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AERIAL SURVEY OF THE THREATS TO MT. KILIMANJARO FORESTS



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AERIAL SURVEY OF THE THREATS TO MT. KILIMANJARO FORESTS

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FOREWORD

This aerial survey report highlights some destruction of natural resources on Mt. Kilimanjaro. The report shows the type and extent of forest destruction that has taken place so far in the Forest Reserve, most of which are directly attributable to human activities.

The following categories of forest destruction, which threaten the whole ecosystem of Africa's highest Mountain and one of the World Natural Heritage Sites, were recorded during the survey: logging of indigenous trees, fires, charcoal production and shamba system practices. Others include: quarries, livestock grazing, "Forest Villages" (squatters), cultivation of small fields and landslides.

The findings of this aerial survey should remind all of us in Tanzania that we have a duty and concern to conserve Mt. Kilimanjaro for the pride of our country and the international community at large. For continued degradation of the Mountain's natural resources will obviously lead to loss of critical products and services provided by the Mountain. This will include loss of biodiversity, drying up of rivers that originate from the Mountain and decline of agricultural activities that depend on water and favorable climate from the Mountain, loss of hydropower and stifling of the tourist industry. The sum total of all these losses is retrogression of poverty reduction drive that the people and Government of Tanzania are painstakingly spearheading.

On behalf of the Government of Tanzania, I wish to commend UNDP and the United Nations Foundation for launching the COMPACT project around Mt. Kilimanjaro. The Government believes that the support that will be provided through the COMPACT project will go a long way towards empowering local communities to participate effectively in reversing extractive pressures that impact adversely on the Mountain's natural resources.

May I also use this opportunity to pay glowing tribute to the survey team that was drawn from UNEP, KWS, University of Bayreuth, Germany, and the Wildlife Conservation Society of Tanzania for their excellent and highly professional work. Let me assure the team that all stakeholders of Mt. Kilimanjaro will use their findings and recommendations with the view to promote the conservation of Mt. Kilimanjaro.

Thank You.



Philemon Luhanjo
Permanent Secretary
Ministry of Natural Resources and Tourism

ACKNOWLEDGEMENTS

The request for the aerial survey of the forests of Mt. Kilimanjaro was originally presented by UNDP/GEF Small Grants Programme, New York. The objective was to identify the type, extent and location of the threats to the forests and provide a baseline assessment for the newly developed Community Management of Protected Areas Conservation Project (COMPACT). UNDP in collaboration with the United Nations Foundation (UNF) established the COMPACT project in order to promote community participation in the conservation of Mt. Kilimanjaro, which is one of the World Natural Heritage Sites (WHNS). The request was inspired by a similar aerial survey that was undertaken for the forests of Mt. Kenya in 1999 by Kenya Wildlife Service with support from UNEP, and which has been instrumental for the implementation of the COMPACT project in Mt. Kenya.

Mr. Philemon Luhanjo, Permanent Secretary, Ministry of Natural Resources and Tourism, endorsed the idea of the aerial survey and expressed full support on behalf of the Ministry. Mr. Lota Melamari, Director-General, Tanzania National Parks, repeatedly provided encouragement and support to the survey team. Mr. Patrick Akitanda, Regional Catchment Officer, Division of Forestry and Beekeeping shared maps and information that have been used extensively during the survey and the preparation of the report. The endorsement and support by the Tanzanian authorities have been critical to the successful undertaking of the survey and are very much appreciated.

The survey would not have been possible without the support of Mr. Nehemiah Rotich, former Director of Kenya Wildlife Service and Dr. Timothy W. Foresman, Director of the Division of Early Warning and Assessment, UNEP, who agreed to detach Mr. Bongo Woodley and Mr. Christian Lambrechts, respectively, to Tanzania to undertake the survey flights and allocate them the time required for the production of the report.

The continuous support by Mr. Nehemiah Murusuri, GEF Small Grants Programme, UNDP-Tanzania, greatly helped the survey team, particularly in liaising with various stakeholders and coordinating with the Tanzanian authorities.

The Global Environment Facility and the United Nations Foundation provided the much needed funds for the survey, the preparation of the vegetation map and printing of the report.

Finally, we wish to thank Ms. Sheila Edwards, Programme Officer, United Nations Environment Programme, who kindly edited the text of the report.

The Survey Team

I. BACKGROUND

In the year 2000, the GEF Small Grants Programme implemented by UNDP, in collaboration with the United Nations Foundation (UNF), launched the Community Management of Protected Areas Conservation Project (COMPACT).

The main objective of COMPACT is to demonstrate, by complementing and adding value to existing conservation programmes, how community-based initiatives can significantly increase the effectiveness of biodiversity conservation in and around World Natural Heritage Sites (WNHS).

The project also aims at (i) enhancing the capacities of local organizations and NGOs whose existence and future prospects are closely linked to these protected areas; (ii) increasing local awareness of, and concern for, the protection of WNHS, (iii) promoting and supporting communication and cooperation among park management personnel and other concerned groups, particularly local communities, (iv) increasing general understanding of the synergies between community development and the role of globally significant protected areas in contributing to sustainable development, and (v) drawing lessons from project experience that can be shared widely at local, national and international levels.

Mount Kilimanjaro is one of six World Natural Heritage Sites on three continents participating in COMPACT. Others include: Mt. Kenya National Park; Mornes Trois Pitons National Park in Dominica; Sian Ka'an Biosphere Reserve in Mexico; Puerto Princesa Subterranean National Park in the Philippines; and the Belize Barrier Reef System in Belize.

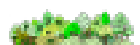
A common methodology to prioritize COMPACT interventions in the six sites has been developed. It involves a participatory approach to identify the main threats to the protected area, and to assess the types of activities that may be carried out by local communities to address those threats while improving their quality of life and livelihoods. This planning process involves a wide range of stakeholders of Mt. Kilimanjaro: community-based organizations, local and national NGOs, local and national authorities with management responsibilities of the mountain, and other programmes and projects present in the area.

The aerial survey, carried out in partnership with UNEP, Wildlife Conservation Society of Tanzania, the University of Bayreuth and the Kenya Wildlife Service, is an extremely valuable tool to determine priorities for interventions to conserve Mt. Kilimanjaro. The results of the survey, together with the findings of a socio-economic assessment recently completed, will help the stakeholders both determine the future and shape of COMPACT and measure the collective progress in conserving the mountain.

The process to carry out the survey and prepare the report is already a major COMPACT achievement. In addition to providing current and accurate information on the threats to the mountain forests, this exercise has fostered dialogue between a large number of organizations, including the protected area authorities of Mt. Kenya and Mt. Kilimanjaro, allowing for a valuable exchange of experiences.

It is expected that the wealth of information generated through the aerial survey will be made accessible to lowland communities. It is essential to share and validate the findings of the report with local stakeholders if they are to contribute the solutions to address the threats.

The survey report and the maps are certainly powerful awareness-raising instruments. Hopefully their effect will transcend national borders, attracting additional funds to support local community initiatives and conserve the biodiversity of Mt. Kilimanjaro.



II. GOAL AND OBJECTIVES

The main goal of the aerial survey was to provide factual information on the type, magnitude and location of the main threats to the forests of Mt. Kilimanjaro. It will help stakeholders in Mt. Kilimanjaro forest ecosystem to determine the effectiveness and weakness of current management practices and to adopt new policy and management decisions for the long-term conservation of the forests. The specific objectives were to:

- (a) Categorise the type, magnitude and location of the threats, in particular destructive activities, in the forests of Mt. Kilimanjaro;
- (b) Provide a well documented, systematic and factual assessment of the current threats to the forests that could be useful for improved management;
- (c) Enhance awareness of the current threats to the forests and the value of the mountain ecosystems.

III. BRIEF DESCRIPTION OF MT. KILIMANJARO FORESTS

A. Overall description

Mt. Kilimanjaro is located 300 km south of the Equator in Tanzania, on the border with Kenya, between 2°45' and 3°25' S and 37°00' and 37°43' E. It is the highest mountain in Africa, composed of three extinct volcanoes, Kibo, Mawenzi and Shira, which reach, respectively, altitudes of 5,895, 5,149 and 3,962 metres. Kilimanjaro is also the world's highest free standing mountain, looming 5,000 metres above an open undulating plain that averages around 800 metres above sea level. The mountain's topography features very deep V-shaped radial valleys, particularly on the western and southern slopes, as well as major barrancos south of Kibo and east of Mawenzi (TANAPA/AWF, 1987). In the cultivated areas on the lower slopes, these valleys, together with some secondary vents, create important refuge areas for natural flora and fauna.

The climate of Mt. Kilimanjaro is characterised by two rainy seasons - from March to June, and during November and December. Rainfall varies with altitude and exposure to the dominant wind from the Indian Ocean, but reaches a maximum of around 3,000 mm annually at 2,100 metres on the central southern slope in the lower part of the forest belt (Hemp, A, 2001a). Rainfall decreases at higher elevations: at 2,400, 2,700 and 3,000, some 90, 70 and 50 per cent, respectively, of this maximum were observed. The northern lee slopes of the mountain receive much less annual rainfall.

Various vegetation zones can be distinguished on Kilimanjaro, including the savanna zone, the densely populated agro-forest area, the forest belt, the sub-alpine and alpine vegetation. The forest belt covers a major part of the mountain. Most of the forest is gazetted as Kilimanjaro Forest Reserve. The upper forest zone that lies above the 2,700 metres contour falls within Kilimanjaro National Park.

The forest belt of Mt. Kilimanjaro is characterised by a high diversity of forest types, because of the wide altitudinal range (from 1,300 m to 3,300 m) and the climatic differences between the slopes.

B. Water Catchment

Mt. Kilimanjaro is a critical water catchment for both Tanzania and Kenya. High rainfall and extensive forests give Mt. Kilimanjaro its high catchment value. About 96 per cent of the water flowing from Mt. Kilimanjaro originates from the forest belt.

The southern and the south-eastern forested slopes form the main upper catchments of the Pangani River, one of Tanzania's largest rivers, which drains into the Indian Ocean near Tanga. Its course provides water to the hydropower plants of Nyumba ya Mungu (8 MW), Hale (17 MW) and Pangani Falls (66 MW), which generate some 20 per cent of Tanzania total electricity output. Fishing in Nyumba ya Mungu dam yields a maximum catch of approximately 4,000 tonnes annually. The river also supplies the large scale South-East Moshi rice scheme. The southern slopes also provide water to Arusha Chini sugarcane plantation. The north-eastern slopes form the catchment of the Tsavo River, a tributary of the Galana River, one of Kenya's major rivers.

Water is also piped from the forest to supply traditional furrow irrigation systems that provide water to the villages, coffee and banana plantations of the densely populated areas of the southern slopes, which have a population of over one million inhabitants. There are also major springs, most of them in Moshi District such as Kiwaramu, Nkotima, Nkamakoe and Nkwakundi.

In Kenya, the Amboseli ecosystem derives from the hydrology of Mt. Kilimanjaro and includes the wetlands of Ol Tukai and Kimana, which support Maasai pastoralists and an abundance of wildlife. Further afield, it is likely that the mountain has an effect on Ol Turesh swamp and possibly Mzima Springs, whose primary catchment is the Chyulu hills. Lake Chala, in the southern foothills of Mt. Kilimanjaro, receives subterranean inflow from the mountain, as well as Lake Jipe, which is mainly fed by the Pare mountains.

Mt. Kilimanjaro is the single most important hydrogeographical feature in the region, and its catchment influences the unique dynamics of the semi-arid lands that surround it.

C. Biodiversity

Ecosystems

Mt. Kilimanjaro has a rich diversity of ecosystems, particularly of vegetation types (see Table 2) that result mainly from a large range in altitude and rainfall (Map 1).

Table 2: Mt. Kilimanjaro major vegetation types

	Vegetation	Altitudinal zone	Altitude (m asl)	Location
	Savanna bushland with <i>Acacia</i> , <i>Terminalia</i> , <i>Combretum</i> , grassland and pasture with <i>Cyperus niveus</i> , <i>Bothriochloa insculpta</i> , <i>Eragrostis superba</i> Agriculture (maize, wheat, sunflowers)	colline	700 – 1,000 (south) 1,400 – 1,600 (north)	All around the mountain
	Densely populated Chagga home gardens (agroforestry system) with a sparse tree layer of <i>Albizia schimperiana</i> , <i>Markhamia lutea</i> covering bananas, coffee, vegetables; remnants of natural gorge forest in deep valleys with <i>Mitragyna rubrostipulata</i> , and <i>Newtonia buchananii</i>	submontane	1,000 – 1,700	South/ East
Forest Reserve*	<i>Ocotea-Agauria</i> forest, consisting of <i>Ocotea usambarensis</i> associated with <i>Agauria salicifolia</i> , <i>Macaranga kilimandscharica</i> and <i>Polyscias fulva</i>	lower montane	1,600 – 2,100	South / South East
	<i>Ocotea-Podocarpus</i> forest, consisting of <i>Ocotea usambarensis</i> associated with <i>Podocarpus latifolius</i> and the tree fern <i>Cyathea manniana</i>	middle montane	2,100 – 2,400	South / South East
	<i>Podocarpus-Ocotea</i> forest with prevailing <i>Podocarpus latifolius</i>	upper montane	2,400 – 2,800	South / South East
National Park*	<i>Croton-Calodendron</i> forest with <i>Olea europaea</i> ssp. <i>africana</i> , <i>Croton megalocarpus</i> , <i>Calodendrum capense</i> and <i>Diospyros abyssinica</i>	submontane	1,300 – 1,600 1,600 – 2,000	West North
	<i>Cassipourea</i> forest with <i>Cassipourea malosana</i> , <i>Teclea simplicifolia</i> , <i>Fagaropsis angolensis</i> and <i>Olea capensis</i>	lower and middle montane	1,600 – 2,200 2,000 – 2,400	West North
	<i>Hagenia-Podocarpus</i> forest with <i>Podocarpus latifolius</i> , <i>Hagenia abyssinica</i> and <i>Prunus africana</i>	subalpine	2,800 – 3,100	South / South East
	<i>Juniperus-Podocarpus</i> forest with <i>Juniperus procera</i> , <i>Podocarpus latifolius</i> and <i>Hagenia abyssinica</i>	subalpine	2,400 – 2,800	North Around the
	<i>Erica</i> forest consisting of pure stands of <i>Erica excelsa</i>	subalpine	2,800 – 3,500	mountain

*The allocation of the different vegetation types between the Forest Reserve and the National Park is merely indicative and does not reflect the exact boundaries of the Forest Reserve or the National Park.



Flora

The forest belt is the most important habitat of Mt. Kilimanjaro in terms of ecosystem and species diversity. On the southern slopes, nearly 740 plant species were recorded in the forest alone, representing some 50 per cent of all recorded plant species in the vegetation zones of the southern slopes (over 1,600 species, Hemp, A., 2001a). In total there may be over 900 species in the forest belt and 2,500 species for the whole mountain. The diversity of the flora in the Forest Reserve is greatest at 1900 m on the southern slope (nearly 300 species), whereas the highest diversity of vascular plants on the southern slopes of the mountain occurs at 1,300 metres, with about 750 species.

There are about 130 tree species from 100 genera and 50 families in the forests of Mt. Kilimanjaro (Hemp, A., unpublished data). The most common species are *Xymalos monospora*, *Ocotea usambarensis*, *Podocarpus latifolius*, *Ilex mitis* and *Rapanea melanophloeos*. Maximum tree species diversity is found between 1,800 and 2,000 metres. There are nearly 170 shrub species in the forests, belonging to over 100 genera and 40 families. Most widespread are *Psychotria cyathicalyx*, *Lasianthus kilimandscharicus*, *Galiniera saxifraga*, *Dracaena afromontana* and *Pauridiantha paucinervis*. In addition, there are 140 species of epiphytes in the forests (Hemp, A., 2001b), mostly pteridophytes of the genera *Asplenium* (Aspleniaceae), *Elaphoglossum* (Lomariopsidaceae) and *Hymenophyllum* (Hymenophyllaceae), followed by orchids mostly belonging to the genus *Polystachia*. Epiphytes are most abundant on the wet southern slopes. There are over 100 climbing species from 80 genera and 46 families in the forests of Mt. Kilimanjaro. The most common lianas are *Senecio syringifolius*, *Rourea thomsonii*, *Schefflera volkensii*, *S. myriantha* and *Begonia meyeri-johannis*. Ferns are also abundant in the forests, especially on the southern slopes where humidity is high. Over 140 taxa of pteridophytes occur on the mountain, mostly (over 90 per cent) in the forests (Hemp, A., 2001a, in press). These constitute about 35 per cent of the pteridophyte flora of Tanzania.

Fauna

The most comprehensive description of Mt. Kilimanjaro's fauna was published nearly a hundred years ago following an expedition led by the Swedish naturalist Sjöstedt (1909).

More recent studies are available for mammals. Grimshaw et al. (1995) recorded about 140 species of mammals for Mt. Kilimanjaro, a number far exceeding the diversity known for Mt. Kenya (Gathaara 1999). Among them, 87 species are regarded as being pure forest species. Black Rhinoceros is now extinct in the area, as possibly are reedbuck and klipspringer. Twenty four antelope species are recorded in the area, as well as 25 species of carnivores and 7 species of primates. The forest is home to the largest known population of Abbot's duiker, which is globally threatened. There are also 25 species of bats (Chiroptera).

Sjöstedt (1909) listed 405 bird species in his expedition report for Mt. Meru and Mt. Kilimanjaro, while Grimshaw (1996) gives a number of 179 highland bird species inhabiting Mt. Kilimanjaro. In an ethno-zoological study, 82 bird species were recorded on the southern slopes in the area of the Chagga home gardens, mostly from an altitude of 1,400 m (Hemp et al. 1999) reflecting the high diversity of bird habitats.

Sjöstedt recorded 1,310 species of beetles (Coleoptera), 594 Hymenoptera, 447 bugs and allies (Hemiptera), and 537 butterflies and moths (Lepidoptera) species for the area including Mt. Meru, but with a main focus on Mt. Kilimanjaro. The insect materials collected highlighted the diversity of Mt. Kilimanjaro and the large number of endemic species: 47 of the 107 known Homoptera species were endemic to the mountain, as well as 27 of the 57 recorded Darkling beetles (Tenebrionidae). A high rate of endemism was also recorded for the Rove beetles (Staphylinidae, 39 per cent endemism) and Scarab beetles (Scarabaeidae, 25 per cent endemism) and derived for the long-horned beetles (Cerambycidae, 36 per cent endemism in the mountain among all species known in East Africa (Forchhammer & Breuning 1986; Hemp & Winter 1999; Hemp, C., 2001).

Grasshoppers and locusts (Saltatoria) have been well studied on Mt. Kilimanjaro. 140 species of Acridoidea have been collected around the mountain in the past 10 years (Hemp & Hemp, in press), which represents 33 per cent of the species found in the whole of Tanzania according to a list published by Johnsen & Forchhammer (1975). Together with the Ensifera, about 190 species of Saltatoria are recorded on the mountain, of which 12 species are

only known from Mt. Kilimanjaro localities (Hemp, C., in press), and three species are still undescribed, representing 8 per cent endemism in this insect group.

D. Medicinal and cultural benefits

An ethnobotanical study (Hemp, A. 1999) showed that the Chagga make use of their plant environment in a great variety of ways, and consequently there is a large vocabulary of plant names. The plants serve as forage for household and agricultural purposes, and many are used in medicinal applications, as drugs and for “magic” purposes. Traditionally, the Chagga hut, the so-called bee-hive hut, was made from local material; specific tree types for the posts, with walls of flexible branches from young trees and shrubs, fixed together using lianas. The roofs were made of grass thatch. These houses are now rarely seen.

The montane forest is the home of many plants with old cultural and magical values, including several species of the dragon tree genus *Dracaena*. *D. cf. steudneri* is wide spread over the whole submontane plantation belt along compound boundaries - but it occurs naturally only in submontane gorge forests. It is now rare since most of this forest type has been cleared. *Dracaena* hedges are protected as they serve also as burial grounds. *Olea capensis* (East African Olive) is also a mystical tree. Because of its very hard, compact wood, which is heavier than water, this tree was worshipped by the old Chagga as the home of their gods.

Bee-keeping is important on Mt. Kilimanjaro. Two bee species are kept: the bigger, stinging honey-bee *Apis mellifera monticola* and a small stingless bee of the genus *Meliponula*. The more thermophilic *Meliponula* bee is kept in lower altitudes, mostly in the plantation belt, while the bee-hives of *Apis mellifera monticola* can be found up to the upper forest border at about 2,800 m.

In former times the forest also provided an important source of meat, hides and other animal parts and derivatives. Pigs and antelopes were caught in pits, while smaller animals such as *Hyrax* were hunted with snares. The horns of the Greater Kudu were used as traditional music instruments, while the skin of *Hyrax* and *Colobus* monkey served for the traditional clothing of the Chagga. Although illegal today, such exploitation of forest products is still practised in many areas.

The area of Old Moshi contains 176 plant species with medicinal properties used in the treatment of the gastrointestinal tract, coughs, dermatological problems and veterinary uses. Haemostatic and dental ointments are also made. The knowledge of medicinal plants is still largely found among the older people.

E. World Heritage Site

The World Heritage Convention, adopted in 1972, aims to conserve cultural and natural heritage sites that are considered to be of outstanding universal value. While cultural heritage is an indispensable part of human identity, diversity of species in natural heritage sites is considered as a life-supporting base for mankind. Concerted efforts at local, national and global levels are necessary to ensure that World Heritage sites are conserved for present and future generations.

Mt. Kilimanjaro is the oldest protected area in Africa and was first declared as a game reserve by the German colonial government in the early part of the 20th century. The area was further gazetted as a forest reserve in 1921. This designation was confirmed by the legislation of subsequent administrations. The area above the main forest line (2,700 metres) was reclassified in 1973 by the Tanzanian Government to form a National Park, covering 75,353 hectares, surrounded by a Forest Reserve of 107,828 hectares. Mt. Kilimanjaro National Park was inscribed on the World Heritage list in 1987, the seventh World Heritage Site in Tanzania. The others are Ngorongoro Conservation Area, Serengeti National Park and the Selous Game Reserve, and the world cultural heritage sites of the ruins of Kilwa Kisiwani and Songo Mnara, and Zanzibar Stone Town.



IV. A BRIEF ON THE FOREST SECTOR

A. OVERVIEW

Tanzania has about 33.5 million hectares of forest and woodland, constituting 38 per cent of the total land area in the mainland. The forests are unique natural ecosystems, and offer habitat for wildlife, beekeeping and genetic resources. They form an important economic base for the country's development.

About 13 million hectares of forest have been gazetted as forest reserves. They include 1.6 million hectares of strategic forests (providing vital services, such as water catchment) and mangroves, as well as 80,000 hectares of industrial plantations. Non-reserved forests cover some 19 million ha (see Table 1).

Most of the "forest" in Table 1 is woodland. Closed forests cover only 1,141,000 hectares. Among them, montane closed forests are of particular importance in view of the critical environmental services that they provide, such as water catchment, soil protection, food and timber supply. Worldwide they are hotspots of biodiversity and endemism. The 3% of Tanzania's forests contributed by Mt. Kilimanjaro are thus much more important than this number indicates.

Table 1: Distribution of forest area area by type, use and legal status	1,000 ha	%
Forest type		
Forests (other than mangrove forests)	1,141	3.4
Mangrove forests	115	0.3
Woodlands	32,299	96.3
Total	33,555	100.0
Use of forest land		
Production forest area	23,810	71.0
Protection forest area (mostly catchment areas)	9,745	29.0
Total	33,555	100.0
Legal status		
Forest reserves	12,517	37.3
Forest/woodlands in national parks, etc.	2,000	6.0
Non-reserved forest land	19,038	56.7
Total	33,555	100.0

B. Management

Forest management falls under two main authorities: the Ministry of Natural Resources and Tourism, the main custodian; and the President's Office, which is responsible for regional administration and local governments. Within the Ministry of Natural Resources and Tourism, the Forestry and Beekeeping Division is the main entity in charge of forest management. The forest areas that are included in national parks, however, fall under the jurisdiction of the Tanzania National Parks (TANAPA).

The ongoing administrative and sectoral reforms aimed at improving the institutional set-up focus on decentralization and devolution of forest management to local governments, communities and the private sector. A major shift is also anticipated when executive agency(ies) take over management of central government forests. In this context, such partnership initiatives as joint forest management and community based forest

management are now institutionalized through the Forest Policy, Forest Act (under revision) and the National Forest Programme.

On the southern and eastern edges of Mt. Kilimanjaro Forest Reserve, a buffer zone, called the half-mile forest strip was demarcated in 1941 to provide local communities with fuelwood, animal fodder, building poles and other wood products. Although located within the Forest Reserve, the zone is managed by the district councils of Hai, Moshi Rural and Rombo.

V. METHODOLOGY

The methodology for the aerial survey of the forests was derived from the long experience gained by East African wildlife departments in counting animal numbers from aircraft following set transects, further adapted as a result of the first ever forest survey of its kind of Mt. Kenya in 1999 (Gathaara, 1999). The principal difference was that the occurrence of forest destruction often had to be viewed from vertically overhead, necessitating a series of continuous loops either side of the transect, in a “figure-of-eight” pattern.

The aircraft used was a tandem-seat Aviat Husky, based at Moshi airport. The crew consisted of a pilot and a rear-seat observer (RSO) who were accommodated at Old Moshi - Kidia Lutheran Mission, some 15 kilometres north-east of Moshi.

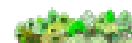
The aircraft was equipped with a Global Positioning System (GPS) Trimble Pathfinder Plus receiver, able to track the flight path of the aircraft on a “rover file”, and was set to record position every 10 seconds. This recorded a detailed and accurate map of the actual flight paths and included the exact flight pattern each time the aircraft left the transect in order to get a better look at the extent of damage or observed threat. The exact position of each observation was recorded as a waypoint in the GPS waypoint file that was later downloaded into a Geographical Information System (GIS) database. The data from the survey is deposited in the office of the COMPACT project at Himo, Moshi. Copies will be deposited at the Institute of Resource Assessment of the University of Dar es Salaam.

The types of damages and threats to the forest were recorded as follows:

- Logging of indigenous trees:
 - Camphor (*Ocotea usambarensis*)
 - Cedar (*Juniperus procera*)
- Logging of other indigenous tree species
- Burnt forest areas
- Charcoal production
- Forest villages
- Shamba (Taungya) system practices
- Livestock grazing
- Small cultivated fields in the indigenous forest
- Landslides
- Quarries

A. Reconnaissance flights

Prior to the aerial survey, reconnaissance flights familiarized the crew with the forest areas to be surveyed. These reconnaissance flights involved Drs. Andreas and Claudia Hemp, of the University of Bayreuth, who have been studying the forests of Mt. Kilimanjaro for the last 10 years. On the basis of these flights, the crew became familiar with the topography of the area. Pre-assessments of the level of disturbances were made to help select the most appropriate flight paths for each area (see below section C), and the most targeted tree species were identified.



Additional flights involving Dr. Inyang Ebong-Harstrup, UNDP Acting Resident Representative, Mr. Patrick Akitanda, Regional Catchment Officer, Division of Forestry and Beekeeping, and Mr. Ole Meikasi, Deputy Warden, Kilimanjaro National Park, TANAPA, introduced them to the methodology and demonstrated some of the threats to the forests.

B. Survey blocks

The area covered by the aerial survey included the entire Kilimanjaro Forest Reserve and the *Podocarpus-Juniperus* forests of Kilimanjaro National Park. The area was divided into 11 blocks (Map 2), demarcated by easily discernible boundaries such as rivers and roads. The actual survey occupied over 38 hours of flight time (see Table 3).

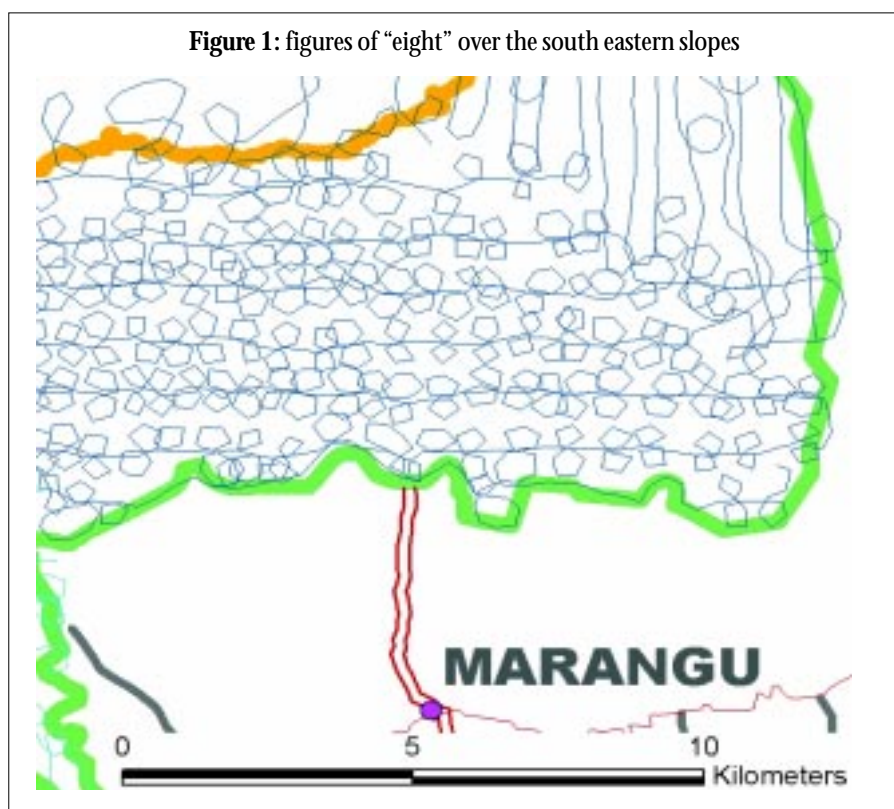
Table 3: Flight time and count time

Date	Take off	Landing	Flight time (hours)	Count on	Count off	Count time (hours)	Block
09-Aug-01	12:55	15:41	2:46	13:38:34	15:13:38	1:35:04	NNW
11-Aug-01	12:17	15:18	3:01	12:48:05	13:05:42	0:17:37	NNW
				13:10:19	14:42:45	1:32:26	N
				14:48:48	16:15:21	1:26:33	NW
				12:38:36	15:11:18	2:32:42	SSW
12-Aug-01	14:26	16:32	2:06	12:33:32	12:43:32	0:10:00	SSW
13-Aug-01	12:20	15:24	3:04	12:48:48	14:31:50	1:43:02	SW
15-Aug-01	12:22	16:29	4:07	14:34:07	16:15:56	1:41:49	WSW
				12:55:16	14:52:49	1:57:33	S
				14:52:59	15:07:06	0:14:07	SSW
				15:12:24	15:23:55	0:11:31	SSE
16-Aug-01	12:47	15:33	2:46	13:34:08	15:59:39	2:25:31	SSE
				12:48:42	13:08:11	0:19:29	SSE
				13:10:05	13:47:20	0:37:15	SSE
17-Aug-01	13:22	16:11		13:49:22	15:05:52	1:16:30	SSE
18-Aug-01	12:38	15:17	2:39	12:08:31	15:27:27	3:18:56	SE
				13:05:10	15:30:11	2:25:01	SE
				13:51:30	16:43:55	2:52:25	E
28-Aug-01	11:56	15:40	3:44	13:13:30	14:53:27	1:39:57	NE
29-Aug-01	12:44	15:41	2:57	14:54:22	15:08:39	0:14:17	N
30-Aug-01	13:36	17:18	3:42	13:05:24	15:21:52	2:16:28	W
				15:23:20	16:14:51	0:51:31	NW
				16:19:22	16:19:33	0:00:11	NNW
				16:26:50	16:46:47	0:19:57	NE
				16:47:58	16:48:41	0:00:43	NE
31-Aug-01	12:26	15:30	3:04	16:50:28	17:04:00	0:13:32	E
				17:04:26	17:04:57	0:00:31	E
01-Sep-01	12:48	17:19	4:31				
Total flight time			38:27	Total count time		32:14:38	

C. Selection of flight paths

Flight paths were selected so as to limit climbing or descending along each transect. They were run east-west (or vice-versa) or north-south (or vice-versa) depending on the direction of slope in each block (Map 3).

Transects were spaced from between 0.5 to 1 kilometre apart, depending on the extent of forest damage witnessed. In areas where disturbances were not recent, transects were one kilometre apart. In areas moderately disturbed, the transects were 500 metres apart in order to document the disturbance activities in the forest more precisely. In heavily disturbed areas, figures of eight were carried out on either side of the transects to enable a more thorough survey of the disturbances (Figure 1). In the latter case, however, the transects were one kilometre apart (and not 500 metres) in order to avoid overlap between two adjacent transects while flying the figure of “eight”.



D. Data recording

The pilot navigated and recorded each observation into the GPS receiver. The RSO took photographs, and recorded the information related to each observation on a data sheet in consultation with the pilot. Both crew attempted to spot and assess disturbance in the forest.

GPS positions of observed disturbances are affected by in-built imprecision of the GPS system and the time lapse between eye observation and subsequent logging of the actual position into the GPS. As a result, GPS position of disturbances may be slightly off the actual position on the ground; the GPS positions of disturbances on the edges of the forest reserves may appear on the maps slightly outside the boundaries.

The recording of disturbance was restricted by aircraft aerial visibility, since disturbance concealed by the canopy was not seen. Tall trees, deep valleys, obscured angles and sunlit tree tops that enhanced dark shadows all affected what was actually seen and recorded. As a result, the recorded observations provide an indication of the extent of the actual disturbance rather than a complete and accurate picture.

For each observation, the following data were recorded:

- Waypoint number as indicated on the GPS
- Type and extent of disturbance
- Frame numbers
- Comment made by the pilot or the RSO

The extent of the disturbances was estimated in hectares for the small cultivated fields on the southern slopes, on the basis of counting the number of football pitches (0.5 hectare) that could fit in each of the fields under observation.

E. Photo records

Most observations are illustrated by photographs. In particular, each Shamba-system area and each “forest village” are documented by at least one photograph. Photographs were taken with a digital still camera Fujifilm model 4700.



F. Data processing in the field

Immediately on landing, the RSO down-loaded the digital photographs, the GPS rover files and the observation waypoint files into a lap-top computer using Trimble Pathfinder software. Maps of the flight lines and the observation waypoints were then printed to identify any double observations within each block and to cross check with the flight lines as to whether or not the area to be surveyed had been completely covered.

G. Data interpretation and analysis

Further analysis was carried out in Nairobi. All data were copied from the data-sheets to an Excel spreadsheet where they were merged with the GPS data (position, date and time). All the MS-Excel data records were then transferred into a GIS using the ArcView v.3.2 software. The boundaries of the Forest Reserve and the half-mile forest strip that are incorporated in the GIS were based on the 1972 map "Kilimanjaro Forest Reserve", prepared by the Forestry and Beekeeping Division, of the Ministry of Natural Resources and Tourism. Digital photographs were used to cross check the information recorded on the data sheets.

VI. RESULTS OF THE AERIAL SURVEY

A. Overall description of current threats to the forests

Mt. Kilimanjaro forests are heavily impacted by illegal logging of indigenous trees in most areas below 2,500 metres on the western, southern and eastern slopes, fire occurrences on the south eastern slopes, and the establishment of forest villages in the western and northern slopes (Map 3).

Southern slopes of Mt. Kilimanjaro

Logging activities affect the entire broadleaved mixed forests below an altitude of 2,500 metres. The moist *Ocotea* forests that cover most of the southern slopes are undergoing serious destruction caused by the intensive illegal logging of camphor trees. During the survey, over 2,100 recently-logged camphor trees were counted. On the lower slopes bordering the half-mile forest strip, there was no recent logging of camphor trees as these areas have already been depleted, but other indigenous tree species were being targeted; some 4,300 recently-logged indigenous trees were recorded. There was evidence of 57 landslides in the heavily impacted *Ocotea* forests.

The south western slopes are significantly impacted by forest fires; there were 37 areas of burnt forest on these slopes. To the east, above Marangu, 19 cleared fields have been opened up in the forest, and a large number of livestock was seen up to 8 kilometres deep into the forest.

There were fewer observations recorded in the half-mile forest strip because the zone is virtually denuded of indigenous trees. Some areas have been completely clearfelled.

Northern slopes of Mt. Kilimanjaro

Logging activities also impact heavily on the east and west sides of the northern slopes; 574 recently-logged cedar trees were counted, as well as over 800 other indigenous trees.

Large tracks of indigenous forests on the north-western and northern slopes have been converted into forest plantation, using fast growing exotic tree species, such as pine (*Pinus patula*) and cypress (*Cupressus lusitanica*). On the north western slopes, the expansion of the forest plantations has reduced the indigenous forest belt to a width of less than one kilometre. The majority of the clear felled compartments within the forest plantations have not been replanted as required by the normal rotation management.

A number of large “forest villages”, some the size of a town, are found in the Forest Reserve. Their presence and likely future expansion pose a threat to the integrity of the narrow forest belt of Mt. Kilimanjaro.

B. Logging of indigenous trees

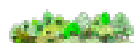
The survey recorded recent logging of indigenous trees in the natural forest (Maps 5, 6 and 7). Two of the most targeted species were identified separately: camphor (*Ocotea usambarensis*) and cedar (*Juniperus procera*). The others are grouped under the category “other indigenous tree species” (Table 4).

Table 4: Logging of indigenous trees

Tree species	Number of trees
Camphor	2,111
Cedar	574
Other indigenous tree species	5,183
Total	7,868



Photograph 1: Logging of camphor on the south eastern slopes





Photograph 2: Logging of camphor on the south western slopes



Photograph 3: Logging of camphor on the south western slopes





Photograph 4: Logging of cedar on the eastern slopes



Photograph 5: Logging of indigenous trees on the south eastern slopes



C. Burnt forest areas

The survey recorded 65 burnt indigenous forest areas (Map 8). The fires had usually taken place some time ago. The majority of these areas were found on the south western slopes of Mt. Kilimanjaro (Table 5).

Table 5: Burnt forest areas

Location	Number of burnt forest areas
South western slopes	37
Eastern slopes	18
Others	10
Total	65

Fires are also a common phenomenon in the forests of the subalpine zone, with the result that the *Podocarpus*, *Hagenia* and *Juniperus* forests have been replaced by *Erica* forests and bushlands in many areas (Hemp & Beck 2001). Fires devastate several hundreds hectares of *Erica* bush every year, but since they occur mostly above the forest line, they were not counted in the survey.



Photograph 6: Burnt forest on the south western slopes

D. Charcoal production

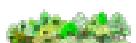
Some 125 charcoal kilns were spotted in the natural forest of Mt. Kilimanjaro (Map 9). All the kilns were located on the south eastern slopes (Table 6).

Table 6: Charcoal production

Location	Number of charcoal kilns
South eastern slopes	125
Elsewhere	0
Total	125



Photograph 7 : Charcoal kilns on the eastern slopes



E. Forest villages

The survey counted 18 “forest villages”. Forest villages are permanent urban settlements varying in size from small homesteads to medium-sized towns (Table 7). All of them were found amid the forest plantations within the Forest Reserve. They were up to 4 kilometres into the forest on the north western and northern slopes (Map 10). The size of these forest villages is based on an interpretation of two mosaiced Landsat 7 satellite images taken on January-February 2000. A false colour composition (bands 4, 3 and 2) was used for the interpretation. These forest villages are densely populated.



Photograph 8: Small “forest village” within the Forest Reserve on the western slope

Table 7: Forest villages

Location	Name of the “forest village”	Size (hectares)
Northern slopes	Nalemoru	41.5
Northern slopes	Rongai	34.8
Northern slopes	Morudit	30.5
Western slopes	Londorossi	26.8
Western slopes	Forest Industries Training Institute	19.9
Londorossi Glades (north western slopes)	(*)	13.5
Tarakia (north eastern slopes)	(*)	12.7
Tarakia (north eastern slopes)	(*)	10.3
Northern slopes	Kamwanga	9.4
Northern slopes	Endonet	6.5
Nduimet Estates (north western slopes)	(*)	6.4
Sesana Glade (western slopes)	(*)	5.9
North eastern slopes	Kasirwa	5.8
Sesana Glade (western slopes)	(*)	5.1
Wasendo Glade (western slopes)	(*)	4.0
Sesana Glade (western slopes)	(*)	3.4
North eastern slopes	Kasirwa	2.8
Northern slopes	(*)	2.4

* Name not known to the survey team



Photograph 9: “Forest village” within the Forest Reserve on the north western slopes



Photograph 10: Zoom into photograph 9



F. Shamba (Taungya) system practices

Forest plantations in Tanzania have usually been established by allowing local farmers to inter-crop annual agricultural crops with tree seedlings in forest plantation areas until the third year of tree growth. By the third year, the young tree canopy casts too much shade for the normal growth of agricultural crops. At this point farmers move out and are allocated another plot, if available. This Shamba system is based on the successful experience of establishing teak plantations in Burma (Myanmar) since the middle of the 19th century. It was identified as a means of providing cheap labour, even free, for establishing forest plantations, contributing to national food production and the creation of rural employment.

The survey recorded the status of forest plantation areas under the Shamba-system (Map 11). Three different categories were identified: areas not planted with tree seedlings, those partially planted, and planted areas (Table 8).

Table 8: Shamba-system practices

Status of Shamba-system areas	Number of areas
Not planted with tree seedlings	22
Partially planted with tree seedlings	10
Planted with tree seedlings	10
Total	42



Photograph 11: Shamba-system area not planted with tree seedlings on the north eastern slopes



Photograph 12: Shamba-system area not planted with tree seedlings on the north western slopes

G. Livestock grazing

Large herds of livestock were found on the northern slopes of Mt. Kilimanjaro. On the southern slopes, livestock was found predominantly above Marangu up to eight kilometres deep into the forest (Map 12). In total, 814 head of livestock were counted; goats and sheep were grouped together as “shoats”, and cattle were counted separately (Table 9).

Table 9: Livestock grazing

Livestock grazing	Northern slopes		South western slopes		South eastern slopes		Total
	No. of Heads	Average No. heads/herd	Average No. heads/herd	No. of Heads	No. of Heads	Average No. heads/herd	
Cattle	315	45	73	18	231	8	619
Goats	135	34	34	11	26	13	195
Total	450	41	107	15	257	9	814



H. Small cultivated fields in the indigenous forest

Small open cultivated fields were found in the indigenous forest on the southern slopes north of Kidia and Marangu (Map 13); 19 cultivated fields totalled an area of approximately four hectares.



Photograph 13: Small Taro field (*Colocasia esculenta*) on the south eastern slopes

I. Landslides

In total, 88 landslides were spotted in the forest (Map 14), mainly in the *Ocotea* forests on the southern slopes, in heavily logged areas (Table 10).

Table 10. Landslides

Location	Number of landslides
<i>Ocotea</i> forest	57
Elsewhere	31
Total	88



Photograph 14: Landslide on the south eastern slopes

VII. DISCUSSION OF THE RESULTS

A. Introduction

The forest destruction recorded during the survey fell under eight categories: logging of indigenous trees, fires, charcoal production, shamba-system practices, quarries, livestock grazing, cultivation of small fields and landslides. All categories of destruction, apart from landslides, are directly human induced.

Each type of forest destruction is discussed against ground data collected before the survey by the University of Bayreuth.

B. Logging of indigenous trees

Camphor (*Ocotea usambarensis*)

The magnitude of forest destruction through logging of indigenous trees is very high. The camphor tree is the most targeted indigenous tree species. Of 7,868 felled indigenous trees, about 2,111 were camphors. Logging of camphor was found throughout the *Ocotea* forests of the moist southern and eastern slopes. It has opened up the forest canopy and threatens the integrity of these forests.

The highest levels of logging were observed above Machame and Kidia (block SSW and east part of block SSE) with less activities between block S and the west part of block SSE. Ground data revealed that exploitation in the fifties, sixties and seventies had reduced the camphor stand significantly.

There was almost no logging of camphor seen between Marangu and Mkuu (east part of block SE), even although the natural *Ocotea* forest belt extends eastwards above Mkuu. Again ground data show that the camphor stand in that area has been depleted. Similarly, only a few recently-logged camphor trees were seen on the lower forest zone on the southern slopes (blocks SW to SE). According to ground observations, this forest zone is dominated by pioneer tree species, such as *Polyscias fulva* and *Macaranga kilimandscharica*, and the liana *Rourea thomsonii*. This indicates that the forest was opened up when camphor trees were extracted some decades ago. In the forest zone above 2,400-2,500 metres on the southern slopes, untouched montane forests still exist.

Cedar (*Juniperus procera*)

Cedar was identified separately as it is easily distinguished from the air. Of the 7,868 felled indigenous trees, about 574 were cedar trees. The major recent felling activities were located above Rongai (block NE) and Nanjara (block E). On the northern slopes (blocks NW and N), few cut cedar trees were recorded, although the main distribution of *Juniperus procera* stretches across the northern slopes above 2,400 metres from block NW to block E. Ground surveys revealed that until the early 1990s the forests in blocks NW, NNW and N have been heavily exploited; most of the cedar and other valuable timber trees have been removed.

Other indigenous trees

In the category "other indigenous trees", about 5,183 recently-logged trees were counted. The other valuable timber trees that had been logged included *Syzygium guineense*, *Fagaropsis angolensis*, *Podocarpus latifolius* (Podo), *Aningeria altissima*, *Newtonia buchananii*, *Olea capensis* (East African Olive) and *Prunus africana*. But nearly all tree species occurring on the mountain (around 130) were recorded as being cut more or less often for firewood during the same ground surveys.

Ground surveys on the southern slopes in the *Ocotea* forests below 2,000 metres revealed the frequent logging of *Syzygium guineense*. Above 2,000 metres in the middle and upper montane zone *Podocarpus latifolius* increases in density, and is being logged especially in areas where *Ocotea* has been depleted (blocks SE and E). The same holds for the subalpine *Podocarpus* forests above the camphor forests of the southern slopes, where the rare *Prunus africana* is also targeted.



On the western, northern and eastern slopes in the submontane *Croton-Calodendron* forests and montane *Cassipourea* forests, the main targeted species are *Fagaropsis angolensis*, *Olea capensis* and, more seldom, *Prunus africana*.

In the submontane gorge forests of the southern slopes outside the Forest Reserve, e. g. in the Mrusunga valley west of Kidia (block SSE - see section J below) *Newtonia buchananii*, *Syzygium guineense*, *Olea capensis* and *Aningeria altissima* are being extracted.

C. Burnt forest areas/Charcoal production

About 65 burnt forest areas/fires were observed, particularly on the south western slopes in the submontane and lower montane *Croton-Calodendron* and *Cassipourea* forests between 1,300 and 2,000 metres and on the eastern slopes. In the central montane zone of the southern slopes between 2,100 and 2,400 metres, fire is uncommon due to very high precipitation. Fire is frequent, however, in the subalpine heath zone of the mountain, but as they occur mostly above the forest line, they were not recorded in the survey. Towards the end of the dry season (February/March) the whole ericaceous belt is usually so dry that it is easily set on fire by people or by lightning. In 1996 and 1997, fires destroyed nearly 90 km² of the *Erica* forests and shrub land on the southern slopes of Mt. Kilimanjaro (Hemp & Beck 2001).

The fires in the forests of Mt. Kilimanjaro are mostly set by people. On the lower slopes along the forest boundary most fires are lit by farmers in their fields; the fires can spread into the neighbouring forest. Deeper inside the forest belt fires are often caused by careless honey collectors, animals hunters and pit-sawyers.

The 125 recorded charcoal kilns were mainly found east of Marangu above Mwika (block SE). Traditional charcoal production poses a considerable fire risk to the forest ecosystems, and charcoal kilns above Mwika were surrounded by burnt forest areas, *Erica excelsa* forest patches and large openings covered by grasslands as a result of recurring fires.

D. Quarries

Three quarries were observed in the Forest Reserve. Although their extent does not pose a major threat to the forest ecosystem, their existence is incompatible with forest conservation and management.

E. "Forest villages" and Shamba (Taungya) system practices

The Forest Reserve contains a recorded 18 medium to large size "forest villages", covering a total area of about 215 hectares. All are found among the forest plantations on the western and northern slopes (blocks W, NW, N and NE).

Based on Landsat imagery, the area allocated to forest plantation is around 13,000 hectares, representing some 12 per cent of Kilimanjaro Forest Reserve. In West Kilimanjaro (block NW) these plantations extend nearly to the moorland boundary, hence dividing the natural forest belt. Only approximately 44 per cent of the area allocated to forest plantations is actually planted with trees, the remaining being under the Shamba-system. The aerial survey revealed that over 50 per cent of the Shamba-system areas is not under tree growing, either replanting was not successful or was not undertaken at all.

F. Livestock grazing

Some 814 livestock were counted grazing in the forest of which the majority were cattle (76 per cent). The impact of grazing is clearly greatest in the areas where it most occurs. Above Marangu (block SE) and to a lesser degree above Kibosho (block S) the forest is now park-like with a similarly aged tree layer and short-cut, pasture-like herb layer, but with no shrubs and young trees. The forest structure in some areas on north Kilimanjaro (blocks NNW and N) indicates that grazing happens there quite regularly.

G. Small cultivated fields in the indigenous forest

Unlike on Mt. Kenya, no fields planted with marijuana (*Cannabis sativa*) were observed, but small fields within the forest planted with crops such as Taro (*Colocasia esculenta*) or beans, were found in blocks SSE and SE. Although small in number (19) and size (mostly less than 0.2 ha), these cultivated fields could be the focus of further expansion and, hence, should be removed completely.

H. Landslides

Based on ground observations it appears that the occurrence of the 88 landslides recorded is linked to three factors: precipitation, the steepness of the slopes and the intensity of the logging activity. Of the landslides 65 per cent occurred in the *Ocotea* forest zone, where rainfall exceeds 3,000 mm per year. In this zone, areas heavily affected by recent logging activities show a significant concentration of landslides.

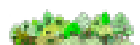
I. Other threats, not recorded during the aerial survey

Forest disturbance, caused by ancient logging activities could not be recorded during the aerial survey, nor the disturbance by big game, such as buffalo and elephants, that has a significant impact on the forests in the western and northern slopes. Their browsing opens the forest and inhibits regeneration. Nevertheless, the large number of elands at higher altitudes on the southern slopes, especially in blocks SW and SSW, does not significantly affect the forest structure and regeneration.

Hunting is common on Mt. Kilimanjaro. In higher zones above 2,600 metres large numbers of traps for pigs and snares for smaller animals were found, especially between Mweka and Marangu, in blocks SSE and SE. Beekeeping is also widespread and is the cause of many forest fires (see section C above). The collecting of fodder on the southern and eastern slopes and the cutting of grass in clearings and on the forest floor also constrain forest regeneration by destroying tree seedlings and young trees.

J. Forest areas outside the Forest Reserve

Near Natiro, west of Kidia (block SSE - see Map 1) natural forest reaches down to about 1,500 metres in the Mrusunga valley. This forest patch is one of the most interesting forest types on Mt. Kilimanjaro, as it links the forest flora of Mt. Kilimanjaro with the submontane forests of the Pare and Usambara mountains. Many forest species, formerly only known from the Eastern Arc Mountains, were found during ground surveys in that forest patch. One fern species is found nowhere else in Tanzania (Hemp 2001a). This forest area is under high pressure from logging activities. This unique ecosystem deserves urgent attention and should be included in the protected area for better protection and conservation.



VIII. CONCLUSIONS

The whole forest belt of Mt. Kilimanjaro is disturbed by human activities. The highest impact is caused by the logging of indigenous trees either recently or during the last decades. Logging activities in the camphor zone seem to have increased during the last 10 years. Pristine montane forests remain only above 2,400-2,500 metres on the southern slope, whereas no undisturbed forest plot could be found below 1,800 metres. In contrast, on the northeastern and western slopes, recently logged trees were recorded in the higher slopes, even above 2,700 metres.

The area allocated to forest plantations has increased since the 1950, and now covers approximately 12 per cent of the Forest Reserve. Together with the “forest villages”, planted forests represent a major threat to the integrity of the montane forest ecosystem on the western and northern slopes. The half-mile forest strip, although meant for timber production to reduce the pressure on the natural forest, is not used effectively. Fires are an important cause of forest degradation inside the forest belt, in particular on the south eastern slopes and in the *Erica* zone.

The current level of threats to the forest belt of Mt. Kilimanjaro is very high. Prompt actions are required to put a halt to on-going forest destruction, if the products and invaluable services that the mountain provides to the region and the whole nation are to be maintained.



ABBREVIATIONS

AWF:	African Wildlife Foundation
COMPACT:	Community Management of Protected Areas Conservation Project
GEF:	Global Environment Facility
GIS:	Geographical Information System
GPS:	Global Positioning System
KWS:	Kenya Wildlife Service
RSO:	Rear seat observer
TANAPA:	Tanzania National Parks
UNDP:	United Nations Development Programme
UNEP:	United Nations Environment Programme
UNF:	United Nations Foundation
WCST:	Wildlife Conservation Society of Tanzania
WNHS:	World Natural Heritage Sites



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ANNEX: MAPS 1 TO 14

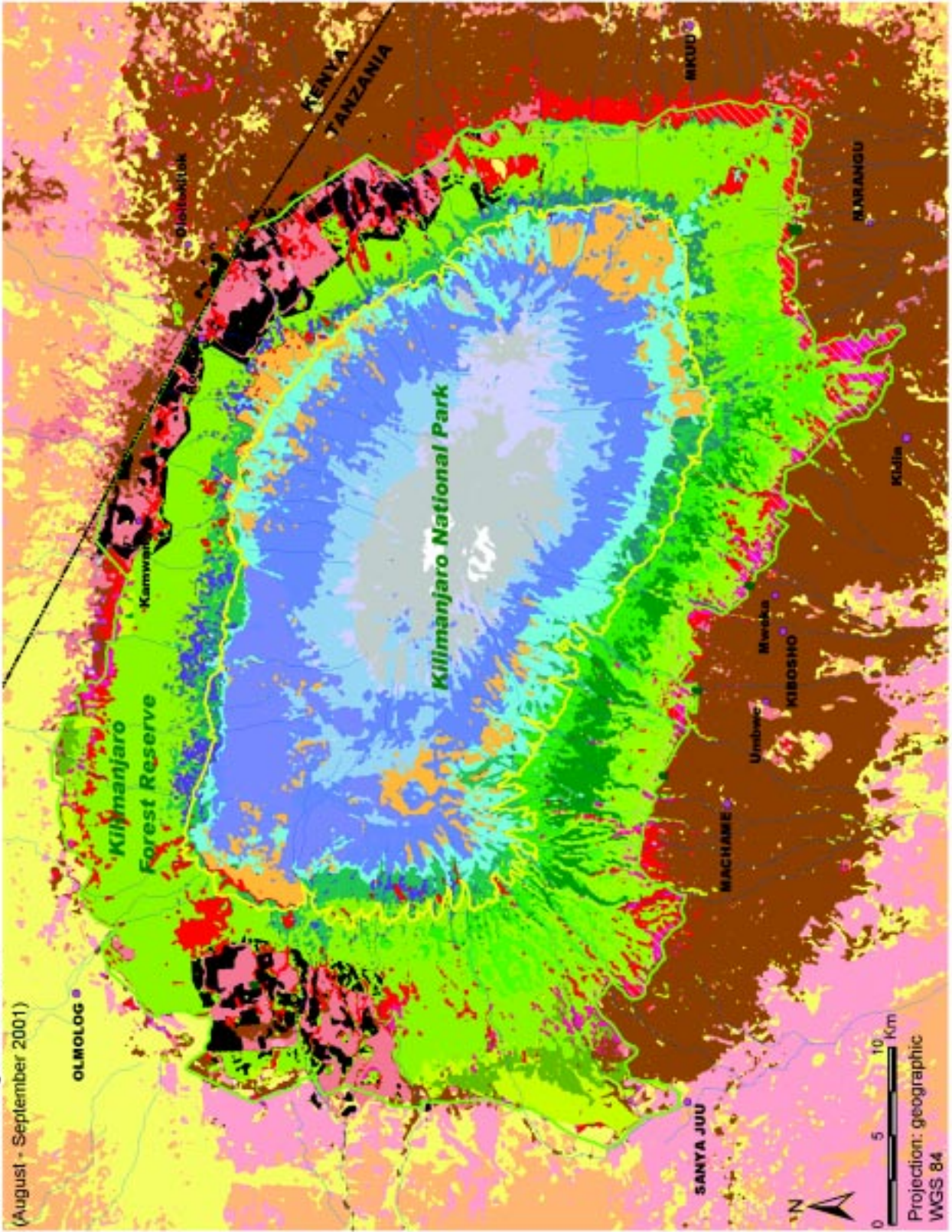
- Map 1:** Vegetation types
- Map 2:** Survey blocks
- Map 3:** Flight lines
- Map 4:** Overall threats to the forests
- Map 5:** Logging of Camphor
- Map 6:** Logging of Cedar
- Map 7:** Logging of other indigenous trees
- Map 8:** Burnt forest areas
- Map 9:** Charcoal production
- Map 10:** Forest villages
- Map 11:** Shamba system practices
- Map 12:** Livestock grazing
- Map 13:** Small cultivated fields in the indigenous forest
- Map 14:** Landslides



Map 1.

Vegetation map

Aerial Survey of the Threats to Mt. Kilimanjaro Forests
(August - September 2001)



- Legend**
- Park HQ
 - Park gates
 - Half-mile forest strip
 - Rivers
 - Urban settlements
 - National Park
 - Forest Reserve
 - International boundary

Vegetation types

Indigenous forest

- submontane Croton-Calodendrum forest
- montane Cassipourea forest
- Olea africana regeneration in submontane forest
- lower montane Agauria-Ocotea forest
- lower montane Ocotea forest
- middle montane Ocotea forest
- upper montane Ocotea forest
- subalpine Podocarpus forest
- subalpine Hagenia forest
- subalpine Juniperus forest
- subalpine Erica excelsa forest
- clearings, forest regeneration
- secondary bushland

Forest plantations

- forest plantations (pine, cypress)
- shamba system (potatoes, carrots)

Cultivated areas

- degraded bushland
- Chagga home gardens (bananas, coffee)
- agriculture (maize, sunflower, wheat)
- shifting cultivation
- grasslands of the colline and submontane zones

Alpine zone

- (tussock) grasslands
- Erica trimera bush (heathland)
- Erica trimera regeneration stages following fires
- Helichrysum newii vegetation
- Helichrysum citrispinum vegetation (alpine desert)
- bare rock and boulder slopes
- glaciers

Other ground cover

- water

Background to the vegetation map

The map is the result of a supervised classification using the software IDRISIS 3.2.

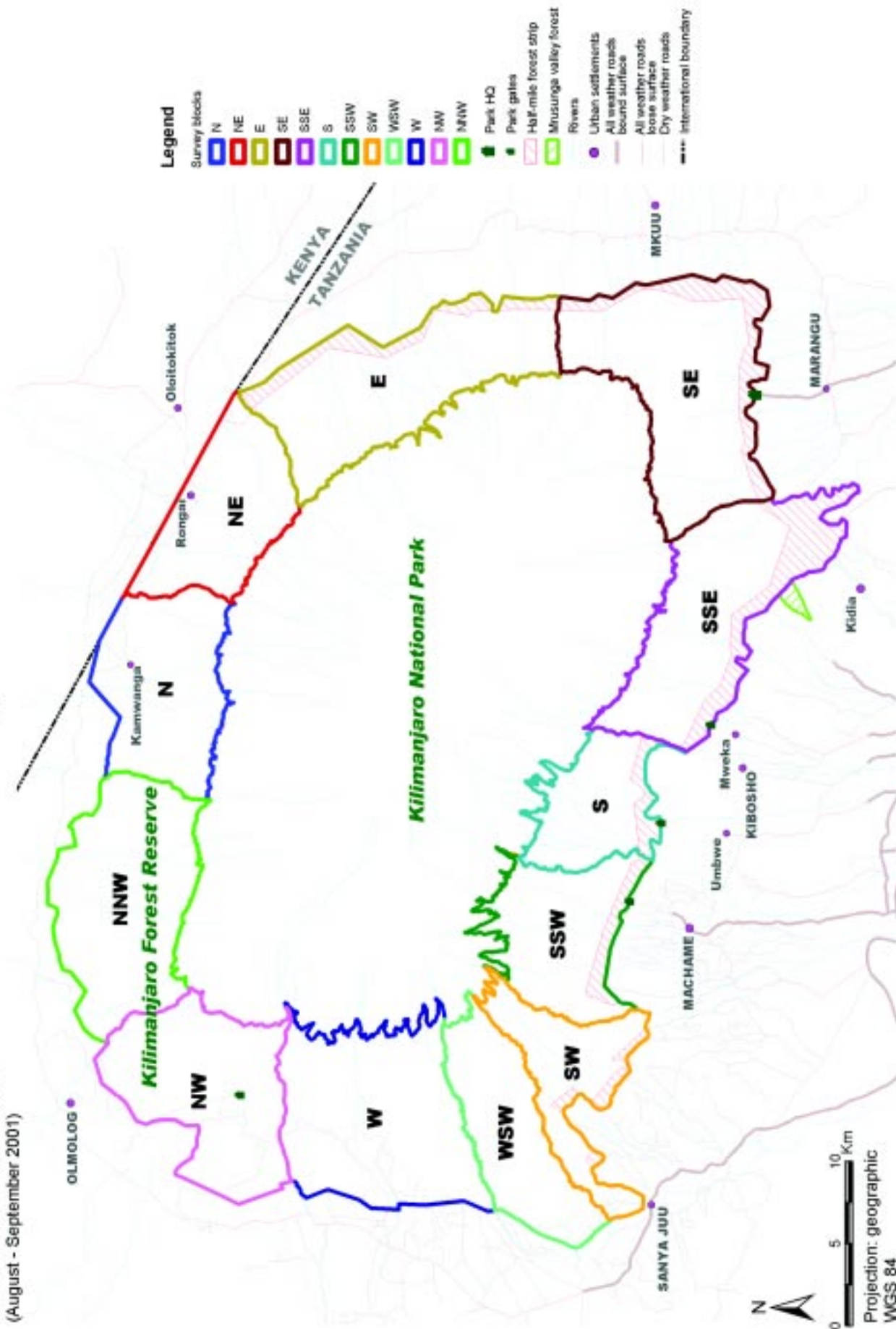
The classification is based on:

- 328 sites selected among over 1,100 surveyed sites by Dr. Andreas Hemp, University of Bayreuth;
- A mosaiced image based on two Landsat ETM 7 images taken on 29 January and 21 February 2000. The bands 1, 2, 3, 4, 5 and 7 were used.

Map 2.

Survey blocks

Aerial Survey of the Threats to Mt. Kilimanjaro Forests (August - September 2001)



Map 3.

Flight lines

Aerial Survey of the Threats to Mt. Kilimanjaro Forests
(August - September 2001)

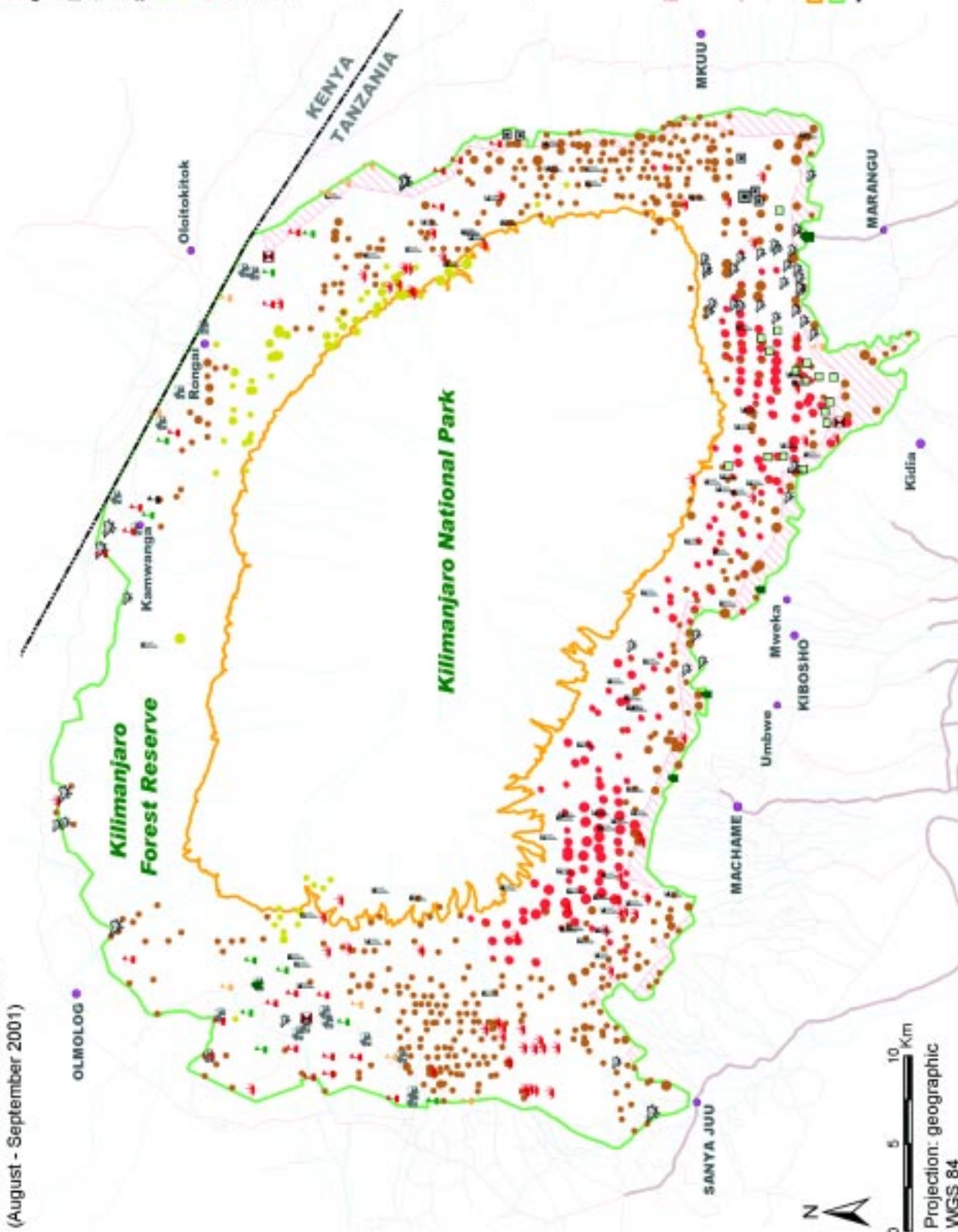


Map 4.

Threats

Aerial Survey of the Threats to Mt. Kilimanjaro Forests (August - September 2001)

- Legend**
- Quarries
 - Charcoal kilns
 - 1 - 20
 - > 20
 - Forest villages
 - Small fields
 - Shamba system
 - Planted with trees
 - Partially planted with trees
 - Not planted with trees
 - Status not determined
 - Livestock
 - 1 - 20 heads
 - > 20 heads
 - Landslides
 - Burnt forest areas
 - Logging of CEDAR
 - 1 - 5 tree(s)
 - 6 - 20 trees
 - > 20 trees
 - Logging of CAMPHOR
 - 1 - 5 tree(s)
 - 6 - 20 trees
 - > 20 trees
 - Logging of other indigenous trees
 - 1 - 5 tree(s)
 - 6 - 20 trees
 - > 20 trees
 - Park HQ
 - Park gates
 - Half-mile forest strip
 - Rivers
 - Urban settlements
 - All weather roads
 - bound surface
 - All weather roads
 - loose surface
 - Dry weather roads
 - National Park
 - Forest Reserve
 - International boundary



Map 5.

Aerial Survey of the Threats to Mt. Kilimanjaro Forests
(August - September 2001)

Logging of Camphor



Map 6.

Logging of Cedar

Aerial Survey of the Threats to Mt. Kilimanjaro Forests (August - September 2001)



**Aerial Survey of the Threats
to Mt. Kilimanjaro Forests**
(August - September 2001)

Logging of other indigenous trees

Map 7.



Map 8.

Burnt forest areas

Aerial Survey of the Threats to Mt. Kilimanjaro Forests (August - September 2001)



Map 9.

Charcoal production

Aerial Survey of the Threats to Mt. Kilimanjaro Forests (August - September 2001)



Map 10.

Forest villages

Aerial Survey of the Threats to Mt. Kilimanjaro Forests (August - September 2001)



Map 11.

Shamba system practices

Aerial Survey of the Threats to Mt. Kilimanjaro Forests (August - September 2001)



Map 12.

Aerial Survey of the Threats to Mt. Kilimanjaro Forests
(August - September 2001)

Livestock grazing



Map 13.

Aerial Survey of the Threats
to Mt. Kilimanjaro Forests
(August - September 2001)

Cultivated fields in indigenous forest



Map 14.

Landslides

Aerial Survey of the Threats to Mt. Kilimanjaro Forests (August - September 2001)



