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A century of village mobilities and landscape dynamics in a forest-savannah mosaic of the Democratic Republic of Congo



Photo 1.
Wet herbaceous savannah with a forest patch in the background,
characteristic landscape of the study area.
Photo C. Demichelis.

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RÉSUMÉ

Effets d'un siècle de mobilité villageoise sur la dynamique paysagère d'une mosaïque forêt-savane en République démocratique du Congo

Sur les lisières de la forêt du Bassin du Congo, où les mosaïques de forêt et de savane dominent les formations écologiques, il est important de connaître le mode d'évolution de ces mosaïques, notamment pour mieux protéger la forêt. Les savanes sont-elles le résultat de la déforestation, ou ont-elles été envahies par des îlots forestiers ? Compte tenu de l'ancienneté de l'occupation humaine dans cette région, cette question doit être abordée par le biais des relations humaines avec l'environnement au cours du temps. Le rapprochement entre les histoires orales sur la mobilité villageoise et l'analyse géographique d'une mosaïque forêt-savane en territoire Bolobo (RDC) renseigne sur la dynamique paysagère de la région. La présente étude s'est basée sur neuf mois d'observation participative quotidienne des pratiques d'utilisation des sols, 40 entretiens individuels et 18 groupes de réflexion mis en place pour analyser l'évolution de la mobilité villageoise de la fin du 19^e siècle à nos jours. Plusieurs cartes ont été produites en intégrant les histoires orales sur la mobilité villageoise passée et l'évaluation de 44 repères GPS correspondant à d'anciens villages. Deux analyses en composante principale (ACP) sur la composition paysagère d'une zone tampon dans un rayon de 250 m autour des repères GPS, selon une carte du couvert terrestre qui distingue 11 catégories paysagères, ont permis de documenter l'envahissement d'anciens villages abandonnés par la forêt et l'effet de la distance depuis les villages actuels. Le couvert forestier s'est étendu dans les villages abandonnés et dans la savane en conséquence d'une eutrophisation environnementale favorisant l'installation de la forêt. L'exploitation forestière décroît à mesure que l'on s'éloigne des villages actuels en raison de la transition d'un mode d'existence semi-sédentaire dans des petits hameaux vers une existence entièrement sédentaire dans des villages étendus plus grands. Les transformations des modes d'existence pendant et après la colonisation ont provoqué un déclin de la qualité des biens environnementaux et du bien-être des populations humaines. Ces constats peuvent contribuer à une meilleure sensibilisation sur des pratiques et des besoins parfois méconnus dans les efforts des ONG pour la conservation et le développement.

Mots-clés : colonisation belge, services écosystémiques, changements des moyens d'existence, sédentarisation, expansion forestière, analyses géo-historiques, Bassin du Congo, République démocratique du Congo, Afrique.

ABSTRACT

A century of village mobility and landscape dynamics in a forest-savannah mosaic of the Democratic Republic of Congo

Along the edges of the Congo basin forest, where forest-savannah mosaics are the main ecological formation, it is important to determine how this mosaic has developed, particularly for forest protection. Have savannah lands resulted from deforestation or have forest patches expanded into them? Given the long-standing human occupation of this region, this question needs to be addressed through human-environment relationships over time. Combining oral histories of village mobility and geographical analyses of a forest-savannah mosaic in the Bolobo territory (Democratic Republic of Congo) can shed light on the landscape dynamics. This study involved nine months of daily participant observations of human land use practices, 40 individual interviews and 18 focus groups to analyse changing village mobility from the late 19th century to the present. Several maps were produced by combining oral histories of past village mobility with an evaluation of 44 GPS landmarks corresponding to former villages. Two Principal Component Analyses (PCA), based on landscape composition within a 250 m-radius buffer zone around the GPS landmarks, according to a land cover map classifying the landscape into 11 categories, were used to document forest expansion into old abandoned villages and the effect of distance from currently inhabited villages. Forest cover expanded into the abandoned villages and the savannah as a consequence of environmental eutrophication facilitating forest establishment. Forest use decreases with distance from currently inhabited villages as a result of a shift from semi-sedentary livelihoods in small settlements to entirely sedentary livelihoods in larger, extended villages. Livelihood transformations that took place during and after colonisation resulted in a decline in the quality of environmental goods and reduced the well-being of human populations. These insights can help NGO conservation and development efforts to be more sensitive to overlooked local human practices and needs.

Keywords: Belgian colonisation, ecosystem services, livelihood changes, sedentarisation, forest expansion, geo-historical analyses, Congo basin, Democratic Republic of Congo, Africa.

RESUMEN

Un siglo de movilidad de los pueblos y la dinámica del paisaje en un mosaico de bosque y sabana de la República Democrática del Congo

A lo largo de las lindes del bosque de la cuenca del Congo, donde los mosaicos bosque-sabana son la principal formación ecológica, es importante determinar cómo se ha desarrollado este mosaico, especialmente para la protección del bosque. ¿Las tierras de la sabana son el resultado de la deforestación o los rodales de bosque se han expandido en ellas? Dada la larga ocupación humana de esta región, esta cuestión debe abordarse a través de las relaciones entre el hombre y el medio ambiente a lo largo del tiempo. La combinación de relatos orales sobre la movilidad de los pueblos y los análisis geográficos de un mosaico de bosque y sabana en el territorio de Bolobo (República Democrática del Congo) puede arrojar luz sobre la dinámica del paisaje. Este estudio incluyó nueve meses de observaciones participativas diarias de las prácticas en el uso del suelo, 40 entrevistas individuales y 18 grupos de discusión para analizar la evolución de la movilidad de los pueblos desde finales del siglo XIX hasta la actualidad. Se elaboraron varios mapas combinando los relatos orales sobre la movilidad de los pueblos en el pasado con una evaluación de 44 puntos de referencia GPS correspondientes a antiguos pueblos. Se utilizaron dos análisis de componentes principales (ACP), basados en la composición del paisaje dentro de una zona tampón de 250 m de radio alrededor de los puntos de referencia GPS, según un mapa de cobertura del suelo que clasificaba el paisaje en once categorías, para documentar la expansión del bosque hacia antiguos pueblos abandonados y el efecto de la distancia a los pueblos actualmente habitados. La cubierta forestal se expandió en los pueblos abandonados y en la sabana como consecuencia de la eutrofización del medio ambiente, que facilitó el establecimiento del bosque. El uso de los bosques disminuye con la distancia de los pueblos actualmente habitados como resultado de un cambio de los medios de subsistencia semiseditarios en los asentamientos pequeños a los medios de subsistencia totalmente sedentarios en las poblaciones más grandes y extensas. Las transformaciones de los medios de subsistencia que se produjeron durante y después de la colonización dieron lugar a una disminución de la calidad de los bienes ambientales y redujeron el bienestar de las poblaciones humanas. Estas observaciones pueden hacer que las ONG dedicadas a la conservación y el desarrollo aumenten su sensibilidad hacia las prácticas y necesidades humanas locales, que a menudo se omiten.

Palabras clave: colonización belga, servicios ecosistémicos, cambios en los medios de subsistencia, sedentarización, expansión forestal, análisis geohistóricos, cuenca del Congo, República Democrática del Congo, África.

Introduction

Deforestation within the Congo basin forest has emerged as a major concern in previous decades, resulting in the implementation of wide-ranging approaches to conserve landscapes, ecosystems, or ecosystem goods and services (Lambin *et al.*, 2003; Lambin and Meyfroidt, 2011; Clay, 2016; Windey and Van Hecken, 2019). Studies of deforestation, however, frequently focus on large-scale land cover, but do not consider changing land uses (Duveiller *et al.*, 2008; Vittek *et al.*, 2014). Although these macro-scale studies do not address land use, they nevertheless tend to attribute anthropogenic changes as explanations for deforestation, highlight the effects of agriculture, wood extraction and livestock breeding, accelerated by technological developments, economic expansion and demographic pressure (Gillet *et al.*, 2016). To better understand Congo forest-edge dynamics and to integrate more fully human action into these dynamics, local, smaller scale approaches are needed.

Heterogeneous forest patch landscapes in Africa have long been considered “degraded” and “deforested” ones (Fairhead and Leach, 1996). Whether forest-savannah mosaics are the result of deforestation or of forest expansion into savannahs is well worth exploring, particularly in light of the current need to protect forest cover and to regulate local climates (Alkama and Cescatti, 2016). Local-scale studies are most appropriate for gaining insight into interactions between anthropogenic activities and forest cover.

With some notable exceptions (Kaplan *et al.*, 2016), forest dynamics tend to be studied over short periods, comparing satellite images over a few years or decades (Mayaux *et al.*, 2003; Ciza *et al.*, 2015). Yet in locations where local populations have long relied heavily on natural resources for their livelihoods, understanding forest cover dynamics requires a longer time-frame of investigation than a few decades, especially because of the long-term economic and political processes that have transformed land governance systems.

This type of long-term investigation requires the use of other kinds of evidence than remote sensing alone, which only offers quality data from the 1970s. In fact, there is evidence that changing population settlement and expansion in a given area over time is linked to the dynamics and transformation of the landscape, including deforestation (Courtin and Guengant, 2011). But the reverse is also true: the landscape, and the associated environmental and sanitary conditions, can be responsible for human mobility, especially in a context of climate change, including migration (Van der Geest *et al.*, 2010; Tankou *et al.*, 2014) and displacement (Gemenne *et al.*, 2017).

The present study examines how village mobility has affected the structure and dynamics of landscape change in the North Batéké Chiefdom, located on the Congo basin forest edge of the Democratic Republic of Congo (DRC). To

understand these landscape dynamics beyond the period for which we have remote sensing imagery, it is necessary to mobilise historical evidence and analysis. Hence, this study uses oral testimonies of those who experienced changes that span Belgian colonisation from the late 19th century through the postcolonial period from 1960, or who heard about such transformations from their parents. These testimonies are coupled with Global Positioning System landmarks from abandoned and currently occupied villages, physical description and uses of these sites, as well as statistical and geomatic analyses, in order to demonstrate how village mobilities have shaped land use and land cover. A socio-ecological system (SES) approach was adopted, integrating social and ecological features that shape a landscape (Redman *et al.*, 2004; Liu *et al.*, 2007; Ostrom, 2009). This SES incorporates a rigorous exploration of land use and land cover changes with historical and anthropological analyses of subjectivities embedded in landscape – “a form of codification of history itself, seen from the viewpoints of personal expression and experience” (Stewart and Strathern, 2003).



Photo 2.

A woman cultivating maize on the site of the former village Nduzumi bonkolo (see figure 5), near the current village of Bodzuna. Photo C. Demichelis.

The term “mobility” is used rather than migration because it includes “large-scale movements of people, objects, capital and information across the world, as well as the more local processes of daily transportation, movement through public space and the travel of material things within everyday life (Van Dijk *et al.*, 2001; Hannam *et al.*, 2006). This study focused on village mobilities, rather than individual mobilities, in order to trace the potential impacts that human settlements could have on land use and land cover.

The authors argue that in this zone on the Congo basin forest edge, past village migrations undertaken by Batio peoples have contributed to forest expansion, rather than engaging in forest cover destruction. At the same time, contemporary sedentarization of these inhabitants has encouraged intensified exploitation of ecosystem services, raising questions about the longer-term sustainability of their agricultural activities.

By studying the past relations between village mobility and landscape evolution since the beginning of colonial rule, this article seeks to understand current human settlement, land use and landscape dynamics. In a globalized world where decisions are taken without considering local realities, and facing climate change requiring urgent adaptation of rural populations, our approach can contribute to more appropriate and effective integrated conservation and development interventions, by documenting changing local land uses and land cover.

Material and methods

Study site

Geography and environment

The study was conducted in the North Batéké Chiefdom of the Mai-Ndombe Province (DRC), situated in forest-savannah mosaic at the edge of the Congo Basin forest (Pennec *et al.*, 2016). Located less than 300 km from the capital Kinshasa, the region supplies agricultural and forest food and other resources for the capital. The region is peopled primarily by Batio speakers (also referred to as Batéké in Lingala). This population lives primarily through farming and hunting, as well as fishing, gathering, and animal husbandry.

The study site itself was defined by the boundaries of traditional village territories where the local nongovernmental organization, Mbou-Mon-Tour (MMT), operates (figure 1). Since the early 2000s, MMT has managed a community forest network to protect bonobo (*Pan paniscus*) populations and encourage sustainable economic development for people living in the region (Narat *et al.*, 2015a). In the mid-2000s, the World Wide Fund for Nature (WWF) also undertook bonobo conservation in the region. Both MMT and WWF are involved in land management and have implemented new natural resource exploitation patterns.

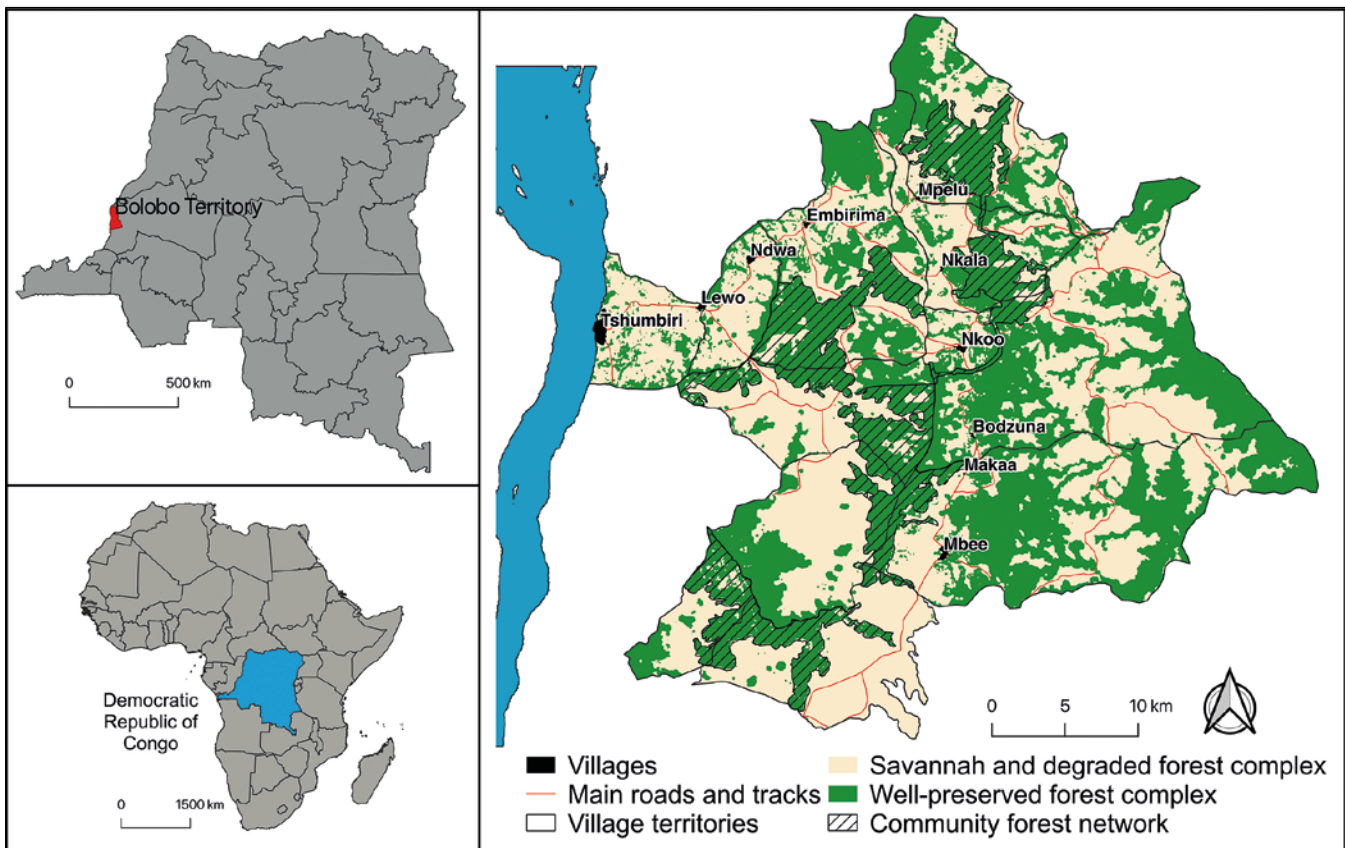


Figure 1. Study site (North Batéké Chiefdom, Democratic Republic of Congo).

History and economy

The present study addresses the relationship between localized human mobility, land use, and land cover over the past century. This mobility and shifting land use have been embedded in a longer-term dynamic of movement and environmental exploitation, linked to processes of the region's integration into a global capitalist economy. Briefly, this region was deeply involved in a dynamic riverine trade in ivory and slaves in the 19th century, bringing wealth and political authority to local traders. Belgian colonization of Congo, however, effectively destroyed its importance (Harms, 1981). Following Henry Morton Stanley's travels through the Congo basin in 1877, Belgian commercial interests (notably the Belgian King Leopold's International African Association) spearheaded a series of treaties with local rulers to initiate trade in ivory; subsequently, this part of the Congo basin experienced an influx of European commercial interests, which decimated locally-controlled trade. European incursions also catalysed violent conflicts with regional inhabitants who sought to safeguard their control of the trade. Such conflicts resulted in violent reprisals, resulting in mass out-migrations into French-controlled territories (Vansina, 1973; Harms, 1981). Although elsewhere in the central Congo Basin, Leopold's concessionary company, the Congo Independent State, had asserted initiated a brutally exploitative system of rubber extraction and coerced local populations to harvest rubber, the Tshumbiri and Bolobo regions appear to have been less affected by this "red rubber" regime because they fled to French-controlled territories (Harms, 1981). By 1909, new local trading patterns developed based on fishing, manioc cultivation, and by 1920, poultry and goat raising, linking mobile traders from the inland forest-savannah mosaic with riverine trade networks (Harms, 1981).

The 20th century brought additional changes to this region of the Belgian Congo. The colonial consolidation of scattered populations into larger villages, censuses, and colonial road construction, as well as missionisation and school construction followed during subsequent decades

(Arthur, 1991; Achberger, 2013). These colonial developments and institutions initiated new settlement patterns and new kinds of mobility. Moreover, these new mobility patterns here as elsewhere in central Africa seem to have contributed to expansion and transmission of sleeping sickness, to which the Belgian colonial state responded through multiple measures, including mobility controls on local population (Coquéry-Vidrovitch, 1972; Harms, 1981; Lyons, 1994).

The country's postcolonial history has been well documented, but generally, early independence was beset by substantial political and economic instability and considerable international intervention (Moreau, 2010; De Witte, 2017; Kent, 2017). Under Mobutu Sese Seko, private enterprises were nationalised, but encouraged a "kleptocracy", in which Mobutu and his allies extracted wealth from these enterprises for personal gain (Moreau, 2010; Bobineau, 2016). Heavily supported by European countries and the United States, Mobutu managed to hold power for multiple more than two decades, but external support for his rule crumbled rapidly following the fall of the Soviet Union in 1989. He held power 1997, but his rapacious extraction of wealth had profoundly negative consequences for the country as a whole. Nonetheless, during this postcolonial period, the site in which the present study was conducted did experience fleeting moments of economic expansion, notably in the 1970s with the expansion of family-cultivated coffee production, and in the late 1990s-early 2000s, with the implantation of the MMT and WWF conservation NGOs.

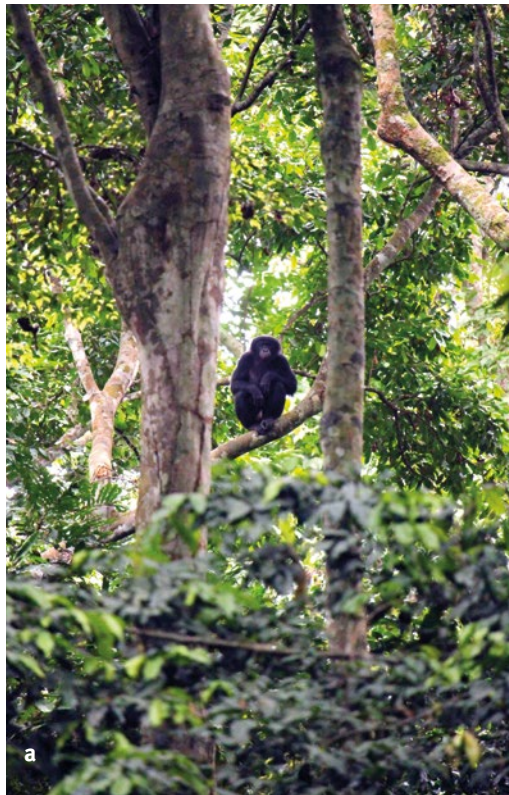


Photo 3.

Bonobo observed in the Bodzuna community forest (a), and Mbou-Mon-Tour tracker taking observation notes (b) as part of the habituation, conservation and local development program.

Photo C. Demichelis.

Data collection

Qualitative and quantitative data were collected during a three-month field visit between July and October 2016, and a six-month visit from May to November 2017 (Demichelis, 2020).

Qualitative data

Three methods were employed to collect qualitative data: focus group discussions (FGD), individual interviews, and archival consultation. FGDs and individual interviews were conducted and recorded in the Etio language with the assistance of a trained translator, and authors transcribed the recordings.

Eighteen FGDs in nine villages were conducted. These nine villages included all villages in the study area, except for Makaa, deemed too small to support two FGDs. Single-gender FGDs, which brought together eight to ten men or women between ages 18 and 90, were conducted. FGDs addressed histories of village mobilities. Dating of mobilities was approximated through links to historical or personal events. Group discussions identified causes of these mobilities.

Further investigation of mobilities was pursued through 40 individual interviews with primarily elderly people, widely recognized as well-informed about the past. Individual interviews addressed village mobilities in the distant and/or more recent past, changing environmental practices, as well as other historical topics about which informants were knowledgeable.

The Africa Archives of the Federal Public Service of the Foreign Affairs Service in Brussels was also consulted to triangulate with FGD and individual oral historical testimonies. Although few colonial reports exist for this territory and only cover 1930s and 1940s labour conditions, health system and agricultural production, a few of these sources confirm some testimonies collected in the field.

Geographical data

Following each FGD, each abandoned village was visited with a volunteer who knew its location. During the visit, a GPS landmark was collected. Individual interviews in which informants mentioned village mobility or an abandoned village not addressed during FGDs were also visited and GPS landmark noted.

Daily participant-observations of land use practices also resulted in the collection of GPS landmarks for abandoned villages. Although regional inhabitants did not know the dates associated with these villages, they easily recognized the villages because of vegetation structure and composition and because historical knowledge transmitted over generations about these sites.

A total of 44 abandoned villages were identified, primarily located near the currently-inhabited village of Bodzuna.

Botanical and land use data

Concurrent with geographic data collections, some botanical data in sites of former villages were also collected. Informants shared knowledge of dominant herbaceous and tree species. Species names were noted in Etio language and written using Lingala pronunciations. WWF and MMT agents experienced in conducting botanical inventories assisted with scientific identification of these species. Informants also detailed current or past use of the site.

Data analysis

History and typology of village mobilities

We combined qualitative, historical data and geographical data by creating maps using a GIS (QGIS). Spatial projection of all GPS landmarks onto a general regional map provided a global vision of former village locations (figure 2). All dates, spatiality, and causes of past mobilities were analysed for this study, but for practical reasons, only two zooms have been detailed here. These zooms reflect all types of mobilities observed within the study area. The first zoom shows mobilities of Tshumbiri, Lewo and Ndwa, and the second shows mobilities of Bodzuna, Makaa and Mbee/Nkuru. According to these results, a typology of village mobilities based on causes and periods has been developed.

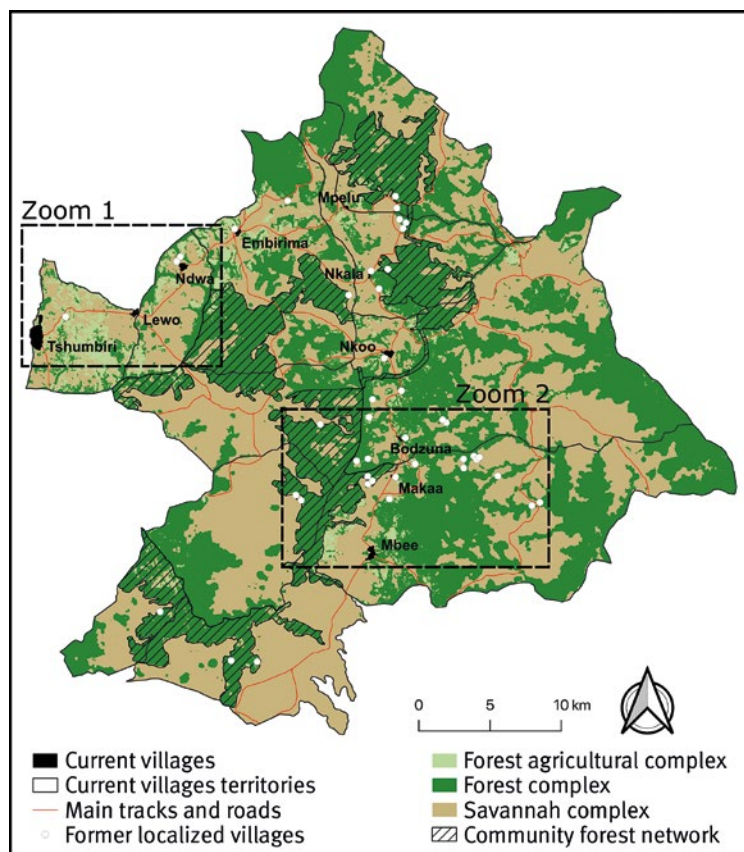


Figure 2. Locations of all identified former villages in the study area and targeted zooms.

Statistical analysis

Two types of categorisations of former villages were carried out following analysis of historical and geographical data. The first categorisation classifies mobility into five historical periods according to results concerning the typology of mobilities and their causes: (i) before 1925, corresponding to scattered villages before Belgian colonisation, (ii) between 1925 and 1935, corresponding to villages after the sanitation phase, grouping scattered villages into larger ones, (iii) between 1935 and 1945, corresponding to villages grouped next to the road, (iv) between 1945 and 1960, corresponding to villages voluntarily abandoned during late colonial rule but following the two grouping phases, and (v) after 1960 corresponding to villages abandoned after independence. The second categorisation classifies abandoned villages according to their distance to the closest active village related to the spatialization of human activities around villages, especially agriculture that is directly linked to forest: (i) < 1 km, where forests are almost entirely allocated to agriculture, (ii) between 1 and 2 km, where cultivated fields are still plentiful with only a few residual forest patches, (iii) between 2 and 4 km, where cultivated fields are progressively fewer and forest cover still largely preserved, (iv) between 4 and 8 km, where few village inhabitants and breeders are opening up agricultural fields near their farm settlements, and (v) > 8 km, where agricultural activities are normally absent.

Two Principal Component Analysis (PCA) were performed using R software. The first evaluated the impact of the date of mobility (that is, the date when the village moved to a new site) on landscape structure, specifically forest cover. The second assessed how former village location and distance from the closest active village influenced both current landscape structure and population uses.

PCAs were based on data from a land cover map developed from remote sensing analysis with a 2016 Sentinel-2 satellite image (figure 3). This map categorizes the landscape into 11 different classes according to a hybrid categorization based on the field surveys that accounted for structure and botanical composition and local perception of the landscape. The methodology used to produce this map, as well as the description of landscape classes, can be found in a previously published article (Demichelis *et al.*, 2020).

Current villages measure only a few hundred meters in radius: 75 m-radius for Makaa, the smallest in the area, compared to 400 m-radius for Mbee, the largest one; Tshumbiri is not mentioned because of its particular location along the river. Moreover, current villages have undergone two phases of regrouping and a significant demographic increase since independence and the last mobilities even if no data are available. Their situation is different from that of the former villages and thus cannot be compared. In fact, abandoned villages before colonisation most correspond to isolated and scattered villages, mainly family villages, which could be compared to the current Makaa village – a small village that experienced no colonial regrouping (13 households counted).

Concerning villages that were regrouped, they became larger but did not reach the size of the present Mbee village. In this sense, a 250 m-radius buffer zone, an average radius between the current Makaa and Mbee villages, was applied around each abandoned village to consider how the landscape evolved since moving, and the percentage of each landscape class was then determined for each buffer zone. A small buffer zone was chosen to focus exclusively on the evolution of the formerly inhabited area. GPS landmarks were taken in the centre of the former villages, as indicated by field informants. Then, percentages of each classes were aggregated. The first PCA used five categories to study the impact of the date of mobility: (i) herbaceous savannahs, (ii) shrub savannahs, (iii) transitional areas (area of savannahs colonised by pioneer forest species and evolving towards a forest state), (iv) terra firma land forests and (v) wetland forests. Agricultural areas were included in terra firma land forests, because swidden agriculture is practiced in such forests. For the second PCA, agricultural areas were removed from the terra firma land forest class, since we sought to understand the relation between territorial exploitation and landscape structure, with distance as an explanatory variable. The second analysis of the influence of distance on landscape composition relied on six land classes: (i) herbaceous savannahs, (ii) shrub savannahs, (iii) transitional areas, (iv) agricultural areas, (v) terra firma secondary and mature forests and (vi) wet secondary and mature forests.

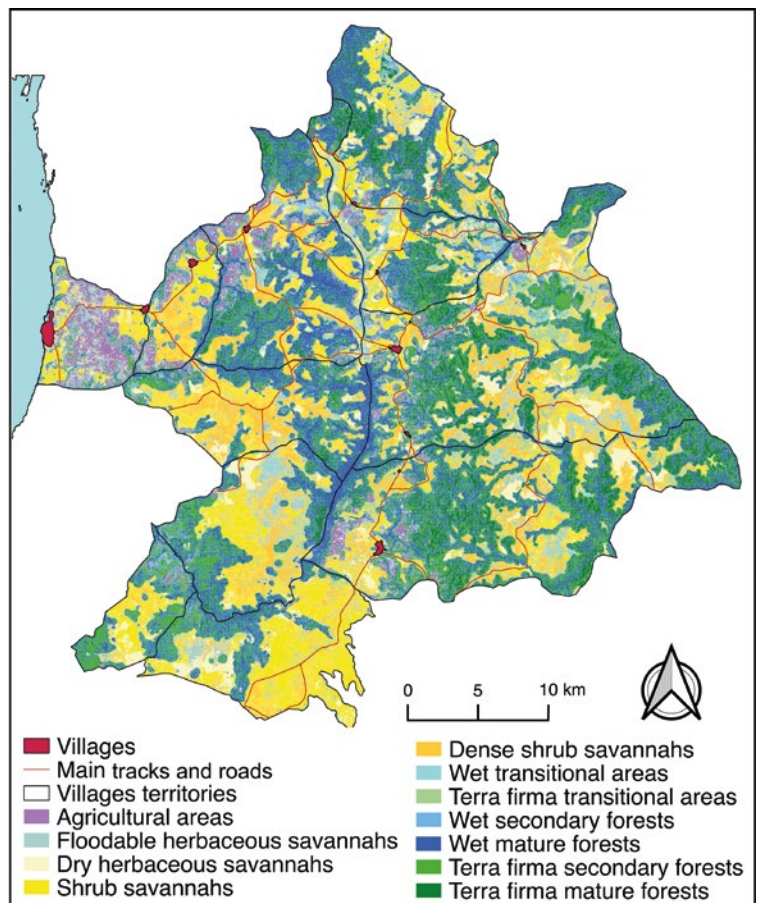


Figure 3.

Land cover map of study area based on a 2016 Sentinel-2 satellite image and used to produce PCAs (Demichelis *et al.*, 2020).

Results

Local migration histories

Although beyond the scope of the present analysis, recent mobility is part of a much longer-term, centuries-old history of Batio migration. According to oral histories, population movements resulted from multiple conditions: colonial relocations (called *regroupement*) for the establishment of colonial control; exhaustion of ecosystem resources and a subsequent search for new resources; adverse ecological conditions, and perceptions that particular sites were “unhealthy” for their inhabitants.

Mobility histories of current villages

Figures 4 and 5 present known village mobilities from the 19th century to the present, based on recollections collected in FGDs and interviews. Figure 4 illustrates past movements of Tshumbiri, Lewo and Ndwa villages.

Tshumbiri history

According to collected oral histories, 19th century Banunu people inhabited sites along the Congo river edge; Batio people lived on hilltops, further inland. At the end of the 19th century, a Protestant missionary consolidated the Nunu village Tsomba and two Téké villages to create the village of Tshumbiri. According to Tshumbiri elders, “*The inhabitants were a little scattered, so they [the missionaries] asked everyone to come closer to the Nunu village, and they changed the name [of the village] to honour the creator of the village Nunu [Tsumba], and it became Tshumbiri.*”

Although Tshumbiri’s location did not change since its founding, its position contributed to its expansion as a market town connecting riverine traffic with a network linking villages in the interior. As an FGD with Tshumbiri elders indicated:

“*The period of creation [of the road] was around 1940, 1941, 1942. But before then, there were Portuguese traders and Africans too, [who] sold salt, pots, pieces of cloth, soap, all kinds of items. People living here sold kola nuts, palm nuts and fibre to make bags. We also sold [ivory] secretly... But after independence, the region became truly multi-ethnic. [People from other ethnic groups] came here... to trade. They found that the environment was rich, that there were many resources and land and that they could make many purchases, but also that there were many customers.*”

Lewo history

Oral historical sources contend that Belgian colonial administrators created Lewo in the early 1940s, following road construction. Its creation consolidated scattered

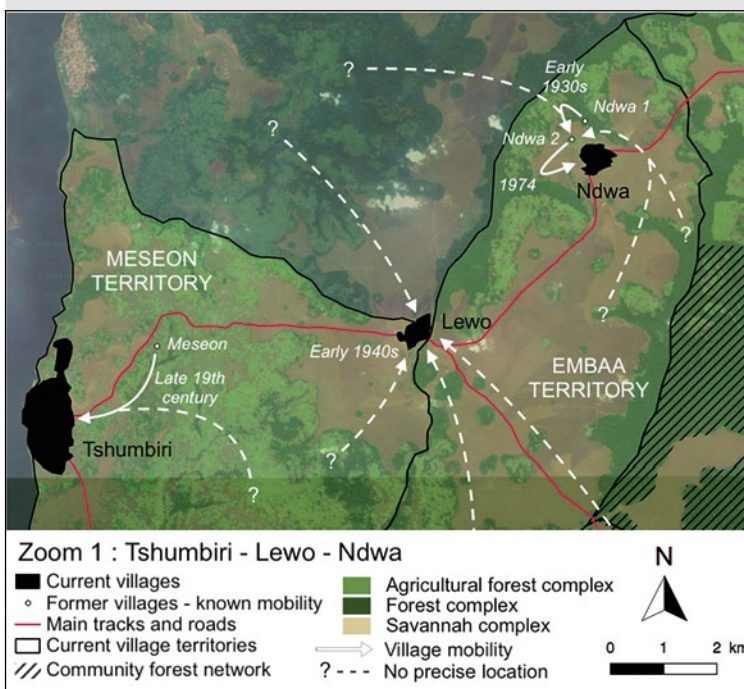


Figure 4. Mobility histories of Tshumbiri, Lewo and Ndwa villages.

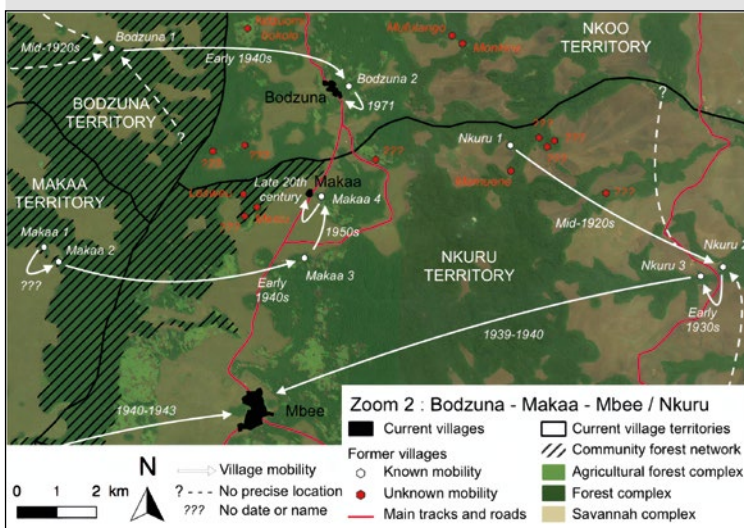


Figure 5. Mobility histories of Bodzuna, Makaa and Mbee / Nkuru villages.

clan villages, situated them next to the road. According to a focus group with Lewo elders, Belgian administrators “grouped [the small villages] on the roadside so that they [Belgians] can have access to rubber and cotton, [...] to be able to sell them and have the financial means [to pay taxes].” As elsewhere in central Africa, this colonial practice of regrouping facilitated tax collection and population control.

Ndwa history

Ndwa is composed of two villages: Ndwa 1, which existed prior to Belgian colonial rule, and Ndwa 2, created

in the 1930s from several villages that colonial administration consolidated next to what would become the road. A focus group of Ndwa elders described the reasons for the village regrouping, explaining that the colonial administrators.

“Told people who were far away that we had to move closer together to form a large village. It was really the state’s injunction. The state didn’t want to have people too far away, too isolated. They said that it was for health reasons. If a woman was pregnant, it would difficult to receive treatment if you are far away. But also the mortality of men. We had to regroup, because it is not good to live in a bad place.”

In 1974, village opted to move to its current site to be closer to the road, but also to escape from soil erosion problems, from which its prior site suffered.

Figure 5 summarizes mobilities of Bodzuna, Makaa and Mbee villages. Red sites designate abandoned clan villages, founded prior to colonization according to oral historical testimonies and currently recognizable by the abundant oil palms that continue to grow there.

Bodzuna history

The village Bodzuna 1 resulted from the consolidation of the clan village Bodzuna with several other clan villages in the mid-1920s. In the 1940s, as Belgian colonial authorities sought to impose greater control over its subjects by locating them closer to roads, Bodzuna village was relocated to Nkoo clan lands. According to an elderly farmer and merchant:

“The old Bodzuna [Bodzuna 1] was a small village that was grouped together with other small villages. It was there before I was born. The reason that inhabitants settled here [Bodzuna 2] was because of the road. The Belgian colonial power asked us to leave to settle along the road.”

In 1971, in the wake of forest expansion into the zone of human settlement, the population decided to move a few hundred meters to create the current village. Although the current village still must cope with forest expansion, its population continues to exploit the abandoned village site for palm nuts and cultivation. People use fire to keep forest growth from encroaching on village spaces.

Makaa history

Makaa 4, currently situated on the road near Bodzuna, is the consequence of several Makaa village relocations. Makaa 1 is the oldest recalled village, which seems to have existed at the end of the 19th century. Following the clan leader’s death in this village, his son assumed his position, creating Makaa 2 few hundred meters away. No precise period was mentioned for this migration, but it is possible that it took place before or during the colonization. In the early 1940s, the colonial administration catalysed another village relocation next to the road, creating Makaa 3, but a decade later, the village moved again because of sorcery accusations, resulting in the creation of Makaa 4. As a 50-year old man described the reasons for this last relocation:

“The roosters no longer crowed, the crops were poor

and the women no longer gave birth. The Makaa clan is in charge of the Nkira Mbali [the spirit protector of all the Batio of the chiefdom] so the clan perceived these evils as a malediction for having left its ancestral lands. The clan chief then bought part of the Nkuru clan land and created a new Makaa [Makaa 4] on it.”

The village has moved incrementally a few hundred meters to position itself next to a small road.

Nkuru history

Nkuru village no longer exists, but its abandoned sites have taken on environmental features in collective memory. According to oral historical testimonies, the first village (Nkuru *Mulilansie*, named for a nearby river) was initially consolidated with several other clan villages, probably sometime in the 1920s, when it was known as Nkuru *ebu* (“Nkuru hole”). According to one elder, the dispersal of small-scale villages provided Belgian colonial authorities with justification for this consolidation, and presumably to distance populations from specific ecologies that facilitated reproduction of *Glossina* spp., the sleeping sickness vector. To facilitate sleeping sickness screening and control, Nkuru was regrouped with other clan villages Mongwoli and Mamuene to create Nkuru 2 (Nkuru *ebu*), although local historical accounts indicate that this relocation precipitated resistance from local population against colonial subjects, leading colonial authorities to burn inhabitants’ houses to force their migration.

In subsequent years, the village voluntarily moved a few hundred meters to escape repeated floods of its prior location (Nkuru 3, Nkuru *mona*, meaning dry or hill). Finally, in the early 1940s, colonial administrators consolidated the village with that of Mbee and relocated the resulting settlement near a road forcibly constructed by local labour. This same elder explained that Mbee’s road conditions were poor because of its proximity to swamplands.

Archival evidence for village mobilities

In certain instances, the Africa Archives of the Federal Public Service of the Foreign Affairs Service in Brussels provide additional evidence for colonial village mobilities. Annual reports¹ show that both Mbee and Mpelu villages moved in 1937. Administrators attributed this relocation of Mpelu to environmental conditions, namely seasonal high humidity and cold that the village suffered because of its proximity to herbaceous flood savannah, confirmed by informants during FGDs. Mpelu was then consolidated with other villages, prior to road construction in 1941. In addition, a hand-drawn map found in the 1940 *Annual medical report* from the Mushie medical service (dated from 1940), documents new village locations following “sanitation” regrouping and corresponds well with oral historical testimonies of Mbee and Bodzuna. Nkala (integrated with Nkoo at the time) and Lewo (not yet in existence, according to oral testimonies) are both absent from the map.

¹ Annual report of indigenous affairs and labor, section B, chapter XXI, 1937, 1941.

Impact of village mobilities on landscape dynamics

Date of mobility and land cover composition

First, the influence of the date of mobility on land cover composition was investigated. Figure 6 shows PCA results which classified villages according to the date of mobility and land cover composition in a 250 m-buffer zone surrounding GPS landmarks.

The PCA shows significantly (Monte-Carlo test, p-value 0.01**) that the date of mobility directly influences landscape structure and composition. The first two components count for 77.63% of the variance (44.22% for axis 1, and 23.21% for axis 2). Axis 1 is positively influenced by terra firma forest land and to a lesser extent, wet land forest, and negatively by herbaceous savannah, shrubby savannah and transitional areas. Similarly, axis 2 is positively influenced by wet land forest and negatively by terra firma forest land. Axis 1 thus provides information on forest cover, and axis 2 on soil humidity. According to the cluster distribution on axis 1, then, older villages are most colonized by forest.

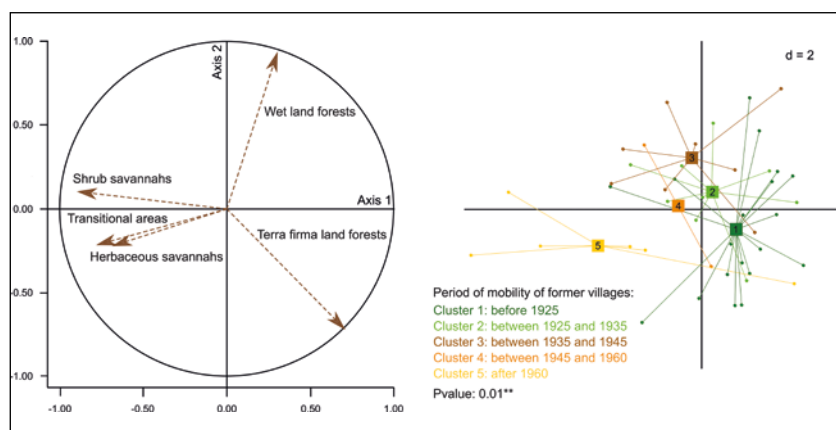


Figure 6.
PCA based on date of village mobility and land cover (Monte-Carlo test, p-value 0.01**).

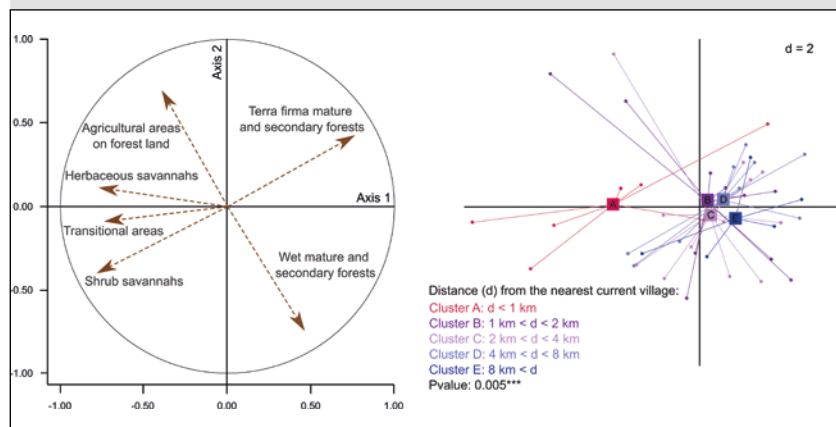


Figure 7.
PCA based on the distance of abandoned villages from nearest current village and land cover (Monte-Carlo test, p-value 0.005**).

Distance to current village and land use

Another PCA was conducted, which linked the distance of abandoned villages to the nearest current village with land cover. Results are contained in figure 7.

The PCA shows that the distance between abandoned and current ones has a significant (Monte-Carlo test, p-value 0.005**) influence on landscape structure. The first two components account for 66.39% of the variance (43.73% for axis 1, 22.66% for axis 2). Terra firma and wet forests positively influence axis 1, which in turn is negatively influenced by herbaceous and shrub savannahs, transitional areas, and agricultural fields. Axis 2 is positively influenced by terra firma forest land (secondary and mature forests and agricultural fields) and similar to the PCA above, negatively by wet mature and secondary forests. Hence, axis 1 provides information on forest cover and axis 2 on soil humidity. According to the distribution of groups on axis 1, abandoned villages closest to current villages are the least forested, and most exploited for agriculture. This dynamic is in play primarily for abandoned villages under one kilometre away from current villages. Conversely, the most distant villages seem to be those with the most developed forest cover, so that

resource exploitation appears to decrease as distance increases. Moreover, the distribution of the groups on axis 2 does not show a correlation between distance and humidity; all groups are distributed along axis 1.

Land use and land cover change following mobility according oral histories and botanical data

Oral testimonies and focus groups indicate inhabitants entirely or partly abandoned their former villages following relocation, leading to three possible land covers.

First, where inhabitants had previously planted many fruit trees and oil palms, people would return to abandoned villages to exploit these trees. In such cases, secondary forest coverage, characterized by pioneer forest species and oil palms, would persist in a relatively stable state.

Second, once-cultivated lands near abandoned villages could eventually revert to forest, which in turn expanded into the former villages themselves. The term *efuna kuba* in Batio language elucidates this phenomenon. Although this term has no direct translation, it expresses this process of forest colonisation of former villages following inhabitants' abandonment of a village. These abandoned villages overtaken by forest are identifiable in the landscape by the presence of oil palms. As one elder explained, "where these oil palms trees were have turned into forest. All places where oil palms grow are abandoned villages, which are now forest."

Finally, although forest may have colonized abandoned villages, people could return to these sites to cultivate fields because they considered the land to be fertile. Note that if for-

mer villages are completely abandoned and no agricultural activity takes place there, oil palm trees tend to decrease in number over time and eventually disappear. Thus, traces of ancient villages may disappear over time, supplanted by a mature forest resembling the rest of the forest network.

Figure 8 illustrates these three possibilities according to botanical data collected in former villages: (i) Stationary secondary forest with oil palm; (ii) Mature forest with oil palm; and (iii) Cultivated forest.

Figure 9 highlights how village mobilities shaped landscape dynamics, specifically in expanding the forest.

Finally, forest colonisation of abandoned villages is understood not only as an ecological process, but also a social and historical one. Not only did it involve the cultivation of a valued tree and result from village mobility, but some forest regrowth could be named for past people. The forest patch Nzamatoro, for instance, was given the name of a respected elder who had been buried in his house prior to the village relocation.

Discussion

This study brings together oral historical knowledge of village mobilities from the late 19th century to the present, some confirmatory archival evidence, and the development of a GIS to evaluate the consequences of human mobility for land cover. Our analyses illustrated changing village mobility within the Bolobo territory from the late 19th century to the present.

Local history of village mobility linked to oral testimonies

Past changes within small-scale, mobile African societies can be contained in oral histories. The present study relies on recalled experiences of informants as well as stories of mobilities that they heard from older generations. There was unifying pattern in the abandonment of villages or the resettlement of others single reason for mobility during the study period. The study found village mobility took place for multiple reasons from the late nineteenth century. Oral histories suggested that there were two main drivers of village mobility. The first is linked to a common practice of Belgian colonial rule, to consolidate populations and establish colonial control (elsewhere, see Pourtier, 1986; Rupp, 2011). The second driver concerns human populations' response to environ-

mental conditions, namely to escape adverse ecological, climatic and health conditions, due to sorcery, the presence of sleeping sickness vectors, flooding and depleted resources.

Oral historical sources were used in most cases to document where, when, and why villages moved. However, historical recollections can be faulty (Giles-Vernick, 2002) because of selective recollection and transmission of past events, people and processes. In fact, it can be difficult to determine the precise date of a past event with only oral sources. For example, the claim that missionaries facilitated the creation of Tshumbiri is inaccurate; Robert Harms, who collected genealogies, oral histories and archival evidence in the region in the 1960s and 70s, finds that Tshumbiri was likely established between 1800 and 1840 as a consequence of an expanding ivory trade (Harms, 1981). Yet triangulation with other complementary sources (Owens *et al.*, 2009; Caquard and Joliveau, 2016) – limited archival evidence available, ecological observations with recording of GPS points – allow some certainty about where abandoned villages were located in relation to current ones. Although triangulate data from different sciences and methods may pose challenges, it can also be a strength: multiple sources limit the bias associated with oral historical data and permits an analysis of the consequences of past mobility on landscape dynamics over time, without the need for exact dating of events.

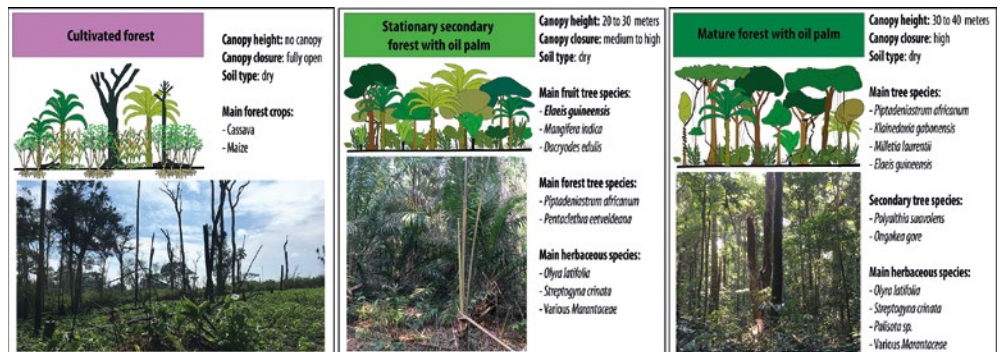


Figure 8. Three possible landscape changes following village abandonment and forest colonisation.

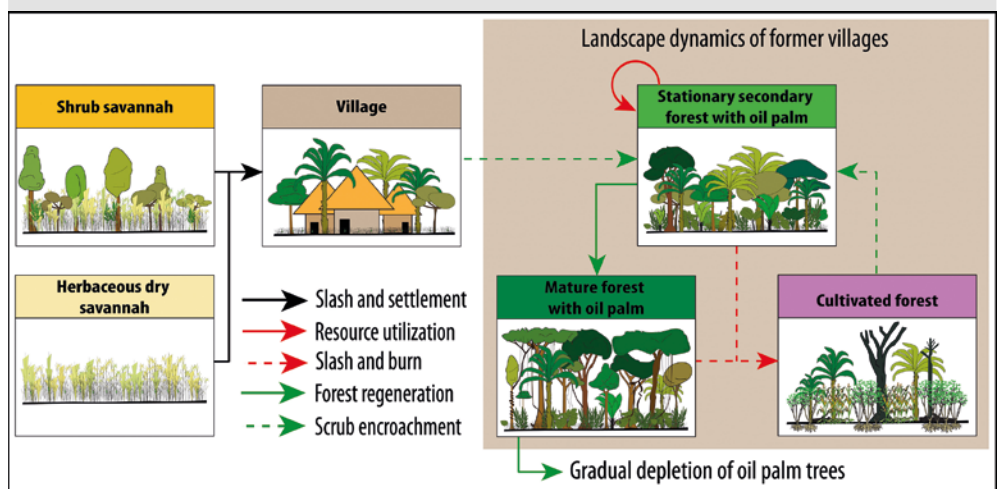


Figure 9. Landscape dynamics after village settlement and abandonment.

Implication of village mobility in landscape dynamics

Forest cover expanded into abandoned villages and the savannahs, the consequence of environmental eutrophication facilitating forest establishment. PCA analyses indicate that older villages were most colonized by forest and that forest exploitation decreased with distance from currently inhabited villages. There was no real correlation between soil humidity and composition and date of village mobility. Villages frequently resettled on dry savannah, but with a water source (river) in proximity. This repeated settlement pattern presumably facilitated the development of terra firma for settled villages and wet forests on village outskirts along rivers.

What is striking about this multidisciplinary analysis of village mobility and landscape change is that the results show multiple possible landscape changes over time, and that village mobility does not necessarily lead to deforestation. A process of eutrophication of the environment can be suggested here: by inhabiting new village sites and planting fruit trees, people enriched soils, and possibly attracted avifauna species which by zoochory would have facilitated seed spreading. In abandoning villages, people facilitated the establishment of pioneer forest species on soils favourable to their development, leading to the creation of a new forest. This creation of forest through human practices has been noted elsewhere in Africa. Fairhead and Leach (1996), for instance, found that people in Guinea were mainly responsible of the creation of forest islands. De Foresta (1990), in studying the Mayombe savannah dynamics elsewhere in DRC, also highlighted the colonisation of savannahs by the forest over the last centuries, hypothesizing that a strong past human occupation facilitated the installation of Marantaceous forests. Similarly, in Sierra Leone, the existence of forest patches around ruined villages has been highlighted, which now form a greater forest cover than the surrounding forests (Nyerges and Green, 2000).

In the Bolobo Territory, Batio people have participated in forest colonization of savannahs, so that human presence has been favourable to the maintenance of forest cover, even in this fragmented ecosystem, and by implication, of bonobos living in forest patches and protected by NGOs MMT and WWF. It is true that certain zones here are heavily influenced by human activities, particularly the outskirts of current villages where agricultural production is most intense. Others, however, initially “seeded” by human activities (fruit tree planting), have been abandoned and left largely to ecological processes. In the absence of village mobility, this situation runs a high risk of overexploitation of resources around villages, which negatively affects supply services, including wildlife.

Contributions to conservation and development programs

Conservation NGOs working in this region have shaped governance of resource use and landscape dynamics, but can also learn from the insights produced by the present

analysis. These NGOs are primarily concerned with environmental and species (notably bonobo) to maintain the integrity of ecosystem services, as well as the promotion of sustainable development. MMT has not only conducted campaigns to conserve local practices of not hunting bonobos, but has also created community forests, which bar certain extractive human activities (Narat *et al.*, 2015ab). This governance of forest and wildlife use is complemented by the development of ecotourism, and thus activities to benefit local populations and reduce anthropic pressure on the environment. This “integrated conservation and development” has long been an approach practiced by NGOs, but its effects can be far-reaching, affecting livelihoods, and socio-cultural and political relations (Albers and Grinspoon, 1997; Agrawal and Ostrom, 2001; Panusittikorn and Prato, 2001; Wilshusen *et al.*, 2002; Jim and Xu, 2003; Roth, 2004; West, 2006; West *et al.*, 2006).

In suggesting that past village mobilities have contributed to forest expansion, our study reveals that movement and environmental exploitation is not uniformly destructive in African forests. This analysis also suggests that contemporary sedentarization of village settlements may place greater pressure on existing resources in proximity to villages. NGOs would do well to heed these past dynamics and risks, and to work closely with local populations to find ways of reducing stress on ecosystems within adversely affecting local livelihoods. Developing alternative economies that simultaneously protect the environment and respect existing human practices would be necessary to limit this pressure on forest ecosystems. Thus, the habituation of bonobo communities by the MMF and WWF in a way to develop ecotourism would be one a good starting point. It could make possible the development of a local service economy rather than an extractive one.

Conclusion

This study sought to investigate the influence of past village mobilities on the structure and dynamics of the forest-savannah mosaic of the North Batéké Chiefdom in Democratic Republic of Congo (DRC). Bringing together oral historical testimonies, geographical analyses and botanical data of past and current village sites, the results suggest that Batio peoples in this region of DRC have largely contributed to forest expansion over time. At the same time, contemporary sedentarization of these inhabitants has encouraged intensified and localized exploitation of resources. Inhabitants shifted from pursuing relatively homogenous resource exploitation from scattered villages to a more heterogeneous resource exploitation located around larger and regrouped villages. This current, concentrated exploitation is risky, both for protected bonobos, but also for biodiversity and for human livelihoods. NGOs and local populations must work together to develop programs that protect bonobos and biodiversity and foster human livelihoods on this forest edge.

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Data availability statement

Because of ethical committee restrictions, data have not been publicly deposited. Upon reasonable request, the corresponding author may make available certain data following agreement by the Principal Investigator of the research project of which this study is a part.

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