical evidence of the pattern of forest use in the Mpigi district was collected as part of a larger detailed research program to study and monitor how various types of institutional arrangements affect incentives and behavior of forest users in Uganda (Gombya-Ssembajjwe and Banana, 1994; Banana and Gombya-Ssembajjwe, 2000; Becker, Banana, and Gombya-

Ssembajjwe, 1995). The overall objective of the program is to collect data over time that can be used to understand the relationships between the sociological and institutional factors affecting a forest to the physical conditions of that forest using the International Forestry Resources and Institutions (IFRI) methodology (Ostrom, 1998; IFRI, 1998).

Data have been collected from a total of 1216 sample plots sampled from 43 forests located in various districts of Uganda. For this study, the regression analysis focused on a subset of the data gathered from forests located within the same agro-ecological zone—the tall grasslands zone around the Lake Victoria basin in the Mpigi District of Uganda (see Figure 1). This was necessary in order to control for variation attributed to ecological conditions. The forests selected met a number of criteria: a similar range in altitude and similar vegetation type. The research aimed to control for inherent variations due to topography and ecological factors so that differences in the condition of the forests could be attributed largely to effectiveness of the institutions involved in the management of these resources. The forests in this agro-ecological zone are classified as tropical moist, evergreen forests with closed canopies (Howard, 1991; Barbour, Burk, and Pitts, 1987). They are also locally categorized as medium altitude *Piptadeniastrum-Albizia-Celtis* forests after the three typically dominant tree species in the area.

[Figure 1 about here]

Private, sacred, and government forest reserves were chosen to encompass the variability of property regimes found in the area. The majority of the forested land in the Mpigi district is government-owned, so seven government forests were chosen. On the other hand, sacred and private forests are few; three forests of the communal category and four of the private category were chosen. With the exception of sacred communal forests, local forest users are permitted to harvest non-timber forest produce for subsistence use from all the forests in the study. Access rights to sacred communal forests, however, vary quite significantly. In some, no one has a right to withdraw resource units while others provide local communities with a wide range of goods and services (Gombya-Ssembajjwe, 2000). In order to test whether forests close to the administrative center were less degraded than those located in rural areas due to better monitoring and rule enforcement, forests within the same agro-ecological zone were selected within an 10-80 km. range from the administrative center. A total of 373 forest plots was sampled in 14 forests located in the Mpigi district.

In each forest, plots were randomly distributed over the area of the forest. Once the center of a plot was located, three concentric circles were marked. In the first circle,[1] the amount of ground cover by herbs and seedlings was estimated and species identified. In the next circle,[2] shrubs and tree saplings were identified and their heights and stem diameters measured.[3] Trees were identified and their diameter at breast height (DBH) and height measured in the third circle, which had a radius of 10 meters.

As a measure of foraging in the forest, evidence of human disturbance due to timber harvesting, firewood cutting, charcoal burning, cultivation, and any other form of forest harvesting activity was recorded for each plot. Other forms of data were also recorded, including soil characteristics, slope, slope orientation, elevation, and evidence of livestock, insects, and fire damage (IFRI, 1998).

In addition to sampling forests, information was collected on the institutional, geographic, demographic, and socioeconomic characteristics of the villages that use these forests using PRA

[1] The first circle had a one meter radius.
[2] The second circle had a three meter radius.
[3] Saplings were defined as young trees with a maximum stem diameter greater than 2.5 centimeters, but less than 10 centimeters.

techniques. This data provided a context in which to interpret the observed forest use patterns and the condition of the forest resources under study.

Model Used to Predict Effectiveness of Local Forest Institutions

We developed a regression model to test the hypothesis that local branches of national forest institutions are not able to effectively monitor and enforce rules at the forest level. The model included natural, human, and institutional factors that may influence the effectiveness of monitoring and rule enforcement.

The presence (or absence) of evidence of timber harvesting in a forest plot was used as a dependent variable to capture the effectiveness of monitoring and rule enforcement. This is a dichotomous variable whereby 0 = no evidence of timber harvesting, and 1 = presence of evidence of timber harvesting in a plot. The dependent variable was categorical and the data could therefore be analyzed using Logistic Regression Techniques.

The independent variables predicted to determine the effectiveness of monitoring and rule enforcement were plot steepness, plot elevation, forest size, distance to Kampala—the commercial and administrative center, form of tenure, and settlement population. The first four variables were intended to capture the impact of physical factors that affect patrolling (monitoring) of the forest effectively by the forest officials. The fifth independent variable—property regime—attempted to capture how incentives encourage forest owners to monitor and enforce property rights while settlement population—a proxy for size of user-group—sought to capture household pressure. Due to the existence of a large timber market in Kampala, the road distance to the Kampala was also used as a proxy to capture the effect of demand for forest products on monitoring and rule enforcement. The more the demand for resource units the more the rules and monitors needed to regulate harvesting levels—in order to avoid the tragedy of the commons.

The equation for the probability of the forest plot showing evidence of timber harvesting was expressed as:

$Pr\ (Timber = 1) = \alpha + \alpha_1\ (plot\ steep) + \alpha_2\ (plotelev) + \alpha_3\ (fsize) + \alpha_4\ (comfor) + \alpha_5\ (govfor) + \alpha_6\ (distKpla) + \alpha_7\ (setlpop)$

Where:

Plot steep	=	Plot steepness measured in degrees
Plot elev	=	Plot elevation in meters above sea level
Fsize	=	Forest size in ha.
Govfor	=	Government forest
Comfor	=	Communal forest
Privfor	=	dummy variable for private forest
DistKpla	=	Shortest road distance to administrative center in kilometers
Setlpop	=	Population of settlement—a proxy for size of forest user-group
α	=	Constant

Scatter plots were made and pair wise correlation coefficients estimated for each independent variable versus the dependent variable used in the model. This was necessary in order to determine if there was heteroscedasticity—unequal spread of Y scores around the regression line Y^1—among the parameters and to verify that no multicollinearity problems existed. This is useful in understanding the nature and strength of the relationships among the parameters.

Models Used to Predict the Influence of Monitoring and Rule Enforcement on Forests Condition

If one is interested in understanding deforestation practices in a foraging community, it is important to focus the analysis on those species with high demand within the community and in nearby markets. This is necessary because, in any setting where foraging levels are high, the severity of the degradation will manifest itself first in the distribution of those species that contribute most to the communities' livelihoods (Schweik, 2000). Timber is a major product obtained from forests located in the Mpigi district. We therefore predict that the size and number of timber species remaining in each forest plot will capture the impact of timber harvesting on the condition of the forest. We also predict that pitsawyers[4] will harvest the most valuable trees first. Therefore, one would expect to find a large number of bigger trees of under-utilized[5] tree species in each forest plot. In response to ease of monitoring, one would predict that the number of forest plots with evidence of timber harvesting would increase as the distance from the administrative center increases. On the other hand, one would expect to find more and larger timber species as the distance from the market increases.

We constructed a series of eight regression models to predict the condition of local forest resources in the Mpigi district in response to the local rules, incentives, and day-to-day action of local people. We selected size—mean DBH—and number of stems of timber species present in a forest plot as dependent variables.

The first set of four regression models uses stem count of first class (high value furniture timber species), second class (moderately valuable construction timber species), and third class (low value, less desirable timber species) in the forest plot, and total stem count in the forest plot,

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[4] Pitsawing is the process of converting round logs into timber manually using handsaws. This is the most dominant method of processing round logs into timber in Mpigi District.

[5] Timber species used for the manufacture of furniture are the most valuable and are classified by the Forest Department as preferred or first class tree species. Those used for construction fetch a lower value in the market and

respectively, as the dependent variable. The second set of four regression models uses mean DBH of first-, second-, and third-class timber species found in the forest plot, and total mean DBH of all trees in the plot, respectively. The two forest measures used here as dependent variables—tree diameter at breast height and tree density—are routinely used as indicators of forest condition by foresters and ecologists.

The independent variables predicted to determine the condition of the forest resource were plot steepness, plot elevation, forest size; the physical factors, property regime, effectiveness of monitoring, and rule enforcement; the institutional factors, distance to market and settlement population; and forest product demand or market factors.

Since the stem count in the forest plot could not take on negative values, multiple linear regression techniques could not be used to predict the Y_1 values. In addition, stem count of timber species showed a clustered pattern of spatial arrangements. There was a large number of plots where there were no timber species of a given class. In such a situation of overdispersion, the negative binomial distribution assumption is more appropriate (Schweik, 2000). Consequently, the first set of four regression models using stem count as the dependent variable was analyzed using negative binomial and Poisson regression techniques.

The regression estimates for the second set of models based on DBH as the dependent variable were determined using multiple linear regression techniques. The basic form of the Stem count and DBH-based models is:

$$Y_1 = \alpha + X_1\hat{a}_1 + X_2\hat{a}_2 + X_3\hat{a}_3 + X_4\hat{a}_4 + X_5\hat{a}_5 + X_6\hat{a}_6 + X_7\hat{a}_7 + X_8\hat{a}_8$$

Where;

are classified as desirable or second-class timber species. All other tree species not suitable for timber production are classified as “under-utilized” or third-class tree species.

Y_1 = DBH—mean diameter at breast height of all or first-, second-, or third-class trees per plot.

= STEMcount—mean stem count of all or first-, second-, or third-class trees per plot

X_1 = Psteep—percent slope of the plot.

X_2 = PElev—elevation of plot in meters above sea level

X_3 = Fsize—size of forest in ha.

X_4 = DistKpla— Road distance from Kampala to forest

X_5 = Govfor— Government forest reserve

X_6= Comfor—Communal forest

$X_{7=}$ Privfore— a dummy variable for private forest

$X_{8=}$ Setlpop—population in the settlement using the forest

α = Constant

Results

When the results from the forest plots were aggregated to the forest level, significant differences in the structure and composition of species in the different forests were observed. The observed differences in diameter—class structure, number of stems per plot, and biological diversity of the forests (see Table 3) probably reflect both use-patterns and management levels, rather than ecological conditions, since such differences were also observed in neighboring forest patches, but under different management regimes.

[Table 3 about here]

The intensity and pattern of forest use vary widely across the forests. Evidence of commercial firewood cutting, pitsawing, and charcoal making were recorded in more than half of the plots in eight forests, while only two out of 14 forests had evidence of such exploitation in less than 10% of their plots (Table 3). The wide variation in evidence of foraging in the forest probably reflects the wide variation in the effectiveness of local forest institutions to exclude illegal harvesters and regulate harvesting levels.

Based on the index developed in Table 2, the effectiveness of local forest management institutions in excluding illegal harvesters was evaluated. Namungo (a private forest), Mpanga (a government forest) and Mukasa (a sacred communal forest) could be classified as being very effective in the exclusion of illegal harvesters probably through better monitoring and rule enforcement. Lwamunda and Butto-buvuma (government forest reserves), and the Semalizi sacred forest, were categorized as being moderately effective and the others were being exploited as "open-access" forests. Among the forests being exploited as open access forests, three were private, four were government-owned, and one was a sacred forest. The observed wide variation in the level of exclusion within the forests under the same property regime supports the argument that form of tenure alone is not enough to ensure sustainable management of renewable resources.

To explain the observed wide variation in the level of exploitation that we find in study forests, we carried out a logit analysis of factors that may affect the effectiveness of monitoring and rule enforcement at the forest plot level. The beta coefficients and standard errors are shown in Table 4 and indicate the relative contribution of the different variables towards the probability of a forest plot being protected from the foraging activities of timber harvesters. The equation for the probability that the forest plot has evidence of timber harvesting can be expressed as:

$\Pr(\text{Timber}=1) = 1/(1 + e^{z})$

Where Z= -2.87 + 0.026 (Pelev) + 0.026 (Psteep) + 0.0004 (Fsize) + 0.023 (dist. Kpla) + 0.24 (Govfor) – 0.23 (Comfor) – 0.0028 (Setlpop). The chi-square of the model is significant at the P < .001 level, suggesting that the model classified the data well.

The regression indicated that, as the distance between the forest and Kampala—the administrative and commercial center—increased, the probability of the forest plot showing evidence of timber harvesting also increased significantly (P < .001). The predicted increase in the probability of the plot showing evidence of timber cutting as the distance from Kampala increased was, however, unexpected. The *a priori* expectation was that the forest plots close to Kampala would show a higher occurrence of evidence of timber harvesting than those located in the remote part of the Mpigi district because of differences in market pressure. A possible explanation for this unexpected finding may be that there is a higher level of supervision by both the Forest Department headquarters staff located in Kampala and the Mpigi DFO staff also located close to the forests near Kampala. In addition, the forests located near Kampala are close to major highways that make monitoring and rule enforcement less costly.

[Table 4 about here]

The regression predicted that as the forest size increased the probability of the forest plot showing evidence of timber harvesting would increase significantly (P <.001); indicating the inability of forest institutions to monitor and enforce rules effectively in large forests. This is in agreement with theory on common pool resources that predicts monitoring and rule enforcement (excludability) to be difficult and costly in large common pool resources (Ostrom, 1990; Bromley et al., 1992; Banana and Gombya-Ssembajjwe, 2000).

The results of the regression on tenure arrangement did not conform to the expectation that private forests are more secure from degradation by timber harvesting than the communal sacred and government forests. Although not significant at the 0.001 level of significance, the occurrence of evidence of timber harvesting in the forest plots was lower in the sacred forests than in the private and government forests. This finding supports the argument that tenure alone is not a good predicator of sustainable management of forest resources.

Dense population, often depicted as one of the most important factors in forest degradation, was found not to necessarily coincide with of evidence of timber harvesting in the forest plots at the .0001 level of significance. Similarly, the physical variables of plot steepness and plot elevation that are often used to indicate physical limitations in harvesting forest resources emerged as weak predictors of evidence of timber harvesting in a forest plot and were not significant at the .001 level.

Taken together, results of the regression provide some support for the hypothesis that national forest institutions are not effective in monitoring and enforcing rules in large forests and in forests located far away from the District Forest Offices. This highlights the importance of monitoring and rule enforcement in sustainable management of forestry resources in Uganda.

We now turn to the analysis of forest conditions in the Mpigi district as affected by the absence of strong forest institutions. We use the DBH and the Stem count of commercial timber species present in the forest plots to test our hypothesis that weak local forest institutions do not effectively regulate use levels of valuable forest resource units and lead to the deterioration of forest conditions.

Table 5 shows the relative importance of 30 commercial timber species in the study forests. The results show that commercial species preferred by harvesters are ranked very low or are absent in most study forests. The five most dominant and widely distributed tree species were *Bosqueia phoberos, Antiaris toxicaria, Pseudospondias microcarpa, Celtis durandii* and

Macaranga monandra. All are not valuable timber species. On the other hand, the most valuable timber species such as *Albizia coriaria, Entandraphragma angolense* and *Milicia excelsa* were clearly less abundant or absent in most forests. This indicates the depletion or "creaming" of forests of the most valuable timber species.

[Table 5 about here]

The results of the DBH and Stem count regression models used to predict the condition of the forests are presented in Tables 6 and 7. The models are based on the assumption that in forests where rules are enforced, the indicators of condition of forest DBH and stem count would be higher than those forests where rules are not in use. The stem count models performed better at predicting the effect of timber harvesting on the condition of the forests than the DBH models. The following reasons are advanced for the relatively poor performance of the DBH models: (1) large trees of preferred timber tree species may not be harvested because they have a lot of defects and/or poor stem form, and (2) the tree may be too large to be cut without being detected because heavy machinery is needed. Yet a single large tree contributes significantly to the mean DBH of the trees in that plot.

[Tables 6 and 7 about here]

With the exception of the highly valued furniture timber tree species, the regressions show that sacred forests had significantly more and bigger commercial timber trees per plot than the government and the private forests at the 0.001 level of significance. If one compares forests under communal management to those under any other type of management using the marginal effect coefficients, the sacred forests have an average dbh 18 cm. higher and an average of 5.7 more trees than the others. Government forests are also associated with more trees per plot and bigger trees. Average dbh was 7 cm. higher on government forests than on private and sacred forests when considered together. Stem count was two trees more. The fact that both government and communal forests feature larger and more trees per plot suggests that privately owned forests are the least likely to have many large trees per plot.

Certainly private property is not necessary to protect commercial trees. The results conform to our predictions; communal forests in our study were sacred forests with enforced rules that prohibit timber harvesting; hence the presence of bigger timber trees. On the other hand, the private forest owners maximize the return on their resource by harvesting valuable trees as soon as possible, even before maturity. This finding is significant as it addresses an important forest policy question: What property rights arrangement is likely to lead to sustainable forest management in Uganda? Contrary to the popular belief of most researchers and policy makers, private ownership of forest resources may not guarantee the sustainability of forest resources.

Consistent with the evidence of timber harvesting reported in the logit model, the number of trees per plot and dbh of timber species—mostly class two, the timber class that Mpigi Forests supply to the Kampala timber market—decreased significantly ($P>0.001$) as distance from Kampala increased. Trees were on average 15 cm smaller for each 50-kilometer increase in distance away from the administrative center and 5.2 cm smaller for every 1000 ha increase in forest size. Gombya-Ssembajjwe (1996) also observed that basal area/plot of commercial timber species decreases as distance from Kampala increases. Both of these findings support the argument that distance from the administrative center and spatial extent of the forest hamper effective monitoring and are reflected in poor forest conditions. However, the decrease in the stem count and size of non-timber tree species with increase in distance from the administrative center was not significant at the 0.001 level. This indicates a lack of timber demand for this class of trees.

Another interesting finding from the regressions on stem count and DBH is that there is a strong negative relationship between number of people in the villages neighboring the forest – a proxy for size of user group and number and size of trees present in a forest plot. Most interestingly, however, the negative relationship between population and number of non-timber tree species is very strong and significant at the .001 level. Even in the sacred forests, where harvesting rules are enforced, non-timber tree species were not significantly larger or more prevalent than those in the private or government forest reserves. This evidence is consistent with field observations that very few people in the communities are engaged in harvesting trees for timber—the timber user-groups are often small. However, the majority of the population harvests non-timber tree species for firewood, charcoal and poles.

To check the robustness of these models, tests were run for multicollinearity and heteroscedasticity. With the exception of the relationship between settlement population and communal tenure, no problem of multicollinearity was found. The highest correlation was 0.30 between forest size and government forest. Possible problems with multicollinearity, however, affect the relationship between settlement population and communal tenure, which are correlated at 0.62. The presence of multicollinearity implies that coefficients and statistical significance of these variables may be depressed.

A scatter plot of effectiveness of monitoring against distance from the administrative center revealed consistently high levels of timber harvesting beyond 50 km. from Kampala. In the forests within 50 km. of Kampala, a wide variation in the level of timber harvesting was observed. This suggests that forest specific factors not captured in these models may be important in understanding variation when proximity to the administrative center is not an obstacle.

Discussion

The unexpected increase in evidence of timber harvesting and the decrease in the indicators of forest conditions, as distance from Kampala increased were very striking. The proximity to Kampala may be a proxy for two different forces, the effect of high-level monitoring and rule enforcement and market forces. However, it appears that the effect of the former may be more important than the effects generated by market forces. Field observations in other forest patches in Uganda also indicated that forests are in good condition along the road and deteriorate rapidly as distance from the road increases because of better supervision. Agrawal (1995) and Schweik (2000) also reported such observations in India and Nepal, respectively.

The increase in evidence of timber harvesting and the decrease in the indicators of forest conditions, as size of forest increased, was expected. As the common-pool resource increases in size, more investment is needed in monitoring technology, field staff, and time. Increased investment in monitoring and rule enforcement increases rapidly with increase in size of the resource if the resource units are highly valued.

The two variables—distance from Kampala (the administrative center) and forest size—directly affect the ability of local branches of National Forest Institutions to monitor and enforce rules. It can be argued that the District Forest Office with limited staff and a small operational budget of less than $1,500 per month cannot effectively supervise the forest field staff located more than 50 km. away from the district headquarters. Similarly, it cannot effectively monitor rule compliance in large forests, especially when they are located far way from the District Headquarters. This brings up the question of “who monitors the monitor?” in order to improve rule enforcement in the district.

During the process of restructuring the civil service in 1990, the government position of forest guard was eliminated. A large number of forest rangers and forest officers were retrenched during this time as well. In addition, there has been no significant recruitment of staff in the forest sector for the last ten years. Furthermore, the district local councils do not have the funds to hire forest field staff. Consequently, there has been a severe shortage of field staff in the last ten years to monitor and enforce forest rules. Most sub-counties have only one forest guard—locally hired by the DFO, since the post no longer exists in the civil service—to guard and supervise harvesting of forest produce. As a result, forest users who choose not to comply with the rules can easily escape detection. The ability to monitor and enforce forest rules has further been eroded by the low morale of forest staff, caused by the impending dismissal of the majority of staff in the process of transforming the Forest Department into a smaller National Forest Authority. Therefore, given limited budgets and staff, and a legacy of ineffective regulations and local communities that have been stripped of their powers to control their own forests, it is not surprising that forest degradation in Uganda is continuing.

There were more and bigger trees in sacred communal forests than on private and government forest reserves. The better performance of sacred communal forests may be due to the local communities' ability to craft and enforce rules for their sacred forests. The results also provide evidence that private ownership of forest resources may not guarantee sustainability of forest resources. This is because holders of private property rights have no *a priori* reason to conserve the forest resources they own. Economic theory predicts that they will maximize the return on their resource. Private forest owners use high discount rates so as to maximize satisfaction from their resource. This means that if the forest is more valuable to them now as timber than a standing forest, timber tree species will be harvested regardless of the costs that may accrue to society (Gibson, Lehoucq, and Williams, 2001). These findings come at a time when there is a push for collaborative forest management, privatization of forest lands and a decrease in the involvement of government in the management of forest resources. Since the study had only three cases of communal forests in Mpigi, it is important to carry out a bigger study involving a large number and different categories of communal forests in order to validate these findings.

The Way Forward—How Can Local Forest Institutions be Strengthened?

No doubt, the outcome of many national and international policies and agreements on the environment are determined by local communities' resource use and governance patterns. Many contemporary forestry policies in both developed and developing countries are therefore seeking to shift control of forest resources to the community level in an attempt to improve management of local forest resources. Often, when compared to central government institutions, local institutional arrangements are considered better at providing, *inter alia*, rules related to access, harvesting, and management; a forum that can respond to conflict quickly and cheaply; and monitoring and sanctioning methods that are efficient (Ascher, 1995; Ostrom, 1990; Bromley et al., 1992). This is expected to result in improvement of the forest conditions. According to Ostrom (1999a, 2000), communities keep their forests in good condition when they have very high levels of trust among themselves. Individuals find it costly to have their reputation for trustworthiness harmed in that community if they do not comply with the rules in use. This lowers the cost of monitoring and rule enforcement by not relying entirely on formal sanctions. Since local users have to bear the cost of monitoring, they often make rules that make infractions obvious so that monitoring costs are less. In addition, users are often involved in decision-making and therefore, they consider the rules crafted as being legitimate. This raises the level of compliance and also reduces monitoring and enforcement costs.

Strengthening local forest institutions in Uganda is therefore key to reducing the rate of deforestation. Two recent policy changes that provide excellent opportunities for establishing effective local institutions to monitor and enforce forest rules at the forest level include: (a) the Decentralization Statute and (b) the increased emphasis on Collaborative Forest Management in the 2001 forest policy.

Aware of the poor performance of centralized forest management institutions, the national government is seeking to shift control of forest resources to the district councils and local communities using the Decentralization Statute. According to the 2001 Forest Policy, the government intends to enhance the role of local governments with more devolved responsibility for forest resource management. The nested layers of local government administrative structure provide an effective platform for creating and enforcing forest rules at the various levels of local governance. Forest rules crafted by a lower LC should be legally binding and recognized by the LC above it for better enforcement. The various layers of local governance should be empowered to resolve forest-related conflicts and give graduated sanctions to rule violators. The higher LC would inflict a greater punishment upon repeated offenders.

Collaborative forest management is a process of shifting control of forest resources to the community. Among the more important factors that affect the level and type of consumptive utilization of forests in many settings is the right that local residents possess in relation to the forest resource. This is important because individuals whose access rights to the forest resource are not guaranteed are strongly tempted to use up these resources before they are lost to the harvesting efforts of others. According to the new Forest Policy, the government intends to encourage more active participation of local communities and farmers in the management of the country's forests and to enhance the role of cultural and traditional institutions in forest sector development. Community involvement in forest management may increase the motivation of individuals to protect the resource due to an enhanced sense of ownership and the anticipated increase in benefits. However, we must note that after four decades of no involvement by local communities in forest management, it is going to take a long time and a lot of effort to organize locally, develop the rules, develop a sense of legitimacy, and put in place a mechanism to monitor and sanction.

In addition to strengthening local forest institutions, there is a need to review the amount and nature of penalties given to those who repeatedly fail to comply with forest rules and regulations. Evidence presented earlier in this paper showed that there is inadequate sanctioning of violators of forest rules. Monitoring, by itself, does not significantly reduce CPR appropriation. Quite the contrary, Moir (1999) claims that monitoring without sanctions increases appropriation from the common pool resource because appropriators see what others are doing and react by increasing their own appropriation rates. Therefore, a combination of monitoring and sanctioning of well-crafted and legitimate local rules significantly reduces CPR appropriation (Hallenstvedf, 1995; Gregersen and Lundgren, 1989). Ostrom (1990) also acknowledges the role of monitoring sanctions in resource management but goes further to suggest that appropriators who violate legitimate operational rules should be assessed graduated sanctions. A small penalty may be sufficient to remind the first-time infractor of the importance of compliance. In addition, a small penalty for first offenders allows for honest mistakes in following rules or for errors in assessing compliance. On the other hand, repeated offences suggest a failure to learn. A large monetary fine imposed on a person may produce resentment and unwillingness to conform to the rules in the future. In a long run, a large monetary fine may also act as an incentive for bribery since it is cheaper for the infractor and worthwhile for the monitor (Gibson, 1999). We suggest that, for the Decentralization and Collaborative Forest Management policy initiatives to be effective, the LC at all levels and the Forest Management Committees must be empowered to prosecute those who break forest rules crafted by the elected officials. We believe that when fully implemented, these policy changes will lead to a pattern of forest resource use not consistent with the tragedy of the commons.

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Table 1. Number of sample plots with evidence of illegal consumptive disturbance (N=1216 sample plots randomly located in 43 forests)[6]

Type of Disturbance	Frequency	%
No Disturbance	723	59.5
Charcoal and Firewood	358	29.4
Timber	103	8.5
Cultivation	27	2.2
Poles	5	0.4
Total	1216	100

[6] The Uganda Forest Resources and Institutions Center (UFRIC) collected empirical evidence of the pattern of forest use in Uganda as part of a larger detailed research program to study and monitor how various types of institutional arrangements affect incentives and behavior of forest users in Uganda. Details of the research strategy are presented in the section on Sampling techniques and data collection.

Table 2. Effectiveness of exclusion in forests under different tenure regimes

Tenure	Effectiveness of Exclusion		
	Open-access[7]	Moderately effective[8]	Very effective[9]
Communal n= 7	28.6 %	57.1%	14.3%
Government n= 28	39.3%	35.7%	25%
Private n= 8	50%	-	50%

[7] Percentage of Forests with 45% or more of sample plots showing evidence of illegal harvesting.

[8] Percentage of Forests with 26-44% of sample plots showing evidence of illegal harvesting.

[9] Percentage of Forests with 0-25% of sample pots showing evidence of illegal harvesting.

Table 3. Characteristics of sampled forests in Mpigi district

Forest name	No. of plots	Forest size/ha	Tenure Regime	Distance to admin. Center in Kilometers	% plots with evidence harvesting	Mean of Trees/ha	Mean Dbh	Species Richness	Simpsons Index
Butto-buvuma	30	453	Government	23	43.3	331.5	22.5	64	25.1
Kizzikibi	30	520	Government	72	50	322.9	24.4	54	13.8
Kyambogo	30	760	Government	66	73.3	381.3	24.3	68	20.4
Lukambagire	30	100	Private	70	80	261.4	22.2	44	12.1
Lwa munda	30	1096	Government	29	40	341.1	23.3	65	27.3
Magezigoomu	30	20	Sacred	79	70	312.4	21.8	41	20.1
Mpanga	30	500	Government	34	6	401.6	25.1	68	22.7
Mugalu	30	150	Private	32	86.7	318.8	25.8	50	20.7
Mugomba	26	150	Government	28	83.3	153.0	25.4	34	13.4
Mukasa	8	2	Sacred	24	0	401.6	28.4	24	13.2
Najjakulya	30	50	Private	60	53.3	251.8	20	43	12.2
Namungo	30	40	Private	31	23.3	363.1	24.5	63	29.8
Semalinzi	5	2	Sacred	10	40	548.3	22.8	16	6
Wangeregezi	30	120	Government	24	70	245.4	18.8	54	29.3

Table 4. Rank of relative importance values of timber species and forest name

Species Name	Rank of Timber Species and Forest Name														Species Status
	Mpanga	Butto-buvuma	Kizzikibi	Kyambogo	Lukamba	Lwamunda	Magezigom	Mugalu	Mugomba	Mukasa	Najakulya	Namungo	Semalizi	Wangere	
Preferred First-Class Timber Species															
Albizia coriaria	0	0	41	25	0	32	0	0	0	0	28	60	0	0	Depleted
Aningeria altissima	7	18	0	0	0	51	0	0	0	0	0	0	0	53	Depleted
Cordia millenii	0	32	0	0	0	0	0	0	0	16	0	0	0	0	Depleted
Entandraphragma angolen.	46	41	14	27	0	59	0	0	0	0	0	33	0	19	Threatened
Entandraphragma cylindric.	29	47	0	0	0	46	0	38	0	0	0	39	0	0	Depleted
Fagara angolensis	0	0	36	54	0	22	8	0	17	0	0	0	0	0	Depleted
Fagara leuprieurii	0	30	0	0	0	26	0	0	0	0	0	15	0	0	Depleted
Lovoa brownii	38	44	7	46	0	20	2	12	28	14	3	44	0	9	Abundant
Milicia excelsa	0	50	0	0	0	0	0	0	0	0	0	0	0	42	Depleted
Prunus africana	0	0	33	32	16	19	0	8	0	0	0	47	0	13	Threatened

Desirable Second-Class Timber Species														
Albizia grandibracteata	0	0	46	0	0	22	0	0	0	20	0	26	0	0	Depleted
Albizia zygia	17	0	0	30	0	27	22	23	0	0	21	54	1	0	Threatened
Antiaris toxicaria	5	0	4	7	0	5	6	6	0	3	1	5	2	0	Abundant
Canarium schweinfurthii	24	27	0	35	33	48	4	28	0	9	0	0	0	0	Threatened
Celtis mildbraedii	1	0	52	9	0	3	0	0	0	0	23	8	0	29	Threatened
Funtumia elastica	27	12	19	4	27	14	34	3	0	15	24	9	0	29	Abundant
Holoptelea grandis	0	0	0	49	42	53	0	42	0	0	0	0	0	0	Depleted
Maesopsis eminii	44	1	23	51	23	17	1	20	6	10	7	45	0	5	Abundant
Piptadeniastrum africanum	35	19	10	0	0	30	3	41	0	0	8	7	0	15	Abundant
Pycnanthus angolensis	34	24	46	55	28	39	23	37	0	23	0	36	0	26	Abundant
Underutilized Tree Species														
Alangium chinense	60	35	45	44	0	24	0	49	26	0	0	46	0	27	Threatened
Blighia unijugata	22	55	9	12	0	10	16	13	25	0	17	16	0	12	Abundant
Bosqqueia phoberos	2	13	1	1	12	12	19	1	30	2	6	2	0	6	Abundant
Celtis durandii	8	3	2	6	35	1	21	10	0	11	0	21	12	0	Abundant
Celtis zenkerii	4	14	0	0	0	25	0	0	0	0	0	50	0	14	Threatened
Croton	50	22	28	53	0	0	40	0	0	0	0	32	0	50	Threatened

macrostachys															
Ficus capensis	41	0	20	19	10	9	0	5	11	0	39	18	0	16	Abundant
Ficus exasperata	26	6	24	5	0	6	30	0	0	0	28	22	0	16	Abundant
Parkia felicoidea	16	53	17	23	11	59	0	38	23	0	34	23	0	43	Abundant
Pseudospondias microcarpa	31	8	0	3	2	8	9	2	9	1	0	1	0	7	Abundant

1- Zero in the rows indicates that the species was not observed in that forest. The number of zeros in the row would indicate the status of that species.

2- The number of zeros in the columns is indicative of the condition of the forest

3 Importance value of each species is the summation of the relative density, dominance and frequency together divided by three. A species with a rare occurrence in the plots and being small in size would have a very low importance value and ranked last among the species occurring in that forest.

Table 5. Logistic regression results for variables explaining effectiveness of monitoring and rule enforcement

Variable	Expected Direction	B	S.E	Effects of change Mean to Max. with all other variables at mean.
Psteep	_	0.026	0.025	0.11
Pelev	_	0.0003	0.0002	0.034
Fsize	+	0.00040***	0.0001	2.5
Govfor	_	0.243	0.285	0.48
Comfor	_	-.0.2	0.654	0.38
DistKpla	_	0.023***	0.006	0.165
Setlpop	+	-0.0002	0.0008	0.o21
Constant		-2.879	0.635	0.034
N	372			
Log Likelihood	-205.0			
Pseudo R^2	0.08			
Prob>Chi^2	0.00			

* = Significant at the P < 0.001 level

Table 6. Regression estimates of forest conditions using DBH models

Independent Variables	Expected Direction	Model 1 Total Tree DBH	Model 2 DBH-Class 1 Trees	Model 3 DBH-Class 2 Trees	Model 4 DBH- Non-Timber tree species
Intercept	-	27.3 (2.026)	8.93 (3.31)	29.9 (4.41)	33.03 (3.37)
Psteep	-	-0.003 (0.094)	0.087 (0.155)	0.65*** (0.20)	-0.334* (0.158)
Pelev	-	-.0005 (0.0007)	0.0014 (0.0012)	-0.002 (0.001)	-0.001 (0.001)
Fsize	-	-0.0004 (0.0003)	0.0017*** (0.0006)	-005*** (0.0008)	-0.003*** (0.0006)
DistKpla	+	-0.023 (0.022)	-0.004 (0.037)	-0.151*** (0.049)	-0.071 (0.037)
Setlpop	-	-0.008*** (0.002)	0.0009 (0.0046)	0.015* (0.006)	-0.021*** (0.004)
Govfor	+	0.726 (1.042)	4.14 (1.70)	7.08*** (2.26)	0.564 (1.73)
Comfor	+	4.189 (2.068)	4.70 (3.37)	18.59*** (4.5)	2.18 (3.44)
N Prob>F R^2		372 0.23 0.024	372 0.06 0.036	372 0.000 0.13	372 0.000 0.13

* = significant at the P < 0.10 level

** = significant at the P < 0.05 level

*** = significant at the P < 0.001 level

Table 7. Regression estimates of forest conditions using stem count models

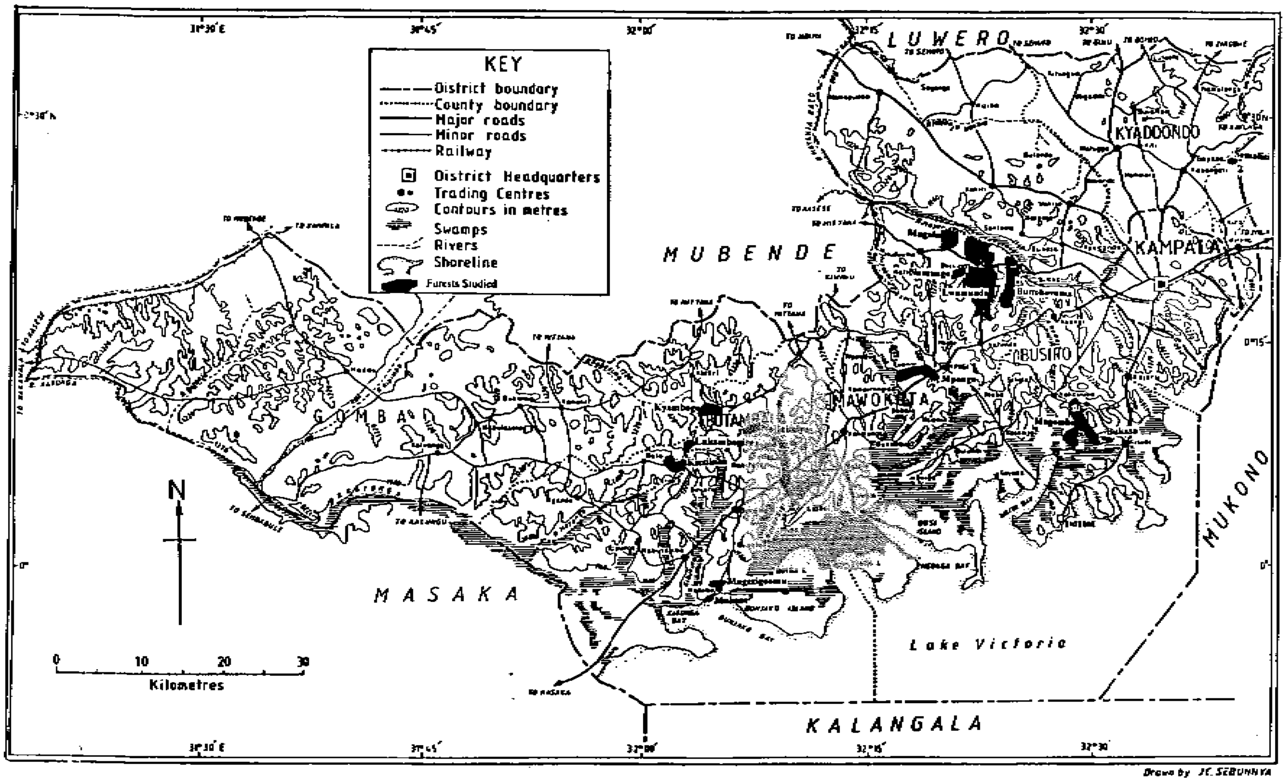
Independent Variables	Expected Direction	Model 1 Total Tree Count/Plot	Model 2 Class 1-Tree Count/Plot	Model 3 Class 2-Tree Count/Plot	Model 4 Non-Timber tree Count/Plot
Intercept	-	2.8 (0.112)	-0.72 (0.43)	1.50 (0.24)	1.84 (0.22)
Psteep	-	-0.012* (0.005)	0.024 (0.018)	-0.001 (0.011)	-0.011 (0.011)
Pelev	-	-0.00007 (0.005)	8.0^{-6} (0.00019)	-0.0001 (0.0001)	-0.00006 (0.00007)
Fsize	-	-0.00002*** (7.88)	0.0043** (0.00013)	-0004*** (0.0007)	-0.0004*** (0.0006)
DistKpla	+	-0.003*** (0.01)	0.0015 (0.004)	-0.11*** (0.002)	-0.005* (0.037)
Setlpop	-	-0.00089*** (0.00015)	0.0003 (0.0005)	0.013*** (0.006)	-0.0018*** (0.003)
Govfor	+	0.205*** (0.056)	-0.044 (0.215)	0.47*** (0.11)	0.530*** (0.113)
Comfor	+	0.481*** (0.112)	.481 (0.415)	1.35*** (0.213)	0.319 (0.24)
N Log Likelihood $P>Chi^2$ Pseudo R^2		372 93.35 0.000 0.041	372 30.99 0.0001 0.039	372 100.7 0.000 0.078	372 87.3 0.000 0.056

* = significant at the $P < 0.10$ level

** = significant at the $P < 0.05$ level

*** = significant at the $P < 0.001$ level

Figure 1. Map of Mpigi district showing approximate positions of study sites



Source: Gombya-Ssembajjwe (1996).