A COMPARATIVE STUDY OF THE PLANT ECOLOGY OF THREE ESTUARIES: MGENI, MHLANGA AND MDLOTI

by

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ABSTRACT

The vegetation of the Mgeni Estuary, Mhlanga Estuary and Mdloti Estuary was analysed according to the Braun-Blanquet phytosociological method using quadrats of $4m^2$ and $25m^2$ in area placed subjectively and the Point-Centred Quarter method with points chosen whilst traversing. A classification of plant communities is given. These are described floristically and related to habitat variables. Indicator species of the climatic climax of coast forest occur within the study area.The absence of coast forest is ascribed to low altitude, tidal inundation and the consequent effect of salinity, basal inundation resulting in a high water-table and the influence of man. The floodplain of the Mgeni Estuary is dominated by mangrove vegetation comprising mainly *Bruguiera gymnorrhiza* and *Avicennia marina* whereas vegetation established on Athlone Island is dominated by mesophytic thicket comprising mainly *Schinus terebinthifolius*, *Lantana camara*, *Chromolaena odorata* and *Cardiospermum grandiflorum*. The floodplain of the Mhlanga Estuary is dominated by *Phragmites australis*. The shores of the Mdloti Estuary are dominated by *Barringtonia racemosa*, *Phragmites australis* and *Echinochloa pyramidalis*. Major differences in vegetation patterns of the three systems are related primarily to the differences in the open nature of the river mouths. This is controlled mainly by river flow and longshore drift. Differences in vegetation patterns within an estuary are dependent on differences in tolerances to salinity, basal inundation and shade, together with variations in altitude and edaphic factors and competition between species. Generally soils of Mgeni Estuary had higher contents of small sized fractions, bulk densities, reserve acidities, organic matter, salts and exchangeable bases and lower pH than soils at Mhlanga Estuary and Mdloti Estuary. Differences exist between mangrove and non-mangrove soils at Mgeni Estuary and differences between the non-mangrove soils at the three study sites. Major differences in soil characteristics are as a result of differences in tidal inundation, geogenetic parameters and biotic factors. Information on topography, hydrology, geology, climatic factors, biotic factors and historical background of the area is given. A check-list of vascular plants is included. The work is illustrated by 44 figures.

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CHAPTER 1

INTRODUCTION

Estuaries, the seaward termini of rivers, present an interesting subject of study. They form a heterogeneous boundary between the marine and terrestrial environments and, as such, are influenced by a complex interplay of both marine and land based factors. This leads to the development of influencing factors that are peculiar to estuarine ecosystems. They are one of the more important and also more sensitive parts of the environment as well as being one of the more productive (Hill *et. al.*,1971; Grindley,1973; Day,1977; Haines,1978; Baird and Winter,1979) .

Generally, South African estuaries are faced with the ubiquitous problem of siltation caused by high erosion rates in catchment areas (Du Toit, 1926; King,1942; Day,1951; Begg,1978; Brown and Jarman,1978; Alexander, 1979; Begg,1980; Day,1981a; 1981b) . Estuaries suffer the common fate of increased pressure due to urbanization and industrialization which affect their aesthetics as well as their functioning as biological entities (Clarke and Hannon,1967; Mallows *et.al.*,1970; Heydorn,1972; Grindley, 1974) . This is not surprising as estuaries form focal points of development. Their aesthetics attract both residential and recreational development while the fertile alluvial material in the floodplains attract agricultural development and the flat lands attract industrial development.

The term estuary, used in this report, is applied to the three systems and is based on the following definition: an estuary is a partially enclosed coastal body of water which is either permanently or periodically open to the sea and within which there is a measurable variation of salinity due to the mixture of seawater with freshwater derived from land drainage (Day,1981e) .

This research project attempts to explain differences in vegetation of the three estuaries, despite their close geographic proximity, on the basis of major environmental factors. This research project is offered as a contribution to the plant ecology of estuaries and the results are offered as an aid to management.

CHAPTER 2

PHYSIOGRAPHIC FACTORS

2.1 LOCALITIES

The three estuaries selected: Mgeni, Mhlanga and Mdloti are on the north coast of Natal. These three estuaries form isolated sites of study extending from 29°49'S to 29°38'S in latitude and from 31°08'E to 31°00'E in longitude (Fig.1) . The shoreline distance between the Mgeni and Mdloti estuaries is 23km. In total, the three study sites incorporate 204ha.

The Mgeni Estuary extends from 29°47'S to 29°49'S and from 31°00'E to 31°01'E (Fig.2) . The total area of the estuary is 104ha of which the Beachwood Mangroves Nature Reserve incorporates approximately 56ha.

The Mhlanga Estuary extends from 29°41'S to 29°43'S and from 31°05'E to 31°06'E (Fig.3) . The estuary incorporates an area of 48ha.

The Mdloti Estuary extends from 29°38'S to 29°39'S and from 31°06'E to 31°08'E (Fig.4) . The estuary incorporates an area of 52ha.

2.2 PLACE NAMES

Names of places and geographical features used in this report are those

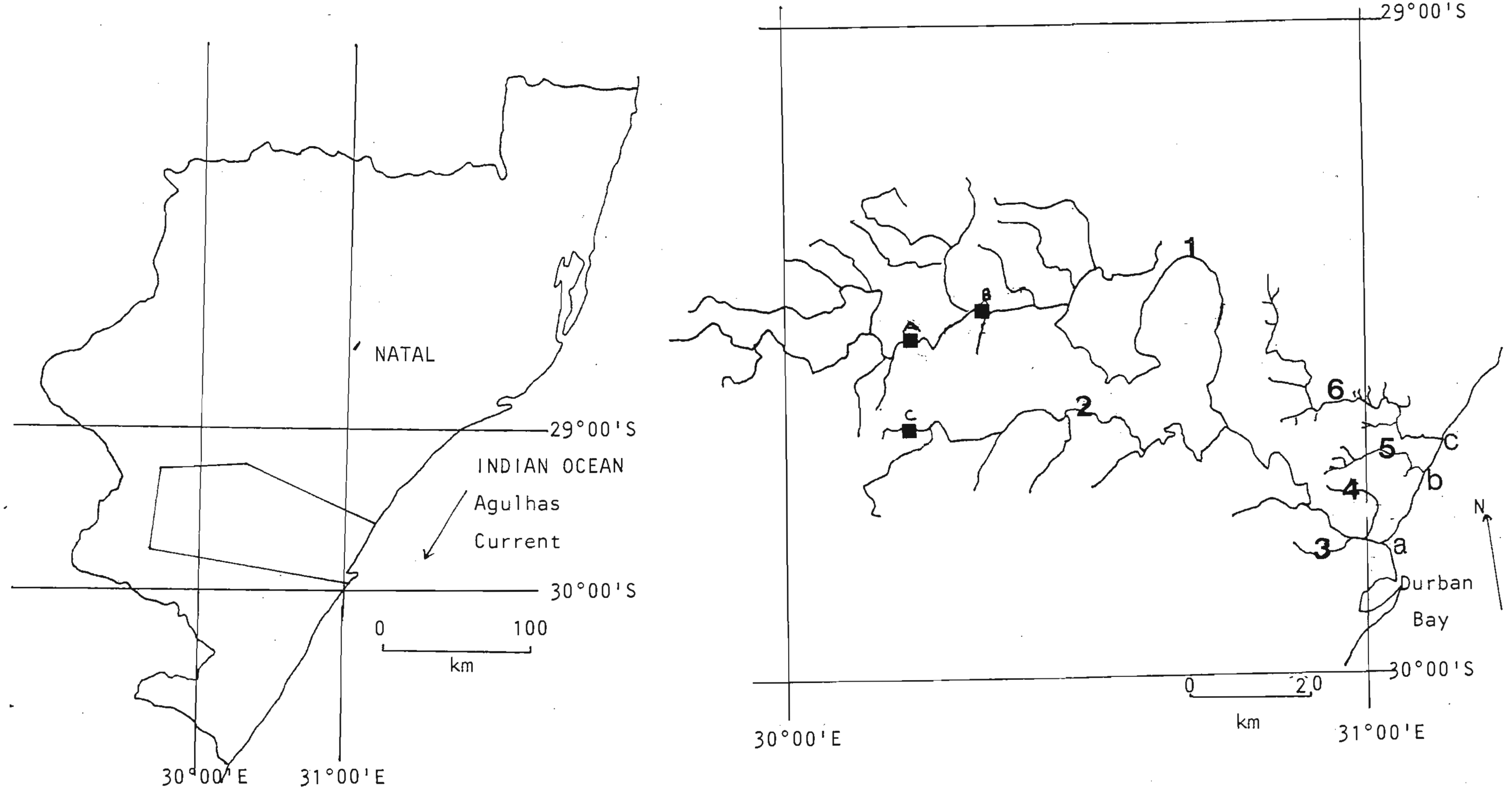


FIG. 1. Map showing locality of the study sites: Mgeni, Mhlanga and Mdloti and their catchment areas relative to their position in Natal (Redrawn from World Aeronautical Chart ICAO 1:1 000 000, Durban 3398). Details of study sites are shown in Figs. 2, 3 and 4. Key: a to c Estuaries; a Mgeni Estuary; b Mhlanga Estuary; c Mdloti Estuary; 1 to 6 Rivers; 1 Mgeni; 2 Msunduze; 3 Palmiet; 4 Mhlangana; 5 Mhlanga; 6 Mdloti; A to C Dams; A Midmar; B Albert Falls; C Henley.

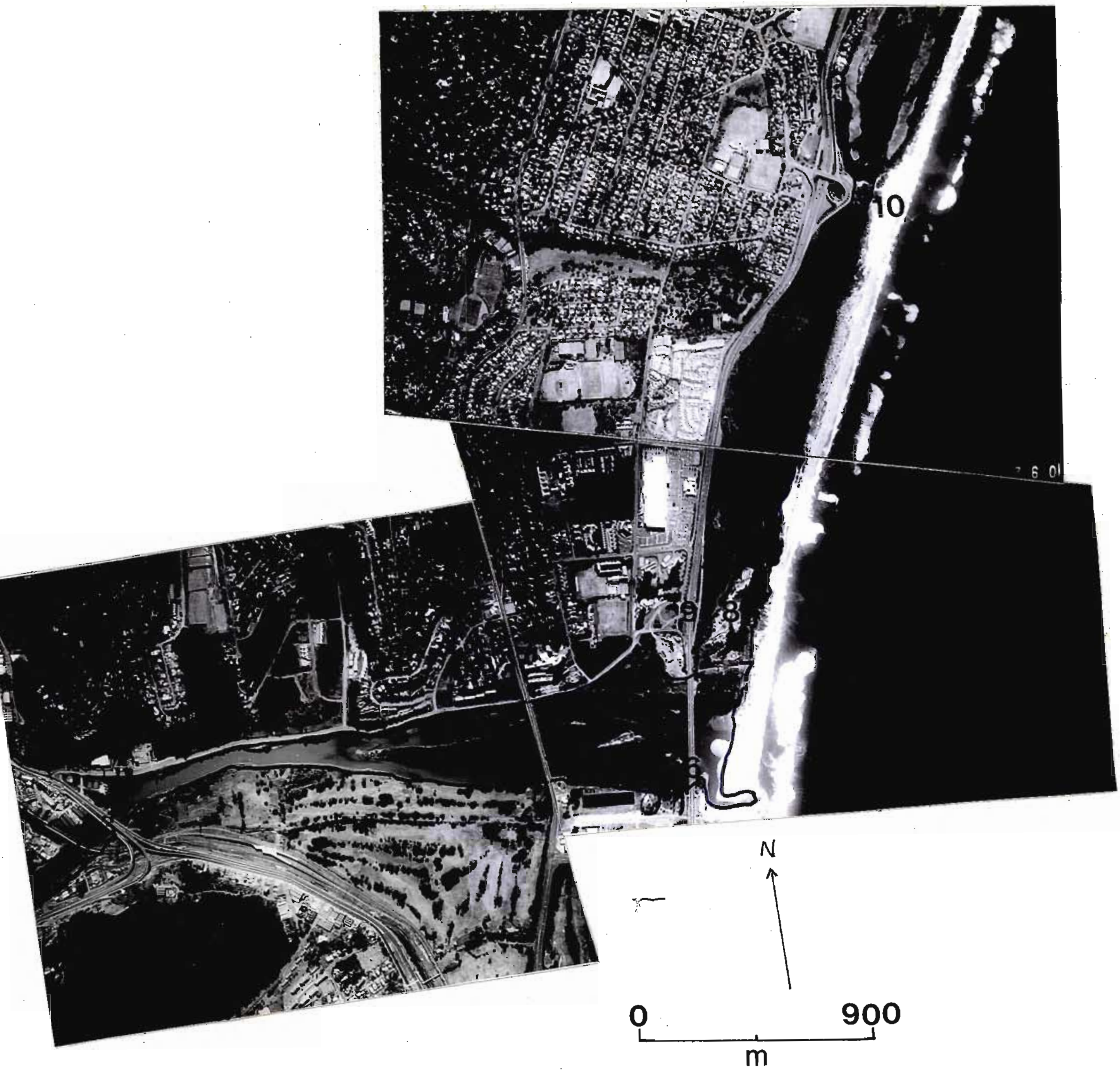
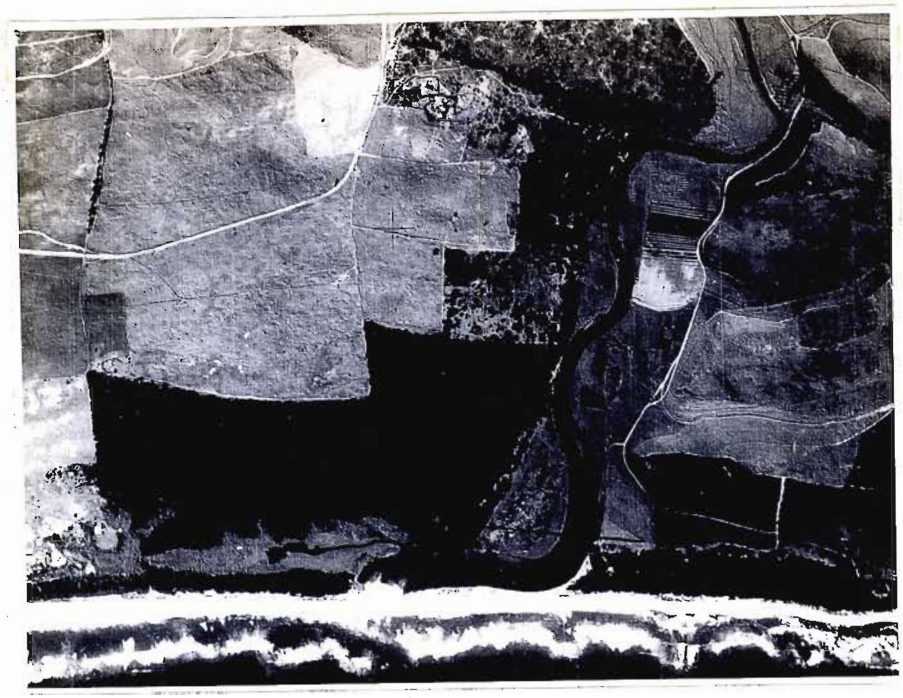


FIG. 2. The study site: Mgeni Estuary (1985). 1, Mgeni River 2, Mgeni Railway Bridge 3, New Connaught Bridge 4, Athlone Island 5, Athlone Bridge 6, Ellis Brown Viaduct 7, Beachwood Creek 8, Beachwood Mangroves Nature Reserve 9, Leo Boyd Highway 10, Rocket Hut Beach 11, Beachwood Golf Course. The extreme northern end of mangrove stands is nowadays within the Beachwood Golf Course and is above tidal influence.



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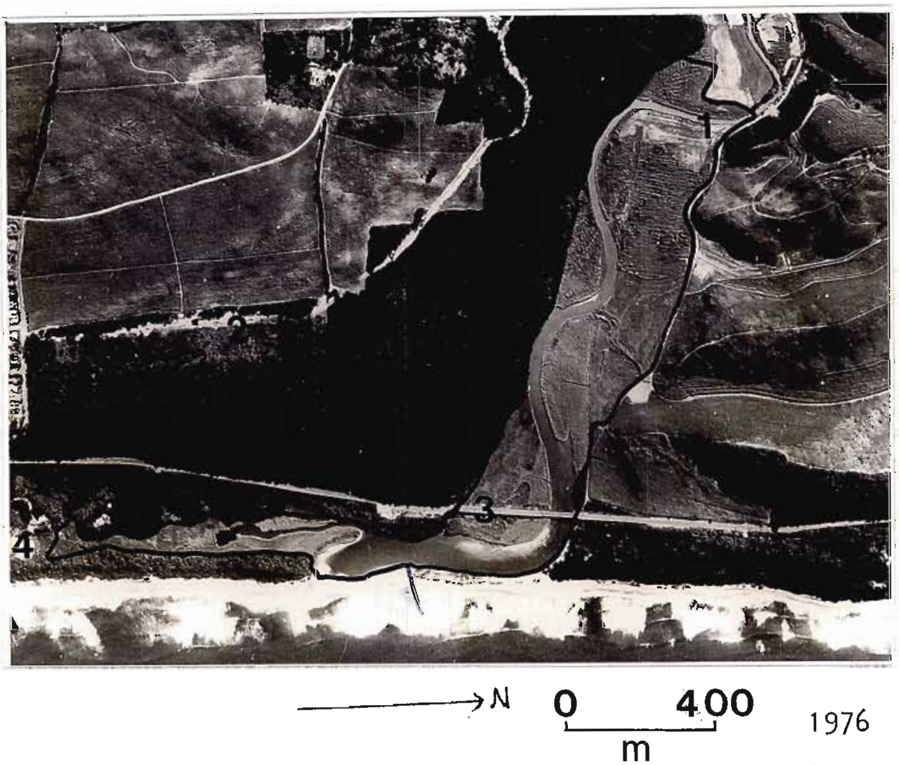

1976

FIG. 3. The study site: Mhlanga Estuary (1937 & 1976) 1, Mhlanga River 2, Hawaan Forest 3, North Coast Road 4, Borough of Umhlanga. Bridge construction and reduced sugar cane cultivation in the estuarine catchment have occurred.

FIG. 4. The study site: Mdloti Estuary (1937 & 1976) . 1, Mdloti River 2, National Road 3, Umdloti Beach 4, La Mercy 5, Picnic site. Changes in channel courses and increased establishment of hygrophilous vegetation on sandflats have occurred since 1937 and particularly since bridge construction in 1960.

used by the Trignometrical Survey Office. Two maps were used in particular:

i. 1960, 4th edition of South Africa: 1:50 000 Sheet 2930DD and 2931CC Durban.

ii. 1952 edition of South Africa: 1: 50 000 Sheet 2931CA Verulam.

Orthophoto maps of Mgeni Estuary at 1: 2 000 compiled in 1978 by the City Engineer's Department, Durban, were used. Also used were Orthophoto maps supplied by the Department of Community Development and State Auxiliary Services (Surveys and Mapping Branch) for Mhlanga Estuary and Mdloti Estuary at 1: 10 000 compiled in 1978.

Names have been supplemented by locally used names. In particular, names of estuaries are used according to Begg (1978) .

2.3 ACCESSIBILITY

The Mgeni Estuary is the most easily accessible of the three named systems. Roads are present on both banks, but down to the mouth on the south bank only where the road ends on a groyne. Entry to the Beachwood Mangroves Nature Reserve is possible by means of a restricted entrance gate at the southern end and a public entrance gate at the northern end at Rocket Hut Beach.

The Mhlanga Estuary is the least accessible of the three named systems. Vehicular access is possible through the Borough of Umhlanga in the south and by a private road owned by Tongaat-Hulett Group Ltd. in the north.

The Mdloti Estuary, on the south bank, is accessible through the town of Umdloti Beach. Roads are present on the north bank, both east and west of the national road. Easy access on the north bank to the beach and estuary is possible by means of a tarred road.

2.4 TOPOGRAPHY

Estuaries are regarded as temporary features of the environment (Day, 1981e) . Estuarine topography is influenced by a number of factors:

i. Geological changes in sea-level has influenced topography with regard to coastal plain inundation, the development of floodplains, the position and direction of river courses and the position of river mouths (Day,1981e) .

ii. Annual and seasonal floods result in erosion of banks, flushing of accumulated sediments, alteration of mouth positions, deposition of alluvial material on the floodplains and river beds or the formation of levees (Figs. 5 and 6) .

iii. Daily tidal action assists in the scouring of the river bed and, with river flow, assists in maintaining open mouth conditions.

iv. Climatic factors, especially the effect of wind on unstabilized soil, particularly dry sand, brings about topographical changes. A sufficient lowering of disturbed dunes on the sea-shore by wind, results in wave overwash. The build-up of sediments in water-courses influences tidal inundation.

v. Vegetation tempers the effect of erosion by wind and water (Ward, 1980) . Water movement is reduced and siltation increases (Tait, 1981) . Mangroves stabilize accumulating silt (Thom,1967) .

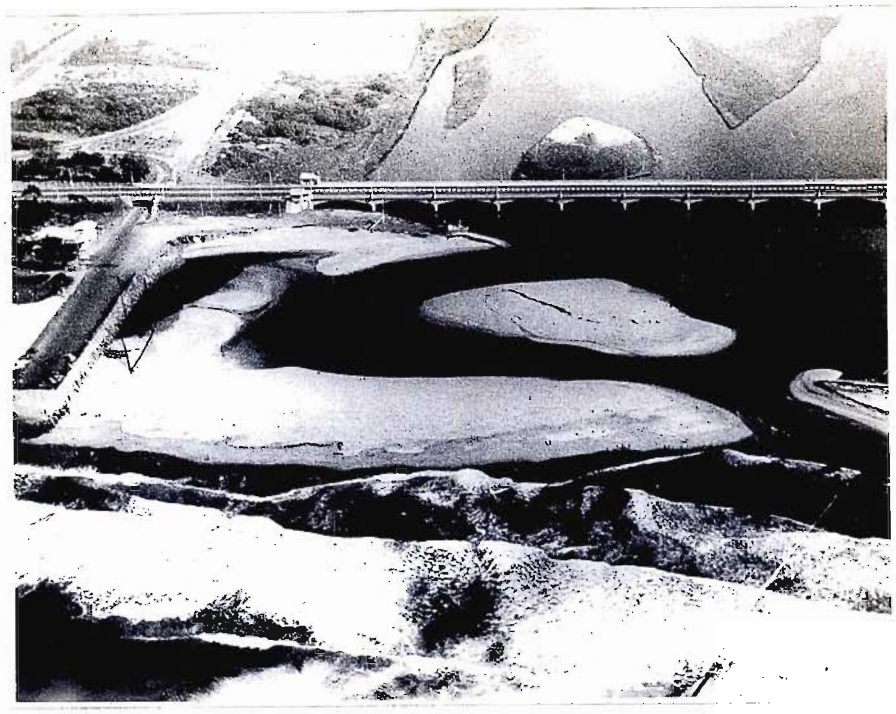

FIG. 5. Changed Mgeni mouth position caused by flooding. Deposition of alluvial and marine sediments has also occurred. (Photo: The Daily News, 28 July'59).

FIG. 6. Flooding brings about changes in topography as is indicated by the straight shoreline margin of Athlone Island on its southern (further) bank. Athlone Island covered by mainly hygrophilous vegetation. (Photo: The Daily News, 29 April'64).

vi. Ocean currents are responsible for the longshore transport of sediments influencing the closure of estuarine mouths (Day, 1951). The formation of these sandbars is promoted during periods of low river flow when tidal action alone is insufficient to keep the mouths open.

vii. Man has through his engineering works including bridge and road construction and canalization of rivers affected topography. These have had a secondary influence on siltation, flooding and tidal interchange.

2.4.1 Mgeni Estuary

The Mgeni Estuary extends from the railway bridge on the Mgeni River to the mouth over a distance of 2,5km. Fluctuations in water-level due to tidal action occur beyond this point but no salts were measured. The Beachwood Creek extends southward to its confluence with Mgeni River over a distance of approximately 3km. A centrally placed 14ha Athlone Island on the Mgeni River reaches a maximum altitude of 3m. It is approximately 1 200m long and 220m wide at its widest point. The total shoreline length of the estuary, as here delimited, is 15,3km and includes the island which has a perimeter of 2,5km.

Greater stabilization of intertidal sandbanks has been achieved because of bridge construction and the colonizing vegetation on the Mgeni River. Smaller islands have coalesced to form a single unit and old shorelines are marked by characteristic vegetation.

The maximum recorded depth on the Mgeni River at high tide was 260cm at the Ellis Brown Viaduct and the depth at the head of the estuary was 200cm for the same tide.

The southern bank is low and flat. In parts, especially adjacent to the Windsor Park Golf Course, the bank rises steeply to approximately 150cm above the low tide mark. The northern bank rises steeply to 5m.

The eastern boundary of the Beachwood Mangroves Nature Reserve is a series of stable and semi-stable sanddunes approximately 5m in height and rising in parts to a maximum of 9m. Greater stabilization of dunes have been attempted by the introduction of *Carpobrotus dimidiatus* and *Ipomoea pes-caprae* along the Beachwood shoreline. Earlier stabilization by means a bamboo fence was partially successful.

The western boundary of the Beachwood Mangroves Nature Reserve is the Leo-Boyd Highway at 10m altitude. The average altitude of the mangrove swamp is approximately 2m. Depressions occur to the west of the mangrove fringe. The floodplain is approximately 300m wide at its widest point.

The maximum recorded depth at the confluence of the Beachwood Creek and Mgeni River at high tide was 145cm. The maximum recorded depth on the Beachwood Creek at low tide was 40cm approximately 1 600m from the mouth.

The mouth of the estuary seldom closes and has been stabilized by the building of a groyne. This interferes with longshore drift and prevents mouth closure.

Sedimentation within the estuary is indicated by the following bedrock figures:

i. Mgeni Railway Bridge: -52m (Krige,1932)

ii. Connaught Bridge: -45m (King,1972)

iii. Athlone Bridge: -51m (King,1942)

iv. Ellis Brown Viaduct: -11m at its north end and -22m at its south end (King,1972).

Accelerated sedimentation, recently, has been due to the reclamation of the Springfield Flats, the canalization of the Mgeni and Mhlangana rivers and bridge construction at the head of the estuary. Siltation figures are detailed in Begg (1978). Briefly, values at the Connaught Bridge varied from a minimum 14ppm to a maximum of 1 632ppm with a mean monthly suspended figure of 165ppm.

2.6.2 Mhlanga Estuary

The Mhlanga Estuary extends from just north of the Borough of Umhlanga to the northern bank over a distance of 1,4km. The westward extension of the estuary, in a straight line, is approximately 1,3km while the shoreline distance is approximately 2,0km. The banks above this point were not considered as they are occupied by sugar cane. The total shoreline length of the estuary is approximately 6,4km.

The eastern boundary of the estuary is formed by a line of stable and semi-stable sanddunes interrupted by two possible mouth positions. The southerly mouth position opens more regularly, across a rocky sill, than the northerly mouth position which usually opens across a sandbar during flooding. The dunes are between 5m and 25m in altitude.

The western and south-western boundaries are occupied by the Hawaan Forest on a slope rising to 55m in altitude. On the north bank, east of the roadbridge, a forested dune rises to approximately 26m. The steeply sloped south-facing bank of this dune is undercut and has slumped (Fig.7) . The floodplain is below 5m in altitude and is approximately 300m wide.

Siltation, within the estuary, in recent times has been due to the construction of the N2 Outer Ring Road approximately 1km above the head of the estuary. Siltation due to agriculture has been minimal and has been ascribed to modern farming methods (Begg,1978) .

Observations indicate that the maximum depth of 180cm occurs during closed mouth conditions at mid-channel. During open mouth conditions a a maximum depth of 50cm at low tide was recorded. Depth is primarily dependent on the height of the sandbar, river flow and the period of mouth closure.

2.4.3 Mdloti Estuary

The Mdloti Estuary extends from just north of the town of Umdloti Beach for a distance of 650m to the north bank. The westward extension of the estuary, in a straight line, is approximately 1,5km although water floods beyond this point during closed mouth conditions. The river banks are occupied by sugar cane.The total shoreline length of the estuary is 7,4km and includes an island, west of the roadbridge, which has an area

FIG. 7. Mhlanga Estuary. Undercutting of south facing slope on the north bank of the estuary. Flooding causes open mouth conditions exposing sandflats. Prolonged exposure leads to death of *Potamogeton pectinatus* present between reed debris.

of 3,5ha and a perimeter of 1,4km.

The eastern boundary comprises a line of semi-stable sanddunes extending for 300m, and rising to 5m. The southern boundary, east of the roadbridge, comprises a forested dune rising from approximately 5m to 70m in altitude. The floodplain is approximately 500m wide and rises to 5m at the head of the estuary and the south-western bank. The island is 600m long and 150m wide at its widest point. It rises to approximately 3m in altitude.

Siltation is considered to be a serious problem in the catchment. A maximum sediment concentration of 230 ppm at Oakford Priory (approximately 20km west of the estuary) has been recorded (Wylie,1968) . Other figures are detailed in Begg (1978) . Briefly, the annual silt load has been estimated to be 0,15% of the mean annual run-off of 51 920m^3 $year^{-1}$. The highest sediment concentration was 0,87% when the river flow was 0,82m^3 sec^{-1}.

Observations indicate a maximum depth of 240cm in the north channel and a maximum depth of 220cm in the south channel during closed mouth conditions. At low tide, following mouth opening, the maximum depth recorded was 140cm approximately 650m from the mouth. Depth is influenced by similar factors as those for Mhlanga Estuary as well as siltation.

2.5 DRAINAGE

Geology, topography, catchment area, rainfall, flow rate, tidal inundation, catchment utilization and vegetation affect drainage.

Lengths of rivers, catchment areas and rainfall affect flow rates. The Mgeni River has the greatest length and largest catchment area of the three named systems and consequently the highest flow rates. Run-off which affects flow rates depends upon catchment utilization and vegetation. Poor agricultural practices result in increased siltation. Dam construction results in reduced flow. Vegetation helps to diminish run-off and also decreases erosion (Morisawa,1968) .

The occurrence of floods are primarily due to surface run-off (Wisler and Brater,1959) and have the effect of scouring river bottoms, depositing alluvial material and changing drainage patterns by altering paths followed by channels and mouth positions. These are indicated by removal of sediments during breaching of the sandbar at the Mdloti Estuary during non-flood conditions, a changed mouth position during flooding at Mgeni and Mhlanga estuaries and the deposition of alluvial material at Mgeni Estuary as indicated by Fig. 6.

Tidal inundation results in an input of clear, saline waters. This is of importance to salt tolerant species as it reduces competition between salt tolerant and salt intolerant species.

Vegetation within an estuary affects local drainage patterns. The presence of reeds, together with a closed mouth condition, as at Mhlanga and Mdloti estuaries reduces water flow and promotes the settling out of silt particles. In deep areas the lack of water movement results in the deposition of fine organic matter and anaerobic conditions in the overlying water (Simpson *et.al.*,1972) . At Mgeni Estuary the magnitude of tidal inundation is reduced landward of water-courses by intervening mangrove vegetation.

2.5.1 Mgeni Estuary

The Mgeni River rises in the vleis and marshes of the Impendle area and is approximately 230km long. The total catchment area is approximately 4 000km^2.

Rainfall in the catchment area is seasonal and between 750mm and 1 200mm per annum (Town and Regional Planning Commission,Natal,1973) . The mean annual rainfall at Impendle is 1 028,3mm (Turner,1983,pers.comm.) . The high average seasonal rainfall and the ground water reserves at the source enables the Mgeni to be a perennially flowing river.

The mean annual run-off is 707 x 10^{6}m^3 (Midgley and Pitman,1969) . Approximately three quarters of the mean annual run-off for the total Mgeni catchment occurs in the Midmar Dam and Albert Falls Dam catchments (Town and Regional Planning Commission,Natal,1973) .

Flow rates vary geographically and seasonally. These variations are reported in Begg (1978) . In summary, the mean summer flow is 18,4m^3

sec^{-1} and the mean winter flow is 6,5m³ sec^{-1}. The highest recorded flow was 532m³ sec^{-1} and the lowest flow was 4,5m³ sec^{-1}. Severe flooding for the previous century has been recorded (Mann,1859; Brown, 1875; 1877) . These have resulted in washing away sandbars and causing changed mouth positions.

The effects and occurrences of floods have been tempered by dam construction and this has resulted in a reduced freshwater influence at the mouth. The dams are:

i. Henley Dam (1942) ; present capacity unknown
ii. Nagle Dam (1950) ; 20,8 x 10^6m³ capacity
iii. Midmar Dam (1963) ; 172 x 10^6m³ capacity
iv. Albert Falls Dam (1975) ; 261 x 10^6m³ capacity (Begg,1978)
v. Inanda Dam presently under construction (1986) .

The freshwater sources of the Mgeni Estuary are the Mgeni River and the Beachwood Creek. The former makes a greater contribution while the latter arises locally, just outside the estuary. Beachwood Creek is supplied with water from the Beachwood Golf Course and from three large stormwater drains. Effluent finds its way into the estuary from the Sea Cow Lake Sewage Works and by drains from the industries located just beyond the railway bridge.

Diurnal tidal variations are responsible for the inflow of saline waters. Tidal variation on the Mgeni River is depicted in Table 1 and Fig.8. Variation in the Beachwood Creek at low tide is indicated in Table 2. Level fluctuations and salinity profiles at the confluence of the

TABLE 1. Physical measurements at Mgeni Estuary (Mgeni River) at high tide (24 Aug.'85) taken over over a one hour period. First measurement taken at Station 1 at expected high tide. Final readings at Station 9 taken over a 15 minute period indicated no changes in salinity. Station positions are indicated in Fig. 19. Distances indicated are actual distances and not straight-line distances. Key: D Depth; S Secchi Disc; T Temperature; Sa Salinity.

Mouth-	STATION																																			
Station	1				2				3				4				5				6				7				8				9			
Distance	280m				430m				750m				1040m				1410m				1770m				2220m				2670m				2840m			
Depth	D	S	T	Sa	D	S	T	Sa	D	S	T	Sa	D	S	T	Sa	D	S	T	Sa	D	S	T	Sa	D	S	T	Sa	D	S	T	Sa	D	S	T	Sa
cm	cm	cm	°C	‰	cm	cm	°C	‰	cm	cm	°C	‰	cm	cm	°C	‰	cm	cm	°C	‰	cm	cm	°C	‰	cm	cm	°C	‰	cm	cm	°C	‰	cm	cm	°C	‰
20			18,5	28,0			17,0	31,5			18,0	31,0			18,5	30,5			18,5	31,8			17,0	10,0			18,5	6,8			17,0	5,5			17,0	3,0
40			18,5	29,0			17,0	32,0			18,5	33,0			18,5	32,5			18,5	32,0		40	17,0	14,5			18,5	7,0			17,0	7,5			17,0	3.0
60			18,5	30,5			17,0	32,0	60	60	18,5	33,0			18,5	31,5			18,5	32,0	60		17,0	26,4		60	18,5	7,8		60	17,0	9,2		60	17,0	3,0
80			18,5	30,5			18,5	32,5							18,5	32,0		80	18,5	32,0							18,5	14,0			17,0	10,6			17,0	3,0
100			18,5	30,5			18,5	32,5					100	100	18,5	32,0	100		18,5	32,0							18,5	19,5			17,0	12,0			17,0	5,0
120			18,5	30,5			18,5	32,5																			18,5	28,5			17,0	24,0			17,0	5,0
140	140	140	18,5	30,5			18,5	32,5																			18,5	24,0			17,0	24,5			17,0	5,0
160						160	18,5	32,5																	160		18,5	24,0			17,0	24,5			17,0	5,0
180							18,5	32,5																							17,0	24,5			17,0	5,0
200							18,5	32,5																							17,0	24,5	200		17,0	5,0
220							18,0	33,0																							17,0	24,5				
240							18,0	33,0																							17,0	24,5				
260					260		18,0	33,0																					260		17,0	24,5				

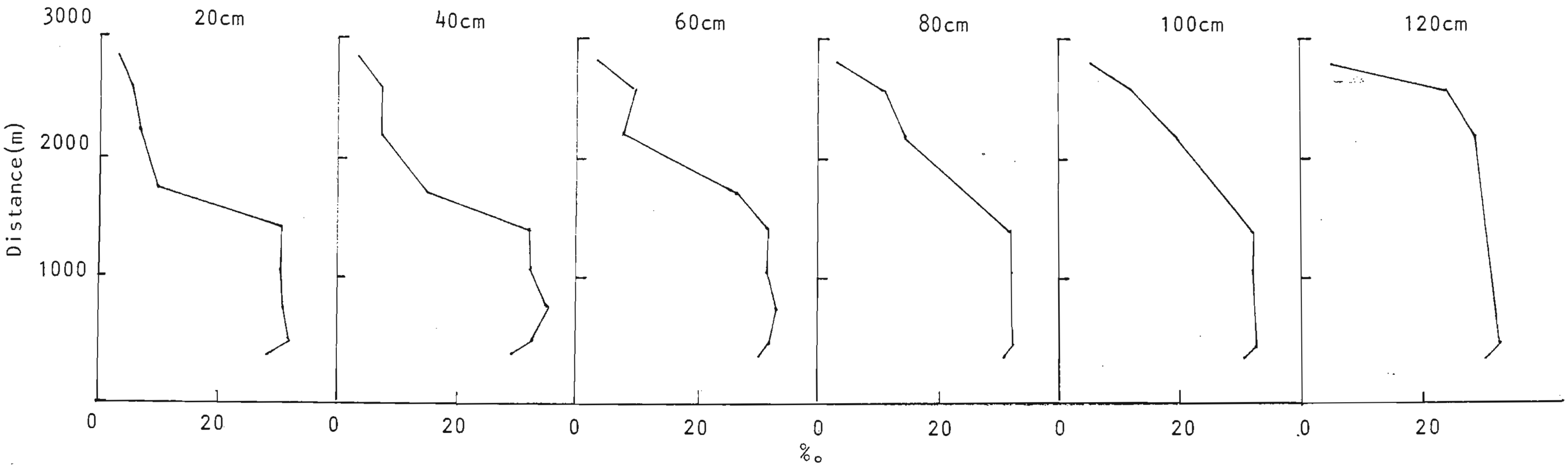

FIG. 8. Graphical representation of part of Table 1 indicating salinity profiles at different depths at different distances from the mouth. Decrease in salinity occurred approximately 1 400m from the mouth. The tide penetrates upstream as a salt wedge. Measurements made on 24 Aug.'85 over a one hour period starting at Station 1 at expected high tide (09h21) .

TABLE 2. Physical measurements at Mgeni Estuary (Beachwood Creek) at low tide (20 July'82) taken over a one hour period. First measurement taken at Station 1 at expected low tide (09h28) . Station positions are indicated in Fig. 19. Distances indicated are actual distances. Key: D Depth; S Secchi Disc; T Temperature; Sa Salinity.

	STATION																															
Mouth-Station	1				2				3				4				5				6				7				8			
Distance	420m				890m				1200m				1400m				1620m				1780m				1820m				2100m			
Depth	D	S	T	Sa	D	S	T	Sa	D	S	T	Sa	D	S	T	Sa	D	S	T	Sa	D	S	T	Sa	D	S	T	Sa	D	S	T	Sa
cm	cm	cm	°C	‰	cm	cm	°C	‰	cm	cm	°C	‰	cm	cm	°C	‰	cm	cm	°C	‰	cm	cm	°C	‰	cm	cm	°C	‰	cm	cm	°C	‰
10	10	10	18,0	22,0			18,0	19,0			17,2	15,0	10	10	19,2	9,0			20,0	6,0	10	10	20,5	4,5			19,4	4,0			20,0	1,0
20							18,0	19,0			17,2	15,0					20	20	20,0	6,0					20	20	19,4	4,0			20,0	1,0
30					30	30	18,9	22,0	30	30	17,2	21,0																	30	30	20,0	1,0

Beachwood Creek and Mgeni River for a spring tide, an equinoctial spring tide and a neap tide are presented in Figs. 9, 10 and 11. The maximum depth recorded for an equinoctial spring tide was 2,8cm at 40m along Transect 1 (Bench Mark 1). Levels recorded on 31 Oct. 1986 show that a tidal range of 137cm for that day occurred in the Mgeni Estuary. Salinity changes approximate depth changes and a salinity of 13‰ was recorded at low tide.

Bridges are considered to interfere with tidal inundation and currents within the estuary. Bridges found on the estuary include:

i. Ellis Brown Viaduct: 200m from the mouth
ii. Athlone Bridge: 1 400m from the mouth replaces an older bridge at the site (Stayt,1971)
iii. New Connaught Bridge: 2 500m from the mouth replaces the Connaught Bridge (1906) and the older Queen's Bridge (1860) (Brown,1875)
iv. Mgeni Railway Bridge: 2 700m from the mouth replaces an older bridge washed away in 1917 (Lugg,1970)
v. Footbridge across the Beachwood Creek replaces older bridges at the same position. In 1972, tidal range at the bridge was reduced from 110cm to 20cm (Moll,1972).

Mouth closure occurs occasionally during periods of low flow. The mouth closed in September 1983. This resulted in the backing up of water so as to inundate the lower estuarine section and the southern extent of the Beachwood Mangroves Nature Reserve (Fig. 12). Extended periods of basal inundation were prevented by artificially breaching the sandbar until

FIG. 9. Salinity and depth profiles at the point of entry of Beachwood Creek into the Mgeni River (9 May'86). A tidal range of 80cm was experienced. Salinity remains moderately high at low tide; changes approximate depth changes. Salinity readings at 20cm depth.

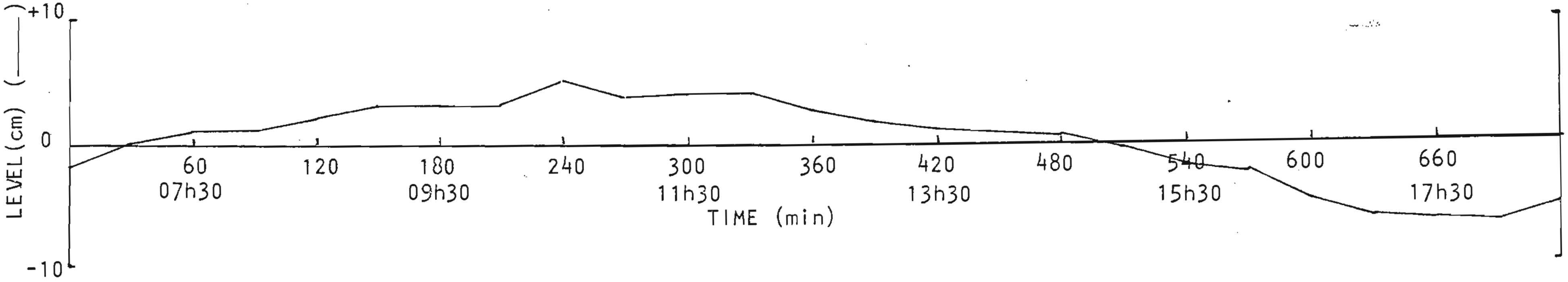

FIG.10. Depth profile at the confluence of Beachwood Creek and Mgeni River for a neap tide (27 Sept. '86). Tidal range of 13cm measured (13cm forecast). A +30minute lag from expected high tide and a -45 minute lag from expected low tide was experienced. The period between high and low tides was 6,5 hours. Basal inundation of only shoreline mangrove fringe and pneumatophores occurred. Salinity readings were taken at 20cm depth.

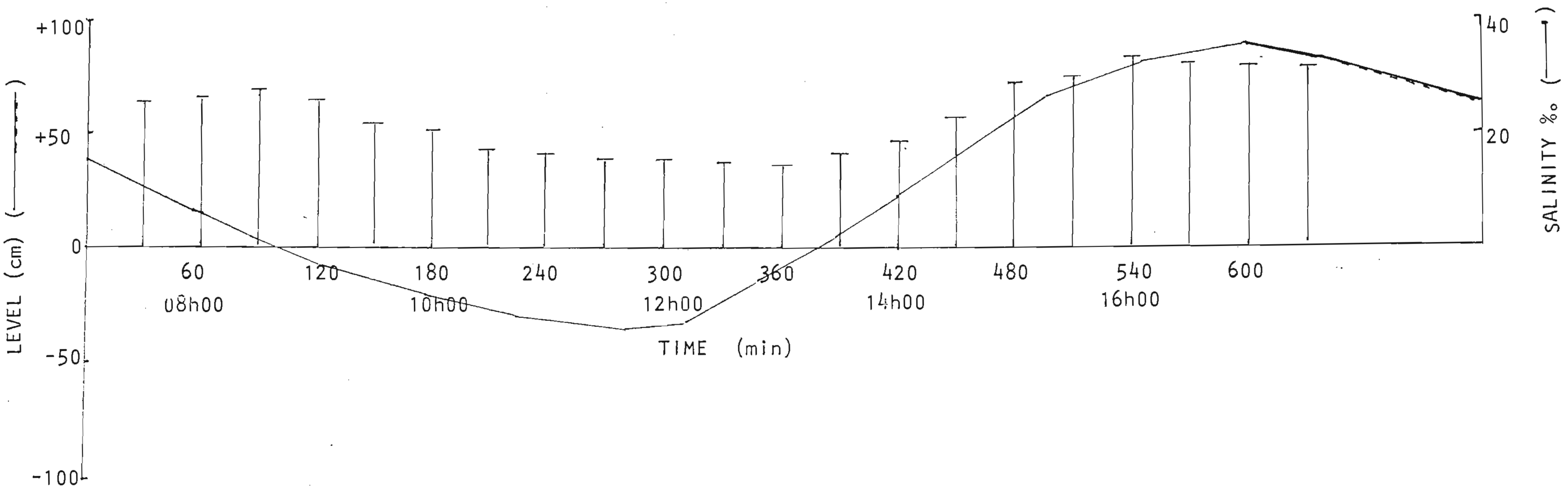

FIG. 11. Salinity profile and tidal variation during an equinoctial spring tide at the confluence of Beachwood Creek and Mgeni River (4 Oct.'86). Tidal range of 120cm was measured (213cm for ocean forecast). A lag of +60 minutes from expected low tide was experienced. The period between low and high tide was approximately 5 hours. Salinity variation was 17‰. Salinity readings were taken at 20cm depth.

FIG.12.Basal inundation of the southern sector of the Mgeni Estuary occurs during closed mouth conditions(1983).

river flow was strong enough to maintain an open mouth condition.

2.5.2 Mhlanga Estuary

The source of the Mhlanga River is in the vicinity of eKuphameni (west of Phoenix). It is approximately 28km in length. The catchment area is approximately $120km^2$.

Average rainfall in the catchment is approximately 1 000mm per annum (Whitfield,1980a). The mean annual run-off is $19,7 \times 10^6 m^3$ to $29,5 \times 10^6 m^3$ (Begg,1978). There are no dams on the river and the entire run-off has a chance of flowing into the estuary. Flow rates are estimated to range from $0,02m^3\ sec^{-1}$ to $1,75m^3\ sec^{-1}$ with an average flow of $0,28m^3\ sec^{-1}$ being reported for 1964 (Brand *et.al.*,1967). The river flows perennially.

The Mhlanga River is the major freshwater source together with run-off from localised drains and local seepage.

Tidal influence occurs during open mouth conditions and is measurable to 2,2km (Begg,1978). Mouth opening occurs in times of flooding and artificial breaching. Wave overwash occurs more frequently at the southerly mouth position than at the northerly mouth position. This influences the local salinity of the impounded waters. The period of open mouth condition is determined by river flow and longshore drift. Salinity stratifications occur following the opening of the mouth: surface salinities of 7‰ and bottom salinities of 32‰ have been

TABLE 3.Physical Measurements at Mhlanga Estuary during closed mouth conditions(6 July '82). Station sites are indicated in Fig.19.

Key: D Depth; S Secchi Disc; T Temperature; Sa Salinity; south refers to the channel extending southward from the mouth.

Mouth-													STATION																
Station	1				2				3				4				5				6				7			
Distance	570m south				210m				550m				760m				1270m				1680m				2030m			
Depth	D	S	T	Sa	D	S	T	Sa	D	S	T	Sa	D	S	T	Sa	D	S	T	Sa	D	S	T	Sa	D	S	T	Sa
cm	cm	cm	°C	‰	cm	cm	°C	‰	cm	cm	°C	‰	cm	cm	°C	‰	cm	cm	°C	‰	cm	cm	°C	‰	cm	cm	°C	‰
20			16,2	1,0			16,0	0,9			15,0	1,0			15,0	0,9			14,5	0,6			14,1	0,5		20	13,9	0,4
60			15,5	1,0			15,0	0,9			14,9	1,0			14,9	0,9			14,5	0,7		60	14,0	0,6			14,0	0,4
100		100	15,5	1,0		100	15,0	0,9		100	14,8	1,0		100	14,8	0,9		100	14,5	0,7			14,0	0,8			14,0	0,4
140	140		15,1	1,0			15,0	0,9	140		14,8	1,0			14,8	0,9			14,5	0,7			14,0	0,8			14,0	0,4
180					180		15,0	0,9					180		14,8	0,9	180		14,5	0,7	180		14,0	0,8	180		14,0	0,4

recorded (Day,1981c) .

River flow is insufficient to keep the mouth open, at either position, for a considerable length of time. During November 1982 the mouth opened at its northerly position for a three day period. Table 3 indicates physical measurements made during closed mouth conditions. Salinities were consistently less than 1‰ and no stratification was evident. Greater variations occurred with temperature and depth than with salinity and depth.

2.5.3 Mdloti Estuary

The source of the Mdloti River is in the vicinity of Ndwedwe. It is approximately 100km long. The catchment area is approximately $400km^2$.

The average rainfall in the estuarine area is approximately 1 028mm per annum (Midgley and Pitman,1969) . The mean annual run-off is given as $97 \times 10^6 m^3$ and $134 \times 10^6 m^3$ (Begg,1978) . A part of this run-off finds its way into the Hazelmere Dam, 20km upstream having a capacity of $24 \times 10^6 m^3$.

The average flow rates are given as $2m^3 \ sec^{-1}$ to $2,5m^3 \ sec^{-1}$ (Begg,1978). These figures represent three-quarters of the total flow due to the position of the gauging station. The lowest recorded rate was $0,34m^3 \ sec^{-1}$ (1951/ 1952) while a maximum flow rate of $5m^3 \ sec^{-1}$ (1964) (Begg,1978).

The major freshwater source is the Mdloti River. Within the estuary, a major stream enters the formerly north main channel. This north channel

FIG. 13. Mdloti Estuary. Alteration of channel courses resulting from bridge construction. The former main north channel is linked to the south channel by means of a drain. *Barringtonia racemosa*, in parts, line shorelines. (Photo: The Daily News, 26 June '62).

drains into the main south channel by means of a drain at the road bridge (Fig.13) . Minor channels drain the sugar cane fields to the north of the estuary.

Tidal influence is only possible during open mouth conditions except for the localised influence of waves washing over the bar. Mouth opening occurs during floods or by artificial breaching. The natural point of exit is on the south bank against a rocky sill but the river also breaks across the sandbar.. Physical measurements at low tide and for a closed mouth condition are depicted in Tables 4 and 5.

River flow alone is insufficient to keep the mouth open. During 1982, the mouth was open in February for a four day period, in March for a five day period and in November for a five day period. Salinity stratification was evident; surface salinities were 1,5‰ whereas sub-surface salinities were 21,5‰ and was indicative of a salt wedge. At the mouth, surface salinities at the outer edges (5‰) were lower than those of the central channel (14‰) . During closed mouth conditions water salinities were reduced to less than 1‰ and salinity stratification and temperature gradients with depth were absent.

2.6 GEOLOGY

The estuaries of Natal are believed to be due to submergence with later emergence (King,1942; Day,1951) .

Sedimentation within the estuaries has been due to riverine deposition

TABLE 4. Physical measurements at Mdloti Estuary during low tide (21 March '82). Station sites are indicated in Fig. 19. Key: D Depth; S Secchi Disc; T Temperature; Sa Salinity; north and south refer to the channels.

Mouth-	STATION																							
Station	1				2				3				4				5				6			
Distance	30m				400m				650m				850m north				1230m north				790m south			
Depth	D	S	T	Sa	D	S	T	Sa	D	S	T	Sa	D	S	T	Sa	D	S	T	Sa	D	S	T	Sa
cm	cm	cm	°C	‰	cm	cm	°C	‰	cm	cm	°C	‰	cm	cm	°C	‰	cm	cm	°C	‰	cm	cm	°C	‰
20			24,5	13,5			26,0	16,0			22,5	3,0		20	23,0	7,2		20	23,5	0,4		20	25,0	0,2
40	40	40	24,5	17,0	40	40	26,0	16,0		40	22,0	4,5	40		23,0	27,0	40		23,5	0,4			25,0	0,2
60											22,0	16,0											25,0	0,0
80											22,8	23,8									80		25,0	0,0
100											23,0	26,2												
120											23,0	28,5												
140									140		23,0	28.0												

TABLE 5.Physical Measurements at Mdloti Estuary during closed mouth conditions(23 July'82). Station sites are indicated in Fig. 19. Key: D Depth; S Secchi Disc; T Temperature; Sa Salinity.

Mouth-													STATION															
Station	1				2				3				4				5				6				7			
Distance	30m				400m				650m				870m north				1230m north				790m south				1320m south			
Depth	D	S	T	Sa	D	S	T	Sa	D	S	T	Sa	D	S	T	Sa	D	S	T	Sa	D	S	T	Sa	D	S	T	Sa
cm	cm	cm	°C	‰	cm	cm	°C	‰	cm	cm	°C	‰	cm	cm	°C	‰	cm	cm	°C	‰	cm	cm	°C	‰	cm	cm	°C	‰
20			14,8	0,1			14,8	0,1			14,8	0,0			14,8	0,0			14,8	0,1			15,1	0,0			15,1	0,0
60			14,8	0,1			14,8	0,1			14,8	0,0			14,8	0,0			14,8	0,1			15,1	0,0			15,1	0,0
100		100	14,8	0,1		100	14,8	0,1		100	14,8	0,0		100	14,8	0,0		100	14,8	0,1		100	15,1	0,0		100	15,1	0,0
140	140		14,8	0,1			14,8	0,1			14,8	0,0			14,8	0,0			14,8	0,1			15,1	0,0			15,1	0,0
180					180		14,8	0,1			14,8	0,0			14,8	0,0			14,8	0,1	180		15,1	0,0			15,1	0,0
220									220		14,8	0,0	220		14,8	0,0	240		14,8	0,1					220		15,1	0,0

and to longshore drift (Moll,1976). These sediments comprise mainly alluvium, grey aeolian and coastal dune sands (Maud,1980). Longshore drift at river mouths, when interfered with by rocky outcrops on the south bank, results in the formation of south-pointing bars (Macnae, 1963). Without the protection of rocks on the south bank river mouths rapidly close.

Begg (1978) illustrates cross sections of sediment patterns for Mgeni and Mdloti estuaries. Generally, these comprise surface and sub-surface fines with intermediate sand and a shale bedrock with dolerite intrusions for Mgeni Estuary and surface fine sand and sub-surface mud with a sandstone bedrock for Mdloti Estuary.

The Mgeni River traverses a variety of rocks of different geological characteristics including dolerite intrusions, granites, shale, sandstones, dwyka tillite and alluvium (Du Toit,1926; Krige,1932; King, 1972; Moll,1980). The recent sands and muds in the estuary are largely derived from rocks in the catchment area or are as a result of marine, aeolian and fluvial deposition.

The Mhlanga River traverses Natal Series Sandstone, Dwyka Conglomerate and Ecca shales (Chew and Bowen,1971). The Mhlanga Rocks are composed of sandstones belonging to the Middle Ecca Beds of the Karroo system (Eyre and Stephenson,1938). Recent tertiary sediments surround the estuary (King and Belderson,1961).

The Mdloti River traverses Archaen Granites, Natal Series Sandstone, Dwyka Conglomerates, Ecca shales and recent deposits (Brand *et.al.*, 1967) .

CHAPTER 3

CLIMATE

The climate of the area according to Köppen's classification is humid temperate (warm) with summer rainfall, mean temperature of the warmest months being 22°C (Category Cfwa) while that of Thornthwaite's classification is sub-humid warm with sufficient moisture in all seasons (Category CB'r) (Schulze,1947; Moll,1976). The climate of the Natal North Coast is sub-tropical and has been described as hot in summer, warm in winter with fairly high and constant humidity and a rainfall of 980,0mm to 1 102,5mm per annum (Pistorius,1962).

Climatic data are taken from the unpublished records made at the Meteorological Office at Louis Botha Airport, the Meteorological Station at the Botanic Gardens (Durban), Stamford Hill (Durban) and the Meteorological Station at the South African Sugar Association (SASA) Experimental Station (Mount Edgecombe). The Louis Botha Airport is 21km south of the Mgeni Estuary, the Botanic Gardens is 6km south-west of the Mgeni Estuary and Stamford Hill is 3km south of the Mgeni Estuary. Mount Edgecombe is 5km west of Mhlanga Estuary and 8km south-west of Mdloti Estuary.

The data are supplemented from information in the researched literature.

3.1 INSOLATION

Summers are cloudier than winters; the mean number of hours of sunshine per month from September to March is less than 50% of the theoretical maximum whereas from April to August it is above 60% for Louis Botha Airport, Stamford Hill and Mount Edgecombe (Table 6; Fig.14). A maximum average of 72% is recorded for July and a minimum of 38% is recorded for November at Louis Botha Airport. The average number of hours of sunshine per month is highest at Mount Edgecombe. The number of fine to partly cloudy days in winter (127) is higher than that of summer (93).

A part of the incoming solar radiation is in the form of diffuse radiation and mid-summer radiation is higher than mid-winter radiation (Preston-Whyte,1980). The radiation is intercepted by cloud, mist and pollutants.

Light interception by intervening foliage is responsible for the low light intensity values at the ground layer in forests. In mangrove stands, depending on species and canopy height, light intensities varied from 0,33% to 14,10% of full sunlight at Isipingo Beach (Ward, 1980). Greatest interception at the ground layer occurred in a *Bruguiera gymnorrhiza* stand where light intensities varied from 0,88% to 37,5% of full sunlight and least interception in an *Avicennia marina* stand where light intensities varied from 2,2% to 20,1% of full sunlight at Mgeni Estuary. Intermediate values of 6,4% to 32,5% for mixed mangrove stands were obtained (Fig.15). At Mhlanga Estuary

TABLE 6. Sunshine at: i, Louis Botha Airport for 1951-1975; ii, a combination of data for Louis Botha Airport and Stamford Hill for various periods; iii, Stamford Hill for 1939-1948; iv, South African Sugar Experimental Station, Mount Edgecombe for 1967-1983. Key: A Total Possible Sunshine; B Mean Sunshine; C Mean/day; D Mean as a percentage of possible; E Fine to partly cloudy; F cloudy to overcast; G Maximum Possible Daily.

	i				ii		iii		iv		
	Hours			%	Days		Hrs.	%	Hours		%
	A	B	C	D	E	F	C	D	G	C	D
Jan.	428	201	6,2	47	16	15	6,5	47	13,8	6,0	44
Feb.	390	190	6,5	49	17	11	6,7	51	13,2	6,6	50
Mar.	383	207	6,6	54	18	13	6,2	50	12,3	6,7	55
Apr.	342	209	6,9	61	20	10	6,8	60	11,4	7,0	61
May	333	224	7,0	67	22	9	7,4	69	10,7	7,0	65
June	366	223	7,4	61	22	8	6,9	68	10,2	7,6	75
July	323	234	7,5	72	23	8	6,9	66	10,4	7,4	71
Aug.	340	229	7,3	67	23	8	6,9	63	11,0	7,0	64
Sept.	357	190	5,9	53	16	14	5,8	49	11,9	5,9	52
Oct.	386	171	5,6	44	14	17	5,2	41	12,8	5,9	46
Nov.	409	158	5,3	38	14	16	5,7	42	13,7	5,8	42
Dec.	431	196	6,2	45	14	17	6,0	43	13,9	6,1	44
Year	428	205	6,5	48	219	146	6,4	43	12,1	6,6	55

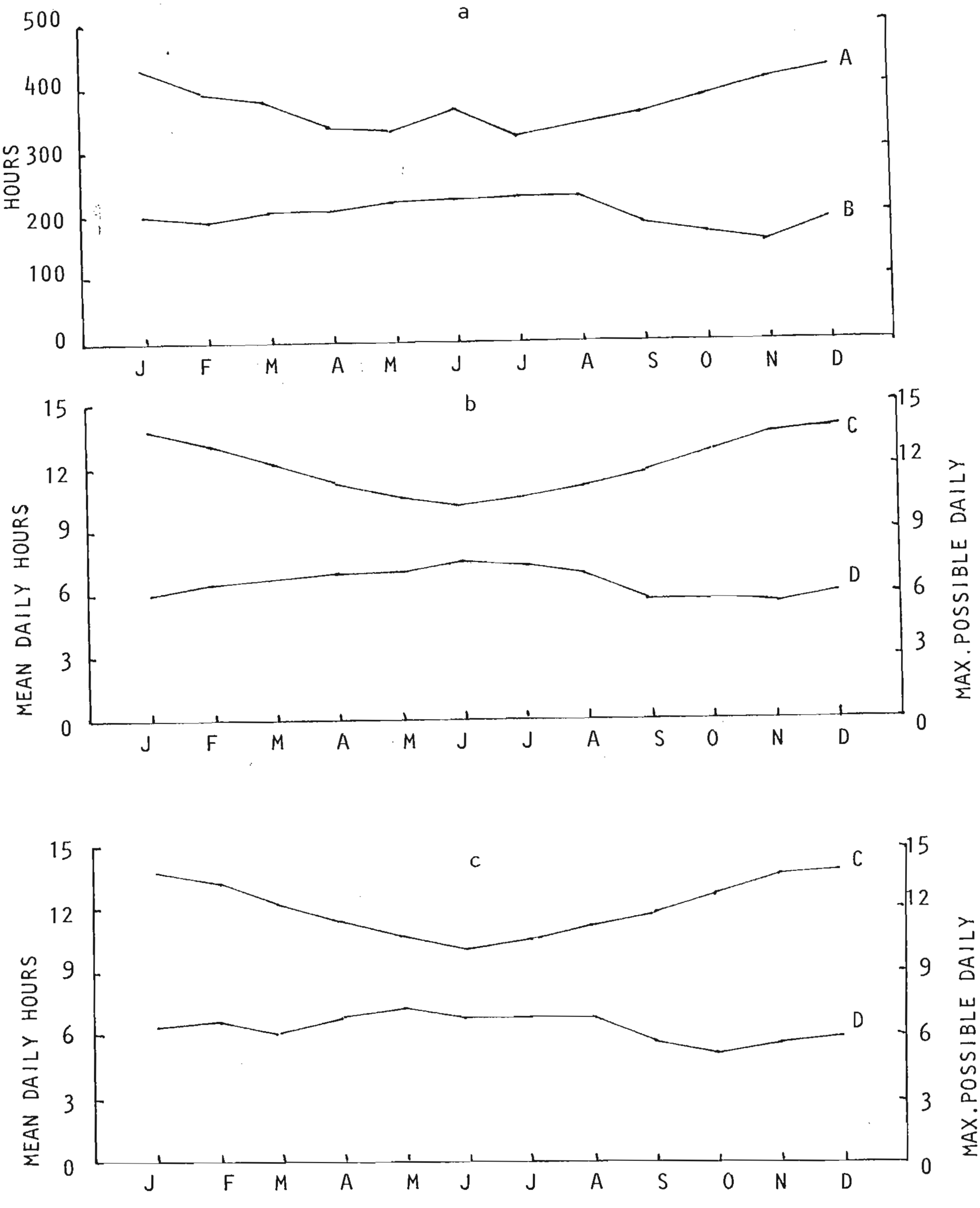

FIG. 14. Sunshine at: a, Louis Botha Airport for 1951-1975; b, South African Sugar Experimental Station, Mount Edgecombe for 1967-1983; c, Stamford Hill for 1939-1948. Key: A Total Possible Sunshine; B Mean Sunshine; C Maximum Possible Daily; D Mean Daily (all in Hours).

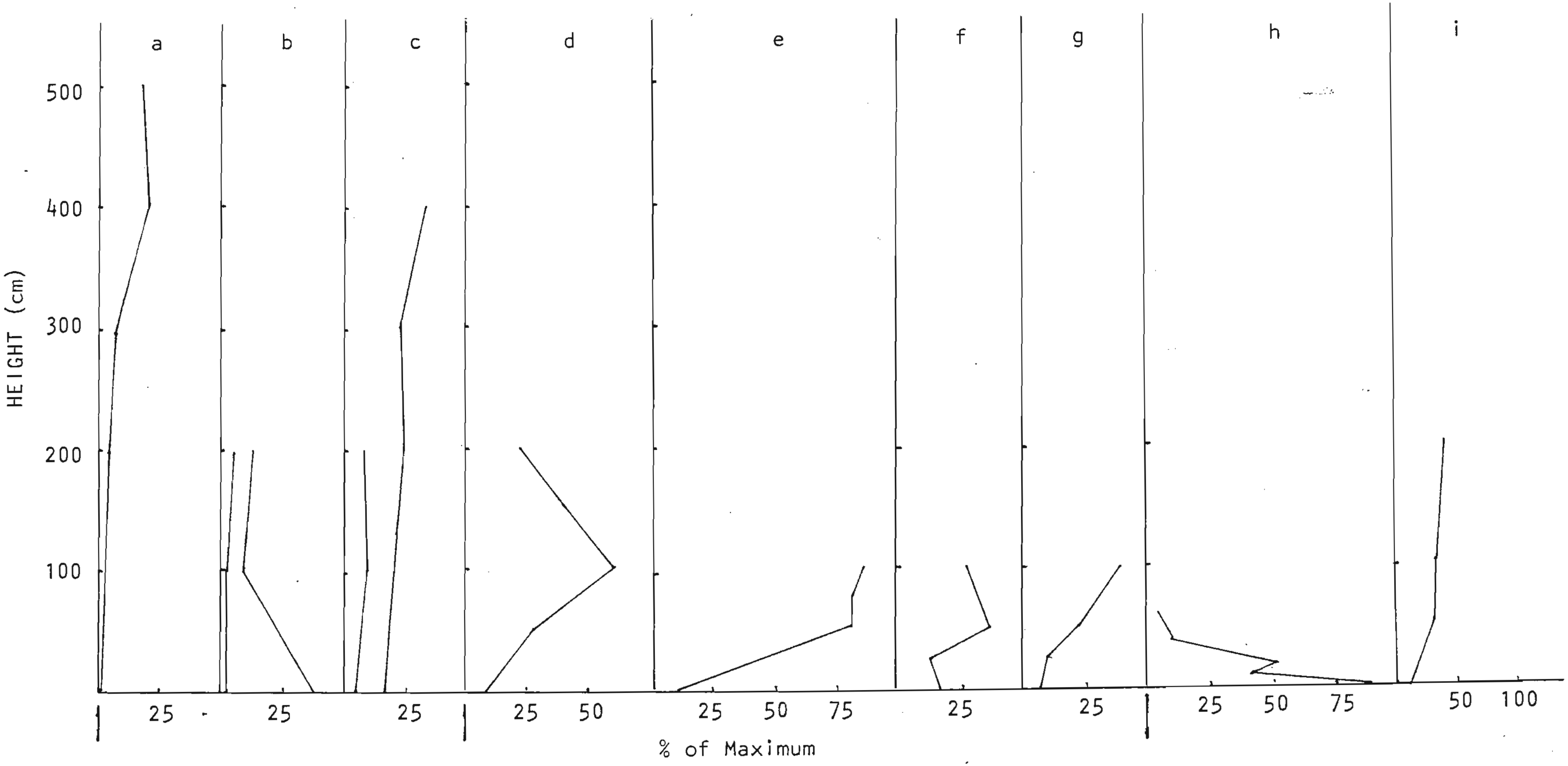

FIG. 15. Light intensity readings at the three study sites. a to c Mgeni; d to g Mhlanga; h and i Mdloti. a *Avicennia marina* stand (canopy 8m); b *Bruguiera gymnorrhiza* stand (canopy 4m); c mixed mangrove stand (canopy 7m); d mixed herb stand 2m tall; e *Echinochloa pyramidalis* stand; f *Phragmites australis* stand 3m tall; g mixed *P.australis* stand 2m tall; h *E.pyramidalis* basally inundated to 60cm; i *Barringtonia racemosa* stand (canopy 7m). High light intensities below lower lower intensities are due to lateral light entering from open margins.

light intensities varied from 4,3% to 60,0% in a mixed herb stand comprising *Typha capensis*, *Phragmites australis*, *Polygonum salicifolium* and *Stenotaphrum secundatum*, from 7,5% to 85,5% in an *Echinochloa pyramidalis* stand and from 7,3% to 47,6% in a *P.australis* stand (Fig.15) . At Mdloti Estuary light intensities were reduced to 3,0% at 50cm depth in an *E.pyramidalis* stand and varied from 6,0% to 19,5% of full sunlight for a *Barringtonia racemosa* stand (Fig.15) . The latter stands are generally open on the shoreline margins and closed on the landward margins where their extent is limited by steep slopes.

In water, light penetration is primarily affected by the turbidity of waters (Meadows and Campbell,1978) . The presence of silt in water causes greater light scattering resulting in an increased percentage of diffuse radiation. Turbidity of waters decrease during incoming tides and closed mouth conditions and, increase during outgoing tides and flood conditions. The Secchi Disc was visible at 140cm at Mgeni Estuary during high tide. At Mhlanga and Mdloti estuaries, during closed mouth conditions, the Secchi Disc was visible at 100cm. The Mdloti and Mgeni estuaries are generally more turbid, because of stronger flow and higher sediment loads, than the Mhlanga Estuary.

3.2 TEMPERATURE

The mean annual temperature for Louis Botha Airport is 20,4°C, for Durban Botanic Gardens it is 21,6°C, for Stamford Hill it is 20,5°C and for Mount Edgecombe it is 20,2°C (Table 7, Fig.16) . Temperatures are mild to warm throughout the year. The warmest month is February

TABLE 7. Temperature (°C) at: i, Louis Botha Airport for 1956-1983; ii, Durban Botanic Gardens for July 1974 to December 1983; iii, Stamford Hill for a 15 year period; iv, South African Sugar Experimental Station, Mount Edgecome for 1967-1983. Key: A Mean; B Mean Maximum; C Absolute Maximum; D Mean ~~Maximum~~ Minimum; E Absolute Minimum

	i					ii					iii					iv				
	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E
Jan.	23,8	27,7	35,4	20,6	11,9	24,8	28,7	37,8	21,0	12,0	23,9	26,5	33,3	19,4	14,0	23,7	32,8	38,3	16,2	14,0
Feb.	24,1	28,0	39,4	20,7	13,3	25,2	29,1	34,4	21,3	16,7	24,1	26,5	31,9	20,1	15,0	23,7	31,5	34,0	16,1	14.2
Mar.	23,5	27,7	34,8	20,2	11,6	24,2	28,3	35,6	20,0	14,0	23,3	26,0	32,3	19,4	14,6	22,9	31,1	33,6	14,9	13,2
Apr.	21,4	26,0	35,1	17,0	8,6	22,7	27,3	33,0	18,1	9,4	21,6	27,7	37,2	16,8	10,8	21,0	29,9	32,5	12,2	8,9
May	18,8	24,4	33,4	13,3	4,9	20,1	25,2	34,4	15,0	9,4	19,1	24,3	34,7	14,0	6,8	18,7	30,0	38,6	9,3	5,2
June	16,3	23,1	35,7	9,9	3,3	18,0	24,1	35,6	11,8	5,0	17,0	23,5	32,2	11,1	5,0	16,7	28,7	35,0	6,8	5,0
July	16,3	22,7	33,3	9,9	2,6	18,1	23,5	32,0	11,6	5,6	16,5	24,0	33,3	10,8	4,1	16,5	30,1	33,1	6,6	4,4
Aug.	17,4	22,8	37,1	11,9	2,6	18,5	23,2	36,0	13,7	8,0	17,5	22,9	31,4	12,1	5,1	17,1	30,8	36,4	7,7	4,9
Sept.	19,0	23,3	36,9	14,8	4,5	20,0	24,0	33,3	15,9	6,7	18,8	28,4	41,9	14,2	8,0	18,6	31,4	38,1	9,4	5,4
Oct.	20,0	24,1	40,8	16,4	7,5	20,9	24,1	37,0	16,8	11,0	20,1	24,0	30,8	15,9	9,9	19,8	32,3	38,7	11,2	8,1
Nov.	21,4	25,2	34,3	18,0	10,3	22,2	26,1	36,0	18,2	13,0	21,5	27,1	38,9	16,8	10,4	21,1	32,0	37,6	12,9	9,2
Dec.	23,0	26,8	35,9	19,6	12,3	24,3	28,4	37,8	20,1	10,0	22,9	26,2	32,3	19,1	13,3	22,8	30,8	37,5	14,8	10,8
Year	20,4	25,2	40,8	16,0	2,6	21,6	26,0	37,8	17,0	5,0	20,5	27,9	41,9	14,7	4,1	20,2	31,0	36,1	11,5	8,6

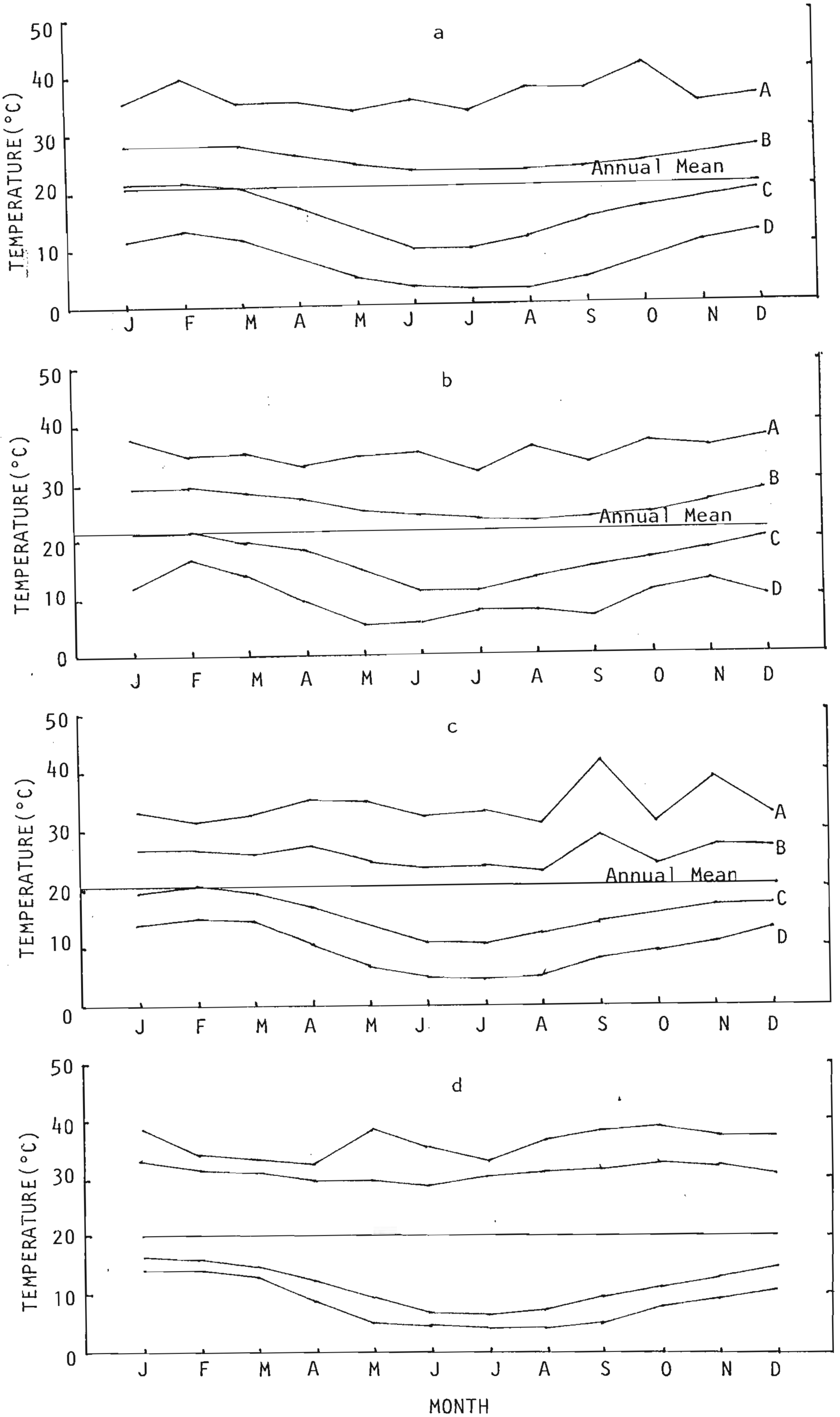

FIG.16.Temperature(°C)at:a Louis Botha Airport for 1956-1983;b Durban Botanic Gardens for 1974-1983;c Stamford Hill for a 15 year period; South African Sugar Experimental Station for 1967-1983.

NOTE:A Absolute Maximum:B Mean Maximum:C Mean Minimum:D Absolute Minimum and the coldest months are June and July. An absolute maximum of 41,9°C at Stamford Hill has been recorded. An absolute minimum of 2,6°C at Louis Botha Airport has been recorded.

No records of frost exist for the study area. Frosts, however, have been recorded in coastal areas for June 1890 (The Natal Mercury) and August 1932 (The South African Sugar Yearbook and Directory). Other observations are recorded in Ward (1980).

High water temperature is one explanation for the distribution of mangroves (Clarke and Hannon,1967; Berjak *et.al.*,1977). Coastal water temperatures are dependent on the prevailing ocean current (Brown and Jarman,1978). Estuarine water temperatures are initially determined by the ratio of tidal water to river discharge and then modified by solar heating and evaporative cooling (Day,1981c).

Observations indicate that estuarine water temperatures are lower than air temperatures. Depth of water influences water temperature. Water temperatures were higher at Mgeni Estuary (18,0°C) at high tide than at Mhlanga Estuary (14,5°C) and Mdloti Estuary (14,8°C) during closed mouth conditions. Measurements made following mouth opening of the Mdloti River indicate a temperature of 24,0°C. The input of warmer saline water is a possible explanation for the higher temperatures at Mgeni Estuary. The development of gradients is influenced by the degree of mixing of waters and small variations usually occur, e.g., 1,5°C over 260cm at Mgeni Estuary on an incoming tide; 1,1°C over 140cm at Mhlanga Estuary and 0,0°C at Mdloti Estuary during closed mouth conditions. Temperatures of the incoming bottom wedge were higher than that of surface waters at Mgeni Estuary for September 1985.

3.3 WIND

The prevailing winds are north-easterly and south-westerly. The predominant wind direction for the strongest winds are south-south-west (Table 8). Summers are generally more windy than winters. The calmest months of the year are May, June and July for Louis Botha Airport, Stamford Hill and Mount Edgecombe. The highest gust recorded was 52,4m sec^{-1} during November 1981 at Louis Botha Airport.

There is a regular alternation of south-east and north-east winds (Heydorn *et.al.*,1978). The diurnal patterns in wind patterns are associated with temperature and are explained in Oliff (1969) and Preston-Whyte (1980). This is related to pressure fluctuations in individual valleys which result in winds blowing down-valley by night and up-valley by day and further related to sea and land breezes. The scouring and ventilating effect of the wind and rain cleanses polluted air over Durban (Preston-Whyte,1980). This polluted air tends to drain off into river valleys (Mallows *et.al.*,1970).

The effect of wind on vegetation is detailed in Clarke and Hannon (1967). Briefly, in estuarine areas winds affect increases in soil salinity by evaporation, the introduction of salt spray adding to soil salinity and physical effects on plants. The physical effects of such winds together with high temperatures are deleterious to plant

TABLE 8. Wind Data for: i, Louis Botha Airport for 1962-1983; ii, South African Sugar Association Experimental Station, Mount Edgecombe for 1967-1983; iii, Louis Botha Airport for 1956-1983; iv, a combination of data for Louis Botha Airport and Stamford Hill for various periods. Key: A Average monthly in m sec^{-1}; B maximum velocity over an hour in m sec^{-1}; C wind direction; D maximum gust in m sec^{-1}; E wind direction; F predominant wind direction; G light to moderate (days) ; H fresh to strong (days) .

	i	ii	iii					iv	
	A	A	B	C	D	E	F	G	H
Jan.	3,5	2,2	19,5	SSW	29,1	SSW	SSW	18	13
Feb.	3,5	2,0	17,0	SSW	32,2	SSW	SSW	17	11
Mar.	3,4	1,8	21,9	SE	30,8	SW	SSW	20	11
Apr.	2,7	1,5	19,2	SSW	33,1	SSW	SSW/SW/S	21	9
May	2,3	1,3	17,4	SW	28,6	SW	SSW/SW	23	8
June	2,1	1,3	17,5	S	25,9	SSW	SSW/S	24	6
July	2,4	1,4	16,0	S	27,5	S	SSW/S	22	9
Aug.	3,1	1,7	22,4	S	32,6	S	SSW/NE/S	18	13
Sept.	3,8	2,0	20,8	S	32,2	S	SSW/NE/S	16	14
Oct.	4,2	2,4	17,9	SSW	28,5	SSW	SSW	16	15
Nov.	3,9	2,4	20,5	SSW	52,4	SW	SSW/S	15	15
Dec.	3,8	2,2	19,0	SW	32,6	SSW	SSW	18	13
Year	3,3	1,9	22,4	S	52,4	S	SSW	228	137

life especially during Berg wind conditions (mainly August to November) . Observations indicate that this leads to wilting of *Bruguiera gymnorrhiza* saplings (approximately 50cm tall) in dense stands.

3.4 PRECIPITATION

3.4.1 Rainfall and Thunderstorms

The mean annual rainfall for Louis Botha Airport is 1 006,0mm, for Durban Botanic Gardens it is 1 017,9mm and for Mount Edgecombe it is 939,0mm (Table 9; Fig.17) . The mean annual rainfall at Impendle is 1 028,3mm (Turner,1983,pers.comm.) and in the Mhlanga catchment is 1 000,0mm (Whitfield,1980a) .

Rain falls throughout the year but summer falls represent approximately 66% of the annual distribution for Louis Botha Airport, 68% for the Durban Botanic Gardens and 69% for Mount Edgecombe. The maximum rainfall recorded for any one month is 397,0mm and the maximum in a 24 hour period is 311,0mm at Louis Botha Airport. Excessive rainfall leading to floods have been recorded by Mann (1859) , Brown (1875; 1877) , Bews (1912) , Bulpin (1954) , Holden (1963) and Lugg (1970) .

Drought periods have also occurred. The most recent was from 1979 to 1983. Rainfall in Durban for 1980 was 602,3mm and that at Impendle for 1982 was 586,5mm. High rainfall during the normally dry winter months

TABLE 9. Rainfall data for: i, Louis Botha Airport for 1951-1975; ii, Louis Botha Airport for 1956-1983; iii, a combination of data for Louis Botha Airport and Stamford Hill for various periods; iv, Durban Botanic Gardens for 1934-1983; v, Durban Botanic Gardens for 1975-1983; vi, Stamford Hill for various periods; vii, South African Sugar Association Experimental Station, Mount Edgecombe for 1927-1983. Key: A Maximum in 24 hours; B Mean; C Maximum; D Minimum; E Thunderstorms (days); F Hail (days) .

	i	ii						iii	iv			v				vi			vii						
	mm	mm			days				mm			days			mm	mm			mm				days		
	A	B	C	D	B	C	D	E	B	C	D	B	C	D	A	A	E	F	B	C	D	A	B	C	D
Jan.	311	128,2	270,2	9,5	16	22	7	5	130,1	383,0	9,7	14	20	8	96,7	65,8	4,4	0,0	127	374	4	263	14	20	4
Feb.	143	110,9	272,6	20,4	13	18	8	3	123,7	357,8	21,8	11	16	7	160,0	132,1	1,9	0,1	113	274	15	171	12	18	7
Mar.	81	123,6	397,0	21,4	13	19	7	4	114,5	363,7	12,5	12	15	8	160,5	71,1	3,0	0,0	106	357	6	156	11	16	4
Apr.	142	85,7	302,0	18,9	10	16	4	4	81,1	315,3	7,8	7	12	5	81,1	95,8	3,3	0,0	72	241	14	109	8	14	4
May	59	60,8	227,1	3,0	7	12	3	2	66,3	293,9	3,9	6	10	4	40,8	142,2	1,7	0,1	53	232	1	149	5	12	2
June	109	25,2	139,1	0,0	4	8	0	1	35,3	356,1	0,0	4	6	1	19,7	84,8	0,5	0,0	32	430	0	264	4	10	0
July	100	43,5	147,1	1,4	3	12	1	1	29,9	108,7	0,4	4	8	1	57,7	62,2	0,5	0,0	26	107	0	82	4	12	1
Aug.	64	56,9	252,3	2,5	8	16	3	1	48,3	186,4	2,0	8	12	4	57,5	43,2	0,5	0,0	41	150	0	96	6	12	0
Sept.	61	66,8	148,2	12,6	11	18	5	2	64,4	151,4	6,8	9	16	5	70,0	49,3	1,7	0,0	64	153	9	139	9	16	3
Oct.	85	88,2	250,6	23,7	13	21	5	4	90,8	203,4	21,5	12	20	6	93,8	63,5	5,4	0,1	87	274	25	93	13	20	6
Nov.	51	105,7	240,8	38,9	18	24	12	5	120,8	308,9	21,3	14	17	12	98,0	145,0	4,9	0,2	109	276	21	80	15	21	7
Dec.	163	110,5	330,5	43,7	16	21	10	6	113,8	360,7	40,1	12	16	8	108,5	86,9	6,1	0,2	107	293	27	98	15	22	8
Year	311	1006,0	1305,5	602,3	132	163	118	38	1017,9	1396,5	631,3	114	143	96	160,5	145.0	33,9	0,7	939	1434	618	264	115	139	82

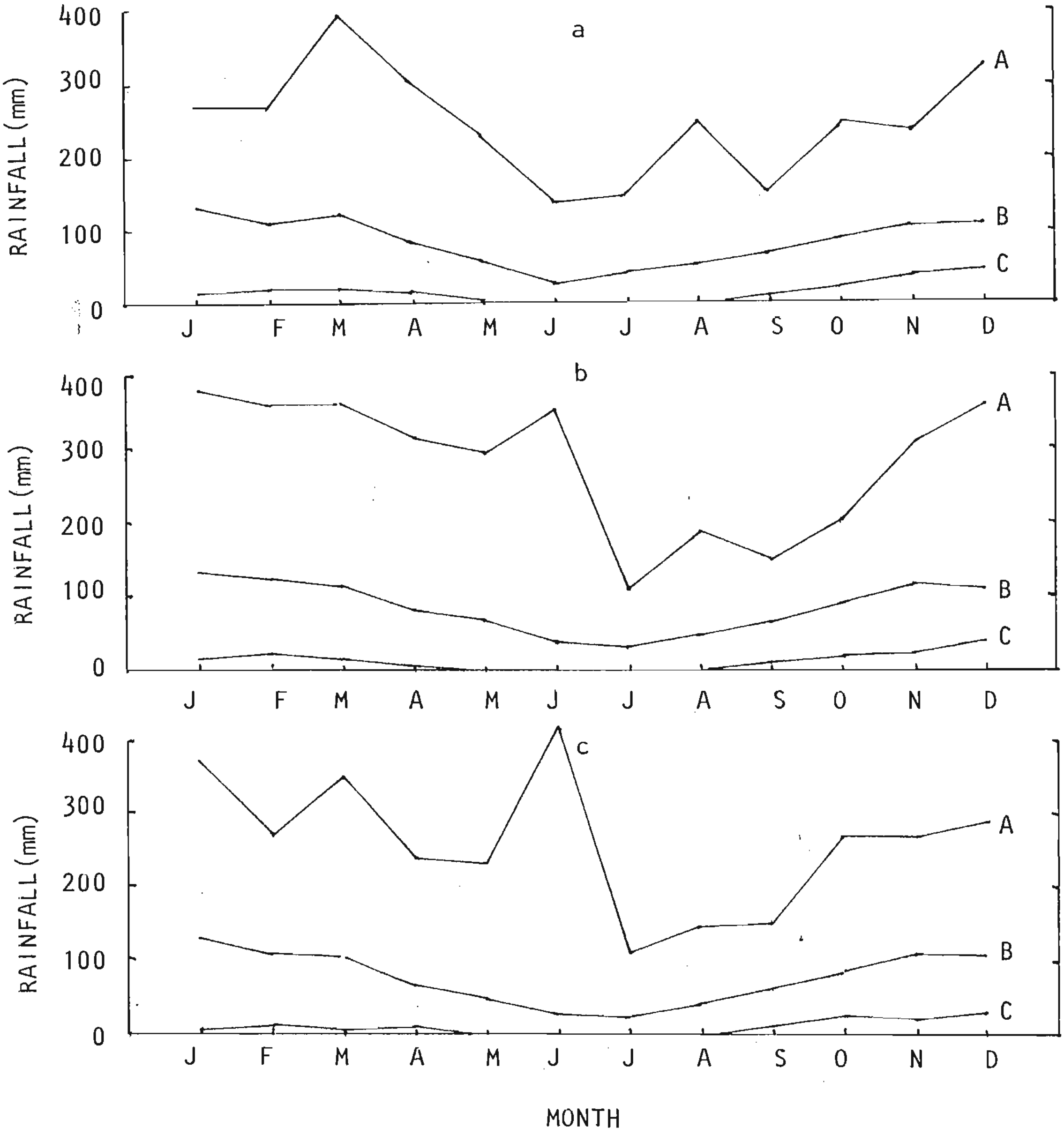

FIG. 17. Rainfall for: a Louis Botha Airport for 1956-1983; b Durban Botanic Gardens for 1934-1983; c South African Sugar Experimental Station, Mount Edgecombe for 1927-1983. Key: A Monthly Maximum; B Monthly Mean; C Monthly Minimum.

has been recorded.

Thunderstorms, accompanied by lightning, are infrequent in the study area. These result from their spreading from their places of origin further inland or from frontal activity. Thunderstorms are responsible for appreciable run-off into rivers in the Mgeni catchment (Turner, 1983, pers.comm.) .

Rainfall influences salinity and turbidity of water. River flow rates determine the open nature of river mouths. Salinity levels within closed estuaries are reduced when river inflow exceeds evaporation. Turbidity of water increases following rains. Increased flows are sometimes responsible for opening normally closed mouths. Rains from Cyclone Demoina in January 1984 opened the mouths of the Mhlanga and Mdloti estuaries. At Louis Botha Airport 207,7mm fell during a three day period from 29 to 31 January for the period of the cyclone.

3.4.2 Fog/Mist

A high deposition of moisture below mist clouds occurs along the coast. Their formation is influenced by topography, temperature inversion and cold air drainage. In the study area, these are usually dissipated by the early morning.

3.4.3 Dew

Dew is a common occurrence on cool, calm, clear winter nights in the low-lying areas. Dew provides an additional source of water but is subject to rapid evaporation on exposure to direct sunlight.The decreased light intensities during the winter period perhaps retard evaporative losses and make contributions to moisture contents more significant. Salt laden moisture also forms on leaf surfaces.

3.4.4 Hail

Hail sometimes accompanies thunderstorm activity. In the study area the stones are of small size and little damage to plants has been observed.

3.5 RELATIVE HUMIDITY

Although relative humidity is high throughout the year, the mean is at its lowest in the dry winter months (Table 10) . Generally, relative humidity is higher in the early mornings than in the afternoons. Low relative humidities are associated with Berg wind conditions. The lowest relative humidity recorded at Louis Botha Airport was 11% on 4 October 1958 when the temperature was 40,1°C during Berg wind conditions. Transpiration rates are reduced when the relative humidity is high.

TABLE 10. Relative Humidity (%) at: i, Louis Botha Airport for 1951-1975; ii, Durban Botanic Gardens for 1978-1983; iii, South African Sugar Association Experimental Station, Mount Edgecombe for 1967-1983. Key: A Mean; B Mean Maximum; C Mean Minimum; D Lowest; E Mean 08h00; F Mean 14h00; G Lowest 08h00; H Lowest 14h00; I Mean 08h00; J Lowest 14h00.

		i				ii			iii	
	A	B	C	D	E	F	G	H	I	J
Jan.	81	95	64	34	82	79	64	48	79	72
Feb.	81	95	64	30	82	78	62	62	81	71
Mar.	81	95	63	30	80	76	26	55	82	71
Apr.	79	95	59	22	81	75	52	42	81	67
May	76	94	51	19	80	73	48	40	77	63
June	72	95	45	14	76	72	36	26	70	53
July	73	95	47	16	78	70	42	40	71	54
Aug.	76	93	48	12	81	74	52	44	75	60
Sept.	78	95	58	12	79	75	32	53	77	67
Oct.	79	94	61	11	77	78	30	50	74	68
Nov.	89	95	64	29	80	78	42	40	74	70
Dec.	81	95	63	33	80	75	55	50	76	71
Year	78	795	57	11	80	75	30	26	76	66

CHAPTER 4

HISTORICAL BACKGROUND

This historical background refers to the effects of man on the local environment. Changes have been effected through residential, recreational, agricultural, engineering and industrial development.

The earliest inhabitants of Natal were the Bushmen (1200AD) who were succeeded by the Bantu (1400AD) (Brookes and Webb,1965). Settlements occurred in the catchments of all three study sites (Bryant,1929; Fynn,1969). The first permanent white settlement was established at Durban Bay in 1824 (Axelson,1973). Indians first arrived in 1870 as indentured labourers to work the sugar cane farms (Brookes and Webb,1965) and stayed on after the period of their tenure. Workers lived on the cane farms and cultivated market gardens to the river banks.

The initial major activity in the study area was sugar cane cultivation. This necessitated removal of coastal vegetation. It is estimated that 95% of the coastal vegetation of Natal has been cleared (Moll,1976). Poor land utilization and poor agricultural practices including burning at the wrong time of the year, clearing of riverine vegetation, draining of swampy areas, overstocking and subsequent overgrazing and planting to the river banks have led to reduced cover (Grindley,1972). The use of fire as amanagement tool in the upper Mgeni catchment has affected vegetation and reduced cover (Moll,1968). Reduced cover has accelerated siltation. Holden in 1844 noted the clarity of waters, but also noted that they became turbid following heavy rains (Moll,1976) .

Estuarine aesthetics has attracted large-scale residential development, especially on the north bank of the Mgeni Estuary. The floodplain and the estuaries serve for the development of recreational activities. The Windsor Park Golf Course on the south bank of the Mgeni River and the Beachwood Golf Course to the north have influenced the development of bank vegetation.

Sugar cane cultivation was practised on the banks of the Mgeni River in the Springfield area, approximately 1km beyond the head of the estuary as considered for this project. Increased population necessitated improvements in transport and communication systems. The railway line crossed the Mgeni River in 1878 and the north coast road crossed the estuary at two sites; at George's Drift (near the mouth) and Morewood's Drift (higher up) (Bulpin,1954) . Bridges have been built in subsequent years at these sites. Greater accessibility has led to increased littering and dumping in the estuarine area.

Industrial development has been rapid within the environs of the Mgeni Estuary. The development of the Springfield Flats recently as an industrial site required the canalization of the Mgeni River and the lower Mhlangana River. This resulted in increased siltation within the estuary especially between Athlone Bridge and Ellis Brown Viaduct where stabilization of sediments has been effected through the establishment of *Avicennia marina*. Industrial development in the Phoenix/Ottawa areas, presently being undertaken, was warned against as it would result in drainage of pollutants into the Mgeni (and Mhlanga) valleys unless care was taken (Mallows *et.al.*,1970) . The Sea Cow Lake Sewage Works together with the industries are responsible for riverine pollution (Livingstone *et.al.*,1968; Moll,1976) . The discharge of strong effluent had been reduced by 1972 (Simpson *et.al.*,1972) .

The Mgeni Estuary and floodplain was described as being swampy with sandy soil for the previous century (Hattersley,1940) . The dominant vegetation on the banks and islands was reeds (Ingram,1895) . The mouth of the Mgeni River was choked by the sand of the sea-shore (Holden,1963).

The Beachwood Mangroves Nature Reserve on the Mgeni Estuary was proclaimed in 1976 and is under the control of the Natal Parks, Game and Fish Preservation Board.

Sugar cane cultivation has remained the primary activity in the Mhlanga catchment since the late 1800's. The estuary has always been reed dominated. Parts of the reed swamp had been drained for sugar cane cultivation but have now been allowed to lie fallow. Dune disturbance, bank destruction and road works have resulted in siltation (Heydorn, 1977/1978) .The Mhlanga Lagoon Nature Reserve was proclaimed in 1979 and is under the control of the Natal Parks, Game and Fish Preservation Board.

Sugar cane cultivation is the main agricultural activity in the Mdloti catchment and cultivation in parts occur to the river banks (Fig.18) .

FIG. 18. Cultivation of sugar cane to the banks of the Mdloti River introduces sediment into the estuarine system.

Industrial development has increased in Verulam (approximately 10km west of the estuary) in recent years. The river was described as a shallow sandy stream at Verulam in 1856 (Mann,1859). Lugg (1970), for the period prior to the 1917 floods, described the river as a well wooded stream with old trees and numerous pools along its lower course. Holden (1963) described an open mouth condition prior to 1855 for the Mdloti River. Overgrazing in the Ndwedwe area has led to increased erosion. The north bank of the estuary, east of the road bridge, has recently been developed as a picnic site.

CHAPTER 5

THE FAUNAL COMPONENT

This chapter on the faunal component of the study area reflects a summary of published data and personal observations.

The fauna of the study area reflects a warm water component derived from the Indian or Indo-West Pacific region (Heydorn *et.al.*,1978) .

5.1 ZOOPLANKTON

Conditions in the Beachwood Creek do not favour the survival of estuarine and marine forms of zooplankton. Fresh-water forms were recorded by Begg (1978) . Zooplankton form the base of the estuarine food web and are largely primary consumers (van der Elst,1977) . The degree to which they form a food source for other organisms varies. At Mhlanga Estuary 1,7% of the fish population fed on zooplankton (Whitfield,1979) .

5.2 PHYLUM: ANNELIDA

The central Mgeni Estuary was found to be more productive than the confluence of the Beachwood Creek and Mgeni River (Simpson *et.al.*, 1972) . Polychaetae are abundant in the lower reaches of the Mgeni Estuary and dominate the benthic community where 16 species have been found (Begg,1978) . Members include *Ceratonereis* spp., *Desdemona* spp. and members of the Archiannelida. They occur at the top 2cm of the sediment and have a high tolerance to low salinity but a low tolerance to eutrophication. Oligochaetae found at Connaught Bridge are indicative of a fresh-water influence (Simpson *et.al.*,1972).

5.3 PHYLUM: ARTHROPODA

Prawns and crabs are the predominant Crustacea; the latter occur frequently on the surface of exposed muds.

Caridina sp. and *Alpheus crassimanus* have been reported for Mgeni Estuary (Begg,1978) . The latter was found along the banks in the fringes of *Avicennia marina* pneumatophores. *Caridina* sp. was dominant in spring (Begg,1978). Fertile *Alpheus crassimanus* were recorded for October. *Callianassa* sp. was found on the western shore of Mhlanga Estuary (Day,1981c) .

Three species of mud crabs are found at Mgeni Estuary. These are *Sesarma meinerti*, *S.catenata* and *S.eulimene*. Observations indicate that the genus is more common in the Beachwood Mangroves Nature Reserve than in the Mgeni River section of the estuary. They occur at elevated regions in moist *Bruguiera gymnorrhiza* stands and are also found at the upper limits of *Avicennia marina* stands. *S.meinerti* is found at higher levels and its distribution is dependent on salinity and vegetation (Macnae,1963) whereas *S.catenata* and *S.eulimene* live lower down (Day and Morgans,1956) . These crabs are responsible for localized accumulation of sediments, soil turnover and mixing of organic matter, aeration of muds and initial breakdown of detrital material (Ward, 1980) .

Three species of fiddler crabs are found at Mgeni Estuary. These are *Uca urvillei*, *U.lactea-annulipes* and *U.chlorophthalmus*. Observations indicate that *Uca* spp. are found in the Beachwood Mangroves Nature Reserve and in the Mgeni River section of the estuary. In the reserve they are especially common along water-courses in sandy soils or the landward fringes of narrow mangrove stands. On the Mgeni River, they extend to just above the mid-estuarine reaches on intertidal sandy banks. Although each species has a particular set of environmental requirements, overlapping does occur (Berjak *et.al.*,1977). According to Macnae (1963), *U.urvillei* and *U.chlorophthalmus* are found on open banks of creeks with little shade. Day and Morgans (1956) recorded *U.urvillei* burrowing during waterlogged conditions and *U.annulipes*, in better drained soils, extending into the shade of mangroves. Freshwater apparently eliminates them (Begg,1978).

Scylla serrata is the largest of the species of crabs at Mgeni Estuary. It has been recorded also at Mhlanga Estuary (Heydorn,1977/1978).

The release of sewage leads to eutrophication (sewage works are located on all three systems) to which crustaceans are intolerant (Simpson *et.al.*,1972).

5.4 PHYLUM: MOLLUSCA

Ten species of Gastropoda are found in the Beachwood Mangroves Nature Reserve (Begg,1978). The most conspicuous of these is *Cerithidea decollata* which is more common in the tidally inundated areas. They have been noted on mangrove trees on an incoming tide and on the substrate at the ebb. *Natica tecta* is present in the Reserve on moist, less exposed substrates in the upper estuarine sections.

5.5 PHYLUM: CHORDATA

5.5.1 Class: Osteichthyes

Estuaries provide the necessary nursery habitat for certain juvenile fish species. At high tide, juveniles of mullet have been noted amongst pneumatophores of *Avicennia marina* fringing creeks and water-courses.

Thirty species have been recorded for the Beachwood Creek (predominantly mullet Begg,1978) and 32 species at Mhlanga Estuary (Day,1981c) . Five species have been recorded at Mdloti Estuary (Begg,1978) .

Periophthalmus sobrinus was observed along banks at Beachwood and on those of the Mgeni River. Their burrowing activity is responsible for oxygenation of surface layers, mixing of soils and transport of detrital material.

Industrial pollution hasresulted in fish kills at Mgeni Estuary in 1971 (Cooper,1972) and 1980 (Whitfield,1980b) . Numbers of *P.sobrinus* have been reduced (Begg,1978) . A similar kill has occurred at Mdloti Estuary in 1977 (Begg,1978) .

5.5.2 Class: Reptilia

Varanus sp. have been observed on the banks of Beachwood Creek and especially on the banks of Athlone Island. Crocodiles were present at Mgeni until 1908 (Fynn,1969) . Pythons have been recorded in the reeds of Mhlanga Estuary (Mann,1859) .

5.6.3 Class: Aves

The estuarine avifauna is not a true component of the estuarine ecosystem being mobile visitors and a part of the tree canopy in a terrestrial habitat (Berjak *et.al.*,1977) . Recorded number of species and listing of species in the study area are contained in Cooper (1968) , Begg (1978) and Siegfried (1981) . Estuaries form areas for bathing, preening, drinking, roosting, feeding and nesting. Feeding by birds is considered to result in a food drain from estuaries especially by waders and piscivorous birds. Ward (1980) however reports estuarine enrichment by birds.

5.6.4 Class: Mammalia

Many of the larger mammals recorded earlier have disappeared. Elephants, hippos, hyenas, jackals and lions were known to have occurred in the study area as late as 1870 (Bulpin,1954) . Vervet monkeys, grey duiker, banded mongoose and Cape clawless-otter have been reported for Mgeni Estuary (Begg,1978) . Vervet monkeys enter mangrove stands from adjacent coast forest and tend to remain in the tree canopy where breakage of slender twigs occur. They are generally found in the upper estuarine section.

CHAPTER 6

SOILS

6.1 METHODS

Soils were extracted by means of a soil corer, from 3 to 5 cores making up a sample. Soils were collected either during low tide or during open mouth conditions for Mgeni, Mhlanga and Mdloti estuaries respectively. Samples were air dried, ground with a wooden gavel, passed through a 2mm sieve and stored in glass bottles. Sample sites were chosen subjectively so as to represent major plant communities.

The following analytical procedures were used: particle size distribution by the hydrometer method (Bouyoucos,1962) , pH of field moist and air dry samples on a 1:1 soil to water suspension using a glass electrode (Jackson,1958) ; reserve acidity by extraction with barium acetate and titration with sodium hydroxide (Peech,1965) . Aluminium was determined spectrophotometrically by the aluminon method (Yuan and Fiskell,1959) as was acetate soluble sulphate by extraction with ammonium acetate at pH 4,8 (Bardsley and Lancaster,1965) ; iron was extracted with 0,3M sodium citrate and determined as extractable iron oxide by atomic absorption (Jackson,1958) ; organic matter by the Walkley-Black method (Jackson,1958) and available phosphorus extracted with sulphuric acid containing ammonium sulphate and determined spectrophotometrically by the chlorostannous reduced molybdophosphoric blue colour method (Jackson,1958) .The exchangeable cations were extracted with a 1N ammonium acetate solution at pH 7,0. Concentrations of Calcium, Magnesium, Potassium and Sodium were determined by atomic absorption, while the cation exchange capacity was obtained by the summation of exchangeable bases and reserve acidity (Peech,1965). A Zeiss PM 2 DL spectrophotometer and a Varian-Techtron 1200 atomic absorption were used. The exchangeable sodium percentage was calculated as a percentage of the cation exchange capacity. Bulk density was measured using a steel cylinder with a volume of 789cm^3. The electrical conductivity was measured on a saturation extract using a Metrohm 644 Conductometer (Jackson, 1958). Soil salinity classification is after Hausenbuiller (1978).

Soil sample sites are represented in Fig.19 while the vegetation characteristic of the sites are represented in Tables 11, 12 and 13 for Mgeni, Mhlanga and Mdloti estuaries respectively.

6.2 RESULTS

6.2.1 Mgeni Estuary

The results of the analysis of soils of the Mgeni Estuary are presented in Table 14.

Soils had a high percentage of small sized fractions for most samples. Mangrove soils were predominantly clay soils or had a predominance of small sized fractions. Soils supporting scrub vegetation, on the island, were predominantly sandy. Surface soils tended to have a much higher

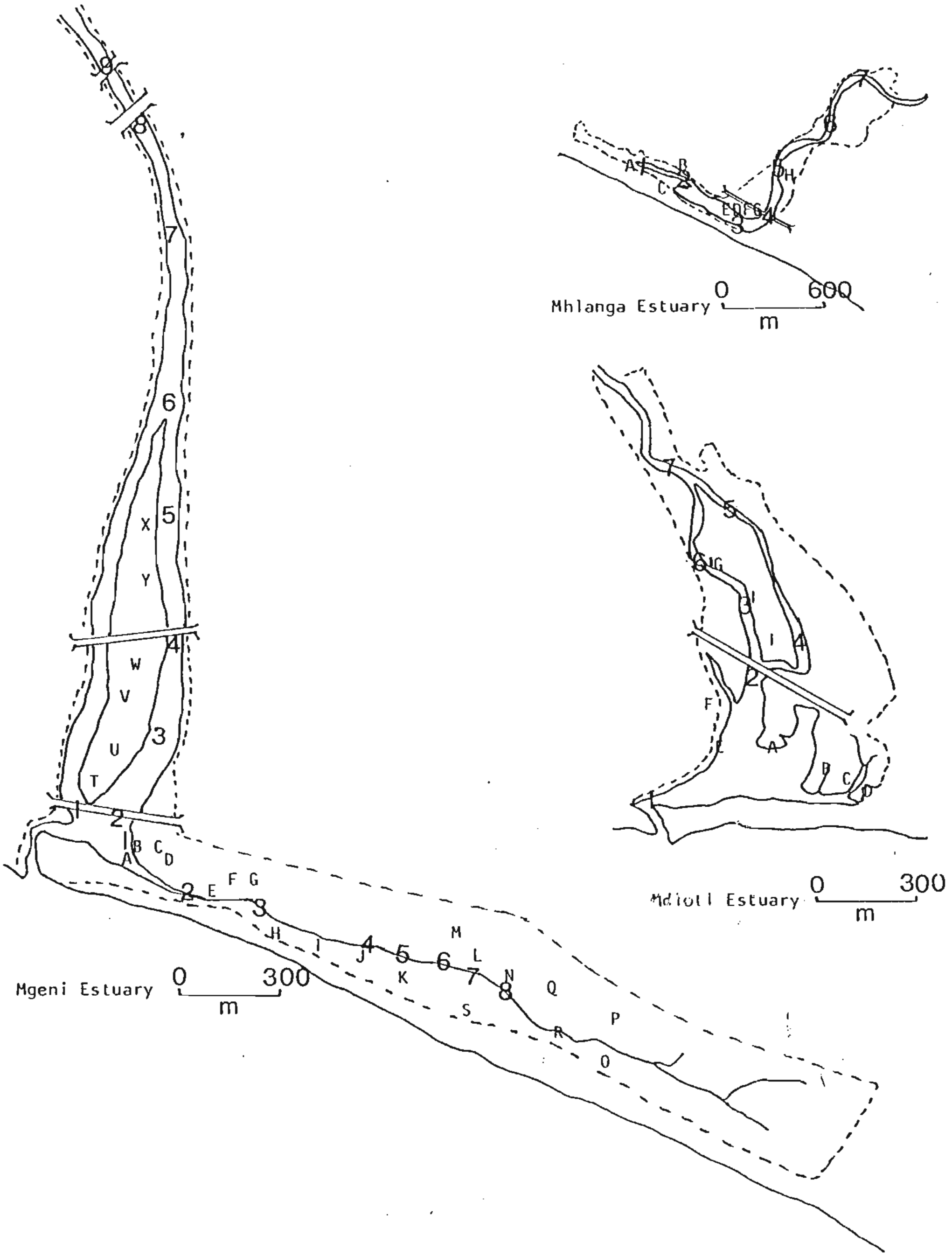

FIG.19.Soil sample site localities at the three study sites;Mgeni,Mhlanga and Mdloti. ——— shorelines,- - - - site boundary. Numbers indicate station numbers where physical measurements were made.

TABLE 11. Sample site descriptions for Mgeni Estuary. Sampling carried out at low tide. All sites, except W, X and Y, are tidally inundated. Canopy heights of stands are indicated in parentheses.

SAMPLE	DESCRIPTION
A	Unconsolidated, bare sediment.
B	*Avicennia marina* (6m) and *Bruguiera gymnorrhiza* (1,5m) stand.
C	As B.
D	Mixed *A.marina* (3m), *B.gymnorrhiza* (2m) and *Sarcocornia natalensis* stand.
E	*B.gymnorrhiza* seedlings and *Phragmites australis* (1,5m) marginal to *B.gymnorrhiza* stand (6m) .
F	Pure *B.gymnorrhiza* (4m) stand.
G	*Juncus kraussii* (1,0m) stand.
H	As D.
I	Mixed *A.marina* (1,5m), *B.gymnorrhiza* (1,5m) and *J.kraussii* (1,0m) stand.
J	Mixed *A.marina* (5,0m), *B.gymnorrhiza* (5,0m), *P.australis* (1,0m) and *S.natalensis* stand.
K	Mixed *A.marina* and *B.gymnorrhiza* stand (5,0m) stand.
L	Dominant *J.kraussii* stand (1,0m) with *Hibiscus tiliaceus*, *Chrysanthemoides monilifera*, *P.australis* and *S.natalensis* stand

cont. p. 69

M	As L.
N	Pure *B.gymnorrhiza* stand (7,0m).
O	As N.
P	Dominant *B.gymnorrhiza* (5,0m) and occasional *A.marina* (5,0m) stand.
Q	As N.
R	As N.
S	As P.
T	Pure *A.marina* stand (6,0m).
U	As K.
V	Pure *Stenotaphrum secundatum* stand.
W	Thicket (5,0m) comprising *Schinus terebinthifolius*, *Lantana camara*, *Chromolaena odorata*, *Cardiospermum grandiflorum*, *Melia azedarach*, *Brachylaena discolor*, *Erythrina lysistemon* and *Acacia mearnsii*.
X	As W.
Y	As W.

TABLE 12. Sample site descriptions for Mhlnaga Estuary. Sampling carried out following mouth opening. All sites are basally inundated during closed mouth conditions. Canopy heights of stands are indicated in parentheses.

SAMPLE	DESCRIPTION
A	Dominant *Phragmites australis* (2m) stand with *Typha capensis* and *Lemna* sp.
B	As A.
C	As A.
D	Mixed stand comprising *Hibiscus tiliaceus* (4m), *P.australis* (4m) and *Stenotaphrum secundatum*.
E	*Potamogeton pectinatus* stand.
F	Mixed *Bruguiera gymnorrhiza* and *Phragmites australis* stand (4m).
G	Pure *P.australis* (3m) stand.
H	As G.

TABLE 13. Sample site descriptions for Mdloti Estuary. Sampling carried out following mouth opening. All sites are basally inundated during closed mouth conditions. Canopy heights of stands are indicated in parentheses.

SAMPLE	DESCRIPTION
A	Pure *Phragmites australis* (3m) stand.
B	Mixed herb stand (2m) comprising *Echinochloa pyramidalis*, *Schoenoplectus littoralis*, *P.australis*, *Stenotaphrum secundatum* and *Polygonum salicifolium*.
C	As B.
D	Unconsolidated sediment on bare shoreline.
E	Pure *Barringtonia racemosa* (7m) stand.
F	As E.
G	Mixed stand (5m) comprising *B.racemosa*, *Phragmites australis* and *Ipomoea cairica*.
H	As G.
I	*B.racemosa* (6m) and fringing *P.australis* (4m) stand.

TABLE 14. Physical and Chemical Properties of Soils from Mgeni Estuary. Key: PSD Particle Size Distribution; s sand; si silt; c clay; scl sandy clay loam; sl sandy loam; cl clay loam; ls loamy sand; A bulk density in g cm^{-3}; FM field moist; AD air dried; B reserve acidity; C Al^{3+}; D soluble sulphate; E Fe as Fe_2O_3; OM organic matter; F Electrical Conductivity in S m^{-1}(x 10^{-3}) ; ESP exchangeable sodium percentage; G salinity classification; s-s saline-sodic; ns-s non saline-sodic; ns-ns non saline-non sodic; CEC cation exchange capacity; H available phosphorus in μg ml^{-1}.

SAMPLE	LAYER	DEPTH	PSD %			CLASS	A	pH		B	C	D	E	OM	F	ESP	G	Exchangeable Bases					H
		mm	s	si	c			H_2O FM	AD	mw 100g^{-1}				%				Ca	Mg	K	Na	CEC	
																		me 100g^{-1}					
A	1	0-250	58	10	32	scl		6,3	6,2	0,66	0,25	2,75	4,84	0,45	10 48	74,8	s-s	1,4	8,2	2,9	39,2	52,4	1,88
B	1	0-250	70	6	24	sl	1,03	5,9	5,5	0,50	0,16	2,55	4,57	2,15	16,54	84 5	s-s	0,8	5,1	2 2	47,0	55,6	0,70
	2	250-500	85	7	8	ls		5,7	5,5	0,63	0,16	2,77	3,22	1,60	17,75	84,9	s-s	0,6	5,1	2,2	47,9	56,4	1,60
C	1	0-250	44	20	36	scl	1,21	5,5	5,4	0,80	0,20	3,69	7,52	4,41	16,89	80,2	s-s	2,0	9,3	5,1	69,6	86,8	0,83
	2	250-500	32	24	44	c	1,47	5,3	5,5	0,77	0,19	3,59	8,33	2,84	16,54	80,9	s-s	1,7	9,3	4,1	67,0	82,8	0,88
	3	500-750	30	22	48	c		5,5	5,0	1,42	0,22	5,07	7,52	3,87	13,94	82,6	s-s	2,1	9,1	4,1	78,3	94,8	0,88
D	1	0-250	42	20	38	cl	1,22	6,2	5,7	0,65	0,20	2,72	7,52	3,03	16,64	81,5	s-s	0,4	5,1	3,7	43,5	53,4	0,85
	2	250-500	70	8	22	scl	1,20	5,8	5,6	0,60	0,17	2,66	4,84	1,31	14,64	83,0	s-s	0,3	5,1	2,9	43,5	52,4	0,25
	3	500-750	64	14	22	scl		5,7	5,3	0,84	0,19	2,61	2,42	2,96	19,75	79,0	s-s	0,8	8,2	3,6	50,5	63,9	0,78
	4	750-999	80	6	14	ls		5,4	5,4	0,65	0,16	2,49	1,88	1,55	20,32	73,0	s-s	0,4	10,7	3,3	40,9	56,0	2,25
E	1	0-250	22	22	56	c	1,00	6,2	6,2	0,42	0,22	2,71	8,06	4,09	5,53	75,6	s-s	2,5	8,2	4,1	47,0	62,2	0,33
	2	250-500	32	26	42	c	0,97	6,3	5,2	0,70	0,32	3,64	5,91	2,89	24,77	78,9	s-s	1,1	9,2	3,9	55,7	70,6	0,40
	3	500-750	68	12	20	scl		5,6	5,2	1,02	0,23	3,69	3,76	2,96	13,59	79,5	s-s	0,6	6,7	4,5	49,6	62,4	0,68
F	1	0-250	18	4	58	c	0,80	5,4	5,5	0,66	0,22	3,05	9,03	3,91	20,48	61,1	s-s	5,2	12,3	8,1	41,3	67,6	0,38
	2	250-500	9	30	61	c	0,99	5,6	5,4	0,73	0,23	3,29	8,18	4,33	17,08	79,0	s-s	4,5	2,1	3,9	42,2	53,4	0,43
	3	500-750	14	23	63	c		5,5	5,2	1,12	0,23	4,79	9,03	5,49	13,53	79,6	s-s	5,0	2,1	6,3	56,6	71,1	0,33
	4	750-999	43	20	37	cl		5,8	4,8	1,38	0,24	5,29	3,67	5,49	22,38	82,9	s-s	3,5	1,2	4,9	53,3	64,3	1,15
G	1	0-250	15	23	61	c	0,97	6,0	6,2	0,45	0,21	3,98	6,20	4,72	19,75	79,3	s-s	4,5	2,5	7,3	56,6	71 4	6,80
	2	250-500	9	22	69	c	0,97	6,0	5,6	0,65	0,20	3,94	8,18	4,47	25,72	79,3	s-s	4,9	2,5	5,8	53,3	67,2	6,38
H	1	0-250	27	23	50	c	0,90	6,9	5,4	0,84	0,26	3,79	3,38	4,23	17,11	82,3	s-s	4,4	1,2	5,7	55,5	67,6	6,53
	2	250-500	75	8	17	sl		6,3	6,2	0,41	0,56	3,20	6,79	1,66	18,80	78,9	s-s	7,1	0,8	3,6	44,6	56,5	1,75
I	1	0-250	12	22	56	c	0,95	6,4	5,8	0,60	0,43	3,24	7,90	4,30	18,38	80,3	s-s	4,5	2,1	3,2	42,4	52,8	0,60
	2	250-500	19	20	61	c		6,0	5,3	0,90	0,45	3,98	6,49	4,33	18,67	80,1	s-s	3.6	1,7	6,5	51,1	63,8	0,50
J	1	0-250	19	26	55	c	1,04	6,1	5,2	0,70	0,35	4,70	7,62	6,62	13,72	79,9	s-s	4,9	2,1	7,6	60,9	76,2	0,65
	2	250-555	19	24	55	c		6,0	5,4	0,74	0,59	3,84	6,77	4,37	10,41	78,5	s-s	3,5	1,2	9,9	67,4	82,7	0,45
K	1	0-250	14	35	51	c	0,64	6,2	5,4	0,66	0,67	4,24	9,59	4,09	21,72	66 3	s-s	4,5	16,5	8,1	58,7	88,5	0,68
	2	250-500	20	31	49	c		6,2	5,4	0,74	0,30	5,57	5,05	6,62	24,83	66,5	s-s	5,0	15,4	9,9	68,5	99,5	0,75
L	1	0-250	29	22	49	c	1,04	6,4	6,0	0,45	0,74	3,69	5,92	4,44	21,46	81,0	s-s	3,1	2,1	7,1	54,4	67,2	0,73
	2	250-500	27	23	50	c		6,4	5,4	0,71	0,47	3,00	6,20	4,05	19,94	82,0	s-s	3,2	0,8	7,3	54,8	66,8	0,55
M	1	0-250	25	18	57	c	0,99	6,1	5,8	0,30	0,56	3,15	7,33	4,33	25,65	81,4	s-s	3,5	2,1	6,5	54,4	66,8	0,55
	2	250-500	37	20	43	c		6,0	5,8	0,43	0,82	2,79	6,20	2,43	21,02	82 3	s-s	2,7	0,8	7,3	52,2	63,4	0,48
N	1	0-250	31	20	49	c	0,38	6,2	6,0	1,63	0,40	0,44	112,81	6,53	31,37	66,3	s-s	3,4	8,2	3,6	33,1	49,9	0,10
	2	250-500	17	20	63	c		6,4	6,1	1,00	0,50	0,43	102,07	6,46	25,46	76,6	s-s	2,9	6,7	4,3	48,7	63,6	0,03
O	1	0-250	58	10	32	scl	1,09	7,1	6,9	0,60	0,27	0,34	77,89	4,96	22,10	69,8	s s	3,9	6,7	1,6	29,6	42,4	0,13
	2	250-500	70	10	20	scl		7,1	6,7	0,62	0,32	0,32	37,60	3,54	19,81	67,8	s-s	4 4	5,6	3,6	29,9	44,1	0,10
P	1	0-250	26	22	52	c	0,58	6,5	6,4	1,23	0,36	0,52	115,49	6,24	14 03	78,1	s-s	3,5	8,2	2,7	55,7	71,3	0,08
	2	250-500	18	24	58	c		6,8	6,8	0,88	0,45	0,40	104,75	6,17	21,21	72,9	s-s	3,1	7,2	2,4	36,5	50,1	0,03
	3	500-750	20	28	52	c		7,2	6,9	0,52	0,53	0,38	75,21	5,00	27,56	71,8	s-s	2,6	7,8	2,1	33,1	46,1	0,03
Q	1	0-250	34	21	45	c	0,44	7,0	5,9	1,11	0,40	0,53	94,01	6,75	45,21	67,8	s-s	3,2	8,2	2,4	31,3	46,2	0,10
	2	250-500	19	29	52	c		7,2	6,3	0,94	0,56	0,50	83,26	6,68	31,88	73,2	s-s	3,1	6,8	2,6	36,5	49,9	0,03
R	1	0-250	22	26	52	c	0,50	6,5	6,2	0,88	0,34	0,48	116,12	6,68	57 85	66,7	s-s	2,8	8,2	4,6	33,1	49,6	0,25
	2	250-500	16	22	62	c		6,5	6,3	0,80	0,53	0,54	85,95	6,61	8,83	73,0	s-s	3,2	10,3	4,5	33,1	51,9	0,10
S	1	0-250	26	27	47	c	0,54	6,2	6,1	1,09	0,35	0,55	118,18	6,72	14 67	67,2	s-s	2,9	6,7	2,9	27,8	41,4	0,28
	2	250-500	5	28	57	c		6,4	6,0	1,11	0,25	0,52	94,01	6,61	44,13	73,0	s-s	2,7	8,2	3,5	41,8	57,3	0,10
T	1	0-250	56	20	24	scl	1,08	5,7	6,3	0,55	0,41	0,28	80,57	2,82	17,22	57,5	s-s	1,5	9,5	7,7	26,1	45,4	0,15
	2	250-500	44	22	34	cl		6,5	6,8	0,67	0,46	0,36	85,95	3,21	9,21	59,5	s-s	1,8	10,3	6,5	28,3	47,6	0,15
	3	500-750	46	28	26	l		6,5	6,9	0,72	0,30	0,25	75,21	3,03	12,70	66,3	s-s	1,6	7,5	2,3	23,9	36,0	0,13
	4	750-999	70	22	8	sl		6,9	7,0	0,52	0,20	0,24	34,92	0,92	10 86	78,9	s s	0,1	5,7	0,4	25,0	31,7	0,18
U	1	0-250	72	10	18	ls	1,04	6,5	7,0	0,57	0,23	0,30	53,72	1,27	16,13	70,2	s-s	0,9	9,5	1,5	29,4	41,9	0,18
	2	250-500	44	18	38	c		6,0	6,7	0,82	0,26	0,43	99,38	2,04	16,76	66,8	s-s	1,3	8,2	3,2	27,2	40.7	0,15
	3	500-750	26	41	36	cl		6,0	6,7	0,84	0,32	0,40	107,44	3,56	20,19	60,2	s-s	1,8	10,3	5,8	28,3	47,0	0,15
	4	750-999	92	2	6	s		5,7	6,7	0,28	0,26	0,35	16,11	0,43	25 65	74,0	s-s	0,2	6,4	1,5	23,9	32,3	0,23
V	1	0-250	36	40	24	ls		5,5	6,4	1,62	0,37	0,40	102,06	6,58	12,13	67,4	s-s	2,1	7,0	1,9	26,1	38,7	0,18
W	1	0-250	86	6	8	ls		5,7	6,3	1,20	0,44	0,20	94,01	4,51	3,25	5,4	ns ns	5,7	6,9	1,9	0,9	16,6	0,18
	2	250-500	86	6	8	ls		5,4	6,0	1,07	0,35	0,21	37,60	0,64	1,40	1,3	ns-ns	0,4	0,9	0,4	0,4	3,2	0,15
X	1	0-250	68	18	14	sl		5,1	5,8	1,46	0,32	0,21	51,03	2,78	1,09	66,2	ns-s	4,7	7,3	0,4	27,2	41,1	0,18
	2	250-500	72	14	14	cl		4,7	5,7	1,73	0,42	0,20	104,75	1,45	0,64	42,6	ns-s	1,1	3,6	.	4,3	10,1	0,15
Y	1	0-250	58	22	20	scl		6,1	6,6	1,13	0,31	0,25	94,01	6,65	0,85	1,1	ns-ns	8,7	7,6	0,5	0,2	18,1	0,33

clay fraction than sub-surface soils. The highest clay fraction was recorded for Sample G (69%) and the highest sand fraction for Sample W (80%).

Bulk density values ranged from 0,38g cm^{-3} to 1,47g cm^{-3}.

Field moist pH values ranged from 4,7 to 7,2 while air dry pH values ranged from 4,8 to 7,0. Reserve acidity values ranged from 0,8 me 100g^{-1} to 1,73me 100g^{-1}. Contributions to reserve acidities are made by aluminium, soluble sulphate and iron. The aluminium values ranged from 0,16me 100g^{-1} to 0,82me 100g^{-1},the soluble sulphate values ranged from 0,20me 100g^{-1} to 5,57me 100g^{-1} and the iron values ranged from 1,88me 100g^{-1} to 118,18me 100g^{-1}. Samples A to M had considerably lower iron contents than Samples N to Y.

Organic matter content ranged from 0,43% to 6,75%. Surface layers generally had higher organic matter content than sub-surface layers. Mangrove soils had higher organic matter content, especially in the sub-surface layers, than non-mangrove soils.

Using the criteria of electrical conductivity and exchangeable sodium percentage, soils were classified as mainly saline-sodic. Non-mangrove soils of the Athlone Island were classified as either non saline-non sodic or non saline-sodic.

The dominant cation at Mgeni Estuary was sodium. Values ranged from 0,2me 100g^{-1} to 78,3me 100g^{-1}. Other cation concentrations were:

calcium ranged from 0,1me $100g^{-1}$ to 8,7me $100g^{-1}$; magnesium ranged from 0,8me $100g^{-1}$ to 12,3me $100g^{-1}$ and potassium ranged from 0,0me $100g^{-1}$ to 13,4me $100g^{-1}$. Cation exchange capacity was high; values ranged from 3,2me $100g^{-1}$ to 103,0me $100g^{-1}$. Mangrove soils had higher cation exchange capacities than non-mangrove soils.

Available phosphorus concentrations ranged from 0,03µg ml^{-1} to 6,80µg ml^{-1}. Non-mangrove soils had lower concentrations than mangrove soils.

6.2.2 Mhlanga Estuary

The results of the analysis of soils of the Mhlanga Estuary are provided in Table 15.

Soils were generally sandy. Highest sand fractions were recorded for Samples D and G (99%) whereas the highest clay fractions were found in Samples A and B (10% to 28%).

Bulk density values ranged from 0,32g cm^{-3} to 0,73g cm^{-3}.

Field moist pH values ranged from 6,2 to 7,4 while that of air dried pH values ranged from 5,3 to 9,0. Reserve acidity values ranged from 0,02me $100g^{-1}$ to 0,87me $100g^{-1}$. Aluminium values ranged from 0,08me $100g^{-1}$ to 0,28me $100g^{-1}$, soluble sulphate values ranged from 4,03me $100g^{-1}$ to 26,86me $100g^{-1}$.

TABLE 15. Physical and Chemical Properties of Soils from Mhlanga Estuary. Key: PSD Particle Size Distribution; s sand; si silt; c clay; scl sandy clay loam; sl sandy loam; A bulk density in g cm^{-3}; FM field moist; AD air dried; B reserve acidity; C Al^{3+}; D soluble sulphate; E Fe as Fe_2O_3; OM organic matter; F Electrical Conductivity in S m^{-1} ($x\ 10^{-3}$) ; ESP exchangeable sodium percentage; G salinity classification; s-s saline-sodic; ns-ns non saline-non sodic; ns-s non saline-sodic; CEC cation exchange capacity; H available phosphorus in μg ml^{-1}.

SAMPLE	LAYER	DEPTH	PSD %			CLASS	A	pH H_2O		B	C	D	E	OM	F	ESP	G	Exchangeable Bases					H
		mm	s	si	c			FM	AD	me $100g^{-1}$				%				Ca me $100g^{-1}$	Mg	K	Na	CEC	
A	1	0-250	55	23	22	scl	0,32	7,4	6,0	0,72	0,26	0,65	22,83	6,79	37,47	49,5	s-s	26,2	4,9	3,7	34,8	70,3	0,35
	2	250-500	56	22	22	scl		6,9	6,0	0,14	0,10	0,69	13,43	6,89	33,67	80,3	s-s	6,2	0,8	3,6	43,5	54,2	1,13
B	1	0-250	66	12	22	scl	0,33	6,7	6,2	0,68	0,24	0,50	16,12	6,75	12,19	43,8	s-s	15 0	4,4	2,2	17,4	39,7	1,05
	2	250-500	55	17	28	scl		6,8	7,0	0,54	0,25	0,44	20,14	6,61	10,22	39,2	s-s	18,7	3.5	2,3	16,1	41,1	0,93
	3	500-750	83	7	10	sl		6,8	5,3	0,87	0,21	0,55	9,40	5,33	9,14	34,2	s-s	8,7	3,6	1,4	7,6	22,2	1,85
C	1	0-250	94	3	3	s		6,7	6,5	0,03	0,19	0,27	6,72	0,14	2,99	9,9	ns-ns	77,3	1,8	0,4	8,7	88.2	0,43
	2	250-500	94	4	2	s		6,9	6,7	0,06	0,10	0,35	5.37	0 32	1,70	9,6	ns-ns	67,3	3,9	0 1	7,6	79,0	0,35
	3	500-750	92	5	3	s		6,9	6,5	0,04	0,07	0,29	9,40	0,65	1,65	1,5	ns-ns	53,6	3,9	0,3	0,9	58,7	0,43
D	1	0-250	80	9	11	sl		6,9	6,5	0,28	0,22	0,26	21,49	2,04	1,16	18,4	ns-s	33,7	3,6	0,9	8,7	47,2	1,43
	2	250-500	98	.	2	s		7,4	9,0	0,07	0,08	0,32	8,06	0,32	0,92	11,5	ns-ns	71,1	3,6	0,3	9,8	84,9	0,68
	3	500-750	99	.	1	s		7,4	8,8	0,15	0,09	0,31	4,03	0,14	1,20	9,8	ns-ns	76,1	3,5	.	8,7	88,5	0,43
E	1	0-250	94	3	3	s	0,73	7,3	6,6	0,02	0,17	0,29	8,06	0,24	1,76	1,8	ns-ns	48,7	1,1	0,3	0,9	51,0	1,48
	2	250-500	96	2	2	s		7,3	6,7	0,03	0,08	0,28	12,09	0,10	1,24	1,6	ns-ns	62,4	5,4	0,3	1,1	69,2	0,35
F	1	0-250	70	14	16	sl		6,5	6,5	0,04	0,26	0,35	25,52	1,78	2,10	20,3	ns-s	27,5	4,7	1,5	8,7	42,8	1,70
	2	250-500	96	1	3	s		6,4	6,5	0,17	0,17	0,30	26,86	0,32	1,83	0,3	ns-ns	72,4	4,7	0,3	0,2	77,8	2,13
	3	500-750	97	1	2	s		6,6	7,4	0,14	0,20	0,38	24,17	0,21	0 86	0,8	ns-ns	10,0	2,9	0,3	0,1	13,4	2,78
G	1	0-250	99	.	1	s		6,2	7,2	0,04	0,16	0,36	9,40	0,14	2,98	0,8	ns ns	21,2	4,8	0,4	0,2	26,6	5,30
	2	250-500	97	1	2	s		7,0	7,2	0,06	0,13	0,24	9,67	0,17	1,06	0,8	ns-ns	34,9	0,3	0,3	0,9	36,2	2,68
H	1	0-250	79	9	12	sl		6,1	7,5	0,32	0,14	0,54	20,10	2,15	5,11	24,9	s-s	18,7	4,9	2,3	8,7	34,9	1,48
	2	250-500	73	13	14	sl		7,0	6,5	0,18	0,28	0,33	19,88	1,89	9,14	22,5	s-s	29,9	4,7	2,7	10,9	48,4	1,10

Organic matter content ranged from 0,10% to 6,89% and generally increased with increasing depth.

Soils were classified as saline-sodic and non saline-sodic.

Sodium and calcium were the dominant cations. Sodium values ranged from 0,16me $100g^{-1}$ to 43,5me $100g^{-1}$ and calcium values ranged from 6,2me $100g^{-1}$ to 77,3me $100g^{-1}$. Magnesium values ranged from 0,3me $100g^{-1}$ to 5,4me $100g^{-1}$ and potassium values ranged from 0,0me $100g^{-1}$ to 3,7me $100g^{-1}$. Cation exchange capacities were high and ranged from 13,4me $100g^{-1}$ to 88,5me $100g^{-1}$.

Available phosphorus concentrations ranged from 0,35μg ml^{-1} to 2,78μg ml^{-1}.

6.2.3 Mdloti Estuary

The results of the analysis of soils of the Mdloti Estuary are presented in Table 16.

Soils were predominantly sandy (Samples A to E) or had moderately high percentages of small sized fractions (Samples F to I) . Highest sand fraction was recorded for Sample A (96%) whereas the highest clay fraction was recorded for Sample B (45%) .

Bulk density values ranged from 0,62g cm^{-3} to 0,96g cm^{-3}.

TABLE 16. Physical and Chemical Properties of Soils from Mdloti Estuary. Key: PSD Particle Size Distribution; s sand; si silt; c clay; sl sandy loam; sc sandy clay; scl sandy clay loam; A bulk density in g cm^{-3}; FM field moist; AD air dried; B reserve acidity; C Al^{3+}; D soluble sulphate; E Fe as Fe_2O_3; OM organic matter; F Electrical Conductivity in S m^{-1}(x 10^{-3}) ; ESP exchangeable sodium percentage; G salinity classification; ns-s non saline-sodic; ns-ns non saline-non sodic; s-ns saline-non sodic; CEC cation exchange capacity; H available phosphorus in µg ml^{-1}.

SAMPLE	LAYER	DEPTH	PSD %			CLASS	A	pH		B	C	D	E	OM	F	ESP	G	Exchangeable Bases					H
		mm	s	si	c			H_2O			me 100g^{-1}			%				Ca	Mg	K	Na	CEC	
								FM	AD									me 100g^{-1}					
A	1	0-250	95	2	3	s		6,8	6,8	0,11	0,09	0,21	37,60	0,24	1,10	50,6	ns-s	1,6	2,1	0,5	4,4	8,7	2,53
	2	250-500	94	4	2	s		6,9	7,1	0,08	0,09	0,16	13,43	0,03	0,33	12,5	ns-ns	2,4	0,1	0,2	0,4	3,2	3,18
	3	500-750	96	1	3	s		7,2	6,9	0,08	0,20	0,26	14,77	0,14	0,33	53,2	ns-s	0,4	2,0	0,4	3,3	6,2	2,45
	4	750-999	96	1	3	s		7,2	6,5	0,42	0,15	0,19	13,43	0,50	1,82	78,4	ns-s	1,1	0,1	0,5	7,6	9,7	1,75
B	1	0-250	33	22	45	c	0,62	7,0	6,4	0,74	0,09	0,31	81,92	5,77	2,87	43,7	ns-s	3,9	5,0	5,0	0,6	18,1	0,55
	2	250-500	80	6	14	sl		7,4	5,8	0,54	0,26	0,30	21,49	0,94	4,00	9,4	s-ns	5,5	4,1	0,5	1,1	11,7	2,15
C	1	0-250	76	10	14	sl		7,5	6,0	0,44	0,26	0,23	28,86	0,87	1,96	46,6	ns-s	2,7	2,6	0,5	5,4	11,6	0,75
	2	250-500	99	.	1	s		7,3	6,8	0,10	0,18	0,23	14 77	0,43	0,55	36,0	ns-s	1,1	0,1	0,3	0,9	2,5	1,25
D	1	0-250	79	7	14	sl		7,2	6,2	0,38	0,21	0,34	42,98	1,49	0,95	42,2	ns-s	3,2	3,3	0,5	5,4	12,8	0,73
E	1	0-250	61	4	35	sc	0,96	7,1	6,4	0,60	0,21	0,24	73,86	2,88	0,64	51,6	ns-s	3,6	4,4	0,6	9,8	19,0	0,56
	2	250-500	91	3	6	s		7,0	6,9	0,20	0,13	0,28	26,86	0,87	0,47	5,9	ns-s	1,2	1,4	0,4	0,2	3,4	2,15
	3	500-750	91	4	5	s		7,1	6,9	0,17	0,07	0,23	29,55	0,54	0,65	8,0	ns-s	1,4	2,7	0,3	0,4	5,0	1,10
	4	750-999	88	7	5	s		7,2	6,7	0,29	0,11	0,23	18,80	1,60	4,06	12,0	s-ns	1,8	4,1	0,4	0,9	7,5	2,35
F	1	0-250	67	14	19	sl		7,2	6,5	0,40	0,24	0,24	55,06	1,67	3.24	17,2	ns-s	1,9	4,4	0,5	1,5	8,7	0,80
	2	250-500	55	17	28	scl		7,1	6,5	0,97	0,23	0,34	64,46	5,40	3,19	53,2	ns-s	3,2	3,3	0,5	9,1	17,1	0,38
	3	500-750	54	20	26	scl		7,1	5,9	1,42	0,21	0,49	38,95	3,79	2,99	63,5	ns s	1,8	3,2	0,6	9,8	19,2	0,65
G	1	0-250	27	45	28	scl		6,9	6,4	1,09	0,19	0,29	75,21	6,57	1,28	30,6	ns-s	4,7	4,5	0,6	4,8	15,7	0,65
	2	250-500	43	19	38	cl		7,2	6,0	0,72	0,25	0,22	59,09	2,95	0,33	34,9	ns-s	3,9	3,1	0,5	4,4	12,6	0,80
H	1	0-250	43	13	44	c		6,9	6,6	0,97	0,26	0,23	72,52	3,57	0,98	37,3	ns-s	4,6	3,4	0,6	5,7	15,3	0,55
	2	250-500	28	39	33	cl		6,9	6,6	0,92	0,21	0,21	71,18	3,76	1,08	36,2	ns-s	3,9	4,1	0,6	5,4	14,9	0,43
I	1	0-250	35	30	35	cl		6,8	6,7	0,72	0,15	0,26	68,49	3,61	0,48	8,4	ns-s	3,6	4,9	0,6	0,9	10,7	2,08
	2	250-500	26	32	42	c		7,2	6,5	0,85	0,19	0,19	65,81	2,95	0,38	51.6	ns-s	3,7	4,1	0,5	9,8	19,0	0,63

Field moist pH values ranged from 6,8 to 7,5 while that of air dried pH values ranged from 5,8 to 7,1. Reserve acidity values ranged from 0,08me $100g^{-1}$ to 0,26me $100g^{-1}$, Aluminium values ranged from 0,16me $100g^{-1}$ to 0,49me $100g^{-1}$ and iron values ranged from 13,43me $100g^{-1}$ to 81,92me $100g^{-1}$.

Organic matter content ranged from 0,03% to 6,57% and generally decreased with increasing depth.

Soils were classified as saline-non sodic, non saline-sodic and non saline-non sodic.

Sodium values ranged from 0,2me $100g^{-1}$ to 12,2me $100g^{-1}$, calcium values ranged from 0,4me $100g^{-1}$ to 5,5me $100g^{-1}$, magnesium values ranged from 0,1me $100g^{-1}$ to 5,0me $100g^{-1}$ and potassium values ranged from 0,2me $100g^{-1}$ to 5,0me $100g^{-1}$. Cation exchange capacities were generally low; values ranged from 3,2me $100g^{-1}$ to 14,2me $100g^{-1}$.

Available phosphorus levels ranged from o,38µg ml^{-1} to 3,18µg ml^{-1}.

6.3 DISCUSSION

In the system for the Soil Map of Africa (5th Draft), soils under mangrove vegetation (Ry 1,Rz 2 and Av) have been defined as "Juvenile soils or marine alluvium" belonging to the order of "weakly developed soils" (Giglioli and Thornton,1965). Other swamp soils associated with mangroves, but not frequently flooded

(Ses.,Te.,Kk.,Br and Ma) , and in which the profile has become differentiated because the uppermost horizons dry out during part or the whole of the year, fall into the order of "Halomorphic soils". They are further divided into "saline" and "saline-alkali soils", depending on exchangeable sodium percentage (Giglioli and Thornton, 1965) .

6.3.1 Particle Size Distribution and Bulk Density

Texture is determined by the depth and frequency of flooding and the rate of water flow when the soils are flooded (Giglioli and Thornton, 1965) . The composition of sediments is determined by various geogenetic parameters including climate, mineralogy of coastal areas and frequency of tidal inundation (Naidoo,1980) .

Marked differences exist between the particle size distribution of the study sites. At Mgeni Estuary differences exist between tidally inundated and non-inundated soils. The differences between the study sites also reflect major textural differences between mangrove and non-mangrove soils. The increased percentage of small size fractions at Mgeni Estuary and Mdloti Estuary than at Mhlanga Estuary is ascribed to greater erosion, larger catchments and the parental rock of those rivers.

Mangroves at Mgeni Estuary are found in predominantly clay soils although a wide variety of textural classes have been recorded elsewhere (Giglioli and Thornton,1965; Clarke and Hannon,1967;

Diemont and Wijngaarden,1974; Coultas,1978; Mukherjee and Mukherjee, 1978). Similar sandy soils, as those of Mhlanga and Mdloti estuaries, for tidal marsh soils have been recorded elsewhere (Coultas,1969; 1970; Coultas and Gross,1975; Coultas *et.al.*,1979; Darmody and Foss, 1979; Coultas,1980).

Profile development was lacking in the samples taken. This is ascribed to the large size of the sample cores. Tidal action at Mgeni Estuary mixes the fine sized fractions, especially in the surface layers (Naidoo,1980).

Bulk density increases with an increasing percentage of coarse fractions. The low bulk density values for Mhlanga and Mdloti estuaries, despite their sandy soils, are due to the high organic matter content and the presence of roots in the surface layers. A low bulk density with a high clay content is indicative of excessive shrinkage which would occur upon draining (Coultas and Calhoun,1976). Other values recorded for mangrove soils (van Breemen,1976; Naidoo,1980; Naidoo and Raiman, 1982) and those for tidal marsh soils (Coultas,1969; Coultas and Calhoun,1976) are similar to those recorded for Mgeni, Mhlanga and Mdloti estuaries respectively.

6.3.2 Acid Properties

Changes in pH have been related to soluble sulphate content (Tho and Egashira,1976), high levels of sulphur (Coultas and Calhoun,1976) and salinity (McMillan,1974). Contributions to acidity are made by aluminium and hydrogen ions (Pitty,1978). Generally in marine sediments, sulphur from seawater is reduced forming sulphide which oxidizes to sulphate on exposure to air drying (Fleming and Alexander,1961). Ferric iron acts as an intermediate oxidant (van Breemen,1973).

pH values, in this report, are in the ranges recorded by other workers for mangrove and tidal marsh soils (Watts,1960; Fleming and Alexander,1961; Thornton and Giglioli,1965; Diemont and Wijngaarden, 1974; Coultas and Gross,1975; van Breemen,1976; Coultas and Calhoun, 1976). Acidity increase, following air drying, is not in keeping with most other reports. This increase is related to the presence of alkaline earth carbonates and to the minimal tidal inundation of those soils, especially for the soils of Athlone Island at Mgeni Estuary and at Mhlanga and Mdloti estuaries.

pH values at Mhlanga and Mdloti estuaries were higher than at Mgeni Estuary. This is due to the presence of alkaline earth carbonates in beach sand at Mhlanga and Mdloti estuaries. At Mgeni Estuary the expected high acidity is neutralized by the presence of basic cations in tidal waters.

Aluminium, soluble sulphate and iron values were higher than those previously recorded for Mgeni and Mdloti estuaries (Naidoo,1980; Naidoo and Raiman,1982). Low sulphate values and high iron values for Samples N to Y at Mgeni Estuary are considered to reflect the infrequency of tidal inundation and genesis from Natal red loams. A further indication is the general decrease in iron content with depth at the study sites as marine sediments are approached.

6.3.3 Organic Matter and Salinity

Soils at Mgeni Estuary had high organic matter content in all layers except for elevated soils at Athlone Island. Soils at Mhlanga and Mdloti estuaries had high organic matter content in the surface layers. This is related to clay content, vegetation and the mixing activity by crabs at Mgeni Estuary. Non-penetration due to a permanently high water table at Mhlanga and Mdloti estuaries is responsible for high organic matter content. Closed mouth conditions at these two sites allow for *in situ* decomposition and retention of organic matter, although stronger flushing by flood waters occurs at Mdloti Estuary. Strong tidal flushing for samples close to water-courses is responsible for the non-accumulation of organic matter and the lower content in the surface layers at Mgeni Estuary. Organic matter content has been related also to silting rates in intertidal swamps (Naidoo,1980), to water movement (Simpson *et.al.*,1972) and to fine clay content in the uppermost soil horizons (Martel *et.al.*,1978).

Generally for the study area high organic matter content was related to a higher percentage of small sized fractions. The generally higher content at Mgeni Estuary than at the other two sites is related to the contribution made by vegetation and to differences in clay content. Samples at Mhlanga and Mdloti estuaries displayed a decreasing content with increased depth as have been previously recorded elsewhere (van Breemen,1976; Coultas,1978; Rosenfeld,1979) .

Soil salinity is primarily influenced by tidal inundation, distance from water-courses and exposure. Soils at Mgeni Estuary were saline except for those above tidal influence. Non-mangrove soils not subject to regular tidal inundation are due to the raising of the water-table during tidal inundation, the exposed sample sites resulting in capillary action bringing salts up to the surface layers and evaporation. Saline soils at Mhlanga and Mdloti estuaries were weakly saline and were generally located in sheltered parts of the estuaries and at greater depths than those of Mgeni Estuary. The lack of tidal inundation at Mhlanga and Mdloti estuaries is responsible for the non-saline soils while the lack of either freshwater or tidal flushing is responsible for weakly saline soils in sheltered locations. The non-sodic soils at these two sites is also an indication of the lack of tidal influence.

6.3.4 Exchangeable Cations, Cation Exchange Capacity and Available Phosphorus

Sodium was the dominant cation at Mgeni Estuary, sodium and calcium had similar values at Mhlanga Estuary and sodium, calcium and magnesium had similar values at Mdloti Estuary. A high concentration of sodium and magnesium were reported by Coultas (1969; 1970), Coover *et. al.* (1975), Coultas and Calhoun (1976) and Naidoo (1980), while high concentrations of calcium and magnesium were reported by Tho and Egashira (1976) and high concentrations of calcium and sodium were reported by Coultas and Gross (1975) for tidally inundated soils. The high concentration of these ions is indicative of their high concentrations in seawater.

Calcium and potassium concentrations decreased with increasing distance from the sea with increased elevation. Greater dilution from freshwater sources occurs landwards. The greater dilution at Mhlanga Estuary than at the other two sites, due to abiotic catchment characteristics, is most likely responsible for the higher calcium values recorded there. Potassium concentrations for mangrove soils at Mgeni Estuary were higher than previously recorded values (Naidoo, 1980; Naidoo and Raiman,1982) .

Cation exchange capacities were related to clay and organic matter content and contributions made by vegetation for the study area. The cation exchange capacities of soils at Mhlanga Estuary were surprisingly high although soils were predominantly sandy. Martel *et.al.* (1978) indicated that sand sometimes makes important contribution to the cation exchange capacity as well as silt, inorganic particles and surface area. The cation exchange capacity at Mdloti Estuary was low and related to the high sand and low organic matter content especially in the surface layers.

Phosphorus values were higher at Mhlanga and Mdloti estuaries than at Mgeni Estuary and this is related to possible inputs by the use of phosphate fertilizers on sugar cane farms in the lower catchments of these rivers. The weakly alkaline soils at Mhlanga and Mdloti estuaries reduced phosphorus fixation by iron and aluminium.

Contributions at Mgeni Estuary are made by the Sea Cow Lake Sewage Works; soils at lower elevation having higher concentrations than the elevated soils of Athlone Island.

Phosphorus concentrations at Mgeni Estuary increased with decreased particle size (Simpson *et.al.*,1972) .

CHAPTER 7

VEGETATION

7.1 METHODS

A reconnaissance of the study area was undertaken and an initial checklist of estuarine vascular plants was completed.

Vegetation analysis was based on the Braun-Blanquet phytosociological approach (Werger,1974a; 1974b) and the Point-Centred Quarter Method (Mueller-Dombois and Ellenberg,1974) .

Varying numbers of quadrats of different sizes were laid out at the different study sites. These were placed subjectively in considered physiognomic homogeneous stands. Homogeneity was assessed with the aid of aerial photographs and reconnaissance work. Heterogeneous, ecotonal and narrow fringing stands were not sampled. The method does not require a constant plot size although plot size was constant in physiognomically distinct areas. Nested quadrats were laid out and from species-area curves (Werger *et.al.*,1972) and, in the case of woody vegetation, from density-area curves, quadrat sizes were determined. These are represented in Fig.20.

The distribution of the quadrats at the three study sites is represented in Fig.21. At Mgeni Estuary, 230 quadrats of which 181 for woody vegetation were 25m^2 and 49 for herbaceous vegetation were 4m^2 were

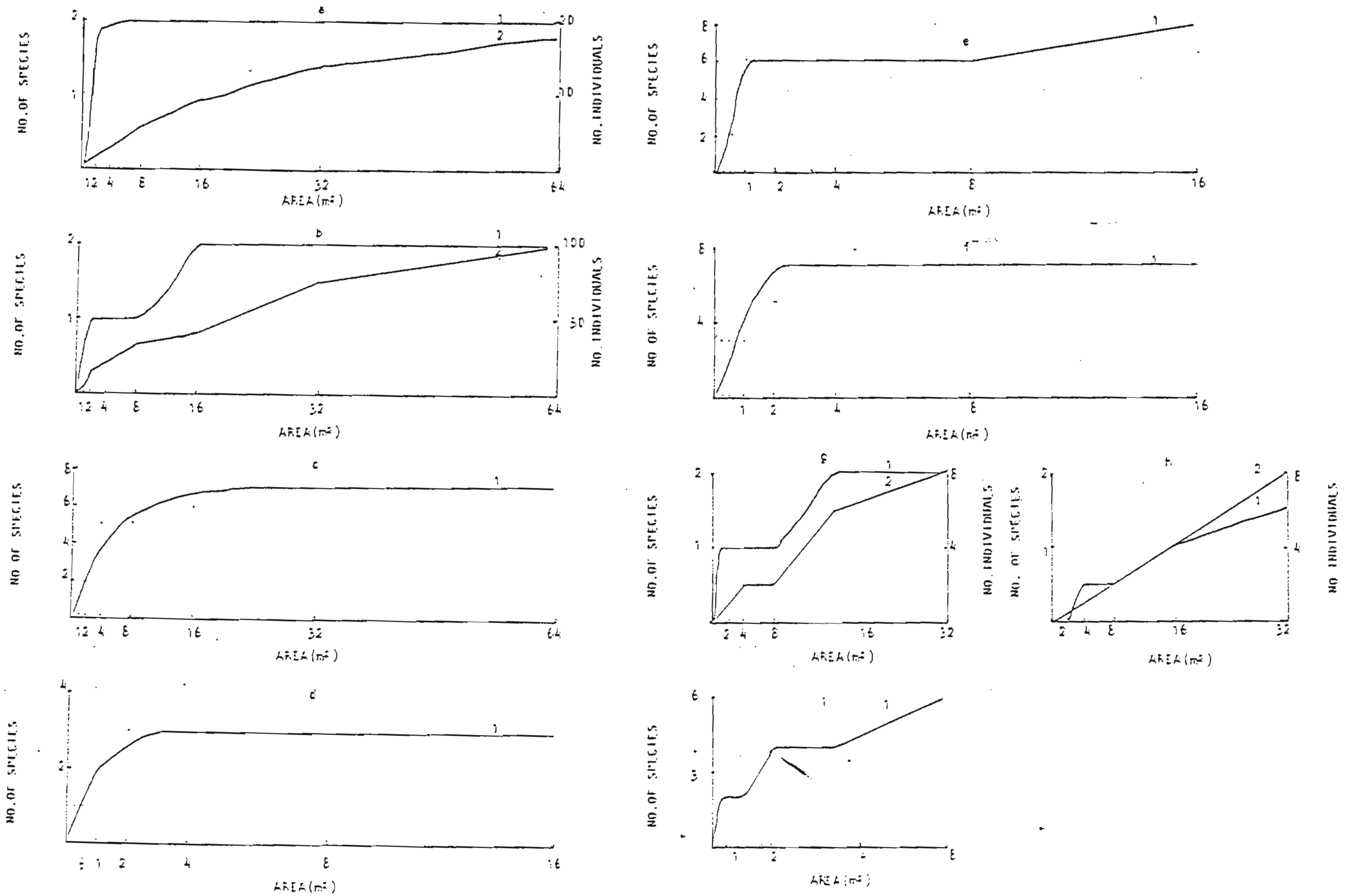

FIG. 20. Species-Area (1) and Density-Area (2) Curves for the study area: Mgeni (a - c); Mhlanga (d - f); Mdloti (g - i). Key: a *Avicennia marina* stand; b *Bruguiera gymnorrhiza* stand; c *Schinus terebinthifolius* stand; d *Echinochloa pyramidalis* stand; e *Phragmites australis* stand; f mixed herb stand; g & h *Barringtonia racemosa* stand; i mixed herb stand.

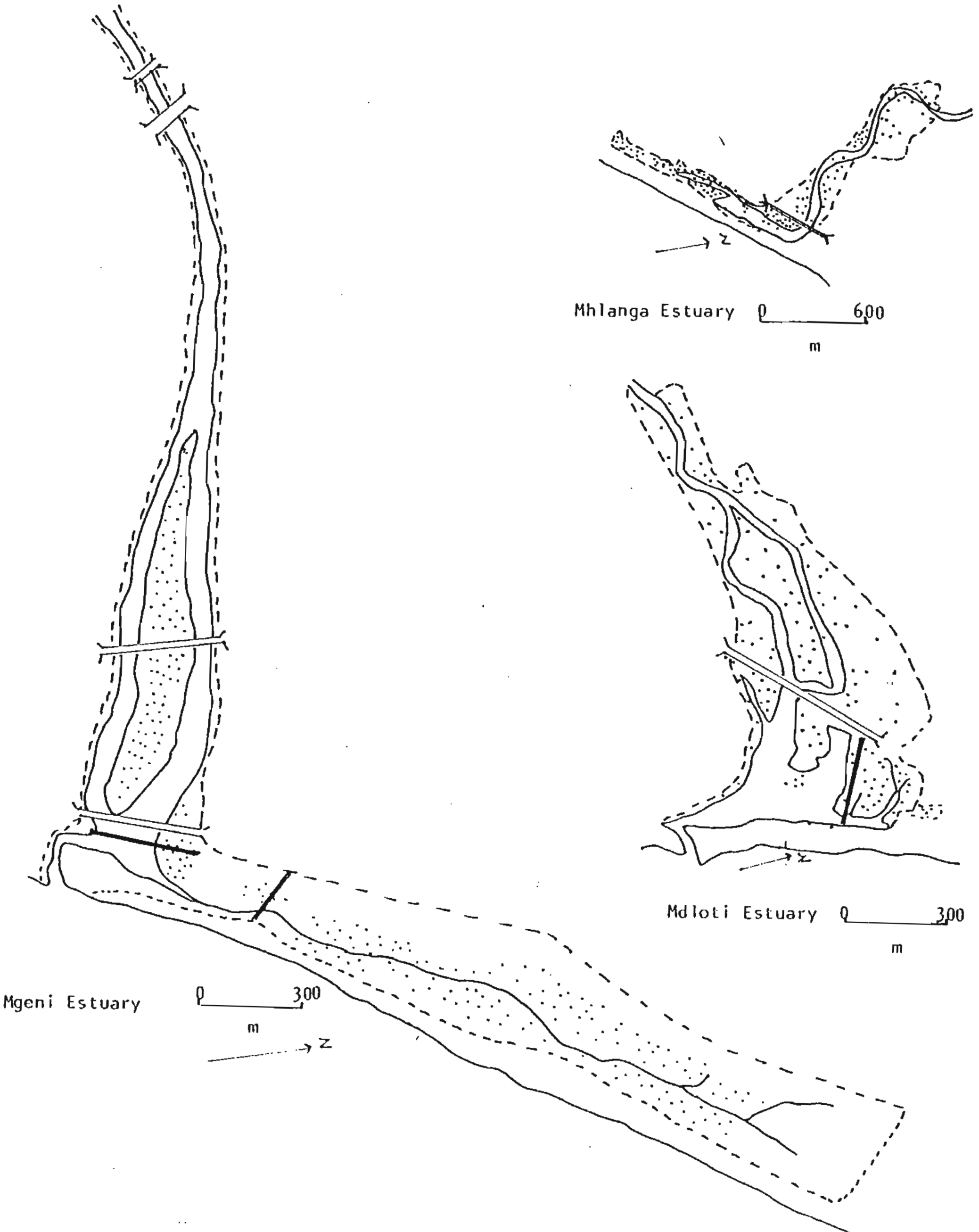

FIG. 21. Distribution of quadrats and transects in the study area.

Key: ——— Shorelines; - - - - - Site boundary; • quadrat;

•———•Transect.

placed. At Mhlanga Estuary, 114 quadrats of which 6 at 25m^2, 103 at 4m^2 and 5 at 1m^2 were placed. At Mdloti Estuary, 122 quadrats of which 38 at 25m^2 and 84 at 4m^2 were placed.

The following variables are reflected in the association table: releve number, quadrat size, aspect, soil type, total number of species and cover-abundance for all as well as individual species. The cover-abundance values are in accordance with the Braun-Blanquet cover-abundance scale (Braun-Blanquet,1932) . Fidelity (Braun-Blanquet,1932) and constancy (Werger,1974b) of individual species is reflected in the tables. These scales are summarized below:

Cover-abundance scale: r rare with negligible cover; usually single specimen;
+ present with a small cover, not abundant;
1 cover between 1%-5%, few individuals;
2 cover between 5%-25%, independent of abundance;
3 cover between 25%-50%, independent of abundance;
4 cover between 50%-75%, independent of abundance;
5 cover between 75%-100%, independent of abundance.

Fidelity scale: 5 exclusive taxa;
4 selective taxa;
3 preferential taxa;
2 indifferent taxa;
1 strange taxa.

Constancy scale:
I 1%-20% presence;
II 21%-40% presence;
III 41%-60% presence;
IV 61%-80% presence;
V 81%-100% presence.

In addition to the above mentioned phytosociological attributes, a count per plot of mangrove individuals and frequency of all plants was determined from the quadrats.

Re-arrangement and synthesis of the raw data was completed according to Mueller-Dombois and Ellenberg (1974) .

At Mgeni Estuary, on the banks of the Mgeni River, species in the intertidal area were assessed on the basis of constancy values. Values were based on the occurrence within a 50m section of the bank, of variable width, divided into 5 x 10m segments. Data are presented in a series of histograms.

At selected sites at Mgeni Estuary and Mdloti Estuary, belt transects were laid. These belts were analysed as a series of contiguous 1 x 1m quadrats. In each quadrat all plants were counted, the heights measured and the position of the bases recorded. Each quadrat was levelled to a common datum using a Fuji-Koh Sunray S-302 automatic level. The data are presented as a histogram of cover values, as topographic and canopy profiles and as a plot of recorded bases. Tabulated data are not re-arranged. Observed vegetation was divided into zones along the transect on the basis of species composition, cover and height of plants. Transect positions are shown in Fig. 21.

Mangrove species for both quadrat and transect analyses are differentiated into tall (greater than 100cm) and short (less than or equal to 100cm, but having at least the first photosynthetic leaves) individuals.

The Point-Centred Quarter Method was employed for woody mangrove vegetation at Mgeni Estuary and woody vegetation at Mdloti Estuary. Points were taken along a traverse within considered homogeneous stands such that no specimen was sampled twice. Measurements were made to the centre of the trees, the heights, diameter at breast height and circumference at breast height (140cm) were taken. Density, frequency and dominance were calculated.

Vegetation was mapped for the three sites with the aid of aerial photographs covering a period of approximately 50 years. A Bausch and Lomb Stereo Zoom Transfer Scope was used in the completion of the maps using orthophotos as the base.

7.2 RESULTS

Results of quadrat analysis at Mgeni Estuary are represented in Tables 17, 18, 19, 20 and Fig.22. These provide the basic data for the description of vegetation types depicted in Fig.23. Table 17 represents the association table in which 67 species occurred in 230 quadrats.

TABLE 17.Cover-Abundance of Plant Species at Mgeni Estuary as recorded in two hundred and thirty releves.Releves are between one and five metres in altitude on flat surfaces. Key: s sand; c clay; F Frequency; C Constancy; Fi Fidelity.

Releve No.(O)	1 2 1 1 3 8 3 7 1 1 4 9 7 8 1 1 2 2 5 6 2 2 2 1 3 2 2 3 3 3 2 4 4 4 4 4 1 1 2 2 2 2 2 2 2 2 2 2 2 1 1 2 2 1 1 1 2 2 1 1 1 1 1 1 2 2 2 1 1 1 1 1 2 1 4 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2
	3 1 4 3 6 2 5 8 1 8 4 0 6 3 0 9 7 2 2 2 7 0 8 2 7 8 9 9 2 3 4 5 6 0 0 1 1 1 1 1 2 2 2 2 2 6 7 0 0 5 9 9 0 0 0 2 0 2 1 2 3 0 0 0 1 0 2 2 2 0 0 9 0 9 8 8 9 5 4 9 8 6 9 9 7 7 6 8 7 9 8 7 6 8 7 6 6 7 6 6 4 4 5 5 5 5 5 6 8 8 4 6 8 8 9 5 7 7 7 0 0 1 1 1 2 2 3
	5 3 1 0 1 7 2 3 3 4 5 7 8 9 2 5 6 8 9 6 9 6 0 6 4 5 1 2 7 7 5 1 7 0 2 4 5 7 0 9 2 8 3 6 3 4 8 1 0 7 0 9 6 9 1 3 1 7 6 7 2 3 0 4 2 2 5 0 5 8 1 0 3 5 6 7 1 2 3 4 7 9 5 4 3 6 8 9 7 8 2 8 4 8 5 8 9 0 1 2 6 3 4 0
	2 3 3 4 5 7 8 9 2 5 6 8 9 6 9 6 0 6 4 5 1 2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 3
Releve No.(N)	1-5 6-10 1 1to1 1 1 2 2 2to2 2to2 3 3 3 3to4 4 4 4 4 4 4 4to5 5 5 5 5 5 5to6 7to7 7to1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 2
	1 2 7 8 9 0 1 2 5 6 9 0 1 2 3 1 2 3 4 5 6 7 8 9 2 3 4 5 6 7 8 9 0 8 9 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 3 3 3 3 3 3 3 3 3 3 4 4 4to5 5 5 5 5 5 6 6 6 6 6 6 6 6 6 6 7 7 7 7 7 7 7 7 7 7 8 8 8 8 8 8 8 8 8 8 9 9 9 9 9 9 9 9 9 9 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 3
	3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0
Total No.of Species	1 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 1 3 3 3 3 4 2 4 4 4 2 2 1 1 1 3 3 3 4 5 7 6 1 8 1 6 5 6 5 6 6 5 6 5 7 6 1 7 7 1 2 2 3 3 2 2 2 4 3 5 3 2 2 2 2 3 6 3 1 5 6 5 3 6 8 6 3 3 4 4 4 4 4 4 6 6 6 7 8 6 8 5 5 5 3 5 7 5 2 6 2 5 4 4 4 4 6 7 3 6 6 5 4 4 8 5 6 6 8 7 9 8 2 6 5 4
	0 2
Size(m²)	25 25 2 25 2 2 2 2 25 25 2 2 2 25 2 2 2 2 2 2 2 25 2 2 2 2 2 25 25 25 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 4 4 4 4 4 4 4 4 4 4 2 2 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 2 4 2 2 2 2 2 4 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
	5 5
Soil	s/c sc c c c c c c c c c c c c c c c c c c c c c c c c c c c c c c c c c c c c c c c c c c c c c c c c c c c c c s s
Altitude(m)	1-2 1-2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2-3 3 3 3 2 2 2 2 2 2 2 2 3 3 3 3 3 3 3 3 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5
Total Cover	5 4 5 5 5 5 5 5 5 5 4 4 3 5 3 3 2 4 5 5 5 5 4 4 5 5 5 5 5 5 5 5 5 5 4 3 3 3 3 4 3 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 3 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 2 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5

SPECIES		F %	C	Fi
Avicennia marina	5 4 5 5 5 5 4 4 4 3 3 3 2 3 2 2 1 2 3 3 3 2 + + 2 2 2 1 + 2 + + + + + 2 1 2 2 1 2 2	40	II	3
Bruguiera gymnorrhiza	+ 1 2 3 2 2 1 2 1 1 1 3 2 2 1 3 4 4 4 4 4 4 5 5 5 5 5 5 5 5 5 5 3 2 2 1 2 1 2 2 2	45	III	3
Acrostichum aureum	3 3 2 1	2	I	4
Ipomoea cairica	1 1 2 1 3 3 2 1 3 5 2 3 5 4 1 2 1 1 1	6	I	3
Sarcocornia natalensis	1 1 2 3 3 3 3 4	4	I	4
Juncus kraussii	1 + 1 5 5 5 5 2 1 + 1 2	4	I	4
Stenotaphrum secundatum	1 1 4 5 5 1 3 2 2 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 1	17	I	3
Phragmites australis	+ 1 1 2 1 1 2 1 3 + + 3 2 2 2 1 + + 3 2 2 2 2 2 1 1 1	7	I	4
Ipomoea congesta	1 1 + 5 5 4 2 2 3 2 2 3 2 2 2 3 + 1 1 2 2 + + 3 + 1 1 1 2	19	I	3
Commelina diffusa	+ 1 1 2 + 1 1 1 + + 1 1 1 1 1 1 1 + 1 1 + + 1 1 + 1 2 2 2 2 3	10	I	3
Asystasia gangetica	1 1 1 + 1 2 3 + 1 + 1 + + 2	6	I	3
Typha capensis	1 2 2 1 2 2 2 2 1 1 + + + + 3 3 2 1 2	4	I	4
Colocasia antiquorum	3 3 5 4 3 2	2	I	4
Momordica involucrata	1 1 1	1	I	3
Scirpus sp.	1 1 1 1 1 + + 1 1 1 1	4	I	3
Centella asiatica	2 1 1 1 2 2	3	I	4
Desmodium canum	1 1 +	2	I	3
Rhynchelytrum repens	1 4 4	1	I	3
Hypoxis rooperi	2 1 2	1	I	3
Panicum maximum	1 1	1	I	3
Chromolaena odorata	1 1 2 2 2 3 4 1 2 3 1 1 2 3 2 3 2 3 3 4 3 3 2 3 3 3 2 3 3 2 2 1 1 3 1 + + 1 1 1 2 1 2 + 2 2 2 + 2 2 2 3 2 1	23	II	3
Lantana camara	1 3 1 1 2 2 1 3 + + 2 5 3 4 3 3 1 3 4 2 3 + 2 2 2 3 + 1 1 2 1 1 2 + + 1 3 3 3 2 2 3 1 3 1 2	20	I	3
Hewittia sublobata	1 2 3 1 1 1 + 2 + 1 1 1 + 1 + + + + + 1 1	9	I	3
Cardiospermum grandiflorum	+ 1 + 2 2 2 1 + + + 2 1 2 1 1 2 2 2 + 2 1 + 2 2 2 2 +	11	I	3
Schinus terebinthifolius	1 1 4 3 5 5 5 5 5 4 4 4 4 3 3 3 3 3 2 2 2 1 3 2 2	12	I	3
Bridelia micrantha	+ 3 + 2 1 2 3 3 2	3	I	3
Indet.Coll.No.1885	1 2 2 + 1 2 3 2 + +	4	I	3
Melia azedarach	+ 1 + 1 1 + 1 2 3 2 +	4	I	3
Brachylaena discolor	1 + 3 3 2 + + 1 2	4	I	3
Cynodon dactylon	2 1 1 2	1	I	3
Setaria megaphylla	1 + 1 + + 2	4	I	3
Amaranthus sp.	1 3 3 1 2 1	1	I	3
Ficus natalensis	3 + + 1	2	I	3
Phoenix reclinata	1 1 1	1	I	4
Ricinus communis	+ 1 2 1	2	I	3
Melanthera scandens	2 1	1	I	3
Opuntia vulgaris	1	1	I	3
Sesbania punicea	+	1	I	3
Hydrocotyle bonariensis	1	1	I	4
Carpobrotus dimidiatus	2 2	1	I	3
Ludwigia octovalvis		1	I	4
Passerina rigida	2	1	I	4
Chrysanthemoides monilifera	+ 1 2	2	I	3
Ageratum conyzoides	1 2 1	1	I	3
Helianthus argophyllus	2 1 +	1	I	3
Cassia didymobotrya	1 1 1	1	I	3
Strelitzia nicolai	2 2	1	I	3
Acacia mearnsii	1	1	I	4
Erythrina lysistemon	1 1	1	I	4
Morus alba	4 3 4 3	2	I	3
Hibiscus tiliaceus	1 1	1	I	3
Mimusops caffra		1	I	4
Canna indica	1 1	1	I	3
Polygonum salicifolium	1	1	I	4
Bidens pilosa	+	1	I	3
Thelypteris dentata	1 1 2	1	I	3
Pavonia patens	1	1	I	3
Equisetum ramosissimum	+			

The list of infrequent species includes the following: Eichhornia crassipes, Zornia capensis, Alternanthera sessilis, Solanum acanthoideum, Cyperus sphaerospermus, Asclepias physocarpa, Solanum mauritianum, Trema orientalis, Protasparagus falcatus.

TABLE 18. Count per plot of *Avicennia marina* and *Bruguiera gymnorrhiza* as recorded for community demarcations of Table 17. Plants are distinguished as being either tall (greater than 1m) or as being short (less than or equal to 1m). Original relevé numbers are listed. All plots are 25m².

Relevé No.	3	5	31	134	136	1	6	12	104	111	135	2	34	60	114	115	144	21	143	13	36	11	99	108	139	4	10	35	100	8	32	7	14	33
A.marina-tall	14	46	12	10	20	10	4	3	4	11	12	6	10	18	10	15	9	7	9		26	2	4	8	17	4	2	27	9	9	18	11	4	10
A.marina-short	10	20				40			4			18			2					4						5	10			2		2	30	
B.gymnorrhiza-tall														10	2	2	3	30	15	12	13	7	1	1	3	10	5	11	13		7	2	34	30
B.gymnorrhiza-short											1	4	5		1						12			3			1			2			25	

Relevé No.	80	81	83	85	113	141	142	15	18	41	9	78	84	101	63	82	95	112	16	23	20	59	67	47	50	51	58	61	62	64	71	72	73	79	88	140
A.marina-tall	3	6	4	3	1	5	1	17	12	1	2	7	5	8	6	3	3	2	1		14	5	2		2	1	2		3	2	2	1	2	1		1
A.marina-short																								1												
B.gymnorrhiza-tall	7	9	22	13	10	15	8	5	9	3	4	16	18	19	28	9	20	6	50	40	26	30	29	27	42	22	11	99	21	21	53	17	34	17	28	40
B.gymnorrhiza-short																				30			2	30		20		1					2			

Relevé No.	48	49	65	66	70	76	77	96	94	97	75	89	90	91	92	93	86	87	98	19	24	25	26	27	52	53	54	55	56	57	68	69	74	220	221	227
A.marina -tall				1																																
A.marina -short																																				
B.gymnorrhiza -tall	37	42	35	31	15	18	26	20	17	11	13	55	50	17	27	32	34	69	12	50	60	75	96	73	23	50	42	31	33	99	39	19	19	10	15	13
B.gymnorrhiza -short					1																				20		5			1				15	12	80

Relevé No.	17	30	28	22	37	38	39	29	208	209	210	211	212	223	224	230	Total	Density ha^{-1}
A.marina -tall	16	6				2		38	3	5	5	2	7	1	1	2	598	1957
A.marina -short				15	11		2										176	577
B.gymnorrhiza -tall	17	7	7		2	6								2	2	3	2373	7790
B.gymnorrhiza -short																20	293	961

TABLE 19. Rearranged count per plot of *Avicennia marina* and *Bruguiera gymnorrhiza*. Plants are distinguished as being either tall (greater than 1m) or as being short (less than or equal to 1m). Original relevé numbers listed. All plots are 25m².

Relevé No.	39	22	113	1	3	104	9	211	12	208	6	209	210	212	134	111	31	136	29	34	135	2	8	4	7	114	14	10	36	51	67	73	108
A.marina-tall			1	10	14	4	46	2	3	3	4	5	5	7	10	11	12	20	38	10	12	6	9	4	11	10	4	2	26	1	2	2	8
A.marina-short	2	15	10	40	10	4	20															18	2	5	2	2	30	10					
B.gymnorrhiza-tall																								10	2	2	24	5	13	22	29	34	1
B.gymnorrhiza-short																				5	1	4	2			1	25	1	12	20	2	2	3

Relevé No.	230	47	9	11	15	16	17	18	20	21	30	32	33	35	38	41	50	58	59	60	62	63	64	66	71	72	78	79	80	81	82	83	84	85	95	99
A.marina-tall	2		3	2	17	1	16	12	14	7	6	18	10	27	2	1	2	2	5	18	3	6	2	1	2	1	7	1	3	6	3	4	5	3	3	4
A.marina -short		1																																		
B.gymnorrhiza-tall	3	27	4	7	5	50	17	9	26	30	7	7	30	11	6	3	42	11	30	10	21	28	21	31	53	17	16	17	7	9	9	22	18	13	20	1
*B.gymnorrhiza*short	20	30																																		

Relevé No.	100	101	112	115	139	140	141	142	143	144	223	224	98	23	37	93	52	54	57	61	70	220	221	227	19	24	25	26	27	28	48	49
A.marina-tall	9	8	2	15	17	1	5	1	9	9	1	1																				
A.marina-short																																
B.gymnorrhiza-tall	13	19	6	2	3	40	15	8	15	3	2	2	12	40	11	4	23	42	99	99	15	10	15	13	50	60	75	96	73	7	37	42
B.gymnorrhiza-short														30	2	12	20	5	1	1	1	15	12	80								

Relevé No.	53	55	56	65	68	69	74	75	76	77	86	87	88	89	90	91	92	93	94	96	97
A.marina-tall																					
A.marina-short																					
B.gymnorrhiza-tall	50	31	33	35	39	19	19	13	18	26	34	69	28	55	30	17	27	32	17	20	11
*B.gymnorrhiza*short																					

TABLE 20 . Constancy values for species within sixteen distinguished communities at Mgeni Estuary. Key: 1 Pure *Avicennia marina* Community; 2 Dominant *A.marina* Community; 3 Mixed *A.marina-Bruguiera gymnorrhiza* Community; 4 Dominant *B.gymnorrhiza* Community; 5 Pure *B.gymnorrhiza* Community; 6 *Sarcocornia natalensis* Community; 7 *Juncus kraussii* Community; 8 Hygrophilous Fringe Community; 9 Pure *Stenotaphrum secundatum* Community; 10 Dominant *S.secundatum* Community; 11 *S.secundatum-Phragmites australis* Community; 12 Mixed *P.australis* Community; 13 *Chromolaena odorata-Lantana camara* Community; 14 *Schinus terebinthifolius* Community; 15 *Avicennia marina-Bridelia micrantha* Community; 16 *Hibiscus tiliaceus* Community.

	COMMUNITIES															
SPECIES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Avicennia marina	V	V	V	V		V									V	II
Bruguiera gymnorrhiza		V	V	V	V	IV										IV
Acrostichum aureum					I			I								
Ipomoea cairica					I			III								
Sarcocornia natalensis						V										
Juncus kraussii						II	V									II
Stenotaphrum secundatum						I	III	I	V	V	V	I				
Phragmites australis						I	I	III			V	V				II
Ipomoea congesta							III	IV		I		IV	II	II	V	
Commelina diffusa							I	II		II	I	II	I	II	I	
Asystasia gangetica								I		I	I		I		IV	
Typha capensis								II				I				
Colocasia antiquorum								II								
Momordica involucrata								I								
Scirpus sp.								I		III	I	II				
Centella asiatica								I		I	I					
Desmodium canum								I		I	I					
Rhynchelytrum repens								I			I					
Hypoxis rooperi								I		I						
Panicum maximum										I						
Chromolaena odorata								III				III	V	V	II	
Lantana camara								II				III	V	IV	II	
Hewittia sublobata								I				III	II	II		
Cardiospermum grandiflorum								I				II	IV	II		
Schinus terebinthifolius								I				II	I	V	I	II
Bridelia micrantha														I	V	
Indet.Coll.No.1885								I					II	I		
Melia azedarach								I					II	I	I	
Brachylaena discolor												I	II	I		II
Cynodon dactylon								I					I			
Setaria megaphylla													II		III	
Amaranthus sp.													I			
Ficus natalensis								I				I			II	
Phoenix reclinata													I	I		
Ricinus communis								I					I			
Melanthera scandens																II
Opuntia vulgaris													I	II		
Sesbania punicea								I								
Hydrocotyle bonariensis								I								
Carpobrotus dimidiatus								I								
Ludwigia octovalvis								I				I				
Passerina rigida								I								
Chrysanthemoides monilifera								I					I			
Ageratum conyzoides								I								
Helianthus argophyllus														I		
Cassia didymobotrya													I	I		
Strelitzia nicolai													I	I		
Acacia mearnsii													I			
Erythrina lysistemon								I								
Morus alba													I			
Hibiscus tiliaceus								I								V
Mimusops caffra																II
Canna indica								I								
Polygonum salicifolium								I								
Bidens pilosa								I								
Thelypteris dentata								I								
Pavonia patens								I								
Equisetum ramosissimum								I								

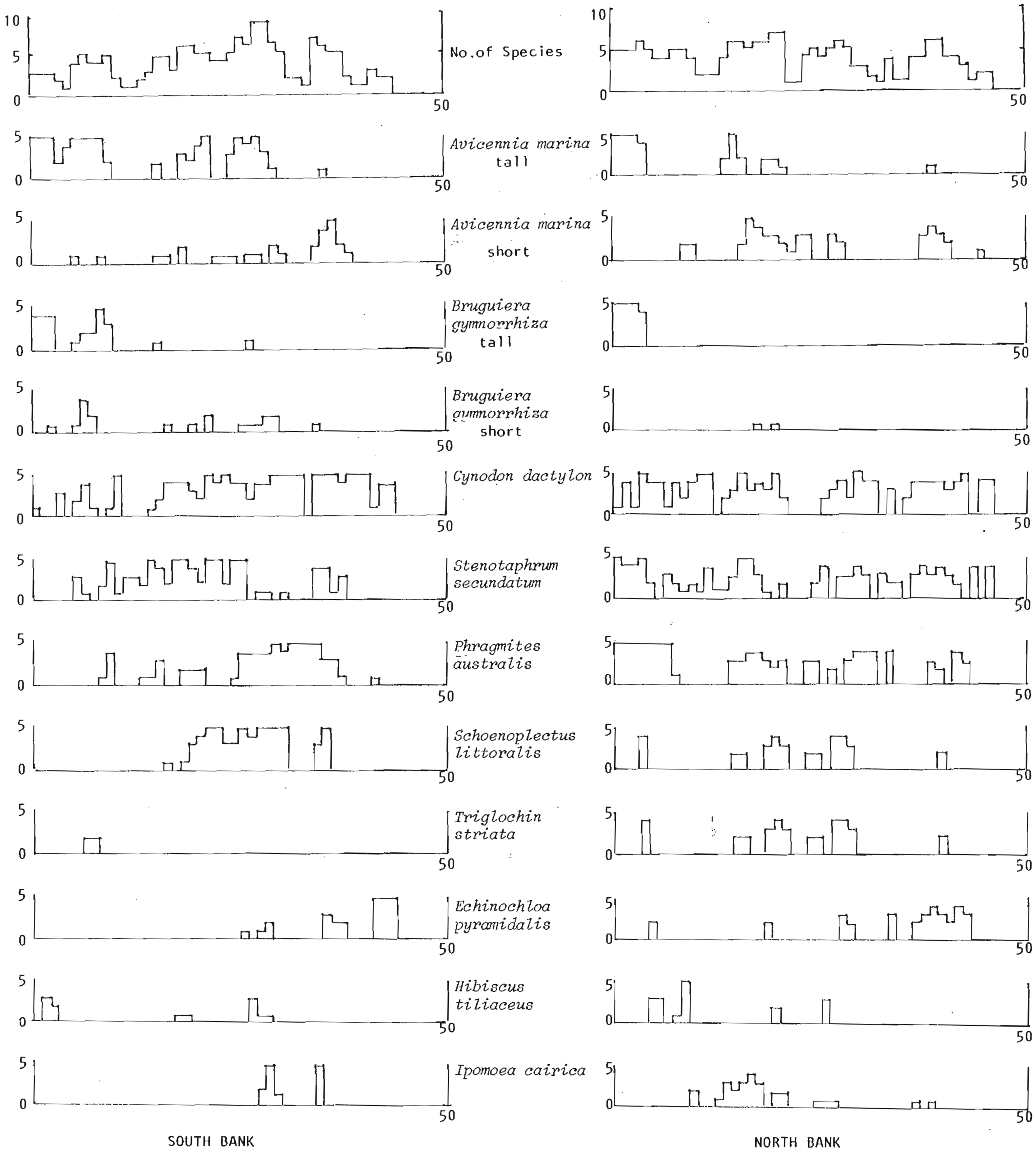

FIG. 22. Species on the South bank and north bank of the Mgeni River as recorded on a scale of 0-5 representing presence in 10m segments of each 50m section. A total of 44 and 46 fifty-metre sections were recorded on the south and north banks respectively starting from beneath the Ellis Brown Viaduct westward to beyond the Railway Bridge.

Species of low presence in the intertidal area include the following: Asystasia gangetica, Ageratum conyzoides, Commelina diffusa, Hewittia sublobata, Atriplex patula, Aneilema aequinoctiale, Scirpus sp., Typha capensis, Ludwigia octovalvis, Sesbania punicea, Canna indica, Alternanthera sessilis.

FIG. 23. Vegetation map based on quadrat analysis for Mgeni Estuary. Other major vegetation types are indicated. Key: ▥ Pure *Avicennia marina* Community; ▥ Dominant *A.marina* Community; ▤ Pure *Bruguiera gymnorrhiza* Community; ▤ Dominant *B.gymnorrhiza* Community; ⊞ Mixed mangrove stands; ∵ *Sarcocornia natalensis* Community; ♦ *Stenotaphrum secundatum* Community, ● *Phragmites australis* Community; ○ *A.marina-Bridelia micrantha* Community; ■ *Hibiscus tiliaceus* Community; ▨ Hygrophilous Fringe; □ Mesophytic thicket; ◇ Coast Forest and precursors; ∴ dune stands; ◇ *Juncus kraussii* Community; ▬ fence at Rocket Hut Beach.

This represents approximately 45% of the total number of species recorded at that study site. The count of individuals per plot is represented for the community demarcations in Table 18 for mangrove species. Table 19 represents the same data in a re-arranged table. Table 20 represents constancy values in the 16 distinguished communities. Approximately 0,7% of the study site was sampled. Fig. 22 represents the occurrence and constancy of species on both banks of the Mgeni River. Fig.23 is a vegetation map based on the above data. Physiognomic distinctions based on aerial photography are also included in this figure.

Data from Transect 1 at Mgeni Estuary are reflected in Tables 21 and 22 and in Figs. 24 and 25. A count per plot of mangrove plants is reflected in Table 21 for the distinguished vegetation zones. Table 22 represents constancy within the vegetation zones. Fig. 24 represents topographical and vegetation profiles in relation to tidal inundation as observed at that site. Total cover and contributions to cover values by mangrove species is also represented (Fig. 24) . Fig. 25 represents a belt transect indicating bases. Observed vegetation is divided into 7 zones which are discontinuous in some places.

Data from Transect 2 at Mgeni Estuary are reflected in Tables 23 and 24 and in Figs. 26 and 27. A count per plot is reflected in Table 23 for the distinguished vegetation zones. Table 24 represents constancy within vegetation zones. Fig. 26 represents topographical and vegetation profiles in relation to tidal inundation as observed at that site. Total cover and contributions to cover values by the more frequently occurring species is also represented (Fig. 26) . Fig. 27 represents

TABLE 21. Count per plot of *Avicennia marina* and *Bruguiera gymnorrhiza* in 1m x 1m contiguous quadrats of Transect 1 at Mgeni Estuary. Plants are regarded as either tall (greater than 1m) or short (less than or equal to 1m) .

Quadrat No.	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
B.gymnorrhiza-tall	1	2	1	5	7	5	3	5	4	5	4	1	4	1	1	4	4	1	4	1	2	7	4	1	1	1	1		7	6	1		
B.gymnorrhiza-short			7	7	3	6	1	8	8	6	1		7	5	2			2	3	6	2			2	2	3	4	1	2		1	1	10
A.marina-tall																																	
A.marina-short																																	

Quadrat No.	38	39	43	44	45	46	47	48	51	52	53	54	55	56	57	60	63	73	74	75	76	77	78	79	80	81	82	84	85	86	88
B.gymnorrhiza-tall	1					1	1	1					2	4	1		1	1	2	4	2	1	5	12	2	1	2	1	2	1	1
B.gymnorrhiza-short			1		1	2			1	3																					
A.marina-tall					2					1	1					1															
A.marina-short	4	1		2	1					4	3	2				1															

Quadrat No.	91	93	94	95	101	111	112	113	129	130	131	132	135	136	140	141	142	145	146	147	148	149	150	151
B.gymnorrhiza-tall	1	1		1				1																
B.gymnorrhiza-short	1		3		1	1							1					1						
A.marina-tall							3	1	4	3	2	2		2		3	1	1			1		1	1
A.marina-short						2									1				1	2	2	2		1

Quadrat No.	152	154	155	159	160	163	165	169	171	172	173	176	177	178	179
B.gymnorrhiza-tall															
B.gymnorrhiza-short															
A.marina -tall		1	1	2	1		1	1	2	1	1		1	1	2
A.marina-short	1					6		2				1			

TABLE 22. Constancy values in vegetation zones of Transect 1 at Mgeni Estuary. Key: 1 Mesophytic herb zone; 2 short *B.gymnorrhiza* zone; 3 short *B.gymnorrhiza-A.marina* zone; 4 tall *B.gymnorrhiza* zone; 5 tall *B.gymnorrhiza* zone with *A.marina* understorey; 6 tall *A.marina* zone; 7 short *A.marina* zone

	ZONES						
SPECIES	1	2	3	4	5	6	7
Cynodon dactylon	I						
Hewittia sublobata	I						
Ipomoea cairica	I						
Commelina diffusa	I						
Bruguiera gymnorrhiza		V	IV	V	V	I	
Avicennia marina			IV		V	V	V

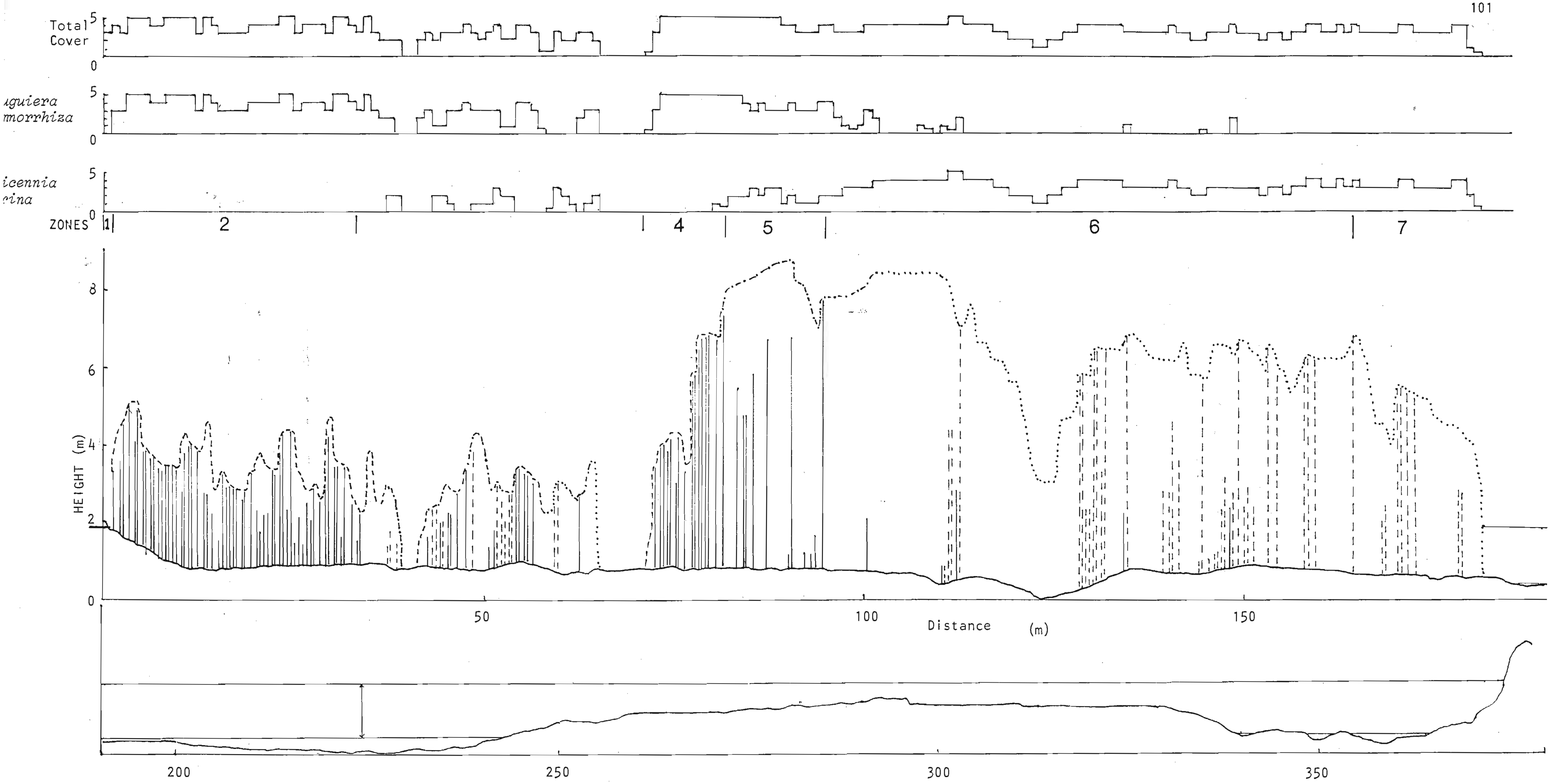

FIG. 24. Topographical and vegetation profile with total cover and contributing cover values by *Avicennia marina* and *Bruguiera gymnorrhiza*. Tidal inundation for a high equinoctial spring tide (upper line) and a low equinoctial tide (lower line) are indicated. The canopy is formed by trees outside the transect. Refer to Table 22 for Zones 1-7. Key: *Avicennia marina* trees ┆ ; *A.marina* canopy ······· ; *Bruguiera gymnorrhiza* trees | ; *B.gymnorrhiza* canopy – – – – – ; Mixed canopy –·–·–·–· .

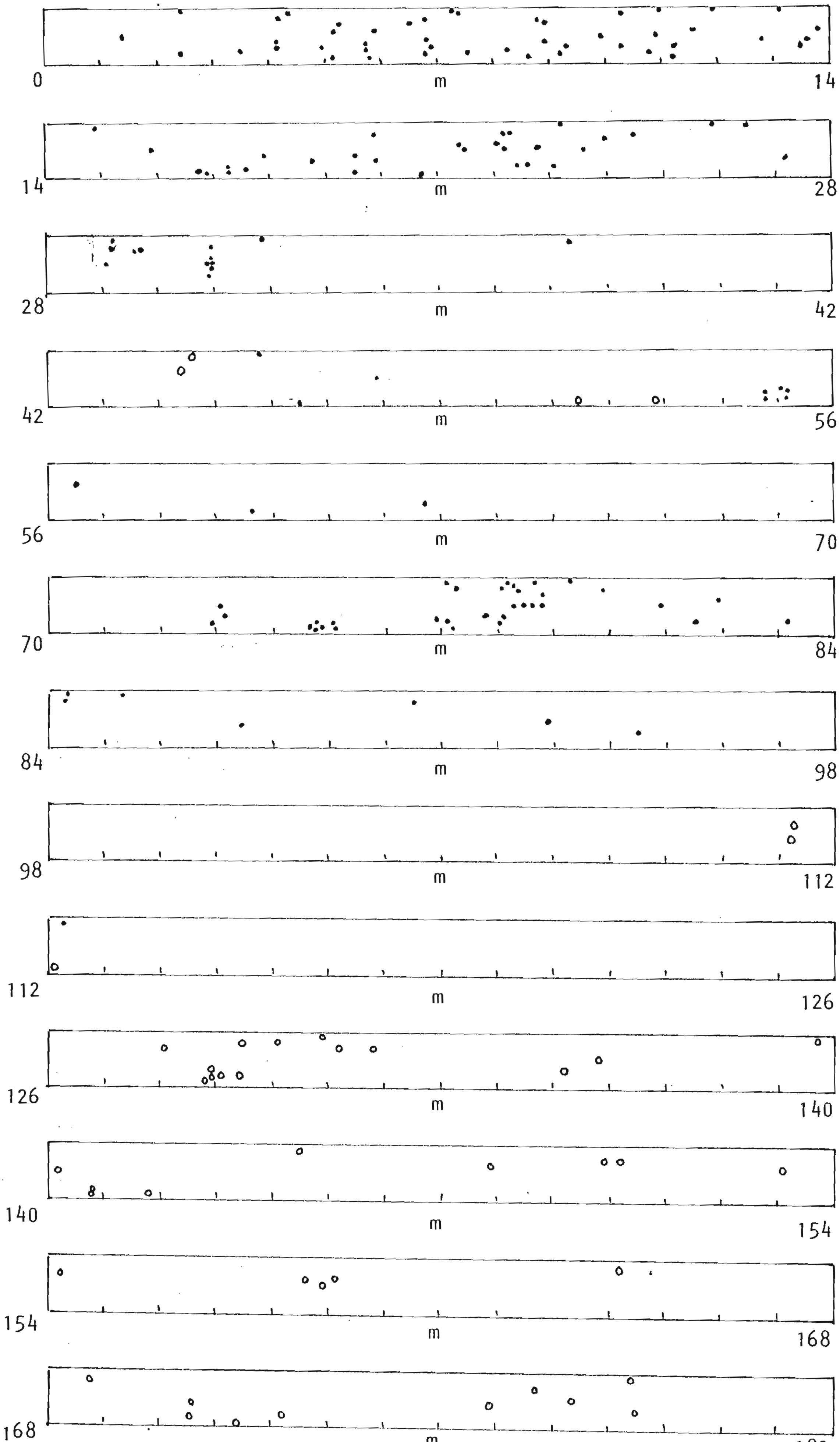

FIG.25. Position of bases of *Avicennia marina*(○) and *Bruguiera gymnorrhiza*(•) along Transect 1.

TABLE 23.Count per plot of mangrove plants in 1m x 1m contiguous quadrats of Transect 2 at Mgeni Estuary.Plants are regarded as either tall(greater than 1m)or short(less than or equal to 1m).

Quadrat No.Original	60	72	74	75	76	108	109	110	111	112	114	115	116	117	118	119	120	121	125	126	127	128
Bruguiera gymnorrhiza-tall						12	2	1	7	5	1	2	4	3	2	3	2	1	1	3	3	1
B.gymnorrhiza-short	1		1	1		4													2		2	
Avicennia marina-tall																						
A.marina-short		1			1																	

Quadrat No.Original	129	133	135
B.gymnorrhiza-tall	1	4	2
B.gymnorrhiza-short		2	
A.marina-tall			
A.marina-short			

TABLE 24: Constancy values in vegetation zones of Transect 2 at Mgeni Estuary. Key: 1 *S.secundatum* zone; 2 *J.kraussii* zone; 3 *B.gymmorrhiza* zone; 4 *A.marina* zone

	ZONES			
SPECIES	1	2	3	4
Chrysanthemoides monilifera	II			
Panicum maximum	II			
Commelina diffusa	II			
Stenotaphrum secundatum	V			
Phragmites australis	I	II	I	
Centella asiatica	III			
Juncus kraussii		V		
Bruguiera gymmorrhiza		I	V	
Avicennia marina		I		V

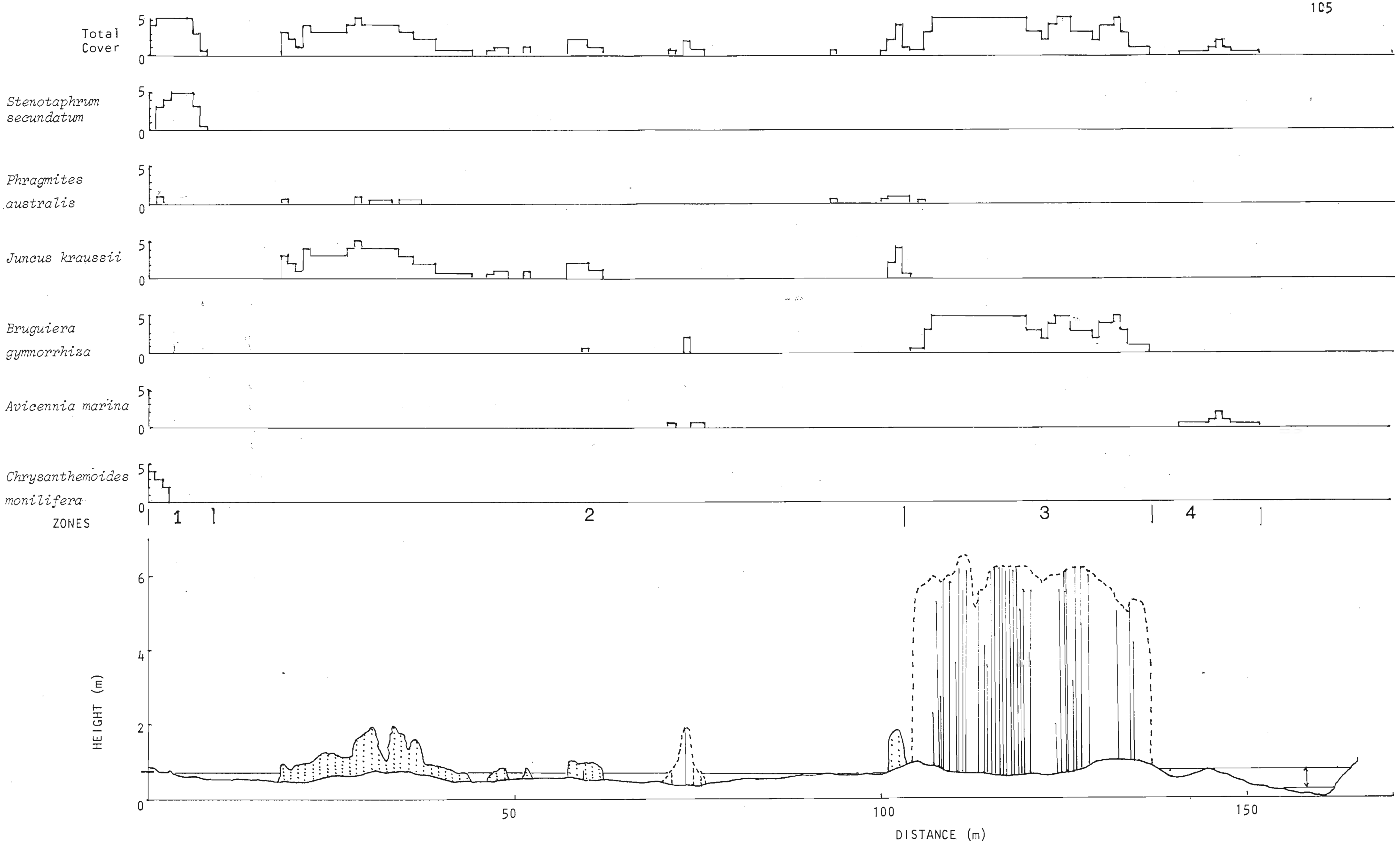

FIG. 26. Topographical and vegetation profile of Transect 2 at Mgeni Estuary. Total cover and contributing cover values are indicated. Tidal inundation for a high equinoctial spring tide (upper line) and a low equinoctial tide (lower line) are indicated. The canopy is formed by trees outside the transect. Refer to Table 24 for Zones 1-4. Key: *Juncus kraussii* ⁝ ; *J.kraussii* canopy ⌒ ; *Avicennia marina* trees ¦ ; *Bruguiera gymnorrhiza* trees | ; *B.gymnorrhiza* canopy – – – – – .

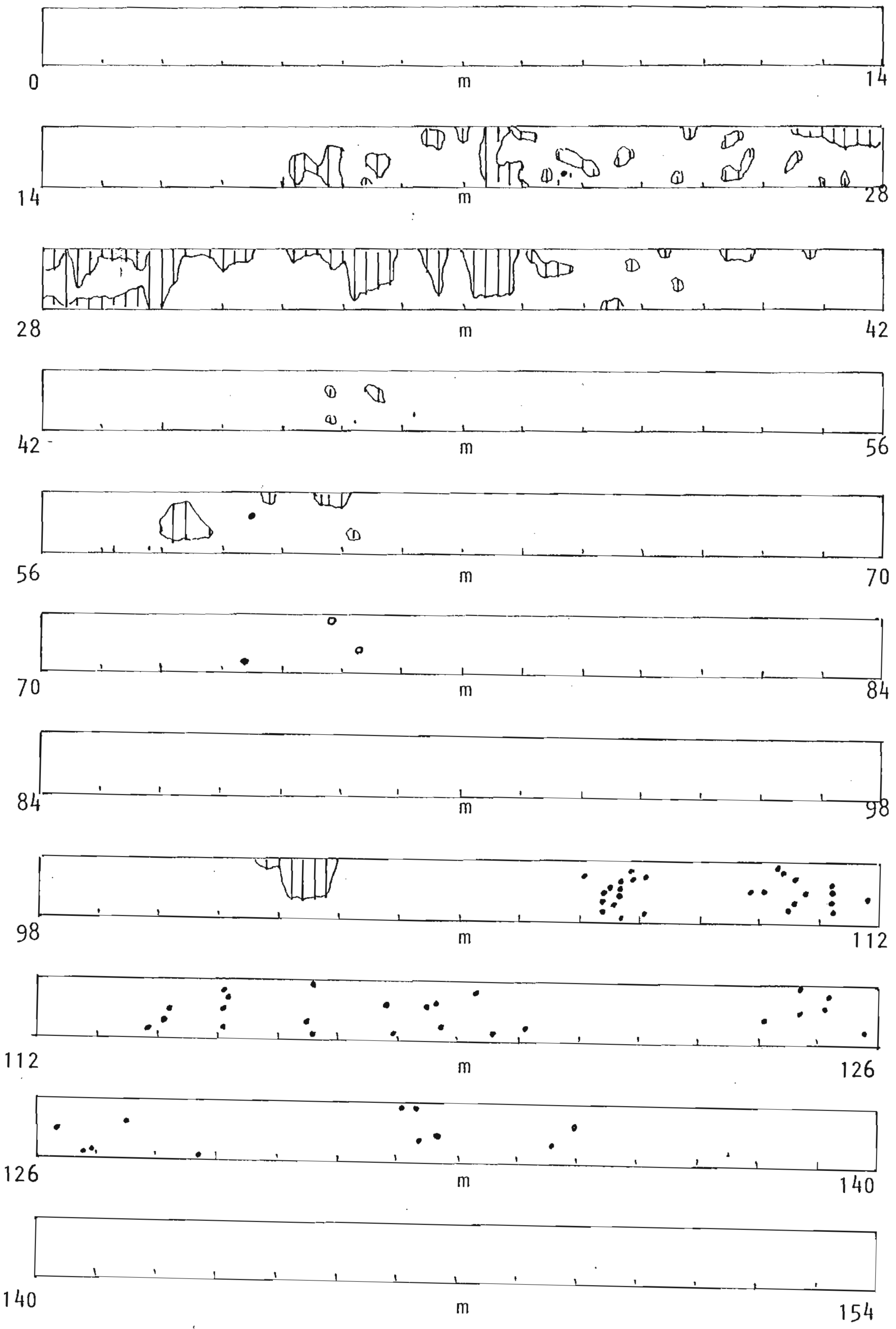

FIG.27.Position of bases of *Juncus kraussii*(◫),*Avicennia marina*(○) and *Bruguiera gymnorrhiza* (•)along Transect 2.

a belt transect indicating bases. Observed vegetation is divided into four zones which are discontinuous in some places.

Results from the Point-Centred Quarter analysis at Mgeni Estuary are reflected in Table 25.

In addition to a vegetation map, historical maps drawn from aerial photographs for 1949, 1961, 1970 and 1976 for Mgeni Estuary are shown in Fig. 28a - d.

Results of the quadrat analysis at Mhlanga Estuary are presented in Tables 26, 27 and 28. These provide the basic data for the description of the vegetation types depicted in Fig. 29. Table 26 represents the association table in which 26 species occurred in 114 quadrats. This represents approximately 37% of the total number of species recorded at that study site. Table 27 represents a count per plot of *Bruguiera gymnorrhiza*. Table 28 represents constancy values in the 7 distinguished communities. Approximately 0,6% of the study site was sampled. Fig. 29 is a vegetation map based on the above data. Physiognomic distinctions based on aerial photography are also included in this figure. Apart from the vegetation map, historical maps drawn from aerial photographs for 1937, 1953, 1968 and 1976 are shown in Fig. 30a - d.

Results of the quadrat analysis at Mdloti Estuary are presented in Tables 29, 30, 31 and 32. These provide the basic data for the description of the vegetation types depicted in Fig. 31. Table 29 represents the association table in which 32 species occurred in 122 quadrats. This represents approximately 34% of the total number of

TABLE 25. Point-Centred Quarter Analysis for Mgeni Estuary. Key: A number of quarters; B number of points; C total distance; E total basal area; F mean basal area; I.V. Importance Value ((Rel.Density+Rel.Frequency+Rel.Dominance)/3); Abs., Absolute; Rel., Relative.

Locality	Species	A	B	C (m)	D (m)	DENSITY (ha^{-1})		FREQUENCY (%)		E (cm^{-2})	F (cm^{-2})	DOMINANCE (m^{-2})	(ha^{-1})	I.V.
						Abs.	Rel.	Abs.	Rel.			Abs.	Rel.	
Beachwood/Mgeni Confluence	Avicennia marina	61	18	211,58	3,47	669,4	76	90,00	67	9138,12	149,81	10,03	92	78
	Bruguiera gymnorrhiza	19	9	58,42	3,07	208,5	24	45,00	33	758,21	39,91	0,83	8	22
	Total	80	20	270,00	3,38	877,9	100	135,00	100	9896,33		10,86	100	100
West of Creek, below footbridge	Bruguiera gymnorrhiza (= Total)	80	20	109,79	1,37	5309,5	100	100,00	100	2099,33	26,24	13,93	100	100
East of Creek, above footbridge	Avicennia marina	197	110	295,19	1,50	1066,8	21	45,83	32	47746,34	242,37	25,86	50	34
	Bruguiera gymnorrhiza	763	237	1036,27	1,36	4131,8	79	98,75	68	47074,36	61,70	25,49	50	66
	Total	960	240	1331,46	1,39	5198,8	100	144,58	100	94820,70		51,35	100	100
West of Creek, above footbridge	Avicennia marina	64	42	65,77	1,03	605,6	8	21,54	18	11398,28	178,10	10,79	24	17
	Bruguiera gymnorrhiza	716	193	842,15	1,18	6775,0	92	98,97	82	35881,96	50,11	33,95	76	83
	Total	780	195	907,92	1,16	7380,6	100	120,51	100	47280,24		44,74	100	100
East and west of Creek (Total Creek)	Avicennia marina	261	152	360,96	1,38	905,6	15	34,94	26	59144,62	226,61	20,52	42	28
	Bruguiera gymnorrhiza	1479	430	1878,42	1,27	5131,7	85	98,85	74	82956,32	56,09	28,78	58	72
	Total	1740	435	2239,38	1,29	6037,3	100	133,79	100	142100,94		49,30	100	100
Athlone Island	A.marina (= Total)	80	20	123,90	1,55	4168,8	100	100,00	100	8838,88	110,49	46,06	100	100
TOTAL	Avicennia marina	402	190	696,44	1,73	1057,8	20	38,38	29	77121,62	191,84	20,29	47	32
	Bruguiera gymnorrhiza	1578	459	2046,63	1,30	4152,3	80	92,73	71	85814,02	54,38	22,58	53	68
	Total	1980	495	2743,07	1,39	5210,1	100	131,11	100	162935,64		42,87	100	100

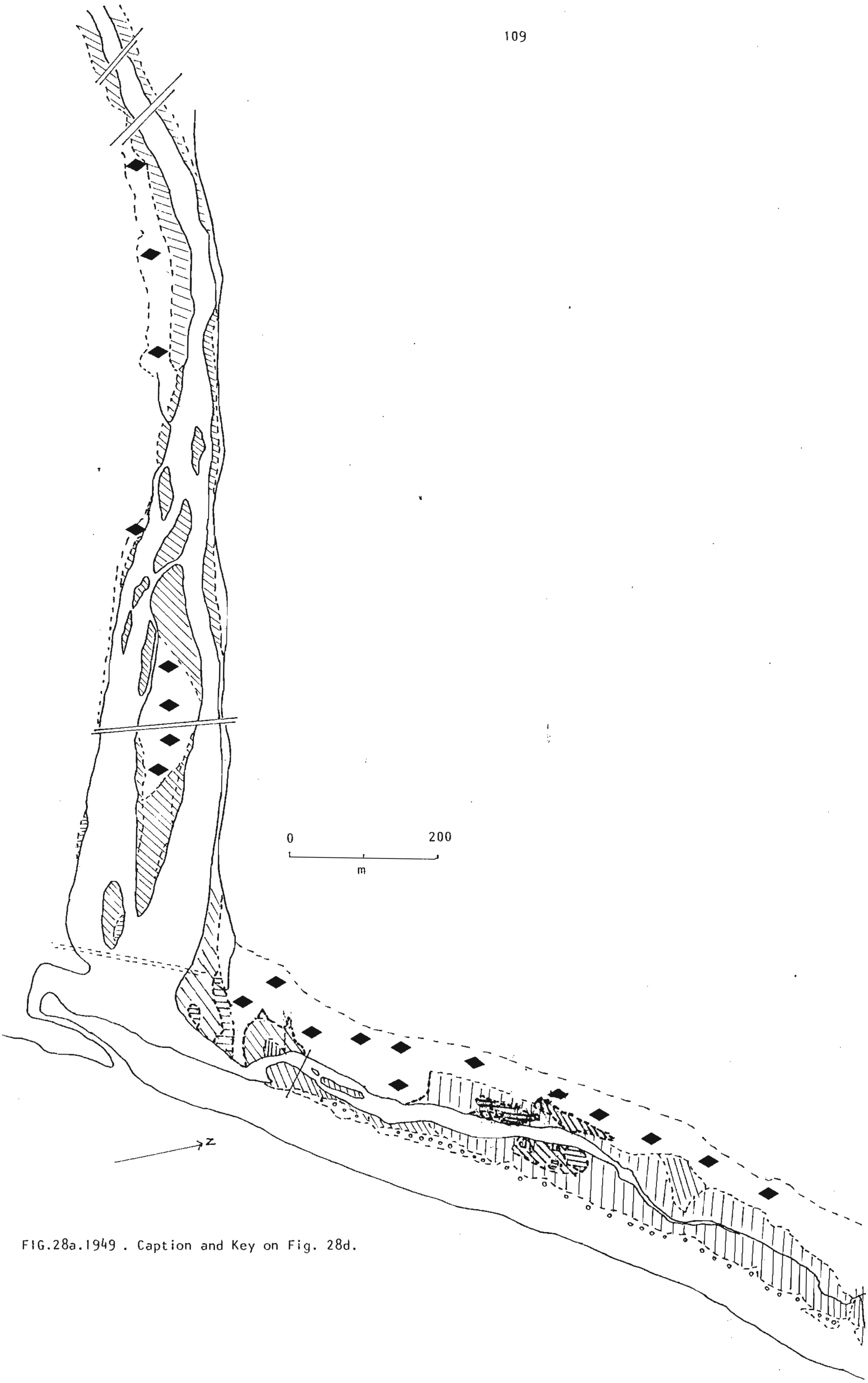

FIG.28a.1949 . Caption and Key on Fig. 28d.

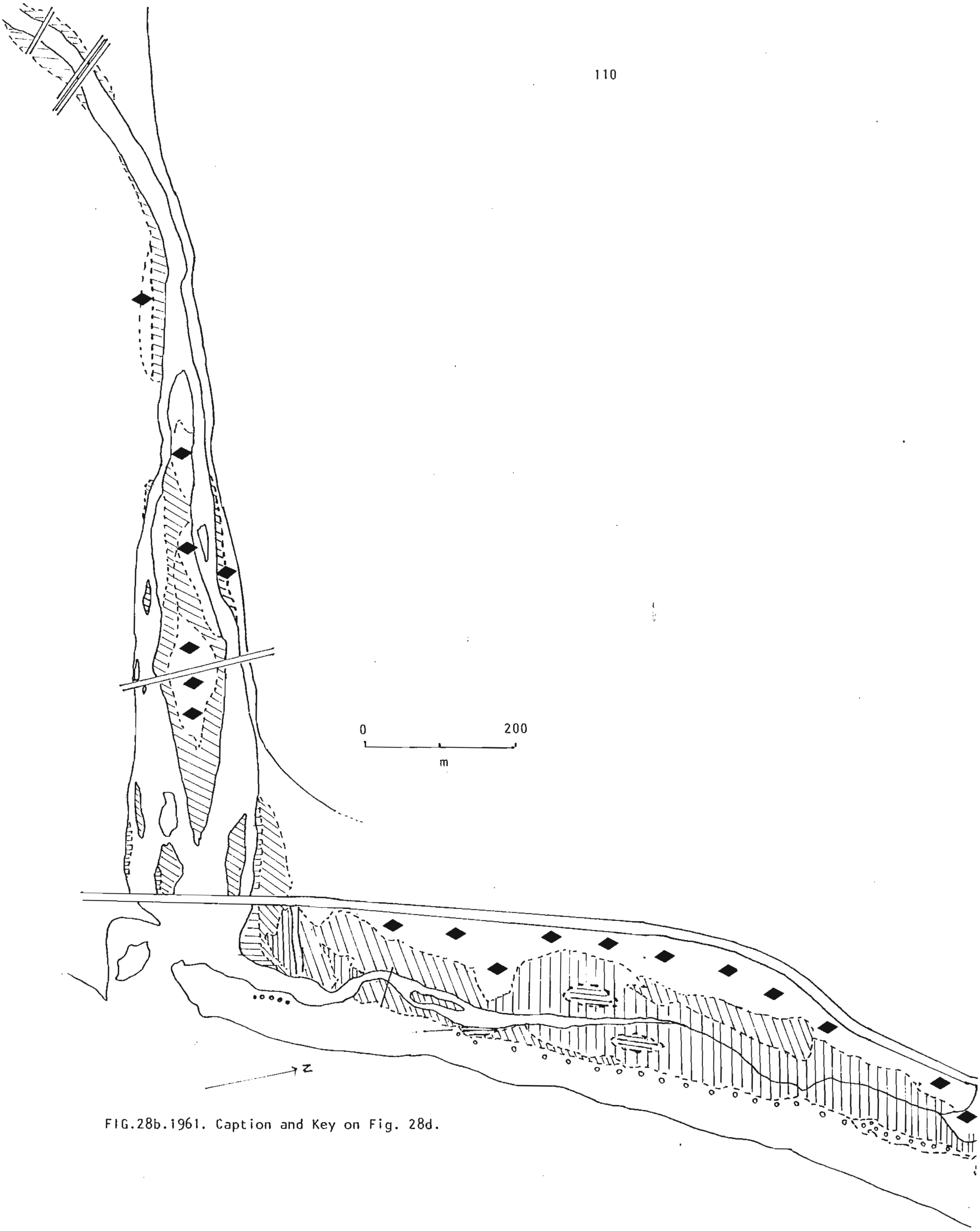

FIG.28b.1961. Caption and Key on Fig. 28d.

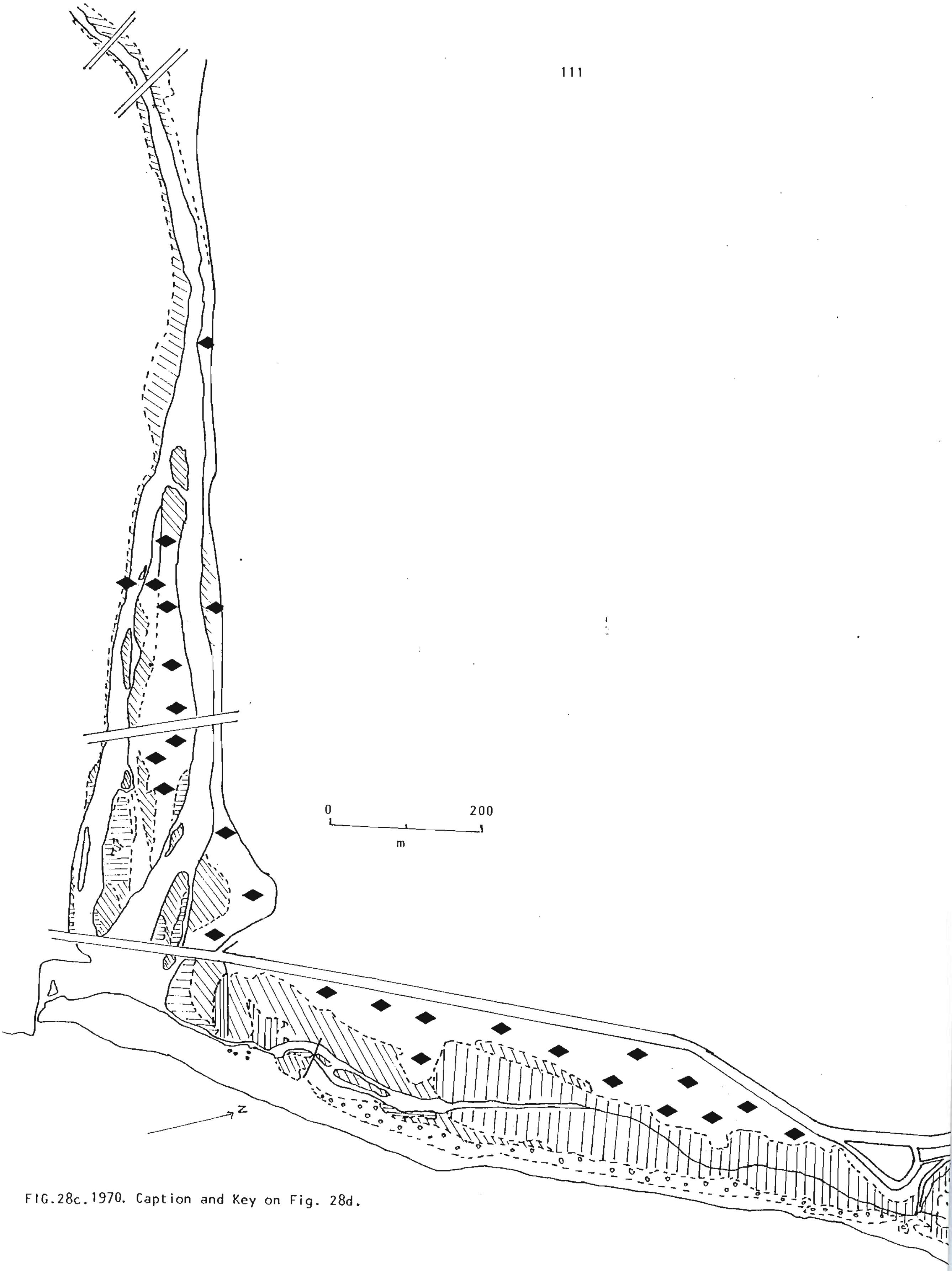

FIG.28c.1970. Caption and Key on Fig. 28d.

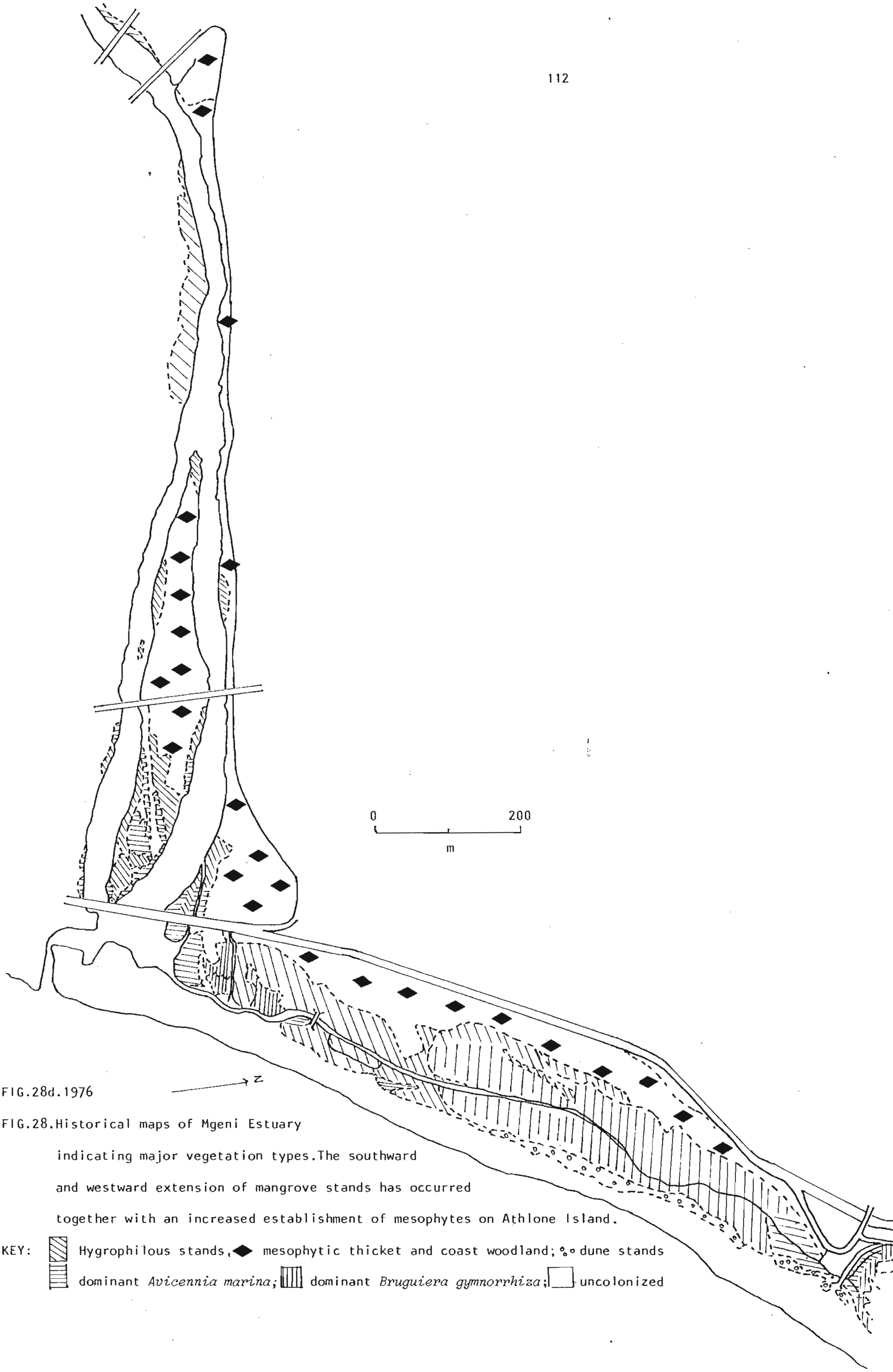

FIG.28d.1976

FIG.28.Historical maps of Mgeni Estuary indicating major vegetation types.The southward and westward extension of mangrove stands has occurred together with an increased establishment of mesophytes on Athlone Island.

KEY: ▨ Hygrophilous stands, ◆ mesophytic thicket and coast woodland; °∘ dune stands
▤ dominant *Avicennia marina*; ▥ dominant *Bruguiera gymnorrhiza*; ☐ uncolonized

TABLE 26. Cover-Abundance of Plant Species at Mhlanga Estuary as recorded in one hundred and fourteen relevés. All relevés are between 1 to 3 metres in altitude on flat surfaces and basally inundated soils except for relevés 111 to 114. Soils are sands overlain with clays. Key: O Original; N New; F Frequency; C Constancy; Fi Fidelity.

Relevé No.(O)			10	11	12	14	17	63	64	76	84	85	86	93	94	95	96	13	23	27	28	29	30	31	24	25	38	61	8	9	68	67	69	70	73	71	65	66	72	74	75	26	33	34	111	112	113	114	19	21	1	2	3	4	5	6	7	106	107	108	109	110	F	C	Fi
Relevé No.(N)	1 to 42	43 to 54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	%		
Total No.of Species	1	1	2	2	2	3	2	2	2	2	2	3	2	2	3	4	2	4	4	3	3	2	2	2	6	7	4	4	6	4	4	3	4	2	3	4	4	4	3	4	3	4	2	1	8	6	5	5	2	2	1	2	2	2	2	2	2	1	1	1	1	1			
Size(m^2)	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	25	25	25	25	25	25	4	4	4	4	4	4	4	4	4	4	4	4			
Total Cover	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	4	4	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	3	3			
SPECIES																																																																		
Phragmites australis	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	4	4	4	4	4	4	3	2	2	2	1	2	1		+			2	1	1	1	1		2							2	3													80	V	4
Ipomoea cairica			+	+	+	+				+	2	2		2	3		3	1	+		1				+	+	1	1	2	1	5	5			+		+	2		3	2	+			2	1	2	3															27	II	3
Typha capensis																1							1	1	1	2	2	2			1	2	2	1	2	3	2	2	3	3	3		4		1																		18	I	3
Commelina diffusa						+						1	2		1	2		1	+						1	1	+		1	1															2	1																	12	I	2
Polygonum salicifolium																													1		+	4	4	5	3	1			2																								7	I	5
Thelypteris interrupta																												2									3	3							2		2	2															5	I	2
Echinochloa pyramidalis																																																			5	5	5	5	5	5	5						6	I	5
Lemna sp.							+	1	1																																											+	+	+	+	+	+						8	I	4
Potamogeton pectinatus																																																										5	5	4	3	3	4	I	5
Stenotaphrum secundatum																				+	+				+	2				3												+																					5	I	3
Schoenoplectus littoralis																				+		+			+	1																																					4	I	3
Hibiscus tiliaceus																			1																							3	5	5	2	4	5	5															7	I	4
Panicum maximum																													1				2			1																											3	I	3
Cyperus sphaerospermus																+		+								+			1																																		4	I	3
Bruguiera gymnorrhiza																																																	4	5													2	I	4
Hewittia sublobata																																								1	2																						2	I	3
Aneilema aequinoctiale																																													2	1	1	1															4	I	4
Ipomoea congesta																																													2	3	2	2															4	I	3
Cyperus immensus																																													1	1																	2	I	4

The list of infrequent species includesthe following:Ludwigia stolonifera,Alternanthera sessilis,Hydrocotyle bonariensis, Lantana camara,Ludwigia octovalvis,Centella asiatica,Chromolaena odorata.

TABLE 27:Count per plot(25m^2)of *Bruguiera gymnorrhiza* at Mhlanga Estuary.

			Total	Density ha^{-1}
Releve No.	19	21		
Number	21	21	42	8400

TABLE 28. Constancy values for species within seven distinguished communities at Mhlanga Estuary. Key: 1 Pure *Phragmites australis* Community; 2 *Phragmites australis-Ipomoea cairica* Community; 3 *Typha capensis*-mixed herb Community; 4 *Hibiscus tiliaceus*-mixed herb Community; 5 *Bruguiera gymnorrhiza-Phragmites australis* Community; 6 *Echinochloa pyramidalis* Community; 7 *Potamogeton pectinatus* Community

	COMMUNITIES						
SPECIES	1	2	3	4	5	6	7
Phragmites australis	V	V	IV	I	V		
Ipomoea cairica		III	IV	IV			
Typha capensis		I	V	II			
Commelina diffusa		II	II	II			
Polygonum salicifolium			III				
Thelypteris interrupta			I	III			
Echinochloa pyramidalis						V	
Lemna sp.		I				V	
Potamogeton pectinatus							V
Stenotaphrum secundatum		I	I	I			
Schoenoplectus littoralis		I	I				
Hibiscus tiliaceus		I		V			
Panicum maximum			I				
Cyperus sphaerospermus		I	I				
Bruguiera gymnorrhiza					V		
Hewittia sublobata			I				
Aneilema aequinoctiale				III			
Ipomoea congesta				III			
Cyperus immensus				II			

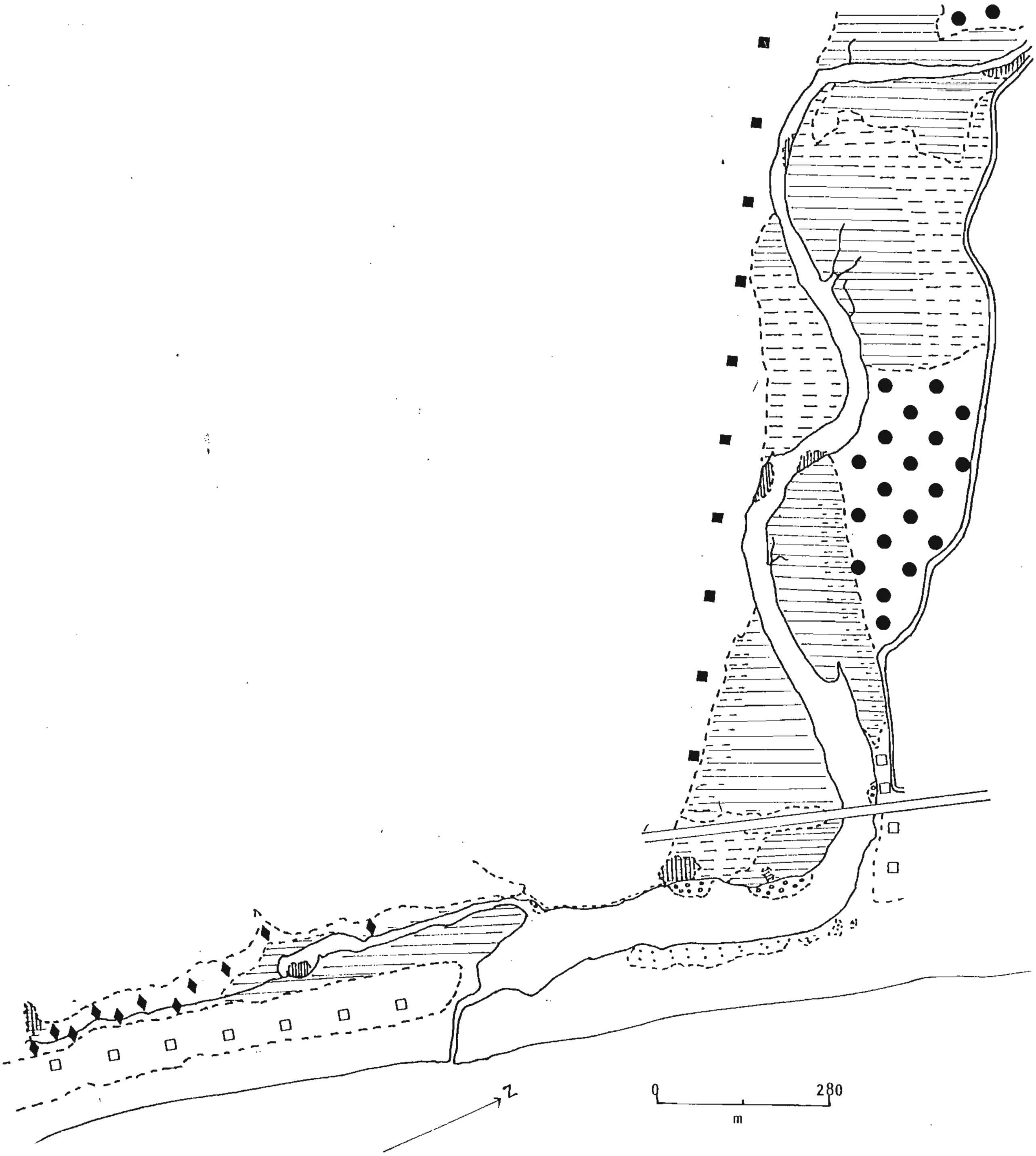

FIG. 29. Vegetation map of the Mhlanga Estuary, as considered for this report, based on quadrat analysis. Other major vegetation types are indicated. Key: ▤ Pure *Phragmites australis* Community; ☷ *P. australis-Ipomoea cairica* Community; ◆ *Typha capensis*-mixed herb Community; ▦ *Hibiscus tiliaceus* Community; ▨ *Bruguiera gymnorrhiza-P.australis* Community; ▥ *Echinochloa pyramidalis* Community; °o° *Potamogeton pectinatus* Community; □ Dune Forest; ∴ dune stands; ● sugar cane; ■ Coast Forest

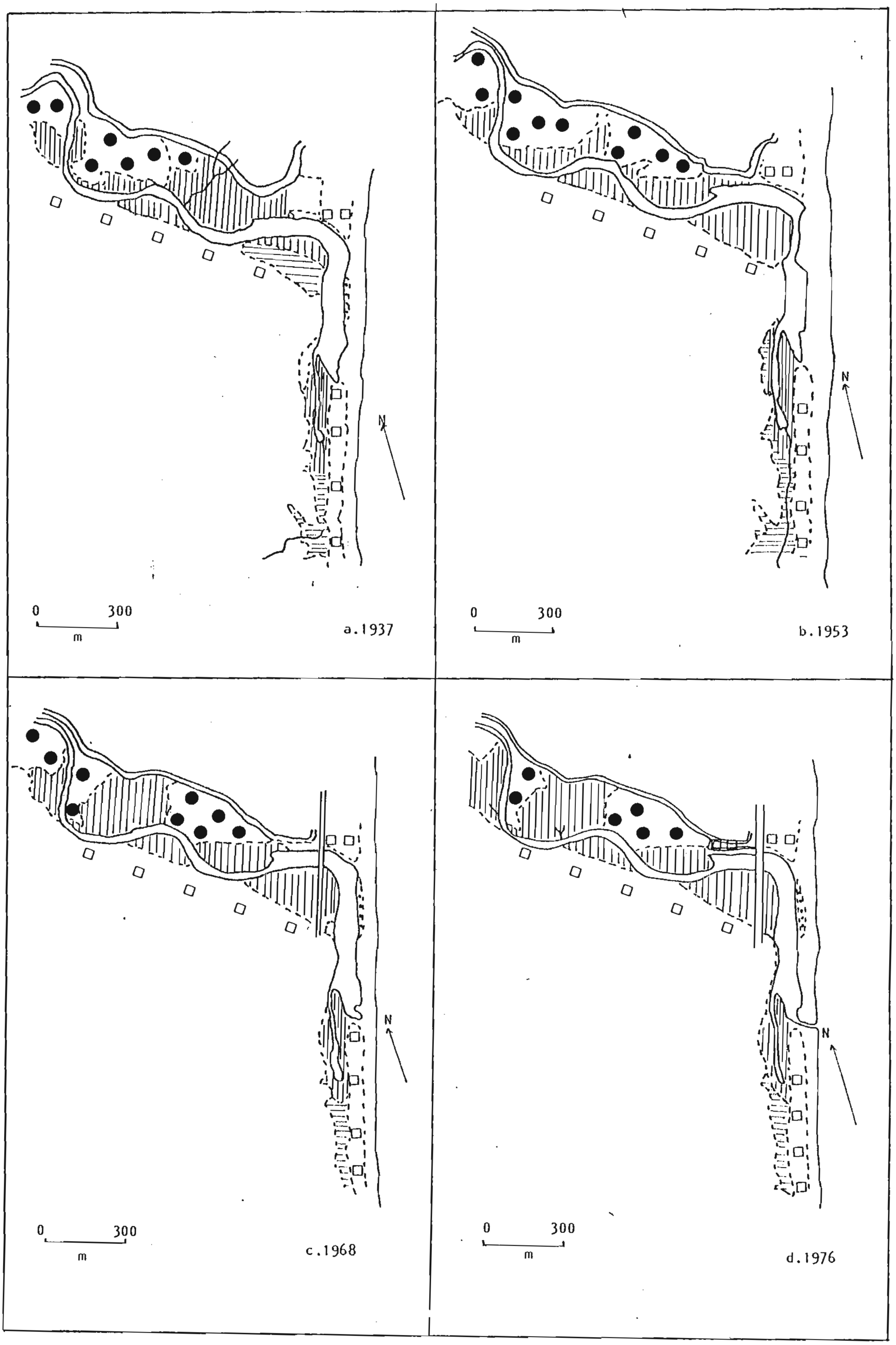

FIG. 30 (a-d). Historical maps of Mhlanga Estuary indicating major vegetation types. Reeds have always formed the dominant vegetation in the estuarine catchment. A decrease in cultivation of sugar cane on the floodplain has occurred in recent years.

Key: ● sugar cane: □ dune forest: ⁚ early dune stands: ▥ reed: ☰ hygrophilous

TABLE 29.Cover-Abundance of Plant Species at Mdloti Estuary as recorded in one hundredand twenty two relevés.All relevésare between 1m to 5m in altitude on flat surfaces.Key: 0 Original; N New; c (surface) clay; s (surface) sand; F Frequency; C Constancy; Fi Fidelity

Relevé No.(O)			1	10	14	70	71	117	8	49	50	102	112	101	104	113	120	51		73	72	81	98	38	107	100	34	84	99	40	41	66	69	80	94	97	67	37	16	33	103	35	36	39	4	5	58	87	59	60	61	62	57	115	93	96	89	91	68	77	79	92	75	105	108	109	19	20	85	18	65	82	90	64	74	76	83	86	88	106	114	32				121	122	F	C	Fi
Relevé No.(N)	1 to 8	9 to 13	14	15	16	17	18	19	20	21	22	23	24	25	36	27	28	29	30 to 34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98 to 108	109 to 114	115 to 120	121	122	%		
Total No.of Species	1	2	2	2	2	2	2	2	3	3	6	5	6	5	3	4	3	3	1	5	5	4	4	4	5	3	3	3	3	2	2	2	2	2	2	2	2	2	2	2	3	2	1	2	3	2	6	5	8	8	8	7	4	3	3	3	3	3	3	3	4	5	4	3	3	3	2	2	2	2	2	2	2	2	3	4	3	4	5	4	5	4	1	1	1	4	3			
Size(m²)	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	4	4	4	4	25	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	25	25	4	4	4	4	4	4	4	4	25	4	4	25	4	4	4	25	4	4	4	4	4	4	25	4	4	25	4	4	4	4	25	25	45	25	4	25	4	4	3	4	4			
Soil	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c/s	c	c	s	c	c	s	c	c	c	c	c	c	s	s	s	c	c	s	c	c	c	c	c	c	c	s	s	c	c	c	c	c	c	c	c	c	c	c	c	s	s	s	s	c	c	s	s	c	c	c	c	c	c	c	c	c	c	c	c	c	s	c	c	c/s	c/s	c/s	s	s			
Total Cover	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	4	4	4	4	4	5	5	5	5	5	5	5	5	5	5	5	5	5	4	3	5	4			
SPECIES																																																																																										
Barringtonia racemosa	5	5	5	5	5	5	5	4	5	4	3	4	3	4	5	5	3	4					3	+	1																							1							2		2	2				2			1			2	2	2	1	1	1				2	2	3	3	1	1						41	III	4
Ipomoea cairica		1	+	+	1				+	1	1	2	2	2	2	2	2	1		2	2	1	2		1			1	3					1			3										+	+	+	1	1	+	+	1	3	2	1	2	1		2	3	2		1	1	+							1	3	2	3	2	1	2	1					2		45	III	2
Phragmites australis								3		2		1	1	+		2	2	2		2	1	1			2								1								2							1		+				5	5	5	5	5	5	5	4	4	4	4	4	4	4	4	4	3	5	5	5	5	3	3	3	3	3	3		3	5	4	3			54	III	4
Echinochloa pyramidalis													3	2	2	2			5	5	5	5	5	3	3	5	5	5	5	5	5	5	5	5	5	5	4	4	4	3	3			2										2					1	+	+	1																		1	3	1						33	II	4
Commelina diffusa											1	1	1							1	1	1	1		2	1			2			1			1	1					1				1			+		+	+					1				1	1		2	1											1	2											1	21	II	2
Stenotaphrum secundatum											2													2						+												5	5	5	5	5	5	5	3	3	2	1																										2							1	2	14	I	4
Panicum maximum											1		2													+																								+		4	3												1																								6	I	2
Hydrocotyle bonariensis																																													1	1	1		+	+	1	+																																				6	I	5
Cyperus sphaerospermus																																															2		3	2		2	2																																			4	I	5
Centella asiatica																																															+		+	+	1	+																																				4	I	5
Polygonum salicifolium											1													2			1	1			1							3																													+												1	1		3	2						9	I	3
Pavonia patens																																															1		+		+	2																																				3	I	5
Canna indica														1						2	1																																									1																			1							4	I	3
Equisetum ramosissimum												+																																					1	1																																					3	I	1
Rauvolfia caffra						1	3																																																																																	2	I	5
Schoenoplectus littoralis																											+														2		+																																													3	I	5
Saccharum sp.																																																			+		2																																			2	I	1
Thelypteris interrupta																																																															2													1												2	I	4
Eichhornia crassipes									2																														+																																																	2	I	1
Ageratum conyzoides																																																					4																																			2	I	1
Phragmites mauritianus																																																																																						3	3	2	I	5
Ipomoea congesta																																																																																						1		1	I	4

The list of infrequent species include the following:Lantana camara,Typha capensis Lemna sp.,Ludwigia octovalvis,Rubus rigidus, Hewittia sublobata,Bridelia micrantha,Smilax kraussiana,Chromolaena odorata,Ricinus communis.

TABLE 30. Count per plot of *Barringtonia racemosa* as recorded for community demarcations of Table 29. Plants are distinguished as being either tall (greater than 1m) or as being short (less than or equal to 1m). Original relevé numbers are listed.

Relevé No.	2	3	6	7	12	13	31	15	9	11	54	55	56	1	10	14	70	71	117	8	49	50	102	112	101	104	113	51
Size-m^2	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
No.Tall	13	16	7	10	22	37	28	22	25	23	12	8	11	6	24	23	10	10	6	11	3	8	3	6	3	10	12	4
No.Short	1	1							2	2					3						6		2		3			

Relevé No.	98	38	107	87	93	89	91	42	108	20	85	18	82	90	86	88	106	114	32	Total	Area	Density-ha^{-1}
Size-m^2	25	25	4	4	25	4	25	25	4	4	25	4	25	4	25	4	25	4	25	413	986	4189
No.Tall	2		1	1	6	2	2	5	1	2	2	3	1	3	3	2	2	1	1	24	250	960
No.Short	3	1																				

TABLE 31. Count per plot of *Barringtonia racemosa*, rearranged. Plants are regarded as either tall (greater than 1m) or short (less than or equal to 1m). Original relevé numbers listed.

Relevé No.	38	49	98	101	102	10	11	9	2	3	12	13	14	15	31	7	8	54	56	70	71	104	113	50	55	1	6	42	93	112	117
Size-m²	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
No.Tall		3	2	3	3	29	23	25	13	16	22	37	23	22	28	10	11	12	11	10	10	10	12	8	8	6	7	5	6	6	6
No.Short	1	6	3	3	2	3	2	2	1	1																					

Relevé No.	18	51	86	90	20	32	82	85	87	88	89	91	106	107	108	114
Size-m²	4	25	25	4	4	25	25	25	4	4	4	25	25	4	4	4
No.Tall	3	4	3	3	2	1	1	2	1	2	2	2	2	1	1	1
No.Short																

TABLE 32. Constancy values for species within eight distinguished communities at Mdloti Estuary. Key: 1 *Barringtonia racemosa* Community; 2 *Barringtonia racemosa-Ipomoea cairica* Community; 3 Pure *Echinochloa pyramidalis* Community; 4 Dominant *Echinochloa pyramidalis* Community; 5 *Stenotaphrum secundatum*-mixed herb Community; 6 Dominant *Phragmites australis* Community; 7 Fringing *Phragmites australis* Community; 8 *Phragmites mauritianus* Community

SPECIES	1	2	3	4	5	6	7	8
Barringtonia racemosa	V	V		I	I	III		
Ipomoea cairica	II	V		III	IV	IV		III
Phragmites australis		IV		II	I	V	V	
Echinochloa pyramidalis		II	V	V	I	II		
Commelina diffusa		II		III	II	II		III
Stenotaphrum secundatum		I		I	V	I		V
Panicum maximum		II		I	II	I		
Hydrocotyle bonariensis					IV			
Cyperus sphaerospermus					III			
Centella asiatica					III			
Polygonum salicifolium		I		II		I		
Pavonia patens					II			
Canna indica		I		I		I		
Equisetum ramosissimum		I			I			
Rauvolfia caffra	I							
Schoenoplectus littoralis				I	III			
Saccharum sp.					I			
Thelypteris interrupta						I		
Eichhornia crassipes		I		I				
Ageratum conyzoides					I			
Phragmites mauritianus								V
Ipomoea congesta								III

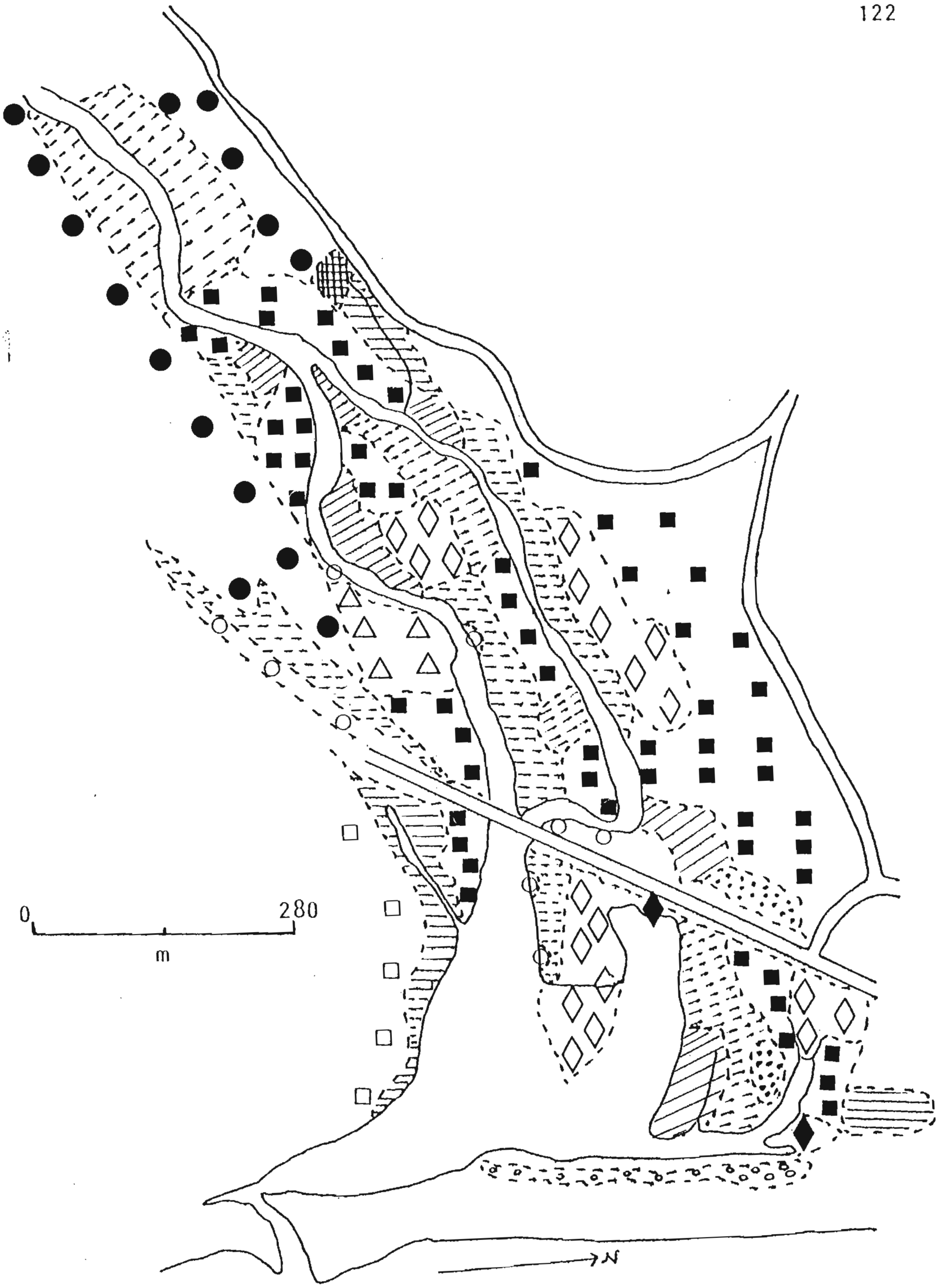

FIG. 31. Vegetation map for Mdloti Estuary as delimited in this report. Other major vegetation types are indicated. Key: ☰ *Barringtonia racemosa* Community; ▤ *B.racemosa-Ipomoea cairica* Community; ▧ *Echinochloa pyramidalis* Community; ▨ Dominant *E.pyramidalis* Community; ⁚· *Stenotaphrum secundatum* Community; △ Mixed Secondary Grassland; ■ Dominant *Phragmites australis* Community; ◇ Fringing *P.australis* Community; ○ *P.mauritianus* Community; ● sugar cane; □ forest; ▦ bamboo thicket; ◆ *Casuarina equisetifolia* stands; °° early dune stands.

species recorded at that study site. Table 30 reflects a count per plot of *Barringtonia racemosa* for the community demarcations. Table 31 represents the same data in a re-arranged table. Table 32 reflects constancy values in the 8 distinguished communities. Approximately 0,3% of the study site was sampled. Fig. 31 is a vegetation map based on the above data. Physiognomic distinctions based on aerial photography are also included in this figure.

Data from the single transect at Mdloti Estuary are reflected in Table 33 and Fig. 32. Table 33 represents constancy within distinguished vegetation zones. Fig. 32 represents topographical and vegetation profiles in relation to observed variations in basal inundation. Total cover and contributions to cover values by the considered important species is also represented (Fig. 32) . Observed vegetation is divided into 7 zones along the transect.

Results of the Point-Centred Quarter analysis at Mdloti Estuary are given in Table 34.

In addition to the vegetation map, historical maps drawn from aerial photographs for 1937, 1953, 1968 and 1976 for Mdloti Estuary are shown in Fig. 33a - d.

7.3 COMMUNITY DESCRIPTIONS

The analysis of mangrove stands at Mgeni Estuary revealed the presence of only two species. However others are present. *Rhizophora mucronata* (50 in number) has been introduced from Durban Bay although the plant

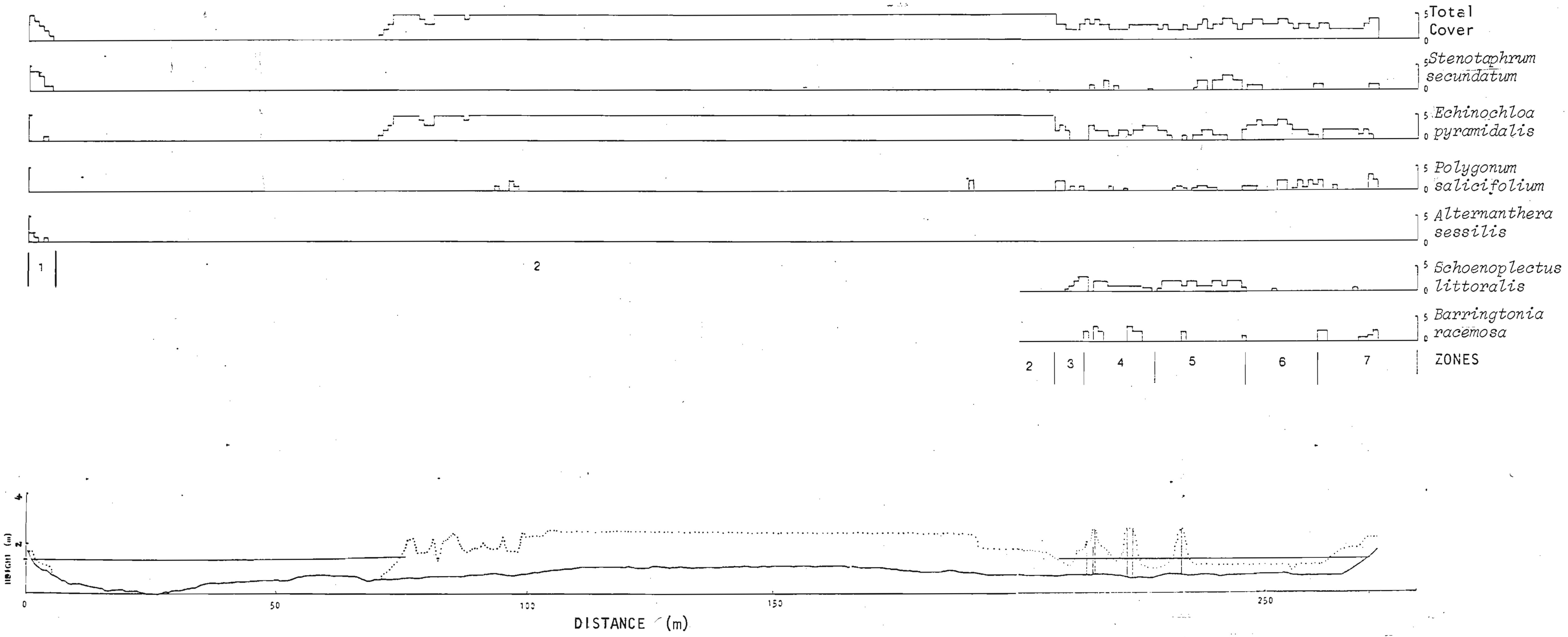

FIG. 32. Topographical and Vegetation profile from the single transect at Mdloti Estuary. Total cover and contributing cover values are indicated. Level of basal inundation during closed mouth conditions indicated. Refer to Table 33 for Zones 1-7. Key: canopy ....; *Barringtonia racemosa* trees | .

TABLE 33. Constancy values for species in vegetation zones of Transect 1 at Mdloti Estuary. Key: 1 *S.secundatum* zone; 2 *E.pyramidalis* zone; 3 *S.littoralis* zone; 4 *E.pyramidalis-S.littoralis* zone; 5 *S.littoralis-P.salicifolium* zone; 6 *S.secundatum-E.pyramidalis-S.littoralis* zone; 7 *E.pyramidalis-P.salicifolium* zone.

	ZONES						
SPECIES	1	2	3	4	5	6	7
Stenotaphrum secundatum	V			II	I	V	I
Alternanthera sessilis	III						
Panicum maximum	III						
Chrysanthemoides monilifera	I						
Echinochloa pyramidalis	I	V		V	II	IV	V
Polygonum salicifolium		I	III	I	IV	III	III
Schoenoplectus littoralis		I	V	V	V	IV	I
Barringtonia racemosa			II	II	I	I	II
Scirpus sp.							I
Commelina diffusa							I

TABLE 34. Point-Centred Quarter Analysis for Mdloti Estuary. *Barringtonia racemosa* was the only plant recorded. Key: A number of quarters; B number of points; C total distance; E total basal area; F mean basal area; I.V. Importance Value ((Rel.Density+Rel.Frequency+Rel.Dominance)/3); Abs., Absolute; Rel., Relative.

Locality	Species	A	B	C (m)	D (m)	DENSITY (ha^{-1}) Abs.	Rel.	FREQUENCY (%) Abs.	Rel.	E (cm^{-2})	F (cm^{-2})	DOMINANCE $(m^{-2})(ha^{-1})$ Abs.	Rel.	I.V.
South Bank	B.racemosa	144	36	233,17	1,6192	3814,2	100	100	100	30446,92	211,44	80,65	100	100
North Bank	B.racemosa	20	5	33,91	1,6955	3478,6	100	100	100	4352,19	217,61	55,82	100	100
West of Bridge	B.racemosa	16	4	47,28	2,9550	1145,2	100	100	100	2529,61	158,10	18,06	100	100
Mdloti Estuary (TOTAL)	B.racemosa	180	45	313,64	1,7424	3293,9	100	100	100	37328,72	207,38	68,31	100	100

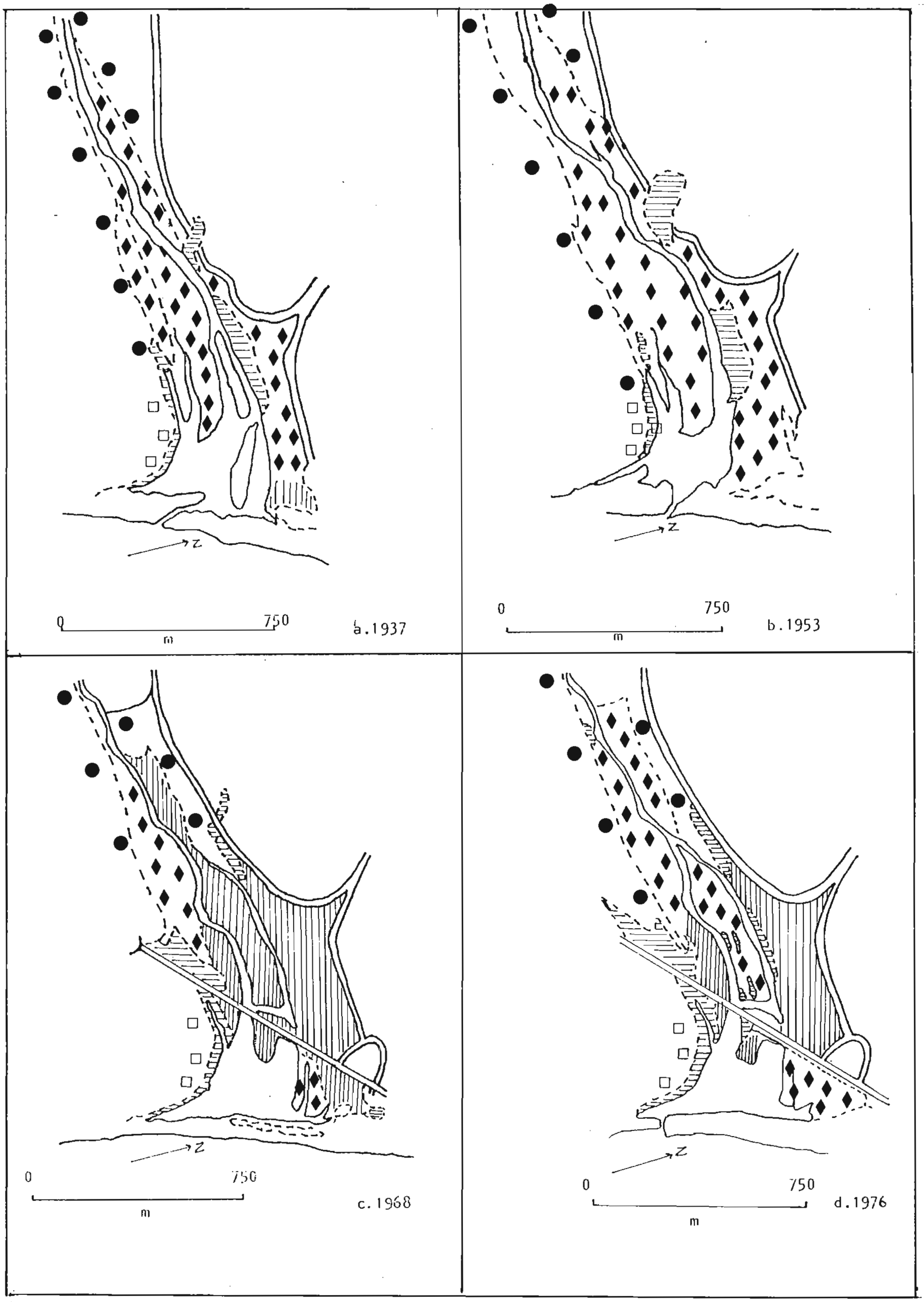

FIG. 33 (a-d). Historical maps of Mdloti Estuary indicating major vegetation types. An increase in reed dominated vegetation to the west of the bridge and an increase in hygrophilous herbaceous vegetation to the east of the bridge has occurred. Sugar cane cultivation remains the primary agricultural activity. Key: ● sugar cane; ▤ *Barringtonia racemosa* woodland; ▥ reed swamp; ◆ hygrophilous (herb) vegetation; □ forest.

also occurs naturally within the study site. *Ceriops tagal* and *Lumnitzera racemosa* (6 and 8 in number respectively) have been introduced from Kosi Bay (Natal's most northerly estuary). A *Bruguiera* sp. (single specimen) has been introduced from Australia.

Although estuarine communities were analysed, the vegetation of Athlone Island was also included as being representative of the Mgeni Estuary system as the island has been built up of alluvial material.

The extent of the Mhlanga and Mdloti estuarine systems is greater than depicted for vegetation analysis, but these areas comprise primarily sugar cane cultivated lands.

7.3.1 Pure *Avicennia marina* Community

This pure community at Mgeni Estuary occurs close to the mouth on newly exposed sandflats overlain with clays and on rapidly accreting exposed mudflats. Zone 7 of Transect 1 and Zone 4 of Transect 2 characterize the community.

Of all vascular plant communities, this community experiences greatest tidal inundation. Tidal inundation during equinoctial spring tides occurs to a height of 120cm but during neap tides minimal inundation at the outer fringes occurs. This outer fringe is based on the outermost mangrove fringe of Transect 1.

Soils were sandy especially in the sub-surface layers, had moderate bulk density values, were weakly acidic and had low organic matter content, moderately high cation exchange capacities and available phosphorus levels.

The trees form a continuous canopy of between 6m and 8m high. The foliage is such that light penetration occurs to the ground. As a result of light penetration (to a minimum of 2,5% of available sunlight), an intermediate stratum of saplings below the main canopy at 3m is found. This stratum is irregular in spacing. Individuals are usually slender having a diameter at breast height of 8cm to 10cm.

The production of pneumatophores, in all directions, especially towards water courses assists in reducing the effects of water currents, helps in sediment stabilization and the trapping of litter debris. These aid the establishment of a fringe of *A.marina* seedlings. Fringing stands are also found along Beachwood Creek and in parts constricting the creek (Fig. 34). Young *A.marina* are found on the south bank of the Mgeni Estuary and on the north bank of Athlone Island between Ellis Brown Viaduct and Athlone Bridge.

Eichhornia crassipes is a transient member of the community being washed in from freshwater sources further upstream. These plants are killed by salt water.

7.3.2 Dominant *Avicennia marina* Community

This community at Mgeni Estuary is characterized by the presence of tall *A.marina* (8m) with the occurrence of *Bruguiera gymnorrhiza* as an

FIG. 34. Fringing *Avicennia marina* stand to Beachwood Creek. Pneumatophore extension into the creek results in increased siltation by interfering with water currents and effecting the trapping of litter and debris. Constriction of the creek therefore occurs.

important component of the sub-canopy (3m to 4m). Analysis indicates that *A.marina* is the more important tree in the area (Table 25). Fewer *A.marina* seedlings than in the previous community were found. Light penetration was reduced by a well developed canopy (2,5% of maximum) allowing for the establishment of *B.gymnorrhiza* seedlings.

The pure *A.marina* community merges into the dominant *A.marina* community and occurs in the less tidally inundated areas. Zone 6 of Transect 1 characterizes the community and it is also present on Athlone Island.

Soils close to shorelines were sandier and had a lower organic matter content and a lower cation exchange capacity than those away from shorelines. Soils were weakly acidic and moderately saline (saline-sodic).

7.3.3 Mixed *Avicennia marina-Bruguiera gymnorrhiza* Community

This community at Mgeni Estuary is characterized by equal cover values for both species. The canopy maintains a constant height of approximately 6m and the trees occur landward of water courses. The character species are *A.marina* and *B.gymnorrhiza*. Zone 5 of Transect 1 characterizes this community.

Soils were clayey, weakly acidic and had a high organic matter content and a high cation exchange capacity. Soils were saline-sodic.

Recorded light values at the ground layer indicate a 12,5% possible of the maximum.

7.3.4 Dominant *Bruguiera gymnorrhiza* Community

This community at Mgeni Estuary is characterized by the presence of tall *B.gymnorrhiza* (6m to 7m) with the occasional tall *Avicennia marina* in clay soils (Fig. 35). Light is a limiting factor in *A.marina* seedling establishment. Values recorded indicate a 5% of maximum sunlight. *B.gymnorrhiza* is numerically dominant and has a greater frequency of slender individuals than has *A.marina* . Diameter at breast height measurements indicate an average of 10cm for *B.gymnorrhiza.*

The community is present landward of the Beachwood Creek and occurs along both eastern and western margins of Beachwood Mangroves Nature Reserve. Along the eastern margin *B.gymmorrhiza* is shorter (5m) than along the western margin (10m) . This is due to the arid environment on the east (due to wave overwashed beach sand) and higher salinities as opposed to the westward margin which is fed by numerous freshwater drains and streams which reduce both water and soil salinities. A greater nutrient input is also effected along the westward margin.

The boundaries along both margins are abrupt. The eastern margin abuts onto dune vegetation and the western margin passes into hygrophilous vegetation. *Acrostichum aureum* and *Ipomoea cairica* are associates along this western margin. The hygrophilous vegetation is above tidal influence.

Soils were clayey, weakly acidic and had a high organic matter content and a high cation exchange capacity. Soils were saline-sodic.

FIG. 35. Dominant *Bruguiera gymnorrhiza* stand in the southern sector of Beachwood Mangroves Nature Reserve. An increase in elevation allows for the establishment of *Juncus kraussii* (foreground) .

7.3.5 Pure *Bruguiera gymnorrhiza* Community

The community is extensive at Mgeni Estuary and occurs in areas of reduced tidal effect occupying the central mangrove stand in the northerly sector of Beachwood Mangroves Nature Reserve.

At Mgeni Estuary, Zone 2 of Transect 1 and Zone 3 of Transect 2 characterize the community. Trees are 5m to 6m tall and are slender. Diameter at breast height values are between 5cm and 10cm.

Soils were clayey, had moderate acidities, had the highest organic matter content and highest cation exchange capacities of mangrove soils. Soils were saline-sodic.

The dense canopy reduces light penetration to a minimum. Values recorded indicate a 2,5% of maximum sunlight. Only a few saplings and seedlings occur in the community.

7.3.6 *Sarcocornia natalensis* Community

This community occurs at Mgeni Estuary and occupies exposed parts between mangrove stands on slightly raised substrates. The community is present in the lower Beachwood Mangroves Nature Reserve landward of water courses (Fig. 36) .

Soils were sandy, especially in the sub-surface layers and had high bulk densities. They were moderately acidic, had a lower organic matter content, were saline-sodic and had a moderate cation exchange capacity.

FIG. 36. *Sarcocornia natalensis* occurring with tall (3m to 5m) *Avicennia marina* and *Bruguiera gymnorrhiza*. Stands are usually away from water-courses.

The community comprises *S.natalensis* which forms mats of up to 100cm in diameter. *Bruguiera gymnorrhiza* and *Avicennia marina* (which occur as tall specimens of 2m to 3m in height), *Juncus kraussii*, *Stenotaphrum secundatum* and *Phragmites australis* occur as associated plants. *A.marina* occurs more frequently with *Sarcocornia natalensis* than does *B.gymnorrhiza*. This frequency is thought to be due to the high salinities on evaporation and the degree of exposure. *Stenotaphrum secundatum* and *P.australis* occur as incidentals.

7.3.7 *Juncus kraussii* Community

This community occurs at Mgeni Estuary landward of mangrove stands at a higher elevation than the *Sarcocornia natalensis* Community on compacted sands with muds. Sites are exposed and tidal inundation is possible at high tides.

Soils classified as clays were weakly acidic and had high organic matter content and high cation exchange capacities. Soils were saline-sodic.

J.kraussii grows to a height of between 100cm to 150cm and tends to form pure stands on compacted, exposed and tidally inundated muds in the southern sector of Beachwood Mangroves Nature Reserve. At the landward fringes, freshwater or mesophytic associates are present. These include *Stenotaphrum secundatum*, *Ipomoea cairica*, *I.congesta* and *Commelina diffusa* (Fig. 37).

7.3.8 Hygrophilous Fringe Community

This hygrophilous community is found adjacent to the western margin of mangrove stands in the southern sector of Beachwood Mangroves Nature

FIG. 37. *Juncus kraussii* Community on slightly elevated soils. Where tidal inundation is greater *Bruguiera gymnorrhiza* and, more recently, *Avicennia marina* have become established.

Reserve. The area is characterized by the presence of a high water-table caused by drains entering the area. The substrate is moist grey sands.

The stands are characterized by the presence of *Ipomoea cairica*, *I.congesta*, *Phragmites australis* and *Typha capensis*. Also present and indicative of a freshwater influence are *Commelina diffusa*, *Colocasia antiquorum*, *Zantedeschia aethiopica*, *Centella asiatica*, *Hydrocotyle bonariensis*, *Ludwigia octovalvis*, *Canna indica* and *Polygonum salicifolium*. At more elevated sites, *Sesbania punicea*, *Chromolaena odorata*, *Hibiscus tiliaceus*, *Lantana camara*, *Ricinus communis* and *Asystasia gangetica* are present.

7.3.9 Pure *Stenotaphrum secundatum* Community

This community is found along the south-western fringe of mangrove stands at Beachwood Mangroves Nature Reserve and on Athlone Island. Stands are present at elevated sites above normal tidal inundation on loose sandy soils with surface clays. Exclusion of mesophytic plants is due to saline soils caused by seepage and evaporation.

7.3.10 Dominant *Stenotaphrum secundatum* Community

This community is located at higher elevation than the previous community at Mgeni Estuary in clay soils. Stands are landward of *Juncus kraussii* and mangrove stands. Frequently occurring associates include *Ipomoea cairica*, *Commelina diffusa*, *Scirpus* sp., *Asystasia gangetica* and *Hypoxis rooperi*.

Soils were clayey, had low bulk density values, were weakly to moderately acidic, had intermediate organic matter content, were saline-sodic and had high cation exchange capacities.

7.3.11 *Stenotaphrum secundatum-Phragmites australis* Community

This community at Mgeni Estuary is restricted mainly to Athlone Island between Ellis Brown Viaduct and Athlone Bridge. The community is landward of the mangrove stands on sandy soils overlain with clays. The community is above normal tidal influence. Associated plants include *Commelina diffusa*, *Ipomoea cairica*, *I.congesta* and *Asystasia gangetica*. The presence of *Rhynchelytrum repens* with a high cover value (4) is partially indicative of disturbance.

Soils were categorized as loamy sand, were weakly acidic with high organic matter content and were saline-sodic with low cation exchange capacities.

7.3.12 Mixed *Phragmites australis* Community

This community at Mgeni Estuary is restricted to Athlone Island and western marginal fringes of Beachwood Mangroves Nature Reserve. Cover values were high. Important associates include *Chromolaena odorata*, *Lantana camara*, *Cardiospermum grandiflorum*, *Hewittia sublobata* and *Ipomoea cairica*. Possible reasons for the admixture of species include the lack of basal inundation and disturbance.

7.3.13 *Chromolaena odorata-Lantana camara* Community

This community at Mgeni Estuary is restricted to the raised central parts of the alluvial Athlone Island. *C.odorata* and *L.camara* are the character species. Important associates are *Cardiospermum grandiflorum*, *Ipomoea cairica* and *Hewittia sublobata*. *Schinus terebinthifolius*, *Melia azedarach* and *Brachylaena discolor* are occasional.

Soils were sandy, weakly to moderately acidic, with very low organic matter content and were either non saline-sodic or non saline-non sodic with low cation exchange capacities.

The community is above tidal influence and is basally inundated only during extreme freshwater flooding.

7.3.14 *Schinus terebinthifolius* Community

This community at Mgeni Estuary is restricted to the central parts of Athlone Island. The character species is *S.terebinthifolius* and important associates include *Chromolaena odorata*, *Lantana camara*, *Cardiospermum grandiflorum*, *Ipomoea cairica*, *Hewittia sublobata* and *Commelina diffusa* (Fig. 38) .

Soils were sandy, weakly to moderately acidic with a very low organic matter content and were either non saline-sodic or non saline-non sodic and had low cation exchange capacities.

The community lies above tidal influence and normal flood level.

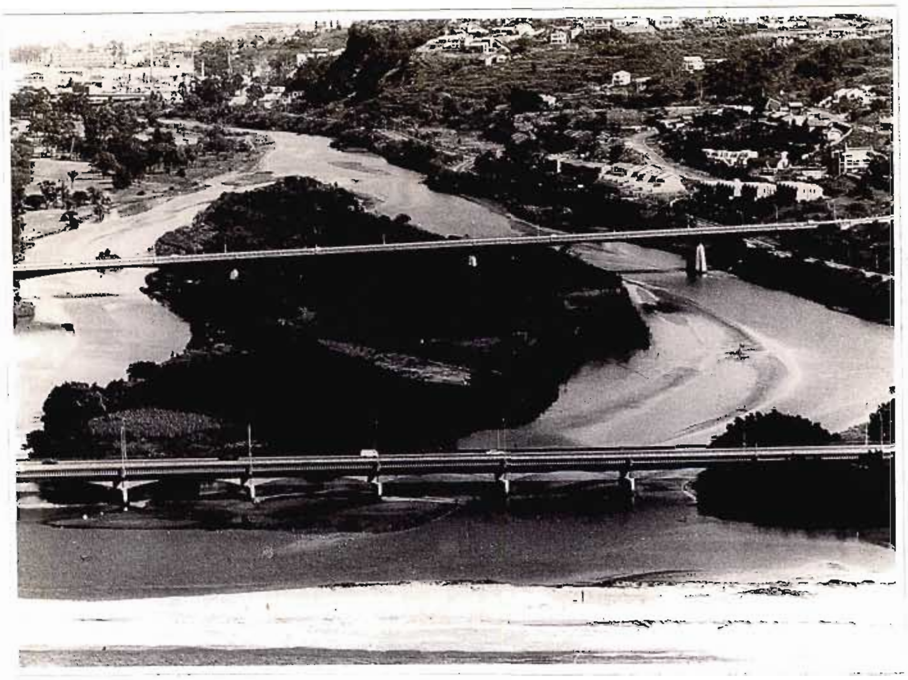

FIG. 38. Athlone Island, east (foreground) to west (background). A rise in level of the substrate has promoted the establishment of mesophytes especially in the central western parts. The eastern section of the island is occupied by mangroves, primarily, *Avicennia marina*. Saplings of the plant have also become established on the north-east bank on fluvial sediments. *Phragmites australis* and *Stenotaphrum secundatum* are found on raised substrates in this eastern sector. Old shorelines are marked by discontinuities in vegetation. (Photo: The Daily News, 17 Nov.'81).

Stratification is minimal, the named species form a dense stand and occupy all strata of this thicket community. Some species are restricted to the field layer. These include *Cynodon dactylon* and *Setaria megaphylla*. The maximum canopy height was 5m. Isolated individual trees are taller (8m) .

7.3.15 *Avicennia marina-Bridelia micrantha* Community

The community at Mgeni Estuary is restricted to the north-western end of the Beachwood Creek in the vicinity of Rocket Hut Beach. It forms a woody ecotonal zone between the saline mangrove stands and the mesophytic coast forest. It is above normal tidal influence on moist sandy substrates.

Cover values are high. The community has three strata. The canopy layer, from 4m to 6m, is characterized by the presence of *A.marina* and *B.micrantha*. The shrub layer from 1m to 2m is formed by *Chromolaena odorata* and *Lantana camara*. The field layer (below 100cm) is characterized by the presence of *Commelina diffusa*, *Asystasia gangetica* and *Melanthera scandens*. *Ipomoea cairica* is present in all three strata.

No saplings of *Avicennia marina* were recorded. This is ascribed to a shading effect. Although tolerant of freshwater and basal inundation, it is suggested that seedling establishment is not favoured under stagnant water conditions.

7.3.16 *Hibiscus tiliaceus* Community

This community at Mgeni Estuary is present along the western fringe of the mangroves, at the northern end of the Beachwood Mangroves Nature Reserve and on the banks of the Mgeni River especially between Ellis Brown Viaduct and Athlone Bridge. Soils were generally loose sands and sites were above normal tidal influence.

Important associates include *Bruguiera gymnorrhiza*, *Avicennia marina* and *Brachylaena discolor* which form the canopy layer of 6m. *Mimusops caffra* and *Melia azedarach* occur occasionally. *Melanthera scandens*, *Juncus kraussii* and *Phragmites australis*, in parts, form the field layer below 100cm.

7.3.17 *Potamogeton pectinatus* Community

This community at Mhlanga Estuary is present on sandy banks in isolated patches to the east of the road bridge. Plants are totally inundated during closed mouth conditions to a depth of approximately 100cm. Waters are generally of low salinity (1‰) and low turbidity.

Soils were sandy, had low bulk density values and were weakly acidic to weakly alkaline with a low organic matter content and were non saline-non sodic with high cation exchange capacities.

7.3.18 *Echinochloa pyramidalis* Community

This community at Mhlanga Estuary occurs in isolated stands both east and west of the road bridge. Plants are either rooted on banks or in shallow water and extend into open water. The soils are sandy. Waters are of low salinity (1‰) and low turbidity. *Lemna* sp. is an associate (Fig. 39). Stands are pure or almost pure because of their presence in open water.

7.3.19 Pure *Phragmites australis* Community

This pure sub-woody community is present at Mhlanga Estuary. The community is extensive on sandy soils, sometimes overlain with clays. Stands are either basally inundated to 100cm at the shoreline margins or occur on exposed moist substrates (Fig. 39).

Soils were sandy, were weakly acidic to weakly alkaline with a low organic matter content and were either non saline-non sodic or saline-sodic with low to moderate cation exchange capacities.

The maximum height of the community is approximately 4m with moderately high cover values. Inland regions of the stands have a rich litter layer which makes a substantial contribution to the organic matter content by *in situ* decomposition.

Extension of the community into open water occurs by rhizomes. Basal inundation excludes competitors.

7.3.20 *Phragmites australis-Ipomoea cairica* Community

This community at Mhlanga Estuary is extensive at the landward margins

FIG. 39. Pure, fringing *Phragmites australis* Community at Mhlanga Estuary. In parts, the reed fringe is interrupted by the presence of *Echinochloa pyramidalis* (foreground), especially in quiet waters.

of the main reed swamp and in disturbed areas. The character species are *P.australis* and *I.cairica*. Although basal inundation does occur, a feature of most of the community is non-inundation, thus allowing for the introduction of other species. Associated species include *Commelina diffusa* and *Stenotaphrum secundatum*. Where the community is adjacent to open water *Schoenoplectus littoralis* and *Lemna* sp. are present. *Panicum maximum* and *Hibiscus tiliaceus* are occasional.

The community is two layered. The upper stratum comprises *Phragmites australis* to 3m and a field layer with *C.diffusa* and *S.secundatum* present. *I.cairica* is present in both strata.

7.3.21 *Typha capensis*-mixed herb Community

This community at Mhlanga Estuary is localized in the southern extension of the estuary in moist sandy soils. The character species are *T.capensis*, *Phragmites australis*, *Ipomoea cairica*, *I.congesta* and *Polygonum salicifolium*. Associated species include *Commelina diffusa*, *Thelypteris* sp. and *Stenotaphrum secundatum*. *Cyperus immensus* is important in parts.

Soils were classified as sandyclay loams or sands, were weakly acidic to weakly alkaline with a high organic matter content and were either saline-sodic or non saline-non sodic with high cation exchange capacities.

Total cover values were generally high. The community is two-layered, comprising an upper stratum (2m-3m tall) of *Typha capensis*, *Phragmites australis* and *C.immensus* and a lower stratum (up to 100cm) which includes the other species.

7.3.22 *Hibiscus tiliaceus*-mixed herb Community

This woody community at Mhlanga Estuary is localized on the western bank of the estuary opposite the southern mouth position and on the southern extension of the estuary. The substrate comprises firm moist sands which are basally inundated during closed mouth conditions on the western bank and moist sands due to the presence of drains in the southern parts. Substrates are exposed during open mouth conditions.

Soils, sandy and moderately alkaline, had a low organic matter content and were classified as non saline-non sodic with high cation exchange capacities.

Character species are *H.tiliaceus* and *Phragmites australis*. Associated species are *Ipomoea congesta*, *I.cairica*, *Thelypteris interrupta*, *Cyperus immensus*. *Centella asiatica* and *Ludwigia octovalvis* are occasional. *Typha capensis* and *Chromolaena odorata* are found at the landward margins of stands.

Total cover was usually high with *H.tiliaceus* occurring as a low (3m to 4m), well-branched tree where basally inundated and up to 5m tall on permanently exposed substrates. This together with *P.australis* comprises an upper stratum. An intermediate stratum between 1m and 2m is formed by *T.capensis*, *C.odorata* and *Cyperus immensus*, while the field layer (below 100cm) comprises *Commelina diffusa* and *Centella asiatica*. *I.congesta* and *I.cairica* are found in all strata.

7.3.23 *Bruguiera gymnorrhiza-Phragmites australis* Community

This community at Mhlanga Estuary is restricted to a small stand within the *P.australis-Ipomoea cairica* Community.

The substrate has a higher percentage of small sized fractions than the surrounding areas. Soils were classified as sands or sandy clay loams, were weakly acidic to weakly alkaline with a low organic matter content and were further classified as non saline-non sodic with high cation exchange capacities.

Basal inundation during closed mouth condition occurs to 100cm but the substrate is exposed during open mouth conditions. Periods of closure are prolonged; during 1982 the sandbar was breached on a single occasion in November.

Total cover values were high. *B.gymnorrhiza* was up to 5m tall but had poor foliage development. A mean count of 21 per 25m^2 plot was obtained and translates to a density of 8 400ha^{-1}. However the whole area occupied by *B.gymnorrhiza* at Mhlanga Estuary was approximately only 40m^2.

7.3.24 Pure *Echinochloa pyramidalis* Community

This community at Mdloti Estuary occurs frequently on margins of water courses, both old and new, and is also present on the central parts of the mudflats. The community is characterized by Zone 2 of the transect.

Pure stands are possible because of basal inundation and an ability to raft into open water. Firm rooting on banks and mudflats prevents movement by water currents.

The community is monospecific except in the backwaters of the north channel where it merges into a transient *Eichhornia crassipes* stand. This also occurs in the main channel under prolonged blocked mouth conditions. It is present within the estuarine area because of low salinity waters (1‰) . Plants are washed into the main estuarine section during floods and periods of high flow. Waters are generally turbid especially during high flow periods. This strong flow has the effect of transporting decomposing material and results in a low organic matter content of soils.

The community reaches approximately 150cm height in parts. It occurs between 2m to 4m in altitude. Cover values are high and prevent light penetration to the ground. This results in decomposition of the lowermost leaves which, in areas of weak water currents, allows for retention of organic matter.

7.3.25 Dominant *Echinochloa pyramidalis* Community

The community at Mdloti Estuary occurs on sand and mudflats adjacent to the previously described community and is basally inundated during closed mouth conditions. The character species are *E.pyramidalis*, *Ipomoea cairica* and *Commelina diffusa*. *Phragmites australis*, *Barringtonia racemosa*, *Polygonum salicifolium* and *Stenotaphrum secundatum* occur occasionally (Fig. 40) .

FIG. 40. *Echinochloa pyramidalis* Community at Mdloti Estuary occupies the central sand and mudflats. *Phragmites australis* and *Schoenoplectus littoralis*, in parts, line the shores.

The community is characterized by Zones 4, 5 and 6 of the transect.

Soils were classified as clays or sandy loams, had a low bulk density, were weakly acidic to weakly alkaline with a high organic matter content in the surface layer and were further classified as either non saline-sodic or saline-non sodic with low cation exchange capacities.

The maximum height of the community is 150cm except where *B.racemosa* occurs as an emergent which it does up to 300cm tall. This occurs where basal inundation is reduced. Cover values were high.

7.3.26 *Stenotaphrum secundatum*-mixed herb Community

This community at Mdloti Estuary occurs on the central mudflats and is localized adjacent to the east dune and previously cultivated canelands. The community in the low lying parts is basally inundated during closed mouth conditions but is exposed when the mouth opens.

Total cover values were high. Character species are *S.secundatum*, *Cyperus sphaerospermus*, *Hydrocotyle bonariensis*, *Centella asiatica* and *Ipomoea cairica*. *Panicum maximum*, *Polygonum salicifolium* and *Phragmites australis* are occasional.

Total cover values were high. Parts of the community represent a secondary grassland phase established on old sugar cane lands cultivated to the river banks. *Saccharum* sp. is still present in parts.

7.3.27 Fringing *Phragmites australis* Community

This community at Mdloti Estuary is present marginal to water courses to the east of the road bridge and occupies the internal (landward) fringe of *Barringtonia racemosa* on the north bank of the north channel of the estuary. Basal inundation on sandy substrates occurs to approximately 150cm to the east of the road bridge but inundation to the west of the road bridge is less.

Soils were classified as sandy clay loams or clayey loams, were weakly acidic to weakly alkaline with a low organic matter content and were further classified as non saline-sodic with low cation exchange capacities.

Cover values were high. The community occurs at approximately 2m in altitude and attains a height of 3,5m. *B.racemosa* occurs only very occasionally in this community.

7.3.28 Dominant *Phragmites australis* Community

This community at Mdloti Estuary is extensive to the west of the road bridge. Basal inundation to 100cm occurs in the extreme lower parts.

Soils were sandy, weakly acidic to weakly alkaline with low organic matter content and were classified as non saline-non sodic with low cation exchange capacities.

Character species are *P.australis*, *Ipomoea cairica* and *Barringtonia racemosa*. The last-mentioned usually occur as short individuals approximately 2m tall and occasionally as tall as *P.australis* to 4m. *Echinochloa pyramidalis* and *Commelina diffusa* are present occasionally.

7.3.29 *Barringtonia racemosa-Ipomoea cairica* Community

This mixed community at Mdloti Estuary is present, in parts, on shoreline margins to the east and west of the road bridge and on the island west of the bridge. Basal inundation to 100cm occurs during closed mouth conditions but substrates are exposed when the mouth opens. The substrate is moist firm mud.

The character species are *B.racemosa*, *I.cairica* and *Phragmites australis*. *Echinochloa pyramidalis* and *Commelina diffusa* are occasional.

The community is stratified. A canopy layer of between 4m to 6m comprising *B.racemosa* is succeeded by a mid-stratum of between 3m to 4m comprising *P.australis*. *E.pyramidalis* and *C.diffusa* form a field layer (under 100cm tall). *I.cairica* and *I.congesta* occur in all strata.

7.3.30 *Barringtonia racemosa* Community

This community at Mdloti Estuary is extensive on shorelines. Basal inundation to 150cm occurs during closed mouth conditions but substrates are exposed when the mouth opens (Fig. 41).

Soils were classified as sandy clay loams, sandy loams or sands, were weakly alkaline with moderately high organic matter content (especially in the sub-surface layers) and were further classified as

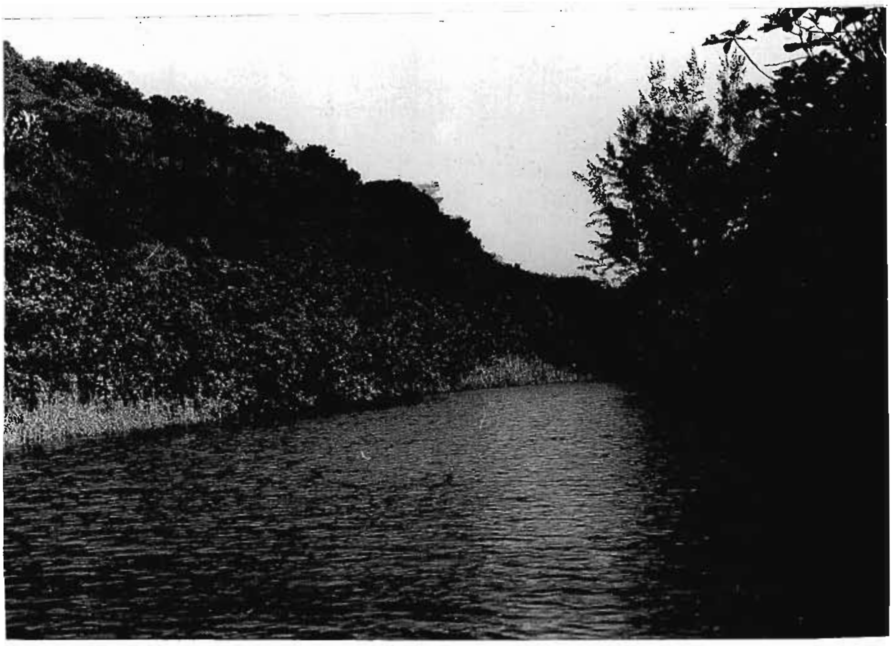

FIG. 41. Fringing *Barringtonia racemosa* Community forms a narrow strip along water courses. The extent of the stand is limited by the steeply sloped coastal dune to the left. The presence of *Phragmites australis* is an indication of a freshwater influence.

non saline-sodic or saline-non sodic with low cation exchange capacities.

This woody community comprises tall *B.racemosa* (8m to 10m). *Ipomoea cairica* and *I.congesta* are strongly associated with *B.racemosa*, in parts, and comprise the upper stratum of a two layered community. *Raufolfia caffra* (8m to 10m tall) is present occasionally, especially in elevated parts west of the road bridge. *B.racemosa* seedlings (up to 100cm tall) comprise the lower stratum especially at the landward margins where basal inundation is less than along shorelines.

Point-Centred Quarter Analysis indicates a mean density of 3 293,85 ha^{-1} and a mean basal area of 207,38cm^2 for *B.racemosa* (Table 35).

7.3.31 *Phragmites mauritianus* Community

This community at Mdloti Estuary occurs on the elevated banks carrying the road, on elevated shorelines east and west of the bridge and on raised parts of the south bank. It is above basal inundation occurring at 5m altitude on dry sandy soils.

The character species are *P.maurirtianus*, *Ipomoea congesta* and *I.cairica*. *Stenotaphrum secundatum*, *Smilax kraussiana*, *Chromolaena odorata* and *Commelina diffusa* are occasional.

Albizia adianthifolia, *Ricinus communis*, *Bridelia micrantha*, *Brachylaena discolor* and *Schinus terebinthifolius* are present occasionally with *P.mauritianus* and are indicative of a possible succession to coast forest.

7.4 DISCUSSION

The study area falls into the Coast Forest and Palm Veld of Moll (1976). Earlier classifications similar to that of Moll include the following: Coast Belt Region (Krauss, 1839, in Bews, 1921a), the Tropical African Region (Bolus, 1886, in Werger, 1978), the Coast Forest (Fourcade, 1889, in Moll, 1976), the Semi-Tropical Coast Region (Thode, 1901, in Moll, 1976), the Evergreen and Deciduous Bush (Pole Evans, 1936, in Moll, 1976) and the Tongaland-Pondoland Regional Mosaic of Werger (1978).

Walter (1979) referring to mangrove communities in general included mangroves as a halobiome in Zonobiomes I and II which are Evergreen Tropical Rain Forests with equatorial brown clays and Tropical Deciduous Forests with red clays respectively.

Acocks (1975) included mangroves as a sub-type of Coastal Forest and Thornveld. Acocks' categorization generally refers to climax communities. Hence he designated the mangrove sub-type under Veld Type I, 1, e as being Coastal Tropical (I) Forest Type (Coastal 1 Forest and Thornveld). This classification is equivalent to earlier classifications of Bews (1912) who included mangroves in his Lagoon Type Mangrove Formation and *Barringtonia* Association. In 1925, Bews included mangroves in his Tropical Sub-Tropical Trees and Shrubs while Adamson (1938) included mangroves and *Barringtonia* in his East Central African Region.

Mgeni Estuary is therefore placed in Acocks' sub-type I, 1, e and Mdloti Estuary in Bews' *Barringtonia* Association. Although difficult to place in the above classification, Mhlanga Estuary like the other two systems show tropical and sub-tropical affinities as indicated by Bews (1925). Local variations within a veld type occur and are reflections of the variations in the local habitat, environmental, climatic and topographic conditions.

Variations in vegetation patterns amongst the three estuaries are ascribed to the following:

i. The nature of the mouth, in regard to its being open or closed is dependent upon catchment characteristics. This is important because stronger river flow, as in the Mgeni River, enables a more frequent open mouth condition to be maintained. This flow is able to overcome the effects of longshore drift which tend to close river mouths as in the case of Mhlanga and Mdloti estuaries.

ii. The consequent interplay between saline and non-saline waters, as at Mgeni Estuary, creates varied conditions which allow for the introduction of a greater diversity of species.

iii. Accessibility to the estuaries and subsequent human disturbance, as at Mgeni Estuary, has allowed for the establishment of ruderals, garden escapes and invader species.

iv. Alluvial flooding and high sediment loads have resulted in the building of Athlone Island at Mgeni Estuary. At Mhlanga Estuary and Mdloti Estuary, disturbances have been effected through road and bridge construction, infilling and sugar cane cultivation. Similar disturbances have occurred at Mgeni Estuary further upstream and for a longer period. It is considered that the greater turbidities, resulting from higher silt loads, at Mgeni Estuary and Mdloti Estuary preclude the establishment of submerged macrophytes.

Variations in vegetation patterns within an estuary may be ascribed to the reasons above. In addition, differences in substrate conditions, variation in tidal inundation (and consequent salinity effects), elevation and shading effects are important at Mgeni Estuary. At Mhlanga Estuary and Mdloti Estuary, substrate variations, the degree of turbidity, elevation and basal inundation are important.

7.4.1 Lower Orders

This work has been on vascular plants primarily although algal presence have been noted.

Lack of extensive macroscopic algal development within estuaries may be related to the release of waste material into the estuaries and the scouring action of sand (Rice and Ferguson, 1975; Seagrief, 1980) and the lack of suitable substrates. All three sites have sewage works in the vicinity, lack the presence of extensive rocky substrates and in the case of Mgeni and Mdloti estuaries are turbid with high flow rates.

At Mgeni Estuary, an abundance of diatoms and macroscopic alga on pneumatophores of *Avicennia marina* has been observed. Development is especially marked on pneumatophores trailing into waters whereas those encrusted by sediment have poor development. Work is currently being undertaken on mangrove epiflora by a team from the University of Durban-Westville. Exposure of sediments at the mid-tidal level on

Athlone Island reveals the presence of a filamentous alga.

At Mhlanga Estuary, a decrease in the biomass of epiflora occurred because of mouth opening and was due to the prolonged exposure of vast areas of the estuary and reed swamp and to a large scale substrate movement caused by floodwaters leaving the estuary (Whitfield,1979). Diatoms are found attached to stems of *Phragmites australis* and to *Potamogeton pectinatus* as have been recorded elsewhere (Grindley and Heydorn,1979; Howard-Williams,1980). A filamentous alga is localized in the southern section of the estuary in slowly moving water.

At Mdloti Estuary, a filamentous alga is localized to the north-eastern section of the estuary in quiet waters.

Pteridophyta are restricted to the freshwater areas of these estuaries. At Mgeni Estuary along the western margin of Beachwood Mangroves Nature Reserve, *Acrostichum aureum* is found with *Bruguiera gymnorrhiza*. Other species at Beachwood Mangroves Nature Reserve are *Equisetum ramosissimum*, *Nephrolepis biserrata*, *N.cordifolia* and *Stenochlaena tenuifolia*. On the Mgeni River *Nephrolepis* sp. is found on the river banks above tidal influence on alluvial sediments at the uppermost tidal reaches of the estuary. This is associated with mesophytic species including *Bidens pilosa*, *Ipomoea congesta*, *I.cairica* and *Stenotaphrum secundatum*. *E.ramosissimum* is occasionally present within the estuary on sandy substrates in mixed herb stands and along the hygrophilous western fringe of Beachwood Mangroves Nature Reserve.

At Mhlanga Estuary *Thelypteris interrupta* is present in a mixed herb stand of *Typha capensis*, *Echinochloa pyramidalis*, *Phragmites australis* and *Stenotaphrum secundatum*.

At Mdloti Estuary, *Thelypteris interrupta* is present and is especially common in secondary grassland. *Equisetum ramosissimum* is also present occasionally in the same stands. *Microsorium scolopendrium* is present on elevated banks in rocky areas.

7.4.2 Angiospermae

The major plant communities are compared below.

The only submerged vascular macrophyte noted was *Potamogeton pectinatus* at Mhlanga Estuary. The distribution of this plant within the estuary is limited and is considered to be due to lack of suitable sand banks as well as increased turbidity of waters. The stands are inundated by low salinity (1‰) waters during closed mouth conditions but become exposed when the mouth opens. During open mouth conditions they may be inundated by tidal waters. The degree of inundation depends on the tidal phase. A rise in water level does not adversely affect the plant (Ward,1976) . Prolonged exposure leads to die-back of aerial shoots. Mouth opening results in an inflow of saline waters; 32‰ was recorded for bottom waters following mouth opening (Day,1981c) . The species has been recorded in salinities between 0,5‰ to 26,5‰ (Congdon and McComb, 1981; Day,1981d) . However, high salinities are reduced during mouth closure with river inflow.

The absence of *P.pectinatus* at Mgeni Estuary is ascribed to the diurnal variation in salinity, scouring action of sediments due to strong river flow and a high silt load, high turbidities and a lack of suitable substrates. At Mdloti Estuary, substrate conditions, sediment burial, turbidity and strong river flow are considered to be important factors.

Mangroves were recorded for Mgeni Estuary and Mhlanga Estuary. They are typically tropical or sub-tropical being restricted to sheltered intertidal areas of coasts and estuaries in particular (Meadows and Campbell,1978; Walter,1979) . Their presence outside the tropics, along the east African coast has been explained by the dominance of the strong south-westerly flowing warm Agulhas Current and their location in sheltered estuaries (Macnae,1962; 1968) . Mangrove presence at Mgeni Estuary is ascribed to an open mouth condition and to the presence of suitable substrates, in addition to those factors mentioned above.

An open mouth condition, at Mgeni Estuary, is ensured by strong river flow and the stabilization of the mouth position by a groyne on the south bank. The consequent tidal inundation, resulting in high to moderate soil and water salinities, allows for the establishment of mangroves on both sandy and clay substrates.

An open mouth condition is also responsible for propagule dispersal by the action of tidal currents. The establishment of propagules is determined by suitable substrate conditions. Propagules are either deposited at the high water mark or stranded at the low water mark. Successful establishment results in landward and shoreline extension of stands due to the entrapment of detrital and sediment material.

The southward and westward extension of mangroves is indicative of a changed tidal pattern within the estuary. The increased influence of tidal water and decreased influence of freshwater is possibly due to the more frequent opening of the mouth than previously and reduced river flow due to dam construction.

At Mgeni Estuary stands contain two main species, *Avicennia marina* and *Bruguiera gymnorrhiza*. There were a few *Rhizophora mucronata* in the system prior to the addition of individuals having being transplanted from Durban Bay. *Ceriops tagal* (6 in number) and *Lumnitzera racemosa* (8 in number) were introduced from Kosi Bay (Natal's most northerly estuary) and have flowered recently (T.D.Steinke,1986 ,pers.comm.) .

The various mangrove communities comprise mainly a combination of *A.marina* and *B.gymnorrhiza*. Competition between species is ascribed to salinity tolerances, edaphic factors and shade.

Salinity is influenced by a complex interplay of factors related to the nature of the mouth being open, tidal inundation, soil type, the degree of exposure and the presence of impeding structures and plants. The degree of exposure influences capillary action of water bringing salts to the soil surface and maintaining moderately high salinities in areas of infrequent tidal inundation. Percolation of waters is impeded by clay soils. Edaphic factors concern primarily soil texture which is influenced by sedimentation rates. Shade affects the establishment of seedlings (Fig. 15) .

The composition and structure of mangrove stands vary with local conditions. At Mgeni Estuary, the stands are dominated either by *A.marina* or by *B.gymnorrhiza*. The development of an understorey, where present, is influenced primarily by light intensities and soil texture. Both *A.marina* and *B.gymnorrhiza* become established in light shade on clay substrates. In addition, *A.marina* becomes established in exposed sites and in light shade on sandy substrates. Macnae (1963) records for *A.marina* that it cannot grow in the shade of *B.gymnorrhiza* and dies when 2m high and 2cm diameter. *B.gymnorrhiza* becomes established in moderate shade on clay substrates.

The distribution of plants is influenced by salinity. *A.marina* has a wider distribution than *B.gymnorrhiza* on the Mgeni River, being found at the uppermost and lowermost sections of the estuary and is indicative of a wider tolerance to salinity changes. *A.marina* occurs at the lowermost and uppermost sections of Beachwood Mangroves Nature Reserve. Within the Beachwood Golf Course, *B.gymnorrhiza* is more frequent in impeded standing water or slow moving water than is *A.marina* and this is indicative of its greater tolerance to basal inundation. *B.gymnorrhiza* is more frequent to the west of Beachwood Creek because of the freshwater streams draining into this area. *A.marina*, in this area were destroyed by freshwater basal inundation in 1972 (Moll,1972) . All species die out if continuously shaded while basally inundated (Macnae,1963) . To the east of the creek, the influence of marine sands and wave overwash appear to be important factors. However, movement of dune sands leading to burial of *A.marina* results in the death of these plants.

A.marina and *B.gymnorrhiza* are strongly associated in three of the delimited mangrove communities. They, however, differ in their values for cover, basal dominance and density where values may be equal, greater or lesser for either species (Table 25) .

At Mhlanga Estuary, *B.gymnorrhiza* was the only mangrove species recorded. This plant occurred in two small stands, comprised virtually of one parental tree plus 20 saplings and a larger group of two parental plants and 21 saplings of different ages. The stands were strongly associated with *P.australis* , which was indicative of the freshwater influence. Individuals are short with poor foliage development indicative of extended periods of basal inundation with little or no water movement or variation in levels of inundation. Basal inundation and strong shade inhibit successful seedling establishment.

The presence of extensive mangrove stands at Mgeni Estuary and not at Mhlanga Estuary is explained by regular change in water levels and salinity, as also reported for Sodwana by Bruton (1975) . The presence of *B.gymnorrhiza* at Mhlanga Estuary is most likely due to a chance recruitment during a period of simultaneous mouth opening and propagule dispersal.

The *Sarcocornia natalensis* and *Juncus kraussii* communities are exclusive to Mgeni Estuary. They occur in exposed sites on either muddy or sandy substrates. The latter occurs at a higher elevation. *J.kraussii* has been reported to occur in waterlogged places (Macnae,1963) . During closed mouth conditions basal inundation occurred. Both communities occur as pure or almost pure stands in places of infrequent tidal inundation, although the soils are saline because of seepage and capillary action. Minimal development at the east duneward margin on loose sands and areas close to the mouth are due to high salinities, as also reported by Clarke and Hannon (1970) .

S.natalensis is restricted to the lower section of Beachwood Mangroves Nature Reserve where it occurs with *A.marina* and *B.gymmorrhiza.* *J.kraussii* forms a fringing zone at the landward and duneward margins of mangrove stands, as also reported by Congdon and McComb (1981) . At Beachwood Mangroves Nature Reserve, this fringe is narrower on the duneward margin in sandy soils and passes into seral dune communities. On the western fringe, this zone passes into mesophytic communities. The plant also occurs occasionally at the western margin within mangrove stands where the canopy is open.

The absence of both communities at Mhlanga Estuary and Mdloti Estuary is due to freshwater basal inundation for extended periods. Greater competition by other plants in non-saline soils and lack of suitable substrates are other factors.

Barringtonia racemosa occurs only at Mdloti Estuary. *B.racemosa* has been described as a fringing community characteristic of tropical coasts (Adamson,1938) . This fringe is generally narrow but where the slope is gentle the fringe is wide. At Mdloti Estuary the extent of the fringe is limited by a steeply sloping hill and by sugar cane cultivation. The plant is subject to basal inundation during closed mouth conditions and it is suggested that this freshwater influence increases competition by other plants, especially *Phragmites australis*, and reduces the extent of the *B.racemosa* fringe. Associated trees include *Rauvolfia caffra*, *Bridelia micrantha* and *Phoenix reclinata*. *R.caffra* occurs more frequently to the west than to the east of the road bridge at higher elevation. *Rhus nebulosa* is also present on the elevated banks of the national road, and together with the above mentioned plants, is an indicator of a succession to coast forest.

The presence of *Barringtonia racemosa* at only Mdloti Estuary is related to weakly saline soils comprising a moderately high percentage of small sized fractions and to basal inundation. Such occurrences have also been recorded by Bews (1912; 1921a; 1921b; 1925), Adamson (1938), Moll (1969) and Berjak *et.al.* (1977). At Mgeni Estuary, salinity of soils and water precludes the development of the plant whereas at Mhlanga Estuary soils are generally sandy and non-saline.

Echinochloa pyramidalis communities occur at Mhlanga Estuary and Mdloti Estuary and the plant is present at Mgeni Estuary. At Mgeni Estuary, the plant is restricted to small stands on both banks of Mgeni River and in the Beachwood Creek. On the Mgeni River, *E.pyramidalis* occurs with *Schoenoplectus littoralis*, on sandy soils, together with seedlings of *A.marina* and *Bruguiera gymnorrhiza*. On the Beachwood Creek *E.pyramidalis* fringes tall (5m) *B.gymnorrhiza* on clay substrates. The plant occurs extensively above the tidal limit on the Mgeni River.

E.pyramidalis communities are more extensive at Mdloti Estuary than at Mhlanga Estuary and its greater development is favoured by the presence of extensive sand and mudflats and its tolerance of basal inundation. The ability to raft into open water is limited by river flow rates and it occurs to a greater extent, in this form, at Mhlanga Estuary than at Mdloti Estuary.

At Mhlanga Estuary, *E.pyramidalis* is marginal to reed swamp stands and occurs in mixed herb stands. At Mdloti Estuary, *E.pyramidalis* is associated with *Phragmites australis* and *Schoenoplectus littoralis* on the river banks, and *Barringtonia racemosa* (short) and *Polygonum salicifolium* to the landward margins. *Eichhornia crassipes* occurs entrapped in the quiet backwaters of the north feeder channel adjacent to *Echinochloa pyramidalis* at Mdloti Estuary. These are washed into the easterly estuarine parts during flooding and decompose when the river mouth opens.

Hibiscus tiliaceus Community is present at Mhlanga Estuary and Mgeni Estuary. At Mhlanga Estuary, the community is present on firm sandy substrates that are basally inundated by freshwater during closed mouth conditions. This period of inundation is up to eight months and depends on river flow and flooding. Its presence as a well branched, short tree is indicative of basal inundation for extended periods. Associated plants are *Phragmites australis* and *Typha capensis*. In less inundated areas, but influenced by drainage streams at the southern extension of the estuary, *H.tiliaceus* occurs with *Ludwigia octovalvis*, *Hydrocotyle bonariensis*, *Centella asiatica*, *Cyperus immensus*, *Ipomoea cairica*, *I.congesta*, *Commelina diffusa*, *Typha capensis* and *Asystasia gangetica*. Reduced basal inundation at this site is reflected in greater floral diversity.

At Mgeni Estuary, *Hibiscus tiliaceus* is present either as individual plants or as small stands or as a narrow fringe to the Beachwood Creek. On the Mgeni River, the plant is present on both banks, to the east of Athlone Bridge as small stands on elevated, firm, alluvial banks and attains a height of approximately 5m. The plant is associated with *Phragmites australis* and *Brachylaena discolor* on the north bank and with *Avicennia marina* on the south bank. *Arundo donax* also occurs in parts.

H.tiliaceus has been recorded in brack waters overlapping with landward fringes of mangrove swamps (Berjak *et.al.*,1977) . At Mgeni Estuary, the plant is found only very occasionally with *Bruguiera gymnorrhiza* on raised sandy substrates to the east of Beachwood Creek. *H.tiliaceus* is present as a fringing zone to the Beachwood Creek and western marginal fringes in the upper section of the estuary where it is frequently associated with *B.gymnorrhiza. A.marina*, *Brachylaena discolor* and *I.cairica* also occur.

High soil salinities and tidal inundation either result in stunted growth or death of the plant.

H.tiliaceus is present at Mgeni Estuary and Mhlanga Estuary and not at Mdloti Estuary because of the greater depth of basal inundation and lower soil salinities at Mdloti Estuary.

At Mgeni Estuary the western landward fringe of Beachwood Mangroves Nature Reserve is characterized, in parts, by a narrow fringe of freshwater influenced vegetation. Plants found include *Colocasia antiquorum*, *Sesbania punicea*, *Ludwigia octovalvis*, *Phragmites australis*, *Typha capensis*, *Zantedeschia aethiopica* and *Ipomoea cairica. Chromolaena odorata*, *Lantana camara* and *Schinus terebinthifolius* occur at higher elevation. This western fringe is characterized by a high water-table due to seepage waters draining from the Leo Boyd Highway, streams and drains, and soft yielding soils. Waters are oligohaline (1‰) . Drainage into the Beachwood Creek and percolation of water is impeded by clay soils supporting tall (8m to 10m) *Bruguiera gymnorrhiza* stands.

P.australis communities are present at the Mgeni, Mhlanga and Mdloti estuaries but are more extensive at Mhlanga Estuary and Mdloti Estuary.

At Mgeni Estuary, distribution of *P.australis* is limited by soil and water salinities and the extent of the stands is limited by lack of basal inundation, strong river flow and the influence of man. The plant is present on Athlone Island and to a limited extent on the western fringes of Beachwood Mangroves Nature Reserve. The disappearance of previously recorded extensive reed vegetation on the islands in the Mgeni Estuary (Ingram,1895) perhaps reflects a changed tidal pattern within the estuary. The presently raised substrates support mesophytic communities.

At Mhlanga Estuary, *P.australis* occurs extensively throughout the floodplain as either a pure stand or as an almost pure stand. Basal inundation for extended periods during closed mouth conditions apparently causes no harmful effects. Waters are of low salinity (1‰) and low turbidity (Secchi Disc 120cm) .

At Mdloti Estuary, *P.australis* occurs extensively on sandbanks and mudflats close to the water's edge. The stands are basally inundated by oligohaline waters (1‰) . Stands are either pure or mixed.

The purity and density of stands are due to water depth, shading, nutrient status, aeration, salinity and temperature (Haslam,1971a; 1971b). This is reflected in the greater distribution at Mhlanga Estuary where more extensive basal inundation (150cm) and greater shading effect (light intensity of 2,5% of maximum) occurs than at Mgeni Estuary and Mdloti Estuary. Higher salinities reduce distribution, as at Mgeni Estuary, although the plant is known to occur elsewhere in areas of tidal influence (Edwards,1967). At Mgeni Estuary, associated plants include *Stenotaphrum secundatum* and *Ipomoea cairica* whereas at Mhlanga Estuary the associated plants are *I.cairica*, *Lemna* sp. and *Typha capensis* and Mdloti Estuary the associated plants are *Barringtonia racemosa*, *I.cairica* and *Echinochloa pyramidalis*.

P.australis provides detritus, acts as silt traps, reduces wave action and provides shelter (Millard and Broekhuysen,1970). Contributions to organic matter content by *P.australis* is reflected by the organic matter content of those soils (Table 15, Sample A).

The elevated banks at Mdloti Estuary are occupied by *Phragmites mauritianus* stands whereas the elevated banks at Mgeni Estuary on the north bank of the Mgeni River and the western bank of the Beachwood Mangroves Nature Reserve, in parts, are occupied by *Arundo donax* stands. Both sites are above tidal influence and basal inundation and are associated with mesophytes. Associates common to both sites are *Lantana camara*, *Chromolaena odorata* and *Cardiospermum grandiflorum*. At Mdloti Estuary other associates include *Bridelia micrantha*, *Albizia adianthifolia* and *Rhus nebulosa* while at Mgeni Estuary the associates are *Ficus natalensis* and *Brachylaena discolor*.

A *Typha capensis*-mixed herb community occurs at Mhlanga Estuary. At Mhlanga Estuary the southern extension of the swamp is occupied by this community. *Cyperus immensus* is an associate which occurs more frequently with increased elevation. At Mgeni Estuary *Typha capensis* occurs at the upper tidal limits of the Mgeni River (at the railway bridge) and at Beachwood Mangroves Nature Reserve (western hygrophilous fringe) . At Mdloti Estuary *T.capensis* occurs at the landward margins, at isolated sites, of the estuary.

Stenotaphrum secundatum communities occur at Mgeni Estuary and Mdloti Estuary whereas the plant is present as an associate of *T.capensis*-mixed herb stands at Mhlanga Estuary.

At Mgeni Estuary, *S.secundatum* occurs as either pure or mixed stands at the upper tidal limits on sandy soils. Although salt tolerant, *S.secundatum* is abundant at higher levels above tidal influence (Chapman,1960; Macnae,1963) . At Mdloti Estuary, some stands are basally inundated during closed mouth conditions and at Mhlanga Estuary stands are influenced by seepage waters.

Associated species of *S.secundatum* at Mgeni Estuary are *Commelina diffusa*, *Ipomoea congesta* and *I.cairica*. At Mdloti Estuary associates are *Hydrocotyle bonariensis*, *Centella asiatica*, *Echinochloa pyramidalis* and *I.cairica* at the lower levels and *Canna indica*, *Commelina diffusa*, *Pavonia patens* and *Saccharum* sp. at the higher levels.

Apart from mangroves at Mgeni Estuary, other woody plants are present on the banks of the Mgeni River, on Athlone Island and to a lesser extent at the north end of the Beachwood Mangroves Nature Reserve. This vegetation is above tidal influence.

At Athlone Island, mesophytes have been established on alluvial sediments. Sedimentation within the estuary has been accentuated by erosion in the catchment and canalization of the river above the head of the estuary. A build-up of sediments above normal tidal influence has resulted in the establishment of *Chromolaena odorata*, *Lantana camara* and *Schinus terebinthifolius*.

At the north end of the Beachwood Mangroves Nature Reserve a greater influence of freshwater and reduced tidal influence explains the presence of *Bridelia micrantha*, *Schinus terebinthifolius*, *Mimusops caffra* and *L.camara* and associated species comprising *Canna indica*, *Melanthera scandens*, *Coix lacryma-jobi*, *Trema orientalis* and *Brachylaena discolor*.

The absence of *Chromolaena odorata*, *Lantana camara* and *Schinus terebinthifolius* thicket communities at Mhlanga Estuary and Mdloti Estuary is due to a greater degree of basal inundation, elevation and less human disturbance. Easier accessibility to Mgeni Estuary has resulted in greater disturbance and is reflected in the plants present. These include *C.odorata*, *L.camara*, *Cardiospermum grandiflorum*, *Ricinus communis*, *Melia azedarach*, *Acacia mearnsii* and *S.terebinthifolius*.

7.4.3 Succession

Succession within the three named systems is determined by topography (elevation) , level of the water-table, edaphic factors, basal inundation, distance from water courses and shading effect with an additional factor of tidal inundation (salinity) at Mgeni Estuary.

Successional trends are depicted in Figs. 42, 43 and 44 for the Mgeni, Mhlanga and Mdloti estuaries respectively.

Avicennia marina is the pioneer species on exposed sandy or clay substrates at the lowermost levels of Mgeni Estuary. The area is characterized by greater tidal inundation and longer residence times of tidal water than the more mature mangrove stands. The pioneers form pure stands which later allow for the establishment of *Bruguiera gymnorrhiza* plantlings.

Establishment of *B.gymnorrhiza* is favoured because of a shading effect and the accumulation of silts brought about by *A.marina*. Where the canopy is open, both *A.marina* and *B.gymnorrhiza* plantlings establish themselves although the latter occurs to a greater extent. In stands of closed canopies, where maximum shading occurs, plantling establishment of both species is precluded.

Substrate levels are raised by sedimentation in *A.marina* stands by the presence of pneumatophores which reduce water movement and entrap detrital material. Effects of tidal inundation are therefore reduced.

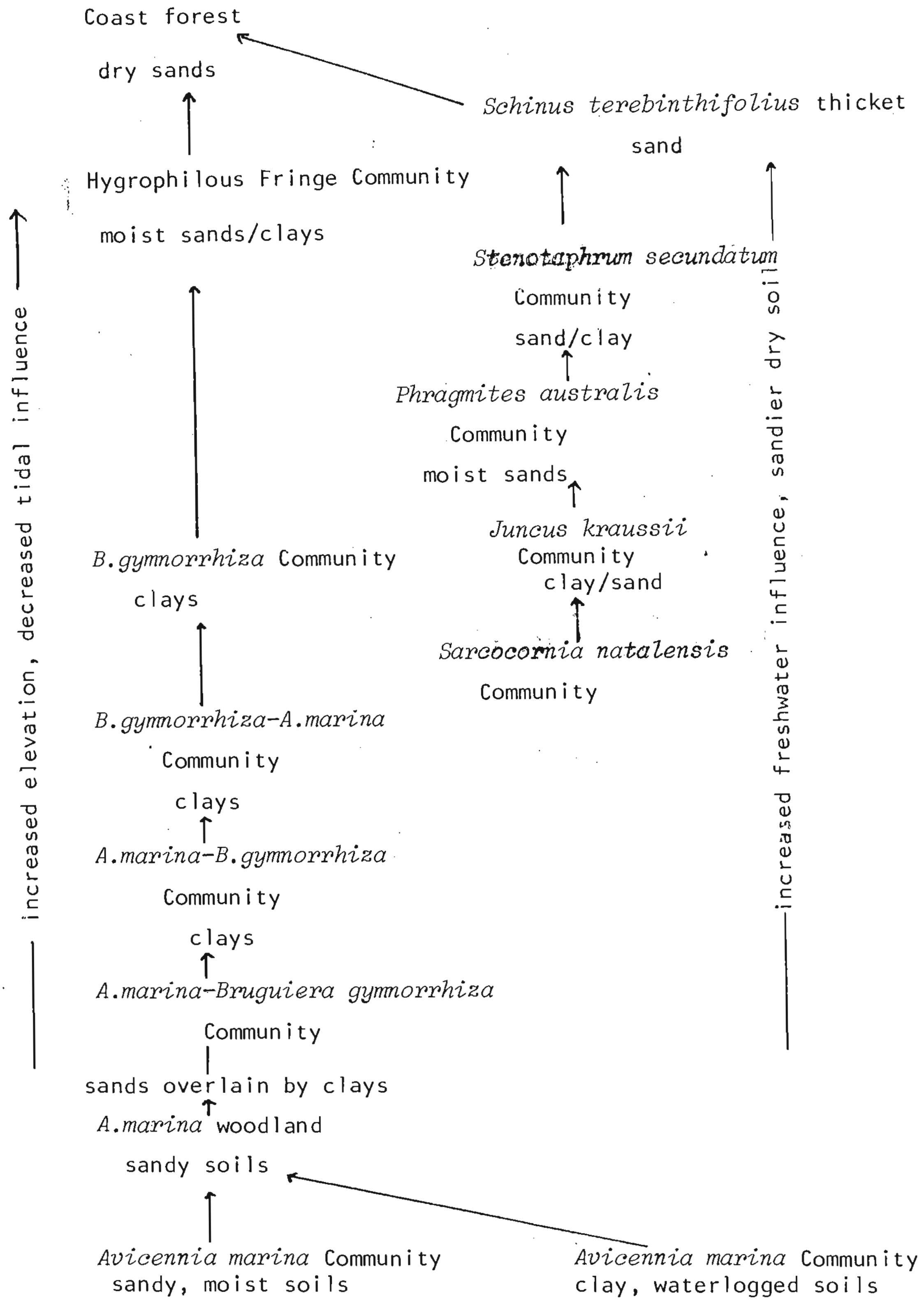

FIG. 42. Schematic representation of proposed successional trends at Mgeni Estuary.

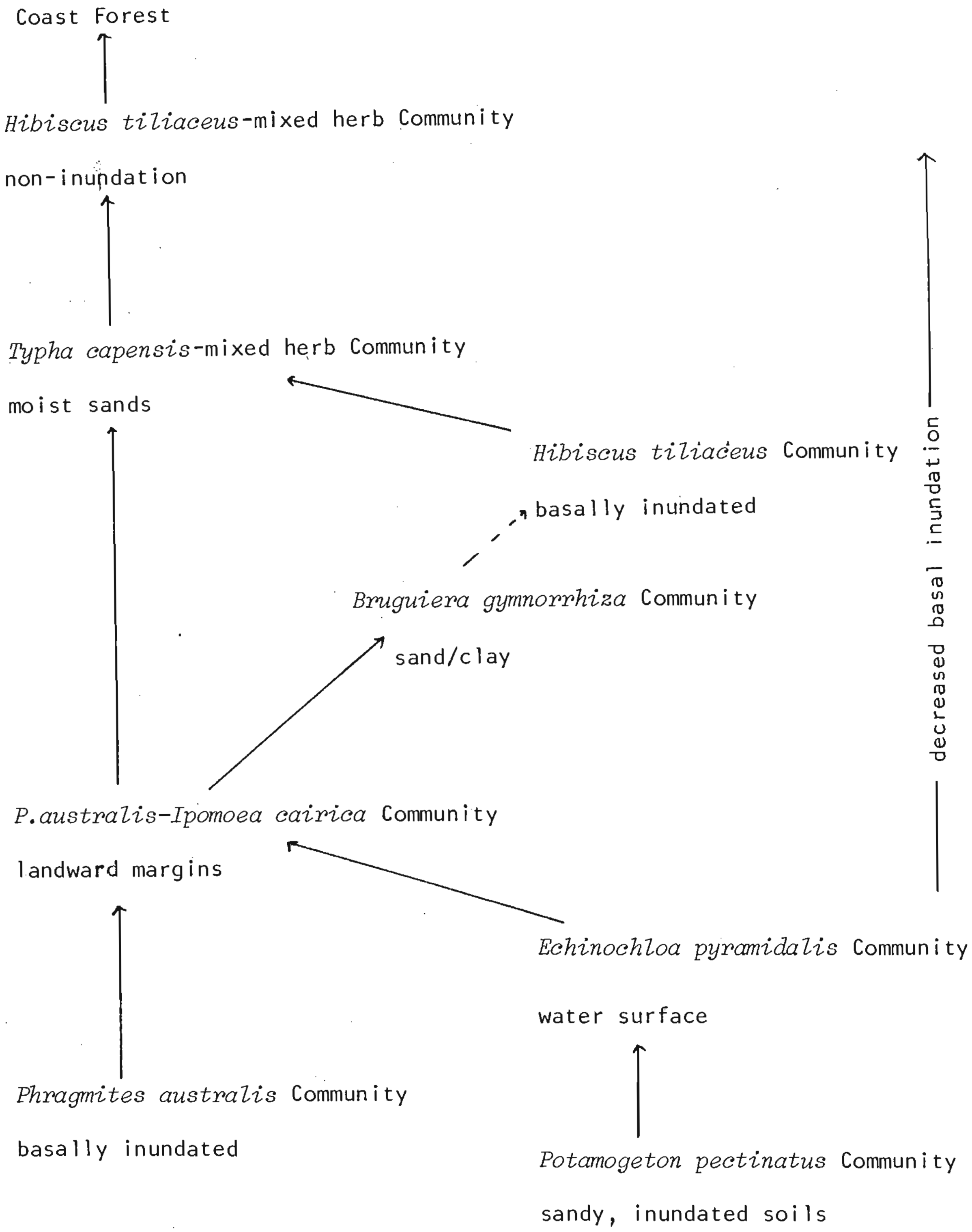

FIG. 43. Schematic representation of proposed successional trends at Mhlanga Estuary.

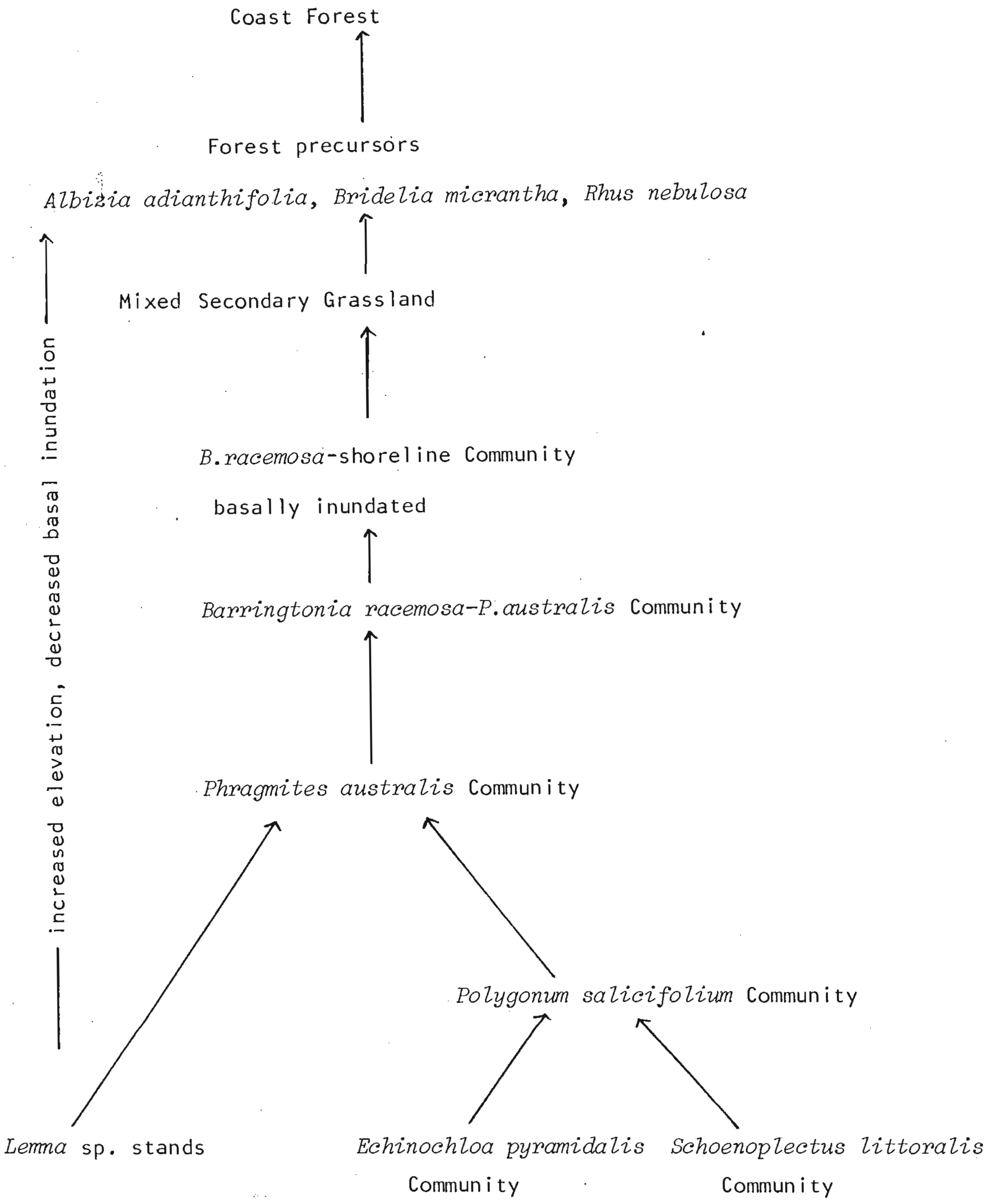

FIG. 44. Schematic representation of proposed successional trends at Mdloti Estuary.

Increased distance from water courses, increased elevation and a subsequent lack of tidal inundation is reflected in a change from saline to less saline and mesophytic communities. High salinities at exposed sites are maintained by seepage and evaporation. Soils are dry and sandy as less alluvial material is deposited on the landward fringes of the floodplain.

The relationship between plant communities is reflected in the following sequence from the more tidally influenced to the less tidally influenced communities accompanied with an increase in elevation.

i. *Sarcocornia natalensis* Community
ii. *Juncus kraussii* Community
iii. *Phragmites australis* Community (on Athlone Island)
iv. *Stenotaphrum secundatum* Community
v. Fringing hygrophilous Community (Beachwood Mangroves Nature Reserve) characterized by the presence of *Colocasia antiquorum*, *Ipomoea cairica*, *I.congesta* and *Zantedeschia aethiopica*.
vi. thicket communities (Athlone Island) characterized by the presence of *Schinus terebinthifolius*, *Lantana camara*, *Chromolaena odorata*, *Cardiospermum grandiflorum* and *I.cairica*.

The thicket communities also comprise plants indicative of a succession to coast forest. These include *Erythrina lysistemon*, *Trema orientalis*, *Ficus natalensis*, *Bridelia micrantha* and *Brachylaena discolor*.

Potamogeton pectinatus is a pioneer species on sandy substrates in clear, shallow waters at Mhlanga Estuary. *Echinochloa pyramidalis* and *Phragmites australis* occur marginal to water courses, usually as pure stands. Increased elevation, decreased basal inundation and a lower water-table allow *I.cairica* and *Typha capensis* to become established. The influence of seepage waters in areas of non-inundation promotes the establishment of *Commelina diffusa*, *Polygonum salicifolium*, *Typha capensis*, *Cyperus natalensis* and *S.secundatum*. *Hibiscus tiliaceus* occurs in basally inundated areas as a small tree and in non-inundated areas as well developed trees up to 5m tall. In non-inundated sites, the plant occurs with *Mimusops caffra* and is an indication of succession to coast forest.

Echinochloa pyramidalis pioneers either sandy or clay substrates at Mdloti Estuary and is tolerant of basal inundation. *Schoenoplectus littoralis* occurs occasionally along margins of water courses. *Polygonum salicifolium* and *Stenotaphrum secundatum* become established in areas of lesser basal inundation. Establishment of *Barringtonia racemosa* is favoured in areas of clay soils and low water-table along shorelines. Basal inundation restricts the establishment of *B.racemosa* seedlings and its landward extension is limited by steep slopes. *Phragmites australis* is associated with *B.racemosa* at lower elevations whereas *Rauvolfia caffra* is an important associate at higher elevations on sandy soils. *R.caffra* together with *Bridelia micrantha*, *Albizia adianthifolia* and *Rhus nebulosa* which occur on the elevated banks of the road are indicative of succession to a coast forest.

CHAPTER 8

CONCLUSIONS

With climatic conditions that are essentially sub-tropical, the climax communities within the demarcated tidally inundated or freshwater basally inundated study sites vary. Succession is influenced by topography, level of the water-table, edaphic factors, basal inundation, distance from water-courses, shading effects and tidal inundation. Plants indicative of a succession to coast forest climatic climax occur in the study area.

At Mgeni Estuary, *Avicennia marina* is the pioneer plant on sandy and clay substrates in areas of greater tidal inundation while *Bruguiera gymnorrhiza* stands are considered to represent the later stages of a halosere on clay, less tidally inundated and sometimes water-logged substrates. The zonation of mangrove stands is not always parallel to the shoreline of local drainage systems, but the discontinuities between them and non-mangrove stands are clearly defined and related to reduced tidal inundation and salinity, increased elevation and changes in substrate conditions. *Schinus terebinthifolius* community on Athlone Island is considered the highest stage of succession to a woodland community. Plants seral to coast forest climax are *Erythrina lysistemon*, *Trema orientalis*, *Ficus natalensis*, *Bridelia micrantha* and *Brachylaena discolor*. The non-mangrove stands display a greater floral diversity than mangrove stands.

At Mhlanga Estuary, *Potamogeton pectinatus* is a pioneer species in open water. *Phragmites australis* occupies an intermediate zone between total inundation and non-inundation. The later stages of this fresh-water hydrosere are represented by non-inundated stands of *Hibiscus tiliaceus* and intermediate transitional *Stenotaphrum secundatum* and *Typha capensis*-mixed herb stands in areas of lesser basal inundation, increased elevation and a lower water-table than *P.australis*.

At Mdloti Estuary, *Echinochloa pyramidalis*, *Schoenoplectus littoralis*, *Eichhornia crassipes*, *Barringtonia racemosa* and *Lemna* sp. are considered to be pioneer species at different parts of the system. The later stages of this freshwater hydrosere are represented by bank vegetation at elevated sites comprising *Rauvolfia caffra*, *Bridelia micrantha*, *Albizia adianthifolia*, *Mimusops caffra* and *Rhus nebulosa*. These plants are indicative of a succession to coast forest. *Barringtonia racemosa* maintains itself as a woodland fringe in most parts of the system.

The composition and character of sediments are determined by various geogenetic parameters and allogenic factors including climate, mineralogy of parent rock and adjacent coastal areas and tidal inundation. These edaphic factors affect successional relationships, especially with regard to the establishment of pioneer species. The organic matter content of soils is determined by soil texture, the contributing detrital material and regularity of flushing of the three systems. The generally high organic matter content of mangrove soils as opposed to non-mangrove soils is due to the contribution made by mangrove detrital material than the contribution made by a variety of forbs. The high organic matter content at Mhlanga Estuary and Mdloti Estuary is due to *in situ* decomposition and assimilation of entrapped detrital material into sediments before flushing by floods. At Mgeni Estuary, detrital material is assimilated into sediments by faunal activity, primarily crab activity.

The marked differences in vegetation patterns and the dominant plants present are ascribed to interdependent factors related to the nature of the river mouths in respect of their being open or closed, river flow and siltation. The mouth of the Mgeni River is normally open because of the higher river flow and the stabilized mouth position which is able to overcome the effects of longshore drift and sediment deposition at the mouth. At Mhlanga Estuary and Mdloti Estuary, where the mouths usually open or are artificially opened across a sandbar, the low flow rates are unable to overcome longshore drift and sediment build-up and the mouths soon close.

The open nature of the mouth influences tidal inundation with concommitant effects on salinity. These in turn influence zonation patterns or species distribution. The extent of tidal inundation is influenced by elevation, slope, river flow and vegetation. Impediments due to bridge construction on the Mgeni River reduce tidal influence. The presence of saline soils and waters have assisted in the development of mangrove stands by reducing competition from mesophytes.

The often closed mouths of the Mhlanga and Mdloti rivers resulting in freshwater or near freshwater conditions have led to the establishment of plants tolerant of prolonged basal inundation and infrequent tidal inundation. At Mhlanga Estuary, *Potamogeton pectinatus* has become established because of a sandy substrate, generally non-turbid waters, lower sediment loads and lower flow rates resulting in less abrasive effects than at the other two sites. The presence of *Bruguiera gymnorrhiza* at Mhlanga Estuary is ascribed to a chance recruitment. Its position within the system suggests recruitment during a simultaneous open mouth period and propagule dispersal. The poor condition of the stand is ascribed to unfavourable conditions related to prolonged basal inundation and lack of variation in water levels.

At Mdloti Estuary, the high water-table and low salinity has allowed *Barringtonia racemosa* to have become established. The plant is absent at Mgeni Estuary, along the Mgeni River, because of high salinities at the upper levels of the floodplain and because of a low water-table. The sandy, partially inundated soils of the western mangrove fringe and its abutment against mesophytic stands perhaps precludes *B.racemosa* at Beachwood Mangroves Nature Reserve. The presence of *Phragmites australis*, and its greater extent at Mhlanga Estuary, is related to low salinities.

All three study sites represent areas of low floral diversity but dense populations. Greater diversity exists in areas of greater disturbance and in areas of less freshwater influence than in protected and less accessible areas. This is reflected at Mgeni Estuary where its easier accessibility and greater disturbance has resulted in the occurrence of more alien invader species than at the other two sites.

CHAPTER 9

SUMMARY

Data on plant communities are presented in Chapter 7, physical measurements of estuarine waters are presented in Chapter 2 and experimental data on soils are presented in Chapter 6. These data are discussed in Chapter 7. The physiographic factors are largely dealt with in Chapter 2. The faunal component and the historical background which includes the influence of man are presented in Chapters 4 and 5 respectively. A check-list of vascular plants is attached as Appendix A. The report is illustrated by 44 figures and includes photographs, line drawings, schematic diagrams and maps. Thirty four tables are included to illustrate relevant features discussed.

Physiographic data indicate that there are major differences in catchment characteristics of the three systems. These are largely responsible for differences in the open nature of the river mouths, turbidity, flow rates and sediment loads. The Mgeni River mouth position is more stable and more frequently open than those of the Mhlanga and Mdloti rivers.

Climatic data for the three sites are similar. These are summarised as: summers (October to March) are cloudier than winters (April to September) ; temperatures are mild (mean annual of approximately 20,2°C) and rainfall is between 939,0mm to 1 017,9mm per annum of which approximately 68% occurs in the summer months. Dew is especially common in the winter months. A high relative humidity is experienced throughout the year. Winds are usually southerly or north-easterly. The microclimate is affected by the type of vegetation present and influences vegetation patterns.

Vegetation at all three study sites has been influenced by man. This has included residential and recreational development, industrial expansion and engineering works including road, rail, bridge and canal development as well as agricultural development.

The Braun-Blanquet phytosociological approach was used to analyse vegetation. In addition, the Point-Centred Quarter Method was used to analyse woody vegetation. Soils were analysed for their physical and chemical properties, in accordance with standard procedures, and they were related to the vegetation present. Differences in soil characteristics were ascribed to various geogenetic parameters. Vegetation results indicate that 16 communities were present at Mgeni Estuary, 7 communities were present at Mhlanga Estuary and 8 communities at Mdloti Estuary. Changes in vegetation patterns were indicated from a study of aerial photographs of different dates.

Vegetation results indicate that at least 185 species occur in the study area. Ten belong to the Pteridophyta, 66 to the Monocotyledonae and 109 to the Dicotyledonae. The number of species reflects the low diversity of estuarine flora. The larger number of species at Mgeni Estuary (149) than at Mhlanga Estuary (70) and Mdloti Estuary (93) is ascribed to the greater disturbance at that estuary.

The major plant communities and factors affecting them and succession at the study sites are discussed in Chapter 7. The more important constituent species are given. At Mgeni Estuary, those stands dominated by *Bruguiera gymnorrhiza* represent the later stages of the halosere. *Schinus terebinthifolius* stands on Athlone Island represent the later stages of succession on the island. At Mhlanga Estuary, *Hibiscus tiliaceus* represent the later stages of the hydrosere. At Mdloti Estuary, the later stages of the hydrosere are represented by bank vegetation comprising *Rauvolfia caffra*, *Bridelia micrantha*, *Albizia adianthifolia* and *Rhus nebulosa*. *Barringtonia racemosa* represents a fringing woodland community along shorelines at Mdloti Estuary.

The potential succession to a coast forest climax is indicated by the presence of *Erythrina lysistemon*, *Trema orientalis*, *Ficus natalensis* and *Bridelia micrantha* at Mgeni Estuary, *Mimusops caffra* at Mhlanga Estuary and *R.caffra*, *B.micrantha*, *A.adianthifolia* and *Rhus nebulosa* at Mdloti Estuary. *M.caffra* also occurs at Mdloti Estuary.

Major differences in vegetation patterns for the three estuaries were related to the open nature of river mouths, tidal inundation, freshwater basal inundation, elevation, edaphic factors and light intensities.

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APPENDIX A

A CHECK-LIST OF VASCULAR PLANTS FROM THE THREE ESTUARIES: MGENI, MHLANGA AND MDLOTI

A check-list of vascular plants from the study area as demarcated in Figs.2, 3 and 4 is presented. All sites have been affected by man.

The Beachwood Mangroves Nature Reserve which forms part of the Mgeni Estuary and the Mhlanga Estuary which forms part of the Mhlanga Lagoon Nature Reserve are under the jurisdiction of the Natal Parks, Game and Fish Preservation Board. The Mgeni River section of the estuary is controlled by the Municipality of Durban. The southern bank of the Mdloti Estuary is controlled by the Umdloti Beach Health Committee and the Development and Services Board. The northern bank of the estuary is controlled by the Borough of Tongaat.

Plants listed include naturalized aliens which are regarded as part of the established flora in the study area as well as those plants apparently introduced into the study area. The presence of the latter is to a large extent due to dumping of garden refuse, especially along the banks of the Mgeni River and also disturbances caused by road and bridge construction.

Numbered specimens mentioned in this check-list have been submitted to the herbarium of the University of Durban-Westville. Those specimens not collected were matched with specimens in the herbarium of the

University of Durban-Westville. Unnamed numbers listed are Raiman numbers, those indicated by W are C. J. Ward numbers and those indicated by C. J. & M. C. W. are C. J. & M. C. Ward numbers. Species are indicated as occurring at Mg, Mh and Md for Mgeni, Mhlanga and Mdloti estuaries respectively.

Plant identifications have been verified by Mr. C. J. Ward who, in addition, is responsible for many of the determinations. The arrangement of families in the check-list follows that of Ross (1972) and Gibbs Russell *et. al.* (1984; 1985) . The arrangement of genera and the names indicated are from Gibbs Russell *et. al.* (1984; 1985) . Species are listed in alphabetical order.

PTERIDOPHYTA

EQUISETACEAE

Equisetum ramosissimum Desf.	Mg,Md	1821

SALVINIACEAE

Salvinia molesta D.S.Mitchell	Mg	

ADIANTACEAE

Acrostichum aureum L.	Mg	W,9289
Cheilanthes viridis Forssk. Swartz var.	Mg	1830

POLYPODIACEAE

Microsorium scolopendrium (Burm.f.) Copel.	Md	1860

DAVALIACEAE

Nephrolepis biserrata (Swartz) Schott	Mg	W,9293
Nephrolepis cordifolia (L.) Presl.	Mg	W,9294

THELYPTERIDACEAE

Thelypteris dentata	(Forssk.) E.St.John	Mg,Mh,Md	W,9288
Thelypteris interrupta	(Willd.) K.Iwats.	Mg,Md	1837

BLECHNACEAE

Stenochlaena tenuifolia	(Desv.) T.Moore	Mg	1838; W,9292

SPERMATOPHYTA

ANGIOSPERMAE

TYPHACEAE

Typha capensis (Rohrb.) N.E.Br.	Mg,Mh,Md	1892

POTAMOGETONACEAE

Potamogeton pectinatus L.	Mh	W,9353

JUNCAGINACEAE

Triglochin striata Ruiz & Pav.	Mg	1802

POACEAE

Coix lacryma-jobi L.	Mg	1851
Saccharum sp.	Mg,Mh,Md	1976
Hemarthria altissima (Poir.) Stapf & C.E.Hubb.	Mg	1905
Rottboellia exaltata L.f.	Mh	C.J.& M.C.W,46
Imperata cylindrica (L.) Raeuschel	Mg,Md	1820;1893
Sorghum versicolor Anderss.	Md	1784
Digitaria natalensis Stent	Mg,Md	1910
Eriochloa meyerana (Nees.) Pilg. subsp. *meyerana*	Mh,Md	C.J.& M.C.W,53
Brachiaria chusqueoides (Hack.) Clayton	Mg,Mh	1906
Paspalum paspalodes (Michx.) Scribn.	Mg	C.J.& M.C.W,47

Paspalum vaginatum Swartz	Mg	1903;1904
Stenotaphrum secundatum (Walt.) Kuntze	Mg,Mh,Md	1789;1814
Echinochloa crus-galli (L.) Beauv.	Mh	C.J.& M.C.W,49
Echinochloa pyramidalis (Lam.) Hitchc.& Chase	Mg,Mh,Md	1815
Panicum deustum Thunb.	Mg,Md	1907
Panicum maximum Jacq.	Mg,Mh,Md	1908;1909
Setaria megaphylla (Steud.) Dur.& Schinz	Mg	1890;1895
Setaria sp.	Md	1911
Setaria sp.	Mg	1988
Rhynchelytrum repens (Willd.) C.E.Hubb.	Mg,Md	1894
Cenchrus brownii Roem.& Schult	Mh	1899
Arundo donax L.	Mg	1977
Phragmites australis (Cav.) Steud.	Mg,Mh,Md	1896
Phragmites mauritianus Kunth	Mg,Mh,Md	
Sporobolus africanus (Poir.) Robyns & Tournay	Mg,Md	1900;1901
Sporobolus virginicus (L.) Kunth	Mg	W,9188
Eragrostis capensis (Thunb.) Trin.	Mg,Md	1897
Eragrostis inamoena K.Schum.	Mh	
Cynodon dactylon (L.) Pers.	Mg,Mh,Md	1902
Bambusa balcooa Roxb. ex Roxb.	Md	1898

CYPERACEAE

Cyperus articulatus L.	Mh	1806

Cyperus distans L.f.	Mh	1920
Cyperus esculentus L.	Mh	1919;1929
Cyperus immensus C.B.Cl.	Mg,Mh,Md	1817
Cyperus sexangularis Nees	Mh	1931
Cyperus sphaerospermus Schrad.	Mg,Mh,Md	1826
Cyperus textilis Thunb.	Mg,Mh	1931
Pycreus flavescens (L.) Reichb.	Mh	
Pycreus polystachyos (Rottb.) Beauv. var. *polystachyos*	Mh	1869;1921;1923
Mariscus sp.	Mg,Mh	1925
Kyllinga elatior Kunth	Mg	1879
Kyllinga sp.	Mg,Mh	1926
Scirpus sp.	Mh	1881
Schoenoplectus littoralis (Schrad.) Palla	Mg,Mh,Md	1778
Fimbristylis ferruginea (L.) Vahl	Mg	1922

ARECACEAE

Phoenix reclinata Jacq.	Mg,Mh,Md	1985

ARACEAE

Zantedeschia aethiopica (L.) Spreng.	Mg,Mh	1878
Colocasia antiquorum Schott	Mg	

LEMNACEAE

Lemna sp.	Mg,Mh,Md	1883

COMMELINACEAE

Commelina diffusa Burm. f.	Mg,Mh,Md	1808
Commelina sp.	Mg	1933
Aneilema aequinoctiale (Beauv.) Kunth	Mg,Mh,Md	1932

PONTEDERIACEAE

Eichhornia crassipes (Mart.) Solms-Laub.	Mg,Mh,Md	1816

JUNCACEAE

Juncus kraussii Hochst.	Mg	1790;1827;1829

LILIACEAE

Gloriosa superba L.	Mg,Md	1844
Protasparagus falcatus (L.) Oberm.	Mg,Mh	1880

AGAVACEAE

Agave sp.	Mg	

LILIACEAE

Smilax kraussiana Meisn.	Md	1866

HYPOXIDACEAE

Hypoxis rooperi S.Moore	Mg,Md	1835

IRIDACEAE

Gladiolus dalenii van Geel	Mg,Md	

MUSACEAE

Strelitzia nicolai Reg & Koerner	Mg,Md	Nair,3

CANNACEAE

Canna indica L.	Mg,Mh,Md	1934

ORCHIDACEAE

Eulophia speciosa R.Br.ex Lindl.) H.Bol.	Mg,Md	1834

CASUARINACEAE

Casuarina equisetifolia G. Forst.	Mg,Md	1779

ULMACEAE

Trema orientalis (L.) Blume	Mg,Md	1885

MORACEAE

Morus alba L.	Mg	1796
Ficus natalensis Hochst.	Mg,Md	1978

URTICACEAE

Laportea peduncularis (Wedd.) Chew	Mh	1875
Droguetia urticaefolia Wedd.	Mg	

POLYGONACEAE

Rumex nepalensis Spreng.	Mh	C.J.& M.C.W,52
Polygonum salicifolium Willd.	Mh,Md	1780;1785;1935
Polygonum senegalense Meisn. forma *albotomentosum* R. Grah.	Mg,Mh	1979

CHENOPODIACEAE

Atriplex patula L. subsp. *verreauxii* (Moq.) Aell.	Mg	1836;1936
Sarcocornia natalensis (Bunge ex Ung.Sternb.) A.J.Scott	Mg	1791;1803

AMARANTHACEAE

Amaranthus deflexus L.	Mg	1937
Alternanthera sessilis (L.) DC.	Mg,Mh,Md	1810

MESEMBRYANTHEMACEAE

Carpobrotus dimidiatus (Haw.) L.Bol.	Mg,Mh,Md	1832

RANUNCULACEAE

Ranunculus multifidus Forssk.	Mg,Md	1938

PAPAVERACEAE

Argemone mexicana L.	Mg	

CRASSULACEAE

Kalanchoe rotundifolia (Haw.) Haw.	Md	1865

ROSACEAE

Rubus rigidus Sm.	Mh,Md	1939

LEGUMINOSAE

Albizia adianthifolia (Schumach.) W.F.Wight	Md	1859
Acacia mearnsii De Wild	Mg	
Cassia didymobotrya Fresen.	Mg	1940
Cassia mimosoides L.	Mg,Md	1947
Cassia occidentalis L.	Mg	1981
Caesalpinia bonduc (L.) Roxb.	Md	C.J.& M.C.W,42
Crotalaria lanceolata E.Mey.	Mg,Md	1945
Indigofera spicata Forssk.	Mg	1941
Sesbania punicea (Cav.) Benth.	Mg	
Zornia capensis Pers.	Mg	1943
Desmodium canum (J.F.Gmel.) Schinz & Thell.	Mg	1794
Desmodium setigerum (E.Mey.) Benth. ex Harv.	Mg	1946
Erythrina lysistemon Hutch.	Mg	1942
Canavalia maritima (Aubl.) Thouars	Mg,Md	1807
Vigna sp.	Mg	1944
Mucuna gigantea L.	Md	C.J.& M.C.W,40

OXALIDACEAE

Oxalis corniculata L.	Mg,Mh,Md	1948
Oxalis semiloba Sond.	Md	

MELIACEAE

Melia azedarach L.	Mg,Md	1986

EUPHORBIACEAE

Bridelia micrantha (Hochst.) Baill.	Mg,Md	1867
Ricinus communis L.	Mg,Mh,Md	1949
Euphorbia heterophylla L.	Mg	1957
Euphorbia hypericifolia L.	Mh	1994

ANACARDIACEAE

Schinus terebinthifolius Raddi	Mg,Mh,Md	1846
Rhus nebulosa Schonl.	Mg,Md	1864;1950

ICACINACEAE

Apodytes dimidiata E.Mey.ex Arn.subsp.*dimidiata*	Mg	1848

SAPINDACEAE

Cardiospermum grandiflorum Schwartz	Mg,Md	1840
Allophylus melanocarpus (Sond.) Radlk.	Mg	1990

VITACEAE

Rhoicissus rhomboidea (E.Mey.ex Harv.) Planch.	Mg,Md	1951

MALVACEAE

Sida dregei Burtt Davy	Mg,Md	1953
Pavonia patens (Andr.) Chiov.	Mg,Md	1952
Hibiscus cannabinus L.	Mg,Mh,Md	
Hibiscus tiliaceus L.	Mg,Mh,Md	1870

CACTACEAE

Opuntia vulgaris Mill.	Mg,Mh	

THYMELAEACEAE

Passerina rigida Wikstr.	Mg	1831

LECYTHIDACEAE

Barringtonia racemosa (L.) Roxb.	Md	1783

RHIZOPHORACEAE

Ceriops tagal (Perr.) C.B.Robinson	Mg	
Rhizophora mucronata Lam.	Mg	1800

Bruguiera gymnorrhiza (L.) Lam.	Mg,Mh	1793
Bruguiera sp.	Mg	

COMBRETACEAE

Lumnitzera racemosa Willd.	Mg	

MYRTACEAE

Psidium guajava L.	Mg,Mh,Md	1954
Eugenia capensis (Eckl.& Zeyh.) Harv.ex Sond.	Mg	1955
Syzygium cordatum Hochst.	Mg,Mh,Md	

ONAGRACEAE

Ludwigia octovalvis (Jacq.) Raven subsp. *sessiliflora* (Mich.) Raven	Mg,Mh,Md	1873
Ludwigia stolonifera (Guill.& Perr.) Raven	Mh,Md	
Oenothera rosea L'Hérit.ex Ait.	Mg,Md	1956

APIACEAE

Hydrocotyle bonariensis Lam.	Mg,Mh,Md	1781
Centella asiatica (L.) Urban	Mg,Mh,Md	1818

SAPOTACEAE

Sideroxylon inerme L.	Mg,Md	1863
Mimusops caffra E.Mey.ex A.DC.	Mg,Mh,Md	1782

APOCYNACEAE

Catharanthus roseus (L.) G.Don	Mg	1982
Rauvolfia caffra Sond.	Mg,Md	1862

ASCLEPIADACEAE

Asclepias physocarpa (E.Mey.) Schltr.	Mg	1958

CONVOLVULACEAE

Cuscuta sp.	Mg	1987
Hewittia sublobata (L.f.) Kuntze	Mg,Mh,Md	1959
Ipomoea cairica (L.) Sweet	Mg,Mh,Md	1813
Ipomoea congesta R.Br.	Mg,Mh,Md	1843
Ipomoea pes-caprae (L.) Sweet	Mg,Md	1983
Ipomoea wightii (Wall.) Choisy	Md	

VERBENACEAE

Lantana camara L.	Mg,Mh,Md	1960
Avicennia marina (Forssk.) Vierh.	Mg	1786;1792

SOLANACEAE

Solanum acanthoideum E.Mey.	Mg	1991
Solanum mauritianum Scop.	Mg,Md	1961
Solanum nigrum L.	Mg,Md	
Lycopersicum esculentum Mill.	Mg,Md	1962
Datura stramonium L.	Mg	1992

ACANTHACEAE

Asystasia gangetica (L.) T.Anders.	Mg,Mh,Md	1799;1824

CUCURBITACEAE

Momordica involucrata E.Mey.ex Sond.	Mg	
Lagenaria mascarena Naud.	Mg	1963

LOBELIACEAE

Lobelia anceps L.f.	Mh	1874

GOODENIACEAE

Scaevola plumieri (L.) Vahl	Mg	1984

ASTERACEAE

Ageratum conyzoides L.	Mg,Mh,Md	1964
Chromolaena odorata (L.) R.M.King & H.Robinson	Mg,Mh,Md	1841
Conyza floribunda H.B.K.	Mg,Mh	1965
Brachylaena discolor DC.	Mg,Mh,Md	1845
Helichrysum cymosum (L.) D.Don	Mg,Md	1973
Helichrysum decorum DC.	Mg	1974
Eclipta prostrata (L.) L.	Md	C.J.& M.C.W,50
Helianthus argophyllus Torr.& Gray	Mg	1966
Melanthera scandens (Schumach.& Thonn.) Roberty subsp. *dregei* (DC.) Wild	Mg	1798
Bidens biternata (Lour.) Merr.& Sherff	Mg	1967
Bidens pilosa L.	Mg,Mh,Md	
Tagetes erecta L.	Mg,Md	1968
Tagetes minuta	Mg,Mh,Md	
Senecio madagascariensis Poir.	Mg	1975
Senecio polyanthemoides Sch. Bip.	Mg	1993
Chrysanthemoides monilifera (L.) T.Norl. subsp. *rotundata* (DC.) T. Norl.	Mg	
Gazania rigens (L.) Gaertn. var. *uniflora* (L.f.) Roessler	Mg,Md	1970
Taraxacum officinale Weber	Mg,Md	1971
Lactuca indica L.	Mg	1972
Lactuca serriola L.	Mg	