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(E78-10132) THE KENYA RANGELAND ECOLOGICAL MONITORING UNIT (Ministry of Tourism and Wildlife) 17 p HC A02/MF A01 CSCL 08E

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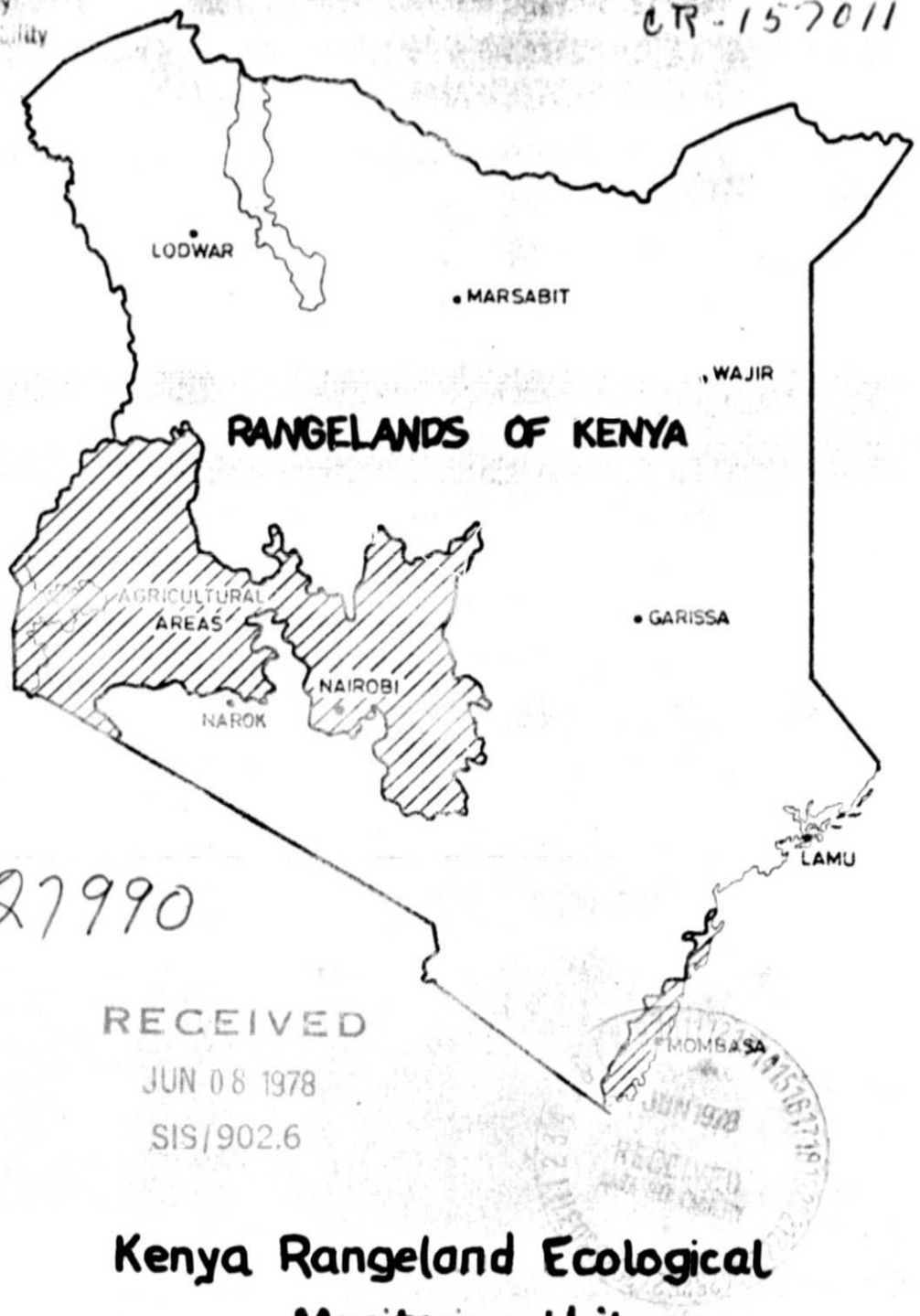

Kenya Rangeland Ecological Monitoring Unit

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LANDSAT II Investigation No. 27990

FINAL REPORT

THE KENYA RANGELAND ECOLOGICAL MONITORING UNIT

W.E. STEVENS
Project Manager

15 February, 1978

Sponsoring Agencies:

Government of Kenya
Canadian International
Development Agency.

I - Introduction

The principal objective of the Kenya Rangeland Ecological Monitoring Unit (outlined in the Statement of work 27990) was to define in quantifiable terms the use being made of the semi-arid Kenyan rangelands by humans, by livestock and by resident wildlife. The parameters to be measured included climate, vegetation, surface and subsurface moisture; plus the numbers and distribution of pastoralists and large herbivorous animals.

The methodology adopted was at regular intervals to systematically sample those phenomena within reasonably uniform ecological zones. With time it should be possible to detect and to forecast changes in rangeland ecosystems in response to natural or artificial pressures. Being able to detect and forecast such trends will allow early remedial alterations in land use practices. The objective in using satellite data is to detect changes in ecological conditions quickly, and over large areas.

If the method proves valid and useful it will have wide application for land management within the semi-arid grasslands of Africa and allow for the orderly development of industries based upon livestock, and the major species of wildlife associated with it.

II - Techniques

As outlined in the Statement of Work No. 27990, the Kenya monitoring project proposed an intergrated approach to rangeland assessment. Data were to be collected by field teams on the ground, by aerial observations and photography from low - flying aircraft, and by study and analysis of Landsat II imagery. The intention throughout the project was to develop a cohesive body of ground truth information to serve as a background for interpreting and using remote sensing data

data and imagery. The need remains to have satellite imagery delivered in Kenya routinely so that ephemeral changes in vegetation and moisture conditions can thereby be assessed over large areas of the rangelands. The ground level studies and the low level aerial work have gone ahead satisfactorily in the anticipation that eventually the satellite information will be available on a real time basis.

A - Ground Level Techniques

The essence of the rangeland monitoring program is systematic and recurrent sampling within uniform ecological areas. Toward that end Kenya rangelands, comprising about 500,000 km^2, were divided into 44 eco-units; as displayed in Figure 1 and named in Table 1. The boundaries of those units, while tentative, have been checked from the air and on the ground. Within each eco-unit a variable number of sampling sites of 10 x 10 km size were chosen, the number depending upon the vegetational diversity. Within each site a station comprising a storage rain gauge and neutron probe access tubes was established for long term monitoring. Representative vegetation types have been selected within each site, and vegetation stands of at least 4 ha. delineated within each type. Each time the vegetation within a stand is sampled a sampling plot of 1ha will be designated; usually the same plot is used on successive visits. Both the herbaceous layer and the woody layer are sampled using standard methods as outlined in Kuchar (11). In as much as the sampling technique includes the clipping of sample plots for drying and weighing it will be possible to estimate the standing crop of vegetation and the available energy. Monitoring of the sites over time will provide information on the trends in rangeland vegetation.

Coincident with the ground sampling of grassland areas, reflectance measurements are made with digital photometers employing filters at 6750 $\mathring{A}$ and 8000 $\mathring{A}$. The ratio

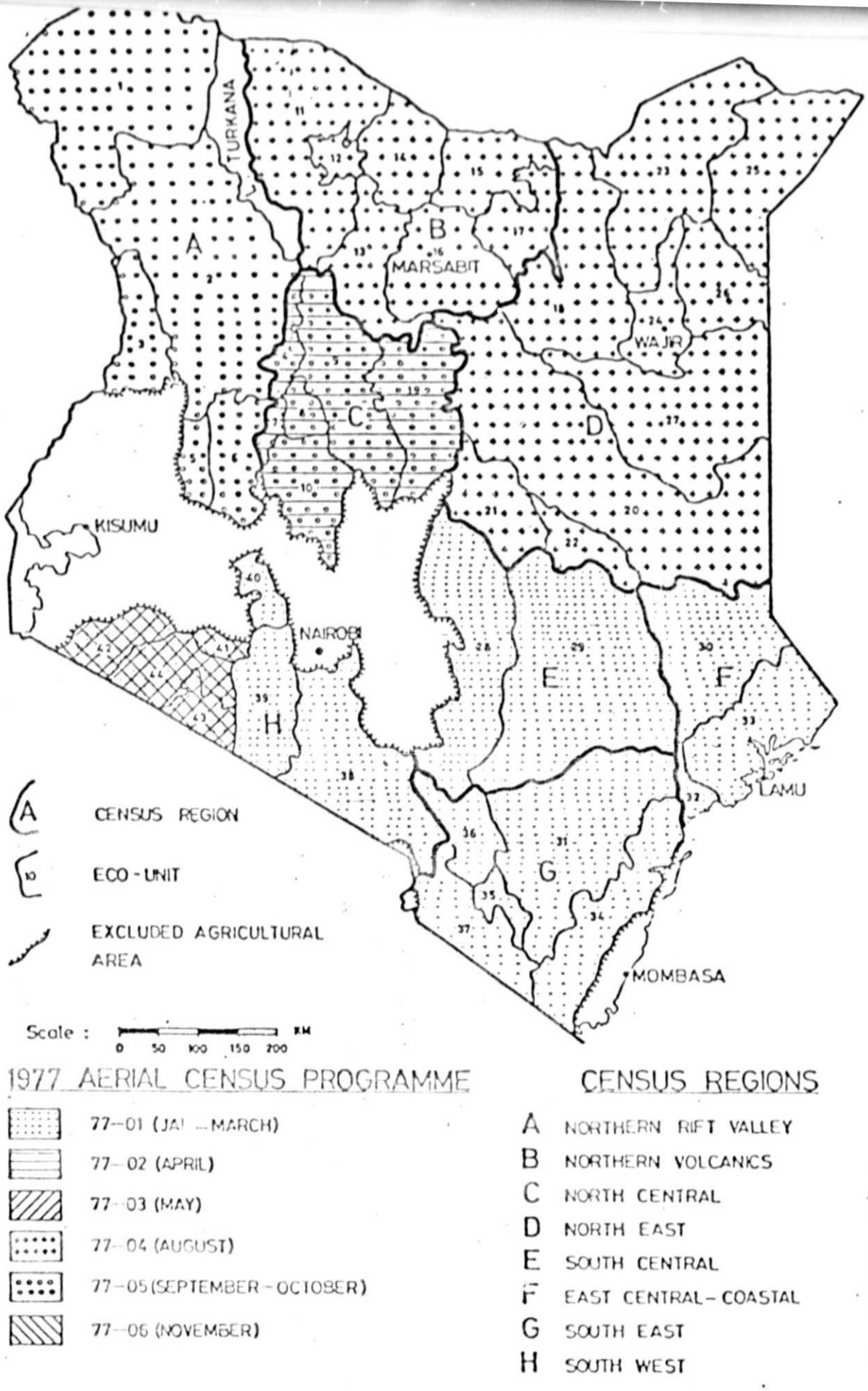

Fig. 1. KREMU's 1977 aerial survey programme. The map illustrates the eight census regions and 44 eco-units which formed the basis of the programme. Also shown is the areal extent of each individual census.

TABLE 1 KENYA RANGELAND ECO-UNITS

(Wherein movement of large mammals is controlled by landforms, settlement, and other attributes of landscape, as delineated by K.R.E.M.U. as at December, 1976. These Units are provisional)

CODE	NAME
1.	North Turkana
2.	South Turkana
3.	Pokot
4.	Suguta Hills
5.	Kerio Valley
6.	Baringo
7.	Lorogi
8.	Maralal
9.	Samburu
10.	Laikipia
11.	Ileret
12.	North Norr
13.	Chalbi
14.	Huri
15.	Sololo
16.	Marsabit
17.	Chera
18.	Bokhol
19.	Archer's Post
20.	Ewaso Ngiro
21.	Meru
22.	Garissa
23.	Tupo
24.	Wajir
25.	Mandera
26.	Khorof Harar
27.	Dif.
28.	Kitui
29.	Hola
30.	Ijara
31.	Tsavo
32.	Tana Delta
33.	Lamu
34.	Kilifi Kwale
35.	Taita Hills
36.	Mtito Andei
37.	Jipe
38.	Amboseli
39.	Magadi
40.	Naivasha
41.	Narok
42.	Lolgorien
43.	Loita
44.	Mara

between those readings, upon calibration, will give a measure of green plant biomass. Similar readings, routinely made from low flying survey aircraft will provide a measure of green plant biomass over wider areas of the country. Those data will be correlated with information from infrared aerial photographs and from satellite reflectance data and imagery. Also sought will be the relationships between the soil moisture measurements and satellite multispectral readings.

B - Air Survey Techniques

As already noted, the Kenya rangelands were divided into 44 eco-units, which units provided the sampling areas for ground and air surveys. During 1976 the boundaries of those units were checked by flying along them to note their accuracy with respect to topograhy, soils, vegetation or cultural features. Thereafter, during that year, much of the available time was spent in the selection and training of air survey staff and developing survey techniques.

The first aerial survey of Kenya, which commenced in January 1977, was an initial reconnaissance to provide a data base for subsequent surveys. Three single-engine Cessna - 185 aircraft were employed, each crew consisting of a pilot, a biologist and two observers. The task of the pilot was to maintain accurate heights and courses, using a radar altimeter and long wave navigational instruments. The biologist (designated front seat observer) identified survey particulars and once every five kilometers of line flown, recorded vegetation type and condition, soil colour, water availability and details of settlement and cultivation. The two rear seat observers identified and recorded by voice the numbers and kinds of livestock (cattle, sheep and goats, donkeys.

camels) and wildlife (about 15 species) seen within a defined census strip about 100 metres wide on either side of the aircraft. Where aggregations of more than 10 animals occurred, they took a photograph using high speed 35 mm colour film. Upon landing they transcribed their data from tape to standard data forms and later used a base-lighted stereo-microscope to count and correct their estimates of animal numbers from the developed colour slides.

At the outset, the survey lines were flown at a height of 100 metres above ground at 150 km. per hour; at intervals of 10 km. Because that provided only about a 2 percent sample, subsequent surveys were made at 5 km. intervals, using the same height, speed and strip width parameters. That boosted the sampling rate to about 5 percent and improved the standard error of population estimates.

The equipment available for aerial photography included two 70 mm Vinten airphoto cameras with a 3 inch and a 12 inch focal length lenses, an intervalometer for actuating either or both cameras, and a gyro-stabilized drift meter. Equipment for film developing, printing and enlargement was at hand together with light tables and mirror stereoscopes for photo examination. No additional items of equipment were available within the project for the handling of satellite imagery, although the Kenya Remote Sensing Census Project had basic items which they were pleased to make available.

Both the Ground Surveys and the Air Surveys generated masses of data which had to be analysed and stored by the Data Management Section. Input of coded data was by way of punched cards to the IBM - 370 computer at the Central Bureau of Statistics. Future input will be by diskette from an IBM - 3742 Dual Data Station, KREMU personnel

prepared the programs for data analysis, storage and retrieval.

Collaboration was arranged with the Ministry of Natural Resources to modify and test a suite of programs to analyse Landsat computer compatible tapes. Unfortunately no tapes were delivered to that Ministry during the reporting period, but the intention still persists.

III - Accomplishments

The complement of expatriate scientific staff for the Kenya Rangeland Ecological Monitoring Project included two aerial biologists, two range ecologists, a systems ecologist with a range management background, and a project leader. Technical staff included an air photo technician and three pilots. For each of those positions there is, or should be, a Kenyan counterpart who will be trained to assume the duties at the termination of the bilateral program. Currently lacking are counterparts for the senior aerial biologist, the senior range ecologist and the systems ecologist. Kenyan scientific, technical and support staff comprises 70 positions in total, with a variable number of additional temporary staff as required.

The training of staff at the technical level has proceeded satisfactorily through on-the-job instruction and supervision. One exception has been the lack of training facilities in remote sensing. That deficiency however, is rapidly being overcome by the establishment of a course of instruction at the University of Nairobi, and by the USAID sponsored remote sensing facilities and staff at the ECA Regional Centre for Services in Surveying and Mapping in Nairobi.

In so far as the KREMU project is concerned it has taken time to recruit staff qualified to make use of remote

sensing technology, and to develop the methods and infrastructure necessary to support such staff. Only near the end of the period of the agreement with NASA were those conditions realized. The monitoring project is a component of the Government of Kenya and is proposed as an on-going program whose data will become increasingly reliable through replication over time. Remote-sensing methods, as a data source, are expected to become more useful as ground truth information accumulates. As a consequence Landsat C imagery will be more relevant to ecological monitoring than was its predecessor and Landsat D likely will have an even greater potential..

From the standpoint of NASA it is likely that the value of Landsat II imagery to the monitoring project was limited. The first imagery did not arrive in Kenya until February 1976, and the last in June of that year. In setting up the system of eco-units for Kenya, the project employed colour - composite imagery of 1:1 million scale obtained from the Kenya Remote Sensing Census project, and 1:250,000 enlargements on loan from the Kenya Soil Survey. That imagery dated from Landsat I and was adequate for the purpose required.

IV Significant Results

There was already a body of data available in Kenya about the terrain, the soils and the vegetation. The Kenya Soil Survey, the East African Herbarium and various aid programs (USAID, UNDP/FAO) already had done a lot of work in local areas that proved invaluable in setting up the national monitoring program.

To the end of 1977 the following achievements were made.

1. Methodology for aerial surveys and ground truth

studies was developed, tested and revised several times to produce reasonably firm methods of procedure.

2. Computer programs were adapted or developed to analyse, store and recall data from the ground and air monitoring surveys. That endeavour has not been finished and is continuing.

3. Both Kenyan and expatriate staff have been selected and trained on the job to perform the tasks required. The problems with recruiting senior Kenyan staff already have been recounted in the previous section. The Kenyan government has agreed to supply additional professional staff to the monitoring project after June 1978.

4. In as much as the rain gauges and soil moisture tubes have had to be placed on private land, it has been necessary to obtain the approval of the land owners. That has been done through the cooperation of the Provincial and District Commissioners by way of a publicity brochure, and through meetings with local chiefs and their people. The Masai pastoralists especially, have been suspicious of any activities on their traditional grazing areas which they did not understand and approve. Of necessity, the understanding and support of land owners will have to sought and reinforced as a part of the continuing program.

5. Good publicity for the ecological monitoring program was obtained through the participation of the KREMU staff in the National Seminar on Desertification which preceded the UN Conference on Desertification held in Nairobi in July 1977. The Kenyan Manager of the monitoring project was an official delegate

to the National Seminar and to the International Conference. Kenya emerged as one of the few countries actively engaged in the systematic monitoring of ecological conditions within its boundaries.

6. Staff members of KREMU have actively participated on the Committee on the Application of Satellite and Space Technology of the National Council for Science and Technology. That Committee has the responsibility for advising the Government of Kenya on the use and development of remote sensing capabilities within Kenya, and on broader policies concerning the establishment of an ECA-sponsored Remote Sensing Programme for Africa.

7. Cooperated by supplying vegetational information for a remote sensing resources survey of Narok District in Kenya, conducted by Dr, Victor Odenyo, and supported by the National Research Council of Canada and the Canadian Centre for Remote Sensing (CCRS).

8. Completed an aerial survey of all of Kenya rangelands and released reports on the populations estimates livestock and wildlife observed therein, Such information on a national scale had not been available previously. See publications list.

9. Established and instrumented of 14 ground survey sites in southern Kenya.

V - Publications

1. Gwynne, M.D. - KREMU habitat monitoring procedures, 7pp typescript July, 1976.

2. Gwynne, M.D. and P. Kuchar - Important range plants of Kenya, KREMU Range Ecol. Report 1. 49pp. cyclostyle, Aug. 1976.

3. Anonymous - A review of the Kenya Rangeland Ecological Monitoring Unit, Phase One - Project Installation, 21pp. cyclostyle, 3 appendices, Aug., 1976.

4. Wahome, E. - Yaliyomo kwa hotuba Stesheni za KREMU za kuarifu, 2pp. Feb. 1977 (In Kiswahili).

5. Gwynne, M.D. - Landsat scene identification for Kenya 3pp. cyclostyled May, 1977.

6. Wetmore, S.P. and G.H. Townsend - A Geographical Code for the identification storage and analysis of ecological data. KREMU Aerial Survey Report 1. 3pp. typescript, 3 Figures May, 1977.

7. Anonymous - Kenya Rangeland Ecological Monitoring Unit. Illustrated brochure with map. June, 1977.

8. Wahome, E. - Using storage rain gauge for monitoring rainfall. 3pp. cyclostyle, June, 1977.

9. Andere, D.K. - Monitoring the Rangeland of Kenya. Paper presented to National Seminar on Desertification June, 1977,

10. Wahome, E. - Calibration of Wallingford soil moisture neutron probe for different range ecosystems. 5pp. cyclostyle, July, 1977.

11. Kuchar, P. and M.D. Gwynne - Habitat monitoring stations in Kenya rangelands: vegetation assessment, 15pp. typescript, plus 10pp.

field forms, August, 1977.

12. Wetmore, S.P., H.J. Dirschl, S.W. Mbugua. A comparison of six aerial censuses of Meru National Park and Conservation Area. KREMU Aerial Survey Report 2. 22pp. cyclostyle Nov., 1977.

13. Dirschl, H.J., S.W. Mbugua, S.P. Wetmore. Preliminary results from an aerial census of livestock and wildlife of Kenya's rangelands. KREMU Aerial Survey Report 3. 12pp. cyclostyle, Jan. 1978.

14. Dirschl, H.J., S.P. Wetmore - Population indices and distribution of the Grevy's zebra in Kenya, 1977. Aerial Survey Report 4, 7pp. cyclostyle, Jan. 1978.

15. Stevens, W.E. The Kenya Rangeland Ecological Monitoring Unit. Paper presented to Seminar on Remote Sensing of Earth Resources, National Council for Science and Technology, 10 January, 1978.

16. Dirschl, H.J., M. Norton-Griffiths, S.P. Wetmore. The training of aerial observers and pilots for counting animals. Aerial Survey Report 5. In preparation.

VI Problems

Two problems were paramount in applying satellite information to the rangeland monitoring project. The first of those was the delay in getting the project operational. Although the agreement with NASA was signed in 1975, the experimental work on the Project did not commence until after the middle of 1976 (financial year 1976-77) and field

operations were further delayed until early in 1977. As a consequence the agreement was due to lapse almost as soon as activity commenced.

Another problem was the delay in obtaining the services of a person trained in the use and interpretation of remote sensing information. Such a person was not on staff until the end of 1977. Because his services will be available for only a year, it is important that a full range of remote sensing information be obtained during 1978.

A recurrent problem is the recruiting of Kenyan staff to fill the senior scientific positions. The relative scarcity of suitably qualified persons and the low governmental wage structure both militate against mounting sophisticated scientific projects within the short time frame that is usually specified in bilateral agreements.

The level of remote sensing technology and equipment is low in Kenya, though very real progress is being made to overcome both deficiencies. That will likely remain a problem for the next year or two, until Kenya, together with other African States, decides on the course it wishes to take in developing its remote sensing technology and in acquiring satellite information.

Finally, in utilizing satellite information to monitor biological phenomena it is necessary that reasonably current imagery be made available to coincide with ground and air surveys. That requirement will present difficulties until better methods of delivery and analysis of satellite data are developed locally.

VII - Data Quality and Delivery

The quality of Landsat II imagery delivered to Kenya was poor and its receipt was much delayed. Although the

satellite was launched early in 1975 the first imagery was not received in Nairobi until about a year later. The last imagery received was in June, 1976.

The year 1976 in any case, was one of extensive cloud cover over large areas of Kenya and obtaining satisfactory data was most difficult. The Kenya coastal areas especially were blanked out because the satellite passage was at about 0930 local time, before the low-lying cloud cover had dissipated. That is a problem inherent in the system however, and may not be overcome with the present scanning devices.

Because of the rather indifferent quality of Landsat II imagery, much of it too dark and with poor resolution, existing projects using satellite information depended for the most part upon the Landsat I imagery already at hand in Kenya.

VIII Recommendations

1. Continue to improve remote sensing training facilities in Kenya, and foster wider use of the technology in order to justify the expense involved in acquiring facilities and trained staff.

2. For the purpose of ecological monitoring, work toward acquiring better equipment for the rapid examination of satellite information. Ideally, that would include facilities for receiving satellite data on a real time basis, the production of quick-look imagery, and a low-cost digital analysis system.

3. Continue cooperative agreements with NASA, and other agencies, for receiving satellite information so that the mounting volume of ground truth information being collected about Kenyan rangelands can be

used in the analysis and interpretation of satellite data.

XI Conclusions

The purpose of the Kenya - NASA agreement was to use the Kenya Rangeland Ecological Monitoring project as a vehicle for assessing the value of satellite information for rangeland management. Although the utility of satellite data has not yet been proven, excellent progress has been made on establishing a body of ground truth measurements. The experiment should be continued because it appears to have good potential for data input, even though the analysis of imagery to date has been electro-optical only. In the long term it is anticipated that much quantitative data required for land-use planning and ecological monitoring can be generated for large areas of Kenya from satellite data, at a considerable saving in manpower and money over the present more laborious methods.