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Gross vegetation changes in the dune area between Richards Bay and the Mfolozi River, 1937–1974*

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ABSTRACT

Marked changes in dune vegetation as shown on air photos taken in 1937 and 1974 are described and quantified. About fifty-five per cent of the study area changed from one mapping unit to another. The changes are due mainly to secondary successions e.g. from grassland to *Acacia karroo* Woodland and *Acacia karroo* Woodland to Secondary Dune Forest. They result from protection by the Department of Forestry, which is also responsible for extensive afforestation. It is estimated that under the existing favourable climatic conditions it takes some dune grassland only 25–60 years to develop to mature *Acacia karroo* Woodland and a further 30 to 150 years to proceed to Secondary Dune Forest.

RÉSUMÉ

CHANGEMENTS MAJEURS SURVENUS DE 1937 *À* 1974 *DANS LA VÉGÉTATION DES DUNES COMPRISES ENTRE RICHARDS BAY ET L'EMBOUCHURE DE LA MFOLOZI*

L'on décrit quantitativement des changements marqués dans la végétation des dunes, tels que les révèlent des photographies aériennes prises en 1937 *et en* 1974. *D'une unité cartographique à l'autre, environ* 55% *de la superficie étudiée a changé. Les changements sont dus en ordre principal à des successions secondaires, p.ex. de prairie à forêt claire dominée par* Acacia karroo *et de cette dernière à forêt secondaire sur dune. Ces changements résultent de la protection exercée par le Département de Sylviculture, qui a également la responsabilité d'un reboisement extensif. On estime que dans les conditions climatiques favorables qui règnent actuellement certaines prairies de dunes n'ont besoin que de* 25 *à* 60 *ans pour se transformer en forêt claire mature à* Acacia karroo, *et de* 30 *à* 150 *ans ensuite pour évoluer vers la forêt secondaire sur dune.*

INTRODUCTION

Huntley (1977), in reviewing terrestrial ecology in South Africa, indicated that "While considerable progress has been made in mapping our country's vegetation, very little effort has been expended in monitoring the rates and kinds of change that are taking place within it, or the processes accounting for these changes." He emphasized the need for obtaining information on the trends of vegetation change and the rate at which these changes are taking place. Edwards (1972) reports Ward (1971) as having effectively used aerial photography to show qualitative changes and trends in coast-dune and estuarine ecology of the Isipingo Beach south of Durban. The availability of various sets of air photos from the year 1937 up to 1974 allowed the present authors to monitor quantitatively, for the first time in South Africa, the development of plant cover over an extensive area and over a period of nearly forty years. The use of the Zoom Transfer Scope facilitated vegetation mapping because of its ability to compensate for distortions and for differences in scale.

Air photos taken in 1937 and 1974 show great differences in the vegetation of the dune area between Richards Bay and the Mfolozi Mouth. The purpose of this work was to qualify and quantify these differences and establish possible causes. This would provide a better understanding of the vegetation as it is now, by disclosing its history and trends, and giving indications of the duration of some successional stages. This knowledge would permit prediction of future vegetation trends and therefore provide a firmer basis for environmental planning and management.

THE STUDY AREA

The study area covers about 8 300 ha and comprises a 60 km strip along the Natal coast between latitudes 28°24′ and 28°47′ South and longitudes 32°06′ and 32°26′ East (Fig. 1). These dunes vary from a few hundred metres to a few kilometres wide. They are partly covered with dense forest and thicket and have a pronounced relief (Fig. 2), the highest dune reaching 188 m. To the west of the dune ridges, the study area includes parts of the Msunduzi–Mfolozi Swamps and sometimes either the flattish or gently undulating sandy areas used by local Bantu for grazing or croplands. Soils are mainly sandy. The climate is humid and warm to hot with a high year-round rainfall, the mean annual rainfall at Cape St Lucia (Fig. 1) being 1 292 mm. In this climate, plant growth is luxuriant. The physiography and vegetation of the area are discussed by Venter (1972) and Weisser (1978a).

METHODS

The vegetation as shown in the air photos of 1937 and 1974 (respectively Job 117–37 of the Trigonometrical Survey and Job 184, University of Natal) was mapped at a scale of 1: 12 000 and areas were measured with a dot grid. For the Richards Bay Peninsual and the area south of Sokulu, which were not covered by the flight of 1974, photos of 1965 (Job 499, Trig. Survey) were employed. The mapping units (Table 1) were chosen in accordance with what could reliably be distinguished and deduced by air-photo interpretation and available field information. They were based on the criteria of the degree of human inetrference and the ecological conditions. Twenty-four mapping units were distinguished. A further subdivision was made, based on the presence or absence of a water table exerting a controlling influence on the vegetation. The group of mapping units not showing direct influence of the water table was arranged in a successional series, beginning with the beach sand with occasional pioneers and ending with the coastal dune forest (Mapping Units 1–8).

Mapping units representing vegetation with raised water table and/or occasionally inundated areas (Mapping Units 9–15) were subdivided according to whether the vegetation is mainly herbaceous (Mapping Units 9–11) or woody (Mapping Units 12–15). Mapping Units 16–24, except 22, are secondary and the direct result of human action.

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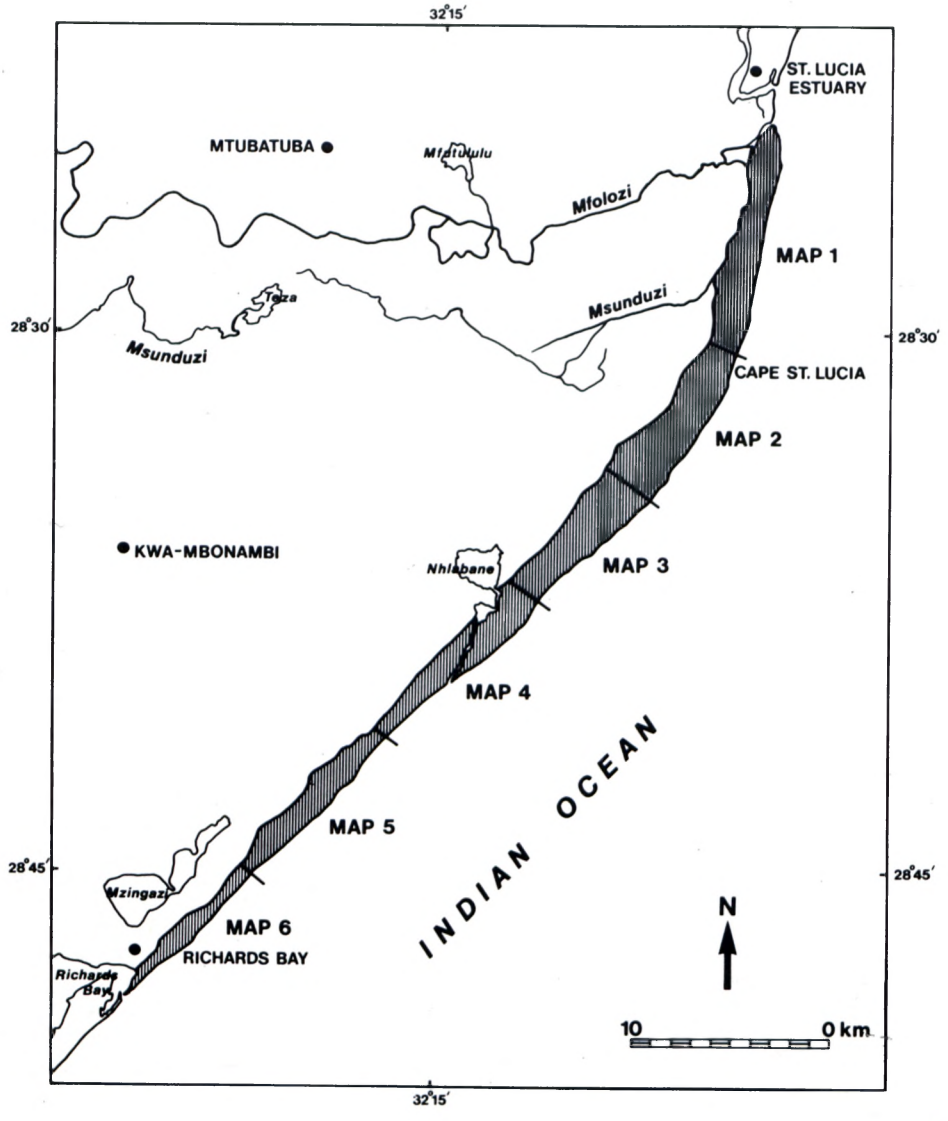

FIG. 1.—Location of the study area (hatched) showing the various map sections used.

FIG. 2.—The Secondary Grassland (Mapping Unit 17), drift sands (Mapping Unit 3) and Coastal Medium Forest (Mapping Unit 7) in the Mapelane area, where the dunes reach up to 188 m.

TABLE 1.—Comparative figures of the areas occupied by the different mapping units in 1937 and 1974. The "%" columns indicate the percentage area that the mapping unit occupies in relation to the total area

	MAPPING UNITS	AREA			
		1937		1974	
		Total ha	%	Total ha	%
1	Beach	326,85	3,96	448,20	5,38
2	Dawson's Rock	3,15	0,04	3,90	0,05
3	Sand	1 610,89	19,54	218,70	2,63
4	Dune Pioneers	3,30	0,04	8,30	0,10
5	*Passerina rigida* Low Scrub	39,90	0,48	18,75	0,23
6	Seaward, Coastal Thicket and Low Forest	272,10	3,30	282,35	3,39
7	Coastal Dune Medium Forest	1 618,52	19,63	1 352,26	16,25
8	Coastal Dune High Forest	116,40	1,41	361,05	4,34
9	*Cyperus papyrus* Swamp	78,60	0,95	59,85	0,72
10	*Phragmites-Typha* Reedswamp	108,15	1,31	127,20	1,53
11	Sedge Marsh	155,85	1,89	19,35	0,23
12	Mangrove Swamp	2,70	0,03	4,05	0,05
13	Swamp Forest	5,85	0,07	42,60	0,51
14	Swamp Forest—*Ficus sycomorus* Forest Complex	19,50	0,24	50,55	0,61
15	Hygrophilous Forest	40,80	0,49	35,25	0,42
16	Cultivation Areas and Secondary Grassland	492,04	5,97	256,70	3,08
17	Secondary Dune Grassland	2 829,49	34,32	399,30	4,80
18	*Acacia karroo* Woodland and Secondary Dune Scrub	428,00	5,19	1 603,45	19,26
19	Secondary Dune Forest	—	—	468,35	5,63
20	*Casuarina equisetifolia* Plantation	—	—	994,05	11,94
21	*Eucalyptus* and *Pinus* Plantation	—	—	1 376,10	16,53
22	Lakes, Ponds and Rivers	88,20	1,07	72,60	0,87
23	Human Dwellings, Camping Sites, Airfields, etc	3,75	0,05	58,05	0,70
24	Firebreaks and Sand Diggings	—	—	63,00	0,76

Qualitative changes in the plant cover were assessed in the field and by comparison of maps. Quantitative changes were measured by comparing the total areas occupied by the different mapping units. For air-photo interpretation and mapping, a TOPCON Stereoscope and a BAUSCH-LOMB ZOOM TRANSFER SCOPE were employed. The main methodological problems were the often unsatisfactory resolution of the air photos and the impossibility of making ground checks on the 1937 photo interpretation. Therefore the results obtained should be regarded as rough approximations.

Further information on the methods applied is given by Weisser (1978a). This work also contains a detailed description of the various mapping units.

RESULTS

1. *The vegetation in* 1937

Air photos of 1937 show highly degraded vegetation owing to activities of the local inhabitants (Figs 7 and 9). Extensive areas of Secondary Grasslands (about 34 per cent of the area), Secondary *Acacia karroo* Woodland and some bare patches are products of human action. Large areas of Dune Forest had been cleared mainly for grazing and shifting cultivation. The grasslands were probably maintained by a régime of regular burning (Weisser, 1978b).

The 1937 map shows a high degree of human interference in the Richards Bay–Cape St Lucia area, while the amount of cleared forest, secondary grasslands and fields diminish considerably northwards. It is reasonable to assume that this difference in degree of human impact is due to the steepness of the northern part of the dune barrier (up to 188 m) and the presence of the inhospitable Msunduzi Swamps that made this area less attractive for settlement (Fig. 1, area of Map 1).

The pattern of the 1937 vegetation map reveals that the local inhabitants usually tended to conserve the vegetation on the seaward dune slope, as most of the area shows a band of well-conserved vegetation on that side of the dunes. It is not clear how much of the drift sands present could be attributed to natural sand deposition by the sea and how much is secondary owing to human action. Wet environments such as *Cyperus papyrus* Swamp, *Phragmites–Typha* Reedswamp and Hygrophilous Forest are less interfered with than drier ones. This is probably related to their unsuitability for cultivation and grazing, their ability to resist fires and also to their more difficult accessibility.

Human settlement in this area probably dates back to the fourth century A.D. Proof of such old settlement was found at Enkwazini, about 45 km to the north by Hall & Vogel (1978). The map published as a supplement to the "Cape Argus" in 1879 (Commission of Inquiry, 1966) is one of the earliest documents of the study area. On this map the Mapelane Forest on the dunes south of Mfolozi Mouth is marked as "yellow wood forest" and it shows "open patches of grass" in its southern parts. This proves that forest clearing had already occurred a century ago.

Stephens (1939) describes the situation on the dunes north of Richards Bay in September 1938 thus: "The amount of cultivation going on in the dunes is very small. The grazing in the dune area is of poor quality, but large areas on the inner dunes are burnt off regularly for grazing, which, we were informed, takes place mainly in the summer months. A little burning was going on while we were there. Some signs of removal of bush for firewood were seen, but this factor does not seem to have been responsible for the destruction of bush on any appreciable scale".

FIG.3. — The Msunduz Swamps covered by *Cyperus papyrus* (Mapping Unit 9), with islands of Swamp Forest formed mainly by *Ficus trichopoda* and *Barringtonia racemosa* (Mapping Unit 13). Since 1937 there has been an increase of this forest type in the area (Photo: H. C. Taylor, July 1974).

FIG. 4.—*Acacia karroo* Woodland (Mapping Unit 18) on former grassland (1937). Pristine coastal dune vegetation in background (October 1975, road between Kwa-Mbonambi Mission Station and Nhlabane Lagoon).

FIG. 5.—Overmature *Acacia karroo* trees south of the Kwa-Mbonambi Mission Station. They will soon be replaced by the sub-canopy formed by dune forest species developing into Secondary Dune Forest (Mapping Unit 19).

FIG. 6.—Five of the mapping units as seen from the road to the mining site at Mapelane. Left foreground: Mapping Unit 17, i.e. Secondary Dune Grassland dominated by *Imperata cylindrica* and an isolated *Passerina rigida* shrub.
Middle: Secondary *Acacia karroo* Woodland (Mapping Unit 18). Left background: *Cyperus papyrus* Swamp (Mapping Unit 9) and Swamp Forest (Mapping Unit 13). Right background: Coastal Dune Medium Forest (Mapping Unit 7) with almost no human interference (September 1975).

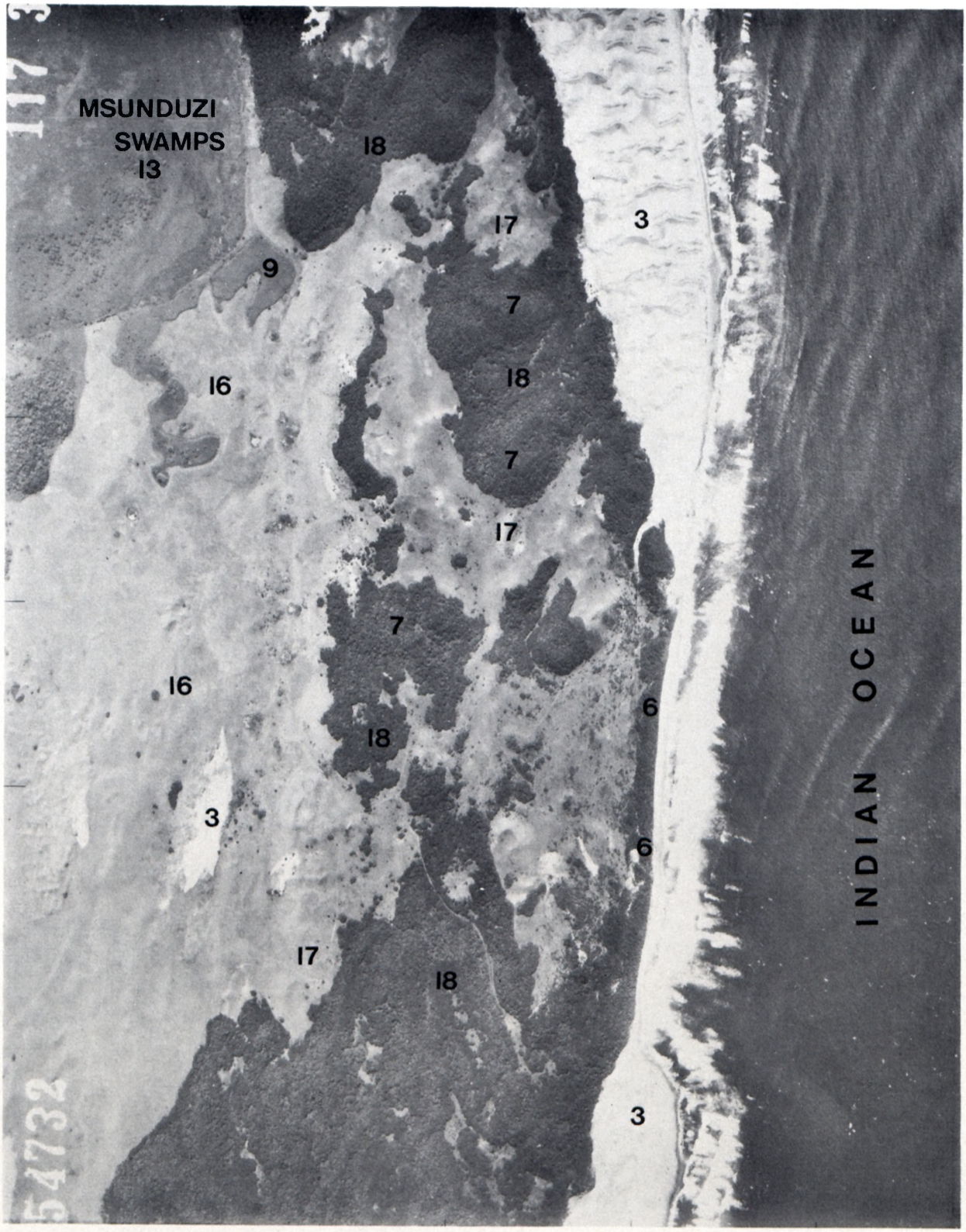

FIG. 7.—Air photo of 1937 showing the dune area south-east of the Msunduzi Swamps with extensive areas of Secondary Grassland (17), patches of Coastal Dune Medium Forest (7) and *Acacia karroo* Woodland (18). Compare with Fig. 8. Numbers refer to mapping units, see Table 1. (Air photo: Trig. Survey).

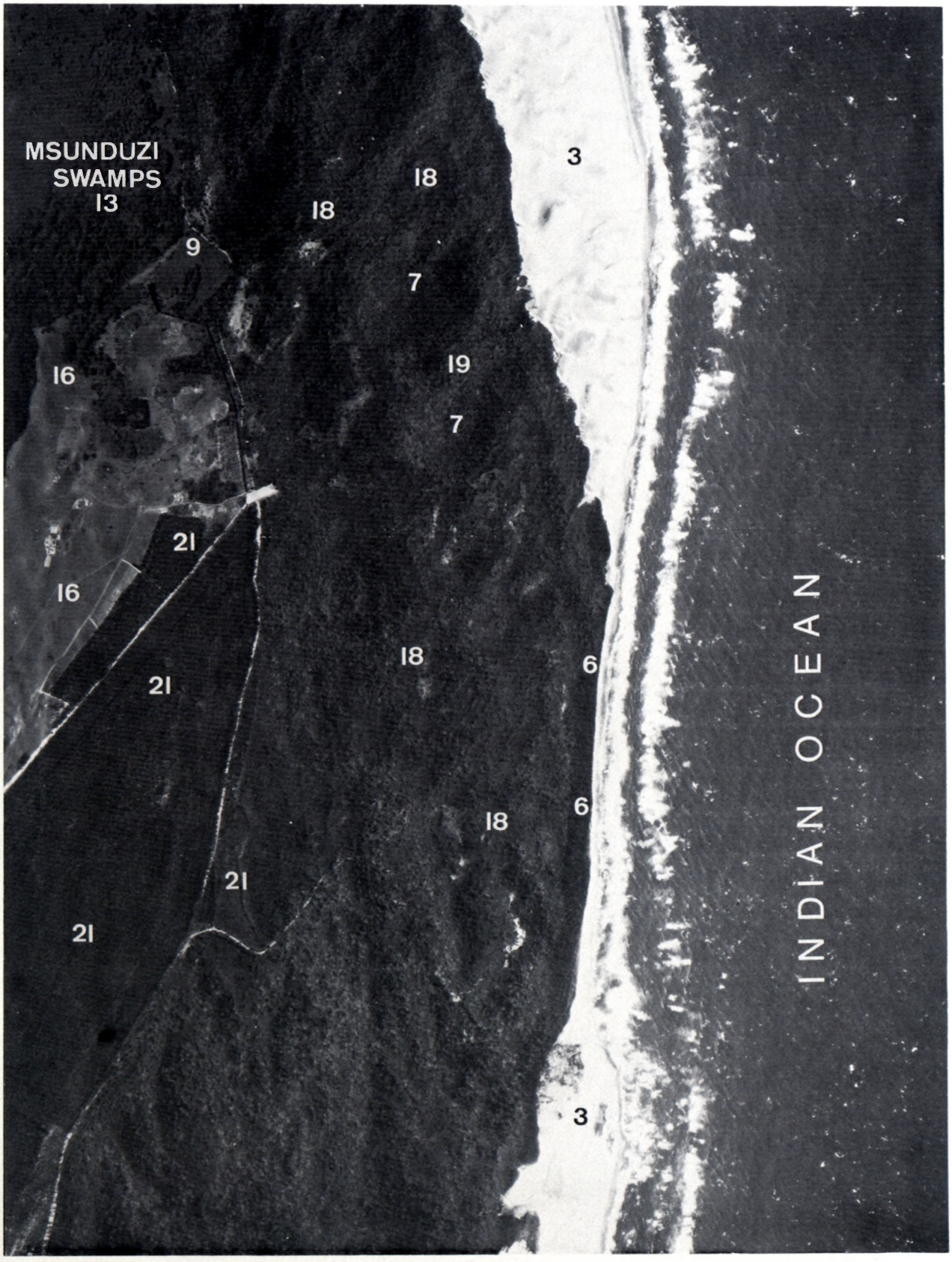

FIG. 8.—The same area as in Fig. 7 photographed in 1974. Note the replacement of most of the grasslands by *Acacia karroo* Woodland (18) and plantations of *Pinus* (21) and the increase of Swamp Forest (13) at the expense of *Cyperus papyrus* Swamp (9). (Air photo: Department of Land Surveying, University of Natal).

FIG. 9.—The Nhlabane Lake area photographed in 1937 showing cultivated fields and old lands in the midst of the Coastal Dune Medium Forest (7) and *Acacia karroo* Woodland (18) colonizing abandoned fields. Numbers refer to mapping units (Table 1). (Air photo: Trig. Survey).

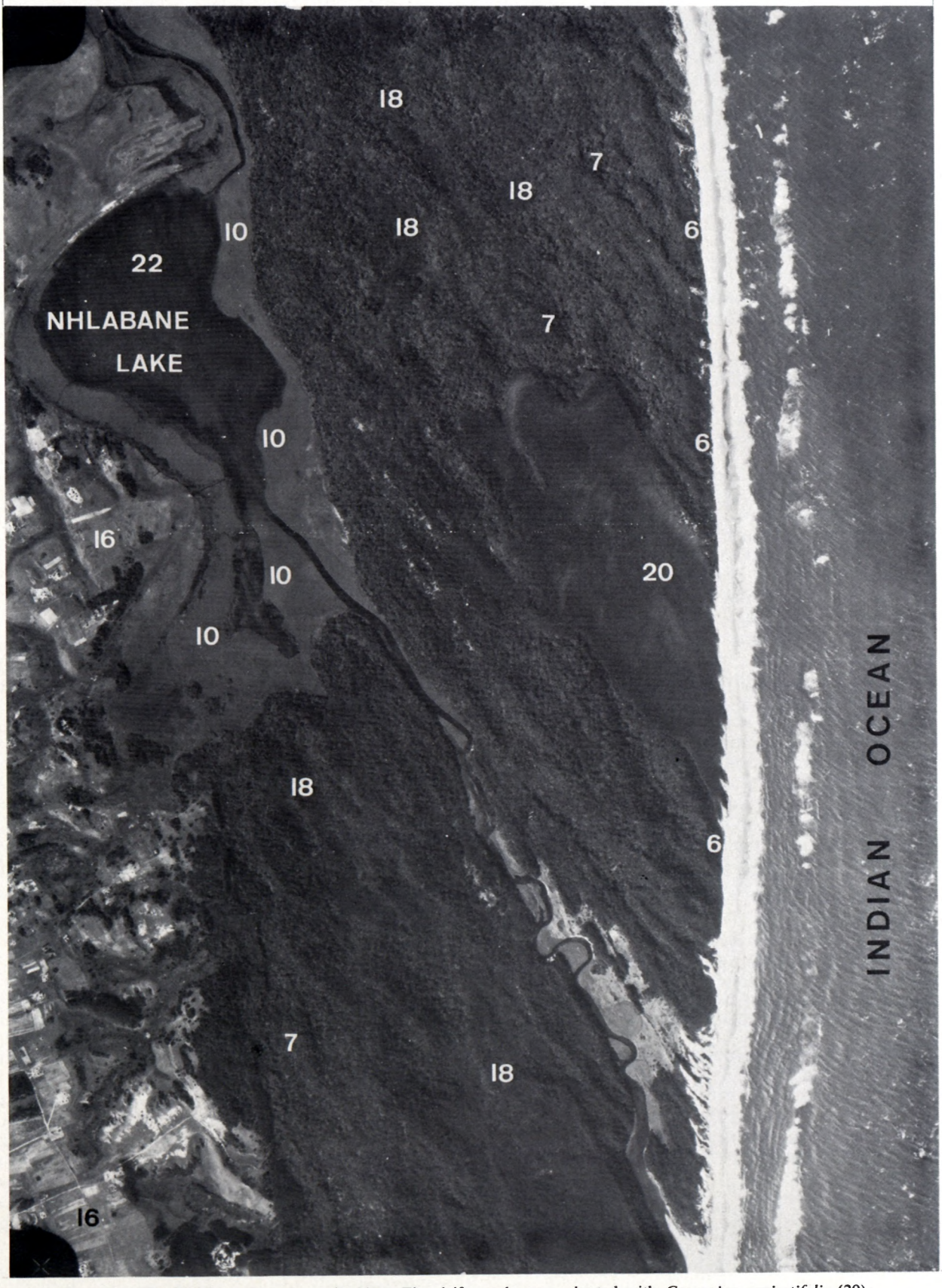

FIG. 10.—The Nhlabane Lake area in 1974. The drift sands were planted with *Casuarina equisetifolia* (20). *Acacia karroo* Woodland (18) has mainly occupied the old cultivated lands. A slight increase in area of the *Phragmites—Typha* Reedswamp (10), especially in the southern part of Nhlabane Lake, can be seen. Numbers refer to mapping units (Table 1). (Air photo: Department of Land Surveying, University of Natal).

2. *Qualitative and quantitative changes* 1937–1974

A comparison between the vegetation map of 1937 and that of 1974 reveals that roughly 55 per cent of the area has changed qualitatively to such an extent by 1974 as to fall under different mapping units.

Four new anthropogenic mapping units were found in 1974. These are (1) Secondary Dune Forest, and plantations of (2) *Casuarina equisetifolia*, (3) *Eucalyptus* spp. and *Pinus* spp., and (4) Firebreaks and Sand Diggings.

Table 1 compares the areas occupied in 1937 and 1974. Whereas there is no doubt about the major changes which have occurred, e.g. reduction of Secondary Grasslands and increase of *Acacia karroo* Woodland, the same cannot be said about the minor changes detected, e.g. reduction of area occupied by sedges and increase of beach area. These minor changes could have been brought about by seasonal conditions or differences in tide level respectively. In addition, difficulties in air-photo interpretation of old photographs and the impossibility of checking the 1937 situation in the field reduce the reliability of the quantitative results. Therefore only changes that seem to be relevant are discussed here.

The greatest change occurred in the Secondary Dune Grasslands (Fig. 2) that decreased from an area of 2 829 ha (34,3 per cent of the area) in 1937 to 399 ha (4,8 per cent of the area) in 1974 (Weisser, 1978b). What happened to the grasslands after 1937? An extensive area was planted with *Eucalyptus* spp. and *Pinus* spp. (Mapping Unit 21) by the Forestry Department (Fig. 8, areas marked with 21). While no afforestation was done before 1937, the surface covered with planted trees (excluding *Casuarina equisetifolia* plantations) reached 1 376 ha, about 17 per cent of the area in 1974. Moreover, owing to protection against fire and the departure of the local inhabitants woody elements increased extensively. The *Acacia karroo* Woodland and Secondary Dune Scrub (Mapping Unit 18) increased from 428 ha (5 per cent in 1937) to 1 603 ha (19 per cent) in 1974, mainly colonizing abandoned fields. Breen (1971) also found *Acacia karroo* colonizing abandoned fields in the Sibayi area.

Some areas that were covered with mature *Acacia karroo* Woodland in 1937 (Fig. 7) had been replaced by 1974 by Secondary Dune Forest (Mapping Unit 19). This change occurred in only 37 years and demonstrates how rapidly plant succession can take place under the existing favourable climatic conditions. In Fig. 8 such an area has been marked "19".

Another remarkable decrease in area occurred in the Sands (Mapping Unit 3), which occupied 1 611 ha (20 per cent) in 1937 and 219 ha (about 3 per cent) in 1974. Most of these drift sands have been planted with *Casuarina equisetifolia* (Mapping Unit 20) which, in 1974, covered 995 ha, about 12 per cent of the area.

Table 1 shows a reduction of the coastal Dune Medium Forest (Figs 2 and 6, Mapping Unit 7) from 1 619 ha (19,6%) to 1 352 ha (16,3%) and an increase in the Coastal Dune High Forest from 116 ha (1,4%) to 361 ha (4,34%). It is difficult to assess whether these inferred changes actually did occur, because the difference in resolution of the 1937 and 1974 air photos could have led to inconsistent interpretation, especially in this case.

In that part of the Msunduzi Swamp studied, the area covered by *Cyperus papyrus* (Mapping Unit 9, Fig. 3) decreased from 79 ha (0,95%) in 1937 to 60 ha (0,72%) in 1974. Most of the area lost has been taken over by Swamp Forest (Mapping Unit 13, Figs. 3, 7 and 8) and by Swamp Forest—*Ficus sycomorus* Forest Complex (Mapping Unit 14). This shows the natural succession towards a Swamp Forest (Fig. 6) in the Msunduzi Swamp. The increased area of Swamp Forest can be seen by comparing Figs 7 and 8 (top left corner).

The reduction of the area interpreted as Sedge Marsh (Mapping Unit 11) from 156 ha (1,9%) in 1937 to 19 ha (0,23%) in 1974 is noteworthy. Some parts seem to have been transformed into Grassland (Mapping Units 16 and 17) and then partly afforested during a dry climatic period. The decrease could also be related to seasonal changes (dry periods) that could lead to misinterpretations of the air photos. Some of the Sedge Marsh could also have been colonized by *Phragmites—Typha* Reedswamp (Mapping Unit 10), which increased from 108 ha (1,3%) in 1937 to 127 ha (1,5%) in 1974.

Mangroves (Mapping Unit 12) showed a slight increase from 2,7 ha (0,03%) to 4,0 ha (0,05%), which corresponds mainly to new areas colonized along the Mfolozi River.

Hygrophilous Forest (Mapping Unit 15) decreased slightly. This could be attributed to local clearing.

Cultivation Areas and Secondary Grasslands west of the dunes (Mapping Unit 16) diminished by 235 ha, being replaced mainly by afforested areas.

Lakes, Ponds and Rivers diminished slightly, which could indicate drier conditions in 1974. This would be consistent with the reduction observed in the Sedge Marsh.

The extent of human dwellings, camping sites and airfields (Mapping Unit 23) increased from 4 ha (0,05%) to 58 ha (0,7%). This increase corresponds to new facilities built by the Forestry Department and the Natal Parks Board.

Firebreaks and Sand Diggings (Mapping Unit 24) increased from 0 ha in 1937 to 63 ha (0,8%) in 1974 which reflects the activities of the Forestry Department and sand mining for heavy minerals.

CONCLUSIONS

There have been important qualitative and quantitative changes in the vegetation of the study area over the years 1937 to 1974. The greatest changes occurred in the Secondary Grasslands, which decreased from occupying about 34% of the area in 1937 to only about 5% in 1974. They were mainly replaced by *Acacia karroo* Woodland, Secondary Dune Scrub and plantations. This corroborates the opinion of Bayer (1938), who stated that "there is no doubt that could grass fires be prevented, the forests of eastern South Africa would be more extensive than they are". The reduction of the drift sands from about 20% to 2,6% of the area in 1974 is noteworthy. Most drift sands have been stabilized with *Casuarina equisetifolia* plantations.

This study shows that certain dune grasslands can develop into a mature *Acacia karroo* Woodland within 25 to 60 years. Field observations indicate that *Acacia karroo* Woodlands are replaced by tree species

from the Coastal Dune Medium Forest. *Acacia karroo* Woodland is therefore clearly a stage in the secondary succession leading from grassland to Secondary Dune Forest. The air-photos also reveal that areas that were mature *Acacia karroo* Woodland in 1937, have been replaced by Secondary Dune Forest in 1974. Field inspection of these areas show the presence of dead trunks or overmature trees of *Acacia karroo*. On the basis of these observations, it could be estimated that the succession can advance from *Acacia karxoo* Woodland to Secondary Dune Forest within 30–150 years. These estimates are only rough approximations, because local climatic, edaphic, topographic and biotic factors can speed up or slow down succession considerably. A case in point is the grassland along the road to the Mapelane mining site (Fig. 6), where the steep, northern exposed section is still covered by grasslands, while the less steep parts already support *Acacia karroo* Woodland. Our field observations confirm the observations of Henkel, Ballenden and Bayer (1936) that when *Isoglossa woodii* colonizes the field layer of the *Acacia karroo* Woodland, the succession towards Secondary Dune Forest is probably retarded.

This study illustrates the aggressiveness of the vegetation cover on the Zululand dunes, because major vegetational changes have occurred in only 37 years. The causes lie in changes in human impact brought about by the assumption of control of the area by the Department of Forestry from about 1949 interacting with the natural successional trends of the dune vegetation under the existing hot and humid climate. The local Bantu, with their cattle, clearing, cultivation and frequent veldburning practices were moved out of the area. The Department of Forestry also enforced fire protection and started drift-sand control and afforestation programmes.

These protective measures prevented the destruction of additional pristine Dune Forest. Succession could then operate, transforming grasslands into *Acacia karroo* Woodland and existing *Acacia karroo* Woodlands (mainly on abandoned fields) to Secondary Dune Forest.

From the management point of view, the rapid recovery of the vegetation towards a climax type of vegetation, when the burning, clearing, shifting cultivation and cattle-grazing is stopped, is noteworthy.

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UITTREKSEL

Merkwaardige veranderinge in die duineplantegroei, soos afgelei van lugfotos geneem in 1937 en 1974, is beskryf en die hoeveelhede bepaal. Ongeveer 55% van die studiegebied het van karteringseenheid verander. Die veranderinge is hoofsaaklik toe te skryf aan sekondêre suksessie soos bv. van Grasveld na Acacia karroo-*boomveld en van* Acacia karroo-*boomveld na Sekondêre Duinewoud. Dit is die gevolg van bewaringsmaatreëls wat ingestel is deur die Departement Bosbou wat ook verantwoordelik was vir uitgebreide plantasies. Daar word bereken dat, onder die huidige gunstige klimaatstoestande, sommige duingrasvelde binne 25-60 jaar tot volwasse* Acacia karroo-*boomveld sal ontwikkel en binne 'n verdere 30-150 jaar tot Sekondêre Duinewoud.*

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