5.7 SOUTH AFRICA

Introduction

South Africa is the second largest country in Region 5, with an area of 1 184 825 km^2. It has a population of 26 124 000 (1983) and therefore a mean population density of 22 persons/km^2. However, the population is heavily concentrated in the eastern half of the country and apart from the southern coastal strip, most of the west has a population density of 2 persons/km^2 or less. South Africa extends 1400 km from north to south, between latitudes 22° 10' and 34°50'S and 1619 km from west to east, between longitudes 16°30'E (Alexander Bay) and 32°52'E (Kosi Bay). It has the longest national coastline in Africa, exceeding 3000 km. It is the only country on the continent to be washed by both the Atlantic and Indian Oceans, and these, by their opposing influences, are important determinants of its climate. Cold polar waters on the Atlantic coast bring arid conditions to the west, while the warm tropical waters of the Agulhas Current lead to reliable precipitation on the eastern and southern coasts.

There is a narrow coastal plain all around the country, widening in Zululand, in the northeast, to some 80 km. On both east and west coasts, the mountains backing the plain lead up through foothills and a series of scarps and minor plateaux, to the great central plateau discussed in the introduction to the region. There, most of the surface lies above the 1000 m contour and comprises flat or gently undulating land which slopes towards the northwest, away from the high southeastern rim formed by the Drakensberg Mountains. The interior plateau reaches its lowest levels along the borders of Botswana and Namibia, at elevations of 600 -700 m asl, in the vast shallow sandy valley of the now seasonal, and sometimes perennially dry, Molopo River.

The southern coastal plain is backed by several ranges of ancient fold mountains, quite separate from the great massif which forms the central plateau. These include the Langeberg, Swartberg, Kougaberge and some ancillary ranges. They rise to heights of over 2000 m and descend, on their northern flanks, to the Great Karroo, a subsidiary plateau which intervenes between the southern coast ranges and the main escarpment of the interior plateau. In places the southern flanks of the coast ranges reach the sea, thus interrupting the coastal plain. All streams of the west coast between the Orange and Olifants Rivers are seasonal. Thereafter, along the south coast, almost all streams are perennial, although highly seasonal in their discharge. All large streams are perennial on the east coast, but towards the north, in Zululand, some small rivers which rise on the coastal plain or its immediate hinterland, are again seasonal.

Climate

For up to seven months of the year (April-October), when high pressure prevails over the interior, the country is predominantly influenced by descending divergent upper air

masses that tend to circulate eastwards causing fine weather and minimal precipitation. Southwesterly and southerly winds bring rain to the southern coastal plain and mountains in winter (April-September), while southeasterly and northeasterly winds, blowing off the Indian Ocean, bring rain to the east coast during summer (October-March). The west coast and western interior is very dry, as is the Great Karroo which is in the rainshadow of the coast ranges. Temperatures frequently reach 40°C in the western and northern interior regions in summer, and may occasionally reach this figure in northern Natal. Frosts are common on the mountains and in the central interior during the winter. Severe hailstorms can occur over almost any part of the country in spring and summer, and have been known to kill large animals, and to decimate huge flocks of birds.

Wetlands

With the exception of the St Lucia system, there are no wetlands of great magnitude in South Africa, but because of the small total extent of wetlands in such a large and predominantly arid country, most sites are of considerable biological and national importance. Several are of international importance as the breeding sites and the southern terminals for numerous species of birds migrating between continents.

The most important and best known South African wetlands are coastal; either estuarine systems, or lakes, swamps, marshes, floodplains and pans on the long coastal plain. On the high mountains of the south and east there are extensive sponges and peat bogs, and perennial herbaceous swamps on many valley floors. On the central plateau, there are a host of seasonal pans, some endorheic lakes, and numerous artificial impoundments, with some small and very irregularly inundated floodplains.

Wetland Flora

Saltmarshes: The lowest reaches of saltmarshes are dominated by *Zostera capensis*, often with some *Spartina nzaritima* above this. The higher levels support such species as *Chenolea diffusa*, *Cyperus fastigiatus*, *C. marginatus*, *Juncus krausii*, *Limonium scabrunz*, *Sarcocornia natalensis*, *S. perennis*, *Scirpus maritimus*, *S. triqueter*, *Triglochin bulbosa* and *T striata*. *Mesembryanthemum crystallinum* occurs on salt pans of the southern and southwestern coasts.

Mangroves: Mangroves occur only on the east coast, beginning just north of East London at the Nahoon River mouth (32°59'S/28°58'E). Thereafter they occur at the mouths of most streams in Transkei, but the southernmost sites contain only *Avicennia marina* in open stands under which saltmarsh species flourish. *Bruguiera gymnorrhiza* joins *Avicennia* in the mangroves on the Mbashe Estuary (32°14'S/28°55'E) and *Rhizophora mucronata* joins the association at the Mngazana Estuary (31°42'S/29°25'E). *Hibiscus tiliaceus* is also present here, but may occur to the south. From Mngazana northwards all four species occur in the tidal forests, although *Rhizophora* is not present in all sites. In the most northern mangrove swamp, at Kosi Bay, *Ceriops tagal* and *Lumnitzera*

racemosa also enter the association. *Acrostichum a*ureum is found in the landward mangrove, under an open canopy, and also occurs in reed swamp where this occurs adjacent to the mangrove. A number of other species, trees and shrubs, are found on the mangrove fringes in northern Natal, all subject to periodic tidal inundation. These include some freshwater swamp forest species and some characteristic of dune or riverine forest. Among the more common are *Acacia karroo*, *Allophyllus natalensis*, *Apodytes dimidiata*, *Barringtonia racemosa*, *Brachylaena discolor*, *Casuarina equisetifolia*, *Chrysanthemoides monilifera*, *Erythrina lysistemon*, *Garcinia livingstonei*, *Macaranga capensis*, *Phoenix reclinata*, *Schinus terebinthifolius* and *Syzygium cordatum*.

Coastal Freshwater Swamp Forest: Here *Barringtonia racemosa*, *Cnestis natalensis*, *Ficus burttdavyi*, *F. sur*, *F. trichopoda*, *F. vogelii*, *Garcinia livingstonei*, *Hibiscus diversifolius*, *Macaranga capensis*, *Myrica serrata*, *Phoenix reclinata*, *Rauvolffia caffra*, *Schefflera umbellifera*, *Syzygium cordatum* and *Voacanga thouarsii* are characteristic species. Several woody lianes, including *Abrus precatorius*, *Dalbergia armata* and *Entada pursaetha* may climb in the trees, which often stand with their trunk bases submerged for many consecutive months. Other climbers include the fern *Stenochlaena tenuifolia* as well as *Capparis* sp., *Gloriosa superba*, *Rhoicissus digitata*, *Secamone frutescens* and *Smilax kraussiana*. Near the sea, little bushes of *Cassia bicapsularis* and patches of the coarse terrestrial fern *Acrostichum aureunz* abound in open spaces between clumps of trees where *Cladium* sp., *Scirpus littoralis* and *Stenotaphrum secundatum* cover the ground. Here there are also many trailing plants, *Ipotnoea* spp., a terrestrial orchid *Platylepis glandulosus* and numerous bulb plants such as *Haetnanthus katherinae* and *Crinum* spp. This type of vegetation may have a transition with typical mangrove vegetation on coastal lagoons and estuaries. The naturalised herbs *Conyza bonariensis* and *C. floribunda* are locally abundant on the fringes of this vegetation.

Riverine Forest or Thicket: This is best developed in the east and is floristically very rich. Constituent species include *Acacia caffra*, *A. schweinfurthii*, *A. sieberana*, *Acokanthera oppositifolia*, *Allophyllus africanus*, *A. decipiens*, *Artabotrys brachypetalus*, *Balanites maughamii*, *B. pedicellaris*, *Bauhinia tomentosa*, *Cassia petersiana*, *Cassine aethiopica*, *Chaetacme aristata*, *Clausena anisata*, *Cordyla africana*, *Dalbergia armata*, *Ficus soldanella*, *F. sycomorus*, *Hugonia orientalis*, *Millettia stuhlmannii*, *Papea capensis*, *Phyllanthus reticulatus*, *Psoralea pinnata*, *Rhus lancea*, *Sesbania seban*, *Strychnos spinosa*, *Trema orientalis* and *Trichelia enzetica*.

Reed Swamps: These are dominated by *Phragmites australis* or *P. mauritianus* depending upon site. The former species is able to tolerate moderate levels of salinity and is often present behind mangrove stands and along estuaries, and often occludes shallow coastal lakes and lagoons. *Typha capensis* frequently forms patches in the *Phragmites* swamp, and on the landward sides, reed swamps often give way to lower growing sedges e.g. *Eleocharis* spp., *Scirpus littoralis* and *S. nodosus*, or swards of *Juncus acutus* and, or *J. krausii*. A number of climbers occur in the fringes of the *Phragmites* swamps, chiefly species of *Ipomoea*. Often there are grasses around the landward fringes, e.g. *Sporobolus virginicus* in saline areas, giving way to *Stenotaphrum secundatum* and *Dactyloctenium geminatum* behind, the latter in wet and the former in drier sites.

In deeper water, outside the *Phragmites* swamp, floating-leaved and free-floating species may carpet the water. Among the former, *Nymphaea caerulea* and *N. capensis* are widespread, while *Lonna gibba* and *Spirodela* spp., are free-floating species. *Eichhornia crassipes* occurs in many systems in Natal, often fully occluding small lakes and estuaries, while *Salvinia molesta* has been identified in other systems. *Leersia hexandra* and *Ludwigia stolonifera* often form masses in the water around the banks. Below the water, and floating at its surface, there may be meadows of *Ceratophyllum demersum*, *Myriophyllum spicatum*, *Najas marina*, *N. pectinata*, *Potamogeton pectinatus*, *P. schweinfurthii*, *Ruppia marina* (near coast), *R. spiralis* and *Utricularia inflexa*.

Papyrus Swamps: Cyperus papyrus is important in northern Natal where it dominates large areas subject to marked seasonal fluctuations in water level. Usually it is associated with *Phragmites mauritianus, Typha capensis* and several lower growing species.

Montane Wetlands: The high alpine sponge bogs are dominated by short mat-forming angiosperms, including both stoloniferous and rosette plants. Common species include the composites *Athrixiafontana*, *Berkehya multijuga*, *Haplocarpha nervosa*, *H. scaposa*, and occasionally *Helichrysum palustre*, also a grass, *Agrostis huttoniae*, sedges, *Carex* spp., *Schoenoxiphium filiforme* and *Scirpus fluitans*, a rush, *Luzulua africana*, and *Limosella capensis*, *L. grandiflora* and *L. longiflora* (*Scrophulariaceae*). Algae dominate the submerged vegetation of pools which occur over springs in the sponges, where species of *Lyngbia*, *Nitella* and *Spirogyra* are most important. *Aponogeton spathaceum* and *Crassula natans* are generally the only true aquatic angiosperms present, but *Limosella* spp. frequently grow in the water with floating leaves. Mosses fringe pools and occur in the ground layer of the sponge, but *Sphagnum* spp., the aquatic bog-forming mosses of the northern hemisphere, are absent. *Grintmia apocarpa* and a species of *Mnium* are most important. Around the drier margins of the bog, but still on peat soil, *Elsiea flanaganii*, *Eragrostis caesia*, *Eriocaulon baurii*, *Geunt capense*, *Kniphofia caulescens*, *Koeleria cristata*, *Moraea* spp., *Ranunculus baurii*, *Rhodohypoxis rubella*, *Sebaea thodeana* and *Senecio cryptolanatus* grow densely between occasional tussocks of *Danthonia drakensbergensis*. *Geranium incanum*, *Oxalis depressa* and *Trifoliunz burchellianum* grow on hummocks in the bog, as well as on the periphery.

At lower elevations, the pale green and much taller *Kniphofia caulescens* grows profusely in bogs together with *Juncus glaucus* var. *acutissimus* and a number of tall sedges. *Danthonia* tussocks again characterise the margins. The vegetation of these bogs is taller than that of the surrounding grassland. Many orchids grow in these bogs, including *Brownleea macroceras*, *Habenaria cornuta*, *Holothrix incurva*, *Satyrium cristatum*, *S. macrophylluin* and *S. neglectum*, together with a variety of alpine herbs.

Tiny streamlets in the alpine zone are fringed by herbaceous communities up to 1 m high, usually dominated by the tussock grasses *Danthonia drakensbergensis* and *D. macowanii*, but with *Berkheya multijuga*, *Carex* spp., *Juncus exsertus*, *Kniphofia caulescens*, *Polygonunz salicifolium*, *Rhodohypoxis rubella*, *Senecio achilleifolius*, and *S. cryptolanatus* between tussocks, and, in places, low woody shrubs of *Cliffortia*

browniana, *Erica thodei*, *E. alopecurus* and *Euyops montanus*.

Lower down the mountains, between 2000-1600 m asl, aquatic and hygrophilous communities are numerous but usually of small size. In occasional tarns, and in open water in upland valley swamps, some algae, and the aquatic mosses *Philonotus laeviuscula* and *P. afromontana*, dominate the submerged community. *Aponogeton junceus* and *Crassula natans* occur in open water, and around the margins, in very shallow water, plants such as *Anagallis huttonii*, *Crassula natans*, *Ericocau ton absyssinicunz*, *E. dregei*, *Limosella capensis*, *L. maior* and *Scirpus fluitans* occur, with a taller fringe of *Cyperus fastigiatus*, *Juncus exsertus* and *Polygonum strigosum*, at the margins, gradually encroaching upon the water as sedimentation procedes. Eventually the open water surface is lost and the pool is occluded by a taller community of the grasses *Arundinella nepalensis*, *Danthonia disticha* and *Pennisetum thunbergii*, with the sedges *Eleocharis dregeana*, *Rhynchospora brownii*, *Scirpus ficiniodes* and *S. macer*, the rushes *Juncus exsertus* and *J. rostratus* and a few other herbs, e.g. *Anoiganthus breviflorus* and *Gunnera perpensa*.

Similar communities develop along foothill streams and here a wide range of other species creeps in as the community ages. These include *Anemone fannanii*, *Aristea angolensis*, *Berkheya macrocephala*, *Helichrysum* spp., *Calpurnia woodii*, *Chironia krebsii*, *Cyrtanthus flanaganii*, *Disa fragrans*, *Drosera natalensis*, *Geranium ornithopodum*, *Gladiolus papilio*, *Moraea spathulata*, *Rabdosia calycina*, *Satyrium neglectum* and *Tysonia africana*. Later hydrosere stages include tall grasses, exceeding 2 m in height, such as *Cymbopogon validus*, *Hyparrhenia aucta* and *Miscanthidium capense*.

On flatter sites that are only seasonally flooded, sedges dominate the vegetation, including *Ascolepis capensis*, *Bulbostylis schoenoides*, *Fuirena pubescens*, *Kyllinga erecta*, *Mariscus congestus*, *Pycreus oakfortensis*, *Scleria welwitschii* and *S. woodii*. Hygrophilous grasses follow in the succession, including *Agrostis huttoniae*, *A. lachnantha*, *Andropogon appendiculatus*, *A. eucomus* and *Stiburus alopecuroides*. There are also many lilies, e.g. *Agapanthus campanulatus*, *A. nutans*, *Galtonia candicans* and *Tulbaghia natalensis* together with various Iridaceae such as *Aristea woodii*, *Dietes vegata*, *Hesperantha lactea*, *Moraea modesta* and sometimes *hypoxidaceous* species, e.g. *Hypoxis acuminata*, *H. filiformis* and *H. gerrardii*.

Wetland Fauna

Invertebrates: The freshwater crab *Potanionautes sidneyi* is widely distributed, ranging from coastal lakes to mountain streams. In southern and southwestern estuaries *Anurida maritima*, *Assiminea globules*, *Deto echinata*, *Exosphaeroma hylecoetes*, *Hymenosoma orbiculare*, *Orchestia rectipalma* and *Palaemon pacificus* are abundant in algal weed beds, while *Cyclograpsus punctatus* dominates the mudbanks and *Callianassa kraussi* is abundant in sand. This latter species also occurs in mudbanks if *Upogebia africana* is absent.

The invertebrate fauna of the mangrove clad, east coast estuaries comprises over 200 benthic species. *Solen cylindraceus* and *Tharyx marioni* occur in the anoxic mud below the low water mark of spring tides. Higher up the shore, in the mud of the *Zostera* beds, *Aglaia capensis*, *Alpheus crassimanus*, *Ceratonereis erythraeensis*, *C. keiskatnina*, *Cirriformia tentaculata*, *Cleistostoma algoense*, *Clibanarius longitarsus*, *Dosinia hepatica*, *Grandidierella bonneroides*, *Melita zeylanica*, *Metapenaeus monoceros*, *Nassarius kraussiana*, *Natica* sp., *Orbinia angrapaquensis*, *Palaemon pacificus*, *Penaeus indicus*, *P. monodon* and *Upogebia africana* also feed there. Under the mangroves *Assiminea bifasciata*, *Cerithidea decollata* and *Littorina scabra* occur in vast numbers and ascend the mangrove trunks. *Sesarma catenata* and *Terebralia palustris* also occur here, the former often climbing into the trees. *Scylla serrata* is common towards the seaward face of the mangroves. *Uca annulipes*, *U. chlorophthalmus*, *U. urvillei* and *U. vocans* are found in the mangroves but are most prolific on the fringes, where *Ilyograpsus rhizophorae*, *Sesarnza guttata* and *S. meinerti* may be abundant.

Orchestia rectipalma and *Perinereis falsovariegata* occur in the patchy algal bostrychieturn on the pneumatophores of *Avicennia*. *Balanus amphitrite* and *Crassostraea cucullata* and calcareous tubeworms attach to mangrove roots, and logs embedded in the mud, almost to the limit of tidal influence. *Martesia striata* (lamellibranch) also occurs in estuaries, and nests of *Oecophylla* spp. and the webs of spiders, e.g. *Gasteracantha* spp., are found in the trees.

Fish: Freshwater fishes of the southwestern and southern coasts include *Barbus burgi*, *Galaxias zebratus* and *Sandelia capensis*. Among estuarine species there are *Argyrosomus hololepidotus*, *Gilchristella aestuarius*, *Gobius multifasciatus*, *Hepsetia breviceps*, *Lithognathus lithognathus*, *Liza richardsoni*, *Mugil cephalus*, *Psammogobius knysnaensis* and *Rhabdosargus globiceps*. However, several species have been introduced, e.g. *Cyprinus carpio* and *Oreochrornis mossambicus*.

The fauna of eastern estuaries and estuarine lakes is richer. *Periophthalmus kalolo* occurs throughout the mangroves. *Acanthopagrus berda*, *Alestes imberi*, *Ambassis commersoni*, *Anguilla bicolor*, *Argyrosomus hololepidotus*, *Barbus paludinosus*, *B. toppini*, *B. trimaculatus*, *Clarias gariepinus*, *C. ngamensis*, *Coryphopterus multifasciatus*, *Ctenopoma multispinis*, *Eutropius depressirostris*, *Gilchristella aestuarius*, *Glossogobius giuris*, *Hydrocynus vittatus*, *Hypseleotris dayi*, *Labeo rosae*, *L rubropunctatus*, *Liza macrolepis*, *Marcusenius macrolepidotus*, *Mugil cephalus*, *Mugilogobius durbanensis*, *Neobola brevianalis*, *Nothobranchius orthonotus*, *Oreochromis mossambicus*, *Pornadasys comrnersonni*, *Rhabdosargus sarba*, *Tilapia rendalli* and *T spamnanii* are some of the others found in Natal.

Amphibians: A number of frogs and toads have been recorded in southern coastal swamps including *Bufo pardalis, B. rangeri, Hyperolius horstocki and Rana grayi*, but there are rather more in the northeast. Here *Afrixalus fomasinii, A. spinifrons, Arthrolepis stenodactylus, A. wahlbergi, Bufo regularis, Cacosternurn boettgeri, Chiromantis xerampelina, Hemiscus marmoratum, Hylanzbates nzaculatus, Hyperolius marmoratus, H. nasutus, H. puncticulatus, H. pusillus, H. semidiscus, H. taeniatus, H. tuberilinguis,*

Kassina senegalensis, Leptopelis natalensis, Phrynobatrachus natalensis, Phrynomerus bifasciata, Ptychadena oxyrhynchus, Pyxicephalu adspersus, P. natalensis, Rana angolensis, R. fasciata, R. grayi, R vertebralis, R. wageri and *Xenopus laevis* are found in wetland situations.

Amphibians also occur in montane wetlands. *Bufo gariepinus* and *Rana hymenopus* reach the summit plateau at over 3000 m asl. Others exhibit a wide altitudinal range and are found from the lower slopes up to the summit plateau. These include *Breviceps adspersus, Bufo gutturalis, Cacosternurn boettgeri, Heleophryne natalensis, Kassina senegalensis, Phrynobatrachus natalensis, Pyxicephalus natalensis, P. adspersus, Rana angolensis, R. fasciata, R grayi* and *R. vertebralis*. Typically these species occur close to water, or damp swampy ground.

Reptiles: *Acontias plumbeus, Brachypodion punzilum, Crocodylus niloticus, Pelosios sinuatus, Varanus exanthematicus* and *V. niloticus* occur in the northern coastal wetlands. *Lygodactylus capensis* occurs in southern reed swamps and the terrapin *Pelomedusa subrufra* occurs from the Cape northwards. Common snakes in coastal wetlands include *Aparallactus capensis*, *Crotophopeltis hotamboeia*, *Lycodononzorphus laevissimus*, *L. rufulus*, *Naja melanoleuca*, *Natriciteres variegata sylvatica*, *Philothamnus angolensis, P. hoplogaster, P. irregularis, P. natalensis* and *Python sebae*, while arboreal snakes found in swamp forest trees include *Dasypeltis scabra, Dendroaspis angusticeps, Philothamnus semivariegatus* and *Thelotornis capensis*. Some species range high into the mountains, favouring damp locations and feeding very largely upon amphibians, e.g. *Lycodonornorphus rufulus, Lycophidion capense* and *Philothamnus natalensis*.

Birds: Birds associated with South African wetlands, and fairly widely distributed, include *Actophilornis africanus, Anhinga anhinga, Ardea cinerea, A. goliath, A. melanocephala, A. purpurea, Arenaria interpres, Bubo africanus, Bubulcus ibis, Butorides striatus, Calidris alba, C. ferruginea, C. minuta, Ceryle rudis, Charadrius marginatus, C. pecuarius, C. tricollaris, C. hiaticula, Corythornis cristata, Egretta garzetta, E. intermedia, Fringillaria capensis, Fulica cristata, Gallinula chloropus, Glareola pratincola, Haematopus moquini, Halcyon senegalensis, Haliaeetus vocifer, Himantopus himantopus, Hoplopterus armatus, Hydroprogne caspia, Ixobrychus minutus, Limnocorax flavirostris, Megaceryle maxima, Nycticorax nycticorax, Pelicanus onocrotalus, Phalacrocorax africanus, P. capensis, P. carbo, P. coronatus, P. neglectus, Phoeniconaias minor, Phoenicopterus ruber, Platalea alba, Plegaclis fakinellus, Philomachus pugnax, Porphyrio porphyrio, Recurvirostra avosetta, Scopus umbretta, Scotopelia peli, Speniscus demersus, Squatarola squatarola, Stephanibyx coronatus, Sterna bergii, Tachybaptus ruficollis, Threskiornis aethiopicus, Tringa nebularia* and *Tyto capensis*.

Many bird species occur in the mountains, the majority at lower elevations where habitats are more diverse. Species commonly seen in mountain swamps include *Anthropoides paradisea, Ardea nzelanocephala, Asio capensis, Bubo africanus, Bubulcus ibis, Burhinus capensis, Buteo buteo, B. rufofizscus, Circus ranivorus, Elanus caeruleus, Francolinus levaillantii, Geronticus calves, Hagedashia hagedash, Milvus aegyptius, Numida*

meleagris, Scopus umbretta and *Tyto alba*.

Mammals: Mammals found in southern and southwestern coastal swamps include *Aonyx capensis, Atilax paludinosus, Felis caracal, F. lybica, Genetta tigrina, Herpestes ichneumon* and *Papio ursinus*. *Mirounga leonina* enters many estuaries. Other small mammals found on coastal floodplains and vlei margins include *Crociduraflavescens, Myosorex varius, Otomys irroratus* and *Rhabdomys pumilio*. The first 6 of these also occur in northern wetlands.

Cercopithecus pygerythrus is common in the canopy and on the ground in mangroves and freshwater swamp forests, which are both also frequented by *Cephalophus monticola, Redunca arundinum* and *Tragecephalus scriptus* in parts of Natal. *Dasymys incomtus* and *Otomys angoniensis* are found throughout the northern wetlands, including tidal swamps. Other mammals found in northern wetlands include *Aepyceros melampus, Canis mesomelas, Cephalophus natalensis, Cercopithecus albogularis, Crocidura cyanea, Cryptomys hottentotus, Cynictis penicillata, Felis serval, Hippopotamus amphibius, Ictonyx striatus, Lutra maculicollis, Neotragus moschatus, Orycteropus afer, Otomys irroratus, Panthera pardus, Pellomys fallax, Potamochoerus porcus, Praomys natalensis, Proteles cristatus* (St Lucia), *Rattus rattus, Rhabdomys pumilio, Sylvicapra grimmia, Thryonomys swinderianus, Tragelaphus angasi* and *Vulpes chama*.

Mammals associated with montane wetlands include *Aonyx capensis, Atilax paludinosus, Genetta tigrina, Ichneumia albicauda, Lutra maculicollis, Otomys irroratus* and *Otomys sloggetti* (up to 3000 m asp. *Rhabdomys pumilio* and *Redunca arundinum* frequent the valley swamps, while *Tragelaphus scriptus* and *Sylvicapra grimmia* are locally common in streamside thickets.

List of Wetlands Described

1. Tidal Wetlands
    (a) Minor Systems
    (b) The Kosi Lake System
2. Coastal Lakes & Swamps
    (a) Minor Systems
    (b) The St Lucia Lake System
    (c) Lake Sibaya
3. Riverine Floodplains & Swamps
    (a) Minor Systems
    (b) The Pongolo River Floodplain
    (c) The North Mosi Swamp
4. Lakes & Pans of the Interior
    (a) Minor Pans
    (b) Barberspan
5. Montane Wetlands
6. Artificial Impoundments

(a) Hendrik Verwoerd Dam
(b) Vaal Dam
(c) Bloemhof Dam
(d) The P.K. le Roux Dam
(e) Pongolapoort Dam

1. Tidal Wetlands

Country: South Africa

(a) Minor Systems

General: Small tidal wetlands occur at the mouths of many streams and rivers and tidal swamps or marshs occur in every estuary, all of which are listed with brief details of catchment size, run-off, human impact and current utilisation by Noble & Hemens (1978), while the 70 estuaries of Natal are dealt with in rather more detail by Begg (1978). The large number of very small sites precludes an individual account of each being given here. Herbaceous saltmarsh vegetation occupies the intertidal zones of the southern and southwestern coasts, while on the warmer eastern coasts, influenced by the Mozambique Current, mangroves occur. The most southerly stand is at the mouth of the Nahoon River (32°59'S/28°58'E). This is a sparse monospecific stand of *Avicennia marina*, but the mangrove association becomes richer and more complex in passing northwards, as indicated in the introduction. Ward & Steinke (1982) give a brief account of the distribution and approximate areas of mangrove vegetation in the country.

On the east coast streams tend to be deflected by the powerful longshore drift, and their lower reaches tend to become long lagoons parallel to the sea but separated from it by dune covered spits. In consequence the mouths of most seasonal streams are closed by sand bars in the dry season. However, if the stream mouth is generally open and its estuary or lagoon is tidal, its shores tend to be colonised by mangroves. Upstream the tidal woodland may grade into freshwater swamp forest, while to landward of the mangroves there may be a reed swamp. This in turn may grade into a floristically diverse herb marsh at its landward fringe, or into bare mudflats, or a saline herb field, depending upon local levels of soil salinity.

Tidal marshes occur at the mouths of the Orange River (28°39'S/16°27'E) and Olifants River (31°43'S/18°11 'E). The mouth of the Orange is largely closed by a bar and the lagoonal area behind it is flushed regularly through a narrow mouth by the tides. When high floods come downstream the bar is breached in many places and the small saltmarshes are inundated by freshwater. The Olifants River has a narrow estuarine section up which tides penetrate for 32 km, periodically flooding the peripheral marshes. The small intervening streams between the Orange and the Olifants are not perennial and they do not support important wetlands. A small saltmarshisalina system occurs farther south at the mouth of the Verloren Lagoon (32°23'S/18°20'E) which is often closed. The system is fed by a small, but perennial rivulet. When the mouth is open the narrow lagoon and estuary, and sometimes the lake into which the estuary widens upstream, become tidal. Here there are about 1000 ha of wetland, including the lake and its fringing reed

swamps, and a valley swamp along the lower reaches of the Verloren rivulet. Grindley *et al*. (1980) give an account of this system.

Immediately to the south, saltmarshes, reed swamps and salt pans occur on the estuary and floodplain of the Great Berg River (32°46'-32°54'S/18°09'-19'E) covering a total of some 5000 ha. The Great Berg River loses only 1 m in altitude over the last 50 km of its course, meandering on a narrow floodplain. During high water in winter the river is turbid and fresh almost to its mouth, where salinities then vary from 2-6%o, with temperatures of 11-15°C. By contrast, in summer, when flow is reduced and sea water enters the estuary, salinities always exceed 25%o at high tide, and frequently reach 35%0, while temperatures reach 27°C. The river is tidal for 70 km, and saline influence is felt at least 50 km upstream. Surface salinities of 9%o were recorded 45 km upstream in February 1979. Heavy rains, combined with high tides, flood the reed swamps that fringe the river, as well as a series of temporary salt pans along the edges of the floodplain. Inundation of the pans is altogether a much more temporary event than inundation of the *Phragmites* and *Juncus* swamps. These are more than 1 km wide in places, but alternate from one side of the river to the other, upstream.

Another substantial wetland, covering 7252 ha, is situated at Langebaan Lagoon (33°04-33°13'S/18°03'E). The lagoon is an open tidal sea water lagoon, oriented SE-NW, which opens to the southern shore of Saldanha Bay. It is 15 km long, up to 3.7 km wide and reaches 6 m in depth. Some 60% of its area is open water, 30% is intertidal saltmarsh, and 10% is herbaceous swampland. Numerous muddy islands are emergent at low tide. The lagoon is separated from the Atlantic Ocean on the western side by a stony spit of land about 1.5 km wide which rises towards the mouth at the northern end, to two hills 188 and 192 m high. Along this side the shores are steep, with deep waterclose inshore. By contrast, the eastern, 'inland', shore is flat and sandy and fringed by low dunes. Here there is a broad intertidal zone, in one place 2 km wide, while behind the dunes are some salt pans, flooded only by spring high tides. A seasonal stream enters the head of the lagoon in the south, through a reed/sedge swamp. Two high islands, Meeuw and Schaapen, are situated in the mouth of the lagoon which is 1.7 km wide. Maximum tidal amplitude is reduced from 1.7 m at the mouth to 1.4 m at the head of the lagoon, and currents of 1 misec are generated at the mouth on the ebb tide. The lagoon hinterland is arid, bleak and windswept.

In passing eastwards along the south coast, small, sometimes very small, tidal saltmarshes are found in the Palmiet, Kleinmond, Uilskraal, Heuningnes, Bre, Duiwenhoks, Kafferkuils, Gouritz, Klein Brak, Groot Brak, Kaaimans, Touw, Swartvlei, Goukamma, Keurbooms, Elandsbos, Storms, Klipdrif, Krom, Gamtoos, Swartkops, Sundays, Bushmans, Kowie, Fish, Keiskamma, Ngqinisa, Kiwane, Gxulu and Buffalo Estuaries. Some of these are not permanently open to the sea including the Gamtoos, Goukamma, Swartvlei, Touw, Kaaimans and Heuningnes estuaries.

Farther north, mangroves and a saltmarsh occur at the Nahoon River mouth, and in passing up the coast towards Natal, trees become an increasingly important feature of tidal marshes. Not all of the host of streams reaching the Transkei and Natal coasts carry

mangroves however, and where they do the stands are very small, some less than a hectare. Many carry only *Avicennia* marina.

The first well developed mangrove swamp is in the Mngazana Estuary (31°42'S/ 29°25'E) which has a total wetland area, including open water, of 260 ha. The Mngazana River, some 150 km long, drains a small catchment (c. 350 km^2) in the coastal hills of Transkei. The estuarine section of the river is about 6 km long and increases in width from 40 to 400 m in proceeding downstream, but narrowing again to 50 m at the mouth. Mean spring tidal amplitude at the mouth is 1.5 m, decreasing to 70 cm at the weir which now forms the head of the estuary. The river is perennial and the mouth is permanently open, being sheltered by a rocky promontory on the south side. Water depth increases from 30 cm at the head of the estuary to a maximum of 2.5 m near the mouth. Immediately behind the mouth the lagoon is 400 m wide, with several shifting mudbanks, and in this region the river receives three small tributaries. The estuarine part of the system comprises a total of 110 ha of open water and about 150 ha of peripheral mangrove and saltmarsh communities. The gently shelving shores of the lagoon, much of a large mud island, and the tributary waterways, are densely fringed by mangrove swamps with broad saltmarshes on higher intertidal land. *Avicennia marina*, *Bruguiera gymnorrhiza* and *Rhizophora mucronata* are the arborescent species. *Zostera capensis* and then *Halophila ovalis* occur in front of the mangroves in progressively deeper water, while *Chenolea diffusa*, *Cotula coronopifolia*, *Falkia repens*, *Samolus porosus*, *Sarcocornia natalensis*, *S. perennis* and *Triglochin bulbosa* occur on the adjacent saltmarshes. *Paspalum distichum* occurs on elevated patches in the mangrove, with fringes of *Sporobolus virginicus* and then *Stenotaphrum secundatum* around the landward margins of the saltmarsh. Riverine mangroves, chiefly *Avicennia marina* and *Hibiscus tiliaceus*, extend upstream for over 5 km, although in the upper reaches they are not continuous, occupying only the prograding mudflats on meander bends away from the current. Along the river, *Cyperus textilis*, *Phragmites australis* and *Scirpus littoralis* grow on the banks behind the mangroves.

The invertebrate fauna is quite rich, over 200 benthic species having been recorded, while 62 species of fish have been collected from the estuary, including many of those cited in the introduction as being present in east coast estuaries. Some species are present all the year, but others are seasonal visitors. A list of all recorded fish is given by Branch & Grindley (1979). The avifauna is not well described, but many *piscivorous* species occur here, including herons, fish eagles and kingfishers. This estuary is at present little disturbed.

In passing northwards again, many small streams are seasonal and many have no important tidal wetlands. Where they do occur, mangrove stands are very small and most are monospecific. There is a mangrove swamp at Sipingo, just south of Durban (29°53'S/31°00'E), while the once extensive swamps in Durban Bay have very largely been cleared. A little over 15 ha remain today. Farther north there are mangroves in the estuaries of the Mgeni (29°48'S/30°02'E) and Mlalazi (28°57'S/31°48'E) Rivers, in Richards Bay, at the Mfolozi River mouth (28°25'S/32°27'E), in the St Lucia (28°24'S/32°27'E) and Mgobezeleni (27°32'S/32°40'E) Estuaries, and in the Kosi Lake system (26°50'-27°11' S/32°38' -32°53 'E).

The mouth of the Mlalazi River at Mtunzini has been deflected northwards for 4 km between high forested sand dunes. The mouth has not closed during the past 35 years, but did so several times in the first half of the century, eventually leading to high water levels in the lagoon which killed all mangrove vegetation before the bar was overtopped and breached. Thus the present mangrove stands are comparatively young, *Avicennia* having first been noticed in 1940. That mangrove vegetation previously occurred in the estuary is evident from buried mangrove stumps and oyster beds in several sites upstream of the present lagoon. The river drains a catchment of some 450 km^2 with an estimated mean annual run-off of 139 million m^3 giving a mean discharge rate of 4.5 m^3/sec. However, during a cyclone in February 1984, when 550 mm of rain fell in 48 hours, the discharge rate is estimated to have approached 1600 m^3/sec. The lagoon behind the mouth is 75-280 m wide, 1-3 m deep at high spring tide, has an open water surface of 90 ha and contains numerous emergent mudbanks. In places, dune forest reaches the water's edge, in others the lagoon is fringed by mangroves with a narrow reed swamp behind. Elsewhere mangroves are backed by bare mudflats and saltmarshes where summer temperatures reach 50°C on the soil surface and 35°C at 5 cm depth. On the coastal plain immediately abutting the dunes, the river is flanked by a short swampy floodplain, containing, on the north shore, a small endorheic lake. Mean annual rainfall is close to 1100 mm, and winds are predominantly from the SE and NE. In total there are some 270 ha of wetland and open water.

The mangroves comprise *Avicennia* marina and *Bruguiera gymnorrhiza*, but with *Casuarina equisetifolia*, *Mimusops caffra* and *Sideroxylon inerme* growing at the water's edge, in some quite regularly tidal sites on the lagoon. Several transitional species occur on the fringes of the mangrove and *Phragmites australis* occurs as thin fringes along parts of the river channel, occludes some backwaters, and dominates the reed swamp. *Sporobolus virginicus* and then *Stenotaphrum secundatum* occur on the landward margins of mangrove swamps along the lagoon. Mangroves also grow along watercourses through the saline mudflats where typical saltmarsh species are dominant. Swampy freshwater parts of the floodplain support a surprisingly rich flora, with numerous clumps of trees and intervening high tangles of herbs as indicated in the introduction.

Hill (1966) lists 156 invertebrates and 58 fish in the system, including *Carcharhinus leucas*. He gives information on their distribution and ecology, but Begg (1978) suggests that the fauna has been impoverished since that time, and indeed, in 1971 Hemens found only 15 fish to be present, but this figure probably underestimates current diversity.

Several frogs, including tree frogs, occur on the swampy parts of the floodplain. *Crocodylus niloticus* is uncommon. Over 50 species of birds occur in the system including *Ardea goliath*, *Glareola pratincola*, *Haliaeetus vocifer* and *Sterna bergii*. Vervet monkeys are common both in the canopy and on the ground in the mangroves, while various buck and duiker visit them from the dune forest and there are resident rodents in the peripheral wetlands.

Originally Richards Bay was a shallow coastal lagoon at the mouth of the Mhlatuze River,

with an open water area of about 2800 ha. It also received several minor streams and the overflows of Lake Cubhu (400 ha) to the southwest and Lake Mzingazi (970 ha) to the northeast. It was converted to a deep water harbour in the 1970s, when the southern part of the lagoon was separated from the northern part by an artificial berm. The Mhlatuze River has been canalised and discharges into the southern section, and thence to sea via an artificial mouth. A large area of peripheral swamp land has been drained for industrial and residential use around the northern part of the bay, but the southern half of the bay has been declared a wildlife sanctuary. Nevertheless, it is rapidly silting up and being invaded by mangroves. Small areas of freshwater swamp forest and papyrus swamp persist along the southern shores, and another much reduced area of freshwater swamp forest occurs along the lower reaches of the Mzingazi River where it enters the north of the bay. Mean annual precipitation exceeds 1325 mm over the system, 80% falling during the summer, October-March. Summers are hot, winters warm and dry.

The St Lucia Estuary is 20 km long and connects Lake St Lucia (see section 5.7.2b) with the sea. Mean annual precipitation is 1200 mm at the estuary mouth. Annual rainfall variations can be dramatic, e.g. 2057 mm in 1925 but only 530 mm in 1926. The estuary mouth, about 100 m wide, used to close periodically, but is now kept open by dredging. The St Lucia wetlands occupy some 66 000 ha, but only the estuary is regularly tidal. Forests of *Avicennia marina* and *Bruguiera gymnorrhiza* flank the estuary, and also the vicinity of the Mfolozi River mouth immediately to the south.

Human Impact & Utilisation: Many systems are polluted by sewage and some carry industrial wastes. Others have been altered for harbour development, e.g. Saldanha Bay and Richards Bay, and yet others have been altered by the construction of marinas and tourist facilities. The systems most remote from centres of population have in general survived best, but a special problem along the Natal coast is that of siltation caused by bad agricultural practices in the hinterland.

Conservation Status: Systems which enjoy some measure of protection on the east coast are the Mgeni, Mgobezeleni, Mlalazi and St Lucia Estuaries, and part of Richards Bay. On the south and southwestern coasts a number of small systems are protected and Langebaan Lagoon is a crayfish sanctuary.

(b) The Kosi Lake System
Coordinates: 26°50'-27°11'S/32°38'-32°53'E
Area: 18 550 ha (c. 4550 ha open water + c. 14 000 ha swampland)
Altitude: 0-5 m as1
Nearest Towns: Ingwavuma (92 km WSW); Durban (363 km SW)
General: The Kosi Lakes lie on the sandy Maputaland coastal plain, some 470 km northeast of Durban. They comprise a series of interconnected, and roughly circular lakes, which open to the Indian Ocean via a shallow estuary near the northern end. They are separated from the ocean by a strip of forested sand dunes 600-2000 m in width and numerous sandy mudbanks, emergent at low tide, occur in the lower part of the system. The total catchment has been estimated as 500 km^2, with the northernmost part draining

into Lake Zilondo (Zilonde) in Mozambique. The lakes are fed by four small coastal streams. The largest of these, the Sihadla, rises to the south in the Mtombeni Pans and drains some 13 000 ha of swampy land before entering the southernmost lake. The system was once the estuary of a much larger river, almost certainly the Ingwavuma. Mean annual precipitation over the lakes and much of the catchment is in the region of 950 mm and the climate follows the regional pattern of hot wet summers and cool dry winters.

Hydrology & Water Quality: The small streams drain through reed swamps and clean sands before entering the lakes and bring very little silt with them. The mouth of the estuary is usually open and the system is fully tidal below Lake Mpungwini, but the dimensions of the mouth vary with every tide, its width altering from 5-100 m. Tidal range in the lower part of the estuary is 75 cm at spring tide. Levels at low neap tide are lower than at low spring tide, because water which enters on the spring flood tide does not all escape on the succeeding ebb tide. In August 1965 the mouth closed altogether, and water levels in the system began to rise, a total of about 30 cm in five months. At the beginning of January 1966, during cyclone Claude, 640 mm of rain fell in the catchment and water rose to 1.6 m above normal spring tide level. The mouth was artificially breached 2 weeks later. Much of the peripheral vegetation, including most of the mangrove forest, was killed by the long-term flooding. Maximum water depths, with the mouth open, are 31 m in Lake Nhlange, 18 m in Lake Mpungwini, 8 m in Lake Makhawulani, but only 3 m in the estuary. Lake Amanzimnyama at the southern extremity, farthest from the sea, is very shallow with a maximum depth of 2 m.

The waters are clear and Secchi transparencies of 7.0 m have been obtained, while readings of 3-4 m are the norm. The waters of the lower tidal basin have chemical characteristics similar to sea water, but on occasions during the summer, salinities have been found to fall below 10%. Lake Mpungwini has a sharp halocline and thermocline at 10 m, the bottom water being highly saline, with a proportional ionic composition similar to that of sea water. Lake Nhlange is not similarly stratified, and is predominantly a freshwater lake, with a salinity range of 0.9-5.6%o. Here the water has an ionic composition different from sea-water. Lake Mpungwini is meromictic, but Lake Nhlange appears to be well mixed. Because of strong N-S winds, the upper waters of Lake Mpungwini show a complex pattern of temperature stratification in summer, but in winter the deep lakes tend to be homothermal. Surface temperatures in the deep lakes range from 19°C in winter to 30°C in summer in open waters, but may exceed 40°C in the shallows in summer. Dissolved oxygen concentrations vary between 7.6-8.6 mg/1 at the surface and 7.0-7.7 mg/1 at 10 m depth, but below this depth in Lake Mpungwini, the bottom waters become anoxic in winter and may contain hydrogen sulphide. Ionic concentrations show regular seasonal changes in the upper waters of Lake Nhlange. Here, principal ion concentrations tend to rise from minima in winter to maxima in summer, and figures for 1967, expressed in mg/1, are sodium 1846-2450; potassium 4-5; calcium 53-84; bicarbonate 121-144; sulphate 209 steady; and silicate steady at 7. Nitrate concentration rose from 52-63 g/1, while orthophosphate remained steady around 19 lag/1.

Flora & Fauna: The shores of the lower tidal basin, the emergent islands, and parts of

the shores of Lakes Mpungwini and Nhlange are fringed by tidal forest, comprising *Avicennia marina*, *Barringtonia racemosa*, *Bruguiera gymnorrhiza*, *Ceriops tagal*, *Hibiscus tiliaceus*, *Lumnitzera racemosa* and *Rhizophora mucronata*. *Bruguiera gymnorrhiza* is the most important of these, having been best able to regenerate after the 1966 flooding, and some specimens on Uhkalwe Inlet now exceed 18 m in height. *Lumnitzera* and *Hibiscus* occur on the most elevated sites, often growing with *Acrostichum aureum*, *Caesalpinia bonduc* and *Chrysanthemoides monilifera*. Saltmarshes occur at the back of the mangrove on the seaward (eastern) side of the lower tidal basin. *Barringtonia racemosa-Hibiscus tiliaceus* forest fringes much of Lake Nhlange, particularly the southern and western shores, and interdigitates with other species in the upper basin. Saltmarsh and reed swamps occur along the streams connecting Lake Zilondo with the estuarine basin, and along the channel between Lake Nhlange and Lake Amanzimnyama. On the western shore of the system, fresh or brackish water swamp forest occurs behind the mangroves on Lake Nhlange, and along most drainage lines entering the system on the landward side. It forms a riparian belt 1 km wide and 7 km long on the Nswamanzi Stream which enters Lake Nhlange. Here, in addition to the typical species, *Raphia australis* is present forming perhaps the southernmost natural population of this species. Two other rare species, the terrestrial orchid *Platylepis glandulosus*, and the climber, *Tiliacora funifera*, occur in this forest, again at the southern limits of their distributions.

Phragmites swamps cover 10 000 ha along the Sihadla River, with *Cyperus papyrus* as an important associate. *Phoenix reclinata* and *Hyphaene natalensis* occur on the fringes of the reed swamps, and on more elevated patches in them. Various floating species occur in the bays and inlets, especially *Nymphaea* spp., but the surface waters of the lakes are free of vegetation. Submerged plants are also confined to sheltered bays and inlets and comprise a mixture of marine and freshwater species including *Ceratophyllum demersum*, *Najas marina*, *Potamogeton pectinatus*, *Ruppia* spp., *Thalassodendron ciliatum*, *Zostera capensis* and numerous algae.

The sand prawn, *Callianassa kraussii*, is the major infaunal organism. Penaeid prawns are not abundant in the estuary, reflecting its low nutrient status. The mangrove fauna reflects the fact that the substratum is predominantly sandy. Malarial mosquitoes occur in the swamps, as do the vectors of human bilharzia, *Bulinus africanus* and *Biomphalaria pfeifferi*.

Blaber (1978) listed 133 fish species in the Kosi system. Of these 85 were marine species found in the lower estuary, 39 were resident estuarine species which penetrated to non-tidal areas, and 9 were freshwater species. Apart from birds, other vertebrates have not been intensively studied here. However, frogs and toads abound in the streams and reed swamps. *Crocodylus niloticus* is uncommon, but occurs in Lakes Zilonde and Amanzimnyama, while *Varanus niloticus* is common throughout. Snakes also occur throughout the system, but collected species from the wetlands and beaches include only *Amblyodipsas microphthalma*, *Boaedon fuliginosus*, *Dispholidus typus*, *Leptotyphlops distanti*, *Philothamnus hoplogaster* and *Psammophis phillipsii*. Of more than 250 birds in the system, most of which were listed by Tinley (1976), the majority are associated with the swamp and dune forests. Perhaps a third, some 85 species, are specifically associated with the open water,

beaches or reed swamps. Among mammals, Hippopotamus amphibius occurs in the system, a few individuals in the estuary, but most on the upper lakes. The water mongoose, Atilax paludinosus, is comparatively common as are various rodents.

Human Impact & Utilisation: The lake and swamp system is still relatively undisturbed as the area is not easily accessible. The local population was estimated as 80 000 in 1968, and the estuary provides a source of fish for these people. Large permanent fish traps, with long guide fences, have been built in the lower tidal basin, but lines and spears are also used, both from the banks and favourite perches in mangrove trees. Fishing with seine nets is prohibited but the practice occurs and is increasing. Pesticide residues have been found in the sediments of the tidal lakes and in the food chain, e.g. 860 lig DDT/kg Mugil cephalus liver. This pollution arises from malaria control operations. Only the insides of habitations are sprayed, the DDT then supposedly not entering the run-off, but it appears that preparative procedures have been faulty and have permitted escapes. The waters of the system are not polluted by faecal matter.

Conservation Status: The coastal dunes and lakes fall within the Coastal Forest Reserve established in 1952. The swamps along the Sihadla River are unprotected, and there have been proposals to drain them and bring the area under agriculture, which would be enormously detrimental to the wetland system. Proposals to establish a deep water harbour in the system, possibly by opening Lake Nhlange directly to the sea, are recurrent. Any such scheme would undoubtedly prove disastrous to the wetland ecosystem.

2. Coastal Lakes & Swamps

Country: South Africa

(a) Minor Systems

General: On sandy beaches all around the coast of South Africa, numerous minor streams terminate in brackish lagoons among the coastal dunes, separated from the sea by sand bars. In such places, water losses from evaporation and seepage through the bar may keep pace with influxes, so that the water levels remain fairly constant, at least during dry seasons. Such lagoons are usually fresh or lightly brackish and swampy areas frequently develop along their flanks, and may extend several kilometres upstream from the lower end of the lagoon. However, during wet seasons, or following unseasonal storms in the catchment, the lagoons may rise and their flood waters may overtop the bars. Alternatively exceptionally high tides generated by storms at sea may breach the bars. In either event, the dammed up waters pour out, scouring the banks of the lagoons and disturbing their vegetation. The frequency with which such discharges occur in any given lagoon is a major factor in determining its morphometry, the composition and disposition of its peripheral swamps, and its fauna. Increased siltation, attendant upon intensive agricultural practices in the hinterlands, is accelerating the encroachment of vegetation into these streams and lagoons, especially along the Natal coast. As the lagoon floors rise so the waters spread, developing new lakes.

Dense beds of *Phragmites australis*, up to 4 m high, develop around the peripheries of these lagoons, where they are not strongly affected by the currents generated during periodic discharges. *Nymphaea* spp. occur in some lagoons and *Eichhornia crassipes* may occlude the deeper water. There are often tangles of *Leersia hexandra* and other aquatic species, e.g. *Ludwigia* sp., where deep water lies close to the banks. There are numerous submerged aquatics including *Najas marina*, *N. pectinata, Ruppia maritima* and *R. spiralis* in addition to those listed in the introduction, and on open fringes there are swards of grass or sedge species. However, lagoons in Natal are usually fringed by trees. Reeds tend to invade the open water as siltation proceeds, in many cases eventually filling the lagoon. In Natal, if the systems are not regularly flushed by high floods a swamp woodland develops, as trees become established in the reeds.

A gradation exists between lagoons which are fully open and fully closed. Some are mostly open and support tidal wetlands and have been dealt with in the preceding section. Others are mostly closed and are essentially non-tidal systems, many of these not becoming tidal even when their bars are breached. These are dealt with here. Yet others have lost connection both with the sea and the streams that once fed them, so that all around the coast, but especially in Natal, there are endorheic lakes, ponds and swamps which originated from estuaries or lagoons. The number of small sites is very large, but it includes Botriviervlei (34°20'S/19°06'E), Kleinriviersvlei (34°25'S/19°22'E), De Hoop Vlei (34°31'S/20°23'E), Salt River Marsh (34°29'S/20°24'E) and Groenvlei (34°00'S/22°50'E) on the south coast.

Sites on the east coast include the lagoons of Zolwane (3 1°04'S/30°12'E), Kandandlovu (31°00'S/30°16'E), Mpenjati (30°58'S/30°17'E), Umhlangankulu (30°57'S/30°18'E), Kaba (30°56'S/30°19'E), Zotsha (30°47'S/30°25'E), Ntshambili (30°38'S/30°33'E), Mhlungwa (30°33'S/30°35'E), Kwa Makosi (30°31'S/3096'E), Fafa (30°27'S/30°39'E), Sezela (30°25'S/30°41'E), Mahlongwana (30°14'S/30°48'E), Mgababa (3000935/ 30°50'E), Msimbazi (30°08'S/30°51'E), Mhlanga (29°42'S/31°06'E), Mdloti (29°38'S/ 31°08'E), Mhlali (29°27' S/31°16'E), Mdlotane (29°21'S/31°22 'E), Zinkwasi (29°16'S/ 31°27'E), Nyoni (29°08'S/31°36'E) and Siyai (28°58'S/35°46'E).

Flora & Fauna: See introduction.

Human Impact & Utilisation: Many sites have been seriously degraded by inputs of sewage, by enhanced siltation and by residential and tourist developments. Road and rail bridges across others have impeded drainage.

Conservation Status: Some of the northern lagoons are enclosed by dense dune forest or dune scrub, and these tend to be difficult, and in some cases impossible to reach by road. Thus, even if not protected by legislation, these systems enjoy a measure of protection by virtue of their isolation, but in Cape Province, systems of this type tend to lack trees and are seldom separated from the sea by high dunes. Most of them are easily accessible to the public and many have been despoiled.

(b) The St Lucia Lake System
Coordinates: 27°22'-28°28'S/32°20'-32°34'E (total system)
Area: c. 33 000 ha (open water) + c. 33 000 ha (swampland).
Altitude: 0-5 m asl
Nearest Towns: Mtubatuba (20 km W); Durban (206 km SW)
General: Lake St Lucia lies on the Maputaland Coastal Plain and drains to the Indian Ocean through a 20 km long estuary. The estuary mouth, about 100 m wide, used to close periodically, but is now kept open by dredging. The St Lucia drainage system is the largest estuarine system in South Africa, and with associated swamps has a total wetland area approaching 66 000 ha. The maximum length of the lake is 42-45 km, depending upon water levels, and the maximum width 15 km. The length of the shoreline varies from 300-400 km reflecting seasonal variations in the size of the lake. The floor of the lake comprises deep mud and lies between 1.0-2.5 m below sea level, while the water surface is usually close to mean sea level. Water levels in the lake have varied from 0.6 m below sea level to 1.06 m above sea level (1951-1956). However in 1984, after intense precipitation in the wake of cyclone Demoina, the surface level in the lower part of the estuary rose 16 m. Storms of this nature appear to occur in the region about 3-4 times a century. Summers in the region are hot arid comparatively wet, from October-April, and winters are warm and dry, from May-September. Mean annual precipitation is 1200 mm at the estuary mouth, but it decreases progressively in passing inland to 625 mm at the western extremity of the lake. Annual rainfall variations can be dramatic, even at the mouth, e.g. 2057 mm (1925) and 530 mm (1926).

The Mkuze River drains the South Mosi Swamp (c. 3000 ha) and crosses an extensive floodplain with numerous pans, before it enters the lake at its northern end through the Mkuze Swamp. This lakehead swamp is an integral part of the system, but is poorly understood. It was once a northern extension of St Lucia Lake which became shallow enough to support rooted and floating vegetation, including vast monospecific stands of *Cyperus papyrus*. A natural bar at the southern end of the swamp inhibits the intrusion of saline water, permitting freshwater fishes and plants to flourish. There are four stretches of open water in the swamp: Ndlaka, Demezane, Mbazwan and Butterfly. Where the Mkuze River enters the swamp there is a delta which contains four open lakes: Mpempe, Ntshangwe, Mdlanzi and Tshanetsha, forming an ecosystem hydrologically separated from the main Mkuze Swamp by two dry sections at the toe of the delta. A channel was once excavated from the Mkuze River near Mpempe Pan to a point near Demezane Pan in an attempt to introduce more freshwater to Lake St Lucia. This channel has now closed and no attempts are planned to re-open it; the probable deliterious effect on the Mkuze swamps would seem to outweigh any advantage that might be gained by reducing the salinity of the northern end of Lake St Lucia. Patches of land with an elevation exceeding 5 m asl occur in the Mkuze Swamp.

The South Mosi Swamp is the most northerly and westerly part of the system. It lies in a long depression, oriented N-S, in an old dune field and is approximately 30 km long at high water, with a maximum width of just over 1 km. The most southerly part of the St Lucia system is the swampy lower floodplain of the Mfolozi River. The bar at the mouth of this latter river, with the second largest catchment in Natal, is northward pointing, and

at times the Mfolozi has poured its waters into the lower part of the St Lucia estuary. However, it now has a mouth about 1.5 km south of the St Lucia mouth, but the two iyituns are connected by a canal some little distance inland. The object of Mb i5 to channel Mfolozi water into the St Lucia system at times of high salinity. The lake and floodplains are separated from the Indian Ocean by high densely forested sand dunes, which reach 180 m asl at Maphelana. The combined St Lucia/Mkuze/Mfolozi system provides a range of habitats beside the aquatic one, including islands, mudflats, reed swamps, papyrus swamps, open grasslands, freshwater swamp forest, tidal swamp forest, coastal dunes, riparian communities, and freshwater pans and beaches.

Hydrology & Water Quality: Water enters St Lucia Lake from four principal rivers, contributing an estimated mean annual total of 295 million m^3. The Mkuze River, which enters the lake at its northern extremity, through the Mkuze Swamps, contributes 56% of the annual riverine inflow, while the other rivers each contribute some 24 million m3, and seepage from the wet eastern shore a further 46 million m3. Direct preciptation accounts for a further 268 million m3, while evaporation takes an estimated 397 million m3. Estimates of the total water storage capacity of the system vary between 295 and 322 million m3. Since the lake is at sea level, and in a normal year influxes exceed evaporation, water overflows to the sea. However, in drought years there may be a net influx of sea water. Spring tide range at the mouth is 1.9 m, falling to 15 cm at the head of the estuary, but persistent winds generate seiches of 30-45 cm on the lake. Wind direction is predominantly from the NE or SW, parallel to the long axis of the lake.

Current annual silt accumulation in the lake has been estimated at 1-2 million m3/yr, which is thought to be two to three times greater than the mean rate over the past 5000 years, and to be due to the acceleration of erosion in the hinterland by agricultural practices. However, sedimentation rate is clearly subject to large scale variations. Cyclonic storms, two of which occurred in 1984, may cause the deposition of more silt in a few days than would normally occur in a decade. The mean annual discharge of the Mfolozi River has been estimated as 729 million m3 (Begg, 1978), while its coastal tributary, the Msinduzi, which joins it on the southern side of the floodplain, contributes a further 89 million m3. The Mfolozi River is notorious for catastrophic floods, during which it deposits millions of m^3 of silt on the floodplain and cane fields.

Salinity varies from place to place in the lake, and from season to season and year to year. In a wet period, there is a salinity gradient from the head of the lake to the estuary. At such times salinity falls to 5.0%o in False Bay and is generally about 25%o at the head of the estuary. Following the drainage of the Mfolozi Swamps for agriculture in 1951, siltation closed the St Lucia estuary, and the Mfolozi River mouth migrated south to its present position. The St Lucia mouth remained closed for 5 years, until 1956, during which time an extreme salinity of 116%0 was attained. The southern part of the lake and the narrow estuary are the most stable parts of the system with regard to salinity. Salinity is normally close to 35%o in the lower part of the estuary. Water temperatures range from 17°C in July to 29°C in January.

Flora & Fauna: Much of the lakeshore is fringed by *Phragmites* swamp with some

Cyperus papyrus, the latter species more common in the north. At times of high salinity the reeds are reduced in vigour, or die back. *Juncus kraussii* and *Scirpus* spp., which always occur in patches, then become more prominent, and salt tolerant grasses such as *Sporobolus virginicus* and *Stenotaphruin secundatuin* spread on the margins. The St Lucia reed swamps are contiguous with those of the Mkuze River in the north and those of the Mfolozi River in the south. The Mkuze Swamp (12 000 ha) at the head of the lake is a dense Cyperus papyrus-Phragmites mauritianus swamp, protected from incursions of saline water by a natural bar. In the south a further 2500 ha of reed swamp occupies most of the lower floodplain of the Mfolozi River. The isolated Mosi Swamp is predominantly occupied by a Cyperus papyrus-Phragmites mauritianus-Typha latifolia association with substantial areas of open water.

Freshwater swamp forest, with a closed canopy up to 28 m high, occurs in a discontinuous belt up the eastern shore of the lake, and in small patches on the Mkuze River, in the Mosi Swamp, and on both sides of the Mfolozi Floodplain. Thickets of *Allophyllus decipiens*, *Ficus capreifolia*, *F. verruculosa* and *Kraussia floribunda* grow around the margins. A thin strip of unique forest, seasonally flooded and containing *Ficus trichopoda*, *F. vogelii*, *Inhambanella henriquesii, Manilkara discolor, Podocarpus falcatus, Schotia brachypetala* and *Spirostachys africana* occurs between the herb swamp at Mosi, and the surrounding sand forest. Riparian forest, subject to seasonal inundation, with dominant *Acacia xanthophloea* and *Ficus sycotnorus*, grows along much of the Mkuze River north of the lake head swamp. It also fringes the pans in this area. Beneath the trees, the zone between high and low water is covered by dense swards of *Cynodon dactylon*.

129 invertebrate species have been recorded from the St Lucia System (Day *et al*., 1954). A comprehensive survey of the benthic fauna is given by Boltt (1975b). The most abundant species is the small gastropod *Assiminea africana*. Most benthic organisms in the system can tolerate salinities of up to 55% and when this concentration has been exceeded recolonisation is effected by planktonic larvae brought into the lake by wind induced water movements. The system is important as a nursery for penaeid prawns and is, for the dominant species, *Penaeus indicus*, the largest reserve in South Africa. However, during periods of low salinity *Macrobachium equidens* may become the most numerous species.

108 species of estuarine fishes are listed by Whitfield (1980) as occurring in the St Lucia System, and at least 13 freshwater species occur in the northern part of the lake and its tributary streams. Various sharks occur in the lower estuary, but Carcharinus leucas and Pristis pectinatus penetrate the whole system. Gravid females of Carcharinus leucas frequently give birth to their young in the system. Some species e.g. *Elops machnata* and *Mugil cephalus* are not adversely affected by high salinity phases, and *Oreochrotnis mossambicus* has been observed to breed in a salinity of 116700. Several species of the lake fish fauna have wide salinity tolerances; 10 species have upper tolerance limits of 65-70%0, while 32 species have lower tolerance limits of 1-3%0 (Whitfield, 1977).

Amphibians abound in the reed swamps and watercourses, and on pan margins. Crocodile breeding places are protected, and crocodiles show marked migratory patterns from

summer breeding places to winter basking grounds. The total *Crocodylus niloticus* population probably exceeds 600, and the species is quite numerous in the Mkuze Swamp where counts are difficult to make. Several snakes occur in the wetlands, including most cited in the introduction. In addition *Bitis gabonica*, which is rare in southern Africa, occurs in the swamps and pans around the lake. Another snake at the southern limit of its distribution is *Atnblyodipsas microphthalma*. This is a burrowing species which frequents the reed swamps and mangroves. *Naja melanoleuca* occurs in the area and has been observed to feed on fish. Other reptiles include *Acontias plumbeus*, *Lygodactylus capensis*, *Pelomedusa subrufra*, *Pelosios sinuatus*, *Varanus exanthernaticus* and *V. niloticus*.

Some 340 species of birds are associated with the St Lucia Lake System which is renowned for its pelicans and flamingoes. It is a recognised breeding ground for about twenty aquatic species including *Anastomus lamelligerus, Ephippiorhynchus senegalensis, Mycteria ibis, Pelecanus onocrotalus* and *P. rufescens*. It is one of only two breeding places in South Africa for *P. onocrotalus*. Other rare species are *Apalis ruddi* and *Batis fratrum*. During high salinity phases most of the birds migrate away from St Lucia and cease breeding (Whitfield, 1977).

Numbers of Hippopotamus amphibius have increased over the last twenty years to about 700. They are found mainly along the eastern shores where they are said to play an important role in carving channels through the swamps, modifying the drainage lines and releasing large quantities of plant detritus into the lake in their faeces. Antelopes such as *Aepyceros melampus, Neotragus moschatus, Redunca arundinum* and *Tragelaphus angasi* are also common on the eastern shore, the first two especially favouring swamp and riparian forest habitats. *Syncerus caffer* and *Diceros bicornis* have recently been introduced to the eastern shore of the lake. Among rodents, *Otornys angoniensis* and *Pelomys fallax* are common throughout the system, while *Dasyinys incomtus* is less so. *Crocidura* spp. occur around pans on the floodplains, and a fruit bat, *Epomorphus wahlbergi*, roosts in swamp and riparian forests throughout the system. Endangered species protected in the system include *Cephalophus natalensis, Cercopithecus albogularis, Crocodylus niloticus, Diceros bicornis, Fells serval, Maids temminckii* and *Neotragus moschatus*.

Human Impact & Utilisation: Agricultural practices in the catchments have been deliterious to the system. Major problems are siltation, and altered drainage patterns which have led to increased salinity. Attempts to lower salinity by dredging and building channels have not been successful and have themselves had further adverse effects upon the system. The more remote northern areas of the Mosi and Mkuze Swamps have been little disturbed. The principal human impact has been on the lake itself, and on the floodplain of the Mfolozi River.

Conservation Status: The water in the lakes and channels and a 1 km wide strip of land along the banks has been declared a Nature Reserve. St Lucia Park, established in 1939, has an area of 12 545 ha. St Lucia Game Reserve, which was established in 1897, covers a further 36 826 ha on the eastern shore and around the north and northwest of the lake, including much of the Mkuze Swamp. Upstream sections of the Mkuze River, including

some floodplain areas are protected in the Mkuze Game Reserve, established in 1912, with a total area of 25 091 ha. The False Bay Nature Reserve, established in 1954, on the extreme western shore of the lake covers 2247 ha. Angling is permitted under license in certain areas in St Lucia Park, but the flora and fauna are otherwise protected in the reserves. Boating is permitted on the lake, and there are two small permanent camps for visitors on the western shore. Much swampland between the lake and the coastal dunes is a prohibited area under military control, and is thus also effectively protected. To the south, on the Mfolozi Floodplain, an important area of freshwater swamp forest, and some adjacent duneland, is fully protected in Maphelana Nature Reserve.

(c) Lake Sibaya
Coordinates: 27°22'S/32°42'E
Area: 9500 ha (lake + peripheral swamps)
Altitude: c. 20 m asl (lake surface)
Nearest Towns: Ubombo (54 km WSW); Durban (307 km SSW)
General: Lake Sibaya is an endorheic lake lying immediately to landward of high and densely forested sand dunes on the coastal plain of northern Natal. In places the sea approaches to within 1 km of the eastern shore of the lake, from the narrow sandy beach of which the dunes rise steeply. The lake was once an estuary, and the three arms which run north, west and south from the main basin indicate the former positions of tributary rivers. The main basin is 8.5 km long and 6 km wide and a maximum depth of 43 m was determined at high water in 1977. At this time the surface was some 23 m above, and the lowest point of the lake bed 20 m below, mean sea level. The lake then had an estimated open water area of 7750 ha with a storage capacity of 981 million m^3. A series of marshy depressions around the periphery, principally along drainage lines, provide a further 1750 ha of wetland. Stream flow into the lake is negligible for much of the year, and the peripheral marshes tend to trap what little silt is carried into the system. The total catchment for the system is estimated as 530 km^2. Summers are hot and wet, while winters are cool and dry. Mean annual precipitation is 1030 mm, over 40% falling in January-March. Prevailing winds are from N and S with normal maximum velocities of 31 km/hr. Much higher velocities are reached during occasional cyclonic storms.

Hydrology & Water Quality: Mean annual evaporation from the lake surface has been estimated as 1420 mm. This exceeds direct precipitation, and the level of the lake surface fluctuates by as much as 4 m over time periods of a few years, depending on stream and groundwater inflow, and seepage to the sea. The former has been estimated as 21 million m^3/yr and seepage at 1-4 million m^3/year.

The main body of lake water, which is well mixed by winds and not markedly stratified, experiences annual temperature fluctuations of up to 10°C, with a range of 18-28°C. However, shallow peripheral water may be heated to 41°C in summer and may cool to 13°C in winter. The water is clear with a mean Secchi depth of 3.2 m, and in the absence of regular stream inflow, siltation is minimal. pH is almost constant, at 8.2-8.3 throughout the year, while dissolved oxygen concentration ranges from 7.0 mg/1 at 30 m depth to about 7.6 mg/1 at the surface in summer. The principal ionic concentrations, in mg/1,

estimated in the winter of 1967 were sodium 86.1; potassium 7.3; calcium 27.5; magnesium 9.0; bicarbonate 135.8 and chloride 131.3. Nitrate and phosphate concentrations were close to 30 and 55 pg/1 respectively.

Flora & Fauna: During periods of normal water level, the sheltered shores of the lake, principally those of the main arms, are fringed by a tall reed swamp with some papyrus and the typical associates. *Ceratophyllum demersunt* is the most important macrophyte in the arms of the lake, while *Myriophyllunt spicatunt* dominates the main basin. The shallow inshore terraces of the main basin are too windswept for the development of macrophyte beds, but support algal communities. During the exceptionally high water of 1977, when the lake rose many metres, the emergent macrophytes were overtopped and destroyed, and the fringe forest of *Acacia karroo*, along the sandy beach adjacent to the dunes was also killed.

The invertebrate fauna is still not very well known, but a variety of benthic organisms are found in the lake, principally Crustacea and Mollusca. The crustacean component is dominated by small burrowing and tube dwelling amphipods and tana ids, mostly of estuarine affinity, but the marine crab *Hynzenosoma orbiculare*, the freshwater crab *Potamonautes sidneyi*, and a freshwater shrimp, *Caridina nilotica*, are common. The molluscs are typical freshwater forms and include the intermediate snail hosts for human bilharzia.

The fish fauna, comprising 18 species, is dominated by cichlids and gobiids. Five species (*Croilia mossambica, Gilchristella aestuarius, Glossogobius giuris, Hepsetia breviceps* and *Silhouettea sibayi*) have marine affinities and reflect the estuarine origin of the lake. Fishes are largely confined to the shallow inshore regions of the lake where vegetation is dense. Only 3 species frequent the bare sandy terraces, *Clarias gariepinus, Glossogobius giuris and Oreochromis mossambicus. Gilchristella* and *Hepsetia* are the only species regularly found in the pelagic zone. The peripheral pools and swamps are inhabited by cichlids (*Pseudocrenilabrus philander, Tilapia* spp.), catfishes (*Clarias gariepinus, C. theodorae*), topminnows (*Aplocheilichthys katangae, A. myaposae*), and the climbing perch, *Ctenoponza znultispinis*. Bruton (1980) gives an account of the ecology of fishes in the lake.

Twenty-two species of frogs and toads have been recorded from Lake Sibaya, and of these 20 are tropical forms near the southern limits of their distributions. Only *Rana f. fasciata* and *Xenopus l. laevis* are temperate forms. All species are associated with the densely vegetated swamps and bays, and only *Xenopus* spp. venture into open water. A check list of anurans is given by Bruton (1980). Eight reptiles (*Crocodylus niloticus, Lycodonomorphus r. rufulus, Natriciteres variegata sylvatica, Philothamnus irregularis, Philothamnus hoplogaster, Python sebae* and *Varanus niloticus*) are closely associated with the wetland system, but a further 59 species occur in immediately adjacent habitats.
Sixty-two of the 279 bird species recorded in the area are closely associated with the wetlands, but great concentrations of birds do not occur here. Important piscivores are *Anhinga rufa, Ardea goliath, A. purpurea, Casmerodius albus, Ceryle rudis, Corythornis cristata, Haliaeetus vocifer, Larus cirrocephalus, Megaceryle maxima, Phalacrocorax*

africanus and *P. carbo*. A check list of birds is given by Cyrus *et al*. (1980).

The mammals closely associated with the lake are *Atilax paludinosus, Dasymys incomtus, Hippopotamus amphibius, khneunzia albicauda, Otomys irroratus* and *Redunca arundinum*.

Human Impact & Utilisation: The lake has always been the principal source of potable water for the local people, and it has always been fished by them. Spears and nets are used throughout the year, but most intensively in the summer when large numbers of breeding *Clarias gariepinus* and *Oreochromis nzossambicus* are taken. Boats are not used, apparently because of a fear of the depth of the lake, and the dangers posed by crocodiles and hippopotamuses. Some 400 indigenous people depend on the lake, which is isolated and seldom visited by outsiders. However, Mseleni Mission Hospital, with a further 300 inhabitants, also depends upon lake water. Crops are grown around the lake area by the indigenous people, but wild fruits and vegetables are also important to them. Part of the catchment has been planted with exotic pines and Casuarina equisetifolia. Because of its inaccessibility the system is virtually unspoiled, but this could change with the rapid expansion of the KwaZulu population, when the system may have to be managed in a sophisticated way to provide both water and protein for a much larger local population. Because of its endorheic nature the lake will be particularly susceptible to pollution by agricultural fertilisers and pesticides.

Conservation Status: The eastern shore of the lake is included in the Coastal Forest Reserve proclaimed in 1952. The rest of the system is unprotected, but it has been suggested that it should be included in a proposed Maputaland National Park.

3. Riverine Floodplains & Swamps

Country: South Africa

(a) Minor Systems

General: In the north there is a small floodplain along the Limpopo River where it forms the border with Botswana, and another, with a series of associated pans, in the vicinity of Pafuri (22°27'S/31°20'E) where the borders of Zimbabwe, Mozambique and South Africa meet. In the central west there is a small floodplain on the Orange River in the vicinity of Upington (28°27'S/21°15'E). Farther downstream, a number of pans and vleis, some very large, lie in a system tributary to the Orange. Here the Sak River and its tributaries, all temporary watercourses, rise on the Roggeveld some 300 km NE of Cape Town and drain to the Orange River. Mean annual precipitation over the catchments is very variable; in some years the river barely flows, while in others it floods the pans and vleis. The largest of these are Groot Vloer (29°43'- 30°14' S/20°27'- 20°39'E), Verneuk Pan (29°57'-30°04'S/20°54'-21°15'E) and Vanwyksvlei (30°25'S/21°48'E).

The floodplain of the Great Berg River on the SW coast has been dealt with in section 5.7.1a, as a tidal system. However, while the tide penetrates some 70 km upstream on that

river, flooding of the peripheral land is almost entirely due to the river borne flood, although it may be exacerbated by high tides. Another floodplain occurs on the Touw River in the southern Cape Province (33°59'-34°00'S/22°35'-22°50'E). Here the Touw River, rising in the Outeniqua Mountains, reaches the sea via the Wilderness Lagoon. Immediately upstream of the mouth it is connected by meandering streams to three small marshy lakes, Eilandvlei, Langvlei and Rondevlei which in total provide some 500 ha of open water. At times the Touw rises to flood these lakes and some peripheral land. Soutriviervlei (32°20'-32°33'S/22°52'-23°05'E), another marshy area, is situated at the confluence of the Salt River and one of its tributaries, east of the town of Beaufort West.

(b) The Pongolo River Floodplain
Coordinates: 26°45'-27°30'S/32°20'-32°33'E
Area: c. 13 000 ha
Altitude: 40-60 m asl
Nearest Towns: Ubombo (15 km S); Durban (288 km SSE)
General: The Pongolo River has a catchment of 8000 km^2 and descends eastwards from the central plateau. Having traversed a narrow gorge in the Lebombo Mountains it winds northwards across the Makatini Flats to a confluence with the Usutu River. It develops a floodplain on the flats which merges with that of the Usutu River in Mozambique, The floodplain incorporates a series of shallow pans separated from the river by low levees. The pans have a total area of some 2600 ha while the floodplain per se, occupies a further 11 000 ha at peak flood levels. The floodplain lies on alluvium of Tertiary and Recent origin. Mean annual precipitation is in the region of 520 mm, while mean class A pan evaporation is 2388 mm. Summers are hot, with a mean monthly maximum of 40.3°C in January, and winters are cool with a mean monthly minimum of 2.3°C in June. Mean annual maxima and minima are 28.7 and 15.8°C. Mean monthly humidity ranges from a maximum of 86% in January to a minimum of 39% in July. Prevailing winds are from S to SE in the first half of the year and from N to NE in the second half of the year. Winds are generally light, with a mean maximum velocity of 10 km/hr in September.

Hydrology & Water Quality: In September and October some rain falls in the catchment and on the plain, but the river is low, and only occasionally do pans with the lowest levees receive water at this time. Consequently pan water levels continue to fall, but water temperatures begin to rise. In summer a marked increase in rainfall results in major floods with a peak in February, when, in an average year, all the pans fill and the entire floodplain is inundated. In April rainfall and floods lessen leaving the pans at maximum retention levels, but most of them lose connection with the river. In the winter months there is little rainfall and lower temperatures prevail. Evaporation causes water levels in the pans to fall progressively. Water which seeps into some of the pans from the soil is unusually saline. This serves to raise the concentration of salts in the already brackish panwater. The mean annual flow of the Pongolo River at Golela is 1082 million m^3. An all time maximum flow of 3295 million m^3 was recorded in 1938/39 with a minimum of 309 million m^3 in 1930/31. Annual variations are not only great, as indicated, but also common; the annual flow can be expected to be less than 690 million m^3 once in every 4 years. About 70% of the total flow usually occurs between November and March, with

the greatest volume (17.5%) in February. Although the flow rate is generally lowest from June-September, floods have been recorded during these months, as a consequence of cyclones. The fourth highest flow ever recorded, 563 million m^3/month occurred in July 1963. Detailed records of river flow for the period 1929-1972 are given by Heeg & Breen (1982).

The sediment load is low and has been estimated at 2.1 million m^3/yr, approximately 0.15% of the total volume flow. The river is now dammed at Pongolapoort and outflow to the floodplain is controlled. The dam has a wall height of 69.8 m, a total storage capacity of 2500 million m^3 giving a mean assured annual yield of 862 million m^3. The quality of pan water varies markedly from pan to pan and from time to time, a matter discussed by Heeg & Breen (1982).

Flora & Fauna: Several distinct vegetational types occur on the floodplain. A riparian forest dominated by *Ficus sycomorus* and *Rauvolfla caffra* with associated *Syzygium guineense* and *Trichilia emetica* occurs on the levees in strips up to 100 m wide, though in most places only narrow fringes now remain. Along seasonal stream banks the trees comprise mainly *Acacia robusta*, *Schotia brachypetala* and *Spirostachys africana*. On the fringes, in sites only irregularly flooded, an *Acacia xanthophloea-Dyschoriste depressa* community forms a narrow belt with occasional *Ficus sycomorus* and *Trichilia emetica*. At lower levels where inundation is regular, a Cynodon dactylon grassland prevails. Marshy areas are dominated by a *Cyperusfastigiatus-Echinochloa pyramidalis* community, while the wettest sites support reed and papyrus swamps. Papyrus is most abundant at the northern end of the floodplain, especially in the Ndumu Game Reserve; it occupies permanently flooded sites where water levels fluctuate seasonally. *Phragmites australis* prevails throughout the floodplain in swampy depressions while *P. mauritianus* predominates along river banks, pan margins and inlet-outlet channels. In pans where permanent, or semi-permanent water occurs, there are permanent and seasonal hydrophyte communities. Permanent communities contain *Trapa bispinosa* and *Nymphaea* spp., while the seasonal communities principally comprise *Potamogeton crispus* and *Najas pectinata*. A detailed vegetational map, compiled by Furness, is included in an account of the system by Heeg & Breen (1982).

The pans serve as a breeding habitat for all the important species of fish found on the floodplain, many of which are stimulated to spawn by the rising flood. Spawning occurs chiefly in shallow waters, where the juveniles are protected from predatory fish. A few species, such as *Oreochromis mossambicus* and *Tilapia rendalli*, which are nest builders and which show parental care for their young, do not exhibit a flood-dependant spawning pattern, but breed with the onset of rising temperatures. A number of rare fish also occur here, including Redigobius pongolensis, once thought to be endemic to the system. A check list of 50 species belonging to 15 families is given by Heeg & Breen (1982).

Frogs, toads and snakes abound on the floodplain. Most of the snakes cited in the introduction for northern swamps are present. Other reptiles include *Crocodylus niloticus, Mabuya striata, M. varia, Varanus exanthematicus* and *V. niloticus*. A large number of bird species utilise the floodplain, either as a breeding or feeding habitat, including 15

listed as endangered in the South African Red Data Book. These are Anast*omus lamelligerus, Ardea goliath, Ardeola rufiventris, Ciconia ciconia, C. episcopus, Gorsachius leuconotus, Haliaeetus vocifer, Henziparra crassirostris, Hydroprogne caspia, Microparra capensis, Pelecanus onocrotalus, Phoeniconaias minor, Phoenicopterus ruber* and *Scotopelia peli*. Species which occur in large numbers (counts of over 8000 birds on a single pan) include *Dendrocygna viduata* and *Bubulcus ibis*. Cyrus *et al*. (1980) give a check list of birds found on the floodplain.

Among mammals *Hippopotamus amphibius* is present in substantial numbers and *Loxodonta africana* still enters the area from Mozambique, at least 50 immigrants having been sighted in a single aerial survey in 1980. However, the populations of large game animals, so abundant in Maputaland until the turn of the century, have now been eliminated, except in the reserves. Wahlberg's epauletted fruit bat, *Epomorphus wahlbergi*, roosts in the riparian forests.

Human Impact & Utilisation: At present the local people fish the river and pans quite intensively, using baskets, palisade traps, gill-nets and rods, and fish is an important local source of protein, as also are ducks, taken while feeding on the pans. Fish and hippopotamus meat is dried, and fish have recently (1980) begun to be sold commercially. The floods deposit alluvium over the floodplain each year, and much annually enriched land is cultivated for the production of crops. In other places the highly productive *Cynodon dactylon* lawns which develop naturally, provide excellent grazing for cattle. Local plants are utilised for food, the tubers of waterlilies and water chesnuts (*Trapa natans*) are harvested, as are the fruits of *Landolphia kirkii*, *L petersiana* and *Strychnos madagascariensis* which grow in woodlands on the margins of the floodplain. The fermented sap of *Hyphaene natalensis* is widely drunk. At present local people live in harmony with the floodplain, except insofar as they destroy riparian forest for their practice of shifting cultivation.

The operation of the Pongolapoort Dam nevertheless poses the greatest threat to the floodplain, and influences it more fundamentally than does the indigenous population. Its major direct effect is the attenuation of the seasonal floods. Research on this, and other floodplains, has shown that key floodplain ecosystem processes are dependent upon periodic flooding and drying out. Here primary production, decomposition by micro-organisms, the migration, reproduction and growth of fish, the seasonal development of *Cynodon dactylon* lawns which provide grazing for ungulates, and the seasonal growth of the riparian forest are all dependent upon the natural regime. Interference with the seasonal flood must inevitably interfere with these processes.

The Pongolapoort Dam is situated at the head of the floodplain, and the lake extends back into Swaziland. It was constructed principally to supply water for the irrigation of the Makatini Flats, the soils of the region being suitable for intensive agriculture, as trials at the Makatini Agricultural Research Station have shown. There can be little doubt that plans to carry out intensive agriculture on the Makatini Flats will be deleterious to the ecology of the Pongolo River Floodplain and to the livelihood of the large indigenous population it now supports. These people will be doubly disadvantaged by the irrigation

schemes proposed. They will doubtless be displaced by the agriculture since they live on the Makatini Flats, and are dependent upon the floodplain which is being degraded. It seems unlikely that any benefits which the presently proposed irrigation schemes will bring to the indigenous population will outweigh the disadvantages attendant upon the destruction of their homesites and way of life, although it will bring paid employment to a proportion of them. There is also the fear that intensive agriculture will lead to increased silting, as has been the experience elsewhere in Natal. By contrast, fish farming on the floodplain seems to have considerable potential, the soils in certain areas being better suited to aquaculture than agriculture.

Conservation Status: Part of the northern end of the floodplain, including 4047 ha of wetland, are protected within the Ndumu Game Reserve. The Great Usutu River forms the northern border of the reserve and also the national boundary. Shokwe and Banzi pans, included in the reserve, are more properly associated with the Usutu than the Pongolo. The Pongolo Nature Reserve, of 6222 ha, at Golela, abuts the river near Pongolapoort and includes 400 ha of water surface.

(c) The North Mosi Swamp
Coordinates: 26°50'-27°13 ' S/32°29'-32°38'E (in South Africa)
Area: c. 15 000 ha (in South Africa)
Altitude: 34-45 m asl (in South Africa)
Nearest Towns: Ingwavuma (58 km NE); Durban (335 km SW)

General: The North Mosi Swamp occupies a series of N-S oriented depressions between lines of stranded sand dunes on the Maputaland Coastal Plain. Part of the swamp is in Natal and part in Mozambique. It is an isolated undisturbed low lying area of impeded or sluggish drainage, characterised by extensive reed swamps on sandy alluvial soils, and it marks the site of river flow during more pluvial phases of the recent past. It is a long narrow swamp, reaching a maximum width of 10 km in South Africa, but widening to more than this in Mozambique. The swamp extends more than 45 km over the border into South Africa at high water. Little is known of the hydrology of the area, and there have been no detailed botanical or zoological surveys. It is situated 25 km inland (west) of the coast at Kosi Bay, and approximately 25 km east of the Pongolo River Floodplain. The area is sparsely populated.

Flora and Fauna: The wetland is principally herbaceous and has few trees, except on elevated sand ridges. The swamps proper are dominated by *Phragmites mauritianus* and *Cyperus papyrus* with the typical spectrum of associates. *Hyphaene natalensis* grows on some of the sand ridges and *Phoenix reclinata* on the sides of some swales. Adjacent pans are fringed by *Acacia xanthophloea* and low bushy *Ficus* spp., *Afzelia quanzensis* reaches its extreme southern distribution on the sand ridges here. The fauna has not yet been well described, but most of the amphibians, reptiles and small mammals cited in the introduction are present. The avifauna is prolific, but poorly known.

Human Impact & Utilisation: Virtually none. The area is very remote and it must be

among the least disturbed of all wetlands on the East African seaboard.

Conservation Status: The northern part of the swamp, adjacent to the Mozambique border, lies in the 29 878 ha Tembe Elephant Park, established in 1983. There are no visitor facilities but a rustic camp is planned. Several endangered species, or species in need of conservation are protected in the reserve, which includes a great deal of wetland. These are Hippopotamus *amphibius, Loxodonta africana, Neotragus moschatus, Redunca arundinum* and *Sylvicapra grimmia*. The elephants, numbering perhaps 120-130 individuals, are the last natural herd in KwaZulu, and they migrate freely, to and fro, across the border with Mozambique.

4. Lakes & Pans of the Interior

Country: South Africa

(a) Minor Pans

General: There are close to 180 endorheic pans and lakes in the interior of South Africa, all mapped by Noble & Hemens (1978). Many lie along the Orange River and its tributaries as they cross the central plateau. Others are situated towards the northern central borders, towards the Nossop and Molopo Rivers, and some in the eastern Transvaal, close to the border with Swaziland. Most pans are filled by a combination of direct precipitation and irregular streamflow. Such pans may dry out completely and may remain dry for several consecutive years during dry cycles, but others, especially the larger ones are semi-permanent. It is believed that some arose as a consequence of animal and wind erosion, but the origin of most is uncertain.

Salt pans are mostly dry but usually contain perennial pools. They are alkaline and highly saline and their flora is restricted to a few salt tolerant species of algae. Their faunas contain temporary water forms like phyllopod crustaceans. Other pans are also usually dry, but their vegetation includes higher plants, usually salt tolerant grasses. Grass pans are seasonal and dry up in winter, but are flooded in summer. They are covered by a dense growth of hygrophilous grasses, often with an admixture of sedges. Alternatively pans may be dominated by sedges. These have a richer flora and are only ever lightly brackish. Reed pans are generally occluded by Phragmites and hold water for most of the year. They often contain a rich hydrophyte flora. The largest pans are semi-permanent and are bigger and deeper. They are often fringed by emergent vegetation and contain beds of submerged plants such as *Potarnogeton* spp.

Lake Chrissie (26°20'S/30°13'E) occupies about 1046 ha (open water) and is situated near Ermelo in the SE Transvaal at an altitude of 1660 m asl. It is the largest of the endorheic pans, being 6 km long and more than 2 km wide. It is semi-permanent but may dry almost completely once in every 10 years. There are sparse reeds and sedges on the banks, and dense beds of Potamogeton in the water, and a fish, *Barbus anoplus*, is present. There are a number of smaller pans close by, the largest being Eilandsmeer (26°20'S/30°19'E) which covers 530 ha some 1679 m asl, and Lake Banagher (26°20'S/30°18'E) of 132 ha at

1660 m asl. Both these latter pans are virtually devoid of higher plants. Both are a few metres deep and both are unprotected.

(b) Barberspan
Coordinates: 26°35'S/25°35'E
Area: 3086 ha
Altitude: 1348.5 m asl (water surface at high water)
Nearest Towns: Lichtenberg (68 km NE); Johannesburg (241 km ENE)
General: This is the largest and best known pan. It is a shallow, perennial, alkaline lake, with some 1750 ha of water surface at maximum high water. It measures 5 km in length by 2.5 km in maximum width, and lies near to the commencement of the fossil course of the Hart's River, which can be traced northwards by the occurrence of a series of similar, but smaller, pans for a further 45 km. The system is essentially endorheic, but Barberspan is connected to the next pan in the series, Leeupan, into which it overflowed in 1943 and 1967, through a shallow channel. Water has been prevented from pushing past Leeupan this century by a limestone obstruction; thus all water entering these two pans is lost by seepage or evaporation. The channel connecting these two pans is 1342 m asl. The two lakes dried completely in 1913, but since water from the Hart's River was artificially diverted into Barberspan in 1918, by the construction of a channel, this has never recurred. In the drought of 1933 the water surface of Barberspan shrank to 275 ha, mostly less than 50 cm in depth, but between 1965 and 1970 the pan was full with maximum depths of 3-9.5 m. The soils of the pans are calcareous, but sandy in parts. They have developed as shallow depressions in thin limestone rocks overlying an ancient volcanic series.

Summers in the region are hot, with mean monthly maxima for January of 30°C (40°C absolute maximum), and winters are cool and dry with a mean monthly minimum of 0°C for June (absolute minimim -6°C). Prevailing winds are from the north and severe dust storms occur in the area. Limestone dust from the pans has been blown into small hills at the southern sides of the pans and for Barberspan and Leeupan respectively these measure 24.4 m and 23.2 m in height. Mean annual rainfall is 557 mm at Barberspan. The highest monthly mean is for January (120 mm) and the lowest is for June (0 mm). The wettest month on record is January with total falls of 320 mm. Mean annual evaporation from the lake surface is estimated at 1812 mm.

Water Quality: Water temperatures vary in a normal year, from an absolute minimum of 9.5°C in June to an absolute maximum of 27.8°C in January, with a mean summer temperature of 19.2°C. The water is reasonably clear with Secchi depths of 40 cm in the central basin in summer and 1.3 m in winter. The pH range is between 8.2-9.8 with a mean figure of 9.4.

Flora & Fauna: The aquatic vegetation is dominated by *Potamogeton pectinatus*, but several smaller and fully submerged species occur on the lake bed, including *Ceratophyllum demersum, Lagarosiphon* and *Ludwigia* spp. Dense swards of *Panicum repens* grow on lake margins where inundation is shallow at high water, providing cover

for birds during times of flood. *Juncus, Cyperus* and *Eleocharis* spp. are also found around the lake edge in shallow water. Away from the shore these latter species grade into a grassland dominated by *Themeda triandra* with several associated species of *Aristida*, *Eragrostis* and *Setaria*. Limestone outcrops on the lakeshore are covered by lawns of *Cynodon dactylon*.

The invertebrate fauna is poorly known. No live molluscs were found during surveys in 1967 and 1972, but old shells of *Anisus, Barnupia, Bulinus tropicus* and *Limnaea* were found. The largest arthropod was *Potamon potamon*. However, 10 fish species have been identified in Barberspan; *Barbus anoplus, B. holubi, B. paludinosus, B. trimaculatus, Clarias gariepinus, Cyprinus carpio, Labeo capensis, L. umbratus, Tilapia sparrmanii* and *Pseudocrenilabris philander*.

Among the reptiles *Pelomedusa subrufra* is common in Barberspan and preys upon young waterfowl. Skinks, lizards and gekkos are uncommon, but those identified are *Abelepharus wahlbergi, Mabuya capensis, Nucras taeniolata ornata* and *Pachydactylus capensis*. Snakes are moderately abundant and include *Bitis arietans, Causus rhombeatus, Crotaphopeltis hotamboeia, Dasypeltis scabra, Hemachatus haemachatus, Lamprophis aurora* and *Naja nivea*. Other reptiles include *Geochelone pardalis* and *Psammobates oculifer*.

Barberspan is best known for its avifauna, some 347 species of birds, mostly waterfowl, having been recorded on it. These include very many of those cited in the introduction. Birds have been ringed at the sanctuary in the NE corner of Barberspan since 1959 and a comprehensive list of species is given by Milstein (1975).

Large mammals protected in the system are *Akelaphus buselaphus, Antidorcas marsupialis, Connochaetes gnou, Darnaliscus dorcas phillipsi, Equus burchelli* and *Raphicerus campestris*. Small mammals have not been studied intensively but many of those indicated in the introduction are present. *Erinaceus frontalis* and *Poecilogale albinucha* are endangered species which are protected here.

Human Impact & Utilisation: This has been minimal since the creation of the Barberspan Nature Reserve. Tourist density is not high and interference with the ecosystem by visitors is negligible.

Conservation Status: Barberspan and Leeupan are situated in the Barberspan Nature Reserve, established in 1954.

5. Montane Wetlands
Country: South Africa
General: Wetland vegetation occurs in sponge bogs which develop over springs and below seepages at all altitudes. It also occurs in mountain valleys where the flow of perennial streams is impeded and water is stored in depressions and behind obstacles,

giving rise, over the country, to innumerable valley swamps. These are best developed in wide valleys, on gently sloping floors. These wetland types occur all along the southern and eastern mountain ranges where precipitation is heavy. The flora of these wetlands, most of which tend to be on acid peaty soils, is rather similar, but dependant upon altitude. Sponges are raised peat bogs and have remarkable water storage capacities, such that even when there has been no rain for 5 months, water may continue to flow from a high altitude sponge, providing the headwaters of a stream, upon which, lower down, a village will depend. Such is the situation along much of the Drakensberg Range in Natal, Swaziland and the Eastern Transvaal.

Flora & Fauna: See introduction.

Human Impact & Utilisation: Apart from forestry projects the higher mountains are now little affected by man. Cattle are kept off the high slopes which are burnt in a controlled fashion by the various authorities to prevent the accumulation of dry matter. This, if permitted to accumulate, produces very hot fires which are extremely deleterious to the vegetation, and which promote erosion. Thus it is considered prudent to have occasional controlled burns. Little thought appears to be given to the effect of burning upon the fauna, and of course, burning prevents the establishment of woody species. In places, the foothills are heavily overgrazed, e.g. in parts of Natal, and these places are subject to very high rates of erosion. Here bogs, streams and pools are heavily utilised by cattle and their banks are trampled down. Under these circumstances many bogs have dried or are in the process of doing so. Many lower valley swamps have been drained, and others have disappeared in small impoundments.

Conservation Status: Large areas of sponge vegetation lie in Mountain Catchment Reserves and State Forest Reserves of the Directorate of Forestry. These are situated all the way along the mountain crests from the Cape Province through to the Eastern Transvaal. Well over 1.5 million ha of mountainous land is protected in these reserves, but this does not automatically imply that all sponges and swamps are well protected. In a few cases both sponges and high valley swamps have been replaced by plantation forests, losing the storage capacity of the wetlands, and deregulating the headwater flow of local streams. Without the bogs and valley swamps, flash flooding becomes a common phenomenon on mountain streams, with greatly increased rates of erosion. However, this is not now a usual practice, and from a water conservation point of view it is essential that all these areas continue to be maintained in pristine condition. A number of sponges and valley swamps are fully protected in nature reserves and national parks. These are too numerous to discuss in detail, but e.g., no less than 38 large sponges are preserved in the comparatively small Verloren Valley Nature Reserve, which covers 6055 ha in the Eastern Transvaal (25°18'S/30°07'E) at altitudes of 2200-2300 m. There are other alpine sponges and numerous valley swamps in the Giants Castle Nature Reserve (34 638 ha, maximum elevation 3451 m as!) and in the Royal Natal National Park (8856 ha, maximum elevation 3282 m asp. Brief mention is made of wetland vegetation in some reserves in South Africa by Greyling & Huntley (1984).

6. Artificial Impoundments

Country: South Africa

General: There are literally thousands of artificial impoundments in South Africa, ranging in size from small farm dams to the Hendrik Verwoerd Dam, which is currently the 14th largest in Africa in terms of surface area (36 433 ha). These dams store a volume of water equivalent to 40% of the total mean annual run-off of all rivers in the country and their total surface area at capacity amounts to some 210 000 ha. Most impoundments are comparatively shallow, and are subject to high incident solar energy and sediment inputs. Many are subject to pollution from agricultural, urban and industrial wastes and some are eutrophic. Toxic algal blooms, which develop periodically, have created problems on some of the smaller dams, and others have become infested with floating macrophytes. Evaporation rates are high and riverine influxes are subject to dramatic annual variations. Five impoundments have storage capacities in excess of one billion m^3, one can store over 400 million m^3 and two exceed 300 million m^3 in capacity. The remainder are much smaller. Some, including the Hendrik Verwoerd Dam, occur in or adjacent to nature reserves. Many are utilised for angling and recreational purposes, but significant commercial fisheries have not yet developed on them. Brief details of the 104 most important impoundments are given by Noble & Hemens (1978).

(a) Hendrik Verwoerd Dam

Coordinates: 30°40'S/25°28'E

Area: 36 433 ha (at capacity)

Altitude: 1259 m asl (upper storage level)

Nearest Towns: Port Elizabeth (335 km S); Durban (480 km ENE)

General: The Orange River rises in Lesotho with sources high on the eastern rim of the southern African Plateau, immediately west of the Drakensberg Escarpment. This first major dam on the river, which is the largest in South Africa, was closed in 1970. It has a storage capacity of 5952 million m^3 and subtends a lake within the co-ordinates 30°29'-30°52'S/25°28'-26°18'E. This has a maximum width of 10 km and extends upstream for almost 100 km, with a tributary arm near the head of the lake extending into the valley of the Caledon River.

(b) Vaaldam

Coordinates: 26°52'S/28°07'E

Area: 29 269 ha

Altitude: 1484 m asl

Nearest Towns: Johannesburg (64 km NNW); Durban (381 km SE)

General: The Vaal River, a tributary of the Orange, rises near the town of Ermelo on the eastern rim of the interior plateau not far from the Swaziland border. It flows westwards to its first impoundment near Vereeniging. The dam here has brought about the inundation of a narrow valley system and created a long lake with many arms between co-ordinates 26°49'-27°06'S/28°05'-28°30'E. It is the second largest artificial lake in the country in terms of surface area, but the fourth largest in terms of capacity, which is 2330

million m^3.

(c) Bloemhof Dam
Coordinates: 27°38'S/25°36'E
Area: 22 821 ha
Altitude: 1229 m asl
Nearest Towns: Johannesburg (240 km NE); Cape Town (975 km SW)
General: This, the second dam on the Vaal River, is situated some 350 km below the Vaal Dam. It has created a broad shallow lake, the third largest in the country in terms of surface area. It extends back upstream for some 90 km with a major arm extending 30 km up the valley of the tributary Sand/Vet River system. Co-ordinates for the lake are 27°27 '-27°49 ' S/25°36 '-26°15 'E.

(d) The P.K. Le Roux Dam
Coordinates: 30°00' S/24°42 'E
Area: 13 867 ha (at capacity)
Altitude: 1170.5 m asl (at upper storage level)
Nearest Towns: Durban (600 km E); Cape Town (740 km SW)
General: This second impoundment of the Orange River is situated some 120 km below the Hendrik Verwoerd Dam and was closed in 1976. It has a storage capacity of 3237 million m^3, the second largest in the country. It subtends a shallow lake with a maximum width of about 20 km which extends upstream for some 55 km. Co-ordinates for the lake are 29°59'-30°23'S/24°42'-25°02'E.

(e) Pongoloapoort Dam
Coordinates: 27°29'S/32°03'E
Area: 13 247 ha (at capacity)
Altitude: 137 m asl (upper storage level)
Nearest Towns: Durban (300 km SSW); Johannesburg (490 km NW)
General: The Pongolo River rises near Wakkerstroom at an altitude of 2200 m asl. It has a catchment of 7081 km^2 and descends steeply to the lowveld west of the Lebombo Mountains. It then traverses a gorge between the Lebombo and Ubombo Mountains to reach the Maputaland Coastal Plain. It is now dammed at the lower end of the gorge and the lake behind the dam extends upstream into Swaziland. Unlike the other major impoundments this is at low altitude. Maximum storage capacity is estimated as 2500 million m^3, making it the third largest reservoir in the country in this respect. The water is intended for irrigation projects on the Makatini Flats, but the effect of the dam on the people and biology of the floodplain of the river (section 5.7.3b) is almost certain to be adverse. The potential impact of the dam is discussed in a report by Heeg & Breen (1982).