N/TANZ Sombroek

the serengeti landscape classification

african
wildlife leadership foundation

THE SERENGETI LANDSCAPE CLASSIFICATION

BY

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Note: This preliminary report has been prepared to accompany the map of the landscape classification units of the Serengeti Ecosystem. It is not intended to be a full explanation of the Serengeti Landscape Classification. More comprehensive descriptions are in the process of preparation as papers.

INTRODUCTION

The Serengeti Landscape Classification is an attempt to combine and modify existing approaches to land classification for the purpose of integrated ecological research. This requires classification units which express the widest possible array of environmental factors thereby becoming of use to the largest possible number of disciplines contributing to the understanding of the Serengeti Ecosystem. To date the main obstacle in the use of land classification systemsfor ecological purposes has been the small scale of the mapping units and the large amount of generalisation involved in the classification.

Existing methods of land classification are aimed primarily at the stratification of an area into small scale units that define broad categories of land use and development potential (e.g. agriculture, forestry, range management, mineral development, road construction, town planning etc.). These classifications are achieved by mapping a single factor, or a very limited range of factors, that correlate closely with the desired objective. They thus produce a generalised classification of relatively large units of area that are homogeneous for only this limited range of factors.

Although adequate for the specified purpose, these classifications are rarely employed by ecologists. Their level of generalisation makes them difficult to use in the type of ecological research required for a detailed understanding of an ecosystem. This is especially so when scientists of different disciplines try to use them as a basis for integrated research. Moreover, ecologists are usually more interested in overall environmental patterns than in single factors, and interdisciplinary ecological research in particular requires a classification that is based on the complex interactions of many factors rather than just a single factor. It is precisely this complexity that is commonly ignored in the generalised approaches to land classification.

The Serengeti Landscape Classification attempts to overcome these shortcomings by basing the classification on working units that are as small and as homogeneous as possible. These units express an integration of several environmental factors. The classification also takes into account the spatial relationships as well as the ecological relationships between different elements of a landscape pattern.

There is relatively little generalisation at the lowest level of classification. By successively building up the primary working units into units of increasing complexity, which involves an increasing amount of generalisation in their definition, a hierarchy of classification is achieved that has a strong vertical integration. This creates a framework of sampling units at different levels of generalisation and complexity that can be used by scientists of many different disciplines, and for quite different objectives.

THE HIERARCHY OF CLASSIFICATION UNITS

Land Facets and Land Elements

Land Facets are the basic working units of the classification. They comprise an ecologically homogeneous part of the landscape with a distinct morphology on a common parent material. Environmental factors such as hydrology, soils, vegetation and microclimate are either uniform over the whole land facet or vary in a simple, consistent and predictable way. A land facet describes what may be termed as a general habitat type, often consisting of an association of a few related single habitats.

In the case of complex terrain, where land facets may be too heterogeneous for some users, they are sub-divided into Land Elements which describe what is generally considered as a habitat for most ecological purposes. Such land elements are only defined within a land facet if they are large enough and distinct enough to have biological significance for most users of the classification.

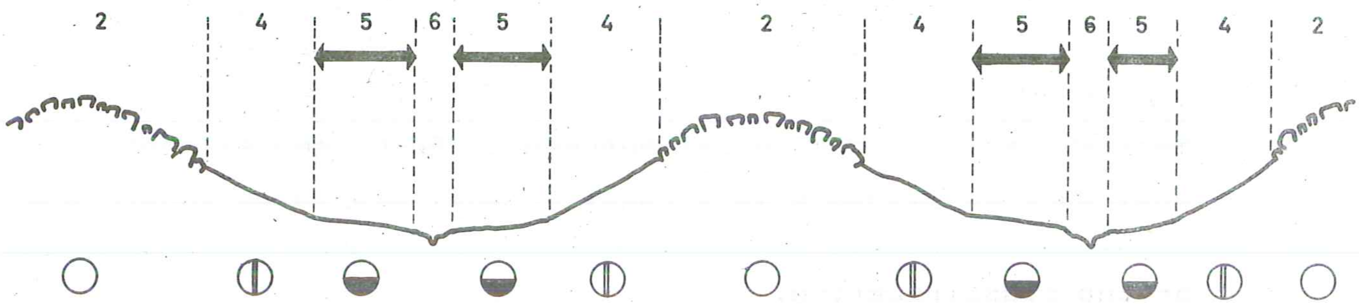
Example:

A slightly undulating landscape may consist of a repetition of such land facets as low ridges with rocky caps, fairly well drained side slopes (flanks), lower slopes with slightly impeded drainage and valley bottoms with incised drainage lines and gullied banks (fig. 1a).

The Lower Slope Land Facet may carry a *Pennisetum mezianum* grassland on its black-cotton type soils, interspersed with very scattered small *Acacia drepanolobium* trees of stunted growth. This would form a general habitat for most purposes. Occasionally there may be smaller or larger patches of denser and more vigorously growing *A. drepanolobium* stands with a few large crowned *Balanites* trees in between and a slightly differing composition in the grass-herb layer, (fig. 1b). Scattered termite mounds will carry small bush clumps on their better drained soils, while erosion scars with patches of bare soil will be used by animals as wallows and water holes. Such biologically significant single habitats would be described as land elements.

Land Systems

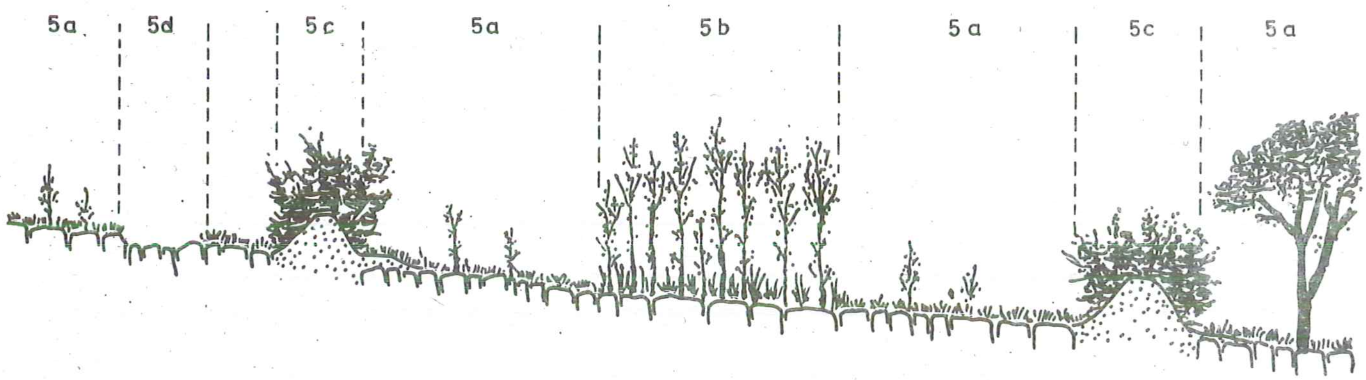
A set of land facets always recurs with a special ecological inter-relationship over a certain area, and forms a typical pattern which gives this landscape a peculiar character. This recurring pattern, which is particularly obvious



2 LOW RIDGE WITH ROCKY CAP ; 4 SIDE SLOPE ; 5 LOWER SLOPE ; 6 VALLEY BOTTOM WITH INCISED DRAINAGE LINE AND GULLIED BANKS.

SOIL DRAINAGE: ○ FREE ◫ WELL ◒ SLIGHTLY IMPEDED

Fig. 1a cross section through the land facets of a recurring sequence within the pattern of a gently undulating landscape.



5a GENERAL LOWER SLOPE ; 5b PATCH OF DENSE ACACIA DREPANOLOBIUM GROWTH; 5c TERMITE MOUND WITH BUSH CLUMPS; 5d BARE PATCH (ANIMAL WALLOW)

Fig. 1b enlarged section of the Lower Slope Land Facet of Fig. 1a showing its component land elements.

on aerial photographs, is called a land system; this is the smallest mapping unit shown on the accompanying map.

A Land System consists of a mosaic of land facets genetically linked together in a consistent relationship concerning their ecological characteristics and their topographic position and sequence in the landscape. A different land system is identified whenever new land facets with genetically different inter-relations cause a break in pattern or where a recognised pattern of predictable relationships changes.

Land system boundaries are always land facet boundaries. Not all parts of a land system need to exhibit the entire set of facets provided the remainder retains the typical inter-relations. Isolated occurrences of facets with no genetic link to their surroundings or small islands of neighbouring land systems are fully included in the description as non-cognate facets. Due to differences in the ecological controls there are never identical nor closely related land systems in widely separated localities (> 30 km) even if the morphological forms are similar.

Land System Associations

A Land System Association is a group of adjacent land systems which are related by similar morphology and general appearance in parts of their component land facets. They may share one or two identical facets. In general, however, their facets, while similar, will not occupy the same proportion of area, nor have the same ecological conditions, nor follow the same catenary sequence or occupy the same ecological position. Because of subtle differences in lithology or climate, the facets of such associated land systems will show differences in soil, vegetation, water regime and microclimate.

Land Sub-Regions

These embrace several land system associations and land systems and combine them into a landscape sub-type which can be defined by certain characteristics prevailing throughout its component land systems, e.g. a major soil or vegetation type, or a common morphogenesis.

Land Regions

A Land Region is a main landscape type which has a common geological history, has undergone a comparable geomorphic influence, and suggests a common climatic regime for some if not all parts of its evolution. Land regions are the largest units of the classification (fig.2) and incorporate a considerable amount of generalisation of ecological factors.

Example:

The Serengeti Plains Land Region (fig.3), is an old peneplain on very old, crystalline rocks that is characterised by a blanket cover of volcanic ash. This forms the landscape type of a generally treeless, gently rolling grassland plain. Within this main landscape type (land region) there are several sub-types (land sub-regions) with distinctly different soils and vegetation. Due to minor differences in local relief and landform that existed prior to the emission of the ash, the deposition of materials, the subsequent soil formation and the hydrology were all affected differently. Superimposed upon this is a texture gradient depending on the distance away from the volcanic source, and a rainfall gradient in approximately the same direction. These have produced variations in vegetation and microclimate, and thus different habitat conditions within each land sub-region. These different conditions are expressed by different land systems which, on the

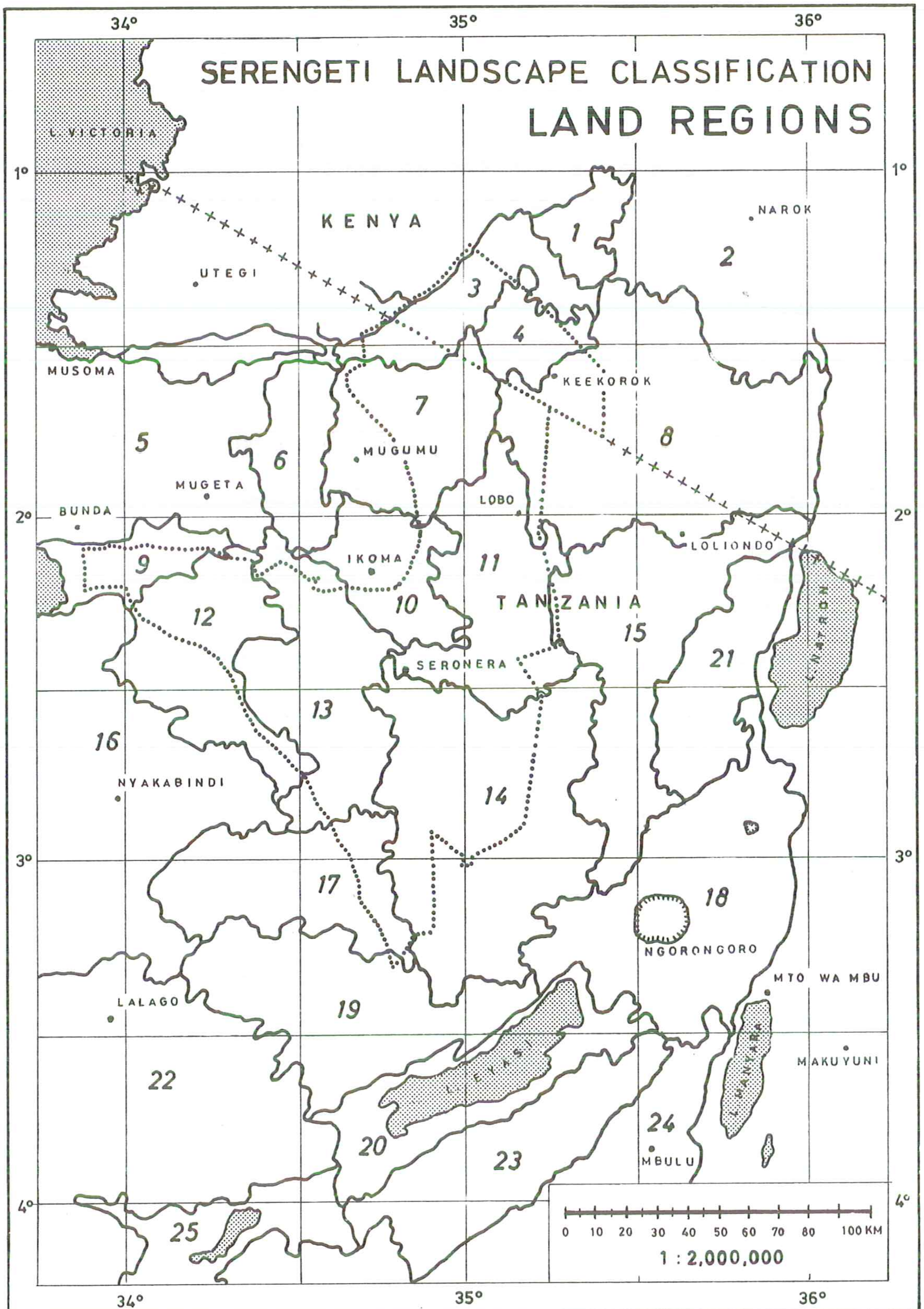


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Fig. 2

Land Region map of northeastern Tanzania
and adjacent Kenyan areas.

Key to Land Region names in Fig. 2.

1	Bardamat	14	Serengeti Plains
2	Loita Plains	15	Gol
3	Lamai-Lorogoti	16	Ntusu
4	Talek	17	Simiyu
5	Zanaki	18	Ngorongoro
6	Ikorongo	19	Maswa
7	Oseru	20	Eyasi
8	Sianna-Loliondo	21	Salei
9	Ndabaka-Ruana	22	Uduhe
10	Ikoma	23	Yaida
11	Grumeti-Orangi	24	Mbulu
12	Simiti-Dutwa	25	Wembere
13	Musabi-Nyaroboro		

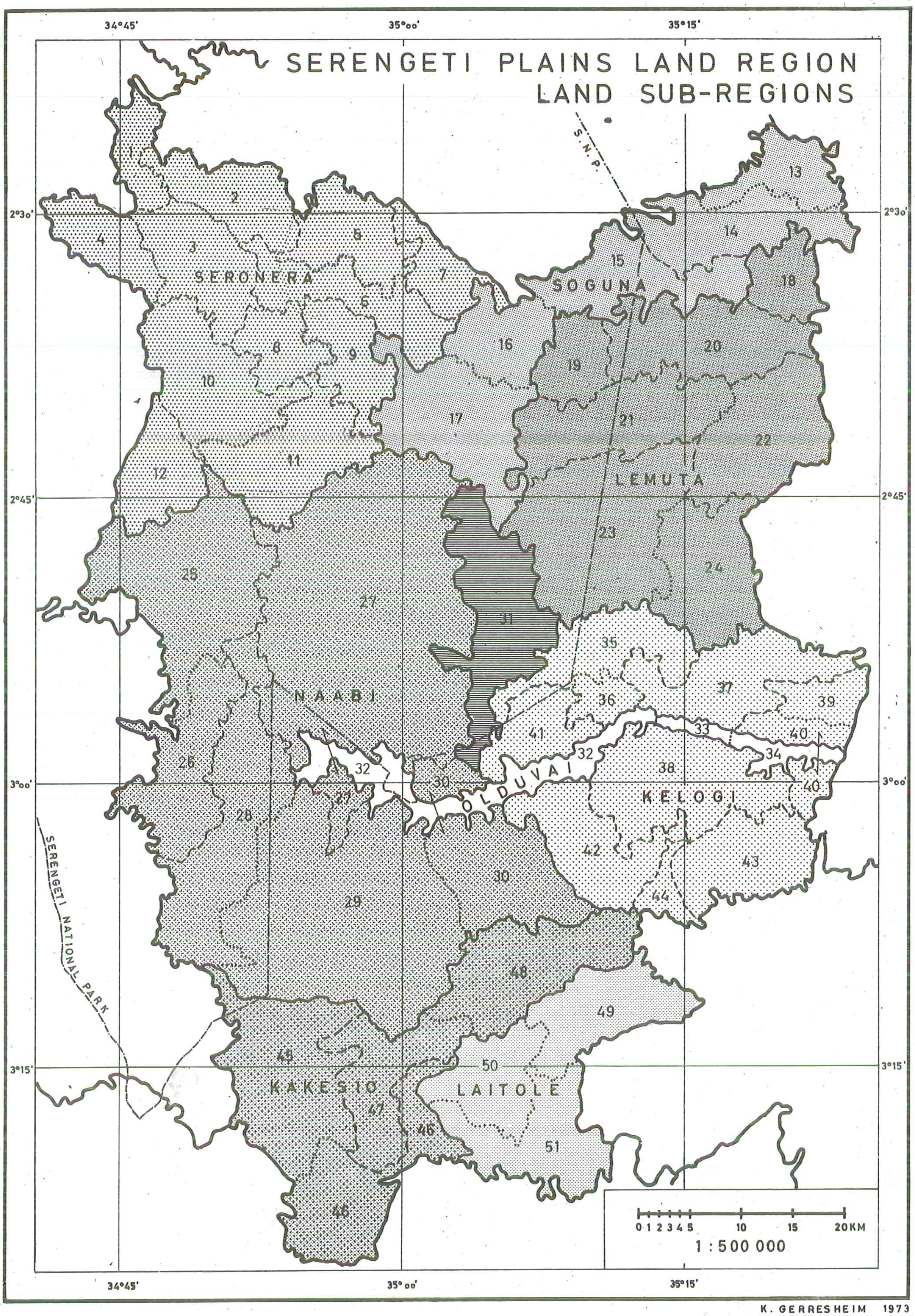
SERENGETI PLAINS LAND REGION
LAND SUB-REGIONS
34°45'
35°00'
35°15'
2°30'
2°45'
3°00'
3°15'
S.N.P.
SERONERA
SOGUNA
LEMUTA
NAABI
OLDUVAI
KELOGI
KAKESIO
LAITOLE
SERENGETI NATIONAL PARK
0 1 2 3 4 5 10 15 20KM
1 : 500 000
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Fig. 3

criteria of dominant characteristics, can sometimes be grouped together as land system associations.

THE CLASSIFICATION PROCEDURE

The goals of this classification are to stratify a large area within a relatively short time and to provide detailed environmental information within the same system. This could only be achieved by employing a new time-saving tool and new techniques. A stereo coverage of small scale aerial photographs has become the backbone of the classification. It served as a detailed base map and as an infinitely exploitable, integrating source of information.

Looking at airphotos under a stereoscope is a very instructive way to study a landscape as a three dimensional model. An integrated view is easily obtained of landforms, geological structures, drainage patterns, vegetation and soil structures as well as erosional forces and human influences in the landscape. To the trained interpreter this produces a fairly complete picture of the inter-relations of the prevailing ecological parameters. And there is always this "automatic integration" that even if one tries to look at a single factor alone, one cannot avoid seeing and noticing the others. Aerial photographs of medium to small scale (1 : 40,000 to 1 : 80,000) show the interpreter a large enough piece of a landscape at any one time to enable him to recognise and compare different types of land and land patterns. This chance of quick comparison and cross-referencing is extremely important and saves much field work.

All classification work for the accompanying map has been carried out on airphotos of a scale 1 : 68.850 which were taken in January 1972 for the purpose of topographic mapping as continuous stereo cover over the entire ecosystem area. The classification was carried out in two successive steps. All land system boundaries were mapped first, followed by detailed mapping and description of land facets and land elements of each land system. The land system mapping of the entire area of more than 25,000 km^2 was completed in approximately six months. The detailed mapping of facets and elements required much more intensive work, particularly in the field and has not been completed yet.

To obtain a first comprehension of an area's pattern, all relevant airphotos were scanned with a mirror stereoscope under low power (fig.4), which enabled one to view the entire stereo-overlap at once, i.e. to see as large a landscape model as possible. The aim was to identify the area's pattern and draw boundaries at any break in pattern, i.e. at tentative land system boundaries. No attempt was made at this stage to define the pattern's units, i.e. the recurring land facets and land elements. If the area was not already known from previous field trips, a short reconnaissance was then made either by vehicle or by low flying aircraft to ensure that the environmental situation was properly understood. Afterwards, all tentative land system boundaries were examined again under high power (x 3), corrected, marked firmly and transferred on to a map of 1 : 250,000 scale.

In complicated and marginal areas, land systems may be defined on their recognition pattern alone pending future detailed field work in the area.

The detailed description of a land system's components starts again as interpretation under the stereoscope where all suspected habitat boundaries are annotated on the photographs under high power. A distinction between land elements and land facets is not yet made. The whole pattern is then viewed stereoscopically under low power to get an idea of the units' relationships and the morphological development.

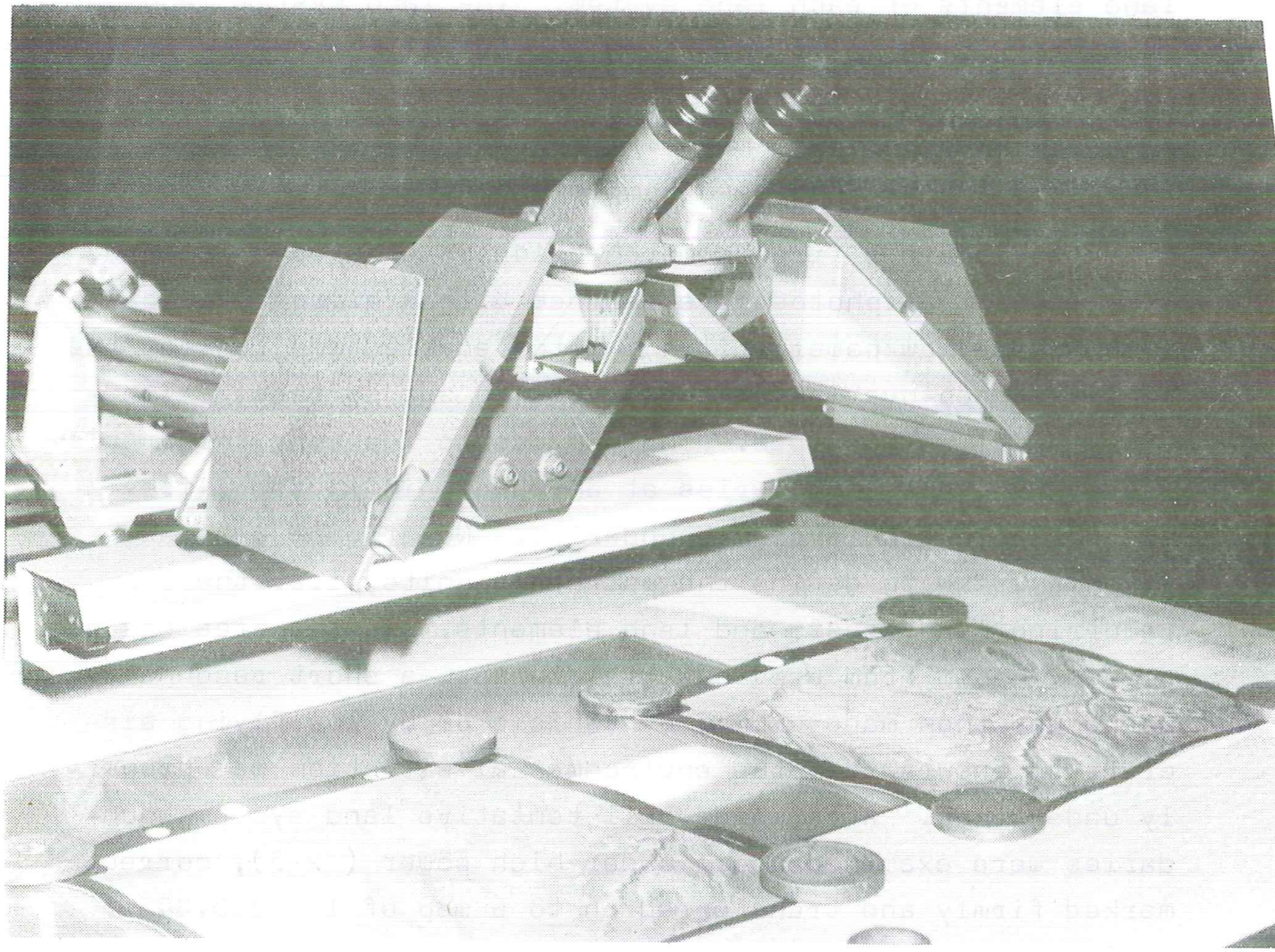

Fig.4

Photo interpretation set-up at the Serengeti Research Institute. The mirror stereoscope is mounted on a parallel guidance mechanism and can accommodate up to six stereo-pairs for quick scanning and comparison.

This usually leaves photo patterns formed by soil, vegetation and hydrological influences or human activity (e.g. fire, deforestation and cultivation) to be explained in the field. A tentative list of facets and their elements is then made with a description based on morphological criteria. Units of unexplained position remain numbered only. All unit numbers are tentatively entered on the photographs to check whether they all fit the description and that none are left out.

Only then are field traverses made to investigate representative sampling and control points selected after the photo interpretation. This provides data for the final definition, description and revision of all boundaries on the photographs. There is a special interpretation and data storage check sheet which lists and cross-references all available information on each land element and facet (fig.5d). It can be used as a convenient count-down for field investigations and is placed in a reference file as a preliminary data storage record.

All environmental information is collected as composite data which cover a homogeneous area as a whole. There is no surveying of single factors separately. Land systems are the smallest units mapped. Reference can however be made to the annotated aerial photographs in file. It would require very detailed topographic maps at least at 1 : 25,000 scale to show most land elements adequately, although the smallest of them requires still larger scales to be represented otherwise than by symbols. Land facets, however, can usually be portrayed satisfactorily on map scales of 1 : 50,000, if these maps show sufficient topographic detail.

Idealised block diagrams rather than maps illustrate the land facet pattern in its three dimensional relationship (fig.5a) and the situation of land elements is explained by additional sketches and cross sections if necessary (fig.1b).

MORU LAND SYSTEM

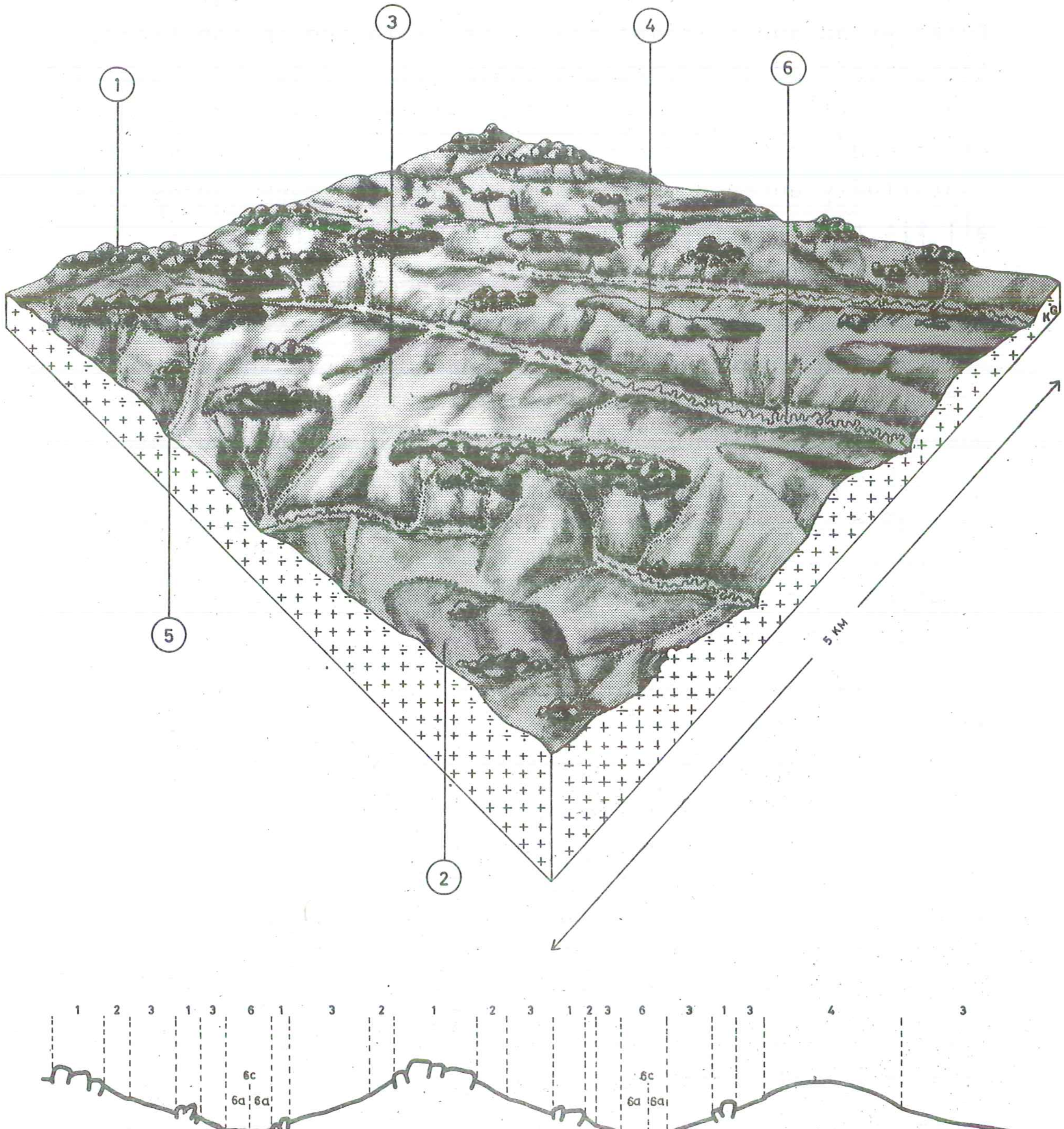

Fig. 5a

Block diagram of Moru Land System. Numbers refer to land facets which can be identified on annotated aerial obliques and verticals (Figs. 6 and 7) and on check sheets (Fig. 5c).

This enables a quick and easy understanding of the set-up of a landscape pattern and allows the emphasis of certain features by drafting, so that everybody can readily understand the situation without studying any maps and long explanatory text. Each land system has a general description of its environmental conditions (fig. 5b). A table lists particulars for each land facet and its component elements about soils and hydrology and about vegetation (fig.5c). Further details are contained on the above mentioned interpretation record sheets (fig. 5d), the predecessor of a comprehensive data storage system which is in preparation.

Naming and numbering of classification units.

The following naming and numbering system has been used to identify each level of the hierarchy.

Land Region: Each region has a number (e.g. 10) and a local name (e.g. Ikoma). On the accompanying map each Land Region is shown in a different colour.

Land System: All land systems within a land region have a consecutive number as a suffix to the land region's number (e.g. 10_1, 10_2, 10_3, ... etc.). Each land system also has a local name. The numbering of land systems falling in land sub-regions or land system associations is also consecutive.

Land Facet: Every land facet, irrespective of where it is found, has an independent number, following the sequence: hills - slopes - drainage lines. Similarities of facets cannot be inferred from the same numbers in different land systems. Each facet is also named on the basis of its main morphological characteristics. Closely

MORU LAND SYSTEM

Location and size:	A triangle of approx. 80 sq.km on the western edge of the Serengeti Plains.
Geology:	Porphyritic or porphyroblastic granite or granodio-diorite of the crystalline basement complex with an estimated age of 300 million years.
Landforms:	Numerous lower and higher granitic inselbergs (kop-jes) standing above a slightly dissected mature lands-cape giving it a characteristic appearance. The bot-tom of the former v-shaped valleys is filled with alluvial deposits.
Altitude and relief:	General terrain level rising between 1580 m amsl. in the north and 1630 m in the south (0.3 % inclination over the longitudinal axis of 15 km). Relief dif-ferences from interfluve crests to valley bottoms are generally between 25 - 30 m forming slopes of 3 - 5 % inclination. The channels of the intermittent rivers are incised between 40 - 100 cm. The height of the inselbergs varies between surface outcrops (rock shields) of a few meters above terrain level to an average of 10 - 15 m and a maximum height of about 40 - 60 m.
Climate:	Unimodal rainfall with a skewed distribution between November and May building up to a peak in April. Mean annual rainfall (November to October) is in the region of the 700 mm isohyete.
Soils:	Residual soils have developed from weathered granite and granodiorite, and from accumulated colluvial and fluvo-colluvial deposits of these materials. Soil colour is generally very dark grey or black (when wet). Sticky clay loams on the surface are followed by an illuvial horizon of medium to heavy clays at 15 - 20 cm up to 60 - 80 cm depth, underlain by lighter tex-tured and paler coloured clay loams. Drainage con-ditions are generally poor and partially very impeded. P.H. - values range from near neutral (7.2) to slight-ly acid (6.7) in the top soil and increase with depth to values of 8.3 and even 8.7 . The conductivity data show slight alkalinity from Sodium locally. Fine and medium calcareous concretions are partially present in the clay horizons. General rooting depth of grasses and herbs is 30 - 40 cm with some roots going down to 80 - 100 cm.
Vegetation:	Very open savannah with few scattered trees. Themeda - Cymbopogon grassland on impeded soils of the inter-fluve slopes grades into Cynodon - Digitaria - Penni-setum stramineum grassland on the better drained in-terfluve crests. Scattered trees are Commiphora tro-thae, Balanites aegyptica, Acacia tortilis, A. clavi-gera, A. sieberiana and A. albida. The inselbergs have a dense tree and bush cover of Ficus species, large Euphorbia candelabrum, Commiphora eminii, Lannea fulva, Combretum molle and Hoblundia opposita.
Game habitat:	Important concentration area of wildebeeste and zebra herds before the start of the migration from the Plains to the Western Corridor at the end of the rainy season. Resident game: buffalo, Topi, Kongoni, and predators. The massive growth of the annual clover Trifolium mas-saiense within facet 5 attracts large numbers of ele-phants in wet years. Concentrations of 300 - 400 ele-phants can form for short periods.

Fig. 5b General Environmental description of Moru Land System.

Facet	Morphology	Soils and hydrology	Vegetation
1	Kopjes: sheet-jointed granitic tors (inselbergs) standing above the surrounding landscape. Height varying between surface outcrops (a few meters above terrain) to an average of 15 - 20 m and a maximum of 50 - 60 m.		
1 a	Kopjes with bare rock surface	Intensive physical weathering by thermal expansion. Few humus pockets in cracks and joints.	
1 b	Kopjes with tree and bush cover	Sandy loams with high humus content. High water retaining capacity in numerous joints and humus soil pockets.	Ficus sp., Euphorbia candelabrum, Combretum molle, Commiphora eminii, Lannea fulva, Hoblundia opposita. Aloe secundiflora, Gloriosa simplex, Setaria sp.
1 c	Kopjes with grassland and shrub cover	Well drained, shallow sandy loams between debris and boulders.	Chloris - Cymbopogon grassland with Aloe secundiflora and Grewia and Cordia bushes
2	Kopje (inselberg) pediment sloping with 3 - 5° forming belts of irregular width (60 - 80 m) around the inselbergs.	Dark brown, clay loam with illuvial clay horizon. Impeded drainage. High surface runoff. Top soil susceptible to wind and water erosion.	Pennisetum mezianum - Themeda grassland with scattered trees (Commiphora trothae, Balaniaegyptica, Acacia tortilis, and A. A. clavigera).
3.	Concave interfluve slopes (inclination 2 - 3°)	Dark brown, sticky clay loam with illuvial clay horizon. Impeded drainage and dry season cracks. Top soil susceptible to wind and water erosion.	Themeda - Digitaria - Pennisetum mezianum grassland with few scattered trees (Commiphora, Balanites, Acacia tortilis and A. sieberiana)
4.	Well drained interfluve crests	Dark grey-brown, fairly sandyloams. Better drained than facet 3. Termite mounds common, but mostly flattened by erosion.	Cynodon - Digitaria - Pennisetum stramineum grassland.
5.	Very shallow, swampy drainage depressions. originating from seasonal springs along the edge of inselbergs.		
5 a	Circular, swampy depressions at spring heads; 5 - 20 m in diameter (game wallows).	Very sticky black clays with an extremely high clay content and deep cracks. Soil compacted by game.	Swampy Cyperaceae grassland
5 b	Shallow drainage depressions, width 5 - 30 m and up to 120 m in places. Length up to 1.5 km.	Highly impeded heavy black clay soils, swampy and wet for about 2 - 3 months after the rainy season.	Pennisetum mezianum - Echinochloa - Sporobolus pyramidalis grassland. Trifolium massaiense becomes locally dominant in wet years and attracts big elephant concentrations feasting on the annual clover.
6	Valley bottoms with minor (intermittent) drainage	Old V-shaped valleys filled with alluvium.	
6 a	General valley bottom either side of the channel (up to 30 m) includ. stretches with surface runoff (no channel) in upper valleys.	Very heavy black clays	Pennisetum mezianum - Echinochloa - Sporobolus pyramidalis grassland with sedges.
6 b	Discontinuous channel incision (30 - 40 cm depth)for a length between 10 to 60 - 80 m and a width of 2 - 6 m.	See 6a. Valley bottom forms a series of small ponds during the rains. Incisions are continuously enlarged by game. (wallows).	See 6a. Few Acacia sieberiana.
6 c	Meandering, slightly incised channel (40 - 100 cm deep and 2.5 m broad)	See 6a.	Banks with fringe of Acacia sieberiana and A. albida and Grewia bicolor bushes.

Fig. 5o Descriptions of Land Facets and Land Elements of the Moru Land System.

MORU LAND SYSTEM	FACET No. 2

Form & morphogenesis: Kopje (inselberg) pediment sloping with 3 - 5 °
forming belts of irregular width (60 - 80 m) around
the inselbergs

Parent material & outcropping rocks: Colluvial material with occasional boulders derived
from granite or granodiorite of the inselbergs

Soil type or catena: Very dark brown, sticky clay loams with a clay horizon
Coarse sand grains throughout the profile. Main rooting only in topsoil
(10 - 15 cm). Distinct illuvial clay horizon of blocky structure between
20 - 60 cm. P.H.(1:1 susp.). 7.2 in top soil (10 cm), 8.6 in clay horizon
and 8.7 at 70 cm with slight alkalinity (sodium).

Termite activity:
Localised some mounds, usually much eroded. Generally
nil to very few mounds

Hydrology: Impeded drainage and considerable surface runoff

Vegetation type: Pennisetum - Themeda grassland with scattered trees

Important species:

trees	shrubs	grasses & herbs
Commiphora trothae	Cordia ovalis	Pennisetum mezianum
Balanites aegyptica	Grewia bicolor	Themeda triandra
Acacia tortilis	Grewia fallax	Chloris gayana
Acacia clavigera		Cymbopogon excavatus
		Aristida adoensis
		Aloe secundiflora

Vegetation samples:

no.: . . ./ . . . . (. ./ . .) no.: . . ./ . . . . (. ./ . .)
no.: . . ./ . . . . (. ./ . .) no.: . . ./ . . . . (. ./ . .)
no.: . . ./ . . . . (. ./ . .) no.: . . ./ . . . . (. ./ . .)

Landuse remarks & burning: Favorite locations for Massai bomas before the area became included in the National Park. Probably frequent burning in Massai times, now only occasional burns.

Ecological status: Stable, dynamic ecology. Continuous addition of debris from inselbergs replaces removal by sheet erosion

Destructive influences: Wind and water erosion starts immediately where vegetation cover is damaged by tracks & trails.

Fig. 5d Land Element/Land Facet record sheet for interpretation and preliminary data storage.

Micro climate: . . . .

Met. station: Accumulative rain gauge . . . Moru . . . records started: June 1970

Sample measurements: ref.no.: . . . . (. ./ . .) ref.no.: . . . . (. ./ . .)

General remarks: . . . .

References:

. . . .

Sample plots: Photo-ecological plot no. . . . .

Forestry measurement plot no. . . . .

Grassland productivity plot no. . . . . started: 19 . .

Extension of facet within land system: about 6% of Land System area

Quarter degree sheet(s): 37/11, 37/111, 37/1V Ecosystem Grid: K19, K20, L19, L20

Aerial photography:

a. Survey (9 x 9"): Tanganyika Film 23 . . . (1953) nos 3136 - 3136

Film 18 . . . (1953) nos 2366 - 2392

Film 18 . . . (1953) nos 2355 - 2360

Film 11 (1953) nos 1588 - 1593

b. R.A.F.: . . . . (19..) nos . . . .

c. S.R.I.: film . . 7013 . . (1971) nos . 1 - 45 , film . . . . . . (19..) nos . . . .

film . . . . . . (19..) nos . . . . , film . . . . . . (19..) nos . . . .

film . . . . . . (19..) nos . . . . , film . . . . . . (19..) nos . . . .

d. Permanent transect no. . . . . , interval: . . . . . . months, started: . . . . . ./19...

Ground photographs: no . . . . . / . . . . . (19..) no . . . . . / . . . . . (19 . .)

no . . . . . / . . . . . (19..) no . . . . . / . . . . . (19..) no . . . . . / . . . . . (19 . .)

no . . . . . / . . . . . (19..) Ecological checkpoint no . . . . started: 19 . . .

Reference to important private photographs: Lamprey panorama photos 1967

Fig. 5d Cont.

related facets within the same land system which have a similar origin (e.g. alluvium deposited by two different rivers), but are large enough to be kept separate units, get the same facet number and an additional capital letter as suffix (e.g. 3A, 3B).

Land Element: Each land element of a land facet is lettered consecutively (e.g. 2a, 2b, 2c ... 3Aa, 3Ab .... etc.) and is also named on its dominant morphological or soil characteristics or its differentiating vegetation cover.

Note: Morphological descriptions are used for naming land facets and land elements because these are least likely to change in time. This does not imply that morphology alone was used to differentiate them.

APPLICATIONS

Although the Serengeti Landscape Classification has only just been completed it has already proved to be of immediate use to scientists of different disciplines working in the Serengeti. The lowest level of generalisation, the Land Facet and Land Element, has been used successfully as a sampling framework to describe vegetation, and as a sampling framework in the study of the seasonal movements of impala and topi antelopes. Land Facets have also been used as sampling units to describe the seasonal behavioural patterns of impala and jackals. An intermediate level of generalisation, Land Systems and Land System Associations, has been used for soil studies and veterinary investigations (incidence of anthrax, and habitat-dependent mortality). The highest and most generalised level, Land Regions, has been used for the description of the climate of the Serengeti Ecosystem, and for the analysis of the annual movements of the migratory wildebeest population.

All these different data can now be integrated at a later stage through the vertical integration that exists between the hierarchially arranged units of the classification system. This capacity for integration is an essential function of the Landscape Classification, and it is made possible through an ecological data storage system.

This ecological data storage system, which is in the course of preparation, will consist of a set of catalogue cards for each land element or facet. There will be cards of different colours for each type of information, e.g. geology, soils, hydrology, termite activity, vegetation, climate, animal utilisation, productivity measurements etc. There will be also general information recorded on all available aerial and ground photography, on published reports and on previous workers in the area. The user can therefore quickly obtain a picture of all available data and see where he can fill existing gaps by his own investigations. A reference library, cross referenced to the data storage, is being built up to hold information on important ground and aerial oblique photographs, vegetation samples, soil samples etc. (Fig. 6 + 7). A code system will provide a subject classification as well as a reference to geographical locations.

ACKNOWLEDGEMENTS

The classification work was carried out between 1969 and 1973 as part of the Serengeti Photo-Ecological Project, a joint project of the International Union for Conservation of Nature and Natural Resources (IUCN) and the World Wildlife Fund which was sponsored by the Government of the Federal Republic of Germany and the Fritz Thyssen Stiftung, Germany. Running costs and materials for the project were largely provided by the Serengeti Ecological Monitoring Programme, sponsored by the African Wildlife Leadership Foundation, Nairobi - Washington D.C. Additional funds were made available by the Frankfurt Zoological Society, Germany.

Fig. 6

Sample of an annotated aerial photograph of Moru Land System.

Fig. 7 aerial oblique showing Moru Land System.

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SELECTED BIBLIOGRAPHY

BECKETT, P.H.T. and WEBSTER, R., 1965. 'A classification system for terrain' Milit. Engng. Experim. Establ., Christchurch, M.E.X.E. report no. 872, 29 pp. and appendices.

BOURNE, R., 1931. 'Regional survey and its relation to stock taking of the agricultural and forestry resources of the British Empire' Oxford Forestry Mem. no. 13, 169 pp.

BRINK, A.B., MABUTT, J.A., WEBSTER, R. and BECKETT, P.H.T., 1966. 'Report on the working group on land classification and data storage' Milit. Engng. Experim. Establ., Christchurch, M.E.X.E. report no. 940, 97 pp.

CHRISTIAN, C.S. and STEWART, G.A., 1968. 'Methodology of integrated surveys' Proc. UNESCO Cong. Toulouse 1964, UNESCO Nat. Resources Research vol. VI, p. 230 - 280.

GERRESHEIM, K., 1970. 'Landscape ecological investigations in the Serengeti National Park, Tanzania' IUCN Landscape Planning Commission Newsletter no. 3, p.12 - 15.

GERRESHEIM, K., 1971. 'Landscape classification and the storage of ecological data' Second Conf. of Land Use in Tanzania, Serengeti Research Institute public. no. 82, cyclostyled, 9 pp.

MONTOYA-MAQUIN, J.M., 1967. 'Ecosysteme et photo interpretation: fondement theorique et pratique des inventaires de resources integrees' Intern. Archives of Photogrammetry vol. 16, IV.2 pp. 37 - 40.

ROBBINS, C.R., 1934. 'Northern Rhodesia - an experiment in the classification of land with the use of aerial photography' J. Ecol. 22, pp.88 - 105.

STEWART, G.A. (editor), 1968. 'Land evaluation' Papers of a CSIRO Symp. in Coop. with UNESCO, Macmillan, Melbourne, 392 pp.

WEBSTER, R. (editor), 1965. 'A classification system for terrain - description of a land system' Milit. Engng. Experim. Establ., Christchurch,M.E.X.E. report no. 955.

WEBSTER, R. and BECKETT, P.H.T., 1970. 'Terrain classification and evaluation using air photography: a review of recent work at Oxford' Photogrammetria 26, pp. 51 - 75.