

Historical and modern repeat photographic documentation of vegetation and land use change around Kigoma, western Tanzania

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Introduction

Repeat photography, the process of reoccupying a site where photographs were taken long ago and photographing the same scene many years later, is a powerful tool for visualizing vegetation and land use change (Schantz and Turner, 1958). Photographs in many ways speak volumes about past conditions: they often allow researchers to make definitive statements across the landscape (Turner, 1998). The study documented here examined these about changes in vegetation type, individual plant species, their size and abundance, as well as their distribution types of changes over an 85 year period (1920-2005) in the Kigoma region of western Tanzania, based on photograph sites originally studied by H. Shantz in 1920 and revisited by him in 1957 (Schantz and Turner, 1958). The Shantz photographic collection, from his lengthy 1920 and briefer 1957 visits to much of Africa, are housed in the herbarium of the University of Arizona (Tucson). Schantz's original study of vegetation change over 37 years (1920 to 1957) in the Kigoma area documented only minor (or in some cases no) changes.

The Kigoma area lies within the, "Dry Tropical Forest" ecoclimatic region, although it is somewhat warmer and moister than most areas thus defined. The native vegetation cover includes small tree dominants, mostly species of *Brachystegia*, *Isoberlinia* and *Diplorrhynchus* (Schantz and Turner, 1958). Today the Kigoma and Ujiji areas are semiurbanized commercial and trading towns, with much higher population densities than at the times of Shantz's visits. My main objective in this study was to evaluate the impact of land use activities on vegetation using the repeat photograph method, by locating Shantz photo sites and orientations and then rephotographing the same scene 85 and 48 years after his visits.

Methods

The Shantz photographs were obtained from the UA Herbarium and digitally scanned at high resolution in Tucson prior to the field season to avoid damage to the originals. Shantz field notes were also photocopied and transcribed to help locate sites (the original notes are stored in the UA Library Special Collections) Schantz's field notes provided little information as to the exact location of the camera station, with imprecise labels, for example, 'Market (fence of bamboo) shelter-Depot in back also bay in background'. However, in most instances his notes were accompanied by his local itinerary, allowing recreation of his daily travel around the Kigoma area. General comments, obvious landmarks in the photos and conversations with local residents allowed us to find the general location of most of the photograph sites relatively easily. A GPS unit was used to record the precise camera station in term of latitude, longitudes and elevation for future reference. I also recorded the compass orientation of camera when taking the photos. All 2005 photos were taken between 21-30 July, 2005, with a tripod-mounted (Nikon Coolpix 4500) digital camera.

I visited all sites that were visited and photographed by Shantz in the Kigoma/Ujiji area for which accurate locations could be ascertained, including parts of Ujiji (south of Kigoma), an area north Kigoma (Nondwa hill parts which is near the Kibirizi fishing village), Mjimwema, near the modern Kigoma water supply (Pump house) looking towards Kigoma Bay from Mlole hill, and some areas in what is now Kigoma town.

Following the collection of the repeat photographs I worked on a preliminary botanical interpretation of the old photographs (1920 and 1957) and the modern scene vegetation, with the help TACARE forester Grace Gobo. We made a list of plants visible in the historical photographs from 1920 and 1957, to be compared with a current plant list for the area. After initial repeat photos were taken I returned to the scenes to "ground truth" vegetation patterns in collaboration with Ms. Gobo to identify different plants that were present on the camera station. More detailed identifications were done at the TACARE herbarium. I plan to identify other species that were not in the TACARE collections at the Department of Botany, UDSM on my return to Dar es Salaam. A spreadsheet of all photo stations,

their site characteristics and vegetation was prepared in Microsoft Excel © Adobe Photoshop © was used to reorient and pair the historic and modern photographs and to help to observe differences in vegetation and land use patterns.

Results and discussion

Detailed observations of the differences between photographs and modern vegetative cover are described in the photo captions below. There are notable changes between the vegetation that exists at the photograph sites and what is observed in the 1957 and 1920 images. Some of plant species that were present in 1920 and 1957 photographs are not present in 2005 photographs. The most common difference was in increase at present in the abundance of crop species and a decrease in tree cover relative to the photographic images.

Plants observed at camera stations:

Grasses - *Hyperrenial filipendulata*, *Hyperrenial sp.*, *Loudetia kagerensis*, *Stipa dregeana var. elongata*, *Phragmites mauritianus*.

Trees (<150cm) - *Rothmania engleriana*, *Ziziphus abbyssinia*, *Cassia sia*, *Acacia hockii*, *Ficus mucoso*, *Manginifer indica*, *c.f. Periopsis sp.*

Herbs - *Indigofera zenkeri*, *Leptactina benguelensis sub sp.*, *Aloe sp.*, *Tinia sp.*, **Asteracea.**

Shrubs- *Brachystegia spiciformis*, *Brachystegia bussei*, *Rubiacea*, *Pseudolancnostyis mapro uneifolia*, *Strychnos innocua*, *Diplorrynchus condylocarpon*, *Anisophyllea boehmic*, *Holarrhema febrifuga*, *Pterocarpus tictorius*, *Psorospermum febrifuga*, *Baphia capparifolia subsp bangweolensis*, *Combretum mollex*, *Abrus schimperi subsp africanus*, *Pareta schummaniana*, *Maerua ethiopica*, *Margartaria sp*, *Markhamia obtusifolia*, *Phyllunthus nummulanifolius*, *Multidentia crassa var. crassa*, *Leonitis nepetifolia*, *Piliostigma petersian*, *Grewia flavescens*, *Albizia antunesiana* and *Isoberlinia sp.*

Nondwa area:

Composite 1. This photo pair (Shantz photo H-4-1920 (left) vs. our LT-27-2005 (right), is taken from near Nondwa point looking south. 2005 photo location is S 4 51.706' E29 36.538', elev. 802m, photo orientation N86E. Trees of various species were dominant in 1920, which is no longer the case. The *Phragmites* sp. along the modern shore line was not mentioned in Shantz's notes, nor is it evident in the photos. In 2005 grasses shrubs and herbs are dominant, cultivation near lakeshore includes introduced crop plants (i.e. okra, tomatoes, maize, eggplant, oil palm and mango trees). Also mango trees and oil palm can be seen at the foot of the hill in the 2005 photo, which are not present in the earlier images. *Phragmites* sp. which were not mentioned in 1920 photo are present along the 2005 shoreline Photo LT-26-2005 (not shown), which is a repeat of H-6-1920,-1957 & Photo LT-25-2005(not shown, a repeat of H-7-1920) show similar contrasts to Composite 1.



Composite 2. This set of photos, taken at Nondwa looking north contrasts our LT-29-2005 (right photo, taken at S 4 51.550', E29 36.539' 796m, looking N32W) with Shantz's H-8-1920 (left) and D-12-1957 (middle): Nondwa looking north. 2005. A cliff, seen in 1920 and 1957 images, had been greatly reduced by removal of fill for construction material by 2005. In 2005 the site has very few shrubs and a higher diversity of grasses and forbs than in 1920 and 1957, probably due to fire disturbance. In the recent photo the site is dominated by grass (*Stipa* sp.,A), whereas earlier images are tree-dominated. Trees on the modern slope are mostly *Ziziphus abbyssinica* (not present in earlier images), and *Maerua ethiopica*, while those along the edge are mostly *Acacia hockii*. *Aloe* sp., evident at the cliff slope in 2005, is not seen in the 1920 & 1957 images. *Phragmites* sp., which was present along shore line in 1920 had disappeared by 1957, having been cleared for cassava cultivation



Composite 3. Looking at one of the peaks in the Nondwa area. Our LT-28-2005 (right panel S 4 51.559', E 29 36.541', 792m, looking N28W) vs 37537 H-9-1920(left),E-5-1957(center).The area in the 2005 photo is dominated by a higher diversity of grasses and dwarfed natural vegetation relative to the earlier photos. By 2005 the area had been deforested, probably due to fire. The negative effect fire can have on the woody vegetation may have eventually allowed the grasses to become dominant because of their higher relative allocation of biomass below ground (Huston, 1994).

Foreground trees in the 1920 image include *Vitex fisheri* & *Randia* sp. The grasses in the 1920 image background is dominated by *Cymbopogon* sp., and is very similar to the 1957 image. In 2005, vegetation in the photo area included *Hyperrenia filipendulata*, *Brachystegia spiciformis*, *Brachystegia bussei*, *Diplorrhynchus condylocarpon*, *Isoblerlinia* sp., *Acacia hockii*, *Trychlos* sp., *Maerua ethiopica*, *Leptactina benguelensis subsp.*, *Albizia antunesiana*, *Loudetia kagerensis*, and *Stipa dregeana* var. *elongata*.



Kigoma Area

Composite 4. LT-23-2005 (right, S 4 52.700', E 29 38.171', 873m), looking NW across Kigoma Bay from Mloli (Mlote?) Hill towards Nondwa Hill, compared with Z-9-1920 (left) & E-5-1957 (middle), In the 1920 & 1957 images we can see a mixture of trees and grasses, but in 2005 a high diversity of grasses (and scattered shrubs and herbs) is observed. The recent photo show almost all grassland with few herbs and shrubs. Soil removal, seen in the 2005 image, is for brick manufacturing, which was not occurring in the photo area in 1920 or 1957. Vegetation in the 1920 image includes *Stipa* sp., *Pterocarpus angolensis*, *Commifora abyssinica*, *Isoblerlinia angolensis*, and *Periopsis*(?) sp. 1957 vegetation is very similar to 1920. 2005 vegetation includes *Paretta mchummaniana*, *Loudetia kagerensis*, *Stipa dregeana* var. *elongata*, *Hyperrenia filipendulata*, *Rothmania engleriana*, *Indigofera zenkeri*, *Tinia* sp, *Leptactina benguelensis subsp*, *Pseudolachnostylis maprouneifolia*, *Strychnos innocua*, *Diplorrhynchus condylocarpon*, *Anisophyllea boehmic*. And unident. *Asteracea* and *Rubiacea*.



Composite 5. Z-12-1920 (left), LT-13-2005 (right, S 4 52.498', E 29 38.123, 897m, oriented S80E): Foreground vegetation is dominated by *Stipa* sp. in all photos. Plants observed in the 2005 survey at this site included *Stipa drageana* var. *elongate*, *Loudetia kagerensis*, *Brachystegia spiciformis* and *Anisophyllea boehimic*. Around Kigoma town (lower background) there are more trees in 2005 than in 1920, which are used for shade and as fruit trees in urban areas at present. Plant types are *Mangifera indica*, *Azedvetchta indica* and *Sena siamea*.



Composite 6. Z-5-1920 (left) and LT-16-2005 (right) –Kigoma town area. Oil palm in the 1920 photo is not seen in 2005. In 2005 planted trees line Lumumba Road, mostly *Sena siamea*, which were not present in 1920

Kigoma town:



Composite 7. Y-9-1920 (left), E-10-1957 (middle) & LT-31-2005 (right). Many more trees are evident in the Kigoma town area in 1957 & 2005 than in 1920. Planted species are dominantly *Mangifera indica*, *Sena siamea*, and *Azedvetchta indica*. Grass cover is limited in the 2005 image because of burning a few days before the photos were taken. Similar small trees and shrubs are evident in the foreground of all three images (1920,1957,2005) (i.e. *Brachystegia* sp, *Isobertinia* sp,*Diplorrynchus* sp. Photos LT-30-2005(E-11-1957,Y-10-1957) & LT-33-2005(E-9-1957) (not shown) illustrate similar vegetation contrasts to those seen in Composite 7.



Ujiji Area. The Ujiji area was settled and semiurbanized much earlier than Kigoma town, and therefore the 1920 images of the area show many more cultivated trees and plantings than Kigoma in 1920 and are much more similar in overall aspect to the later photographs.

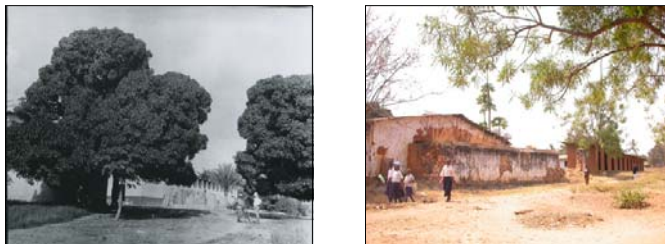
Composite 8. B-3-1920 (left), LT-38-2005 (right) – Oil palm and citrus tree seen in 1920 & *Sena siamea* and *Azedvetchta indica* present in 2005.



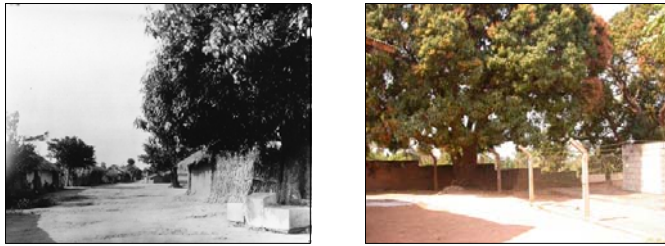
Composite 9. B-5-1920 (left), LT-37-2005 (right) - No changes seen, also no significant change in land use. The mango trees seen in 2005 appear to be the same ones present in the 1920 image.



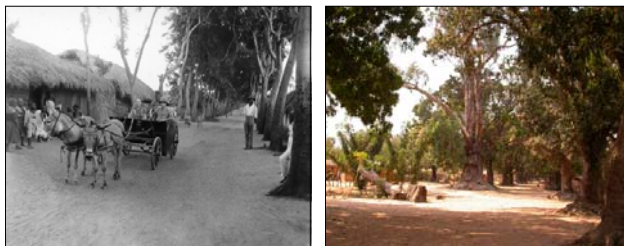
Composite 10. B-6-1920 (left), LT-35-2005 (right) - The mango trees seen in 1920 photo are not present in 2005 phot. Papaya, oil palm and *Azedratchta indica* seen in the 2005 photo are all introduced species. Note new building in 2005 photo.



Composite 11. B-9-1920 (left),LT-41-2005(right) - The Livingstone- Stanley meeting place. The original mango tree in the 1920 image was replaced when it died by the Livingstone - Stanley Monument seen in the 2005 photo (right side). The mango trees behind the Monument were introduced as part of the memorial and for fruit.



Composite 12. Ujiji town area. C-3-1920 (left), LT-40-2005 (right) - *Cassia sia* in the 1920 were replaced by mango trees by 2005. *Cassia sia* disappeared because they were cut for lumber. *Sena siamea*, seen on the left side of the 2005 image, is also an introduced species.



Composite 13. G-10-1920 (left), LT-43-2005 (right) - Cassava, corn/maize, and sweet potatoes, all seen in 1920, are not seen in the 2005 photo. In the backgrounds of both photos are *Mangifera indica* and oil palm. In the foreground of the 2005 photo dried annual herbs are seen. Comparisons are made difficult here because of the different times of year that the photos were taken (1920 wet season, vs 2005 dry season).



Conclusions

The change in vegetation in the Kigoma area observed between 1920 and 2005 seems to be largely the results of intensifying human occupation. Climate in the area has changed relatively little since the 1920s and is unlikely to explain the profound differences observed. Major vegetation changes have occurred accompanying certain types of land use activities, such as cultivation, burning of vegetation, extraction of building materials like soil, grasses harvesting and wood for fuel and furniture especially in Ujiji and expansion of residence areas which is due to increase of population. Vegetation changes in what is now Kigoma town clearly document the increased number of trees planted in the urban area.

The disappearances of species observed in some sites seem to be related to land disturbance related to cultivation and fire. Intentionally set fires appear to have favored a high diversity of grasses and dwarfed trees, as observed in many sites. Cultivation clearly is associated with a much higher density of crop plants in recent images. At North Kigoma Nondwa and Mlote the decrease or disappearance of tree cover has been influenced by fire. In contrast, in

Kigoma town, an increase in tree cover along the streets has resulted from intentional plantings for shading and fruit. At Mjimwema (near the Kigoma Pump House), little difference is observed from 1920 to the present. In Ujiji, long term differences are related to replacement of popular urban area trees with new species.

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