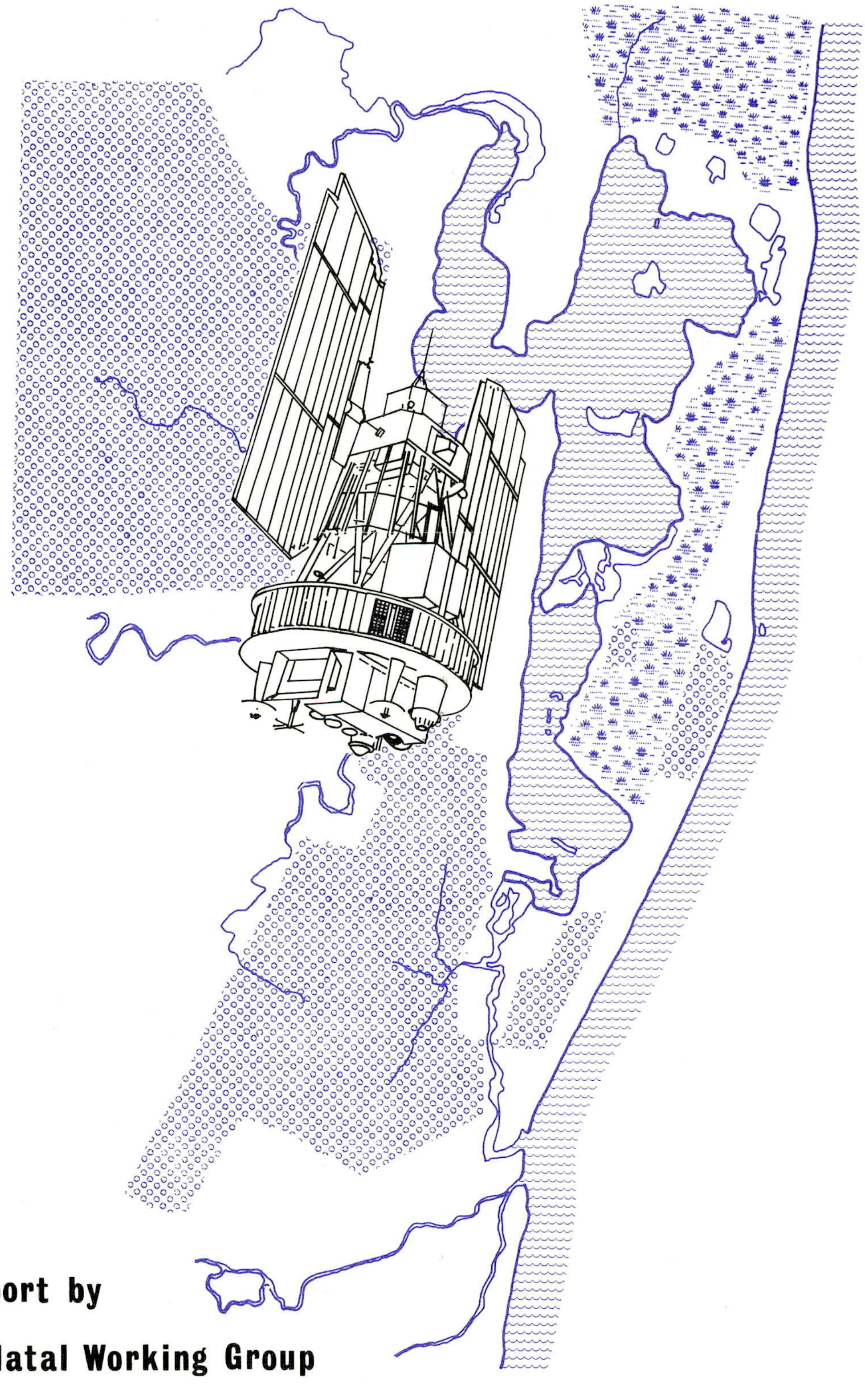
AN INITIAL ASSESSMENT OF THE USE OF LANDSAT IMAGERY IN LAND COVER SURVEYS AT ST. LUCIA AND ITS ENVIRONS



A Report by

The Natal Working Group

AN INITIAL ASSESSMENT OF THE USE OF LANDSAT IMAGERY IN LAND COVER SURVEYS AT ST. LUCIA AND ITS ENVIRONS

A REPORT BY

THE NATAL WORKING GROUP

ISBN 0 909232 21 0

Research Sponsored by Co-operative Scientific Programmes of the C.S.I.R.
Report published by the Natal Town and Regional Planning Commission.

APRIL 1981.

ACKNOWLEDGEMENTS

The Natal Working Group would like to acknowledge the assistance of the following organisations and persons who helped make this study possible :

The Co-operative Scientific Programmes Division of the Council for Scientific and Industrial Research, for financing the study.

The National Physical Research Laboratory, Optical Sciences Division, for the production of the optical and digital output.

The Natal Parks Board for hosting the Natal Working Group at St. Lucia during the field work stages of the study.

The Natal Town and Regional Planning Commission for publishing the report.

All persons from the various departments and organisations too numerous to mention.

CONTENTS

ABSTRACT

Recent studies in the St. Lucia area have shown that planning decisions could be facilitated by knowledge of certain natural resources such as vegetation quality, erosion areas, erosion susceptibility, wildlife habitats, etc. As most of the members of the Natal Working Group had an interest in the St. Lucia area a study was undertaken in late 1978 to evaluate the applicability of LANDSAT imagery to resource and land use management, as well as to enable the participants to gain experience with the technology of using LANDSAT to achieve these aims. This report is an evaluation of the study and summarises the findings of each member organisation. Conclusions are drawn and ideas for future research are presented.

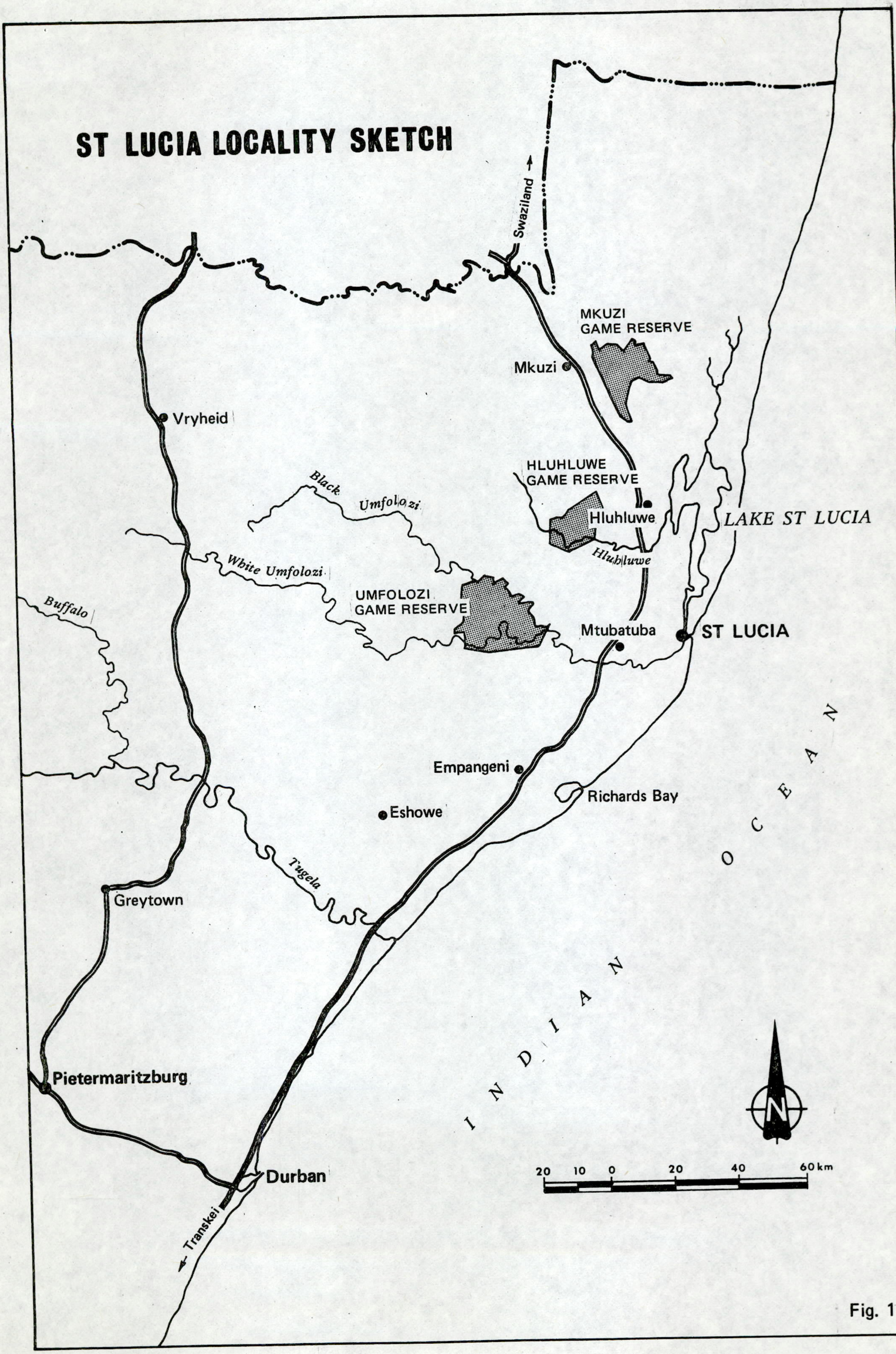
1. INTRODUCTION

St. Lucia, situated in Zululand, is well known for its natural beauty, recreational value, wildlife, and as a challenge to conservationists. To the North and West are some of the province's major game reserves (Fig.1). The Lake itself and its eastern shores are unique conservation areas, managed as such by the Natal Parks, Game and Fish Preservation Board and the Department of Forestry. The environs have a variety of land uses with intensive sugar-cane and mixed farming together with afforestation being the main activities. St. Lucia has been identified as a future growth point for recreation and planning policy; therefore attempts to reconcile the conflict between the needs of holidaymakers, conservationists and farmers are necessary.

Recent studies in the area by the Natal Town and Regional Planning Commission (1, 2) have shown that planning decisions could be facilitated by knowledge of certain natural resources such as vegetation quality, erosion areas
erosion susceptibility, wildlife habitats, water table, residential and urban land, roads and services and recreation areas. These factors were mapped, using aerial photography and ground surveys. At that time there was no better method of determining change other than the repetition of surveys.

As most of the members of the Working Group (see Appendix A) had an interest in the St. Lucia area for the above and other reasons, a study was undertaken in late 1978 to evaluate the applicability of LANDSAT imagery to resource and land use management in the area. A further and important objective of the study was to enable the participants to gain experience with the technology of using LANDSAT data in land use and resource management. Concurrent with this study a feasibility study (3) was undertaken to investigate the preparation of a forestry map of South Africa using LANDSAT data, with research being conducted initially in the St. Lucia area. Consequently matters relating to forestry applications were not studied in detail by the Working Group. The location of the study areas of the Working Group are shown in Figure 2.

This report is an evaluation of the study, and summarises the findings of each member organisation. Conclusions are drawn concerning the use of LANDSAT imagery by various disciplines as well as presenting ideas for future research in the field of land use management from satellite-borne sensors. Unforeseen circumstances have delayed earlier publication of this report.


ST LUCIA LOCALITY SKETCH
Swaziland
MKUZI
GAME RESERVE
Mkuzi
Vryheid
HLUHLUWE
GAME RESERVE
Hluhluwe
LAKE ST LUCIA
Black
Umfolozi
White Umfolozi
Hluhluwe
Buffalo
UMFOLOZI
GAME RESERVE
Mtubatuba
ST LUCIA
Empangeni
Richards Bay
Eshowe
Tugela
Greytown
INDIAN OCEAN
N
Pietermaritzburg
Durban
Transkei
20 10 0 20 40 60 km
Fig. 1

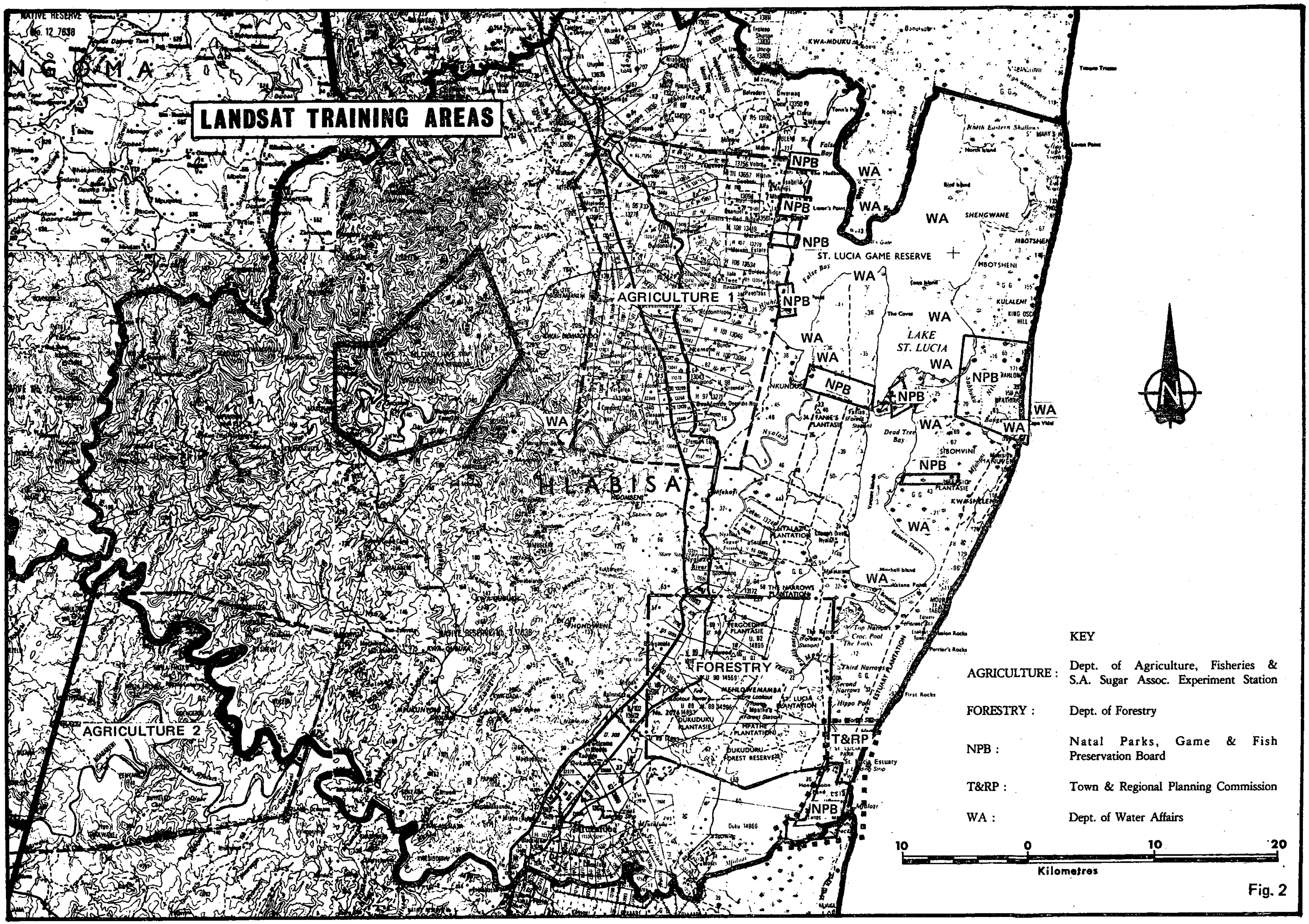

LANDSAT TRAINING AREAS
NGOMA
HLABISA
AGRICULTURE 1
AGRICULTURE 2
FORESTRY
ST. LUCIA GAME RESERVE
LAKE ST. LUCIA
NPB
WA
T&RP
KEY
AGRICULTURE : Dept. of Agriculture, Fisheries & S.A. Sugar Assoc. Experiment Station
FORESTRY : Dept. of Forestry
NPB : Natal Parks, Game & Fish Preservation Board
T&RP : Town & Regional Planning Commission
WA : Dept. of Water Affairs
10
0
10
20
Kilometres

Fig. 2

2. METHODOLOGY

2.0 Software System

All the data processing for this project was carried out at the C.S.I.R. on the C.S.I.R./NPRL VICAR system, this being the only image processing system available when the project was initiated. This software system is currently implemented on the C.S.I.R.'s IBM 370/158 in Pretoria. VICAR (Video Image Communications and Retrieval) is a software package originally developed by the Jet Propulsion Laboratory (JPL) of the University of California for the processing of data from imaging sensors of planetary probes. The System as implemented at C.S.I.R./NPRL retains the original design from JPL but has a modified operating system interface (OS/VS3 VS OS/MFT) and many other additional applications routines.

Most of the applications routines used in this project have been added to VICAR at NRPL, but some of the basic routines (e.g. geometric transforms) have been retained from the original system albeit in modified form. Many of the modifications implemented relate to the data analysed and are not described in this report. A full description of the VICAR system can be found in Fink and Van Zyl (5).

2.1 LANDSAT data

Data from Landsat-1 and Landsat-2 were available in Computer Compatible Tape (CCT) format. These were E1190-07143 from Landsat-1 and E2150-07022 from Landsat-2. It was hoped that Landsat-3 data would become available during the course of the project, but delays at NASA Goddard Space Flight Centre and EROS Data Centre precluded this. Both images available were remarkable for their lack of cloud cover over the study area. However, early processing indicated that the Landsat-2 image had a large amount of intersensor noise (6-line striping), particularly in Band 6 (700-800 nm). In the absence of proven noise removal techniques, it was decided to limit the investigation to the Landsat-1 image gathered on 29 January 1973. (Plate 1).

2.2 Reference Data

One of the major problems in a project of this type is the provision of reference data ("ground truth"). As the project was essentially retrospective no reference data were gathered at the time of the satellite overpass.

The quality of the reference data used to evaluate the results varied considerably between disciplines. For example, in the case of forestry, management maps of the plantations were available but, in the case of hydrology, no data pertaining to sediment load of any rivers or dams at the time of data acquisition could be obtained. Ground reference data for all of the other disciplines lay between these two extremes.

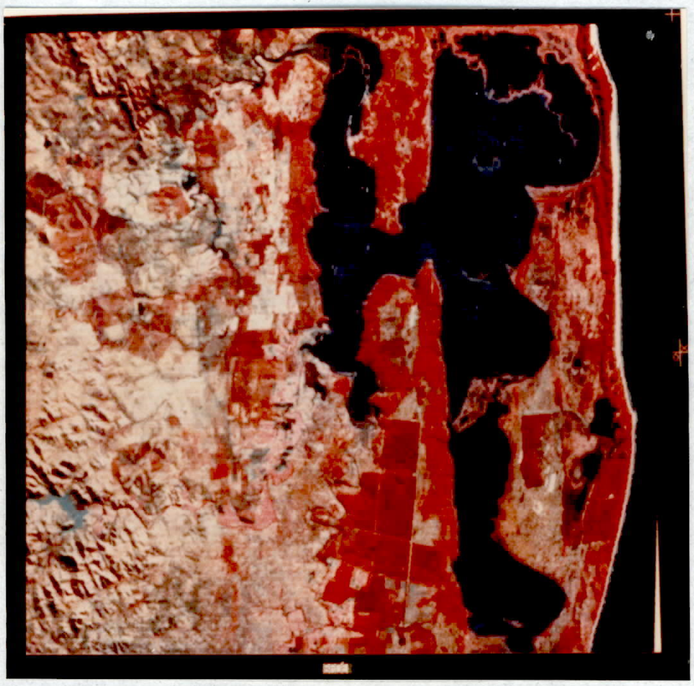


Plate 1 : Part of LANDSAT scene E.1190-07143 showing the St. Lucia area.

2.3 Computing Techniques

Early tests showed that the reference data available were not of sufficient quality to allow the application of Supervised techniques (6). The use of the management data from the Department of Forestry for the definition of training sets for pines etc. resulted in a large amount of mis-classification. The reason for this became apparent later and is discussed under results. An unsupervised/semi-supervised clustering/classification technique was therefore employed.

This technique is based on the ISODATA algorithm of Ball and Hall (1965)(7). Selected training areas for each discipline were clustered and the statistics of the clusters of a "satisfactory" run were used to carry out a Bayesian classification of the whole test area. The results of the clustering phase of the procedure were compared with whatever ground truth was available. If the fit was subjectively satisfactory, the statistics of the classes produced were used as signatures in a supervised Bayesian classification. Otherwise the clustering was run again with altered parameters to increase or decrease the number of classes found.

In some cases, classes from different training areas corresponded to classes required in the final mapping. In these cases, signatures of the required classes were selected from the statistics of the various training sets, and used to construct a signature set which was then applied to the whole area.

2.4 Mapping Techniques

The output of the classification routines was displayed in several different ways and at different scales according to the requirements of the user. The routine output product was a geometrically corrected 1:20 000 line printer map. On this representation, each class was printed as a different character, together with summary statistics indicating the area occupied by the particular ground cover.

This output format was useful in some cases since it could be directly overlaid on 1:20 000 maps used as reference data. Although there was a lack of visual discrimination between classes when looking at the map as a whole, this could be overcome by colouring each class in a different colour. This had the advantage of forcing the analyst to examine the output results in detail, often revealing relationships not apparent at first sight.

A second output format, which produced a high quality image, was to tranfer the data to film using the Optronics Photowrite facility at SRSC at Hartebeeshoek. In the early part of the project, only black and white transparencies could be produced. In order to construct a coloured image, three colour separation negatives were made which were then used to produce a colour composite photographically, using appropriate filters. Later, the capability of producing a colour negative/positive transparency directly on the Optronix was introduced.

Although this form of output is of extremely high quality, its use as a routine output medium was precluded for two reasons. Firstly, the time taken to produce a satisfactory image was relatively long and secondly, due to the limitations of size of the film, the area which could be displayed was small unless scales of 1:250 000 to 1:1 000 000 were used.

From February 1979, a "quick-look" colour television display was available at CSIR/NPRL (8). This allows a relatively fast display of results from the classification run under VICAR. Although only a relatively small area (256x256 pixels) can be displayed at any one time, the fast turn around and relatively high quality of the image produced makes this an excellent method of assessing the results of clustering of training areas.

3. RESULTS

Initial attempts to use a supervised classification system proved unsuccessful. In one attempt, there was confusion between pine plantations and indigenous bush, which could easily be distinguished by eye in relatively homogeneous areas in displays of the raw Landsat data. The reasons for failure were two-fold. Firstly, the reference data available to the analyst was not of sufficient quality to allow the selection of homogeneous training areas. For example, the forestry management maps indicated which areas were planted with pines, but contained no information on the degree and position of bush encroachment. Thus a training set defined as "pines" on the basis of the management maps in fact contained a mixture of pines, grass and bush. Secondly, many of the "interesting" classes are present as relatively small groups of pixels, e.g. in the natural vegetation and agriculture areas which proved insufficient to provide an adequate statistical sample. This approach was therefore abandoned in favour of the unsupervised approach already outlined.

A secondary effect of the "retrospective" nature of this study was the difficulty of providing quantitative assessment of accuracy.

An example of a classified scene is shown in Plate 2.

3.1 Agriculture

3.1.1 Sugarcane

Transparent overlays of all areas under sugarcane were compiled to fit the computer classification of the area. A colour print of the classifcations supplied by the C.S.I.R. was a help in fitting the overlays. It was immediately apparent that all the spectral signatures applicable to areas under sugarcane also appeared elsewhere on the classified scene. In all, six spectral classes which represented the various growth stages of sugarcane were identified with a good measure of confidence. Two growers were visited to obtain confirmation of the identified crop stages on their farms at the time of the satellite overpass. Agreement was found to be good. Burned cane before harvest could not be identified directly.

3.1.2 Mixed farming

Area 2 was intensively farmed. Farms are small and there is a patchwork of irregularly shaped fields of pineapples, sisal and fallow land. The non-cultivated land mainly comprises sand, forest, woodland and open grassland.

Eighteen classes were created to record the land use information. Several of these were positively identified as reflecting a particular land use or plant community. These included a dense *Newtonia hildebrandii* forest on deep sands, *Acacia* spp. woodland of moderate and light tree density, clear water of moderate depth and pineapples. Some inconsistency with pineapples was recorded and was most likely the result of weed growth, marked differences in canopy cover and the predominance of red and grey soils planted to this crop. Newly planted pineapples would have a similar reflectance value to that of bare soil. Other land uses were represented generally by two or more classes.

Sisal plants were easily recognised but were represented by as many as five classes. The reason for this confusion is varying amounts of encroachment by *Acacia* spp. into the old sisal plantations. Sisal is also grown on both well-drained red soils and low-lying dark black clays.

Plate 2 : Example of a 20 class classified scene of Lake St. Lucia and environs

Shallow turbid water and mudflats along the lake shoreline were represented by three classes but reference data was inadequate to draw positive conclusions. Small fluctuations in the level of the lake could result in large areas of mudflats being exposed.

Study Area 3 was located in the Umfolozi valley. The land cover comprised natural vegetation with no cultivation. Results improved as experience was gained. Seven classes were provided and those were matched to a simplified vegetation map with four broad veld types. A detailed vegetation survey at 1:50 000 scale was available but the simplified map provided the closest fit with the seven classes.

The courses of the Black and White Umfolozi rivers was easily discernible and reflected by a single class. Large areas of dry bare sand resulting from a low river probably accounted for this. The dense luxurious riverine vegetation with *Ficus sycomorous* and *Acacia robusta* dominant, and including swamp was mainly reflected by a single class.

Several other classes were interspersed with the riverine vegetation. Overgrazed areas with sandy soils with short grass cover of *Cynodon spp.* were generally separated from the flood plain grassland with some bush. Moist sands with occasional shallow pools were generally represented by a single class. The most extensive class in the area represented open woodland. The influence of degraded and eroded areas on the reflection values was probably considerable but such areas were not accurately identified.

3.2 Natural Vegetation

A number of different classifications were produced and to identify the vegetation formations these showed, they were compared with the vegetation maps of the area, with aerial photographs and by direct ground reference in the field.

The effects of vegetation biomass, cover and spacing on the total spectral reflectance, and hence on the classification of the vegetation formations were evident in the various classi fications. The effect of the amount of vegetation cover was shown by classifying sedge swamp and grassland in the same category. These two vegetation types both have a fairly similar physiognomic structure, although they grow under completely different ecological conditions, and for this reason they should be mapped separately.

It could be seen that as one moved from grassland to the drift sand areas, which are completely devoid of vegetation, several separate classes were recognised. This shows the sensitivity of the classification to decreasing vegetation cover and an increase in the amount of exposed sands.

3.3 Forestry

It was found to be relatively easy to locate bush encroachment in exotic plantations, but while very young plantations could be identified, these were often confused with sparse bush in open grassland. The data were found to be useful in monitoring burned area, but there was difficulty in distinguishing between coniferous and broadleaf species. Areas without vegetation could be easily located, mainly by the presence of white sands. The results obtained were similar to those obtained by Malan, van der Zel and Brink (3).

3.4 Water Resources

The existence and location of water bodies were readily mapped but because of the long delay between the gathering of the satellite data and its analysis, the data were of limited value in water quality monitoring. Two reasons could account for this :

(a) Unlike natural vegetation, for example, water quality is a rapidly changing parameter. For a quantitative assessment of water quality, synchronously gathered reference data are essential.

(b) Although arbitrary classes of water quality can be defined, parameters such as silt load are essentially continuous rather than discrete.

Principal components analysis using the various water bodies as a ''training set'' produced images which show qualitative differences between turbidities and/or water depths.

3.5 Natural Resources and Urban Land Uses

Within St. Lucia, ecological boundaries could be identified from the classification, including massed plant species. Casurinas and pine plantations, reed swamp and *Ficus trichopoda*, indigenous forest (Dukuduku and Eden Park) could also be identified. Even in the town, large undeveloped building plots showed up as coastal forest. Animal habitats could only be inferred. No information could be obtained on the condition of the plant communities (i.e. dead mangroves were classified with live mangroves) and certain communities could not be separate (e.g. phragmites reeds from grassland).

Erosion areas, sand blows, bare sand and dredger spoil were positively identified as one class. LANDSAT produced an accurate map of these areas, and with a knowledge of the ground, it was relatively quick and easy to map the individual detailed use under this heading. Factors such as erosion susceptibility which are based on knowledge of soil quality, land slope, vegetal cover, exposure to wind and salt spray could not be determined directly from Landsat but could possibly be inferred.

Deep water could not be determined accurately but where it had an abrupt boundary, this proved invaluable for orientation. Swampy areas, shallows, turbidity and the occurrence of aquatic macrophytes often occurred in strips too narrow for detection.

Building development was quite readily discerned, but in combination with grassland and forest precursor. Recreation areas could only be deduced. It became clear that existing township maps were more accurate for mapping urban development than Landsat which raised the principle that Landsat should be used in combination with other means of mapping information and not viewed as a total source of land cover data.

3.6 Other Aspects

The ability of Landsat imagery to pinpoint ''windblows'' is a major benefit for conservationists. Small areas of windblows were easily identified and were associated with the deposits of recent sands near the coastline. Identification of one seriously eroded area has already led to a detailed investigation of the site. Cleared firebreaks in the area damaged by wind erosion were also identified. Landsat thus provides a more rapid means of mapping degraded areas than conventional means.

4. DISCUSSION

The user organisations benefitted greatly from participation in this project. As a first step in the direction of a technology transfer programme, the exercise was most successful.

Insofar as land cover mapping is concerned, retrospective studies have inherent problems, in that accurate reference data is not available. Relating reference data to computer classifications is primarily dependent on the accuracy of the data. For example, plantation maps do not record the presence of other features (e.g. indigenous bush encroachment) which might affect the classification. Analysis of line-printer maps, while giving the analyst an insight into the area, is time-consuming - it is far more practical to view the classification on a colour television display (''quick look'') before producing a hard copy map.

The results obtained for sugarcane were promising but the classification needs the support of improved reference data. Because of the interest in accurately identifying the spectral signatures for burnt cane, investigation of the techniques to achieve this need to be continued. Some classes were common to large areas not under cane which severely complicated positive identification of the crop.

Results for agriculture were not satisfactory in all respects but showed beyond doubt that satellite remote sensing holds much promise for the agricultural industry. This pilot study should now be followed by more detailed investigations selected in accordance with user needs. The uncorrected printout scale of 1:20 000 proved useful and the facility of the computer program provide area estimates of all classes was a major advantage. A major disadvantage was the inability to overlay existing maps exactly over digital printouts as the software did not allow co-ordinated points to be plotted. The identification of common land/water boundaries was the most convenient method for user orientation.

Reference data appeared to be inadequate for the number of classes in both study areas. Certain classifications used were inadequate for the complexity of the vegetation patterns. The lack of temporal coverage was also a serious disadvantage.

The classifications produced for natural vegetation were all useful to a degree and tended to emphasise certain vegetation formations but at this stage none of them produced a single map which could be used by the biologist as an overall vegetation map. This is an obvious limitation to anyone working in an area with a variety of habitats. However, if mapping is required to show a specific habitat only, e.g. forestry, a useful classification can be obtained in most cases.

The main limitation of its optimum use by field biologists is the inaccessibility of the data, of computers and of trained personnel to handle the computing operations.

Landsat showed positive signs in respect of national timber plantation inventories in areas for which no good maps are available. However, this study did not provide the opportunity for a detailed assessment of satellite imagery for mapping different species or age classes.

Certain useful conclusions were reached on the use of Landsat for this type of urban-related land cover surveys. Landsat could not substitute for skilled interpretation of of vegetation communities, but it could provide the interpreter with a base map on which to work, with the facility of giving accurate areas for each community which is defined. Positive identification of certain communities (target areas) which are not apparent from air photography would give a broad classification of communities which then requires spot checking and confirmation. This will provide a basis of considerable value in programming field work.

For satellite imagery to be of any use in determining water resources and water quality, particularly in Natal, up-to-date imagery and accurate reference data will be needed. It might be of some practical use in the monitoring of hydrological information but this again is dependent on timely acquisition of imagery.

The study revealed several other important requirements for future studies. These include :

(i) The difficulty of orientation on the computer printout was a serious limitation for users. A system of providing Gauss Conform co-ordinates for the user is an urgent need.

(ii) The selection of training areas is a critical aspect. Criteria and procedures for this exercise should be established. Training areas should be sited in well defined ecological areas of uniform land use patterns. Careful study of the terrain prior to the selection of training areas is necessary.

(iii) A balance should be struck between the detail of reference data and the number of classes used.

(iv) The results were impaired because the study was restricted to a single six-year-old image. In most cases reference data did not coincide with the date of the imagery and land-use in the study area changes markedly over short periods of time. Matching historical, satellite-produced data with reference data of a gross nature was a serious problem. Future projects should be planned to enable ground truth to be synchronised with the date of the imagery.

(v) Changes in land use could not be monitored in this study, but the importance of sequential temporal coverage particularly for agriculture and urban planning, is stressed.

(v i) The value of air-photography of similar date to the imagery was not adequately assessed but the results would have been greatly enhanced had greater use been made of this aid. Negatives of available air photographs at 1:20 000 were made and overlaid on the computer printout. Placing these on a light table assisted orientation and the analysis procedure. A multi-stage approach whereby satellite imagery, air photography and ground surveys are used together offers the best opportunity for accurate mapping of ground cover. It is debatable whether Landsat has any practical value of a scale of 1:20 000. It is suggested that an investigation into a comparison of practical mapping scales for Landsat be undertaken.

(vii) The study showed conclusively that the analysis of satellite imagery should only be undertaken by those with relevant technical experience and with an intimate knowledge of the reference data. Close liaison between user and analyst is necessary.

(viii) The study showed that much of the subjectivity associated with mapping using conventional means is eliminated.

(i x) The power of Landsat to monitor change will become apparent when regular coverage is available. Since the numerical data produced for one scene is considerable, techniques must be developed to process only areas where there has been a change in the land use pattern or only that information which users specify as necessary. This could aid in speeding up processing and data reduction.

(x) Landsat may become far more useful, particularly in determining urban land use, when the resolution improves.

(x i) In the process of classification the C.S.I.R. produced the optimum number of classes for each potential user, but experience showed the need to combine knowledge of the ground with the experimental classification of digital data. This is particularly important since it was found virtually impossible to define a pure set of reference data to train the classifier. (Deep clear water was the sole exception).

(xii) The study showed that the effect of shadow posed a serious problem resulting in misclassification. This will be a serious problem to other studies in Natal in areas with more rugged topography and provides a major challenge for future research.

5. THE FUTURE

For future progress to be made in research of this nature, users need to make known their specific needs, which to date, have not been forthcoming. It is suggested that an acceptable level of standardisation in colour coding should be developed for important land use classes, e.g. forests, grasslands, water, and adhered to. Investigations should be extended to make use of the thermal band to assess soil moisture status, biomass estimates for local vegetation types, mapping of soils, degraded vegetation and erosion, sediment movement and river flooding and irrigation and its related problems.

Research is required to characterise reflectance characteristics of important natural plant species and soil materials. This includes species composition, physiognamy, biomass proportion of the vegetation cover, shadow casting effects, etc. This could help in the choice of training areas.

6. CONCLUSION

Reference data is an essential part of the process of utilizing satellite imagery to its full potential. There needs to be close interaction between the user and the analyst to ensure that the reference data collected is in the right amount of detail and the classes selected are representative of that data. If this link is not forged, the output products could be meaningless or at least not optimum. Training areas need to be intellegently selected so that the above problem need not arise. Temporal coverage will become essential if this method of monitoring and quantifying changes in land cover is to become practical. This could provide a cheap and practical means of monitoring rather than carrying out repetitive surveys. The users of this system need to have specific needs for a sensible system to develop.

The success of this project can be found in the co-operation between the users and the C.S.I.R. which led to a ''cross-pollination'' of ideas, the basis of a successful working relationship which can only improve over time.

7. REFERENCES

1. A'Bear, D.R., A.M. Little, A.J. Phelan and R.H. Taylor (1976) : *St. Lucia Eastern Shores : An Evaluation of Natural Resources.* Paper read at the Wildlife Management Association Symposium, University of Pretoria, July 1976.

2. Little, A.M. and A.J. Phelan (1975) : Paper presented at a Workshop on Evaluation Techniques in Land Use Planning, SAITRP (Natal Branch) December 1975.

3. Malan, O.G., D.W. van der Zel and A.J. Brink (1980) : *Preparation of a forestry map of South Africa using LANDSAT data : Phase 1 - Feasibility Study FIS207.* NPRL-CSIR Pretoria, February 1980 ISBN 0-7988-1764-X.

4. Billingsley, F.C. and A.F.H. Goetz (1973) : *Computer techniques used for some enhancement of ERTS Images.* NASA/GSFC Symposium on Significant Results Obtained from the ERTS-1 VOL. 1 pp. 1159-1167.

5. Fink, W. and A.S. Van Zyl (1979) : *CSIR-VICAR Digital Image Processing System.* CSIR Special Report. FIS 154 and FIS 155.

6. Swain, P.H. (1971) : *Pattern Recognition : A Basis for Remote Sensing Data Analysis.* Laboratory for Applications of Remote Sensing, Purdue University, West Lafayette, Indiana. LARS Information Note 111572.

7. Ball, G.H. and D.J. Hall (1965) *ISODATA : A Novel Method of Data Analysis and Pattern Classification.* Stanford Research Institute, Menlo Park, Calif. Technical Report AD 699616.

8. Sykes, H.M. and A.A. Jackson (1979) : *A Specialised System for the Processing of Digital Images.* Unpublished paper presented at a BEXA 79 Business Efficiency Seminar, 5 October 1979.

APPENDIX A

COMPOSITION OF THE NATAL WORKING GROUP

Organisation	Representatives
Department of Agriculture and Fisheries (Cedara)	Dr D.M.Scotney Mr A.F. Wilby
Natal Town and Regional Planning Commission	Mr A.M. Little Mr P.J. Brough
Natal Parks, Game and Fish Preservation Board	Dr J. van Rensburg Mr R.H. Taylor
S.A. Sugar Association Experimental Station	Mr J.P. Fourie
Council for Scientific and Industrial Research	Mr A.A. Jackson Dr. O.G. Malan Mr P.J. van der Westhuizen
Department of Forestry	Mr C. Schultz
Department of Water Affairs	Mr P. Everritt Mrs D. Kroeger
University of Natal	Professor D.A.Scogings Mr S.E. Piper