Landsat imagery — its possible use in mapping the distribution of major Lichen Communities in the Namib Desert, South West Africa

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ABSTRACT

The feasibility of using false colour composite Landsat images as an aid for mapping some of the major lichen communities in the Namib Desert is shown. Inherent limitations and possible applications of the technique in other regions of the world are discussed.

Die bruikbaarheid van valskleur Landsat beelde as hulpmiddel in die kartering van sommige van die meer uitgestrekte ligeengemeenskappe in die Namibwoestyn word aangetoon. Inherente beperkings asook die moontlike gebruik van die metode in ander wêrelddele word bespreek.

CONTENTS

1 INTRODUCTION

1.1 Global use of satellite imagery

On a global scale satellite imagery has been extensively used in a number of applications (Reeves *et al.,* 1975; Lillesand & Kiefer, 1979), including the mapping of different aspects of vegetation. In South Africa increasing use has been made of remote sensing in a number of applications following the report by Malan (1973). The mapping of a number of regional vegetation types has been undertaken in South Africa, notably that of the Fynbos Biome (Jarman *et al.,* 1981).

By means of ground observations the spectral changes associated with post-fire recovery in subarctic lichens were investigated by Fuller & Rouse (1979). Spectral reflectance measurements of individual lichen species under laboratory conditions and measurements by means of ground observations of bulk albedo values in subarctic lichen woodlands have been made by a number of workers (Fuller & Rouse, 1979).

To the authors' knowledge satellite imagery has as yet not been used as a mapping aid in studies of the distribution of desert lichen communities. Existing reports on the nature of such communities (reviewed by Rogers, 1977) have all used standard ecological techniques.

1.2 Motives for the research

Lichens form the main component of the perennial plant biomass associated with the coastal regions of the Central and Northern Namib Desert and play a major role in the ecology of the area. Apart from general descriptions and incomplete species lists by Zahlbruckner (1926), Doidge (1950), Vogel (1955) and Mattick (1970), little is known about the ecology and taxonomy of lichens found in the Namib Desert.

Rainfall in the hyper-arid Namib desert is extremely irregular and records at Swakopmund indicate a mean annual rainfall of 13 mm (Logan, 1960). However, frequent overcast and foggy days amounting to 204—295 fogdays per year (Walter, 1971) occur along the coast. These and other prevailing environmental conditions appear to be almost ideal for lichen growth and have led to the development of rich assemblages of saxicolous and terricolous lichens.

As the continued unspoilt existence of some of the terricolous lichen communities is endangered due to trampling by off-road vehicles, the desirability of special conservation measures has become evident. Further substantiation of the need for their conservation is found in the fact that lichens grow and colonize extremely slowly. In areas trampled by sheep more than 40 years ago, Rogers (1977) was unable to detect recolonization by lichens.

Since a natural community cannot be properly and predictably managed unless its principal elements and their principal interactions are known (Ehrenfeld, 1970), it was decided, together with the Department of Agriculture and Nature Conservation of S.W.A., to undertake a scientific investigation of the lichen communities occurring in the National West Coast Recreation Area and the Skeleton Coast Park. The findings will be used in selecting and managing lichen reserves. One of the primary objectives in the first phase of the project is to define the geographical distribution and extent of the lichen communities in the biome.

1.3 Study area

The study area extends as a strip (approximately 55 km wide) along the Atlantic Ocean from the Kunene River in the north to the Swakop River in the south, covering an area of ± 22 530 km². It includes the National West Coast Tourist Recreation Area and the Skeleton Coast Park. The vastness of the area, inaccessibility of some parts, limited time available for field work and restricted use of existing black and white aerial photographs (non-existence of clearly delineated lichen communities) prompted this investigation into the possible use of landsat imagery as a mapping aid.

2 METHODS

During two field trips in 1982 specimens of lichens occurring in the National West Coast Recreation Area were collected for identification purposes. At every locality (amounting to at least one site per quarter degree square) the presence and abundance of individual species was recorded. Preliminary distribution maps of individual species and lichen communities were drawn for the study area. Relevant ground reference data were obtained from these maps.

Landsat-3 data of the area were visually examined, interpreted and photographed on the digital image processing system of the Satellite Remote Sensing Centre of the National Institute for Telecommunications of the C.S.I.R.

The data from each of the spectral reflectance bands 4, 5, 6 and 7 were processed to obtain black and white single band images. The individual images were examined and photographed. Bands 4 and 5 measure reflectance between 0,5 and 0,7 μm while bands 6 and 7 measure reflectance between 0,7—1,1 μm. A false colour composite of each image was produced using bands 4, 5 and 7. These composite images proved to

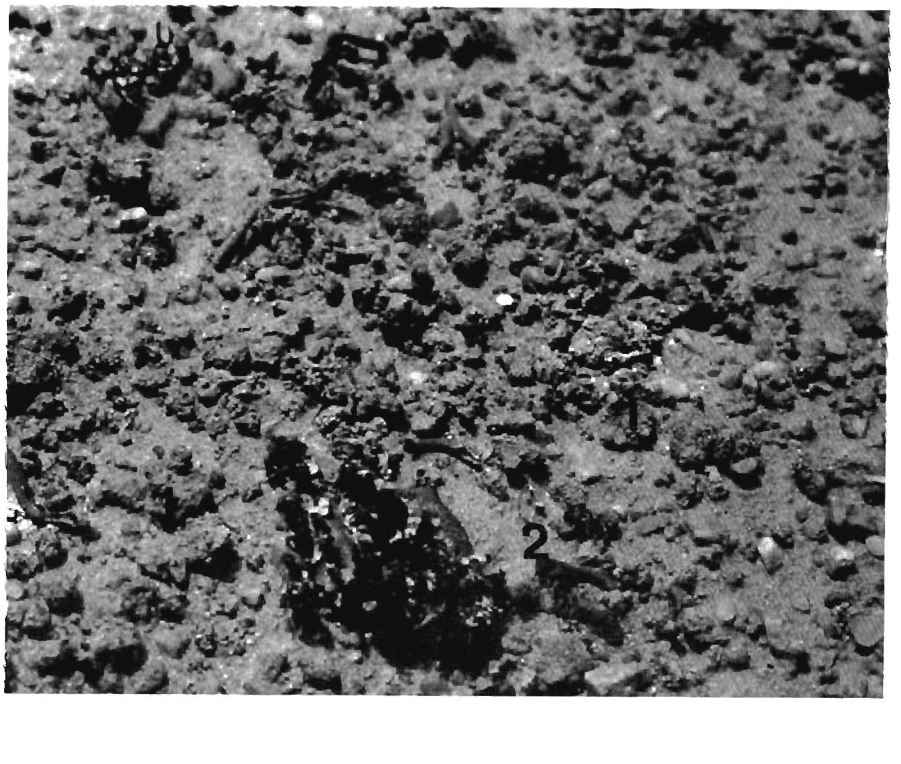

PLATE 1: Lichen cover and species composition of the lichen community on the plains east of Swakopmund.

1. Thalli of *Lecidella cristallina* and *Caloplaca volkii*

2. Thalli of *Xanthomaculina convoluta* in a dry state.

be the most suitable for the recognition of lichen communities. Two prominent lichen communities recognised by means of the ground reference data were investigated.

3. RESULTS AND DISCUSSION

The first lichen community is particularly well developed along the Khomas Hochland road where it is limited to the gypsum and mica rich coarse gravel hummocks east of Swakopmund. A variety of saxicolous species are found in the community. Crustose lichen species are abundant while fruticose growth forms (eg. *Teloschistes capensis* (L.f.) Vain, are sparsely distributed in the area. The general growth form of the majority of lichen species is extremely low and reach only a few millimeters above the substrate.

Lecidella cristallina Wirth & Vézda and *Caloplaca volkii* Wirth & Vézda show vigorous growth and form extensive lichen crusts in the area (Plate 1). The interesting and rare lichen *Xanthomaculina convoluta* (Hue) Hale (Plate 2) is well represented in this community. Individual thalli of this vagant, hygrochasic species can be blown about by wind. *Xanthomaculina convoluta* is thought to be ecologically important as a pioneer in the succession of desert lichen communities (Rogers, 1977). A number of saxicolous species belonging to the lichen genera *Buellia, Caloplaca, Acarospora* and *Lecidea* form part of this lichen community.

PLATE 2: Wet thalli of *Xanthomaculina convoluta* in an unrolled state. Photo B. Budel.

Phanerogams are scarce and scattered. Individuals of *Zygophyllum stapfii* Schz. and *Arthraerua leubnitziae* (O. Ktze) Schz. are the only shrubby inhabitants. These plants occur more frequently in dry watercourses than in the surrounding area (Giess, 1962).

In Figure 1 a portion of this community can be clearly distinguished on the Landsat image, covering large areas on both sides of the Swakopmund-Khomas Hochland road and the road leading to Goanikontes. The sand dunes south of the Swakop River are clearly visible. Even though the colour intensity is less intense than normally associated with actively growing plants, the lichen community can be clearly discerned from the surrounding habitat.

The second community finds its best development northeast of Cape Cross in a slightly undulating terrain dissected by sandy washes (Plate 3). In contrast to the first mentioned community this is a shrub-lichen community. Plate 4 shows the species composition, natural colour and degree of cover associated with this well preserved and colourful lichen community.

Fruticose species such as *Teloschistes capensis, Santessonia* spp. and different species of *Ramalina* are abundant in this community. Dense stands of *Xanthomaculina hottentotta* (Ach.) Hale are found on rocky out-

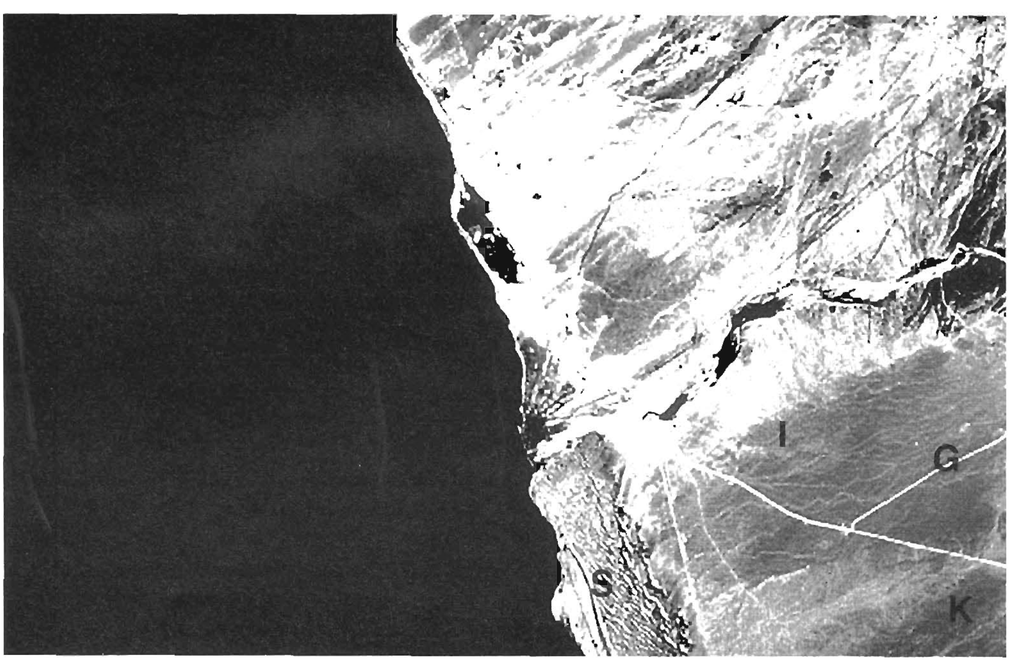

FIGURE 1: Landsat-3 Colour Composite of bands 4, 5 and 7. Image shows part of a nominal frame at scale of 1:250 000. Lichen community (L) covers areas on both sides of the Khomas Hochland-(K) and Goanikontes (G) roads. Sand dunes south of the Swakop River (S) are clearly visible. Image 19276, 29 September 1981 of WRS scene 192—76.

PLATE 3: View over part of the lichen covered plain north east of Cape Cross, showing the ground cover and terrain in which the lichen community is found.

PLATE 4: Species compoition, natural colour and degree of cover associated with the lichen community north-east of Cape Cross. 1. *Xanthomaculina hottentotta* 2. *Santessonia sorediata Teloschistes capensis*

crops along the northern periphery of the plain. *Xanthoparmelia walteri* Knox frequently occurs in dense patches on the plain. Thalli of *Xanthomaculina convoluta* are scattered throughout the community. Saxicolous species belonging to the genera *Buellia, Caloplaca* and *Lecidea* occur in the community.

Apart from an extensive lichen cover the plain is otherwise barren. The dry watercourses are mostly very shallow and carry a somewhat larger phanerogam population than the surrounding flats. A number of *Arthraerua leubnitziae* and *Zygophyllum stapfii* and *Welwitchia bainesii* (Welw.) Carr. plants occur in dry watercourses along the northern boundary of the plain.

The distribution of a portion of the lichen community can be seen in Figure 2. Part of Cape Cross Bay is visible in the southwestern corner of the image. Although the colour of lichen covered areas is less intense than that usually associated with phanerogams, lichen covered and barren areas are still clearly discernable from one another.

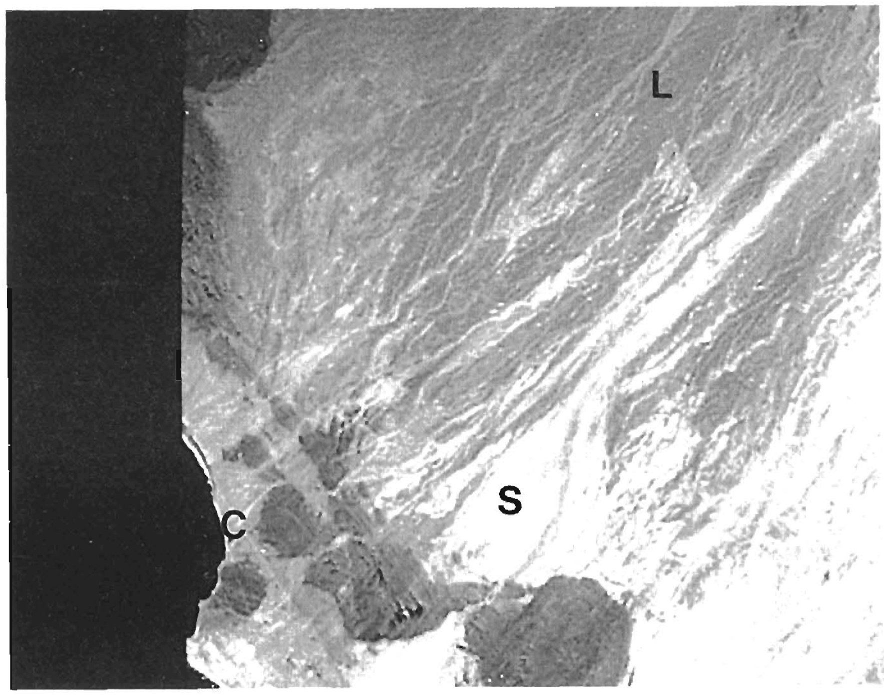

FIGURE 2: Landsat-3 Colour Composite of bands 4, 5 and 7. Image shows part of a nominal frame of scale of 1:250 000. Lichen covered (L) areas between sandy washes (S) can be clearly seen. A portion of Cape Cross Bay (C) can be recognized. Image 19375, 27 July 1981, of WRS scene 193—75.

4 CONCLUSIONS

From these preliminary results (Figures 1 & 2) it is apparent that satellite imagery offers the possibility of an additional aid for mapping the Namib Desert lichen vegetation. This technique might thus be utilized by lichen ecologists as a mapping aid (albeit limited in application) in other regions of the world. However, in the case of lichens it is envisaged that only fairly extensive, exposed lichen communities with moderately dense ground cover of 20—30% and above could be mapped by means of Landsat imagery.

This preliminary investigation has also shown that lichen communities representative of different growth forms can be recognised on satellite imagery.

Since the colour intensity of lichen communities was found to be less prominent than that associated with actively growing higher plants it appears possibly useful as a distinguishing characteristic. As colour differences between lichen covered and bare areas were found to be subtle under study conditions it is evident that extensive ground reference data must be available to aid in the recognition of lichen communities.

Lichen cover in the study area is shorter, less homogenous and sparser than that normally associated with phanerogams. As substrate reflectance characteristics tend to be important, the results obtained by numerical computer classification techniques may be influenced. It is therefore doubtful whether it will be possible to recognize and map lichen vegetation types beyond semi-detailed scales (scales according to Jarman *et al.,* 1981).

Landsat and other remotely sensed imagery might also be utilized in the broad-scale recognition of geological and other features that are ecologically important for the establishment and support of lichen growth. Because of the large extent, such features are often clearly visible in the synoptic view offered by Landsat images but are not as easily noticeable on large scale aerial photographs.

A case in point is the use of satellite images to relatively easily determine the distribution pattern and inland penetration of mist. As the lichens of the Namib Desert are primarily dependent on this recurrent phenomenon for their water supply, such information will be of cardinal value in a full understanding of the ecology of these complex organisms.

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