Vogt, N. D., A. Y. Banana, W. Gombya-Ssembajjwe and J. Bahati. 2006. Understanding the stability of forest reserve boundaries in the West Mengo region of Uganda. *Ecology and Society* **11**(1): 38. [online] URL: http://www.ecologyandsociety.org/vol11/iss1/art38/

Research, part of a Special Feature on Ralf Yorque Memorial Competition 2005

Understanding the Stability of Forest Reserve Boundaries in the West Mengo Region of Uganda

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ABSTRACT. Despite heavy pressure and disturbance, state property regimes have stemmed deforestation within protected areas of the West Mengo region of Uganda for over 50 yr. In this manuscript, we reconstruct the process of creation and maintenance of forest reserve boundaries in the West Mengo region of Uganda to identify why these boundaries have largely remained stable over the long term under conditions in which they may be predicted to fail. The dramatic boundary stability in West Mengo we attribute to key aspects of institutional design and enforcement of boundaries.

Key Words: *common pool resources; institutional arrangements; forest governance; remote sensing; conservation; Uganda*

"If it were possible for a satellite image or aerial photo to show not only the forest structure at a given place but also the tenure structure and the community organizational structures and institutions that exist in forested areas, then we would have a better picture of the world's forests" (Alcorn 1996:234).

INTRODUCTION

While assembling a dataset of remotely sensed images in our efforts to map and measure patterns of deforestation, reforestation, and afforestation in the Lake Victoria agroecological zone of Uganda, a region referred to as West Mengo, we observed that the boundaries of the forest reserves in this area, delineated by the colonial government over 50 yr ago, have remained remarkably stable despite great pressures on the resource and periodic social disturbances. Disturbances and pressures on land use and natural resource management institutions over the past 50 yr include the turbulent regime of Idi Amin (1971-1979), civil war (1980-1985), and the economic recovery since 1986 that has driven urban population growth and higher demands for timber, fuelwood, charcoal, and food crops. Understanding and explaining the long-term stability of these administrative and ecological forest reserve boundaries, despite the disturbances and pressures, has been the focus of subsequent research efforts.

The boundary stability of forest reserves within the West Mengo region is observed in a time series of Landsat images (1986, 1995, and 2002), which were overlaid with forest reserve boundaries and delineated between the late 1930s and mid-1940s. Forest cover is hypothesized to remain stable over the long term when the human population is low and stable, or when external demands for crops or forest resources are minimal (Meyer and Turner 1992, Kaimowitz and Angelsen 1998, Mertens et al. 2000, Geist and Lambin 2001). Stability under conditions of high demand for food, energy, or timber is hypothesized to occur when intensive means of agriculture production are adopted (Angelsen and Kaimowitz 2001), alternatives to fuelwood for energy are identified, transportation costs make importation of timber products from other areas feasible (Richards and Tucker 1988), or when people are excluded through creation of a protected area (Bruner et al. 2001). However, it has also been shown that imposition of exclusive state arrangements, e.g., protected areas, over forests may undermine arrangements of "forest-oriented" societies, and may lead to greater deforestation

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(Richards and Tucker 1988, Schwartzman et al. 2000).

Forest cover in the forest reserves of West Mengo is stable despite the large population, limited adaptation of green revolution technologies, and high reliance of both rural and urban populations on fuelwood and charcoal for energy, both obtained at least in part from the West Mengo region, which points to state arrangements as the explanation of the stability. However, state arrangements have been found to undermine customary arrangements in some cases, suggesting that it is not the state arrangements alone, but some specific characteristics in the design of state arrangements that explain stability of the forest cover.

Since 1985, several principles have been identified as necessary for robust governance of common-pool resources, i.e., the forest resources in the region of West Mengo, and there has been interest in designing interlinking arrangements at multiple levels to meet the goals of community, and national and global stakeholders, e.g., subsistence products and water supply protection for local users, timber for the state, and biodiversity and carbon sequestration for global users. These include devising rules that are congruent with ecological conditions, e.g., rules regarding types of use, harvesting, and timing of use and harvesting, clearly defining boundaries around the resource and user groups, devising accountability mechanisms for monitors, e.g., forest rangers, elders, and authorities in lower administrative levels in this case, applying graduated sanctions for violations, establishing low-cost mechanisms for conflict resolution, involving interested parties in informed discussion of rules, allocating authority to allow adaptive governance at multiple levels, using mixtures of institutional types (Ostrom 1990, Stern et al. 2002, Dietz et al. 2003). A key challenge to designing successful institutions for common-pool resource management is to reduce enforcement costs of the devised rules for access, use, and maintenance of the resource (Stern et al. 2002).

In this paper, we investigate and characterize the processes of reserve boundary creation and maintenance to identify the aspects that make West Mengo boundaries stable under conditions that often are expected to drive deforestation. We hypothesize that the processes of boundary creation and maintenance adhered closely to the above design principles and in doing so increased their legitimacy to local users and reduced the enforcement costs of the forest department, thus explaining the remarkable stability. All central forest reserves in West Mengo, the tropical moist biome in traditional Buganda territory, were created using the same process.

To reconstruct the processes that resulted in this stability, we integrate remote sensing data, historical data, and key informant interviews. One of the great problems in the quest to identify and characterize attributes of robust institutional arrangements that stem deforestation over the long term is that very few studies have been able to examine them over time. Researchers now have the advantage of using remotely sensed data with other methodologies to capture cover change over several decades. Archival research and interviews with elderly residents, government agents, and traditional authorities aid in constructing a narrative of the mechanisms of change observed in a time series of remotely sensed images (Vogt et al. 2005*a*). Thus, the application of these integrated methodologies in this study greatly adds to our understanding of the factors affecting stability and change of forest cover.

STUDY AREA/BACKGROUND

Location and biophysical attributes

The extent of our study region, West Mengo, was determined by biophysical and cultural factors. West Mengo is the region in the traditional Buganda territory that supports tropical moist forests. We wanted an area in which biophysical, demographic, and economic signals for forest use and management were similar for a sense of the outcomes, ceteris paribus, without those reserves. The reserved forest area in West Mengo consists of 61 individual reserves, created and maintained through the processes described herein.

West Mengo is part of the Lake Victoria agroecological zone, and lies in the northwest quadrant of the Lake Victoria basin of East Africa between 0.06’S and 0.30’N and between 32°00' E and 32°45' E (Fig. 1). We chose West Mengo to establish a biophysical context for the institutional arrangements and land-cover patterns under investigation. This banana–coffee–fruit tree agroecological zone receives between 1500 mm and

1800 mm of rainfall/yr. The topography is characterized by regularly spaced, flat-topped hills. Altitudes range from approximately 1100 m above sea level in the valleys to 1200 m above sea level on the hilltops. Vegetation is further differentiated within this agroecological zone by topographic relief, i.e., soil drainage differentiates soil types.

Land use and forest cover

Hillsides were once covered with forests, but are now dominated by the banana–coffee–fruit tree matrix. This matrix includes a mix of perennial, e. g., banana and coffee, and annual crops, e.g., maize, beans, etc., trees of high utility, e.g., *Artocarpus heterophylus, Mangifera indica, Ficus natalensis*, and post-cultivation grasses, e.g., *Pennisetum pupureum.* These productive hillsides are traditionally known as *mitala.* Seasonally inundated valleys also support productive forests, as observed today, but are less conducive to traditional production systems than soils of the *mitala.* Broad, permanently inundated valleys support papyrus swamps, and the summits are short-grassed savannas.

If devoid of people, or sparsely populated, this study area would be largely blanketed by tropical forest, other than broad, flat hilltops and papyrus swamps in broad valleys. This conclusion is supported by observing forest cover in isolated areas of this agroecological zone, i.e., areas with similar climatic and edaphic conditions, that are devoid of people or sparsely populated (Figs. 2 and 3). In the 50-yr time series of forest cover, using Landsat images and GIS products, we observe that most forest patches remaining in this area occur within the forest reserve boundaries delineated by the British colonial forest department over 50 yr ago. The reserves are located in the narrow, seasonally inundated valleys. Most large forest patches located in similar narrow, seasonally inundated valleys, with similar soil types, outside the reserve boundaries in the West Mengo region have been continually harvested and occasionally cropped since before aerial photographs were collected, i.e. ~ 1955 (Fig. 4). Thus, it is not soil type that explains the remarkable forest-cover stability within the forest reserves. The extent of cultivated and forested lands has largely remained the same for at least the past 50 yr as observed in time series of both Landsat images and aerial photographs. Harvesting may be occurring within the forested areas but not at levels that create and maintain gaps in the canopy detectable by Landsat images, contrary to the visibility of conversion to other purposes.

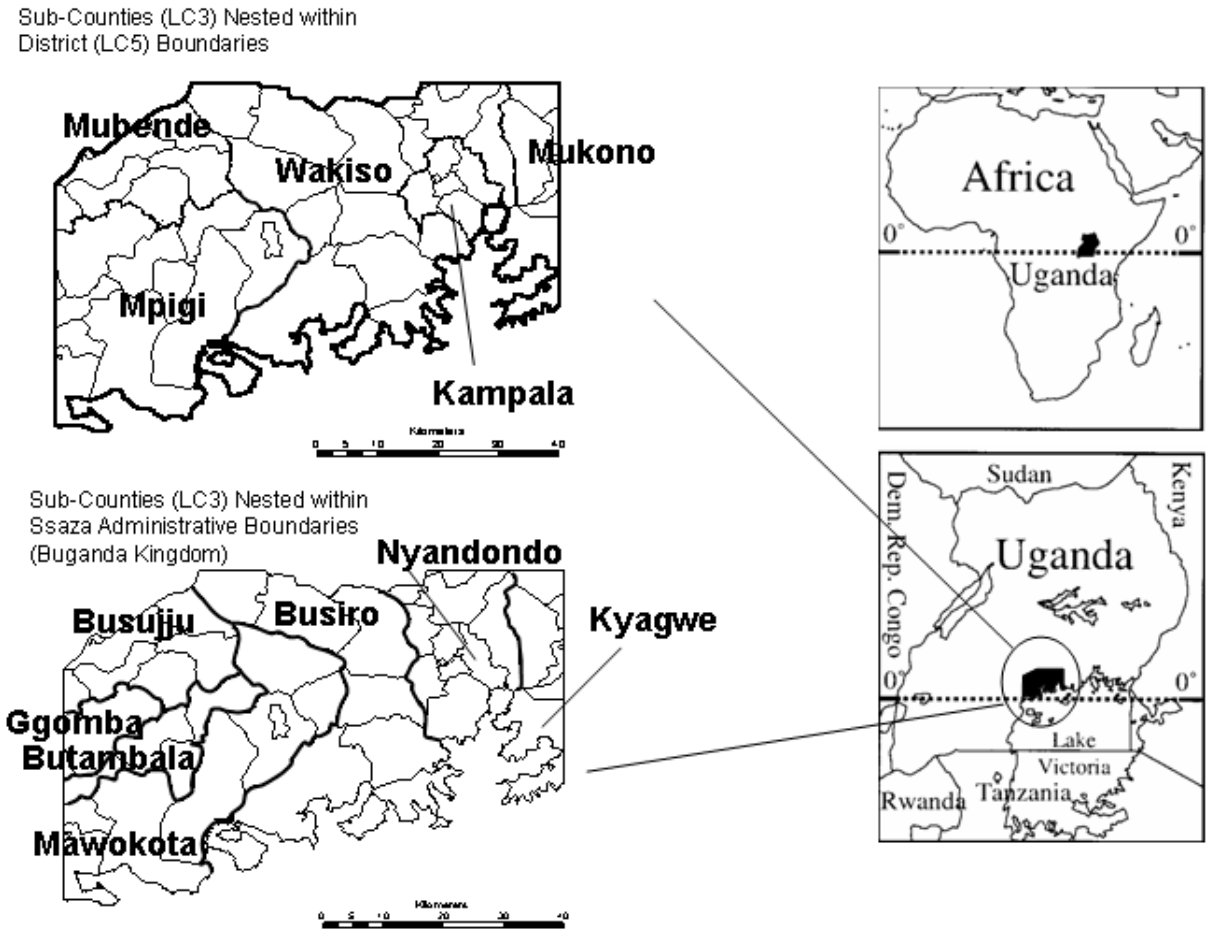
There are a few stable patches of forest remaining outside the forest reserves in the West Mengo region: those found on the islands isolated from the mainland by broad papyrus swamps (Fig. 2) and those protected by private owners (Fig. 5). When the isolated forest islands and the land across the wide swamps isolating them are draped over a digital elevation model (Fig. 6), the isolated islands are found on fertile soils, again, showing that soil conditions do not explain their presence. The presence of the forest islands is due to limited access. The presence and stability of the privately owned forest is due largely to the values of the owner, collaborative creation of rules-of-use between the owner and community members with access to the patch, and monitoring and enforcing those defined rules. The private patch highlighted in Fig. 5 is under investigation and discussed in Becker et al. (1995) and Banana and Gombya-Ssembajjwe (2000). The presence of a forest patch on *mailo* landholdings was a sign of wealth and power in the Buganda Kingdom. These special landholdings were registered land held in perpetuity, but in restricted allotments. However, long-term studies of the private forest patch in Fig. 5 are beginning to reveal that these values are not being upheld by current generations. Stability of the few remaining private forests is beyond the scope of this paper.

METHODS

Proving long-term boundary stability with remotely sensed products

The long-term stability of forest reserve boundaries in the study area can be observed in a multitemporal composite generated using Landsat TM images acquired at red wavelengths, i.e., band 3, on three dates: 28 December 1986, 19 January 1995, and 9 July 2002 (see Sussman et al. 2003 or contact the first author for further details on creating a multitemporal composite), overlaid with the forest reserve boundaries digitized from the 1955 topographic—land cover maps (Fig. 2).The boundaries were originally delineated in the late 1930s and 1940s. Care was taken to choose Landsat images from a dry season on each date.

Fig. 1. Maps of the study area, including those showing the subcounty, gombolola, units nested within both district and traditional county, *ssaza* units, which have importance in this study. Graphics were constructed by Nathan Vogt.



The remarkable respect for forest reserve boundaries in this study area is further illustrated using a multitemporal composite generated for a subset of the study area (Fig. 5). This composite was generated using a Landsat Multispectral Scanner (MSS) image acquired in the red wavelength, i.e., band 2, on 29 January 1974 and two Landsat Thematic Mapper (TM) images acquired at red wavelengths, i.e., band 3, on 28 December 1986 and 19 January 1995, overlaid with the same digitized forest reserve boundaries as shown in Fig. 2. This subset serves to illustrate more dramatically the respect for the boundaries in the study area. In this composite, regeneration is observed to have occurred on individual holdings outside forest reserves sometime during the Idi Amin regime and the civil war, but was subsequently recleared up to, but not beyond, the boundaries of the forest reserves after the civil war refugees returned. From this we see that the forest reserve boundaries were respected even after the disturbing civil war.

When constructing a multitemporal color composite to display changes in forest cover, care must be

Fig. 2. Multitemporal composite illustrating general respect for boundaries of forest reserves located within the tropical forest biome of West Mengo. Vector coverages delineating forest reserve boundaries extracted from a 1955 topographic map are shown by white lines. The yellow area over Kampala is not due to clearing after 1986, but rather is a result of removal of that portion of the 1986 Landsat Thematic Mapper (TM) image due to clouds. White arrows point to isolated areas still mostly forested, demonstrating presettlement cover. This composite was generated with two Landsat TM images and one Landsat Enhanced Thematic Mapper (ETM+) image acquired in 1986, 1995, and 2002, respectively. The composite was constructed by Nathan Vogt.

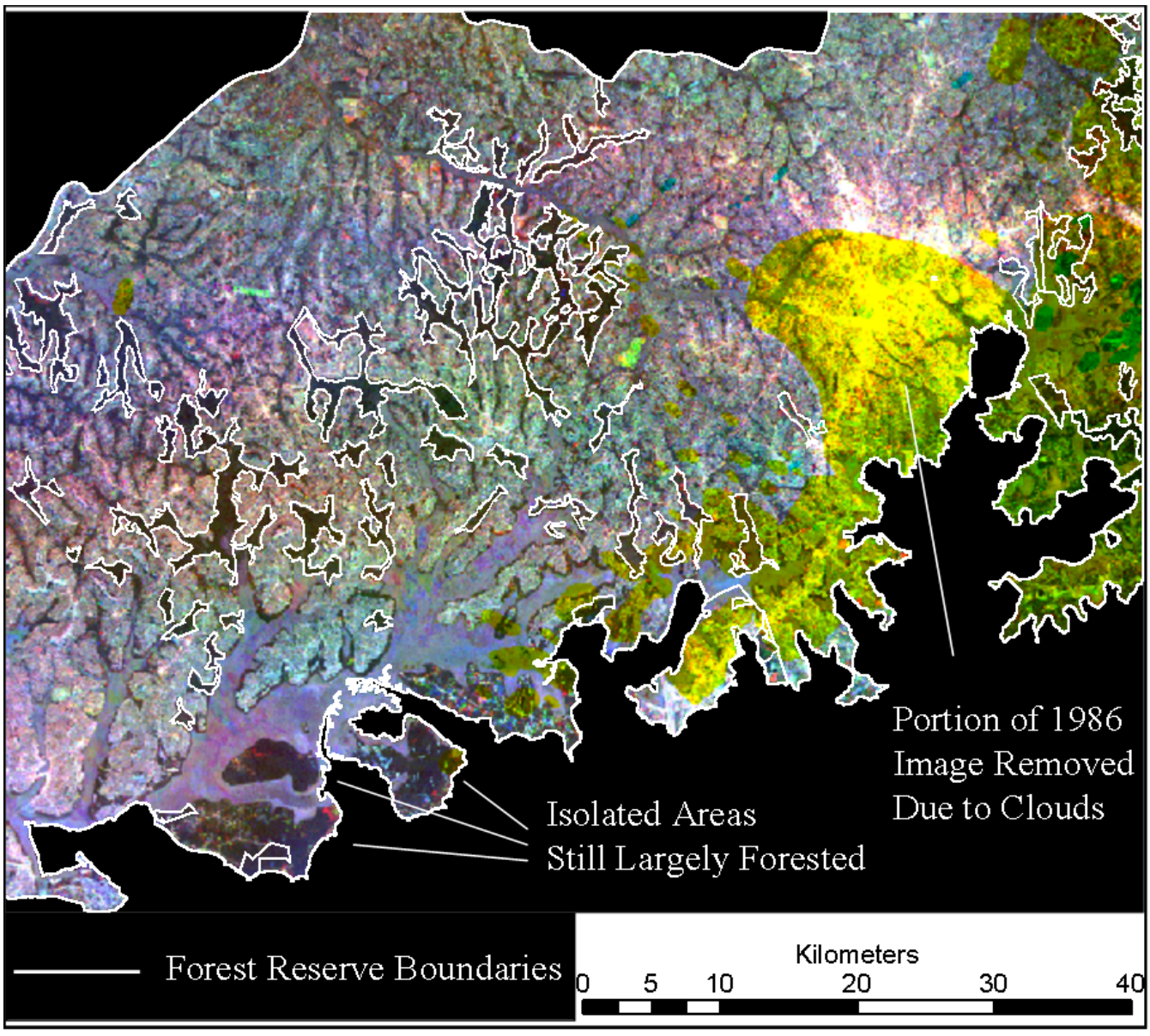
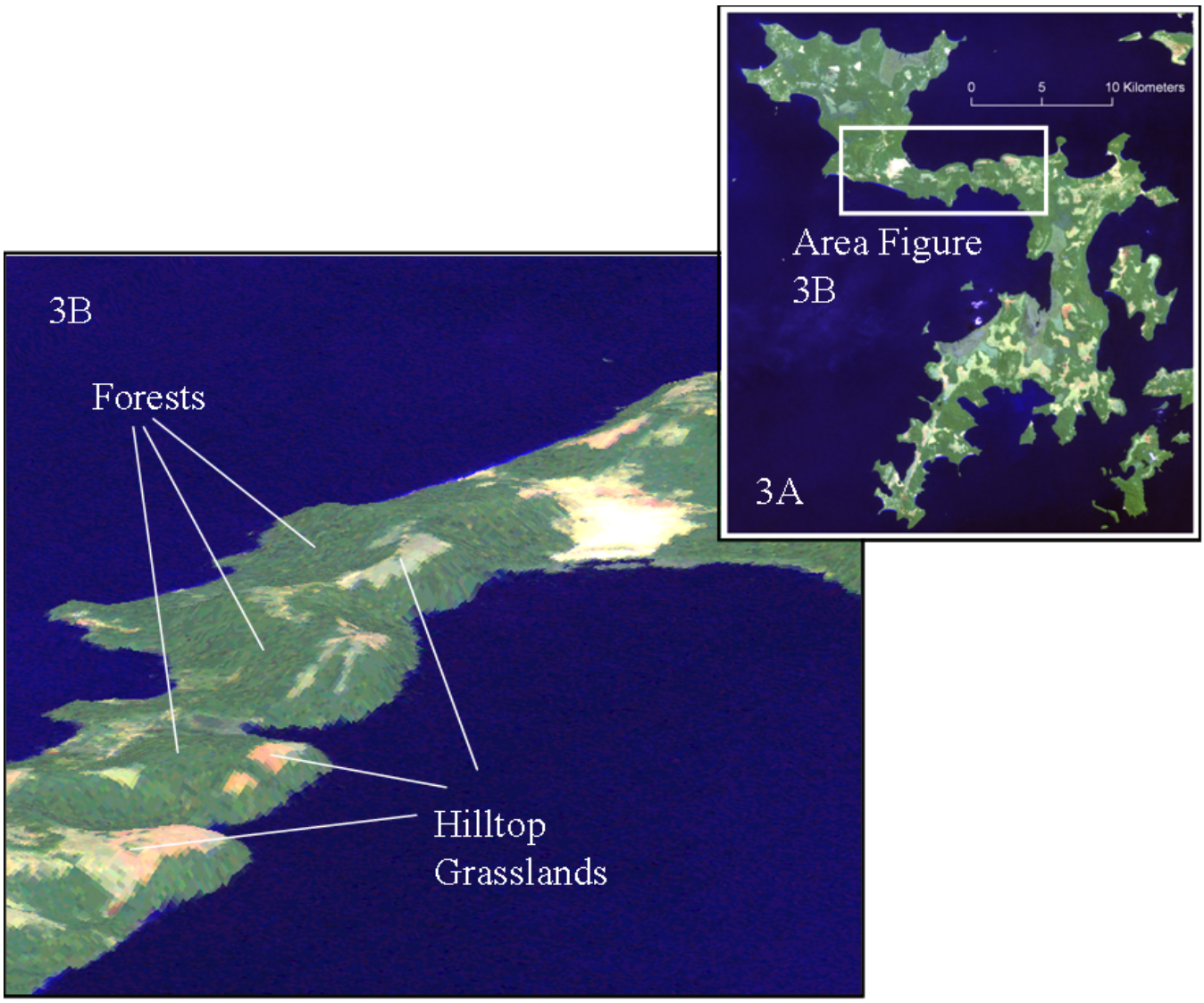


Fig. 3. Multispectral color composite of the sparsely populated Bugala Island, located within 20 km from the study area, and within the same agroecological zone. This composite, when draped over a digital elevation model (DEM), illustrates the natural distribution of forest, greenish colored areas, and grassland, bright, yellowish colored areas, cover in this agroecological zone. This multispectral color composite was generated with a Landsat ETM+ image acquired on 9 July 2002. It is produced by setting band 2, green wavelengths, to drive blue colors, band 5, mid-infrared wavelength, to drive the green colors, and band 7, mid-infrared wavelength, to drive the red colors. The composite was constructed by Sean Sweeney.



taken to identify those spectral wavelength intervals, i.e., bands, in which forest and nonforest exhibit contrasting spectral characteristics, such as those between bare soil and photosynthetic material. In general, tropical soils reflect visible red light, bright in those bands, whereas chlorophyll within the leaves of trees absorbs radiation at these wavelengths (0.6-0.7 μm). Thus, when the visible red bands of a Landsat image are displayed, soils appear bright and forests appear dark. Areas of the

Fig. 4. Subsets of the multitemporal composite used in Fig. 2 are draped over a digital elevation model (DEM) to illustrate land cover in both reserved and unreserved narrow, seasonally inundated valleys, i.e., areas of similar soil types. Long-term forest cover stability, i.e., dark areas, on these soils types is observed almost exclusively within those valleys in which forest reserves were created. In unreserved valleys, forests are either absent, i.e., bright valleys, or we see evidence of heavy harvesting or occasional cropping in the remaining extent of forest, i.e., red and green speckles. The composite was constructed by Sean Sweeney.

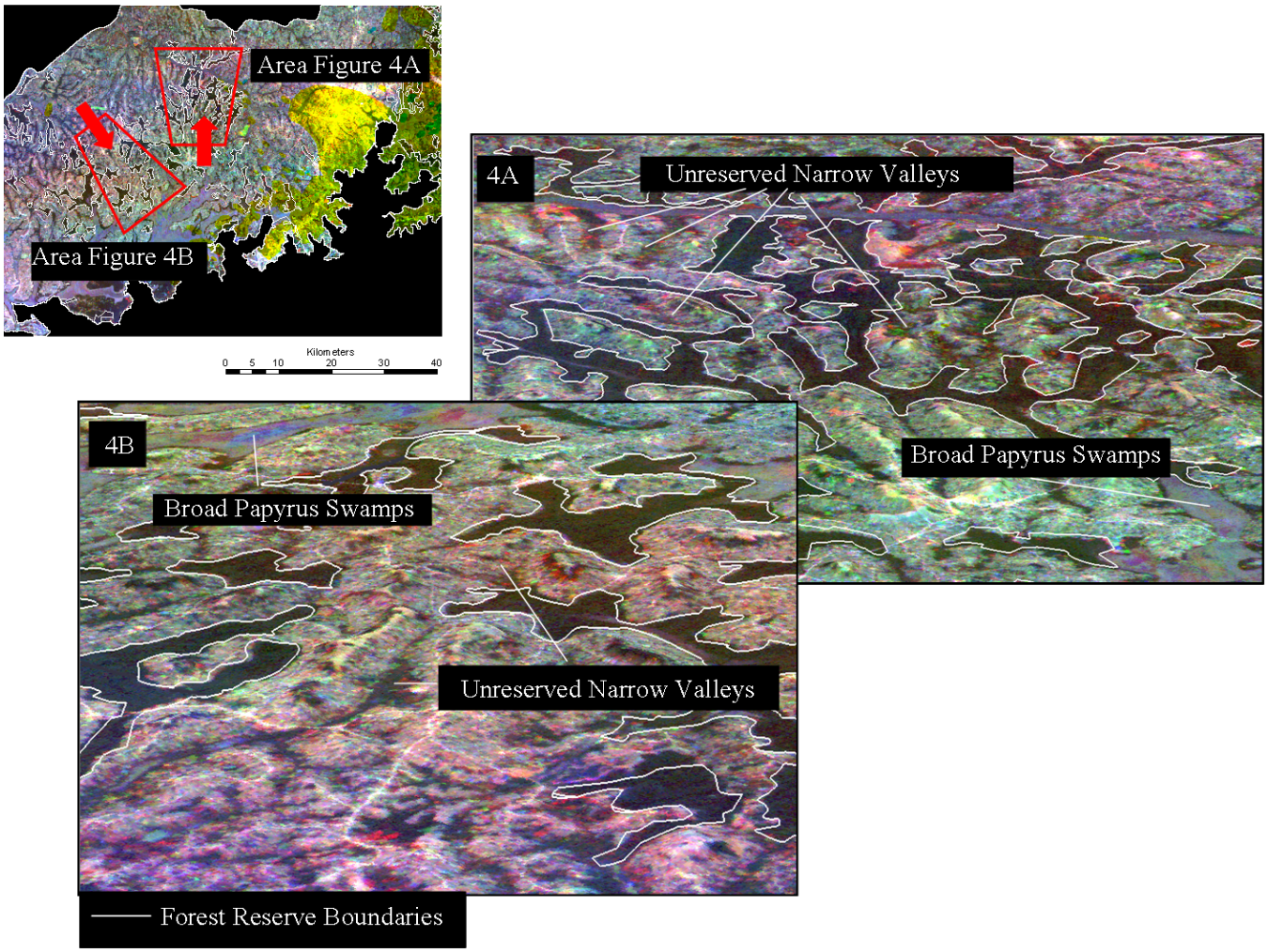
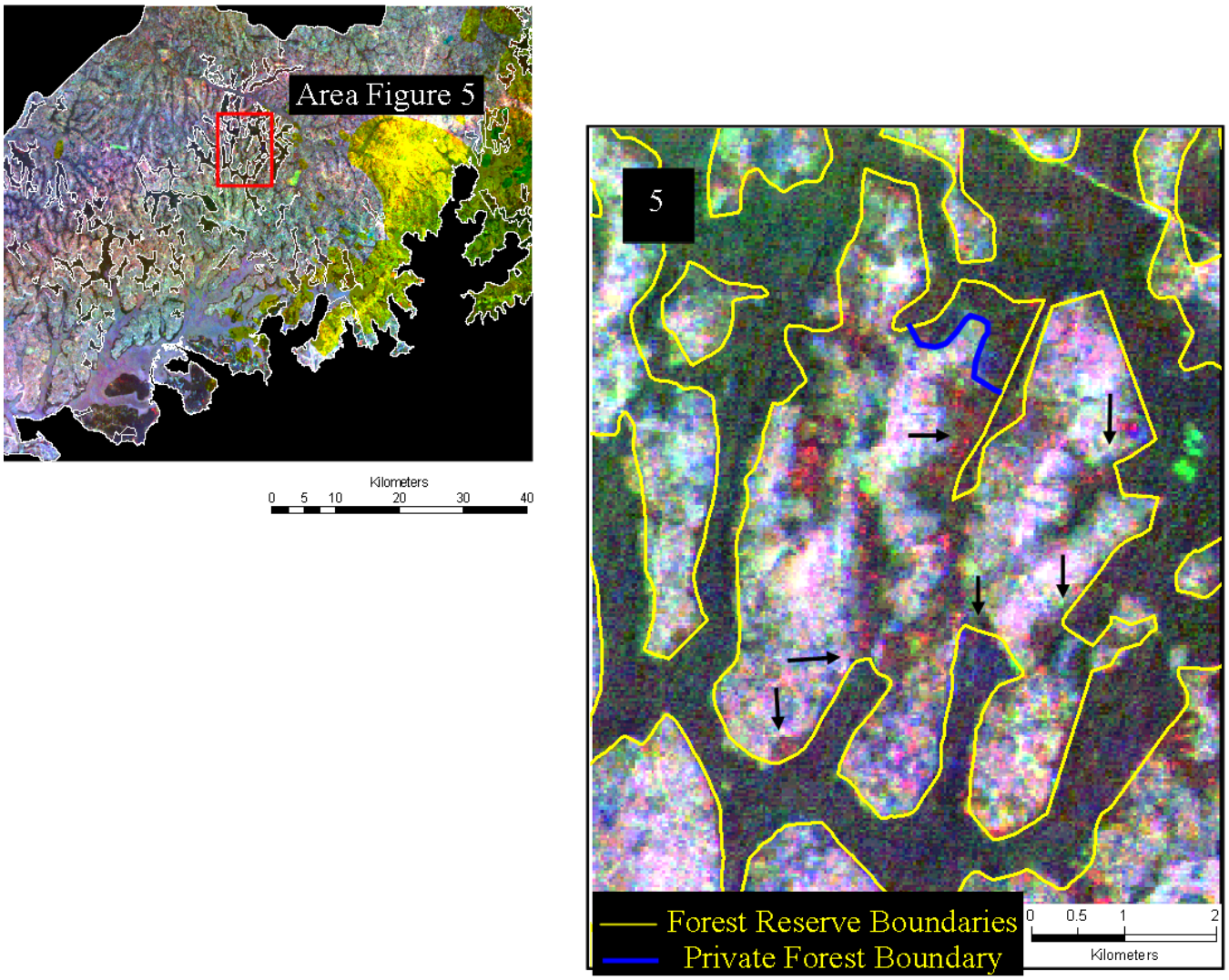


image within the boundaries are dark, with little visible color upon close inspection. This means that the canopy was closed, without exposed soils, on these dates. Harvesting may be occurring within the forest reserves, but it has been at a level and frequency that does not create gaps in the canopy. Such gaps would be brightly visible in the images as in the heavily harvested valley forests outside the forest reserves.

A multitemporal composite constructed in this way may be interpreted as follows (from supplemental online material in Dietz et al. 2003:1):

- **Red:** Forest was stable between the first and second satellite image dates but was cleared by the time that the last image was taken.
- **Yellow:** Forest was cut between the earliest

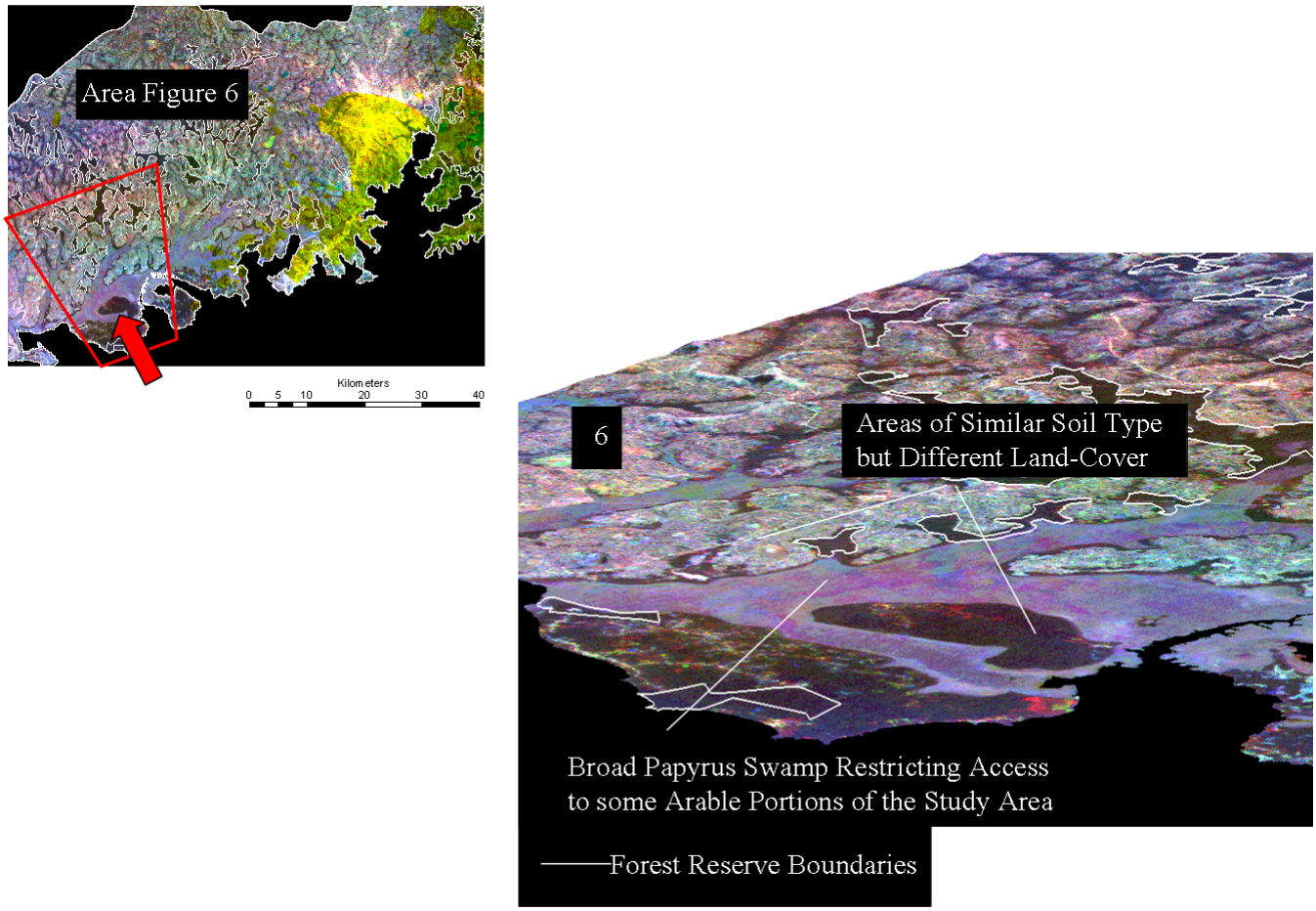
Fig. 5. Multitemporal composite illustrating respect for boundaries of the forest reserves. Red areas indicate a loss of forest cover between 1986 and 1995. Vector coverages delineating forest reserve boundaries extracted from a 1955 topographic map are shown by yellow lines. Black arrows point to areas with heavy forest clearing after January 1986 that proceeded up to, but not beyond, reserve boundaries. This composite was generated with one Landsat Multispectral Scanner image and two Landsat Thematic Mapper images, each acquired in 1974, 1986, and 1995, respectively. The composite was constructed by Nathan Vogt.



and middle image dates and did not regenerate before the last image was taken.

- **Green:** Forest existed when the first image was taken, was cleared before the middle date, and regrew prior to the time that the last image was taken.
- **Blue:** Forest regrew before the date of the middle image and remained as forest until the time that the last image was taken.
- **Black or dark gray:** Forest is stable.

Fig. 6. Subset of the multitemporal composite used in Fig. 2 draped over a digital elevation model (DEM) to illustrate that forest cover stability on these isolated portions of the landscape is due to poor access rather than soil type. As access improves to these areas, we may expect clearing of the nonreserved areas until they appear similar to areas on the opposite side of the wide papyrus swamps. The onset of this process is already evident as indicated by the red and green speckles on forest islands. The composite was constructed by Sean Sweeney.



- **Bright gray or white:** Cleared land, riverbanks, roads, and other nonforested lands that do not change across the three image dates.

Elucidating explanations for long-term boundary stability observed in remotely sensed products

To elucidate explanations for the observed boundary stability, we reconstructed the process of boundary creation and maintenance. We drew on (1) archival records of the British colonial government, particularly past agreements between the British colonial government and Buganda Kingdom, forest department minutes, and policy frameworks that are available at the national archives; (2) past research on the Buganda Kingdom and forest department; (3) in-depth and long-term monitoring studies of nine forest patches in West Mengo conducted by colleagues at Makerere University in Kampala using the International Forest Resources and Institutions (IFRI) Research Program protocol (CIPEC 1994-1999, Gombya-

Table 1. Absolute urban populations in study area: 1980–2002. Table prepared by Nathan Vogt based on the Uganda Bureau of Statisitics (UBOS) data.

Location	1980	1991	2002
Kampala	458503	774241	1208544
Entebbe Municipality	21289	42763	57518
Mityana Town Council	6629	22579	34623
Mukono Town Council	5783	7406	23204
Mpigi Town Council	4577	7283	10217

Ssembajjwe 1996); and (4) personal interviews conducted in 2002 and 2003 with key informants from across this region who aided in interpreting the changes observed in remotely sensed products.

Thirteen villages, i.e., the smallest administrative unit, from across the study area were visited in July 2002. Interviews were conducted with small groups of 5-10 people, consisting of elderly village members and administrators from village councils. These villages were selected by identifying different patterns of directional change observed in remotely sensed products: villages with stable forest cover, dynamic forest cover, and nonforest cover. Traditional village boundaries follow valley bottoms and encompass hills, thus including a portion of the entire soil catena within each village. We conducted interviews in each village to document trends in use and management, and relative scarcity of forest resources between villages with different patterns of directional change in forest cover. We focused on the interplay of the imposed formal institutions, private or state tenure, and traditional arrangements of individual and communal holdings within the village boundaries. Most of our interviews were conducted in villages bordering state forest reserves to derive trends in factors that explain the remarkable stability of reserve boundaries in the West Mengo region. We turn to the other villages only in the discussion to illustrate outcomes in forest cover and village use, and management of forest, tree, and land resources across the soil catena more generally, which occur in the absence of a forest reserve. Information derived from these interviews was then supported with data from in-depth, long-term studies of the influence of institutions on forest patches in the West Mengo region conducted by colleagues at Makerere University (IFRI Network 1992-2005).

In 2003, we interviewed district forest and agriculture officers from the study area, along with a sampling of their subcounty agents. Four interviews were conducted, and 11 key informants participated. Two *Ssaza* chiefs and two subcounty administrators who were also *mailo* landlords from the Mpigi district were interviewed. These informants aided in explaining the impacts of factors at subcounty, district, and state levels on broader trends in land-cover change observed across the West Mengo region in remotely sensed products, including long-term boundary stability and tree-cover change on cultivated lands. We used the aid of both 2002 Landsat images and a time series of aerial photographs from 1955-1995. To protect the anonymity of subjects, we created a confidential list

of persons interviewed and identified them by letters and numbers for referencing purposes in this paper: FO = forest officer or ranger; AO = agriculture officer or extension agent; LC = local council member; LL = *mailo* owner and subcounty councilor; CE = village elder; SC = *Ssaza* chief. Letters were added to the base codes to denote districts, and numbers were added to denote individuals. The first author may be contacted for additional details regarding key informant interviews.

CHALLENGES AND DISTURBANCES TO WEST MENGO FORESTRY INSTITUTIONS SINCE THEIR CREATION

From the time of reserve creation to the time of this study, the resources within the forest reserves and the institutions governing them have undergone various pressures. These include particularly high population densities, urban demands for charcoal and fuelwood, and periods of extreme political and economic turmoil.

Population demands for forest resources

Population pressures on wood resources are high in Uganda relative to other countries in East Africa. Uganda's population growth between 1969 and 2002 was 2.9% compared to 2.0% in Kenya, 2.7% in Tanzania, and 2.2% in Rwanda (UBOS 2002). Over 90% of all Ugandans rely on biomass fuels for energy (Arnold et al. 2003). Rural populations typically consume subsistence products, whereas urban areas consume wood products for construction material, charcoal, and commercial fuelwood.

The demand for wood resources is expected to continue increasing due to the rapid growth rate of the already high population densities in the area. Rural population densities, i.e., densities of local users, in the study area for 1980, 1991, and 2002 were 110, 150, and 220 persons/km^2, respectively. Combined rural and urban densities for the same years were 64, 85, and 126 persons/km^2, respectively (UBOS 1980, 1991, 2002).

Resource demands from nonlocal users

Over the past decade, there has been a high demand for construction lumber and commercial fuelwood, e.g., charcoal, brick burning, and commercial baking needs, from urban centers in the Lake Victoria agroecological zone. High costs of electricity and gas favor continued use of charcoal and fuelwood for domestic and industrial energy needs in urban areas. Over 80% of urban populations in Uganda are reliant on charcoal (MWLE 2000), and the populations in Kampala and the district municipalities that fall within this study area are rapidly growing in response to increasing opportunities in urban areas (Table 1).

Regionally, exceptional economic growth is fueled by the ambitious programs of the Economic Liberalization on the African continent (Reinikka and Collier 2001). Recent improvements in extent and quality of road conditions in the study area make the urban centers readily accessible to rural populations and, conversely, rural forest resources in the study area readily accessible to urban entrepreneurs.

Economic turmoil and war: 1972-1985

Forest management was centralized in 1966 when a new republican constitution was promulgated. Forest reserves were managed under a strict, central command and control from 1966 until 1997 at which time a decentralization policy was implemented. Under the Amin regime from 1971-1979, a new land decree that abolished *mailo* land tenure was introduced. *Mailo* owners became leaseholders with legal rights to holdings, but tenant (*bibanja*) occupancy was not legally recognized, relegating them temporarily to squatter status (Bikaako 1994).

Civil war was fought in this area between 1980 and 1985. This drove occupants to urban centers and western Uganda, reducing pressure on forest reserves and allowing regeneration of trees on individual lands outside reserves, as observed in Fig. 5. Both *bibanja* tenants and *mailo* owners began to reclaim their rightful holdings in 1986 (Gombya-Ssembajjwe et al. 1994), resulting in the reclearance of trees on lands outside the reserves, and further increasing local pressures on reserves.

RESULTS: HISTORY OF FOREST RESERVE BOUNDARIES IN WEST MENGO

Negotiation

All of the land in the West Mengo region of the former Buganda Kingdom was formally titled as either private *mailo* land or crown land under the 1900 agreement between the regents of Buganda Kingdom and the British colonial government. It was determined that the government could claim control of "those forests over which no private claim can be raised justifiably," according to clause 15 of the 1900 Buganda Agreement. Shortly after the signing of this agreement, international prices for rubber made rubber tapping lucrative. When regents of the kingdom discovered that some of the forests on crown land contained rubber trees, they rejected the terms of the 1900 Buganda Agreement, which would have prohibited access to these lucrative trees. The Buganda Agreement was renegotiated. Under the Uganda Memorandum of Agreement (Forest) 1907, it was agreed that the colonial government could claim control of the lands that were not declared as private and were one-half square mile or more in extent (Thomas and Spencer 1938, Sangster 1950).

The colonial government of Uganda convinced kingdom leaders of the importance of maintaining large tracts of forest. They claimed that large tracts of forest were necessary to maintain favorable climatic conditions for tree production. They also explained that by applying western scientific management techniques, these forests would continue to produce the timber and fuelwood needed for future growth in Kampala (SCB6 and SCM7 2003, *personal communication*). Regents of the kingdom agreed to grant the colonial forest department control over some of the forests, which are the central forest reserves that exist today.

The primary goals of formalizing ownership in this area were (1) to reduce tensions between clans in Buganda and win support of these chiefs and (2) to create a middle class of landed cash crop producers (Richards et al. 1973). Forests would aid in maintaining productive capacity and supply Kampala with timber and fuelwood.

Process of identifying boundary locations: soils, customary tenure, and land-use divisions

In many regions of Africa and Asia that support tropical forests, colonial resource management strategies were aligned with the goal of maximizing revenues for colonial governments (Richards and Tucker 1988, Alcorn 1996). In general, the colonial approach to achieving both agricultural and forestry goals was to spatially divide the landscape into nonoverlapping uses and maintain these zones over the long term. Soils suitable for crop production were often privatized, and soils less suitable for crop production became candidates for reservation. Government-controlled forest reserves were often allocated to areas with less productive soils, and the more productive soils were kept for productive uses, rather than for forestry uses.

Sedentary agriculture in the West Mengo region was typically not practiced on soil types found within today's state forest reserves, as they occur mostly on seasonally inundated soils in wide valleys. The dendritic pattern is readily observed in the satellite images (Fig. 2). Poor soil drainage in most central forest reserves prohibits permanent agricultural production using current production technologies, but occasional cropping in dry seasons and higher levels of harvesting are possible and practiced in forested valleys outside forest reserves in West Mengo (Fig. 4).

In West Mengo, as in some other regions of sub-Saharan Africa, prescriptions were sought that would maintain and increase productivity of those soils deemed appropriate for sedentary agricultural production. However, the mapping of soil distributions and formal delineation of land uses based on such an analyses was costly for many colonial forest departments. Another approach was to formalize traditional land-use distributions, e.g., cultivated land and forested lands, but this was also problematic as land uses and traditional tenure patterns at a given point in time are not only a function of soil distributions. For example, these often changed over time due to conflicts, disease outbreaks, or as a function of shifting practices as a soil management strategy.

In the West Mengo region, this problem was resolved by first negotiating with authorities in the upper echelons of the kingdom the areas to be used for state forestry activities, and then specific delineation of the boundaries for each reserve was

conducted with the appropriate local leaders and users at the community level. Due to this process, the reserve boundaries broadly matched informal land-use boundaries between forestry and sedentary cultivation, which are conterminous with broad patterns of soil-type distributions in the study area.

Arguably, costs of delineating land uses by soil types, which first required accurate soil mapping, were reduced through this process. Also, this process arguably explains the relative lack of conflicts over rights of access of individuals to productive land and forest resources today, as exist in other former colonies. Again, the process of first working closely with both upper-echelon authorities to allocate land uses and local leaders and users to delineate forest reserve boundaries contributed greatly to reducing conflicts and the costs of land use zoning by soil type. Identification and mapping of soil and vegetation, in an effort to identify appropriate land uses across all of Uganda, did continue into the next decades (Radwanski 1960, Langdale-Brown et al. 1964, Langlands 1971).

The upper echelons of the kingdom did not agree to place all of the valley forests in West Mengo under reserve, and the use and management of resources today does differ between valleys under reserve and those that were not reserved. In unreserved, formerly forested valleys there is a higher level of stem harvesting, and occasional dry season cropping followed by abandonment, which does not allow tree regeneration to the point of canopy closure. Due to soil exposure, these valleys appear bright in a multitemporal composite, or dark with red and green speckles, rather than dark as they do within reserve boundaries, in which closed canopy forests are maintained (Figs. 2 and 4). However, this use and management strategy, practiced in valleys outside reserves today, is regulated by community members, and does not necessarily jeopardize the flow of forest products on which community members depend.

Boundary delineation and demarcation

Private *mailo* land was demarcated first. Demarcation began in 1904 and ended in 1936. *Mailo* boundaries were demarcated with earth cairns. *Dracaena* sp. shrubs were planted at each cairn. *Ficus natalensis* and *F. brachypoda* were also used in boundary demarcation. *F. natalensis* and *F. brachypoda* were planted as boundary trees because they could be harvested for bark cloth without felling the tree. These species were used to demarcate individual landholdings in precolonial Buganda, and served to aid in managing boundary conflicts (Nsibambi 1987). If an individual in precolonial Buganda wanted a plot of land, the seller approached the village administrator. Upon the consent of the administrator and clan elders, the seller, land purchaser, administrator, neighbors, and clan elders would walk the boundaries together. *Dracaena* sp. bushes were then planted to demarcate the boundaries. Locations of boundaries to individual holdings are generally known in a village, or can readily be determined by consulting those who originally created them, finding boundary markers, or by observing the deep fallow lines that were dug, at the time of planting, to delineate individual holdings (MLC8 2003, *personal communication*). Traditional Buganda land boundaries are associated with rights for control of land. In Buganda, there are four categories of rights to land (Mukwaya 1953, Gombya-Ssembajjwe 1985): (1) clan rights, (2) rights of kings and chiefs, (3) individual hereditary rights, and (4) smallholder rights of occupation.

Delineation and demarcation procedures are the same today. However, the seller and prospector must approach the *mailo* owner rather than the administrator if interested in a plot of unoccupied, nongovernmental land. Today, the *mailo* owner walks the plot boundaries with the land prospector, administrator, neighbors, and clan elders who also sign the agreement. The titles of local administrators have changed, e.g., “appointed kingdom chiefs” to “elected local councilors,” but responsibilities for boundary governance have remained the same (all CE 2003, *personal communication*).

Smallholder farmers with traditionally recognized claims to land have maintained these claims even though they were located on *mailo* lands. In some cases in North America, England, Brazil, and India, formal enclosures that reduced user access rights spurred violence and drove peasants to forest frontiers or urban centers (Guha 1985, Allen 1992, Baland and Platteau 1996). *Mailo* properties were not enclosures that reduced rights of access to land for Baganda smallholders. Smallholders who in precolonial times had maintained secure rights to land through tributes of produce (*nvujjo*) and labor (*busulu*) to clan elders or administrators became *bibanja* on *mailo* landholdings. *Mailo* owners could

also collect taxes from *bibanja* in the form of tributes or labor in the early part of the century. Security in *bibanja* tenancy has fluctuated over the past century, but has generally increased. That is, these smallholder farmers were not rendered landless and forced onto protected or marginal lands. Even if evicted, they would seek tenancy with another *mailo* landlord rather than attempt to illegally squat within the frequently monitored and enforced forest reserve boundaries.

After the completion of *mailo* boundary demarcation in 1936, demarcation of the central forest reserves would begin. In the 1930s and 1940s, the forest reserve boundaries were demarcated with earth cairns covered by stones. The *mutuba* (*F. natalensis* or *F. brachypoda*) or a specific shrub (*Dracaena*) sp. was, and still is, planted at each cairn. Boundaries were marked at each turning point and at center points of unusually long straight lines (Sangster 1950). Relevant *mailo* owners, clan elders, and traditional administrators were present during the process of demarcation of forest reserve boundaries. This served to ensure agreement on the location of the reserve boundary and bring legitimacy of those boundaries in the eyes of smallholders, i.e., local leaders and users, dependent on those resources.

Since the time when the central forest reserves were demarcated, the forest department has periodically "redemarcated" the original boundaries. Community members have always been hired to aid in this effort, which serves to maintain awareness of the precise location of these boundaries across generations. Development of any kind within these boundaries is not permitted. Violators are consistently prosecuted, through the administration of prescriptions and a forest management working plan, which was implemented in 1950. During the first boundary redemarcating effort, conducted in the late 1940s to early 1950s, the tree species *Senna spectabilis* was planted at each cairn. This tree has yellow flowers to make forest reserve boundaries more visible for monitoring, both on the ground and from the air.

Boundary monitoring and enforcement

Regular monitoring, enforcement of use, and management prescriptions for forest reserves developed by the colonial forest department were conducted by the forest department. The colonial government did not feel that local kingdom administrators had the capacity to manage the reserves to maintain production of either subsistence products or commercial products. This was a common sentiment among British colonial foresters (Baland and Platteau 1996). In Uganda, authority over forest reserves was decentralized to the respective district forest officers by 1950 (Forest Department of Uganda 1950).

District forest officers create forest management plans and coordinate reserve monitoring by forest rangers (Banana et al. 2005) who are assigned to each subcounty. Rangers are assigned by the district forest officer, but must keep in good standing with subcounty authorities. Rangers who were respected by local chiefs, e.g., traditional administrators, worked with chiefs and district forest officers to ensure that proper management practices were implemented (Sangster 1950). Up to the time of this study, rangers still worked with administrators at the subcounty level and kept in good standing, despite fewer interactions due to budget cuts (Banana et al. 2005).

This arrangement has continued to provide local administrators and users with a mechanism to block the assignment of a mistrusted ranger or to remove one for not performing duties in a manner acceptable to local leaders or users. This makes state monitors accountable to local administrators and, in turn, local users. However, it is unclear how the current restructuring of the forest department will affect the important relationships among the local authority, ranger, and district forest officer. Rangers are trained in forestry management at Nyabyeya Forestry College, which opened in 1948. Thus, they continue to bring current knowledge of forest management practices to local leaders and users. The structure of the colonial forest department, the areas of forest under their control, and the responsibilities of enforcement and management were retained by postcolonial regimes until recently. Some of these responsibilities have been shifted away from district forest offices to local governments under the 1997 Local Government Act (Banana et al. 2005), and a new Forest Act was also passed in 2003, but the influences of these are beyond the scope of this study.

After the forest reserves were gazetted and demarcated, there was strict resistance to subsequent encroachment. One district surveyor acquired the title of "The Lion of Kyagwe" for his

insistence on the strict enforcement of these boundaries (Thomas and Spencer 1938, Sangster 1950). In the years after demarcation, there were some cases in which trespassers were issued with "licenses to reside." At the same time, the forest department planted the land with timber trees, which eventually drove the trespassers from the land (Forest Department of Uganda 1950).

Trespassing is rare as valley conditions are less conducive to traditionally practiced production systems than the *mitala*, and most residents are aware that they will eventually be evicted and lose their investments. Although valleys have relatively unfavorable ecological conditions for permanent cropping, large-scale forest patches do not exist in other narrow valleys in West Mengo due to relatively higher levels of harvesting and occasional cropping (Fig. 4). Traditional authorities in the Buganda hierarchy are currently using the political process to gain more control over the forests, but they recognize and urge those in the lower kingdom echelons to recognize the current reserves created through negotiations by ancestors in previous Buganda administrations. Cases of encroachment with the intent for permanent agriculture are rare even today due to continued good monitoring and enforcement by local authorities, elders, and the community as a whole.

Some of the communities in which we conducted interviews were those without any observable forest cover in remotely sensed images. In these cases, in which forests are privately owned, community members are not out-migrating or traveling long distances to obtain subsistence forest products, but rather are able to obtain them largely from the trees in agroforestry systems and home gardens (Vogt et al. 2005*b*). Thus, simply reinforcing local forest management strategies in West Mengo alone would not have achieved the same result desired by the forest department, and more recently by habitat conservation groups, i.e., large forest patches produced by the process of reserve creation described herein.

The colonial government adopted traditional mechanisms of conflict resolution and boundary establishment, which are still practiced today (MLC8 2003, *personal communication*). That is, traditional Baganda mechanisms for boundary conflict resolution on individual holdings are similar to those used for conflicts over reserve boundaries. Local administrators may not prevent a farmer, e.g., a *mailo* owner or *bibanja*, from expanding their plots beyond the boundaries of the forest reserves or onto other smallholders' individual holdings. However, if discovered by a forest guard, the encroacher will be evicted and their property will be confiscated. Such cases are adjudicated at the subcounty courts created by the colonial government and recognized by Buganda Kingdom. Likewise, if an individual reports someone for encroaching on his/her individual holdings, the encroacher, if found guilty, will be evicted by the local administrator and elders or by the subcounty courts if a resolution is not found locally (MLC8 2003, *personal communication*).

Traditionally, adjudication of boundary infractions was a responsibility of village administrators, i.e., the lowest administrative level, clan leaders, and village elders. However, if a ruling could not be reached at these levels, they would progressively move up the kingdom administrative hierarchy until a decision could be made. If administrators, clan leaders, or village elders were unable to make a ruling, the *kabaka*, i.e., the king, would make a final ruling (MLC8 2003, *personal communication*). Again, the process is very similar today to that of precolonial times in regard to property encroachment. A forest ranger who finds someone cultivating within reserve boundaries may first try to find a resolution among local administrators, village elders, and *mailo* owners. Then, if a resolution is not reached at this level, rulings are sought at the subcounty courts. Today, if a ruling on a conflict over individual holdings is not reached by local authorities, e.g., councilors, clan leaders, or elders, a final ruling will be reached at the subcounty level by a magistrate appointed to the district by the judicial service committee of the central government, rather than proceeding to the king for a ruling (MLC8 2003, *personal communication*).

After guilt in forest encroachment is determined, government surveyors together with local administrators, elders, and *mailo* owners will determine the precise location and re-establish the forest reserve boundary as is the process used for re-establishing boundaries of individual holdings. Both processes of boundary re-establishment for forest reserves and individual holdings include the types of plants used and the use of the appropriate local leadership in literally walking these boundaries to ensure agreement by all parties in the boundary location.

Rights of forest-reserve use: de jure and de facto uses and forest-cover outcomes

Water, construction poles, fuelwood, and plants used for basket making were, and still are, the main products extracted from the West Mengo forest reserves. Local forest users maintained the rights to extract these products. Thus, the local, subsistence use patterns in government-owned forests were not altered under the colonial agreements with the regents of the kingdom. Local users still maintain the right to remove dead wood for fuel, poles, water, and plants. However, access to commercial trees, i. e., timber and fuelwood species, were regulated, monitored, and enforced strictly by the colonial government and by the postcolonial government from the 1930s until 1997 (Banana et al. 2005). Users, either local smallholders or logging companies, must not fell live, mature stems >10 cm dbh from these forest reserves for personal or commercial purposes without following existing state guidelines.

A forest ranger will usually evict someone caught squatting or expanding crop production beyond the boundaries of a forest reserve. However, a ranger may not always prosecute illegal harvesting of timber or charcoal products. Rangers may not be able to identify the guilty party, may be bribed, or may not be overly concerned with the observed infraction (FO1, FO2, and all CEs 2003, *personal communication*).

Short-term encroachments for timber or charcoal harvesting, followed by a single-season production of horticultural crops, do occur. However, forest regeneration, and thus canopy closure, is rapid even in the seasonally inundated valleys, which are less conducive to the prevailing production system (FO1 and FO 2003, *personal communication*). These short-term encroachments into the forest reserves of West Mengo are difficult to observe with Landsat image analyses sampling at 10+ yr intervals. This is why there are often conflicting projections of the fate of state-held forests in this area. As casual observers toured these forest reserves in recent decades, they likely noticed clearings for the illegal harvesting of charcoal or timber at various locations within the reserves. Areas illegally cleared, by local rather than nonlocal entrepreneurs, are abandoned and left to regenerate, because they will be more closely monitored and perhaps enriched. These areas regenerate in relatively few years to a closed canopy system, and may not be permanently deforested.

DISCUSSION AND CONCLUSIONS

In West Mengo, we elucidated key aspects of the process of reserve boundary "creation" that increased local legitimacy and reduced forest department costs of enforcement over time. These include: (1) negotiation of reserve creation with traditional leaders and local users, including a perceived legitimacy among kingdom leaders of the rationale for their creation; (2) use of traditional mechanisms for boundary establishment and re-establishment; (3) agreement on location of both individual holdings and reserves, i.e., joint land use zoning, prior to reserve boundary demarcation; and (4) boundary demarcation process, i.e., walking boundaries with relevant stakeholders and leaders, and types of markers used similar to those used by local leaders and users. In West Mengo, we found joint that allocation of land uses, or joint zoning of the landscape, e.g., sedentary agriculture and forestry, took place before rules of use and access to forest resources were jointly devised.

Key aspects of the process of reserve boundary "maintenance" in West Mengo that resulted in the observed long-term stability include: (1) assignment of trained forest rangers to lower-level administrative units, partly accountable to those administrators in addition to the district forest officer, to monitor boundaries and forest use and enforce rules; (2) sufficient ranger salaries and budget for frequent monitoring activities; (3) consistent enforcement of penalties by rangers for rule infractions; (4) hiring of local users to reopen recognized boundaries vs. forcing users to redemarcate contested boundaries; (5) local-level adjudication of conflicts, similar to traditional processes of boundary adjudication within the Buganda administrative hierarchy; (6) establishing and re-establishing boundaries with locally recognized and understood mechanisms; and (7) continued observation of local rights to harvest subsistence forest products within reserve boundaries.

Flexibility to facilitate adaptation and change may be a requirement hindered in the West Mengo case. Having rangers assigned to subcounty levels does

nest authority from local to higher levels, thus, creating a better opportunity to assess those local needs, and to devise and update institutions compared to command-and-control arrangements. However, the ability of local groups to organize and propose spatial changes in land use and harvesting levels to higher-level authorities, which was found to be present in the precolonial traditional arrangements, is not in the current state forestry arrangements (Vogt et al. 2005*b*). Rules of land use and harvesting remain fixed without a mechanism to renegotiate these rules among all stakeholders as conditions and priorities change. For example, in other communities in the West Mengo region, in which valley forests are not reserved, the communities occasionally clear portions of the valley forest to produce charcoal during the dry season. Then, food crops, e.g., *solanum anguivii* (Ntula), *solanum* sp. (Nakati), *cleome gynandra* (Jobyo), and *Amaranthuss hybridus* (Bugga), are planted in those opened areas and harvested before the following rainy season. Excess food crops are sold. Finally, these charcoaled areas are abandoned for several years to allow regeneration. This cycle of activities is primarily conducted by the poorest of the community to enhance incomes. This is not because of a breakdown in traditional institutions for resource management, but in the cases observed was found to be permitted and regulated by elders, local authorities, and other members of the community. As long as the flow of subsistence products to the community was not perceived to be jeopardized by these practices, they were permitted. That is, contrary to some arguments within the forestry and conservation fields, local communities in some cases do find ways to maintain the flow of subsistence forest products, under considerable pressures, without the maintenance of a large forest patch (Vogt et al. 2005*b*). Members of communities bordering forest reserves of West Mengo are unable to change resource-use practices in this way to increase income levels, even though the practices may be sustainable in regard to the ecosystem goods and services of interest to them.

Monitoring and enforcement of the forest reserve boundaries in West Mengo by rangers appears to be relatively more effective than in other cases in which underpaid guards are bribed to permit encroachment. Both rangers and forest reserve users stated that on occasion, rangers accepted bribes to allow the illegal collection of restricted products, but they never allowed expansion of agriculture into the boundaries even though occasional cropping in a dry season was possible. This is not due to one factor, but to a combination of several factors that came together as a result of the ad hoc process of institutional creation that happened to apply many of the design principles mentioned earlier in the text.

Delineation of boundaries, land use in this case, and creation of resource-use rules followed traditional processes, making the reserve boundaries relatively more legitimate among local users. Even if local users envision alternative practices, there would be consequences from traditional and state authorities. Rather than illegally encroach, they are relatively more likely to engage in this process again to make changes in the rules of land use and harvesting levels. For example, traditional authorities are currently negotiating with the central government for greater control over these reserves, and would likely change the rules of land use and harvesting levels if they were to gain control.

Another reason for the relatively more effective monitoring and enforcement is that the boundaries are well demarcated and, thus, the costs of monitoring, on foot or from the air, are relatively less expensive than in other cases. All stakeholders know precisely where the boundaries are located; they are visible, and community members are periodically hired to reclear, making the locations and rules known from one generation to the next. If a ranger were bribed and allowed encroachment, both the authorities in the forest department and local authorities would readily detect the expansion beyond reserve boundaries during the next reopening, and there would be consequences for the ranger. This makes the ranger both upwardly responsible to higher-level forestry authorities and downwardly responsible, because they must keep in good standing with local authorities. A final reason for the relatively more effective monitoring and enforcement is that when other members in the community observe illegal practices, they often report the observed illegal increase in income relative to their own, out of jealousy. Again, the conflict resolution mechanism is initiated in these cases. If the encroacher cannot be persuaded to leave, by elders or community-level authorities, the case moves up to the higher-level forestry and court officials who consistently evict and confiscate tools.

Social capital in the study area was and is high. The clans composing the Kingdom have long organized within and between each other, under both clan and Kingdom leadership, to fight wars, clear roads for

Kingdom trade, and maintain wells, for example. The powerful Buganda Kingdom wielded considerable influence over the colonial process of land tenure, e.g., *mailo* and state forest reserves, creation, and maintenance in the West Mengo region. In combination, these factors, in the process of forest reserve design and creation, explain the observed stability of forest reserve boundaries.

Explaining complex human-environment interactions may require the simultaneous application of multiple methods, including a historical component to each. Archival research and interviews with elderly residents, government agents, and traditional authorities aided in constructing a narrative of the mechanisms of change observed in a time series of remotely sensed images (Vogt et al. 2005*a*). We tested our hypothesis about causes of forest reserve stability within the West Mengo region by applying these methods to first construct the processes leading to the stability observed within reserves. We then interpreted the constructed processes of reserve creation and maintenance to see if they adopted the design principles proposed for robust commons governance. This may be termed an applied historical ecology approach, heeding calls to consider historical processes and context in studies of forest change (Fairhead and Leach 1998, McCay 2002, Brondízio 2006, *in press*). The use of such an approach promotes greater attention to long-term processes and takes into consideration variation in ecological, cultural, socioeconomic, sociopolitical, and historical contexts across space when investigating local resource use and management. Here, this approach was integrated with the application of the institutional analysis and development framework to organize the working parts and their relationships (Ostrom et al. 1994, Ostrom 2005).

Institutional arrangements for governing those forest patches within reserves in West Mengo were recently redesigned, culminating in the 2003 Forest Act. This study creates the opportunity to compare the impact on forest cover and ecology of the process of institutional design presented here with that of the current arrangements. The impact may take several years to adequately express itself for comparison. By 2010, there will be four studies completed in each of the International Forest Resources and Institutions (IFRI) sites established in West Mengo, and the impact of the recent forest reserve arrangements, under the conditions of high pressure, may well have expressed themselves by then. Using forest plot data and satellite images, corresponding to each IFRI revisit date, i.e., 1995, 2000, 2005, and 2010, we could conduct detailed ecological assessments of the effects of changes in resource use and management, e.g., illegal encroachment and resource collection practices, resulting from the redesign of these forest reserve arrangements. This study also creates the opportunity to apply these methods to compare and contrast the process of protected area creation and maintenance in other forest biomes, with other ethnic groups, and examine how that process has affected the management of common-pool resources in those regions.

Recommendations

Forest reserve boundaries in West Mengo could be relaxed, or reallocated, to accommodate local institutional and resource-use changes currently underway there. Relaxation of reserve boundaries to support local priorities in forest management may not lead to the continued maintenance of the large forest patches, under prevailing conditions, as observed within reserve boundaries at the time of this study. However, it may result in improved management of locally important forest resources and services and an increase in income levels. That is, as observed, communities that do not contain large forest patches are able to maintain the flow of subsistence forest products and locally relevant ecosystem services while using formerly forested valleys to enhance incomes (Vogt et al. 2005*b*). Robust commons institutional arrangements, e.g., human organization to regulate use and management of a common-pool resource, are those that maintain the "flow" of goods and services desired by members of the collective over the long term. When institutions falter, there is a depletion or absence of the flow of either goods or services desirable to members. We cannot assume that large forest patches are needed by local users to maintain the flow of goods and services from systems of importance to them, as there are examples of some communities that have robust institutions governing that flow without maintenance of a forest patch, also an example of good resource governance by the above definition.

However, if state and global stakeholders desire to maintain large forest patches in West Mengo for reasons important to them such as timber, biodiversity conservation, carbon sequestration,

etc., the arrangements described herein, updated to also reflect current goals and resource management strategies of local users, may have sufficed. The recent attempts to redesign or replace these arrangements may not be supported by traditional Buganda leadership, and may become less legitimate among local users if they do not include (1) the participation of locally legitimate authorities, e.g., upper-echelon kingdom administrators and local authorities in the West Mengo case; (2) land-use rezoning to meet current, local priorities; or (3) boundary delineation of those zones by appropriate administrators and members of local communities. A deficient approach to updating arrangements, which was the case when decentralization was attempted in 1995 and perhaps also the case in the preparation of the 2003 Forest Act, may lead to a worse-case scenario for all stakeholders, producing perverse incentives that drive local users to change use and management strategies in a way that jeopardizes the flow of goods and its benefits to them, and ecosystem services to nonlocal users. In such cases, it may be better to simply relax the boundaries and return forest patches to traditional authorities, when local users would be less likely to suffer from the tragic consequences.

A better approach to successfully maintain the flow of goods and services desired among all stakeholders in West Mengo, as in the first 50 yr of reserve existence, including maintaining the presence of large forest patches for ecosystem services more important to nonlocal users, may be to strengthen and update the existing arrangements described herein, rather than replace them. This could possibly be achieved by entering into informed discussions with a forum of stakeholders from multiple levels of governance, including customary authorities, e.g., *ssaza*, or county, chiefs, thus, replicating the original process of creating the institutional arrangements for forest reserve governance. This may also serve to strengthen, rather than remove, the complex cross-scale, i.e., nested linkages of users and authorities and, thus, improve general adaptiveness of these arrangements to changing challenges, an important design principle that was missing in the original arrangements.

The broader implications of this study are that a rapid assessment of local human-environment interactions, e.g., one-time photos of illegal charcoaling, timber harvesting, or cropping, may result in a "misreading" of the interaction followed by similarly rash decisions to intervene and disrupt a delicate dynamic between stakeholders, e.g., local users, administrators, elders, and the forest department in the West Mengo case. Stakeholders in the global commons may achieve quite different results from what they expect if they decide to replace all existing arrangements across sub-Saharan Africa with "one-size-fits-all" solutions such as pervasive implementation of contemporary versions of centralized command and control, devolution of authority over forests away from central forest departments to local administrative units, or a single form of joint management.

This case illustrates that when design principles, outlined in Ostrom (1990), and further discussed in Dietz et al. (2003), for robust large-scale commons are adopted in the process of creating, and maintaining institutional arrangements for governance of large extents of working forests, the arrangements and desired outcomes of a more diverse set of stakeholders, e.g., both maintenance of stable forest cover for forest conservationists and the flow of subsistence products to local users in the West Mengo case may endure over the long term under high population and market pressures. When these principles are not adopted, we hypothesize that one is likely to observe a relatively fast breakdown in the institutional arrangement, resulting in unintended outcomes for some or all stakeholders, even under less extreme conditions.

Responses to this article can be read online at:
http://www.ecologyandsociety.org/vol11/iss1/art38/responses/

Acknowledgments:

We would like to acknowledge the Ford Foundation and the National Science Foundation (grant SBR9521918) for their financial support, the administrative authority in Kalangala for their assistance, and local communities and key informants for their patience. We also acknowledge the useful comments and criticisms from Arun Agrawal, Eduardo Brondízio, Clark Gibson, Elinor Ostrom, J. C. Randolph, Jon Unruh, Matt Auer, and four anonymous reviewers. We greatly appreciate the thorough editing of Joanna Broderick and her preparation of this manuscript for submission. We thank Sean Sweeney for his assistance with preparation of the figures.

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