Land Use Land Cover Change in the Albertine Rift of Uganda
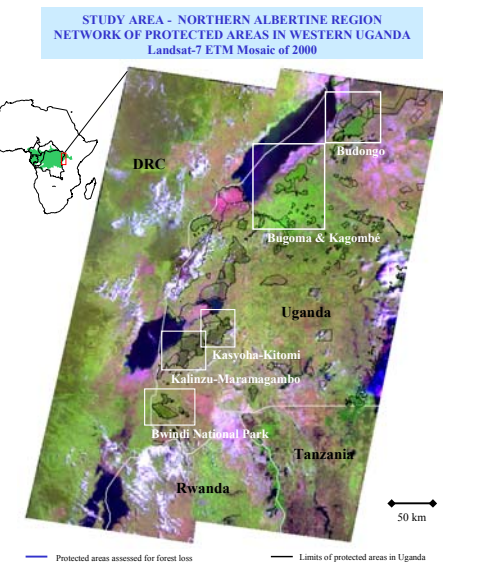
Dr. Nadine Laporte and Tiffany Lin, The Woods Hole Research Center, P.O. Box 296, Woods Hole, MA 02543-0296, U.S.A.
Dr. Andrew Plumptre, Wildlife Conservation Society, Albertine Rift Programme, P.O. Box 7487, Kampala, Uganda
http://www.whrc.org/africa; http://www.albertinerift.org

INTRODUCTION

Monitoring threats to protected areas and species is a major challenge for conservation. In this study, we provide a quantitative assessment of forest loss between the 1980s and early 2000s for the protected areas in the Albertine Rift of western Uganda. In this region, monitoring forest conversion to agricultural land and modeling future threats for the network of protected areas are important to the maintenance of wildlife populations and biological diversity. These tasks are facilitated by combining remote sensing monitoring techniques with traditional field surveys.
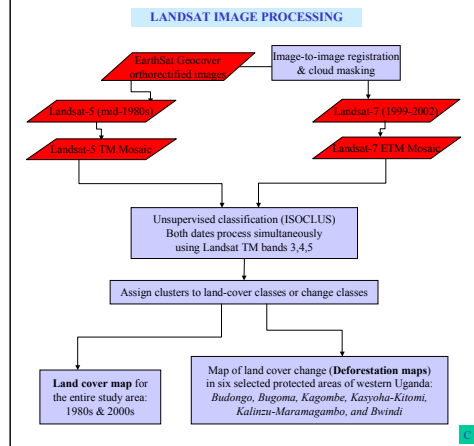
APPROACH

To assess the rate of forest loss for the last two decades around the protected areas of southwestern Uganda, we used a time series of Landsat images (**Table 1**) acquired as part of INFORMS (An Integrated Forest Monitoring System for Central Africa; P.I. Nadine Laporte), a project of the NASA-Land Cover Land Use Change Program. All Landsat-7 images were georeferenced to Landsat-5 images of the Earthsat Geocover orthorectified products. Then a new regional mosaic for the study area was then constructed (**Figure A**). This mosaic is now being used by various NGO's to improve the management of protected areas in the region. It also provides a baseline for monitoring future threats and forest degradation. **Figure C** illustrates the processes of constructing land cover and land cover change maps for assessing forest loss.

Table 1. List of Landsat images used for the study

Data Source Path-Row	Landsat-5 1980s	Landsat-7 1999-2002
172-59	1986-01-17	2002-02-06
172-60	1984-07-06	2001-01-02
172-61	1984-06-20	1999-07-08
173-59	1987-08-07	1999-09-17
173-60	1987-08-07	2001-12-01
173-61	1987-08-07	2000-06-15

STUDY AREA - NORTHERN ALBERTINE REGION NETWORK OF PROTECTED AREAS IN WESTERN UGANDA
Landsat-7 ETM Mosaic of 2000

Protected areas assessed for forest loss — Limits of protected areas in Uganda

The Albertine Rift is a hot spot of biodiversity with many endemic vertebrate and plant species. Most of the forests east of the Albertine Rift are, however, highly fragmented. In Uganda, Rwanda and Burundi, human population densities are some of the highest in Africa.

LANDSAT IMAGE PROCESSING

FOREST LOSS ASSESSMENT

Rates of deforestation in this region have been poorly documented to date. In the six protected areas monitored (**Table 3**), forest loss was estimated using the land cover change map for a 15-km radius of buffer outside of each protected area. Levels of deforestation were then measured as a function of the distance to protected area using consecutive buffers that area 1-km apart (**Figure E**).

ESTIMATION OF FOREST LOSS FROM 1980s - 2002 FOR A 15 KM BUFFER OUTSIDE OF SIX PROTECTED AREAS

— Bugoma — Budongo — Kagombe — Kasyoha — Kalinzu — Bwindi
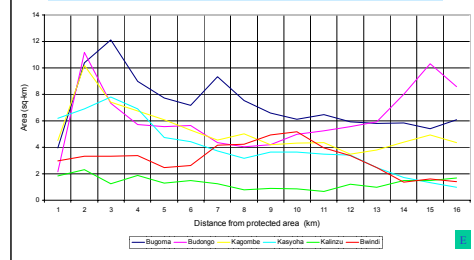
Table 3. Forest loss in the six protected area of western Uganda

Protected Area	Forest loss in the 15-km buffer (sq-km)	Annual rate of forest loss (sq-km/year)	T1	T2	# years
Bugoma	115	7.19	1986-01-17	2002-02-06	16
Budongo	99	6.19	1986-01-17	2002-02-06	16
Kagombe	83	5.19	1986-01-17	2002-02-06	16
Kasyoha-Kitomi	65	4.64	1987-08-07	2001-12-01	14
Kalinzu-Maramagambo	21	1.50	1987-08-07	2001-12-01	14
Bwindi	51	3.92	1987-08-07	2000-06-15	13

LAND COVER CHANGE

Maps of change in forest cover were developed using unsupervised classification combined with expert knowledge to assign spectral clusters. Assessment of forest loss was performed individually for each of the selected protected areas.
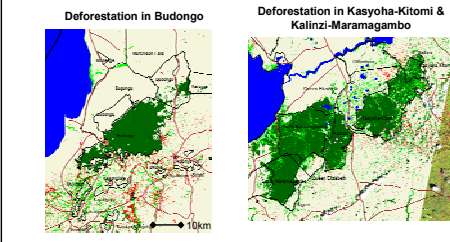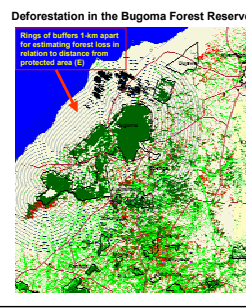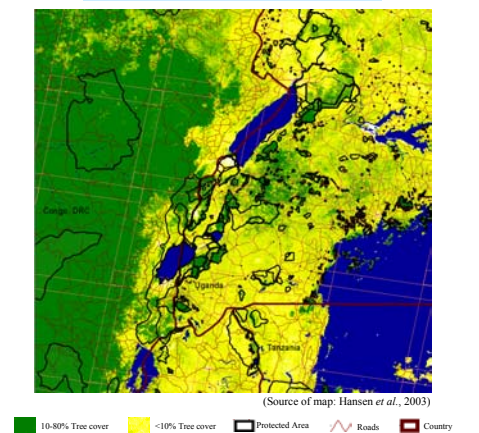
Deforestation in Budongo

Deforestation in Kasyoha-Kitomi & Kalinzi-Maramagambo

Table 2. Legend of the land cover change map- Deforestaton maps

Class	Color
Cloud / Cloud Shadow / Background	
Mature Forest	
Forest loss (deforestation)	
Open Water	
Regeneration / Degraded Forest / Agriculture / Reeds	
Non-forest	

Deforestation in the Bugoma Forest Reserve

Rings of buffers 1-km apart for estimating forest loss in relation to distance from protected area (E)

Bugoma Forest Reserve (right) is one of Uganda's largest forests and has significant chimpanzee populations. It has experienced some small-scale timber harvesting over the years, but the tree species in this forest are not considered as valuable as the neighboring Budongo Forest Reserve (above).

DISCUSSION/ CONCLUSIONS

There are numerous threats to the network of protected areas in the Albertine Rift, and these threats vary by region and country. An approach combining remote sensing analyses with fine-scale field surveys facilitates the management of protected areas by identifying the location of active deforestation and by aiding the predictions of potential threats.

- The largest amount of deforestation is located in the northern part of the protected area network, around Bugoma, Budonga, and Kagombe forests.

- The greatest level of forest loss for Bugoma, is located 2 and 3 km from the protected area limit, and is associated with large-scale farming.

- Kalinzu has the least disturbance in term of conversion to agricultural land, but paths of forest degradation associated with mechanized logging are evident. Mechanized sawmills are only found in Budongo and Kalinzu.

- The majority of forest loss was located immediately outside of the protected area, indicating that the front of deforestation is approaching. However, the discrepancy between the the protected area boundary and the satellite imagery also indicates that the limits could be in need of an update and that deforestation is already occuring inside the protected areas.

- The impact of civil wars in the last 20 years within Uganda, Burundi, Rwanda and eastern DRC has lead to the decimation of wildlife and the degradation of habitat in the protected areas. The re-settlement of population and future migrations are likely to be the most important factor affecting forest loss in the region.

EAST VS. WEST OF THE ALBERTINE MODIS 500m Tree Cover

10-80% Tree cover — <10% Tree cover — Protected Area — Roads — Country

(Source of map: Hansen et al., 2003)

The western part of the Albertine Rift is unrivaled in Africa for its species richness. During the Pleistocene, roughly 1.6 million to 10,000 years ago, it served as a refuge for myriad species from many different habitats. The dramatic difference between the state of the forest east and west of the Albertine Rift is illustrated above. The moist tropical forest of the Democratic Republic of Congo covers 50% of the country, of which 10% is under some form of protection.
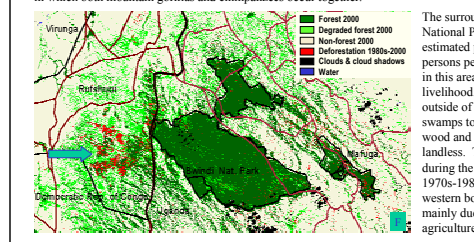
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DEFORESTATION IN THE BWINDI IMPENETRABLE NATIONAL PARK

Bwindi is an African montane rainforest with an exceptionally high level of species endemism. It was designated as one of UNESCO's world heritage sites because of its ecological uniqueness and natural beauty. Gazetted in 1932, the forest reserve became a national park in 1991. Bwindi is home to a number of unique animal species, including mountain gorillas (Gorilla beringei beringei), chimpanzees (Pan troglodytes schweinfurthii), green broadbill (Pseudocalyptomena graueri), Rwenzori Turaco (Musophaga johnstoni), and 22 other birds only found in the Albertine Rift. Bwindi is also the only forest in Africa in which both mountain gorillas and chimpanzees occur together.

Forest 2000 — Degraded forest 2000 — Non-forest 2000 — Deforestation 1980s-2000 — Clouds & cloud shadows — Water

The surroundings of the Bwindi Impenetrable National Park are densely populated, with an estimated population of 800,000, or 400-600 persons per km[2]. The majority of population in this area depends on agriculture for livelihood. Today, virtually no forest remains outside of the park, and most of the papyrus swamps to the south have been cleared for fuel wood and drained for agriculture by the landless. The park itself was illegally logged during the lawless years of Uganda between 1970s-1980s. The large area deforested at the western border of the park (see arrow) is mainly due to the conversion of forest to agriculture and is located in DRC.

The world's population of mountain gorillas is currently estimated at about 650, of which 320 live in the 331 km[2] of the Bwindi forest. The chimpanzee population in the park is roughly at 180-240. In addition, duiker (Cephalophus nigrifrons), elephant (Loxodonta africana), bushbuck (Tragelaphus scriptus), bushpig (Potamochoerus larvatus), giant forest hog (Hylochoerus meinertzhageni) and several small cat species can be found. More than 350 species of birds also have been recorded, of which many are regional endemics. As shown in B, these areas are now geographically and ecologically isolated due to habitat loss, fragmentation, and degradation. More than ever, conservation is vital in order to ensure the survival of this unique ecosystem.