

Aerial photography and land cover mapping of Mt Elgon: Technical report

Mt. Elgon integrated conservation and development project

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Executive Summary

Mt Elgon Integrated Conservation and Development Project commissioned aerial photography of the 215,570 ha project area in March 1999. From these photographs, digital maps of land cover on Mt Elgon were produced in collaboration with Kenya Wildlife Service, the Forest Department and Photomap (Kenya) Limited. Summary statistics of land cover on Mt Elgon in 1999 were derived from these maps.

Digital maps of vegetation cover on Mt Elgon in the 1960s were prepared in the Project's Geographic Information System from topographic maps produced at that time. A comparison of vegetation cover on the mountain in the 1960s and 1999 shows that indigenous forest cover declined by a third in this period, from 53,281 ha (49% of the protected area) to 35,140 ha (33% of the protected area). In the same period, the area of shamba on the mountain increased from zero to 9,582 ha.

Moorland on the upper reaches of the mountain is probably the most important vegetation type on Mt Elgon from a conservation perspective. Continuation of its decline recorded in this study could have grave consequences for survival of species endemic to this vegetation type.

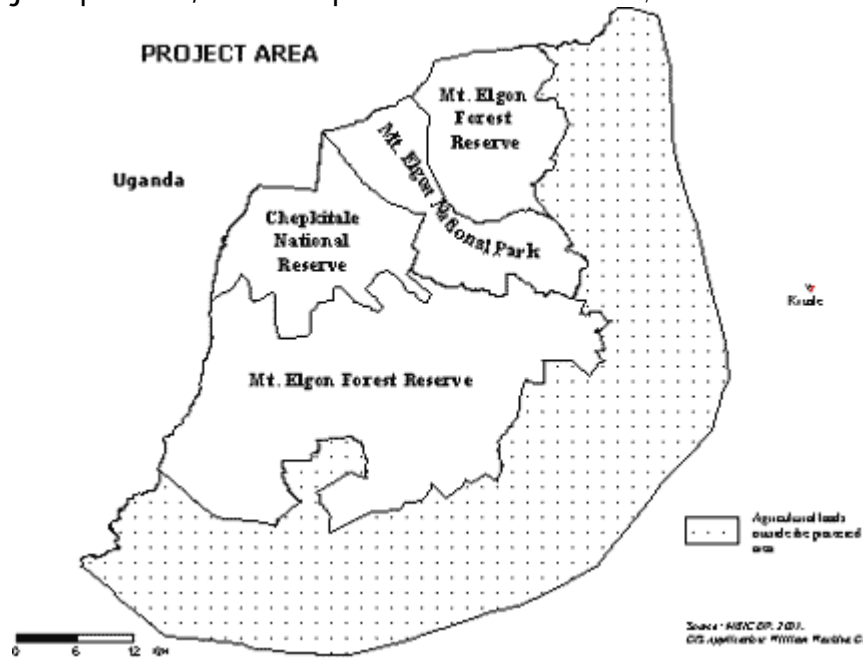
Introduction

One of the tasks prescribed in the project design document for Mt Elgon Integrated Conservation and Development Project (MEICDP) was obtaining new aerial photographs of the project area, which consists of the Forest Reserve, National Reserve and National Park on Mt Elgon, and a strip of predominantly agricultural land within Kenya, within ten kilometres of the Forest Reserve and National Park (see Map 1). This task contributes to the project's first output as described in the Plan of Operations:

"Improved understanding and application of knowledge of the natural resources base of Mt Elgon."

In the Project Formulation Document the task, and its justification, were described thus:

"...carry out an aerial photo survey of the whole protected area and approximately 10 km adjacent area to identify vegetation types, structures, quantities and land uses. Combined with selected interpretation data of the last aerial survey (early '90s) this survey will give an immediate insight of the current situation and the changes since 1990, of the area of intervention. The survey is of paramount importance as a long term monitoring tool, especially since it is proposed that a similar survey will be repeated towards the end of project phase II, and comparisons can be made;...."



Map 1. MEICDP Project area

Early January 1999, the project circulated a Discussion Paper amongst staff of the principal partner institutions (Kenya Wildlife Service (KWS) and the Forest Department (FD)), and IUCN's Regional Office in Nairobi, in which options were presented and a methodology was proposed for this work. The Discussion Paper was framed in accordance with the project's philosophy of working within established structures and avoiding the creation of parallel structures. Some preliminary enquiries before the discussion paper was drafted, suggested that there was ample technical capacity in various agencies in Nairobi to meet the requirements of the work to be undertaken by the project. Hence, the paper proposed that the mapping work be mainly done in Nairobi, though once data generation had been completed, provision was made for field use of PC Arcview, so that the field-based planning team developing the new management plan for Mt Elgon would be able to do basic data spatial analyses, utilising the spatial data created from the project's mapping work.

Methodology

Following consideration of the Discussion Paper by the partner institutions, it was agreed that the following methodology be employed:

The new aerial photography of the project area would be in colour, and at a scale of 1:25 000.

A Technical Liaison Committee (TLC) would be established between KWS, FD and the project to oversee technical details of the mapping work. (This committee was subsequently expanded to include the Department for Resource Surveys and Remote Sensing (DRSRS)).

Digital mapping would be produced from the aerial photographs, utilising Arc/Info GIS.

The project would obtain PhotoGIS software and collaborate with DRSRS and Survey of Kenya (SoK) for development of a digital terrain model for use in conjunction with this software, which would be used for rectification of the data interpreted from the aerial photography.

Employing PhotoGIS software and building a digital terrain model were seen as offering several benefits, despite the extra work involved. Besides enabling rectification of the interpretation of the photos acquired by the project, it would also facilitate rectification of details to be interpreted from the 1990 photography, to enable comparisons of vegetation cover in the two sets of aerial photographs. The digital terrain model also offered the possibility of more sophisticated spatial analyses of the data being assembled for Mt Elgon.

Quotations were invited for the aerial photography and the task was awarded to Photomap Kenya, who flew the photography mission in the middle of March 1999.

The TLC commenced regular meetings in March 1999, to plan and oversee the mapping and photo interpretation work. While aerial photography was being organised, arrangements were made with DRSRS to capture basic map themes (water courses, roads, tracks, administrative boundaries) of the project area from 1:50 000 scale topo sheets. This work commenced in March 1999, and by May 1999, was reported as being completed.

Agreement was reached in May of 1999, with the Survey of Kenya, for scanning and digitising the contour lines from standard 1:50 000 topo sheets covering the project area, with completion of this task initially expected by July 1999.

The PhotoGIS software was obtained in June 1999. Two sets of colour prints of the aerial photography were ordered and delivery was completed by June 1999.

One set will ultimately be deposited with KWS and one set with FD, once the project's use of them for mapping is completed.

Upon receipt of the photographs, the TLC finalised a classification system for their interpretation. A copy of this classification is in Annex 1. Ground verification of the initial interpretation of the photographs commenced in July 1999. Staff from DRSRS also participated in this field visit and a further visit in August 1999, to review the availability of ground control points for use with the PhotoGIS software. The photo interpretation work continued into 2000, and was largely completed by July 2000, although only a provisional interpretation of the summit area of Mt Elgon was possible by then, since access to the summit is difficult in the wet season. Following further field work in January 2001, the interpretation of the summit was revised, and photo interpretation for the protected area has now been completed.

In February 2000, it became apparent that DRSRS would not be able to provide digital map data as originally expected; furthermore, the license for their workstation version of Arcinfo software had expired and it was not clear when it could be renewed, so it became necessary to revise the strategy for the mapping work. Use of PhotoGIS for rectifying data interpreted from the aerial photographs depended absolutely on the digital terrain model of Mt Elgon, which could only be developed through Arc/Info running on a workstation.

A new strategy was drafted and circulated amongst the partners and following their agreement, was implemented from June 2000.

The main elements of this revised strategy were:

- In lieu of using PhotoGIS for rectifying the data interpreted from the photos, this task, as well as capture of basic map themes from the topo sheets, was to be contracted out.
- To enable updating and manipulation of these data, GIS software and equipment were procured for the Project Management Unit (PMU) office, and a consultant was to be hired to edit and update the GIS data and to train the management planning team in the use of PC Arcview for planning purposes.

Photomap submitted the successful quotation for the basic data capture and for the rectification of the data interpreted from the aerial photos. This work was completed by the end of October 2000.

The GIS consultant was hired from the beginning of October 2000, and establishment of the PMU GIS facility (computer, digitising table, PC Arc/Info, PC Arcview, Mapmaker) was completed by the beginning of November 2000. In January 2001 a colour A3 printer was added.

Although the data supplied by Photomap was in Arc/Info compatible format (DXF files), it required further elaboration within Arc/Info to give it full utility within the GIS. For example, labels for polygons of land cover had been developed as a layer in the software employed by Photomap. It was necessary to transfer these data to an attribute table for optimum use in Arc Info.

The work schedule and the initial specifications for the contour digitisation work undertaken by SoK could not be met due to technical constraints, and the digital contour data were not supplied until December 2000. The contour data were supplied on 4mm data tape. As the project does not have a tape drive, the project made several unsuccessful attempts through other organisations, to have the data written to CD ROM. Efforts are now under way in SoK to split the data files and write them to floppy diskettes.

As SoK were not able to fully process the contour data, further editing in the project's GIS will be necessary. The project had supplied to SoK CONTAG software to automatically assign contour values to the contour lines, but as this software could not be made to function properly, contour values will have to be assigned manually by the GIS consultant.

The TLC decided that instead of attempting to map land use in the agricultural lands adjacent to the National Park and the Forest Reserve, it would be more useful to add to the GIS database of the project area, the agro-ecological classification system developed for Kenya by Jaetzold in the 1980s. This task was completed in the project's GIS unit in January 2001.

Results

An initial result from the aerial photography was the discovery that the extent of agricultural land in the Chebuyk area was much greater than the 3,686 hectares excised from the Forest Reserve in 1974. The photographs revealed that approximately 5,000 ha of the Forest Reserve in the Chebuyk area had been encroached, and cleared for agriculture, following the initial excision.

Table 1 shows the areas of various types of land cover on Mt Elgon as at March, 1999. The total area of Forest Reserve and National Park differ slightly from the official published figures, which are 73,705 ha and 16,916 ha respectively. It is worth noting that there has been some confusion over the status of land tenure on Mt Elgon. This confusion has probably arisen because map coverages have not kept up with changes in land tenure on the mountain. The standard topographical maps of the mountain (which date from the 1960s) show on Mt Elgon a nature reserve (corresponding to the present day National Park) and the rest of the mountain is depicted as Forest Reserve. When the project's mapping work commenced, a map supplied to the project showed the present day Chepkitale National Reserve as part of Mt Elgon National Park. The best

data available to the project on land tenure on Mt Elgon is reflected in Map 1 above.

Table 1. Landcover (ha) on Mt Elgon, March, 1999.

Landcover	Forest Reserve TN Dist	Forest Reserve ME Dist	Forest Reserve Total	National Reserve	National Park	Total	Landcover as % of Total Area
Bush	2,298	2,368	4,666	830	1,571	7,068	6.62
Bamboo	6,031	10,988	17,019	18	2,708	19,745	18.51
Indigenous Forest	5,615	24,097	29,712	401	5,027	35,140	32.93
Mod Forest/Bamboo	277	544	821	0	323	1,144	1.07
Grassland	4,206	1,578	5,784	1,739	3,614	11,137	10.44
Moorland	0	1,386	1,386	14,762	2,479	18,627	17.46
Plantat. Mixed	67	9	76	0	0	76	0.07
Plantat. Cypress	1,074	437	1,511	0	0	1,511	1.42
Plantat. Eucalypt	175	53	228	0	0	228	0.21
Plantat. Pine	2,064	310	2,374	0	0	2,374	2.22
Shamba	2,018	7,565	9,582	0	0	9,582	8.98
Tea Zone	19	49	68	0	0	68	0.06
Totals	23,844	49,384	73,228	17,751	15,722	106,700	100.00

The above data are subject to some further minor refinement. For example, the south west boundary of the Forest Reserve in Mt Elgon District has only recently been surveyed. The boundary line used for this part of the reserve in the maps that form the basis of the work reported here is only approximate. When new maps are made from the survey data, some minor changes will ensue.

In the medium term, it should be possible to add more detail about the area classified as "indigenous forest", but some significant conclusions can, nevertheless, be drawn from the above data.

- The extent of shamba within the forest reserve (9,583 ha), even after allowing for the 5,000 ha of encroachment in the Chebuyk area, is well above the area of land planted by the Forest Department in recent years (969 ha between 1995 and 1998), demonstrating that much more land was being cultivated within the forest than was permitted under the Non-Residential Cultivation system, which limits cultivation to those areas on which trees are being established.
- While indigenous forest covers more than any other vegetation type on the mountain, only one third of the protected land on Mt Elgon is covered by indigenous forest.

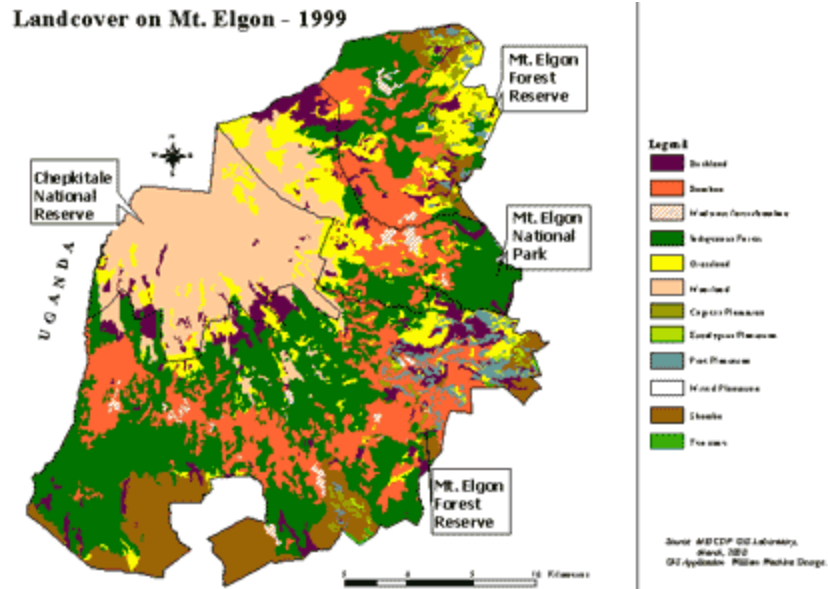
Map 2 depicts the land cover on Mt Elgon in March 1999, and is the source of the data on which the above table is based.

To gain some insight into changes in vegetation cover on Mt Elgon, vegetation cover depicted in the topo sheets, which are based on aerial photography from the 1950s and 1960s, was digitised to establish the location and extent of the vegetation types shown on these maps. Due to the differences in dates of the earlier aerial photographs for the map sheets covering Mt Elgon (Map 3 shows the dates of aerial photography from the 1950s and 1960s on Mt Elgon), it is not possible to depict vegetation at the same date for the entire mountain.

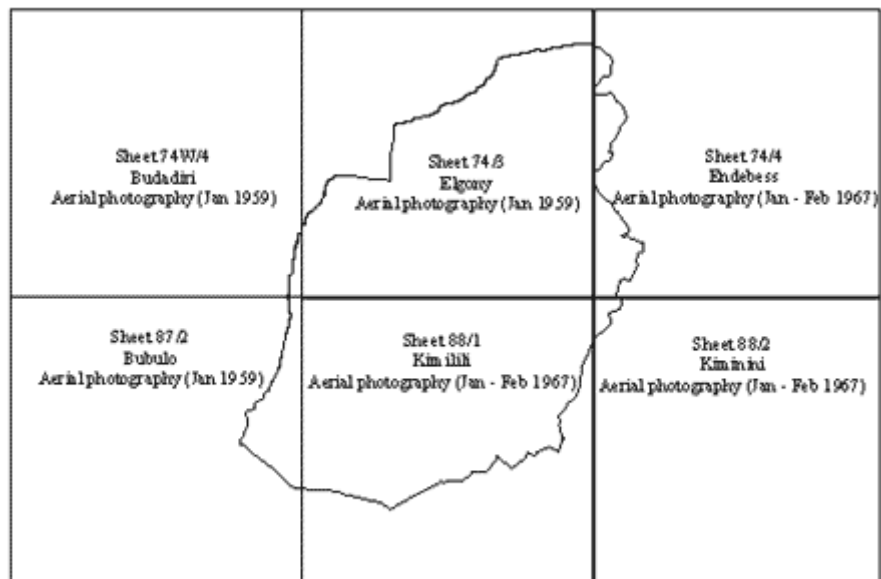
All that can be done is to construct a generalised understanding of vegetation cover on the mountain as it was between 34 and 42 years ago. This information is summarised in Table 3 below, together with land cover in 1999 and the changes detected in vegetation over this period. It should be noted that between the time when the topo sheets were compiled and the aerial photography of 1999, 3,686 ha (the area of the Chebuyk excision computed in the project's GIS is 3,762 ha which is marginally greater than the official figure of 3,686ha) were excised from the Forest Reserve at Chebuyk and 2,604 ha were added to the Forest Reserve at Saboti. This accounts for the decrease in total area shown in the table below - within the limits of accuracy of the maps on which the data are based.

While some generalised trends in vegetation cover on the mountain can be inferred from the data below, some caution is warranted in making comparisons. The vegetation categories depicted in the earlier maps do not correspond exactly to the categories mapped from the 1999 photography.

Nevertheless, it is considered that general trends in vegetation cover on Mt Elgon can be reliably established from this analysis.



Map 2. Landcover on Mt Elgon, 1999



Map 3. Aerial Photography Dates on Mt Elgon

Table 2. Change in vegetation cover (ha) on Mt Elgon.

Landcover	1960s	Percent of Total	1999	Percent of Total
Forest	53,281	49.39	35,140	32.93
Bamboo	15,778	14.63	20,889	19.58

Bush	5,816	5.39	7,068	6.62
Grass	6,675	6.19	11,137	10.44
Plantations	1,546	1.43	4,189	3.93
Moorland	24,765	22.96	18,627	17.46
Shamba	0	0.00	9,582	8.98
Misc	10	0.01	68	0.06
Total	107,871	100.00	106,700	100.00

The major change in vegetation cover in from the 1960s up to 1999 has been the decline in area of indigenous forest. One third of the indigenous forest cover has disappeared in this period and the area of moorland has declined by 25%. Several vegetation types - bamboo, bush, grass and plantations, expanded in extent. The expansion of the area of these vegetation types probably accounts for some of the decline in the area of indigenous forest. The most striking gain has been the expansion of shamba lands from nothing in the 1960s to 9,583 ha in 1999.

Map 4 shows the land cover on Mt Elgon in the 1960s, and is the source of data in Table 2 above.

Maps 5, 6 and 7 highlight changes in forest cover on Mt Elgon between the 1960s and 1999. Map 5 shows forest cover in the 1960s and Map 6 shows forest cover in 1999 as well as areas of shamba. Map 7 has been made by overlaying Map 5 and Map 6 and shows where indigenous forest has disappeared on Mt Elgon between the 1960s and 1999. Most of the indigenous forest loss has occurred in the Chebuyk area, though a sizable loss has also occurred near the northern edge of the Forest Reserve, where indigenous forest of the 1960s has been replaced by scattered trees and bamboo.

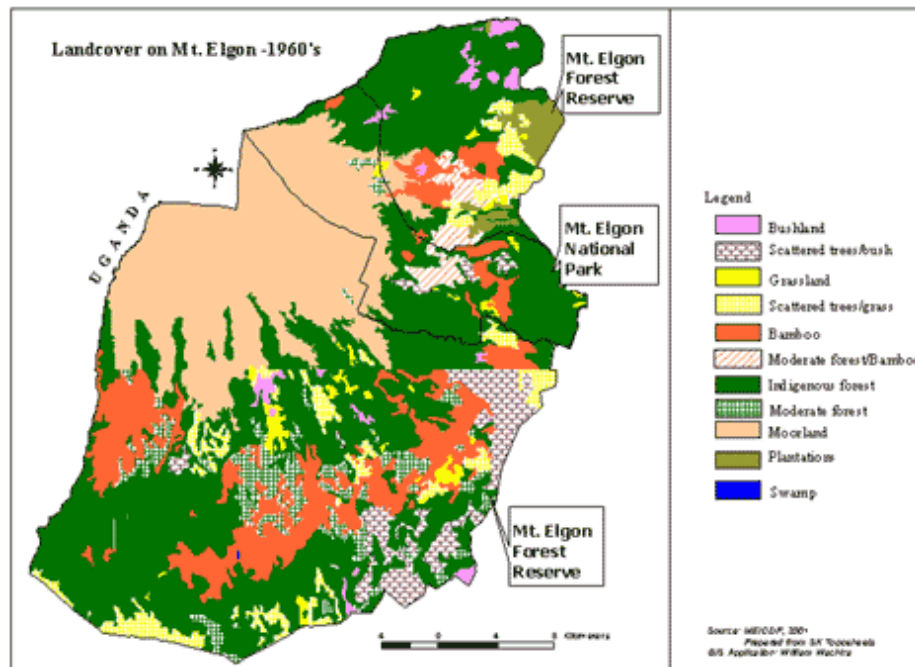
Issues for the Future

To date, the potential of the aerial photographs obtained by the project has not been fully exploited. They have largely served the initial purpose, for which they were acquired, but there is more that could be done with them - they could be used to develop an appreciation of vegetation ecological associations on Mt Elgon. However this is a research project, and would require explicit research as such in a further phase of the project, if it is to continue beyond the present phase.

Apart from the major changes in land cover obviously resulting from human intervention, other, less spectacular changes are occurring in vegetation cover.

Bamboo, bush and grassland have all expanded, while moorland appears to be shrinking. Effective management of Mt Elgon's vegetation will require an understanding of the natural dynamics of vegetation succession on the mountain, and also the past and present impacts on fire, as well as past impacts of grazing and an appreciation of the extent to which today's vegetation distribution has been shaped by past grazing practices.

Probably the most important, yet also the most vulnerable part of the mountain for biodiversity conservation is the upper "moorland" zone, because it represents what is only a very limited area, at a global scale, of a particular biotype. To what extent the present day distribution of moorland on Mt Elgon is natural or of anthropogenic origin is debatable (see Wesche, Mieke and Kaepelli (2000) "The Significance of Fire for Afroalpine Ericaceous Vegetation", Mountain Research and Development, Vol 20 No 4 pp 340-347). Yet it appears that its area is declining, which could have grave consequences for the survival of species endemic to this biotype.



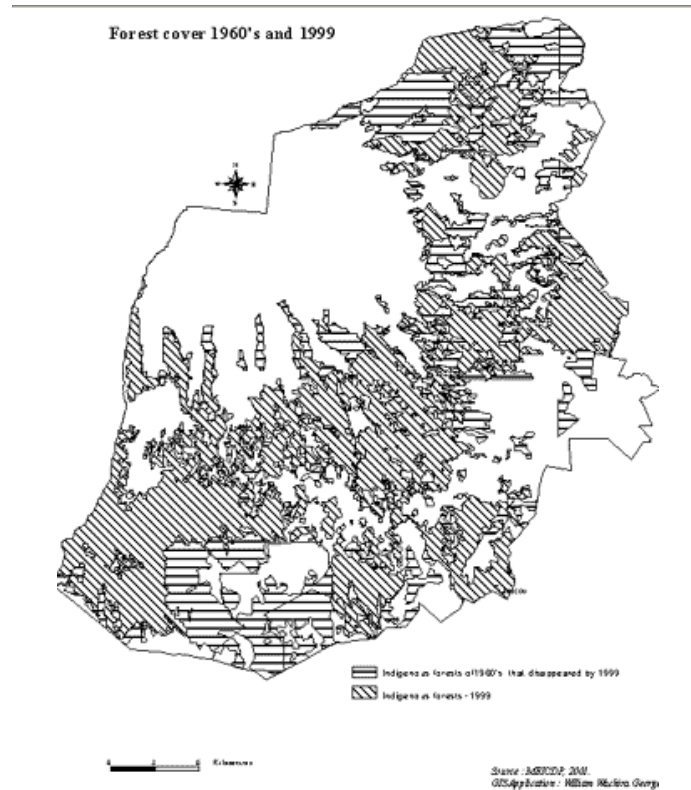
Map 4 Landcover on Mt Elgon 1960s



Map 5. Indigenous forest on Mt Elgon, 1960s



Map 6. Indigenous forest on Mt Elgon, 1999



Map 7. Change in forest cover on Mt Elgon 1960s-1999

Annex 1

Classification System for Aerial Photo Interpretation of the Project Area

This classification system is for the colour aerial photographs of the project area obtained in March 1999, at a nominal scale of 1:25000.

The project area covers lands within the Forest Reserves and National Park on Mt Elgon, and lands within a 10 km band around the FRs and the NP. The lands bordering the FRs and NP are used predominantly for agricultural pursuits.

The focus of the project is biodiversity conservation on Mt Elgon and priority is given to interpretation of vegetation and land use within the FRs and NP. When the FRs and NP have been completed, interpretation will commence on the adjacent lands.

Classification of the agricultural lands should be on an agro-ecological basis which reflects the potentials of these lands for agricultural uses. The method of classifying these lands should be developed in collaboration with the Dept of Agriculture.

Within the FRs and NP, land use and vegetation will be divided into the basic classes set out in the table below which depend on characteristics visible in the photographs.

A finer subdivision of some of these categories is probably feasible, but this will require further field work. For the present, it is considered that interpretation should proceed on the classification presented below. As more information becomes available from field work, opportunities may arise to subdivide some of these categories.

The basic vegetation land use categories recognised in the photos, and the symbols proposed for them are as follows:

Symbol	Vegetation Type	Appearance in Photos
G	Grassland - areas of pure grass	Appears yellow with uniform fine texture. If burned has a brownish colour. Occurs over a wide altitudinal range. Distinctions between grassland types can probably be made on the basis of altitude after field work and review of literature
B	Bush land	Light green with uneven texture; typically intermingled with grassland. Does not occur above the tree line
Bl	Bush land - low : bush no higher than 2m	
Bh	Bush land - high: bush taller than 2m but less than 5m	
M	Moorland	Olive green and fine textured; found above the tree line; can probably be subdivided after field work. Occurs interspersed with grassland
BB	Bamboo - areas with a closed canopy of bamboo species. It may either be pure bamboo or else an understorey within forest areas or else with scattered trees.	Light green very fine texture, extending above the tree line; often with scattered mature trees below the tree line.
P	Plantation	Fine texture, though coarser than bamboo and darker green than BB. Pines are darker than cypress plantation, while
PC	Cypress plantation	

PP	Pine plantation	eucalyptus has a globular texture. Often have geometric shapes and straight boundaries. Small areas of plantations of other species occur, but species can possibly be identified by reference to plantation maps.
PE	Eucalyptus plantation	
F	Indigenous Forest - tree crowns cover 30% or more of the area	Dark green, with texture varying depending on tree size, density and species. A variety of understoreys may be observed in moderately dense forest.
T	Indigenous trees where crown cover < 30%	Dark green, with texture varying depending on tree size and density, but with other vegetation visible beneath the trees.
S	Shamba	Areas used for crop production. At the time the photos were taken these are often brown due to recent ploughing or else if fallow could be yellow like grass or if under crop green and fine textured. May be an understorey in indigenous forest. Where extensive, may be recognised by patchwork pattern of freshly ploughed ground, standing crops and fallow areas, usually with straight boundaries.

Areas with Indigenous Trees (vegetation higher than 5m which is not bamboo or plantation)

Crown Cover	Vegetation Type	Maturity
60% +	Dense Forest - Fd	Mature Fd/m Regrowth Fd/r
Between 30% and 60%	Moderate Forest - Fm	Mature Fm/m Regrowth Fm/r
Less than 30%	Scattered trees (not forest) - Ts	Ts/m Ts/r

Where an understorey is visible in the photos, it will be added to the polygon description by means of a slash followed by the symbol which denotes the type of vegetation which comprises the understorey. For example, scattered trees with a grass understorey would be Ts/G; scattered trees with a high bush understorey Ts/Bh.

Areas which used to be plantations will be designated as such by adding a slash and letters (FP - former / failed plantation or CFP - clear felled plantation) following the description of the overstorey and understorey components of the polygon. For example, high bush on a clear felled plantation site would be Bh/CFP; grass on a failed plantation site would be G/FP.

Areas of rock will be designated R

It is hoped that further field work will enable a finer subdivision of these forest types reflecting the occurrence of individual species or associations of species.

The above classification is based on a review of aerial photos, some field work, and review of the following documents:

Hamilton, A.C. and Perrott, R.A. (1980), *The Vegetation of Mt Elgon, East Africa*.

Van Heist, M, (1994) *Accompanying Report with the Land Unit Map of Mount Elgon National Park*.

Notes to readers

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