A description of the Wetlands Research Programme

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A report of the National Programme for Ecosystem Research

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PREFACE

The national programme for Ecosystem Research is a cooperative undertaking of scientists and scientific institutions in South Africa, concerned with research related to environmental problems. The national programme includes research activities in inland waters and terrestrial ecosystems and deals with aspects of nature conservation.

The Wetland Research Programme has been initiated in order to stimulate research into a previously neglected area of inland water ecosystems. This document is intended to communicate pertinent information on the rationale and operation of the wetland research programme to researchers, administrators and water resource managers.

ACKNOWLEDGEMENTS

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ABSTRACT

This report presents a rationale to the development of a multidisciplinary South African Wetland Research Programme. A definition of what is meant by the term wetland is given along with a general description of what types of wetland occur in South Africa. Functions and values of wetland areas are set in perspective against the major large-scale concern of wetland degradation and loss of the ecosystem type. The goals, project structure and research strategy of the Wetland Research Programme are outlined and key questions within specific research areas are posed. A list of current research projects indicates that there is already sufficient expertise within the country for the development of a successful wetland research programme.

SAMEVATTING

Hierdie verslag verskaf grondredes vir die ontwikkeling van 'n multidissiplinêre Suid-Afrikaanse vleilandnavorsingsprogram. 'n Definisie van die begrip vleiland word gegee tesame met 'n algemene beskrywing van watter tipes vleilande in Suid-Afrika voorkom. Funksies en waardes van vleilandgebiede word in perspektief gestel teenoor die ernstige besorgdheid oor die agteruitgang van vleilande en verlies van die ekosisteemtipe. Die doelstellings, projekstruktuur en navorsingstrategie van die Vleilandnavorsingsprogram word geskets en sleutelvrae binne spesifieke navorsingsgebiede word gevra. 'n Lys van huidige navorsingsprojekte dui aan dat daar alreeds genoegsame kundigheid binne die land bestaan vir die ontwikkeling van 'n suksesvolle vleilandnavorsingsprogram.

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INTRODUCTION

Many countries of the world have already reached or are rapidly approaching the position of maximum economic exploitation of their conventional water resources (Alexander 1985). South Africa, situated in a semi-arid region of the globe, with its extensive agricultural, mining and industrial developments is no exception. The initial development of South Africa's water resources was based primarily on meeting bulk user demands (mainly agricultural) with scant consideration towards water quality or ecological implications. However, in the last twenty years an increasing occurrence of water quality and ecological problems has forced water resource managers to recognize the importance of these aspects. Any approach to developing the scientific and technological expertise required to solve problems within these areas is not one which can be done in a random or an ad hoc fashion. Consequently, in the early 1970's two organizations (The South African Water Research Commission and the Inland Water Ecosystems Programme (IWE) of the CSIR) were established to coordinate research and to develop expertise.

The rationale to the development of the IWE programme has been documented by Noble and Hemens (1978). The programme had its origins in the late 1960's when, largely due to the impetus provided by the International Biological Programme (IBP), numerous university groups initiated limnological studies. The subsequent growth of the programme (Table 1) indicates a pattern of increased sophistication and coordination as experience has developed. There has also been a change in emphasis from the early studies which tended to concentrate on reservoirs. More recently, the IWE programme has moved in the direction of including whole catchment, river and wetland studies.

The current IWE programme is aimed at achieving the following objectives:

- developing the understanding necessary to predict the effects of natural events as well as planned development and management actions on inland water ecosystems;

- contributing to the scientific basis for utilization of these ecosystems;

- seeking solutions to particular environmental and management problems.

The Foundation for Research Development (FRD) is concerned with the administration and coordination of projects within the overall programme such that the necessary expertise is developed. This is largely achieved by promoting appropriate interaction between scientists and decision-makers to develop a mutual understanding of water resource problems and to stimulate appropriate basic and applied ecological research. Although the mission is ideologically sound, in practice success has not always been achieved due to the many complexities involved (Huntley 1987). The programme is operated by a system of committees which

advises staff of the FRD and CSIR executive on its implementation. Factors which can determine the success of a programme include:

- the need for a multidisciplinary approach
- availability of suitable researchers
- the level of funding required
- the contribution which the study will make to developing new skills
- facilities available from participating institutions
- active participation by user agencies.

Major syntheses of the results of these cooperative projects have been published as South African National Scientific Programme reports (Table 1). There has also been a healthy contribution to the international literature with more than 100 papers published in international refereed journals (Huntley 1987).

According to the International Union for Conservation of Nature and Natural resources (IUCN), wetlands are one of the most globally endangered habitat types (Maltby 1986). Throughout the world vast areas of wetland have been modified to alternate land uses. A similar trend in wetland losses has occurred in South Africa and it has been recommended that urgent steps should be taken to improve the conservation and management of wetlands (Begg 1986). In order to do this it is necessary to develop a better knowledge base of the wetland situation in South Africa. In particular, users of wetland areas (private landowners, corporate organizations, municipalities, state and provincial authorities) need to be made more aware of wetlands and their potential value. By developing a national wetland research programme the Ecosystem Programmes Section of FRD is attempting to address the conservation requirements of one of South Africa's most endangered ecosystem types.

This document outlines the goals, project structure and research strategy for the development of the wetland research programme. It is intended to familiarize researchers, administrators and regional land-use authorities with research opportunities, project administration and individual projects which contribute to the management of wetlands in South Africa. A listing of current projects is given with key references which provide background information. New projects to be funded by FRD will be evaluated in terms of their relevance to the key questions listed in this document.

TABLE 1. History of the development of the Inland Water Ecosystem Programme

Project Development	Key Research Team(s)	Key published products	Organisational Development
1. Lake Sibaya (IBP) 1968-1978	Institute for Freshwater Studies, Rhodes University	Allanson (1979)	1968 - coordinated by National Institute for Water Research, CSIR
2. Orange River project 1968-1975	Institute for Environmental Sciences, University of the Orange Free State	Van Zinderen Bakker (1974)	
3. Pongolo Floodplain 1971-1975 (IBP)	University of Natal	Heeg and Breen (1982)	1971 - establishment of an independent coordinator within CSIR
4. Midmar Dam 1973-1983	University of Natal National Institute for Water Research	Breen (1983)	1972 - establishment of National Scientific Programmes Unit (NSPU)
5. Pongolo Floodplain 1975 - ongoing	Multiorganizational	-	
6. Wuras Dam 1976-1983	University of the Orange Free State	-	1976 - establishment of Cooperative Scientific Programmes (CSP)
7. Wilderness Lakes 1977-1984	Rhodes University	Allanson and Whitfield (1983)	
8. P K Le Roux Dam 1977-1985	Multiorganizational	Allanson and Jackson (1983)	
9. Hartbeespoort Dam 1981-1987	National Institute for Water Research	National Institute for Water Research (1986)	
10. Vaal Catchment 1985 - ongoing	Multiorganizational	Braune and Rogers (1987)	1984 - establishment of Foundation for Research Development
11. Wetlands 1985 - ongoing	Multiorganizational	-	
12. Rivers 1985 - ongoing	Multiorganizational	O'Keeffe (1986a,b)	
13. Mgeni catchment 1985 - ongoing	Multiorganizational	Breen et al (1985)	

WETLANDS IN SOUTH AFRICA

The definition of wetland

There are numerous definitions of the term, but the one employed by Begg (1986) is that of the United States Fish and Wildlife Service (Cowardin et al 1979). It provides us with an adequate base on which to develop our understanding. The definition reads:

"...land where an excess of water is the dominant factor determining the nature of soil development and the types of plant and animal communities living at the soil interface. It spans a continuum of environments where terrestrial and aquatic systems intergrade".

The theme is therefore one of a water-dominated area with impeded drainage where soils are saturated with water (at least periodically) and where there is a characteristic flora and fauna. Such areas include marshes, pans, sponges, bogs and swamps. The term "vlei" is applied in South Africa to a wide range of situations. These include seasonally or perennially wet areas within river drainage systems which are dominated by emergent hydrophytes, as well as coastal and estuarine lakes, many of which have extensive areas of reeds and sedges (Noble and Hemens 1978). Noble and Hemens (1978) have described some of the characteristics and distribution of South African wetlands. Included in their review are:

Sponges

Many streams arise in seepage areas or sponges which are seasonally or perennially waterlogged and have a vegetation dominated by sedges and mosses. The best known sponges are those found in the Lesotho, Transkei and the Natal Drakensberg at altitudes between 1 800 and 3 500 m (Jacot-Guillarmod 1962).

Marshes and swamps

Throughout South Africa, there are in most river systems stretches overgrown with reeds and other marshy vegetation (locally termed vleis). Some of these areas can be described as swamps (deeper water level) and others as marshes (shallower water level). Noble and Hemens (1978) have mentioned categories such as sedge marshes, restio marshes, reedbed marshes, reedswamps, papyrus swamps, swamp forests, salt marshes and mangrove swamps.

Floodplains

A few South African rivers have short floodplains developed in their middle or lower reaches. Noble and Hemens (1978) categorize them as Karoo Salt flats (eg van Wyksvlei), floodplain vleis (eg Nylsvlei) and storage floodplains (eg Pongolo, Mkuze).

Pans

Some of the drier parts of South Africa have numbers of pans which have no outlet and which are either semi-permanently or periodically filled with

water. Some of these (eg Lake Chrissie, Barberspan) are large enough and retain water long enough to warrant designation as lakes. Several characteristic pan types can be mentioned (eg salt pans, temporary pans, grass pans, sedge pans, reed pans, and lakes).

All of the above systems fall within the context of the term wetland and need to be included within the framework of any research programme. Further debate is still required on the possible inclusion of systems such as riparian zones of rivers, farm dams, estuaries and certain lakes.

THE VALUE OF WETLANDS

Wetland areas provide benefits which can be divided into six main categories (Figure 1). These include potential values in connection with:

1. Development (agriculture and urban)
2. Social activities (tourism, bird watching, education, utility)
3. Erosion control
4. Hydrology (flood attenuation, water storage)
5. Pollution control
6. Habitat value (vegetation, fish and wildlife).

Wetlands are of extreme importance to the landscape in which they are found. This is because:

1. they influence the flow of water, sediment and nutrients over the landscape, thus have implication for water storage, streamflow regulation, flood attenuation, soil erosion and water purification;

2. abundant moisture and hydromorphic soils allow for the development of a characteristic flora and fauna. Wetlands therefore provide a specific and much sought after fish and wildlife habitat.

South Africa is characterized by a climatic environment in which:

- average annual rainfall (497 mm) is well below the world average (860 mm) and unevenly distributed over the country;
- humid subtropical conditions occur in the east while dry desert conditions occur in the west;
- rainfall and runoff are highly variable on account of severe and prolonged drought periods coupled to irregular flooding;
- for most of the country, average annual potential evaporation is more than the average annual rainfall; and
- the proportion of average annual precipitation that is converted to river flow varies from 50% to almost zero. In most catchments less than 25% of precipitation is converted to runoff.

In a semi-arid country such as South Africa where sparse vegetation, drought periods and flash floods are of common occurrence the presence of wetland areas is highly desirable.

Wetland loss: the extent of the issue

Of major concern at present is the increased evidence that man has succeeded (on an unprecedented global scale) in irreversibly degrading vast areas of wetland by development and poor land-use practices. Estimates for the United States of America show that more than 54% of the original 87 million hectares of wetland have been converted to development (87% of this area has been altered for agricultural purposese). There is evidence that a similar trend in wetland losses has occurred in South Africa. Begg (1986) estimates that wetlands formerly occupied between 10% and 15% of most catchments in Natal and that within the last 50 years they have, in certain catchments, been virtually eliminated.

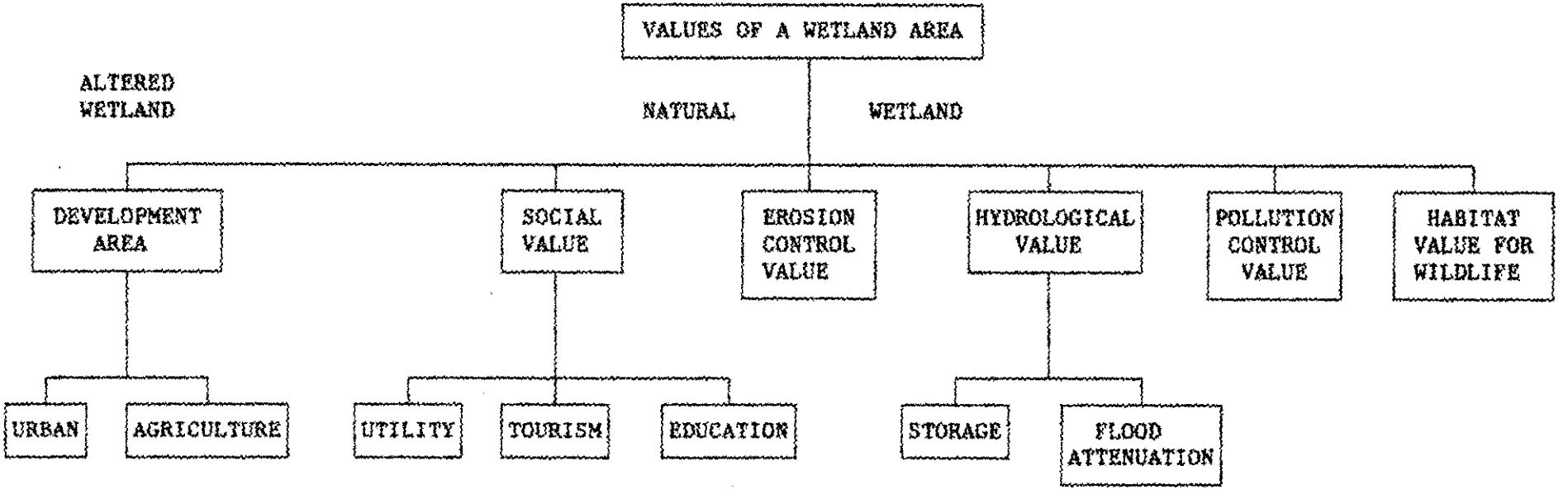

FIGURE 1. Hierarchical structure to wetland values.

At a recent symposium numerous examples of wetland degradation in South Africa were presented (Walmsley and Botten 1987). Practices such as channelization, drainage, overgrazing, crop production, afforestation, waste disposal, water abstraction, infilling and burning have all had an influence in disrupting the structure and function of wetlands. The degradation or loss of a wetland area results in a decrease in its ability to retain water, sediment, nutrients and plant cover.

The situation is further compounded when transposed on to the catchment scale. The cumulative removal of wetlands has severe adverse implications on the ability of the particular catchment to retain water, sediment, nutrients and vegetative cover. In short the destruction of wetlands accelerates the rate of transport of water, sediment and nutrients across the landscape into the ocean.

PROJECT GOALS

The overall goal of FRD's Ecosystem Programmes is to develop a predictive understanding of the structure and functioning of ecosystems as a basis for their wise management. Ten years ago Noble and Hemens (1978) commented "Wetlands appear from several points of view to be potentially highly beneficial components of South African drainage systems and yet at the same time a source of considerable practical problems. Surprisingly, however, totally insufficient information is available on them to take even simple decisions on their conservation, utilization, and management of removal". The Working Group for Wetland Research, established in 1985,has developed terms of reference to address the wetland issue. The objectives of the wetland programme as decided by the Working Group are:

- to develop an understanding of the structure and function of wetlands sufficient to predict their response to major natural and man-derived influences; and

- to identify wetlands of special scientific, conservation or aesthetic value and to develop guidelines for their management towards set objectives.

The Wetland Programme will therefore produce an improved wetland information base which scientists, agriculturists, water resource developers, conservationists and land-use planners can utilize.

PROJECT STRUCTURE AND RESEARCH STRATEGY

Because of the wide variety of benefits to which wetlands can be put and the numerous organizations involved, it is necessary that the wetland programme structure and research strategy should accommodate many disciplines. In establishing a research strategy and structure it is essential that the perceptions of user agencies (wetland managers and policy-makers)are taken into account.

Each wetland has a value which is determined by attributes related to social, hydrological, wildlife, erosion control and pollution values (Figure 1). Depending on which attributes are perceived to be the more important, different user agencies have differing opinions as to the value of each wetland, its environmental problems and the research and information needs.

Begg (1986), in his report on the wetlands of Natal, produced an outline of wetland research needs as conceived by the Natal Wetland Technical Committee. Recognizing that this outline needed to be expanded, a questionnaire was sent to several organizations requesting them to rate the eight categories of research requirement listed in Begg's report. In addition, the organizations were asked to stipulate whether any research requirements had been overlooked.

Table 2 presents a summary of the responses from the sample of users. An overall rating has been arrived at by assigning numeric values to the ratings of each user agency (A = 5, B = 3, C = 1) and calculating an arithmetic mean. Priorities were allocated using mean values in the following ranges:

A = 5
A- = >4-<5
B+ = >3-<4
B = 3
B- = <3

This analysis is not definitive, it is a preliminary guide for allocation of priorities in wetland research. The compilation of inventories of wetlands was the only research field which unanimously received an A rating with the other fields receiving lower ratings, presumably because of the range of local/regional or departmental perspectives.

In order to accommodate the various research fields, the Working Group for Wetland Research has developed a strategy which attempts to:

1. Focus on the development of:

   - ecological principles of wetland management and conservation in southern Africa.

   - methods for monitoring both long- and short-term variability in the dynamics of wetlands.

TABLE 2. A summary of priority ratings given by some user organizations for fields of wetland research

ORGANIZATION	RESEARCH FIELD							
	1. Inventory	2. Classification	3. Hydrology	4. Water purification	5. Sediment accretion	6. Cost benefit analysis	7. Ecosystem structure and function	8. Wetland degradate
Department of Development Aid	A	A	B	C	C	A	B	B
Rand Water Board	A	–	–	–	–	A	–	–
Escom	A	–	–	–	–	A	–	–
Roodepoort Municipality	A	C	B	A	A	B	B	B
Department of Water Affairs	A	A	–	–	–	–	B	C
Anglo American	A	B	B	C	C	C	B	B
Bureau of Natural Resources – KwaZulu	A	B	A	B	B	A	A	A
Department of Agriculture and Water Supply	A	A	A	B	B	B	B	A
Directorate of Forestry	A	A	A	B	B	A	–	A
Wildlife Society	A	A	A	B	A	C	B	A
Natal Parks Board	A	B	A	B	B	A	B	C
OVERALL	A	B+	A–	B–	B	B+	B+	B+

– = no rating given

- methods for assessing the ecological and socio-economic impacts of development on wetlands, and integrating the need for wetland conservation with the importance of development projects.

2. Identify, classify and evaluate wetlands in terms of:

   - environmental determinants
   - biotic composition
   - ecological functions in the landscape
   - conservation value and status.

3. Assess the socio-economic values of wetlands.

4. Improve understanding of the effects of perturbations on wetlands and to monitor the rates of change in wetlands and distinguish those changes which have human-related origins.

5. Make recommendations on the management of wetland areas for long-term sustainability, whether for preservation, utilization or restoration purposes.

6. Encourage collaboration in this field between conservation scientists, land-use administrators and those responsible for the planning of agricultural and economic development projects.

7. Promote the regional and intercontinental exchange of wetland information and management expertise and in particular to encourage interaction with global conservation agencies such as the International Union for the Conservation of Nature and Natural Resources (IUCN), which administers the Ramsar Convention.

Because there is a wide diversity of interests in wetlands and their values, the programme attempts to encourage all activities which are relevant to wetlands. However, there are areas which should receive an immediate high priority (eg inventory)in terms of the contribution to the long-term management and conservation of wetlands. In these areas, Government and Provincial organizations are encouraged to actively participate by committing staff and facilities in a cooperative and multidisciplinary fashion. Without such participation the programme will not be a successful exercise.

RESEARCH AREAS

This section contains key questions which, if answered, would greatly enhance conservation and management of wetlands in South Africa. They are not placed in any order of priority.

Inventory

It is symptomatic of the wetland issue that we have little indication of how size, geographic distribution, vegetation type, utilization etc determine wetland importance. Wetland inventory is a prerequisite to any wetland research and management programme. Countries such as the United Kingdom, France, Germany, Australia, United States of America, Holland and Denmark have all carried out an inventory of their wetlands because it has been accepted that is is not possible to manage or research wetlands without knowledge of certain minimum characteristics.

Key questions

1) What is the current and historical proportion of wetland cover in each catchment?

2) What is the current status of each wetland with regards to utilization and degradation?

3) How does each wetland rank in terms of relative importance for the catchment under consideration?

4) What are the abiotic and biotic characteristics of important wetlands?

5) What is the best methodology for inventory of wetlands?

6) what factors dictate the distribution of wetlands?

Classification

It is felt by many that classification and inventory go hand in hand, ie that one cannot be done without the other. Classification cannot be made without inventory information, but classification aids the inventory process. A classification system for South African wetlands is therefore an essential step towards determining which wetlands should be preserved and for which purposes they can be used.

Key questions

1) What abiotic/biotic characteristics can be best utilized for the development of a classification system(s) for South African wetlands?

2) Which classification system is best suited for inventory purposes?

Structure and function

Wetlands comprise soil, water, vegetation and other biotic components.

An understanding of the characteristics of each of these components and the interactions between them is essential if environmental management is the goal. A factor which influences one of these components can have ramifications for the whole ecosystem. For example, channelization in a wetland area increases outflow, lowers the water table and changes the nature of the vegetative cover. This leads to a deterioration in habitat, a possible increase in erosion and eventually partial or total degradation of the wetland. Studies on structure and function must therefore form an integral part of the wetland research programme.

Key questions

1) What is the relationship between soil moisture and vegetation type?

2) What is the relationship between soil type and vegetation type?

3) What are the environmental requirements of wetland dependent animals?

4) What are the roles of microbiota in maintaining wetland ecosystem function, eg recycling of nutrients?

5) What are the physical, chemical and biological responses to disturbance and perturbation?

6) What chemical transformations take place within wetlands, representative of the types revealed by classification?

Hydrology and erosion

Since soil is transported by water flow and wetlands have a function in reducing erosion, these two research topics have been included in a single section. In South Africa where water is a scarce resource, wetlands are viewed with suspicion in that they retain water (therefore not being directly available for usage) and thus compete with usage for irrigation and domestic and industrial purposes.

By contrast wetlands reputedly play a major role in reducing erosion and in modifying water flow over the landscape. Unfortunately this role has not been unequivocally quantified and further research is essential.

Key questions

1) How do wetlands affect catchment water budgets?

2) Do wetlands have higher rates of evaporation than equivalent open water surfaces?

3) What are the water requirements of wetland areas and how resilient are they to alterations in water supply?

4) How effective are wetlands in the accretion of sediment?

6) How important are wetlands as determinants of perennial stream flow?

Habitat

Wetlands provide an environment in which a wide variety of biota occur. Many of the species are either characteristic of wetlands or are dependent on the specialized habitat. Loss of wetlands means a loss of habitat for numerous species of fish, birds, amphibians, reptiles and mammals. Furthermore certain wetlands contain endangered plant and animal species and therefore require special attention. There is currently an urgent need to establish the value of wetlands as a habitat for fish, wildlife and flora.

Key questions

1) What are the key species which inhabit wetlands and how dependent are they on the habitat?

2) What is the relationship between habitat diversity and species diversity?

Socio-economic

Wetlands have a variety of values (Figure 1) but, in the commercial sense a socio-economic analysis is required. There is an urgent need to obtain a holistic view of wetland values (in monetary terms where possible) such that decisions on wetland utilization can be based on more sound economic grounds.

Key question

1) What are the socio-economic values of wetlands and can these be expressed in monetary terms?

2) What is the recreational potential of wetland areas?

3) What useful materials occur in wetlands (eg peat, thatch, herbs etc) and can these be utilized on a sustainable basis?

4) What is the economic value of wetlands in pollution and erosion control?

Management

Any holistic research programme would not be complete if management aspects were not considered. Within the management section are included activities which investigate practices and policies that influence the degradation of wetlands and promote their conservation and optimal utilization.

Key questions

1) Is existing legislation adequate for the protection and conservation of wetland areas?

2) How should a national inventory be conducted?

3) What is the desirability of establishing a wetland information centre and data bank and is it feasible?

4) How does a wetland respond to a particular stress or degradation practice (eg drought, burning, channelization, overgrazing, effluent disposal)?

5) What are the main causes of wetland degradation?

6) Which wetland sites require special attention and what steps should be taken towards their conservation?

CURRENT RESEARCH PROJECTS

This section carries a list of projects which are currently being carried out or recently completed. It is based on information received from respondents following a questionnaire approach to establishing the wetland research community in South Africa.

Inventory and classification

Bourquin O	Distribution and numerical status of reptiles in Natal. Natal Parks Board.
Begg G W	The wetlands of Natal (Part 2). The distribution, extent and status of wetlands in the Umfolozi catchment. Natal Town and Regional Planning Commission.
Begg G W	The wetlands of Natal (Part 3). The location, status and function of priority wetlands in Natal and KwaZulu. Natal Town and Regional Planning Commission.
Brummer B and Rogers K H	The distribution and status of wetlands in the upper Klip River catchment. Department of Botany, University of the Witwatersrand.
Coke M M	Distribution of freshwater fish in Natal. Natal Parks Board.
Cooper J, P Hockey and P G Ryan	The Atlas and site register of South African coastal birds. Percy FitzPatrick Institute of African Ornithology, University of Cape Town.
Engelbrecht J	The conservation status of lotic wetlands in the Incomati and Limpopo systems. Transvaal Provincial Administration. Nature Conservation Division.
Guillet A and T M Crowe	Behaviour, ecology and biogeography of water birds in Africa. Percy FitzPatrick Institute of African Ornithology, University of Cape Town.
Heydorn A E F and P D Morant	Estuaries of the Cape. National Research Institute for Oceanography.
Hill P	A survey of the Amatikulu drainage basin. KwaZulu Bureau of Natural Resources.
Junor F J R	Natal coastal inventory. Natal Parks Board.

King J M, M J Silberbauer and J A Day	Inventory and classification of wetlands of the south-western Cape. Freshwater Research Unit, University of Cape Town.The
Lambiris A J L	Amphibians of Natal - taxonomy, biogeography and conservation. Natal Parks Board.
Morrey D, G Begg and P Goodman	A numerical analysis of species distribution and associations in relation to environmental factors in the wetlands of KwaZulu and Natal. Department of Pasture Science, University of Natal.
Muller D B	Plantekologie van die panneveld van die Westelike Oranje-Vrystaat. Departement van Natuurbewaring. Bloemfontein.
O'Callaghan M	A study of aquatic vegetation of the Cape estuaries from the Kei River to the Orange River. Botanical Research Institute.
O'Callaghan M	The vegetation around rivers entering False Bay, Cape. Botanical Research Institute.
Parkington J E, J Grindley, J Rogers and J C Vogel	The palaeoecology, geomorphology and archaeology of Verlore Vlei and other Coast River systems. Department of Archaeology, University of Cape Town.
Schwabe C and C M Breen	Wetlands of the Drakensberg/Moluti Mountains. University of Natal.
Seaman M T and D Kok	Inventory of wetlands in the Orange Free State. Department of Zoology, University of the Orange Free State.
Stormanns C H and C M Breen	An inventory and assessment of the conservation value of the Mkuze swamp system. University of Natal, Pietermaritzburg.
van Loggerenberg N	The conservation status of lotic wetlands in the Pongolo and Vaal systems. Nature Conservation Division, Transvaal Provincial Administration.
Weisser P J	Wetland vegetation of the Zululand coast. Botanical Research Institute.

STRUCTURE AND FUNCTION

Buchan A J and C M Breen	Submerged and floating-leaved macrophytes; recovery after drought, response to controlled flooding and importance in ecosystem functioning. University of Natal, Pietermaritzburg.
Ellery K and K H Rogers	Plant community structure and dynamics in the north-eastern perennial swamps of the Okavango Delta. Centre for Resource Ecology, University of the Witwatersrand.
Rogers K H, P J Ashton and A Carter	Patterns and mechanisms of *Phragmites* encroachment in the Kruger Park rivers. Department of Botany, University of the Witwatersrand.
Semmelink M	Nutrient-sediment interaction in Rondevlei. Freshwater Research Unit, University of Cape Town.
Smith V R	Production and nutrient ecology of Marion Island mire grasslands. Department of Botany, University of the Orange Free State.
Steinke T D	Seasonal variation in soil parameters and their effects on mangrove distribution in the Beachwood Mangroves Nature Reserve. Botany Department, University of Durban-Westville.
Steinke T D	Carbon and nitrogen fixation by algae epiphytic on mangroves. Botany Department, University of Durban-Westville.
Steinke T D	Photosynthesis by mangroves. Botany Department, University of Durban-Westville.
Steinke T D	Seasonal trends in appearances and senescence of mangrove leaves. Botany Depart- ment, University of Durban-Westville.
Steinke T D	Litter production by mangroves. Botany Department, University of Durban-Westville.
Steinke T D	Seasonal trends in plant-water relations in mangroves. Botany Department, University of Durban-Westville.

Taylor D and B R Allanson	Carbon flow in a tidal saltmarsh with particular reference to the contribution of grapsoid crabs. Institute for Freshwater Studies, Rhodes University.

HYDROLOGY AND SEDIMENT TRANSPORT

Bosch J M	Determination of the effects of afforestation and management on stream flow. South African Forestry Research Institute.
Chapman A A	Hydrological study at Franklin vlei. University of Natal, Pietermartizburg.
Rogers K H and T S McCarthy	Ecological, hydrological and sedimentological studies of the Okovango Delta. Department of Botany, University of the Witwatersrand.

HABITAT

Batchelor A L	Annual and seasonal variations in the number of waterfowl frequenting the major pans on the Pongolo Floodplain. Department of Development Aid, Pretoria.
Fawcett M H	Factors affecting crocodile nest selection. Natal Parks Board.
Hamer M	The ecology of Branchiopod crustacea of northern Zululand. University of Natal, Pietermaritzburg.
Stoltz L P	Watervoelgetalwisselings op groot staatsdamme in die Oranje-Vrystaat. Departement van Natuurbewaring, Bloemfontein.

SOCIOECONOMIC

Buchan A J and C M Breen	Floodplain grazing resources: production, utilization and significance in local socio-economy University of Natal, Pietermaritzburg.
Furness H D	Changes in the pattern and extent of agricultural utilization of the Pongolo River Floodplain. Umgeni Water Board, Pietermaritzburg.

Wood A, P J Ashton, M Rowley and P G Williams	The use of artificial wetlands for effluent treatment. Division for Water Technology, CSIR.

MANAGEMENT

Begg G	Development of a management strategy for wetlands in Natal. Environmental Advisory Services, Durban.
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