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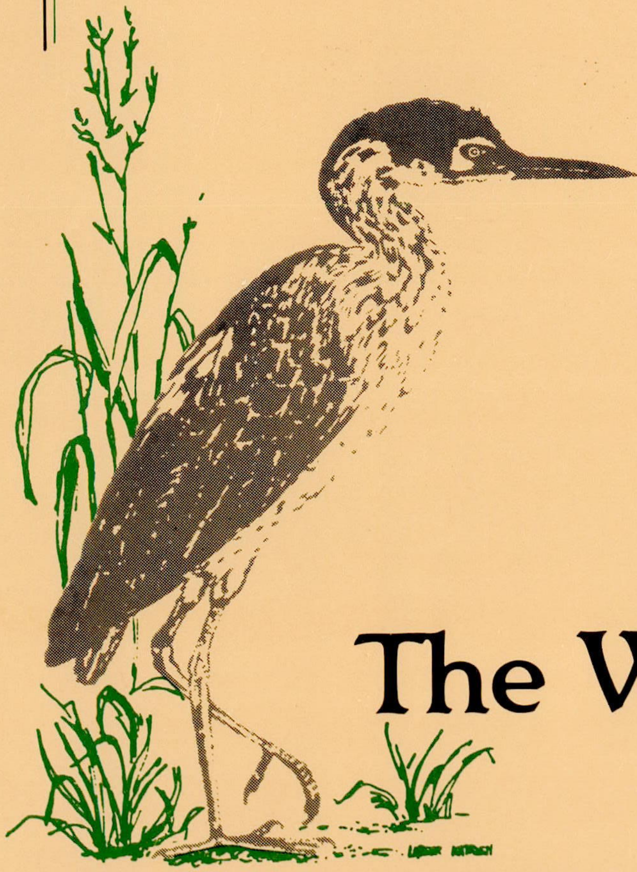

The Wetlands of Natal
(Part 1)

An overview of their extent, role, and present status

THE WETLANDS OF NATAL (PART 1)
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G. Begg
CHRIS MULDER ASSOCIATES INC.,
ENVIRONMENTAL PLANNING CONSULTANTS

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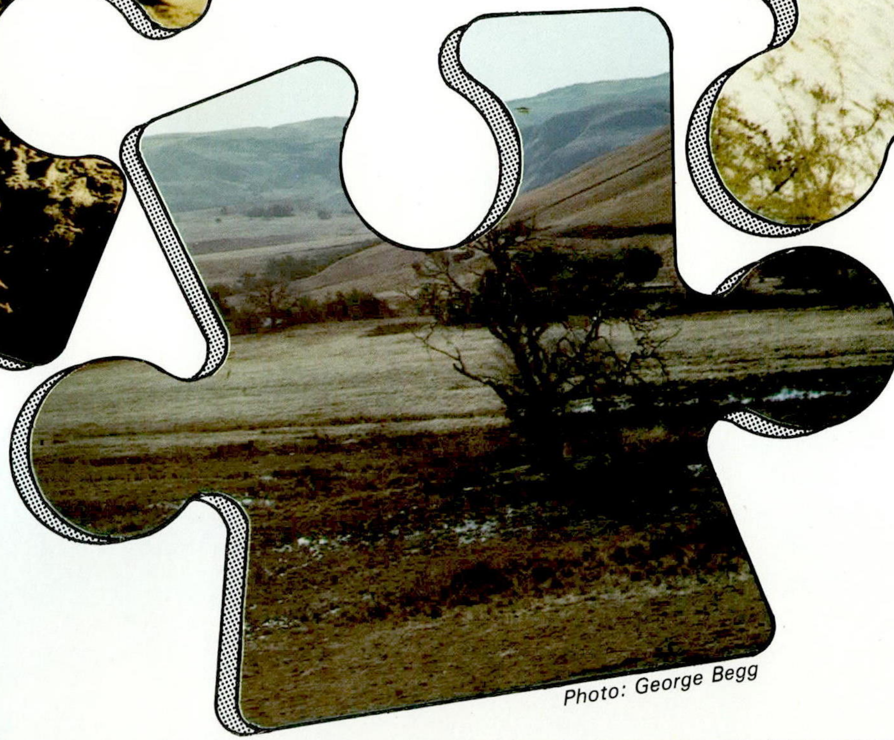
Frontispiece

Amongst many other things, wetland conservation is a potential means of ameliorating the severity of droughts and floods in Natal

Photo: Mark Lyster



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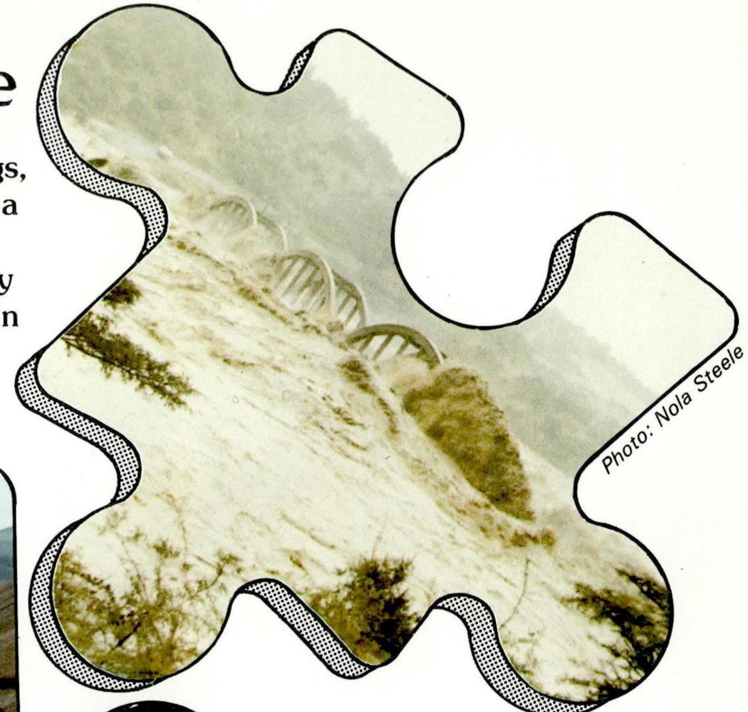


Photo: Nola Steele

Contents

Chapter

Footnote:
The reader's attention is drawn to the fact that *at the back of this report is a map* showing the location of all the place names used in the text.

Preface

This overview on the wetlands of Natal is of great practical significance for two reasons. It is the beginning of a comprehensive inventory of all the wetlands in Natal; but it is also the initial step in the development of a management strategy and policy statement.

In this report Dr George Begg describes the variety of wetland habitats in Natal, and the geology, pedology and climate which have led to their genesis. It highlights not only their natural richness, but also, their existing and potential value to man. Two examples are worth mentioning. Wetlands are an integral part of river systems, as they retain water and regulate river flow, thus combatting floods and assisting in water purification. They also provide rich, flat farmlands or supplementary water supplies — if they are drained. Both these aspects point to the need for us to develop guidelines for the management of wetlands.

The programme which is being followed has been divided into three phases, each directed at manageable objectives:

Phase I : Synthesize the available information on the distribution, structure, functioning, use and value of wetlands;

: Devise an interim "holding" strategy which may be used to regulate the development of wetlands.

Phase II : Develop an inventory and a classification of wetlands;

: Quantify their importance in watershed management;

: Provide a basis for monitoring changes in their functioning.

Phase III: Produce a final report and Policy Statement which sets out appropriate means of managing the wetlands of Natal.

This report, which falls into Phase I, is part of the planning strategy which will culminate in the management policy for these unique resources. The rate at which wetlands are vanishing is accelerating and must be of increasing concern to the peoples of this Province.

The project has come to pass through the concern and support of too many bodies and people to enumerate in a preface. The initiative provided by Professor Charles Breen; the dedication and drive of our research fellow Dr George Begg of Chris Mulder Associates; the financial and technical support of the Department of Environment Affairs are all fundamental. They are supplemented by input from our sister organisation the Natal Parks Board and the Department of Agriculture and Water Supply. Orchestration and support are provided by the Town and Regional Planning Commission.

Wetlands are extremely valuable in the life-support resources which we have available, and we are all proud to be associated in the production of Dr Begg's first report.

AM Little

A.M. Little
Chief Town and Regional Planner

Executive Summary

Despite recognition in many other parts of the world that wetlands have a high value, and are not wastelands to be modified or destroyed at will, this lesson still needs to be learnt in the Republic of South Africa.

In an attempt to correct this failing, this report has been written to obtain an overview of the status of wetlands in Natal and KwaZulu. It has been written in an effort to convince the public at large, as well as politicians and economists, that the intrinsic values of wetlands are real, and that wetlands contribute substantially to the quality of human life. In a country such as South Africa, in which development is known to be limited by its water resources, the loss of wetlands leads to the loss of numerous public benefits. These include:

- water storage
- streamflow regulation
- drought relief
- flood damage protection
- soil erosion protection
- water purification
- wildlife protection
- recreational opportunities
- raw materials, and
- many other less tangible benefits.

Most people do not realise that, in an attempt to meet the demands of our nation's rapidly growing population, these life-supporting resources are dwindling before their eyes. Our research has tentatively shown that wetlands formerly occupied between 10% and 15% of every catchment in Natal. Within the last 50 years wetlands in these same areas have been reduced to a few scattered remnants, and in certain catchments virtually eliminated.

The structure and functioning of the remaining wetlands is being altered each year by channelisation, drainage, crop production, afforestation, waste disposal, water abstraction, infilling, burning and many other man-induced activities.

The downstream consequences are well known, but include more severe floods; more severe droughts; dramatically increased siltation; reduced productivity and recreational value of impoundments, estuaries and lagoons; a marked deterioration in water quality and the disruption of wildlife (in some cases, verging on species extinction). The process of wetland degradation has yet to be halted.

There is evidence in this report to suggest that:

- all of the above consequences were perfectly forseeable, but the warnings sounded by numerous organisations and individuals have gone unheeded
- the legislation which provides for wetland protection is difficult to enforce because it has been based on an inadequate understanding of the functions and values of wetland ecosystems. Thus law and land-use have yet to be reconciled
- the economic return through wetland development to the individual is of dubious significance, when compared with the public value of undisturbed wetlands to the region as whole
- the lack of public awareness, ignorance and short-sightedness are the indirect causes of wetland degradation. As a result, the distribution of a "wetland-related information package" to every registered farmer in Natal is recommended, as an interim means of alleviating this difficulty
- funds are required to support the considerable amount of research that still needs to be done before a management policy, which *acknowledges the rational utilisation of wetlands* is formulated.

Acknowledgements

For someone such as myself, who is still very much of a wetland novice, the preparation of this report has been an education. When the study first began in July 1984, our intention was to leap in at the deep end and produce an inventory of all the wetlands in Natal. However, once in the field this approach proved to be impractical for a variety of reasons, and it became clear that we should first obtain an overview of the subject.

The credit for this lies with Professor Charles Breen (University of Natal), who, as one of the foremost experts on wetlands in Southern Africa, has been the motivating force behind this study. His enthusiasm has been contagious and it has been a joy to work under his direction, as well as to have received the support for this study forthcoming from the "Wetlands Technical Sub-Committee", operating under the auspices of the Natal Town and Regional Planning Commission (NTRPC). I am extremely grateful to Mr A M Little (Chairman), Mrs M Shaw (Secretary), Mr J B Anderson (all of the NTRPC), Mr W D M Fourie (Department of Environment Affairs), Mr A Wilby and Dr D Scotney (Dept. of Agriculture & Water Supply), and Professor C Breen for their continual encouragement and advice since the inception of this project.

This report would never have seen the light of day had the funds to support it not have been forthcoming from the Department of Environment Affairs, or had Chris Mulder Associates Inc., (CMAI) not have been prepared to undertake the work. Despite it being a non-paying proposition, I am filled with admiration by the fact that CMAI initiated this study because of their conviction that it was in the national interest to do so. To compensate for the somewhat dry text, I am indebted to Katrien Lateur of CMAI for reproducing the sketches which occur in the margins of this report, because any technique such as this, which helps to sustain the interest of readers, is clearly advantageous.

Whilst preparing this document, a great many other persons and organizations, inside and outside South Africa, willingly gave me all the help they could. I am particularly grateful to Mr Richard Whitlow (University of Zimbabwe) for his assistance, and for all that I learnt through the medium of his excellent papers on the "dambos" of Zimbabwe.

Various members of the Natal Parks Board, the Department of Agriculture and Water Supply, the Directorate of

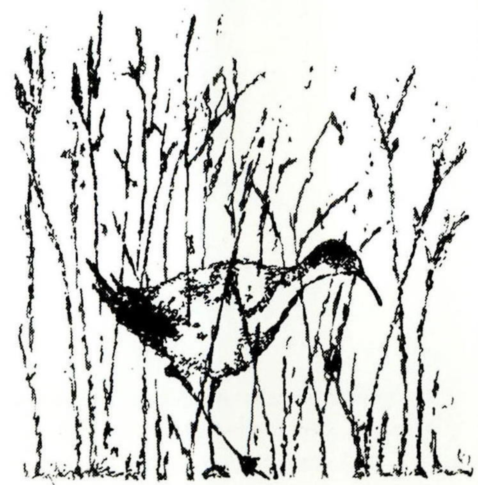
Forestry, the KwaZulu Bureau of Natural Resources, the Wildlife Society of Southern Africa, the Durban Museum and many others have all been of great assistance. With so much yet to achieve, before the wetlands of Natal have received the recognition that they so richly deserve, it is good to know that these sort of people will be there to lean on in the future.

Several people helped with the typing of this manuscript, but I am indebted particularly to Tracey Gawler for her diligence in this regard. Judith Thompson, librarian of the Oceanographic Research Institute, performed the invaluable service of acquiring much of the literature reviewed during the course of this study, and in their normal manner, the staff in the NTRPC's Drawing Office rose to the occasion and helped in many different ways. Heather Young, in particular, expertly reproduced the figures accompanying this report, but to all of these persons I am extremely grateful.

G.W. Begg
Ecologist

Chapter 1

Introduction

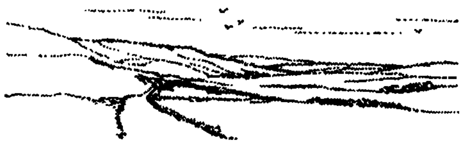


Wetlands throughout the world have long been recognised as key habitats for biological, hydrological and economic reasons. However, they are also regarded as being amongst the most threatened of habitats in the world (90, 198, 107) and so it is appropriate that a study of this nature should be conducted in 1985: the year declared by the IUCN (International Union for the Conservation of Nature and Natural Resources) as the International Year of the Wetland (39).

In South Africa, there is no reason to think that the status of wetlands is any less critical or more secure than elsewhere in the world. This is especially so because the country is poorly endowed with water. The conservation of wetlands is, therefore, of particular urgency, and yet there is little evidence to suggest that the ordinary man in the street really understands how wetlands affect his every day life. The aim of this report is to bridge that gap.

In brief, wetlands are components of the landscape of considerable value to mankind. There are economic benefits to be derived from wetlands which range from fisheries to agricultural production. There are hydrological benefits ranging from water storage and flood control, to water purification, as well as benefits resulting from the wide variety of plants and animals which utilise wetlands.

Wetlands are vital components of a region's water resources and are widely distributed throughout every catchment in Natal. Generally speaking, it is no easy



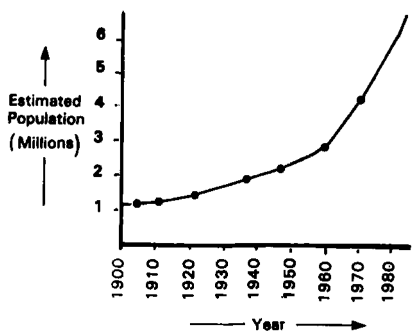


Fig. 1 The growth in the total population of Natal and KwaZulu, over the period 1904 - 1980.
(Data source, Grobbelaar (1984) in NTRP Report No 65)

matter however, to determine precisely where wetlands begin or where they end. The reason is that wetlands are semi-aquatic habitats, or channel phenomena, which merge between wet and dry parts of the landscape. In relatively recent times they have been severely reduced in extent due to a variety of anthropologic pressures ranging from erosion (Plate 1) and channelisation to desiccation by diversion, water abstraction, and burning.

In Natal there is no room for complacency in this regard, due to our rapidly growing human population (Fig 1). As many readers will be aware, in an attempt to meet the demands of our ever increasing population, the technological advances in our society have completely changed the scale of man's influence upon the land (1, 181). At present there are well over 6 million people in Natal and KwaZulu and, depending upon race, the estimated population growth rate varies from 2,2% — 3,5% per annum. It is understandable therefore that man's activities have become a powerful force, strong enough to leave a deep imprint on the surface of the land. The challenge before us is how to moderate the effect of this force, especially in respect of valuable resources such as wetlands, and how to provide management principles which may be used to ensure they continue to serve mankind in the future.

To give an example, for generations farmers have recognized the potential value of wetlands for pasture production, the grazing of cattle and the cultivation of various crops, but they (and others) have seldom realised the downstream consequences of these activities (171, 189).

Few have appreciated the function of wetlands in a catchment context, such as the role of these systems in the regulation of stream flow, and the attenuation of flood water. Few have ever understood the far reaching effects of wetland modification or elimination by never bothering themselves in land management issues beyond the confines of their own farms. Thus, their perspective is, understandably, very different from that of a regional planner. The consequences of this lack of appreciation are evident everywhere in the form of flood damage, silt-charged rivers, dried-up streams, and polluted water (63).

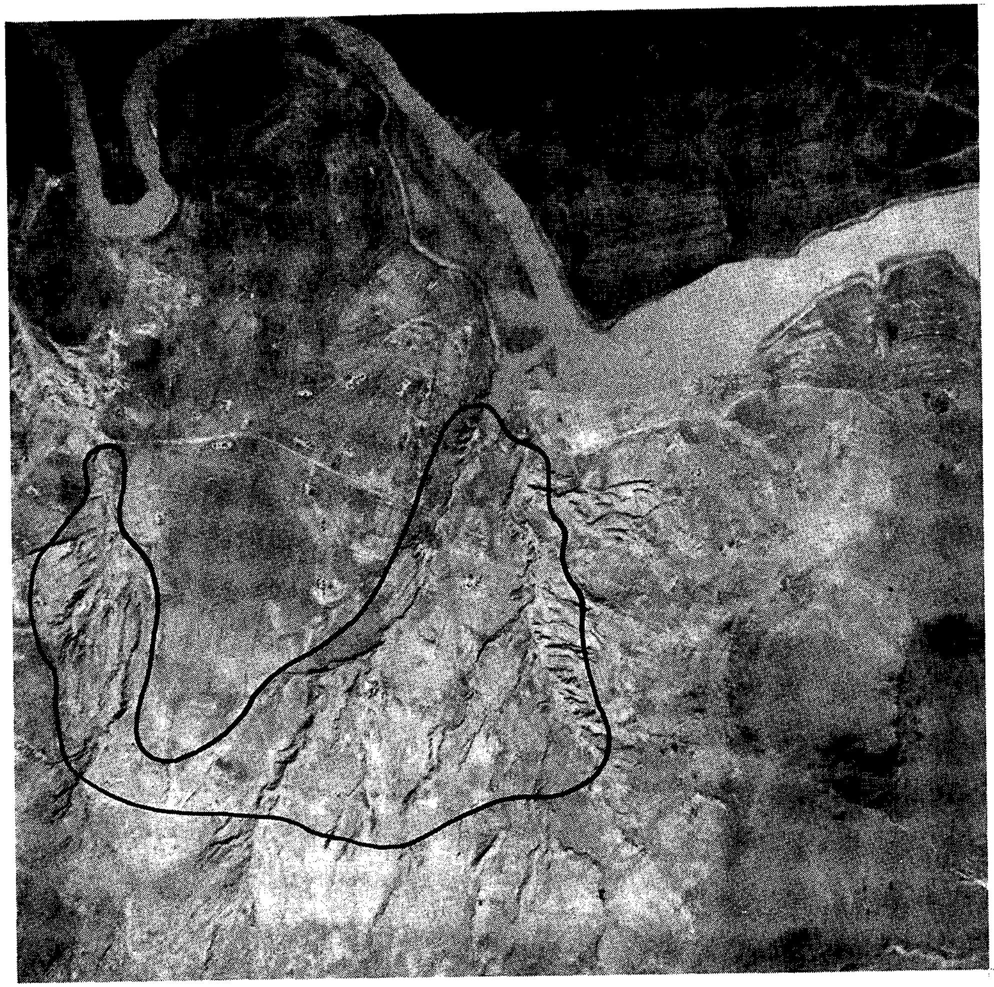
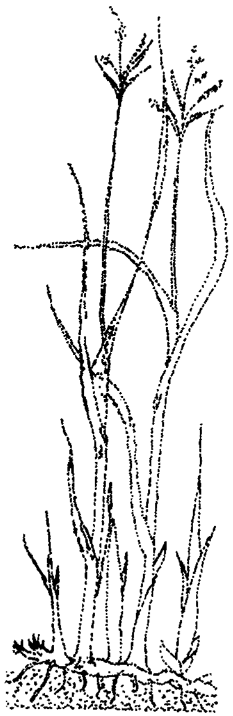


Plate 1

The eroded condition of a wetland area upstream of the Driel Barrage on the Tugela River in August 1982. Its former extent, according to van der Eyk, *et al.*, (1968) is outlined.
(Photo by: J. Armstrong, Aerial Photographic Services, Pietermaritzburg.)



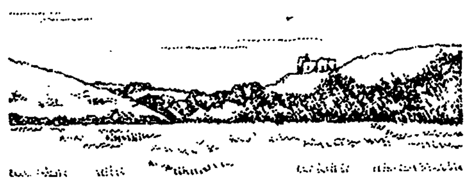
As one of the large scale land use changes occurring in Natal, the urgency of making some firm decisions about the environmental consequences of wetland utilisation (130), stems both from the confusion about wetland values apparent in many circles, and from the fact that water has long been recognised as the limiting factor in the development of South Africa (67, 142). It is of some concern therefore, that law and land use have yet to be reconciled. For example, although the government clearly seeks to protect wetlands by legislation (168), and attempts to prevent the haphazard development of wetlands by careful planning (85), these principles and procedures are still not complied with in many instances. There is also a great need to ensure that any area that has "already been drained or is under cultivation" (168), is correctly managed.

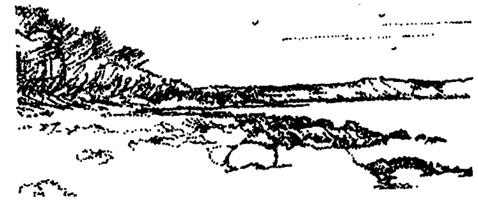
To make matters worse, scientific opinions on the subject also differ widely. Some maintain that wetlands retain sediment (89), others do not (101). Some claim wetland cultivation has no adverse effects (154), whilst others believe that it does (138, 62). Similar arguments arise over the question of water storage in wetlands (129), and so on. Clearly, it is long overdue that these apparent conflicts should be resolved.

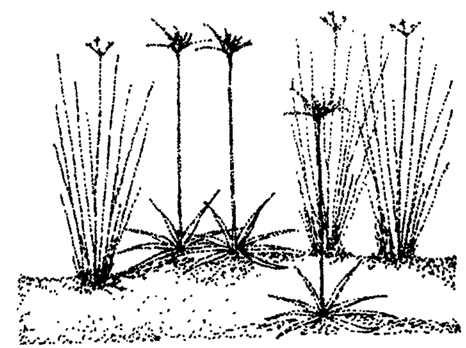
With the harsh economic realities of the recent drought and floods still fresh in the minds of people throughout Natal (47, 77) (see Frontispiece), one would expect the need for rationalizing the use of wetlands to be plainly evident. In certain circles, this does appear to be the case, because being charged with the responsibility of ensuring "the harmonious development of Natal", the Natal and Town Regional Planning Commission have the reputation of undertaking many resource studies in the Province. Indeed, one of the earliest strategies adopted by the Commission was to protect Natal's water supplies. Over the last 35 years numerous climatological and hydrological studies relating to the monitoring of water quality and quantity have been completed. In addition, the lower reaches of Natal's river systems have been, and still are the subject of detailed examination, and some classical studies have been made drawing together information on hydrology, soils and plant ecology, to optimize agricultural production and use of environmental resources. Therefore, Natal is generally in the forefront of change in developments related to water resource management, and so the placement of wetlands under the spotlight in 1985 is another milestone in this process. Having been called for by a great many parties (57, 103, 174), it should also prove to be a turning point in the attitude towards the management of these particular resources.

This report hopes to foster a greater interest in the welfare of wetlands at a strategic level, and to convince people that they can no longer afford to overlook the public value of wetlands. It aims at defining the term 'wetland', at clarifying the role and quantifying the extent of wetlands in Natal.

It also describes the manner in which wetlands are presently being used, and, as a precaution, makes recommendations (in the form of a direct appeal to every farmer in Natal) for the protection of wetlands which have, thus far, escaped destruction. This is done in the hope that until more specific guidelines for the rational utilisation and future management of these resources can be formulated, a degree of protection against further degradation can be afforded to them in the interim. An analysis of the current legislation is also made to identify the opportunities for wetland protection. Finally, an attempt is made to identify wetland — related research projects which could help government agencies seeking to regulate the use of these vital, life-supporting resources.

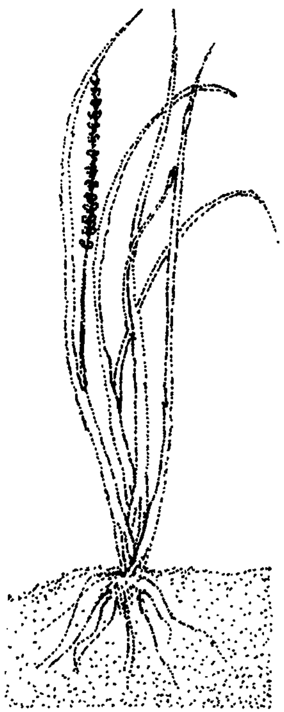






'A town is saved not more by righteous men in it than by the woods and swamps that surround it."

(Henry David Thoreau)



Chapter 2

The definition of a wetland

For anyone who may have read or spoken about the subject, the definition of "a wetland" is something over which few people seem to agree (2, 29, 37, 41, 116). A major reason for this is that wetlands are subject to considerable temporal and spatial variation (180). They occur over a wide variety of sites, from the top of the highest mountains (92) to mud flats at sea-level (27), and are subject to varying degrees of wetness according to differing climatic, hydrologic and topographic influences (Fig 2.)

In this report, the word 'wetland' is purposely adopted to avoid the use of vernacular terms, but in South Africa the most commonly accepted term for a wetland, is "vlei". This is a term derived from the Dutch word "vliet", meaning water course (195). Other water dominated areas to be considered would include marshes, bogs and swamps, often referred to as vegetated or 'palustrine' wetlands by certain authors (107), but, they all have one or more of the following features in common:

- Soil that, at least periodically, is saturated with water (50).
- Soil within which reducing conditions prevail (136).
- Impeded drainage (197).
- A characteristic position in the landscape (176).
- Distinctive plant communities (138), and
- Distinctive animal communities (48).

For the purposes of this report therefore, the best definition of a wetland was that adopted by the United States Fish & Wildlife Service (USFWS) (50, 114). This reads "(a wetland is) *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 surface. It spans a continuum of environments where terrestrial and aquatic systems intergrade".

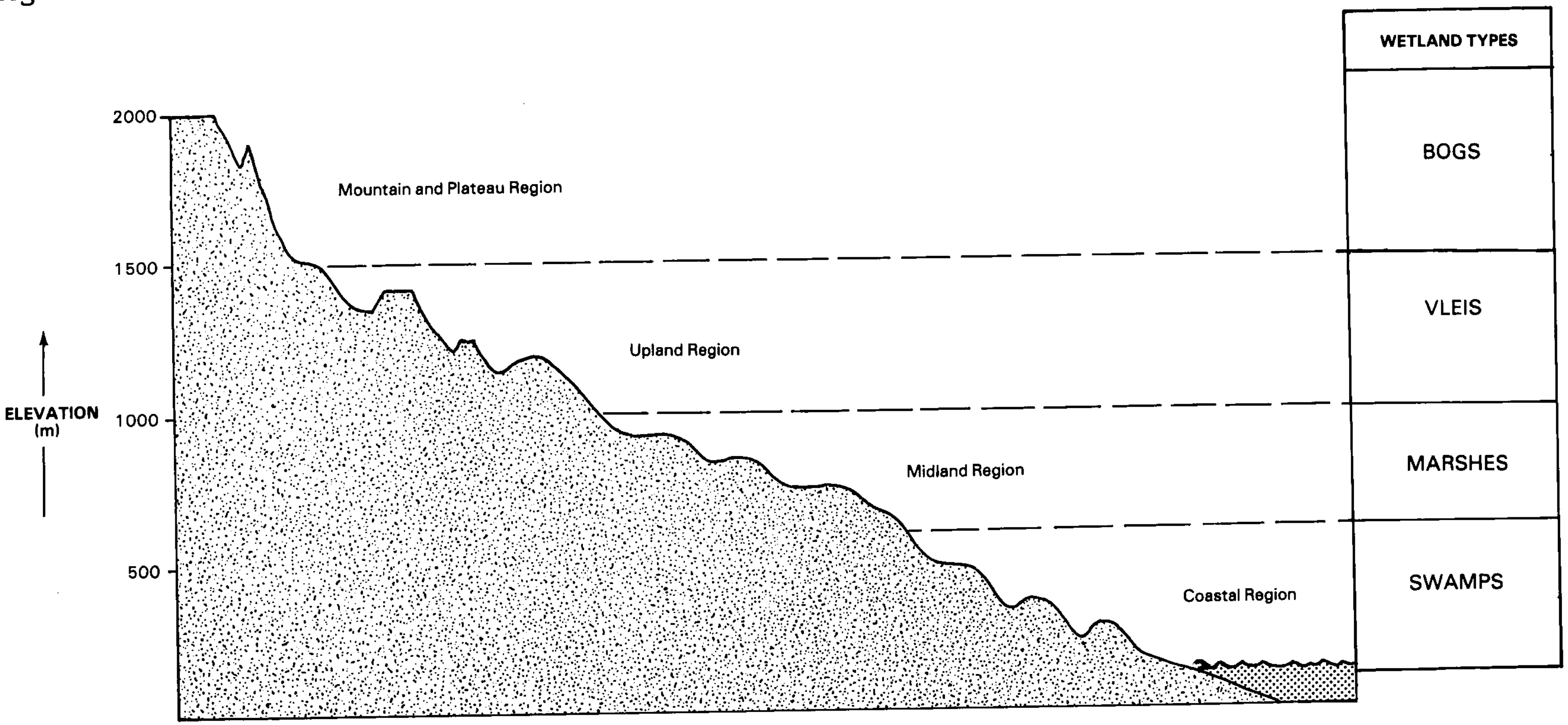
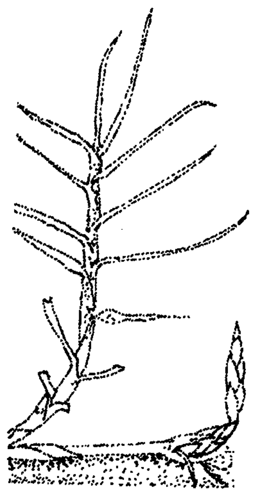
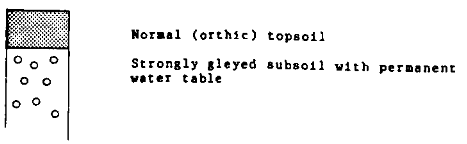


Fig. 2 A provisional method of differentiating between types of wetland in Natal, by using altitude as a determinant.

***Footnote:**
In this context, the term "excess" is taken to mean soils that are flooded for long enough for water logging to become the dominant factor determining the biogeochemical characteristics of the area concerned.



Katspruit Soil Form



Chapter 3

The role of wetlands in Natal

3.1 Hydrological role

A useful way of reviewing the hydrological role of wetlands is to start with first principles (193). This is necessary to understand some of the key processes that are involved in the movement and storage of water in the landscape (Fig. 3).

Of all the various processes operative infiltration is probably the most important. This is the process by which water soaks into the soil, and replenishes the moisture stored therein. Water which follows this particular route, therefore remains within the catchment for the longest possible time, and in doing so, sustains the growth of plants and maintains the flow of streams by basal flow (Fig. 4). It is important to realize however, that any site in the landscape, including wetlands, has a capacity to absorb a certain amount of water before surface run-off (or overspill) occurs (89). For this reason, surface run-off is often referred to as a product of the over-stored groundwater zone, and not as a product of rainfall (17). This capacity is dependent on the soil type, on the degree of soil saturation and the quantity of rainfall involved.

Contrary to popular belief, the nature of certain wetland soils (such as the Katspruit form) restricts infiltration, as the topsoil horizon is seldom deep, and the sub-soil is practically impervious due to the high proportion of clay present (181). Furthermore, because of the saturated soil conditions usually associated with wetlands it is often claimed that wetlands act as aquifer recharge areas (75). However, wetlands are formed by an impervious stratum that impedes the flow of ground-water, and so it is really groundwater storage and *discharge* that are of significance, because of their downstream effects on stream flow (123, 197).

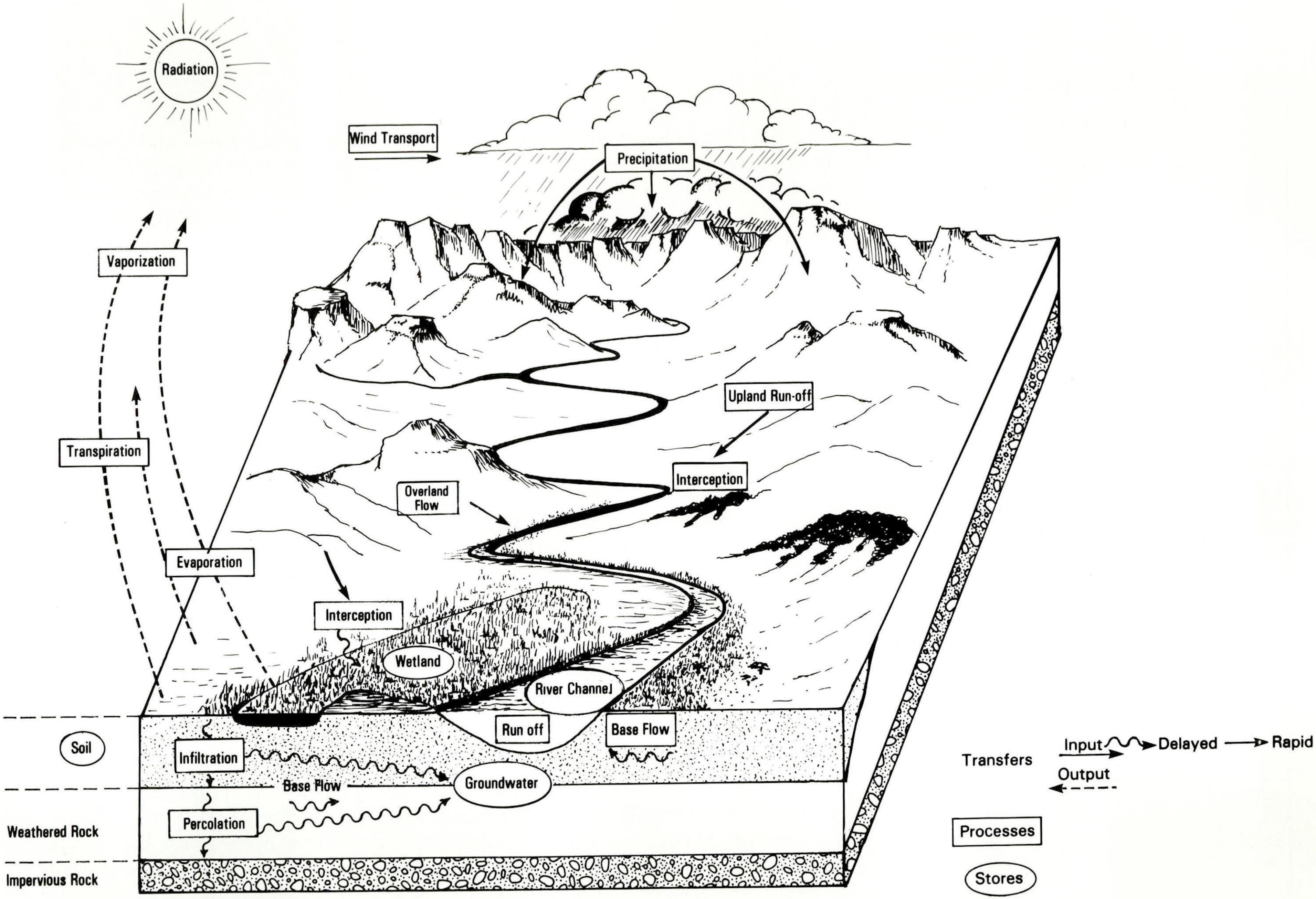


Fig. 3. Systems diagram of the hydrological cycle operative at a typical vlei site in Natal.
(modified from Wicht, 1972; Schulze, 1979; Whitlow, 1983)

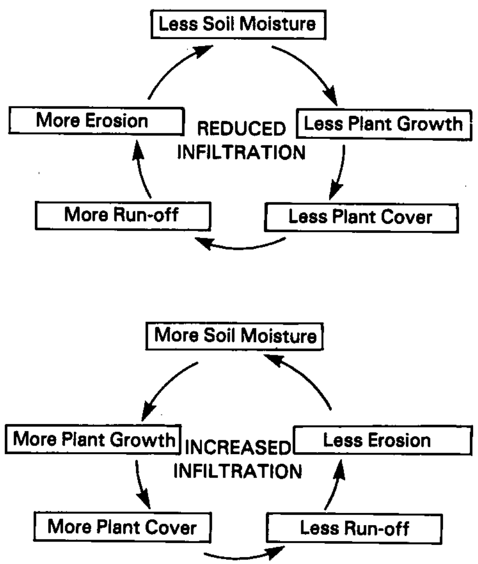


Fig. 4 Infiltration as a key process in the hydrological cycle.

The time lag between the replenishment of a given water store, and initiation of overspill is another important factor, especially in steeply tilted catchments, which lie in areas subject to periods of high intensity rainfall. Natal is a good example, because it characteristically receives most of its rainfall as storm events. During these events, the surface soil becomes saturated, and run-off occurs because the soil cannot store any more water. This is aggravated by the steep topography, and so sites in which detention occurs (i.e. wetlands) are of particular significance for flood attenuation. Here the dense plant cover of wetlands starts to fulfill an important role by intercepting overland flow. In other words, because of the luxuriant growth of plants in this particular portion of the landscape, surface runoff becomes dampened and transformed into less rapid means of transfer by wetland interception (76, 49). In the process, its erosive powers are greatly diminished.

A hydrological characteristic of a catchment well-endowed with wetland areas is therefore attenuated flood waters (see Section 3.1.2), in contrast to the flash flood regime of catchments lacking in wetlands (60, 137). In addition, the 'filtering action' of wetland plants means that particulate matter such as silt settles out in these areas. Many chemical transformations also take place, and so water leaves a wetland cleaner than when it entered (see Section 3.1.4).

Put simplistically therefore, the effect of wetlands is to act as absorbent areas within the catchment which stabilize and cleanse river flow.

3.1.1 Water Storage

Water storage is a function attributed to wetlands intuitively by many people (54, 143, 151), but very little solid, quantitative data are available in South Africa to support this point of view (196). This lack of understanding has probably cost the country more than we would care to imagine (97), because there is reason to believe that although unnoticed by most people, the flow regime of many South African rivers may have altered over the years as a consequence of wetland destruction.

The Blaaukrantz River serves as a good example (30, 31, 83). This river drains a typical highland sourveld area of Natal near Estcourt, in the catchment of the Bushmans River. At its headwaters were numerous sponge areas (or vleis) which gave rise to the river once noted by the Voortrekkers as a strongly flowing stream of clear water which ran throughout the year (83). Over the years the catchment of the Blaaukrantz River, including the wetlands, became intensively farmed and overgrazed, and before long erosion assumed severe proportions. What also became apparent by 1945 was that the flow of the river was no longer perennial, and nor was the water clear.

Over a period of ten years thereafter intensive efforts were made to rehabilitate the area, but despite substantial success, the flow regime of the Blaaukrantz River never recovered. This created an awareness of the fact that once sponge areas in the catchment were destroyed they were impossible to reclaim. Furthermore, the fear was expressed that should farming malpractices of this nature be perpetuated, this pattern of events could well be repeated elsewhere (153).

Since then, the Ntabamhlope Research Station, has been established in the same drainage area, and specific attention given to the hydrological influence of a large undrained wetland on the Ntabamhlope River. Its effect on the duration and volume of stream flow has been shown to be very pronounced (Fig 5). In fact, the research conducted lead to the conclusion that "from the point of view of assured water yields, the preservation of vleis has a significant role to play in a water scarce Souch Africa" (151).

Coming from one of the most respected hydrologists in our country, little else really needs to be said, but it is clear that controversy still surrounds the definition, origin and value of "sponges". In examining the question of water balance, for example, one school of thought is that sub-surface seepage from adjacent uplands is a major source of water in wetlands (138, 143). Another is that direct precipitation is the main input (17, 148). Such disagreement is not due to a lack of insight or endeavour, but due to the complexity of the interactions involved (Fig. 3), and insufficient understanding of the site-specific properties of individual wetlands.

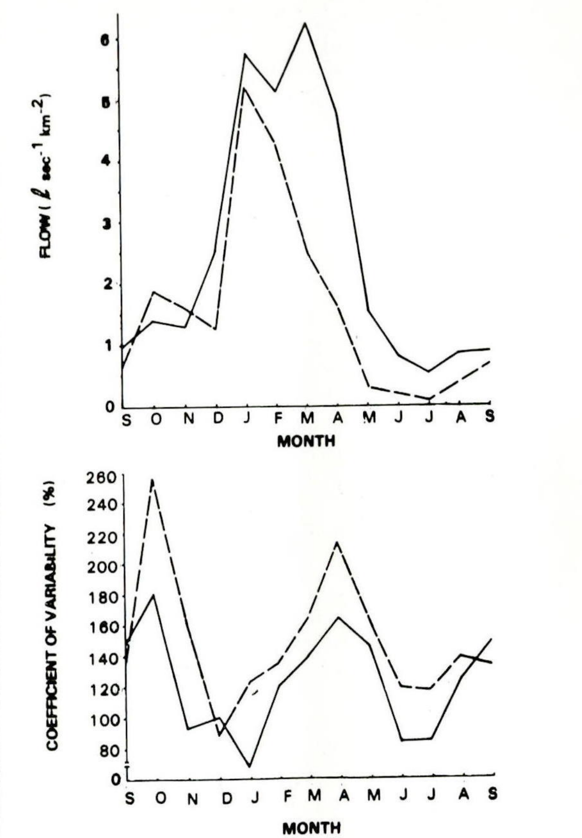
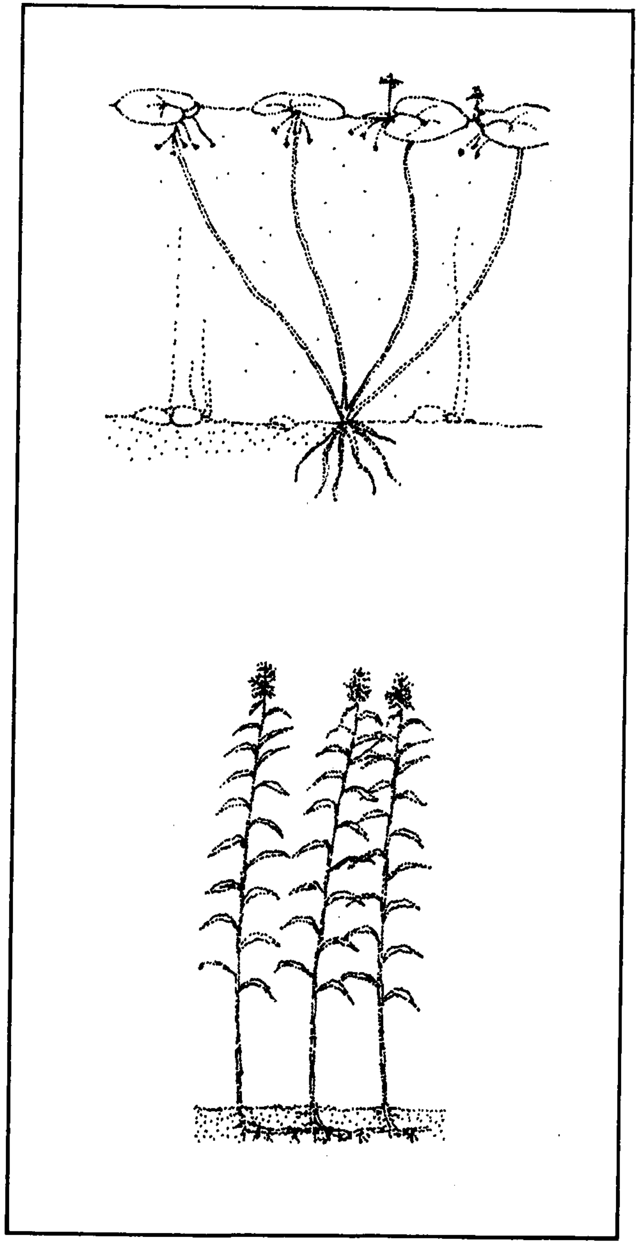


Fig. 5 Comparison of monthly streamflows and coefficient of variability between a 15 km^2 non-wetland influenced catchment (----) and an adjacent, 34 km^2 wetland-influenced catchment (——).

(after Schulze, 1979).



Similarly, the question of water losses from wetlands is open to debate. Most people assume that evapotranspiration within a wetland community is going on at potential (i.e. maximum) rate throughout the year (15, 162). Added to this is the fact that water is spread laterally over a wide area in a wetland, and so the net result is that more water is lost from a wetland than would ever be lost from an equivalent area of open water (89).

Adopting this standpoint, maize production in wetlands has even been advocated as a means of conserving groundwater, on the grounds that the evapotranspiration rate of maize is less than the plants which normally grow in wetlands (61, 62). However, this conclusion is questionable since evapotranspiration of wetland plants has never been adequately quantified and the fact that the wetland has to be drained first, before maize can be established, seems to have been overlooked.

Certain people therefore believe that the water lost by evapotranspiration from wetlands should be put to constructive use (49). As a result, dams have been built on wetland sites to enable the irrigation of crops and pastures, and interestingly, seem to have improved the stream flow in areas where farmers have adopted this practice (Turner, pers. comm.).

On the other hand, others contend that in a dry season certain wetlands use up to 40% less water than open water areas (102), because the soil and the water surface is shielded by the plants from direct exposure to dessicating agents, such as the sun and the wind (125).

The purpose of this document is not, however, to create confusion, but to clarify what areas of mutual agreement appear to exist. These are that:

- the storage capacity of a wetland depends upon the size of the basin, the level of the water table, and the depth of the permeable soil.
- the storage of surface run-off in wetlands is no less temporary than the storage potential of dams, or any other body of water for that matter. In fact, the water losses are similar, but the point is that the water stored in wetlands is simply less available for direct use.

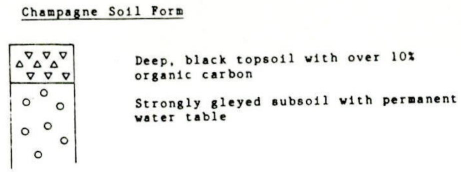
- wetlands represent areas of impeded drainage in which a dense plant cover develops by virtue of the greater moisture availability (194).
- in specialised cases, the dense vegetation creates a deep soil (such as the "Champagne" soil form), which is rich in humus. This increases its water storage capacity but does not materially reduce the water yield of a catchment.
- the hydrologic response of the catchment to precipitation depends on the extent of wetlands within the catchment. The greater the proportion of wetland, the less variable is the surface runoff (17).
- the removal of vegetation from catchments, and especially from stream banks will, in the long term, alter the pattern of discharge from streams (32, 118, 199) and increase the risk of severe erosion (4).

3.1.2 Stream Flow Regulation

From what has already been said it should be apparent that wetlands regulate the flow of streams. However, certain reservations are sometimes expressed about this for two reasons.

Firstly, there is the dualistic role of wetlands in the environment (Fig. 6), since they can be shown to both sustain and deplete water yield (197). Secondly, there is the popular misconception that wetlands release water, as if they possess some magical power to influence this process. The fact of the matter is, that in most wetlands the passage of water through the soil profile is slow, due to the high clay content of the soil, and the factors controlling its movement are normally geologically or topographically determined (128, 187). These include impervious strata, in the form of a dyke or fault that may force ground water to the surface, as well as factors such as the hydraulic gradient, or slope.

The studies of the hydrology and water resources of the Drakensberg (cited in Section 3.1.1) have shown that flow from a wetland buffered catchment was noticeably higher and less variable than a neighbouring, unbuffered catchment (Fig. 5), and that stream flow was prolonged, through attenuation of the mean annual run-off (151).



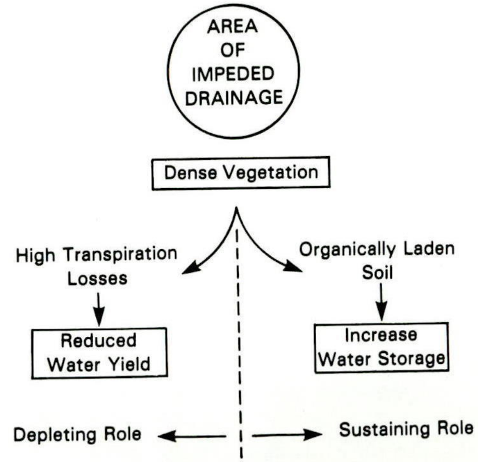
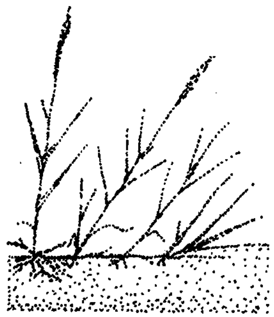


Fig. 6 The dualistic role of wetlands in the hydrologic responses of a catchment.



With evidence of this sort, there seems to be little doubt therefore, that wetlands directly influence streamflow. It also explains why many people intuitively advocate that "a policy of (wetland) preservation is a sound one, and a safe one" (61, 62).

3.1.3 Flood Attenuation

One attribute of wetlands about which there is no doubt is their capacity to modify stormflow (126, 186). This is due to the flat terrain in which wetlands normally occur, and the dense mass of plants that are commonly associated with wetland areas. Floodwaters are forced to spread laterally in topography of this nature, and are further withheld by the vegetation due to the increased drag or hydraulic impedence caused by the plant stems.

The net effect is to smooth (or attenuate) flood peaks by as much as 60—80% depending on the proportion of wetland in a particular catchment (45), and the magnitude of the flood event (Table 1).

Table 1: Effect of wetland area on flood peak reduction (in %) in north central Wisconsin (taken from Verry & Boelter, 1978).

Wetland in a watershed (percent)	Storm recurrence interval (years)			
	2	25	50	100
1	19	22	26	27
2	28	33	38	39
3	34	39	45	46
5	42	48	54	55
10	51	58	63	64
15	56	63	70	71
30	64	71	77	79

Whilst the retardation of downstream floods by a wetland depends upon its size and on the type and density of the plant cover, another important criterion is the height of the water table (16). This is because the capacity of a wetland to store additional water, is reduced when the water table is high. However, this does not imply, that its storage capacity is reduced altogether, or that the volume of storm water flowing into the system does not move out of it at a much reduced velocity. This is because of the all important *upslope* storage of water that occurs in wetlands due to the resistance to flow created by wetland vegetation (Fig. 7). This even accounts for the fact that wetlands, often being on a slope, are far more effective in flood attenuation than a dam of similar dimensions (Breen, pers. comm.).

3.1.4 Water Purification

Generally speaking, as water entering a wetland moves through the system of storages and transfers depicted in Fig. 3, its quality becomes markedly altered by a number of different processes (140). These include a complex series of interactions between rocks, soil, water and vegetation. They include weathering, mineralisation, microbial decomposition, aeration, ion exchange, nutrient uptake and several others.

Because of the complexity of these processes, wetland modifications (such as a change in land use) can generate significant changes in water quality (187). Furthermore, each wetland exhibits a different water quality response, according to the processes operative within the system, and the characteristics of the catchment above it.

One of the critical factors affecting wetland interactions of this sort is the rate at which water passes through the system. This means, that unlike water passing through the soil of a wetland (base flow) water confined between the banks of a river (channel flow)

'Water means life, and we depend on wetlands — ecosystems where the dominant factor is a regular or seasonal abundance of water — in a myriad of ways.' (205)

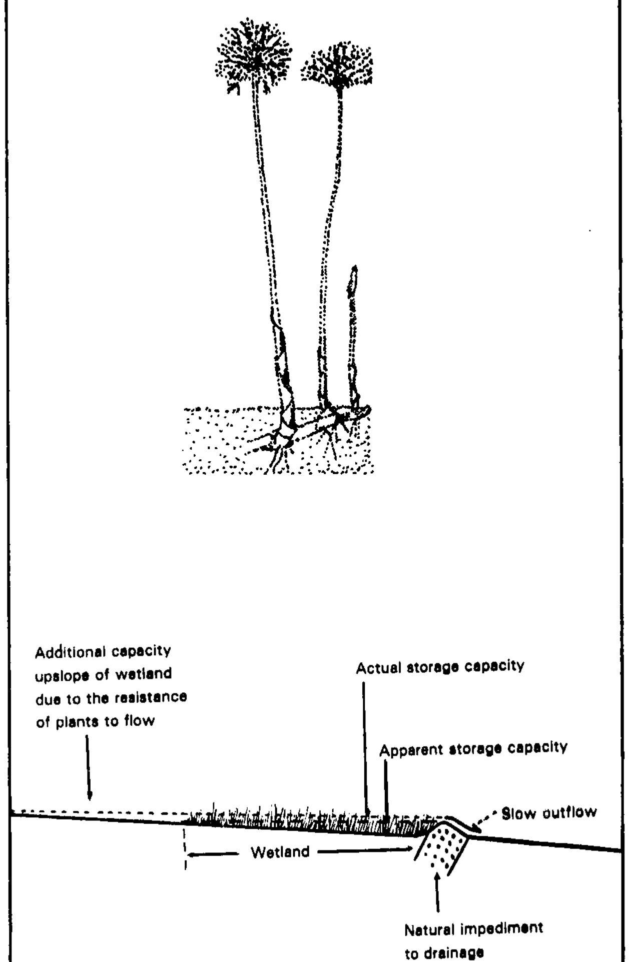
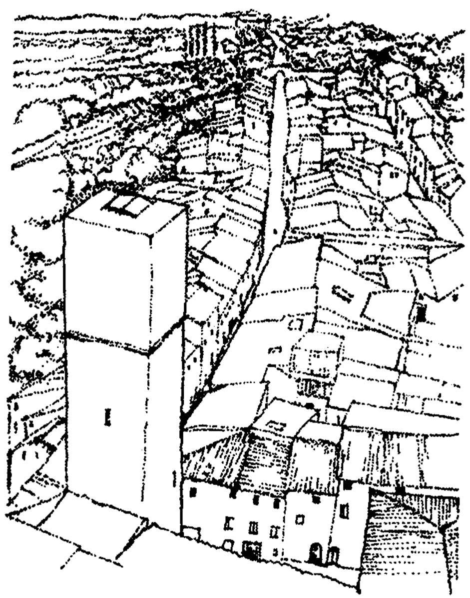


Fig. 7 An explanatory diagram of the upslope capacity of a wetland to store additional water and attenuate floods, even when the normal storage basin is apparently full.



has little opportunity of being involved in these reactions. Similarly, water that is forced to spread laterally within a wetland, or to move through it by overland flow, has a longer residence time within the system. As a result, it can leave the wetland considerably altered in comparison to its chemical nature when it entered (71). Furthermore, the water quality of an entire catchment can become significantly changed in this way, by the collective effect of wetlands, no matter how large or small.

Therefore, unlike the more uncertain effects that wetlands may have on the quantity and constancy of water flowing from a catchment, there seems to be no doubt about their potential to beneficially affect water quality. The following recommendation summarises the significance of wetlands in this role. "That natural wetlands improve water quality should be taken into consideration by all private and government agencies concerned with land use management and planning. In agricultural areas with severe, non-point source pollution problems, wetlands are important features in the landscape. (As a result) every effort should be made to preserve the few wetlands remaining in many agricultural and urban areas" (183). It goes without saying that rural settlements, whose populations draw water direclty from streams, would also profit enormously from this policy.

When this advice is viewed against the fact that in virtually every river of Natal, a stark deterioration in water quality is evident as each flows from its source towards the sea, one cannot help but speculate about how much better the situation could have been had wetlands throughout the Province not been altered or eliminated. In other words, the insidious loss of wetlands in Natal (Chap. 4), is contributory to the observation that "in the 15 mile wide coastal strip, waters of all classes from 3 (water of poor quality) to 4 (foul water that is a public nuisance or is a public danger) occur, mainly because of pollution from sugar mills, canelands, townships, factories, and municipal and industrial areas" (36).

It can be argued that certain of these sources of pollution have been eliminated or reduced in the interim, by revising the standards laid down in the Water Act (28), by stricter vigilance, and by improved effluent treatment (147). However, there is also evidence to show that conditions have worsened, and particularly with reference to the problem of non-point source pollution (12). Without wishing to debate the issue however, the suggestion is that the pollution of Natal's rivers could probably have been significantly reduced if a more effective policy of wetland protection had been adopted years ago.

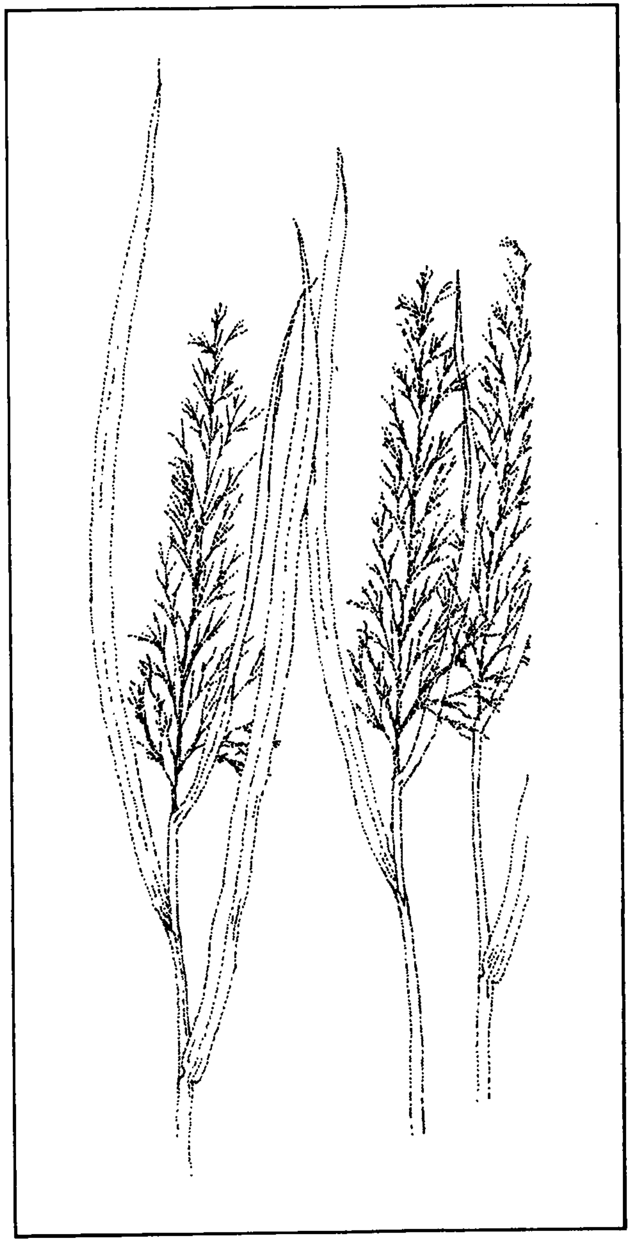
3.1.4.1 Nutrient Assimilation

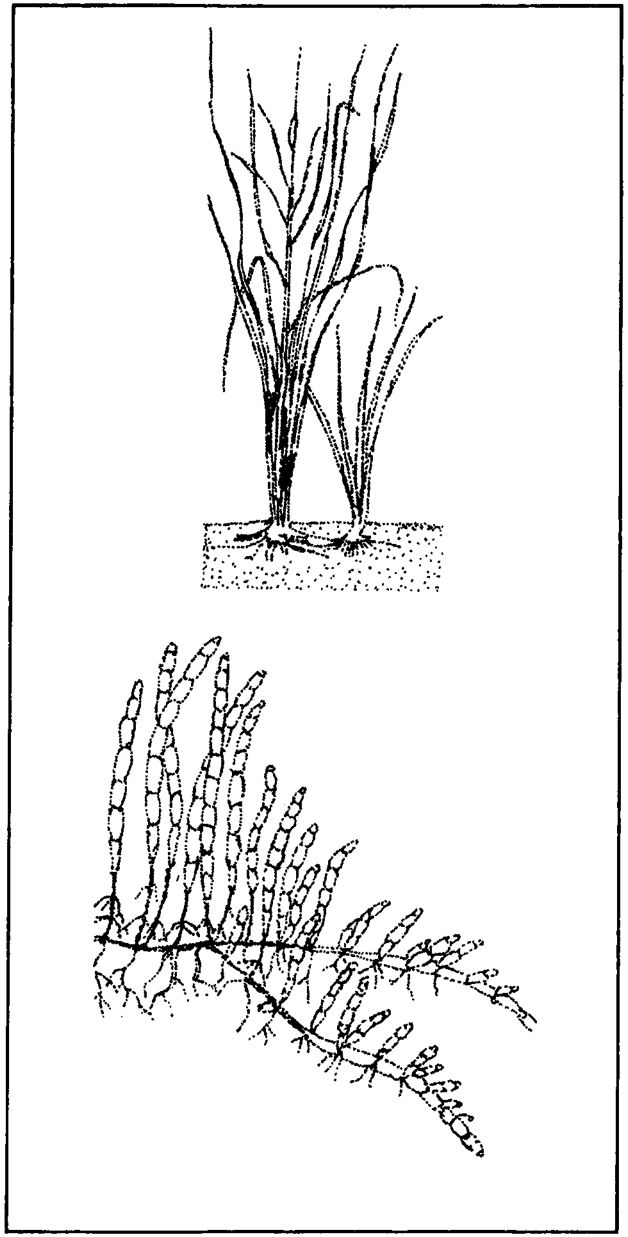
There is a vast literature on the well known phenomenon of eutrophication (120), which warns of the adverse effects that materialise in rivers and impoundments when surface run-off contains high concentrations of dissolved nutrients, such as nitrogen and phosphorus. There is also a good knowledge on the fate of nutrients in anoxic sediments (136), which has revealed that all wetlands behave as nitrogen and phosphorus "traps" (160, 183). As a consequence, the consensus amongst scientists to-day, is that the quality of water passing through a wetland is improved by nutrient removal (87).

There are several ways in which nitrogen is removed from water passing through a wetland (180). Each involves a different chemical transformation, but the most significant is a process called denitrification (98, 99), which involves the reduction of nitrate to gaseous nitrogen by bacteria living under anaerobic conditions. This means nitrogen passing through a wetland system is transformed, with remarkable efficiency, by bacteria, transferred to the atmosphere, and lost from the wetland.

For example, although markedly influenced by the prevailing hydrologic regime and season, removal efficiencies of 90% of the nitrogen in polluted water passing through a wetland have been reported (18, 34).

Apart from nitrogen, phosphorus also features as one of the chief problems in the eutrophication of surface waters. Its removal in wetlands is dependent on two processes involving the physico-chemical binding (sorption) of phosphorus on





inorganic and organic matter, and the direct uptake of phosphorus by vascular plants, and other living organisms (assimilation).

It is widely recognised that submerged soils, high in organic matter, are phosphorus "sinks", but the efficiency of the transformations is much influenced by pH and the presence or absence of oxygen. Thus, depending on circumstances at the time, wetland outflows can be phosphorus enriched (by the release of phosphorus from the soil), or phosphorus depleted (if conditions conducive to phosphorus sorption prevail). It also depends to a very large extent on whether the storage compartments in the wetland (macrophyte tissue, microbial tissue, detritus, sediments and interstitial water) are saturated at the time. If this is the case, phosphorus retention will not occur at all.

Many authors also refer to hydrophytic plants as "nutrient pumps" (89). This means that they take in nutrients such as nitrogen and phosphorus from the soil and transfer them to the shoots. Here, they are immobilised (at least temporarily) until the plants die and decomposition occurs. Thereafter they are released back into the water.

Various studies have been made in wetland ecosystems of the changes in concentrations of other dissolved compounds in water, such as sodium, chloride, calcium, magnesium and potassium (136), but unlike the question of nitrogen assimilation, their fate seem to be less well understood. There is also evidence that wetlands remove heavy metals from polluted waters (159) since removal efficiencies ranging between 15% — 32% have been quoted (204). It is important to realise that wetlands store certain of the components they remove, because the disturbance of wetlands leads to a release of these back into the system. •

On the other hand, water-borne pathogens are not stored, but destroyed by wetlands. For example, removal efficiences of 86% for coliform bacteria were achieved by the passage of water through a marsh area above Lake Michigan in the U.S.A. (65).

In conclusion, there is a lot of evidence to suggest that the establishment of wetlands as buffer zones would significantly reduce eutrophication and the pollution of rivers, lakes, dams and coastal lagoons (111, 112). Certain authors even believe that the "pollution sink" property of wetlands is their most important, yet least studied function (33). It would seem foolhardy therefore, in a country where water is such a scarce resource, for planners to overlook this potential contribution to the management of surface water quality in South Africa.

The fact this study is underway suggests, however, that in Natal at least, a strategy of capitalizing on the opportunities that wetlands offer to society as water purifying agencies, has at long last, a chance of being seriously considered.

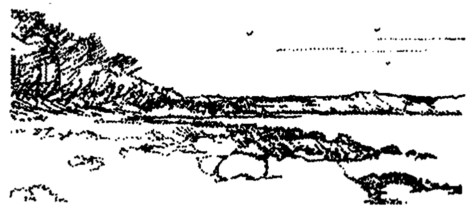
3.1.4.2 Sediment Accretion

The high concentration of suspended sediments in the waters of virtually all of Natal's rivers, means that the downslope movement of soil particles (arising from sheet wash, rill, bank and gully erosion) is a major issue in water quality matters. For the purpose of this report however, a description of the various factors involved (such as the energy associated with the impact of raindrops, the relative erodibility of soils, and the flow velocity of water) seem less relevant than the need to appreciate that wetlands play a crucial role as intercepting agents in the catchment of areas prone to soil loss.

As in the case of flood attenuation (Table 1, Section 3.1.3), the flat terrain and dense mass of plants associated with wetlands bestows an ability upon these areas to settle particulate matter. This is brought about by the reduced velocity of the water in which these materials are being carried.

The role of wetlands in the removal of suspended sediment is another subject in which locally derived quantitative data are lacking. However, in New Zealand, one such study concluded that all of the bedload, and 50% of the suspended load was being deposited in the wetlands of a particular catchment (150).

Although the proportion of sediment trapped by a wetland is a function of its relative size, when one considers that the greatest threat to the continued functioning of



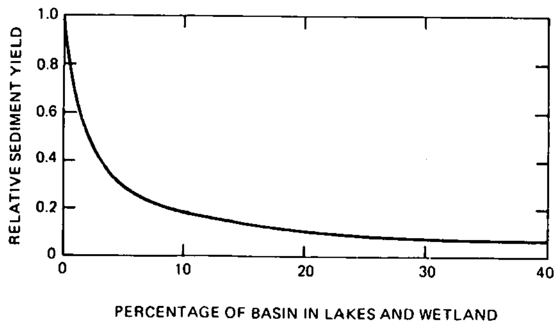
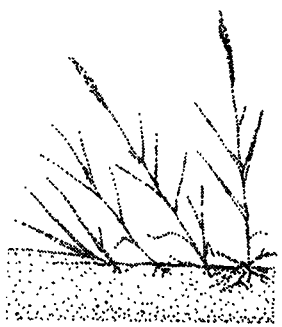


Fig. 8 The relationship between sediment yield and the proportion of lakes and wetlands in a catchment. *(after Novitski; 1978)*



Natal's estuaries and lagoons is silt, (26) the benefit of protecting one resource in the catchment, for the benefit of another on the coast becomes obvious. It has also been postulated that there is a logarithmic relationship between the sediment yield of a catchment, and the percentage of the catchment occupied by wetlands (124). These data suggest that once the extent of wetlands drops below 10% of the overall catchment size, there is a significant increase in sediment yield from the basin (Fig. 8). If this is true, it would seem vital to quantify the amount of wetland in each catchment of Natal (Chap. 4), to prevent wetland losses falling below a critical point.

One potential difficulty in the adoption of such a policy, is the fact that wetlands are subject to change as a result of their efficiency in sediment interception. This is a factor that should not be under-estimated, as the alarming rate at which the storage capacity of estuaries, lagoons, dams and lakes is being reduced by siltation is well known (23, 25). the Gilbert Eyles dam on the Umzimkulwana, for example, lost 41% of its capacity in six years, and 25% of its capacity was lost in one storm in May 1959 (119). With these sort of silt yields in Natal is is quite possible that wetlands could become similarly overburdened with sediment.

In other words, the accretion of sediment and nutrient in wetlands can gradually alter its environmental role (68). there is also considerable spatial and temporal variation in the rate of change according to differences in rainfall, vegetation and terrain. Furthermore, sight should not be lost of the fact that even when a wetland appears to be 'filled' with sediment it may still store considerable volumes of water and so continue to perform important functions in the catchment. The feasibility of wetland rehabilitation appears to be a management option that warrants reappraisal therefore, despite the Blaaukrantz catchment experience (mentioned in Sect. 3.1.1) where the non-recoverability of wetlands was postulated.

The settlement of suspended matter in wetlands has three other important consequences. The first of these is that downstream, the turbidity of any receiving waterbody would be reduced. This in turn, would improve light penetration, promote the establishment of aquatic plants, and ultimately increase the productivity of these ecosystems. Secondly, the muddiness of Natal's rivers has an economic implication. This is because costly filtration or flocculation processes are generally necessary to free the water of silt before it can be used. whether for industrial or domestic purposes. It would seem logical therefore, that a critical area in which to conserve wetlands is the upper part of river catchments, if one is to capitalize on such opportunities.

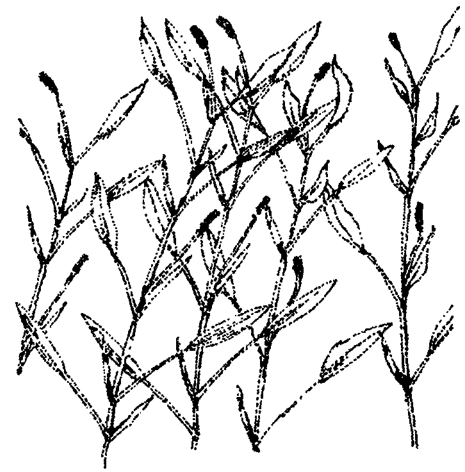
Thirdly, the sediment trap efficiency of wetlands also means that pesticides which are generally absorbed on particulate matter become "buried" in the wetland. While this can have undesirable effects, certain people nevertheless maintain that these contaminants are contained in an area where they can do the least amount of environmental damage (127, 133). In the Transvaal for example, there are wetlands which contain so many harmful chemicals that have washed off mine dumps and from urban areas, that, if these wetlands were to be disturbed, massive releases of toxic materials could result (Fourie, pers. comm.). This suggests that there is an inherent danger in capitalising on the 'pollution sink' property of wetlands without an effective management policy which ensures that materials such as peat for example, are not removed from wetlands which store components of this nature.

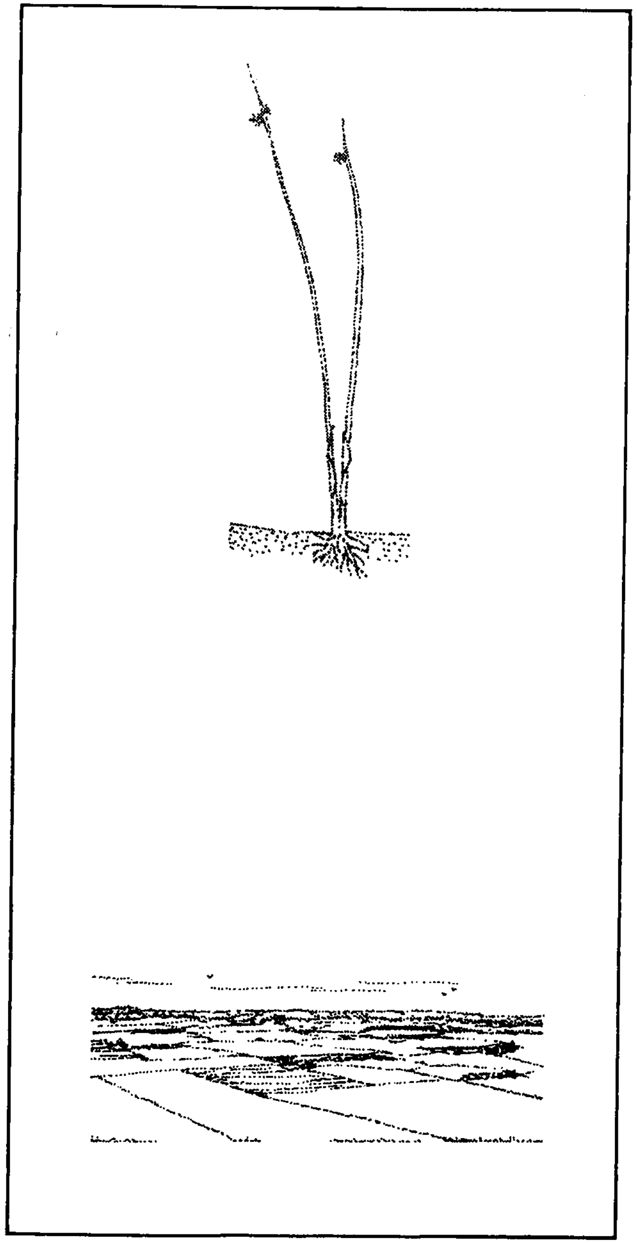
In conclusion, providing that man-made alterations are brought under control, wetland ecosystems act as high capacity sediment sinks, and this function can be used to man's advantage in a variety of different ways. It should also be recalled, that their efficiency as sediment sinks, is the key to artificially creating wetlands, as this is an option that should be given serious consideration in the future (163).

3.2 Economic Role

"Society as a whole has many needs and desires and the destruction of some wetlands can be in the public interest, whenever the value of benefits from the altered use are greater than from the preserved wetland" (66).

This comment reveals another side to the multi-faceted subject of wetlands, and calls for an attempt to evaluate the variety of economic benefits that can be derived from wetlands. Certainly, no one should be so naive as not to recognise that the rational utilization of wetlands may require that certain wetlands have to be traded for other





uses, ostensibly of greater value to society. The issues involved however, are controversial, because one of the first difficulties stems from the need to differentiate between regional benefits, and benefits which may accrue to individual persons or groups of persons with special interests.

3.2.1 Crop Production

The economic importance of crops produced on wet soils is substantial. As yet, there is no accurate way of establishing the proportion of cropland in Natal on wet soils, but data on the agricultural production from vlei soil under "ridge and furrow" development (Table 2) enables an impression of this potential to be gained.

Table 2: Farm Income (in rands/annum) based on 1984 figures from 1050 ha of wet soils under "ridge and furrow" development (A. Wilby), pers. comm.).

	PASTURES			MAIZE		
		Farm Income			Farm Income	
Rating*	Ha	Gross	Net	Ha	Gross	Net
90% efficient	650	1 031 550	266 500	150	114 750	61 500
75% efficient	100	132 300	42 600	50	31 900	17 050
50% efficient	80	70 480	22 720	20	8 500	4 540
	830	1 234 330	331 820	220	155 150	83 090

*as measured against potential production.

Taking into account variation in the extent to which potential production is realised by wetland development, the net farm income from 1050 ha of wetland soil under maize and pasture production amounts to R414 910. Clearly, the costs of production are high, when the difference between the gross income and net income are analysed. Furthermore, the capital costs of production have not been taken into account, and so, in reality, the actual returns are even less than that indicated. If maize production is examined on its own (Table 3) each hectare of wetland being utilized for maize actually represents a net farm income of between R227—455 per year, excluding capital costs.

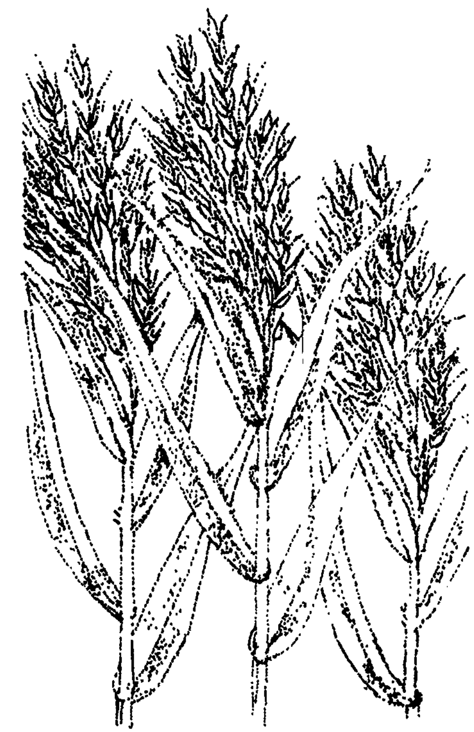


Table 3: Value of maize production (in rand/ha/annum) on wet soils in 1984.

	Yield rating (in %) for 'ridge & furrow' development as measured against potential production			
	100%	90%	65%	50%
Gross Income	850	765	638	425
Less costs (fertilizer, machinery, labour etc)	395	355	297	198
Net Farm Income	455	410	341	227

All figures assuming yield of 4 tons/ha, were supplied to A. Wilby (pers. comm.) by Regional Economist, Department of Agriculture and Water Supply.

The costs of developing wetland soils are not subsidised by the Government, and so there are no hidden costs of this form in these data. However, although the Government attempts to guard against soil erosion and adverse downstream consequences, by controlling the way wetlands are developed, the combined effects of indiscriminant wetland development are considerable, difficult to foresee, and even

more difficult to counteract. The costs of trying to counter effects such as flood damage for example, or from having to treat the water to improve its quality have never been estimated.

Although the Department of Agriculture and Water Supply now recognises the need to improve surveillance over all wetland development, and have recently adopted new regional procedures for considering applications to develop wetlands, the lack of thorough understanding of wetlands still appears to be the fundamental reason why inappropriate decisions are being made. This is no fault of the inspecting officer, but rather a reflection of the complexity of the interactions involved, and the inherent differences between one wetland and the next.

Another problem in this form of analysis lies in the meaningfulness of attributing rand values to the agricultural potential of undeveloped wetlands. For example, it would not be surprising to find that the high value of land these days has, on the one hand, forced farmers to exploit wetlands because of their need to meet mortgage repayments. However, on the other hand wetland development may not actually be economic if, for the dubious benefit of R300/ha/year, important regional losses are being incurred. What these losses amount to in monetary terms has never been quantified, and so, there is no way at present whereby the final "balance sheet" can really be analysed. This is an obvious research need however, re-iterated in Chapter 8 of this report.

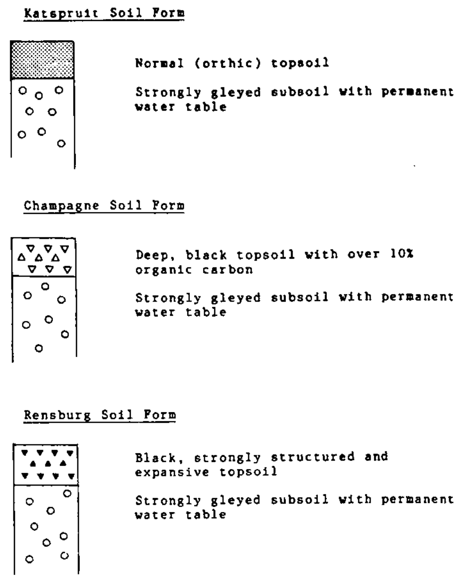
In the sugarcane growing areas of Natal, a significant proportion of the production stems from crops grown on wet soils. The extent to which these soils have been exploited by cane farmers can be partially established from "Beater's soil maps" (19, 20, 21), which show that in Zululand for example, alluvial soils are the most important soil group, comprising 19,2% of the cane growing area. 70% of these had been planted to cane by 1962, and from these the yield of sugar was almost twice as high as that from most other soil types.

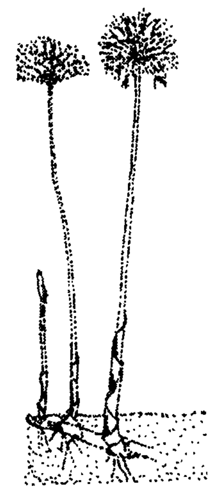
Generally speaking, the fertility of wetland soils is attributable to their high organic matter content, relatively high cation exchange capacity, phosphate and potash levels

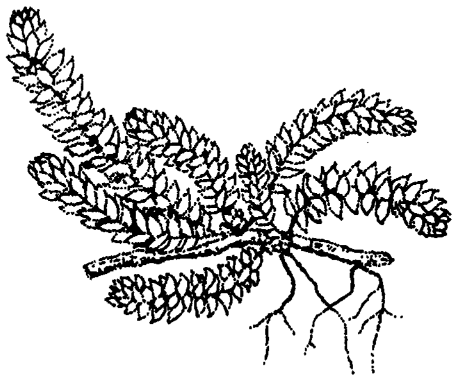
(141). However, unless they can be drained, the value of these soil properties is diminished by excessive moisture. This wetness lowers productivity and limits the sort of crops that can be grown in wetlands. Naturally, some crops are more tolerant of water-logging than others, and different crops can be grown in wetlands in different seasons, but in most commercial farming areas, the cultivation of wetlands has become a norm, and has been practiced traditionally for generations. The so-called advantages of these practices however, are often only temporary, because drainage and cultivation results in the gradual breakdown of the organic fraction in the soil. With the passage of time, yields decline, grazing pressures intensify, gully erosion can develop and the water table can drop. All of these influences can be very significant in the local and regional contexts.

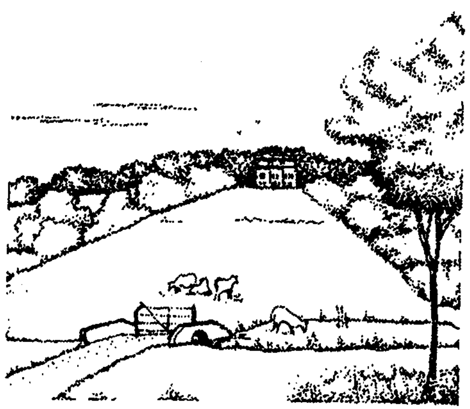
Although some complain of frost damage (155), for the agriculturalist, the crux of the whole problem in wetland development is control of the water table, and the maintenance of satisfactory soil moisture conditions throughout both the wet and dry season (131, 138, 154). However, the works required to accomplish this have to be carefully executed. Furthermore, the vagaries of climate and catchment management upstream complicate the task, but a fundamental risk is that of drying the system out. Over-drainage, as well as the gradual intensification of agriculture around the edges of the wetland, or in the catchment area above it can result in desiccation of the system. Furthermore, the techniques that can be applied to control the water table differ from one wetland to the next, because of differences in hydrology, slope and soil structure. Thus, without the right advice, a lot of mistakes have been (and can be) made (85).

Within agricultural circles, "land improvement" is the preferred terminology for wetland development (154), because wetland development is a technique which certain farmers have learnt to apply successfully without any apparent damage to agricultural resources. This is because they recognise that wetland soils are too valuable to loose through haphazard drainage, exposure, erosion and desiccation, and because they avail themselves of the expertise offered by various consultants, and the Department of Agriculture. On the other hand, the attitude of certain other farmers seems to be to act independently, and herein lies a great danger. They









experiment with wetland drainage, to the permanent detriment of the system, and seem to ignore the consequences providing they have derived some short-term benefit.

A large number of factors have to be taken into consideration when planning the development of a wetland (154). These include a knowledge of soils, slopes, rainfall, catchment characteristics, crop responses and drainage systems. To date, the classification of soil, into capability classes, has served as a logical, and effective way of determining the uses, and management practices permissible in bottomland areas. These include areas where, for example, Katspruit, Rensburg and Killarney soils occur, each of which have a different susceptibility to erosion, and respond differently to agricultural development.

A recent review of approximately 950 ha of farmland in Natal under "ridge and furrow" layouts revealed an encouraging 73% efficiency rate, and no visible signs of any adverse consequences to agricultural resources (201).

Regrettably, this does not mean to say however, that without realising it, a variety of other consequences in the form of reduced flood attenuation, reduced water quality, increased sediment yields or the aridification of the surrounding land, could have arisen.

3. 2. 2 Pasture Production

Nearly fifty years ago Roberts (141) noted "It may well be found that the most economic use to which most vleis can be put will be for the establishment of improved pastures .... ", since they ".......... are capable of being rendered, by judicious treatment, of infinitely greater value than in their natural state". Such a statement is now regarded as being highly contentious.

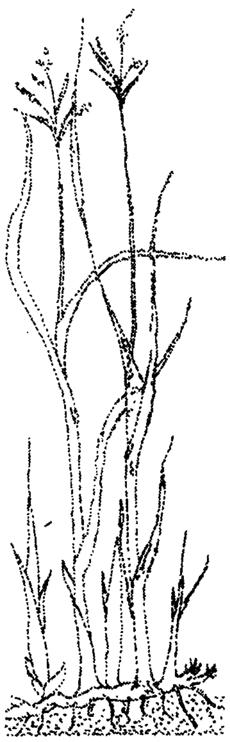
The importance of wetlands as pastures has been thoroughly examined in Natal (175). Conservative estimates are that the quantity of hay produced in wetlands ranges between 10—15 tons of dry matter per hectare per annum. This yield can be substantially increased if modern management practices are applied, including the application of fertilisers, irrigation, and the planting of wetlands with grasses (such as kikuyu), winter cereals (such as rye grass), legumes (such as clover and lucerne), or silage crops (such as maize). Data do exist which suggest that up to 25 metric tons of dry hay can be produced from each hectare under intensive management programmes of this sort (117). After being fed to livestock, the value of each hectare of wetland under pasture production, in monetary terms, is between R284 — R568 per annum (Table 4).

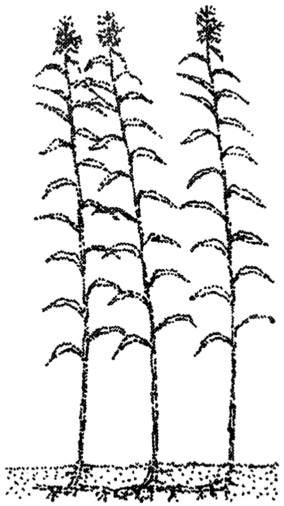
Table 4: Value of pasture production (in rand/ha/annum) on wet soils in 1984.

	Yield rating (in %) for "ridge & furrow" development as measured against potential production.			
	100%	90%	75%	50%
Gross Income	1 763	1 587	1 323	881
Less Costs (fertilizer, irrigation, machinery, labour)	1 195	1 076	879	597
Net farm income	568	511	426	284

All figures based on farm milk and stock sales, were supplied to A. Wilby (pers. comm.) by Regional Economist, Department of Agriculture and Water Supply.

There seems to be a degree of uncertainty about the effects of uncontrolled grazing in wetland areas. This stems from problems which materialise through the trampling of cattle over the wetland, and the effect this has on the compaction of wet soil (73). On occasions wetlands can be trampled into quagmires if organic sediments are deep, or to barren channels where substrates are relatively solid. The problem can be





overcome by excluding cattle altogether, or preventing grazing during wet periods. Others maintain that short grazing periods result in the greatest production (175). Another option is the mowing of wetlands, particularly as more palatable grasses become established, through the supression of the naturally occuring sedge species (80). However, under wet conditions one tractor pass has been known to reduce the infiltration rate in the area of the track by 80% (126) and so, it can be argued that compaction problems arise in the use of farm machinery as well. Whether compaction results through the trampling of cattle or the use of tractors must however, be seen in the light that the sub-soil in wetlands is practically impervious anyway. Of far greater concern is the erosion that can arise through the activities of cattle in wetland sites (193). This is because once gullies begin to form the water table will fall, and what has formerly a wet area, becomes permanently dry (3).

In conclusion, of the various uses to which wetlands are subjected by farmers, pasture production and the mowing of wetlands seem to be the least disruptive. This is because less reduction in the organic matter content of the soil results, and the perennial ground cover which remains is compatible with other wetland functions. The burning of wetlands on the other hand, to extend their grazing potential, has precisely the opposite effect (84, 184) (Chapter 5). From the farmer's point of view one of the draw backs in the utilisation of wetlands as natural pastures stems from the occurence of poisonous weeds in these habitats, such as *Matricaria nigellifolia* (158) and *Moraea* (154), although parasite infestations and foot rot can also cause heavy stock losses. From a regional planner's point of view however, the situation is far more complex (104).

3. 2. 3 Timber Production

It has been asserted that "if the use of vleis (i.e. wetlands) for pastures or crop production is condoned then there is no logical reason why vleis may not be used for afforestation ...." (117).

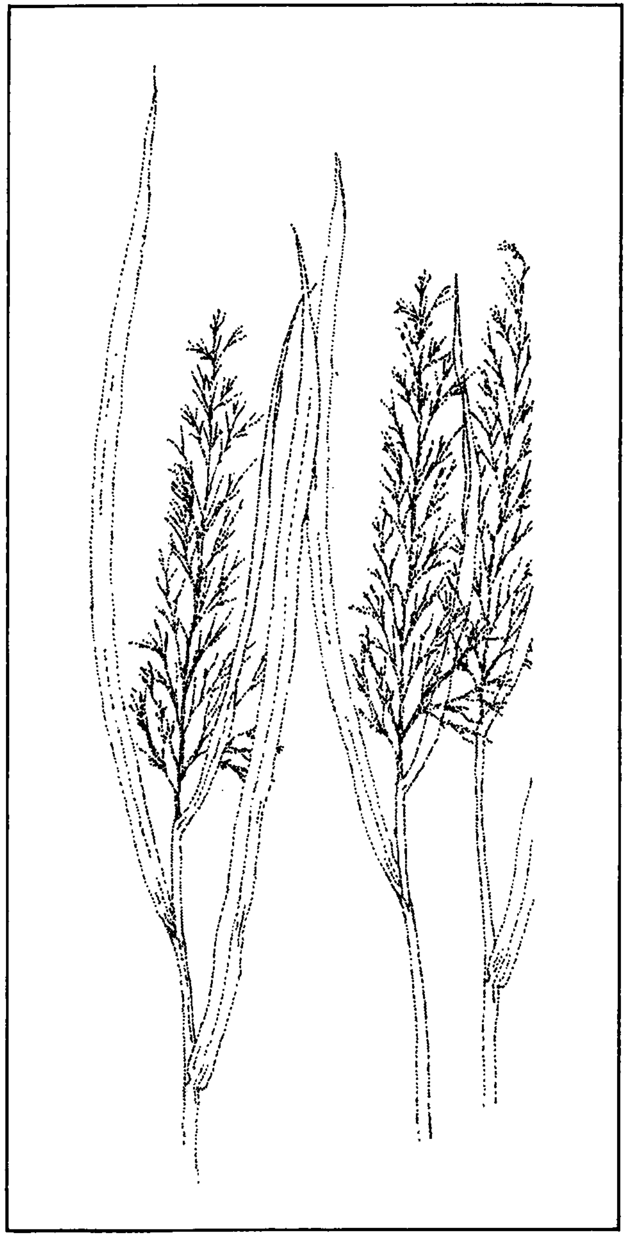
Afforestation is probably the most controversial use of wetlands because they tend to dry up if trees are planted in them. Although well aware of this, the view (quoted above) was based on the belief that agricultural activities make heavier demands on water than forestry, since the volume of dry matter produced per unit area is related to water consumption.

Data on the sort of yields derived from the planting of pine (for sawlogs and pulpwood), gum (for mining timber and pulp), and poplar trees (for matchwood), as well as the profitability of these enterprises, are given in Table 5.

Table 5: Approximate yield and profitability of timber plantations in Natal.

	Yield (tons/ha/ annum)*		Profit (rand/ ha/annum)**
	Range	Average	
Pines			
Pinus patula	11-16	14	140
P. elliottii	14-19	17	–
Gums			
Eucalyptus grandis	8-15	10	55-105
Poplars			
Populus deltoides	5-18	16	350

* data supplied by Dr A.P.G. Schonau, Head of Silviculture Section, Commercial Forestry Research Institute.
** data supplied by Mr G. Rusk, Economist — Forestry Council.



The revenue generated through the planting of trees (Table 5), is one of the numerous benefits associated with the afforestation of catchments, but a major problem is the effect that trees have on water supplies (32,200). This is partially due to the fact that evapotranspiration in South Africa occurs at a rate generally in excess of precipitation (152), and the fact that certain of the tree species used are evergreen. The net consequence for water resource management is that the water yield from rivers and streams becomes reduced (53).

In areas such as wetlands, where water is readily available, it is assumed that evapotranspiration goes on at the maximum rate allowed by atmospheric conditions (193). This means that the water demand placed on the wetland by densely-planted, mature trees, causes a draw down of water (by increased vapour losses), and a drying up of free-standing, surface water. For example, gum and poplar trees are often planted in wetlands deliberately to achieve this result.

In conclusion therefore, although afforestation is thought of as a means of using "non-remunerative" land (134), generally speaking, no account seems to be taken of the other values and functions of wetlands. Indeed, the choice of the word 'non-remunerative' is unfortunate since it implies that wetlands do not perform useful functions unless modified. However, if for no other reason that it advocates the loss of a valuable resource (water) to the atmosphere, when the water needs of entire catchments are taken into consideration, the consensus is that the deliberate drying out of wet areas by the planting of trees is not in the best interest of the region as a whole.

It would seem that the Committee of Investigation into Afforestation and Water Supplies arrived at the same conclusion in 1968, because amongst the recommendations made was that phreatic areas (i.e. lands with a high water table) should not be afforested (106). They also recommended that, because of their effect on water yield, a procedure of delimiting these areas within the catchment should be devised, so as to maintain them as "non-remunerative" cover. For the same reason, limits to the encroachment of pine plantations upon the wetlands on the Eastern shores of Lake St. Lucia, for example, need to be set.

Why the recommendations of the Committee of Investigation into Afforestation and Water Supplies have not been acted upon is difficult to understand. However, the idea of compiling an inventory of wetlands in Natal, (Chapter 8) is seen to be a constructive step in this particular direction.

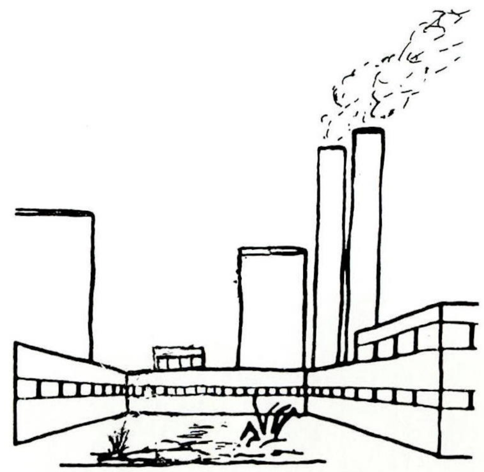
3. 2. 4 Raw Materials

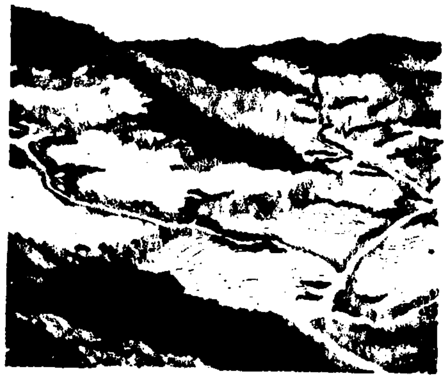
Wetlands are of relatively little value as sources of non-renewable materials for industry. However, in certain cases they have been exploited in Natal for the extraction of sand, gravel, peat, kaolin and coal.

Because building sand and gravel is a scarce resource in the vicinity of many built-up areas, alluvial areas alongside rivers such as the Mgeni (which is close to Durban), the Mhlatuze (which is close to Richards Bay), the Mkomazi, Mtwalume, Mpenjati (and others) have been used over many years for the extraction of sand. Through this activity riparian wetlands have been degraded to a greater extent than any other form of wetland.

Depending on the methods employed for extraction, and the areas selected for stock-piling, the environmental consequences of these activities are site specific and, in some cases, severe. Due to increasingly stringent controls, however, these effects are becoming more localised and less pronounced. Amongst the controls mentioned for example, is the rehabilitation of the site as mining is completed.

Another potential consumptive use of wetlands in Natal is the extraction of coal. This is being practised in the vicinity of Newcastle using open cast mining methods, but on such a limited scale that, like the extraction of kaolin near Nottingham Road, it is not regarded as an activity inflicitng significant damage to the region's wetland resources as a whole.





3. 2. 5 Waste Assimilation

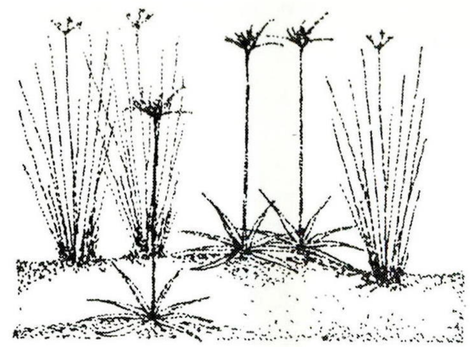
Because of the proven efficiency of wetlands in the removal of numerous water-transported, chemical substances (see Sect. 3.1.4) considerable interest has being shown in exploring the prospect of using wetlands as waste removal systems, for the cleansing of water draining from agricultural, municipal or industrial areas (96, 144, 160).

This interest stems from the obvious economic advantages that are to be gained from purging water of pollutants (such as nitrogen, phosphorus, pathogens and heavy metals) during its passage through wetlands. The most attractive aspects are the low capital, technological and land use costs. Wetlands are being used to treat sewage in several countries of Europe, largely because of the efficiency of wetlands in the removal of nitrogen (ultimately stored in the air) and in the destruction of pathogenic bacteria, although various other pollutants are stored within the wetland itself.

Despite this evidence to suggest that wetlands can be used to man's advantage to perform these functions (203), many attendant problems still remain. This is due to the variety of factors such as climate, retention time, soil type, plant type and pollution history, that affect the efficiency of wetland sites as treatment systems. Testimony to this is the fact that no one is prepared to advocate that wetlands be deliberately used for this purpose (89, 115, 182). The consensus seems to be that "waste water should not be applied to natural fresh water wetlands .... until more is known about the long term effects, (because) present information suggests that the risk of damage may not be worth the gain" (170).

Wetlands are naturally occuring pollution control mechanisms which function continually in each catchment of Natal. As diffuse sources of pollution will become increasingly difficult to control in the future, their usefulness in this respect will become increasingly important. To the minds of many people this is the role that wetland sites should continue to play, and so the deliberate use of wetlands for waste water treatment is not recommended.

The deliberate dumping of industrial wastes such as gypsum into the *Papyrus* swamps of the Mhlatuze and the dumping of municipal waste into the reedbeds alongside many of Natal's estuaries and lagoons (23), are therefore seen as short-sighted and ill-considered decisions. These have been purposely highlighted in Chapter 5 of this report to prevent their repetition, and to emphasize that should there have been a wetland policy statement at the time, these situations may never have arisen.

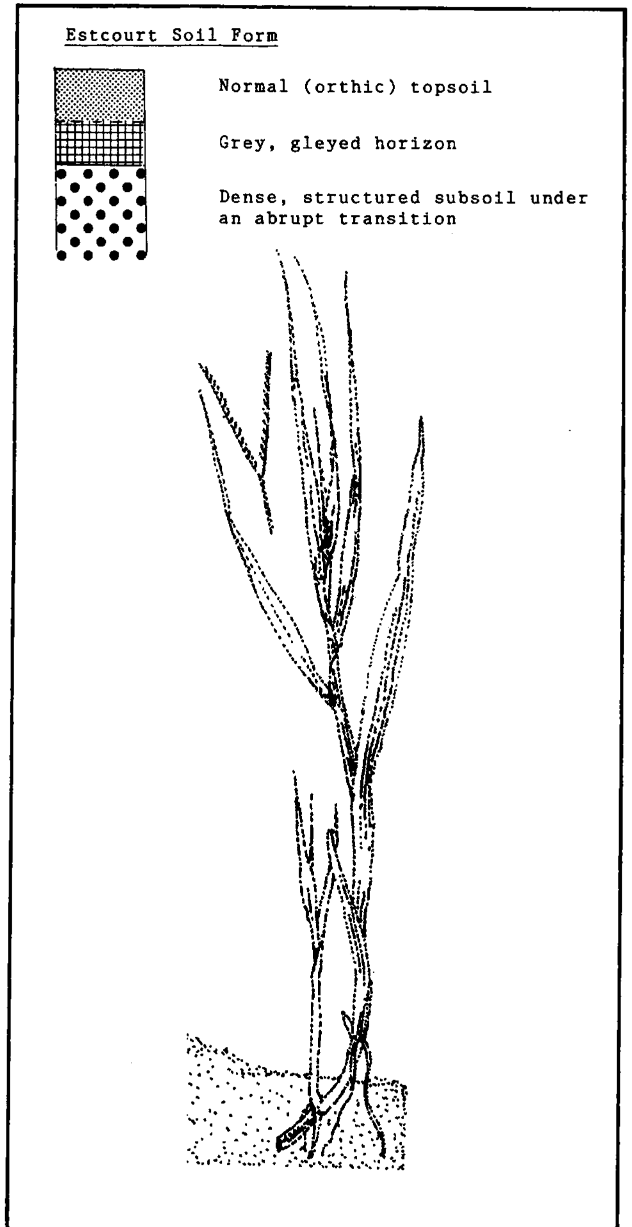


3. 2. 6 Erosion Control

Although a number of excellent studies have been made on the status of soil erosion in Natal (156, 181,), and of the amount of soil being lost each year (56, 145, 146), no one has made a determined attempt to assess the economic consequences of erosion. This is probably because of the enormous effort required to assemble all the information, because there are other more urgent priorities, and because certain intangibles such as the value of soil and water to rural populations complicate the task. The sum of money involved, however, is likely to be staggering to say the least. The control or erosion is also a costly and maintenance intensive process. For example, contour terraces (86, 81, 9), properly designed water ways, improved agricultural and tillage practices, and structures such as gabions (35) and polejacks (79), are all capital intensive remedies.

When examining the economic values of wetlands therefore, the fact that wetland vegetation serves to modify or slow down erosional processes (6), means that the protection of wetlands makes good economic sense.

The role that vegetation plays in erosion control "is not so much the physical protection of the soil on which it grows, but the resistance it offers to flowing water, thereby causing a decrease in velocity and deposition of sediment.........." (4). The proven sediment trap efficiency of wetlands has already been emphasized (see section 3.1.4.2), and logically, is a function that man should use to his advantage in learning how to control the geomorphological consequences of his own activities.



Although periodic, catastrophic floods will uproot and undermine even the best established riparian vegetation (witness what happened to the riverine forests alongside the Mfolozi after cyclone "Domoina"), plant cover is still the most valuable aid man has available to him to prevent soil erosion. The common reed *Phragmites australis* for example, displays a remarkable ability to bind alluvial soils (78), whilst the root reinforcement of river banks by various species of trees (e.g. *Ficus, Voacanga, Bridelia* and *Syzygium* spp.) is generally recognised as the most economically feasible measure known, to guarantee bank stability in the long term (70).

One of the most severe threats to the functioning of wetlands in the upper parts of many Natal catchments is gully erosion along their axes. (5, 194). Their vulnerability lies in the erodible nature of the subsoil which rapidly erodes once human and animal pressures have resulted in the removal of the topsoil in these areas. One of the least stable forms of wetland in Natal are those in which the Estcourt soil form appears (155, 156).

For this reason, in certain parts of the Tugela Basin for example, 90% of the bottomlands characterized by these sorts of soils are severely gully eroded (181). The destruction of these wetlands has resulted from various natural (188) and man-induced factors which include unacceptably high population pressures in the area, high stock densities, poor stock management and sparsely distributed watering points. As already mentioned, once the vegetation cover deteriorates, gully erosion commences, the water table drops, and every wetland function formerly attributed to these sites is ultimately lost in the process.

3. 2. 7 Pest Control

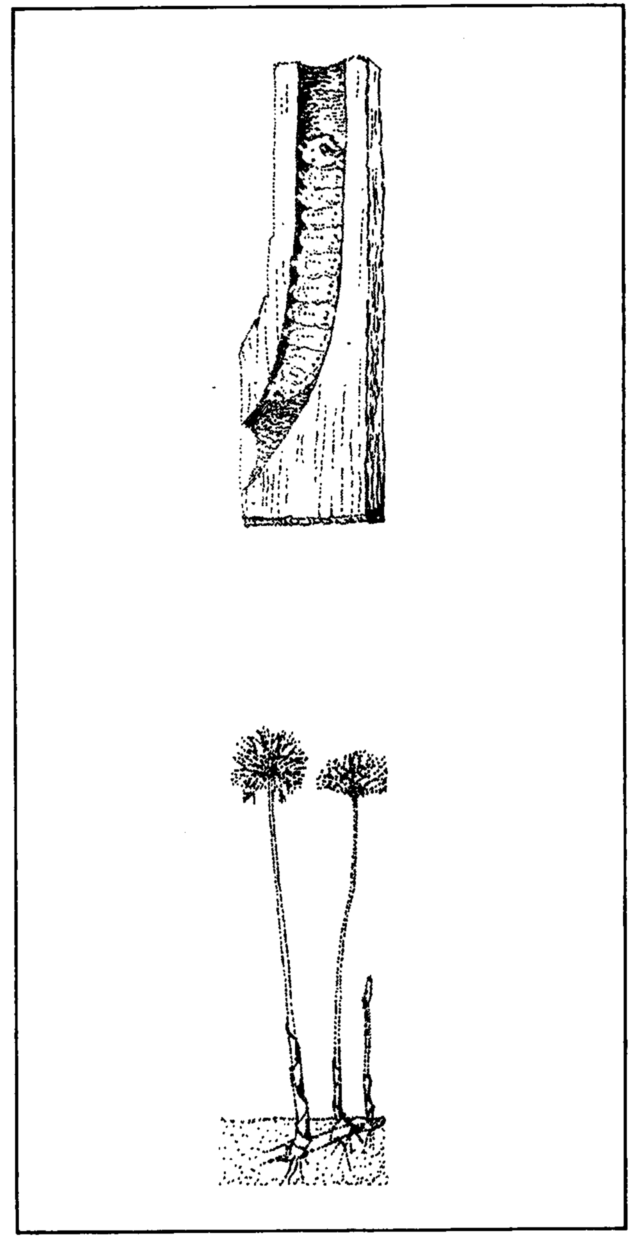
In economic terms, a case can also be made for the protection of wetlands through their indirect effect on the spread of insect pests, such as the infamous stem borer, *Eldana saccharina.*

Over the last 30 years this insect has spread throughout the sugarcane growing areas of Natal, and has accounted for losses in recoverable sugar of at least 0,1% for every 1% of stalks damaged (161). In bad areas such as Amatikulu, up to 30% of the consignments delivered to the mill are infested by *Eldana*.

The natural host plants of *Eldana* are hydrophytic species such as *Cyperus immensus* and *C. papyrus* (13, 74), both of which are confined in their distribution to the narrow coastal strip (42). It can be argued therefore, that this pest has switched to sugarcane as its natural hosts in wetlands have declined through wetland exploitation.

The outbreaks began on the Mfolozi Flats (14), which were formerly covered in papyrus and gradually transformed into sugarcane (7, 21). Consistently high infestations of *Eldana* have also been reported in sugarcane from the vicinity of Richards Bay. This area also lies in an an area where wetlands on the Mhlatuze floodplain once comprised a significant proportion of the landscape. Over the years, these too have been reclaimed, through the planting of sugarcane, the construction of a harbour, and the establishment of industry and townships. If aerial photography (dating back to 1937) is used for the purpose of detecting change in bottomland utilisation (see Fig. 15), similar losses in wetland are also evident in Northern Natal. South of the Tugela river, where less extensive areas of wetlands have been lost, *Eldana* is quite commonly found in its indigenous host plants (43).

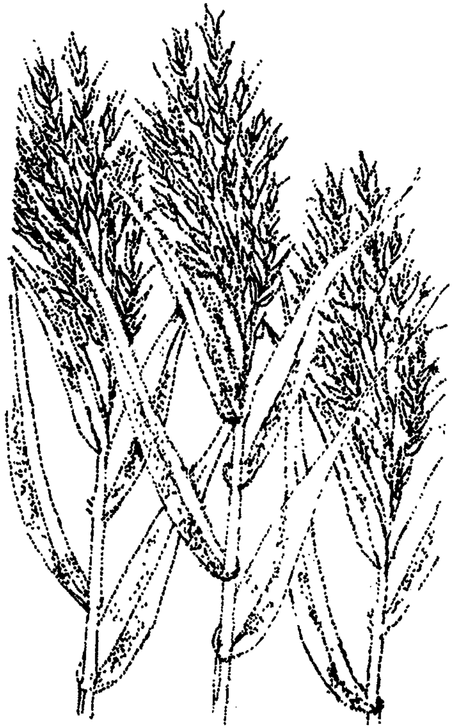
Presented with this sort of background it seems probable that with the spread of sugarcane, *Eldana* was forced to select an alternative host plant. Although the crop loss is not significant to the industry as a whole, but only to specific growers, of greater relevance is the thought that the problem may never have materialised had a policy of selective wetland preservation been adopted at the time these decisions were being made.



3. 2. 8 Utilitarian Values

The asset value of wetlands is by no means limited to commercial utilization, since the rural people of Natal have traditionally used wetlands for a wide variety of purposes

(135). Apart from being used for the grazing and watering of cattle and, to a lesser extent for agrarian pursuits such as the cultivation of maize and vegetables, wetland plants have been used for the manufacture of commodities as diverse as fish traps and musical instruments. They have been described as "a productive resource-base for hut-building, craftwork and thatching materials" in rural areas (51).



One of the most important wetland plants to the Zulu people in Natal is n'cema *(Juncus kraussi)*, which is a sedge used for the construction of sleeping mats. On the south coast *J. kraussi* is used for craftwork, and the weaving of numerous other products such as baskets, hats and bangles, and has come to serve as the basis of a lucrative industry.

The overall level of exploitation is unknown, but in the vicinity of St Lucia, the Natal Parks Board purposely exercises some control over the quantities of n'cema harvested. Records of over 500 people days per month give an impression of human pressure upon this resource (172), while sightings of up to 223 Zulu women collecting n'cema on the floodplain of the Umgababa (25), suggest a danger of over-exploitation in certain areas exists.

Phragmites australis is another important wetland plant used as a hut-building/-thatching material in certain areas of Natal. In the vicinity of the Mosi swamps for example, (the largest *Phragmites* wetland in Maputaland) the harvesting of reeds is an activity that has led to the establishment of a thriving R38 000 per year business, involving the harvesting and distribution of 260 metric tons of reeds (51). Furthermore, there was every indication at the time (1983) to suggest that reed sales were increasing due to improved means of transport.

In other areas, such as the Mpendle district, wetlands are excavated to utilize the clay soils therein for the manufacture of bricks, subsequently used for the construction of houses.

3. 2. 9 Disease Transmission

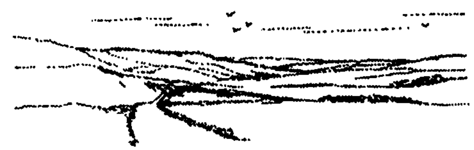
Wetlands have long been recognised as areas associated with the transmission of disease (11, 52) and, as a result, have the reputation of being "unhealthy" places. On these grounds alone, wetlands have often been infilled or reclaimed, to free mankind of the diseases associated with swamps (190).

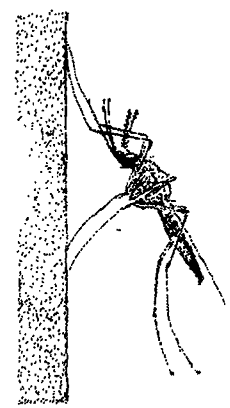
For example, at the turn of the century, a good proportion of the mangroves in Durban Bay were cut down (8) to rid the city of mosquitoes, and in Zululand gum trees were planted in wetlands for the same purpose (158). A wetland drainage programme was also undertaken in certain parts of Zimbabwe to bring about the control of bilharzia (Elwell, pers. comm.). It should be noted however, that in some parts of the world where similar steps have been taken, they have actually led to exacerbation of the disease (52).

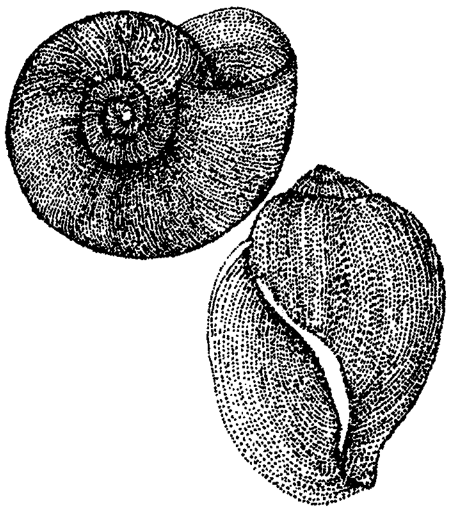
In many parts of Natal, wetland shave been shown to serve as the transmission sites for bilharzia, and as breeding sites for mosquitoes. In Northern Natal, for example, mosquitoes can transmit malaria and various other viral diseases. Consequently, large sums of money have been spent on research programs, and strategies for the control of these diseases. A bilharzia atlas has been compiled, for example, (72) to establish the distribution of the host snails and the incidence of bilharzia throughout South Africa.

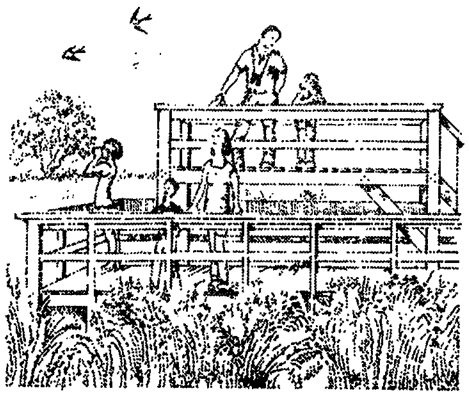
Hookworm is another parasite associated with the moist, shady soil alongside wetlands and, as a result, is frequently contracted by people living in floodplain areas. People in daily contact with swampy areas also encounter the leech *(Limnatis fenestrata)*, renowned because of its internal and external blood sucking habits (10).

From an agricultural point of view, economically important diseases amongst farm animals such as cattle, include liverfluke and footrot, and both can be traced back to contact with wetlands (154).









When considering the role of wetlands in a regional context therefore, certain of their characteristics can be construed as being undesirable. However, it is important to realize that the incidence of diseases such as bilharzia is not restricted to wetlands. In certain parts of South Africa, many water-bodies such as dams, rivers, irrigation canals and even temporary pools commonly act as transmission sites. In fact it can be argued that wetlands, *as defined* in Chapter 2, would be inimical to the successful breeding of snails and mosquitoes, because they are characterized by a lack of open water. However, if disturbed by cultivation, canalization or the grazing of cattle, this situation can easily be altered and the problem of disease transmission can rapidly materialize.

In fact, one school of thought is that the destruction of vegetation alongside the edges of streams and rivers in Natal, has been partially responsible for the high incidence of bilharzia (91). A protective belt of vegetation alongside water courses is therefore seen as a natural control measure which, if implemented over a whole catchment, could result in either the complete disappearance of the host snails as vectors in certain areas, or a marked reduction in infectivity in others.

3. 3 Cultural role

Throughout this report is has been stressed that "wetlands mean many different things to many different people", and so the recreational aesthetic, and educational value of wetlands needs to be recognised as part of the overall asset value of wetlands to society (139).

The point is that wetlands are an amenity, offering enjoyment to a wide variety of people, each of whom may attribute a different value to a given experience. Thus tramping through Franklin Vlei in East Griqualand is an educational experience to some people, a recreational experience to others, and of aesthetic appeal to others. Whatever the case, wetlands are clearly perceived as a distinct natural resource, on a par with rivers, mountains, forests or lakes. All of these resources are there to be enjoyed, simply because of the pleasure that many people derive from being close to nature (80).

Open water areas with marginal wetlands are perhaps the most important from a recreational point of view. This is because open water permits activities such as boating, water-skiing and swimming. Wetlands, distributed along the edge of open water on the other hand, are of great significance to fish and water-fowl as habitats (Sect 3.4). It follows that they are therefore of value to anglers, birdwatchers and duck-hunters (202).

'What is the worth of a wetland to a child wondering just how a tadpole can grow up into a frog?' (205).

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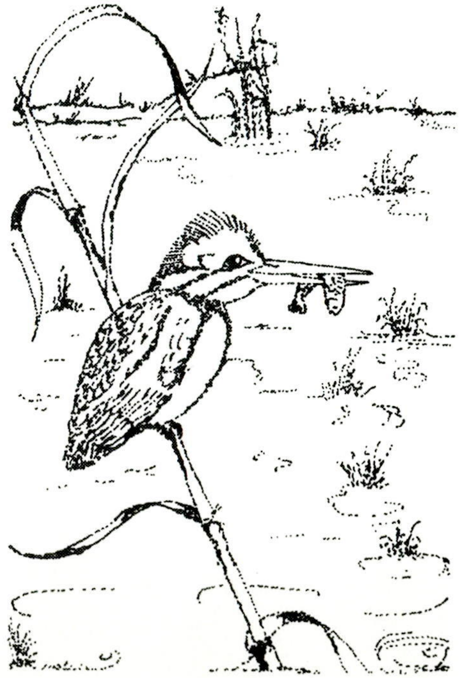
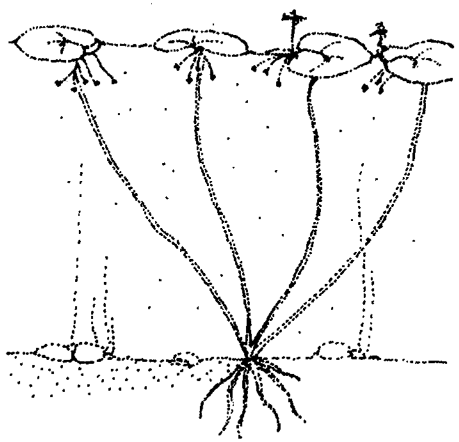
3. 4 Ecological role

Amongst wildlife circles the ecological significance of wetlands has been recognised for an extremely long time. This is because the wetness associated with these habitats exercises a major influence on the species composition of wetland biota. As a result, a great many animals (particularly birds) are wholly or partially dependent upon wetlands for refuge, feeding and breeding purposes.

The abundant moisture associated with these environments also means that wetlands have the reputation of being extremely productive habitats (64). The wet soils stimulate the growth of certain types of plants, and these in turn provide conditions conducive to the establishment of biologically diverse populations of animals. For example, anyone who may have spent an evening in close proximity to a marsh in Natal, would almost certainly have noticed the concentration of biting insects and the cacophony of sounds that characterize wetlands. In reality, these are all indicators of a rich biological resource, which not only supports an enormous biomass, but can also attract a wide variety of animals, including migratory birds and various other consumer species.

To the minds of many people all these forms of life are living on borrowed time. This is



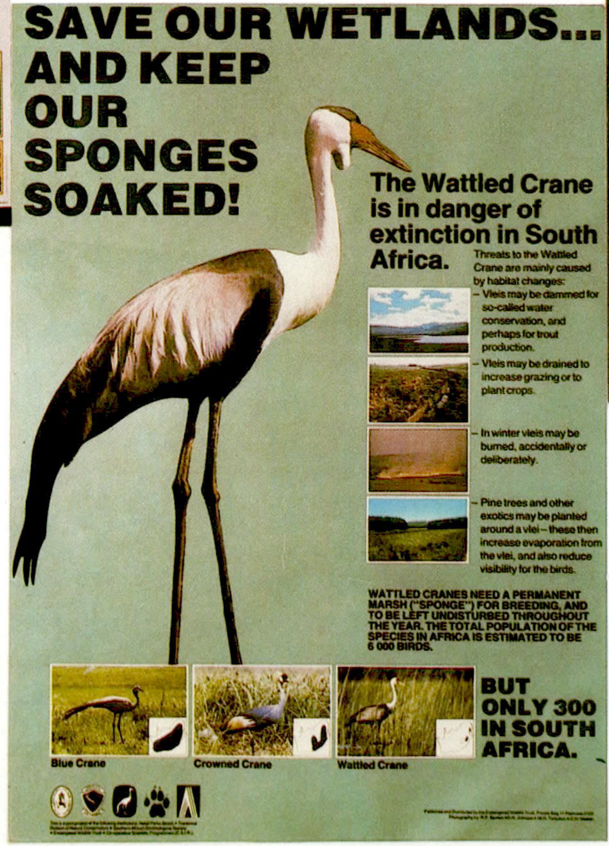


because of the phenomenal rate at which wetlands are being destroyed by mankind through drainage programs (22, 94, 171) and various other related forms of development (Plate 2). In recent times attention has been drawn to this problem through the well known Ramsar conference (held in Iran in 1971) (44), at which specific attention was given to the many species of waterfowl and migrants which are dependent on wetlands throughout the world. Since then, several other conferences have been held on much broader issues, but a theme distinctly common to them all has been concern at the damage mankind is doing to itself in the process of destroying wetlands.

As a form of energy vital to the wellbeing of aquatic communities, the production of detritus is a significant ecological value attributable to wetland ecosystems. Detritus is best described as an "aquatic compost" (149), and its value locally is evident from the fact that in Natal's estuaries and lagoons, it has been shown to be the fundamental energy requirement of the entire food web (191). Detritus is derived from the reedbeds and mangrove swamps which occur in profusion on the water's edge. Their contribution has been shown to be so important that wetland communities have been deliberately designated as "vital areas", and where possible, rigorously protected from alteration (24).

The peripheral vegetation surrounding inland lakes and dams, or alongside rivers, performs the same function. Thus, there is an important relationship between the productivity of water bodies and the integrity of the wetlands which surround them. This has been well illustrated on the Pongola floodplain for example (69), where, because of the above relationship, the protein requirements of a large African population (dependent on fish) have become equally dependent on the productivity of the wetlands which sustain these resources.

Zonation of the hydrophytic plants adapted to wetland conditions is a complex subject that is determined by many factors, such as the duration of time the soil profile remains flooded, oxygen levels and water depth. However, in a typical wetland the centre is generally wetter than the edge, and so a clear transition of vegetation types is evident (58). This often takes the form of concentric zones which correspond to the



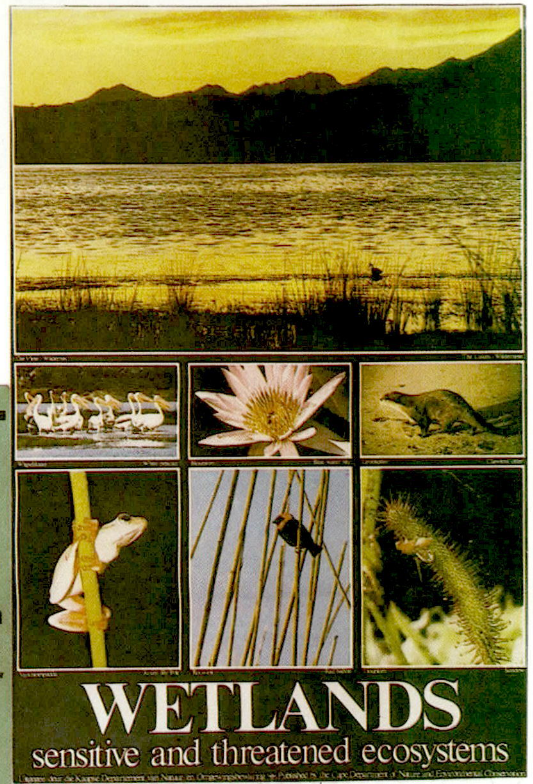
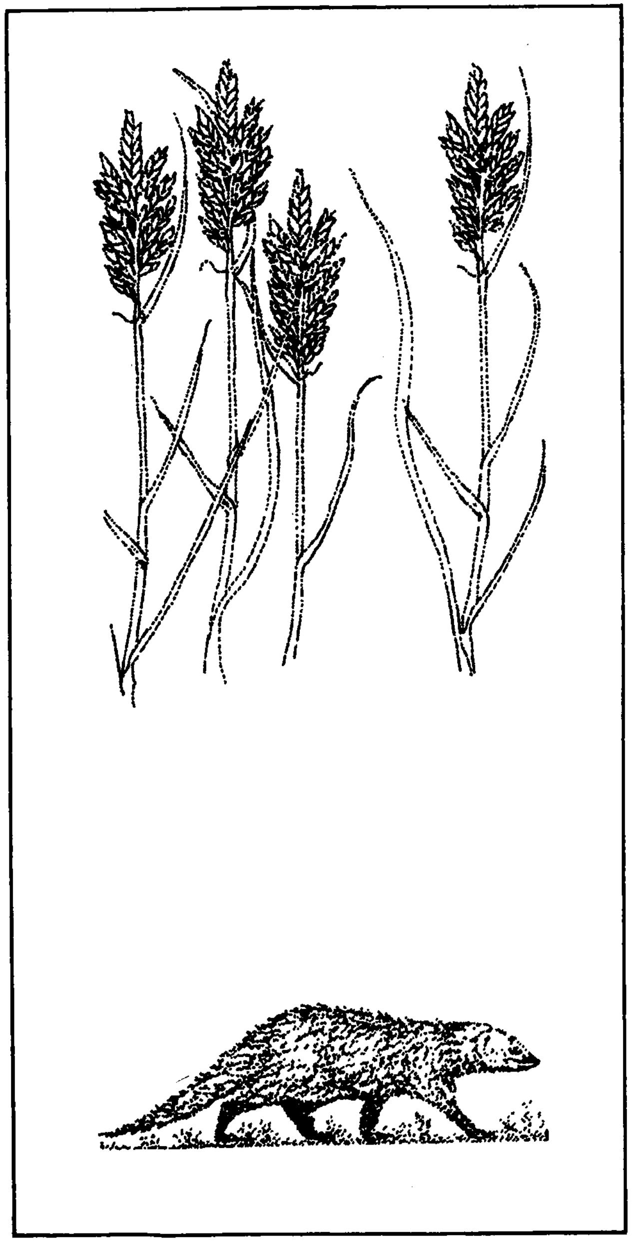


Plate 2

An expression, through the medium of posters, of global concern about the declining status of wetlands and wetland-dependent species.



form of the basin in which the wetland occurs. As a result, short, water-tolerant species of plants generally occur on the edge of a wetland, but these soon give way to tall emergent species adapted to the permanently water-logged soils nearer to the centre (59). If the water table rises any higher, a zone of floating or submerged plants can develop, as in the central area of a wetland, where semi-open water conditions can prevail.

As a consequence of these plant adaptations and growth strategies, niche segregation results (Fig. 9). This means that the animal communities which have become adapted to live in wetlands utilize each zone differently. In the process they maximise resource utilisation.

Many of the ecological studies conducted in wetlands have therefore shown that vegetative heterogeneity results in a high species diversity amongst animal communities. For example, certain wetlands locally, such as Nyamithi Pan in the Ndumu Game Reserve, are renowned for their variety and abundance of wildlife, but this is really a result of their structural diversity and productivity (82). In other words, the high species richness of Nyamithi Pan is largely attributable to the unusually high variety of habitats, which, in this instance, are all contained within the same area.

In most cases, Natal's wetlands are dominated by a dense mass of a single plant species. This results from the infilling of the basin until a uniform habitat results. Depending on the wetness of the site, these may typically comprise grasslands, reedbeds, or sedge communities, and in certain cases, woody species. However, in each case, the structure of these plant communities has a distinct influence on the forms of animal life associated with them. In an ornithological context, the co-occurence of bishop birds and various weavers in reedbeds serves as an example; as does the strong association between wattled cranes and undisturbed grassland vleis. In swamps dominated by trees (such as *Barringtonia racemosa*), night herons are frequently seen, whereas in wetter sites, where the marsh vegetation becomes broken up by areas of open water, various ducks and skulking species such as rails and crakes occur.

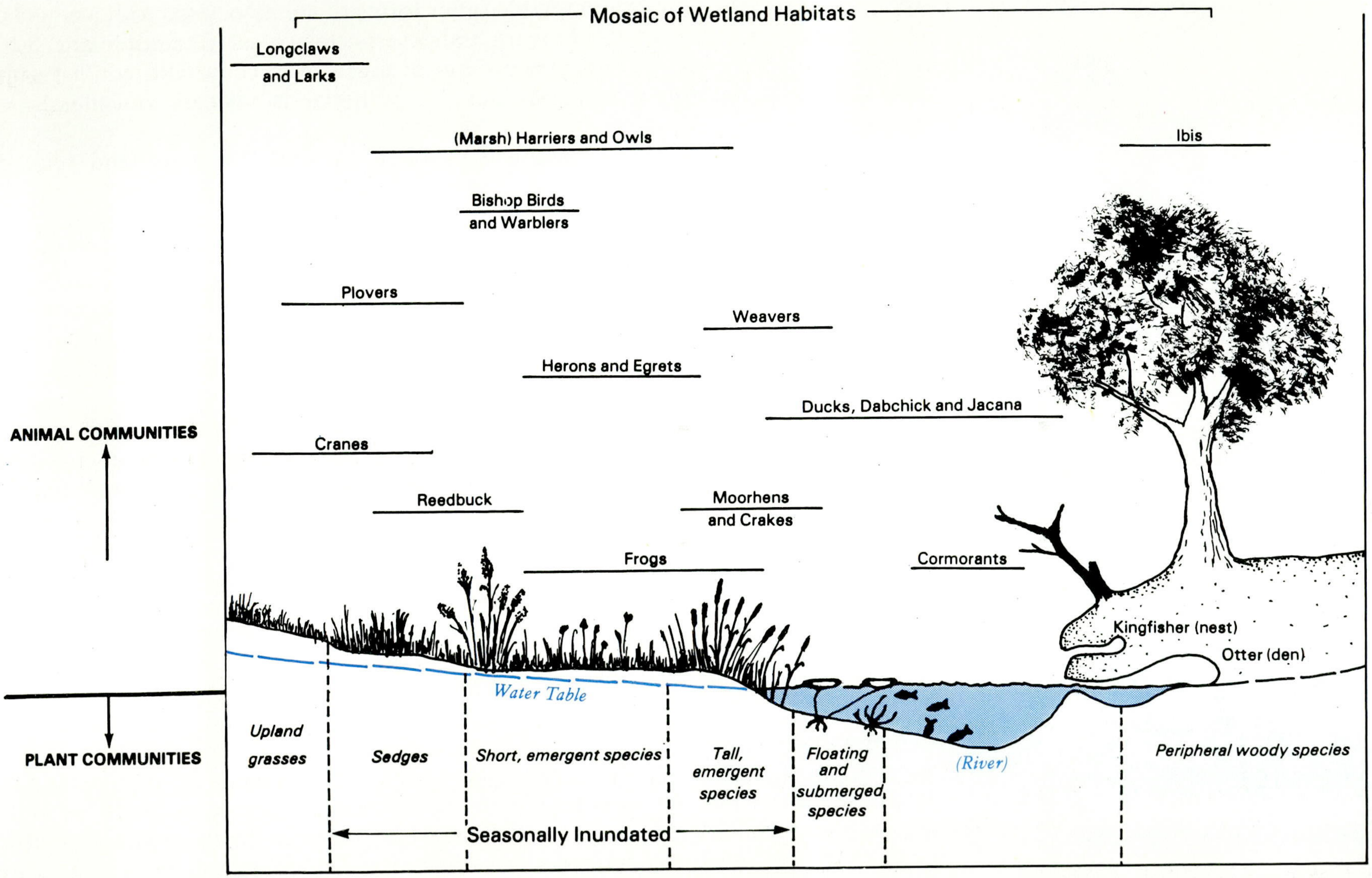
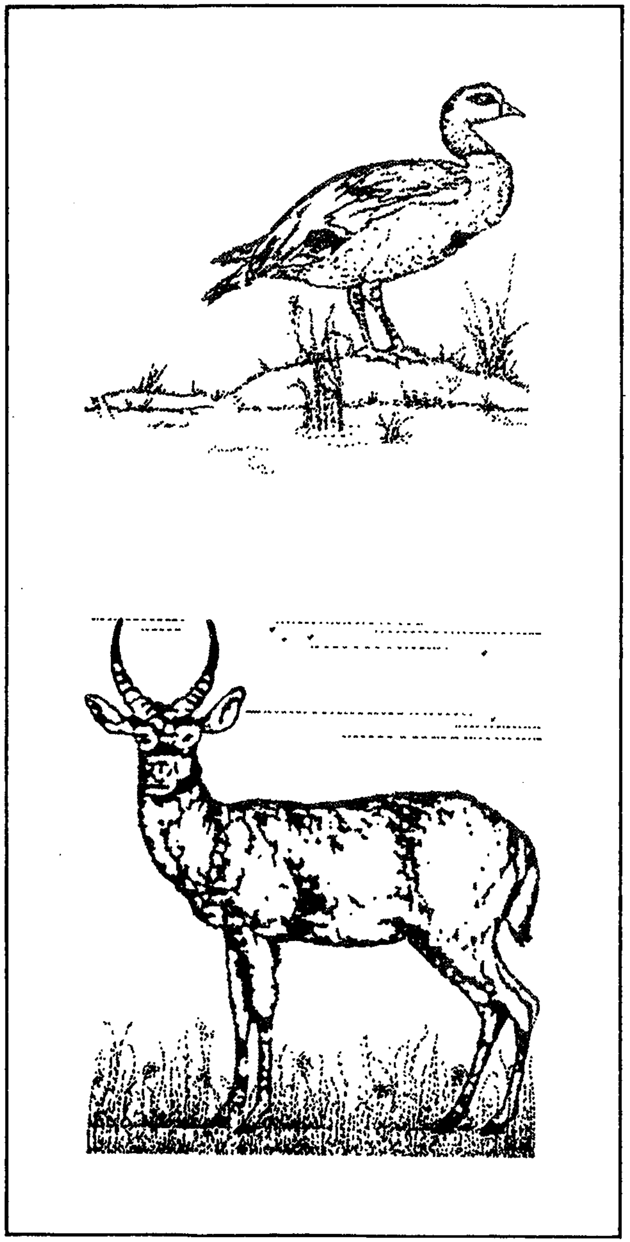


Fig. 9 Conceptualization of the inter-relationships between plant and animal communities in a typical wetland area of Natal. *(adapted from Weller & Spatcher, 1965).*



Apart from this, there are innumerable other forms of life associated with wetlands. These include a wide variety of invertebrates (especially insects), amphibians, fish, reptiles and mammals. Unfortunately some of these have come into conflict with man's interests, not only in wetlands, but also in the lands adjacent to wetlands.

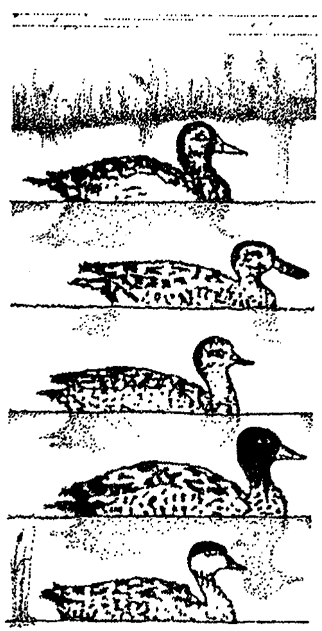
For example, the so-called "reedbuck problem" in Natal is a wetland related controversy (88). It has arisen because reedbuck habitually lie up during the day in wetland areas, but graze on dryland pastures at night. Similar damage can be done by Egyptian geese. In fact at a meeting in 1979 on the pros and cons of damming the Mvoti Vlei, the importance attributed to the ravaging of farmer's crops by these birds had a significant influence on the decision not to dam the vlei. In Canada, farmers receive compensation for "duck damage", since losses of up to 240 dollars/acre have been accounted for by the eating and trampling of barley by wild geese (105).

Another aspect of the plant and animal life associated with wetlands which needs to be reinforced, is the problem of species extinction. This has arisen through the ever-increasing destruction, worldwide, of the habitats of indigenous plant and animal species.

Today, the maintenance of genetic diversity is an internationally accepted principle, seen to be necessary to safeguard endangered species, as well as mankind (90). In South Africa a number of publications have been produced which list those species that are considered either to be endangered, or to be faced with extinction. Many of those listed are wetland associated. Thus, from this point of view alone, it is understandable that considerable concern has been expressed by conservation-conscious organisations about the declining status of wetlands, and the future of the species affected (206). In Natal, 18 species of frogs, 6 species of reptiles and 6 mammal species (mainly rodents) are, strictly speaking, regarded as totally wetland dependent (Bourquin, pers. comm.). However, there are twice as many which, although only partially dependent on wetlands, would still find it extremely difficult to survive without them.

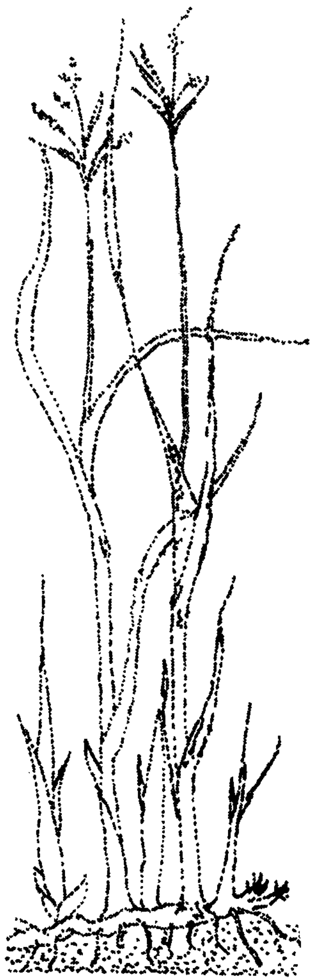
Amongst the 114 wetland dependent bird species in Natal, 24 are listed as 'red data' species, which means they are threatened with extinction (Johnson, pers. comm.). These include the famous white winged flufftail, which is one of Natal's rarest birds, and known only from Franklin Vlei in East Griqualand (113). Another is the wattled crane, a detailed census of which in 1982 revealed that no more than 214 individuals remained in Natal (95). Since then an extensive education program has been mounted by the Natal Parks Board to create an awareness of the importance and vulnerability of wetlands (93). However, with emphasis given solely to the threatened status of these birds, it is feared that, with people being what they are, these commendable efforts will go unheeded.

In conclusion, there is no doubt that wetlands perform a vital role in maintaining the diversity of plant and animal life that we see around us. However, man is one of the species that also enjoys the benefits that wetlands afford, and the declining status of wetlands will only be prevented once mankind has come to appreciate this. In other words, to automatically secure the future of wetlands for wildlife, one first needs to demonstrate the value of wetlands to mankind. The study of Natal's wetlands, as proposed in Chapter 8 of this report, is therefore deliberately geared to achieving this aim.



'A nation unable to support the diversity of its wildlife is unable to maintain the standards of living of its people.'

(Tom Lovejoy)



Chapter 4

The distribution and extent of wetlands in Natal

The only persons to have attempted to calculate the extent of wetlands in Natal, arrived at the conclusion that 8 101 km^2 of the Province were classifiable as wetlands (85, 158) (Table 6).

Table 6: Estimated extent and distribution of wetlands (bottomlands) in Natal. (Modified from Scotney & Wilby, 1983).

Bioclimatic Region	Area (km^2)	Extent of Bottomlands km^2	%
1	10 585	443	5
2	9 023	256	3
3	6 976	190	3
4	17 382	1 463	8
5	1 858	20	1
6	10 266	1 029	10
8	16 800	1 940	12
7, 9, 10, 11	21 222	2 760	15
TOTAL	94 112	8 101	8,6

These estimates were made for the purpose of a land capability analysis using available soil survey reports and Phillips' widely accepted sub-division of Natal into bioclimatic regions (132) (Fig. 10).

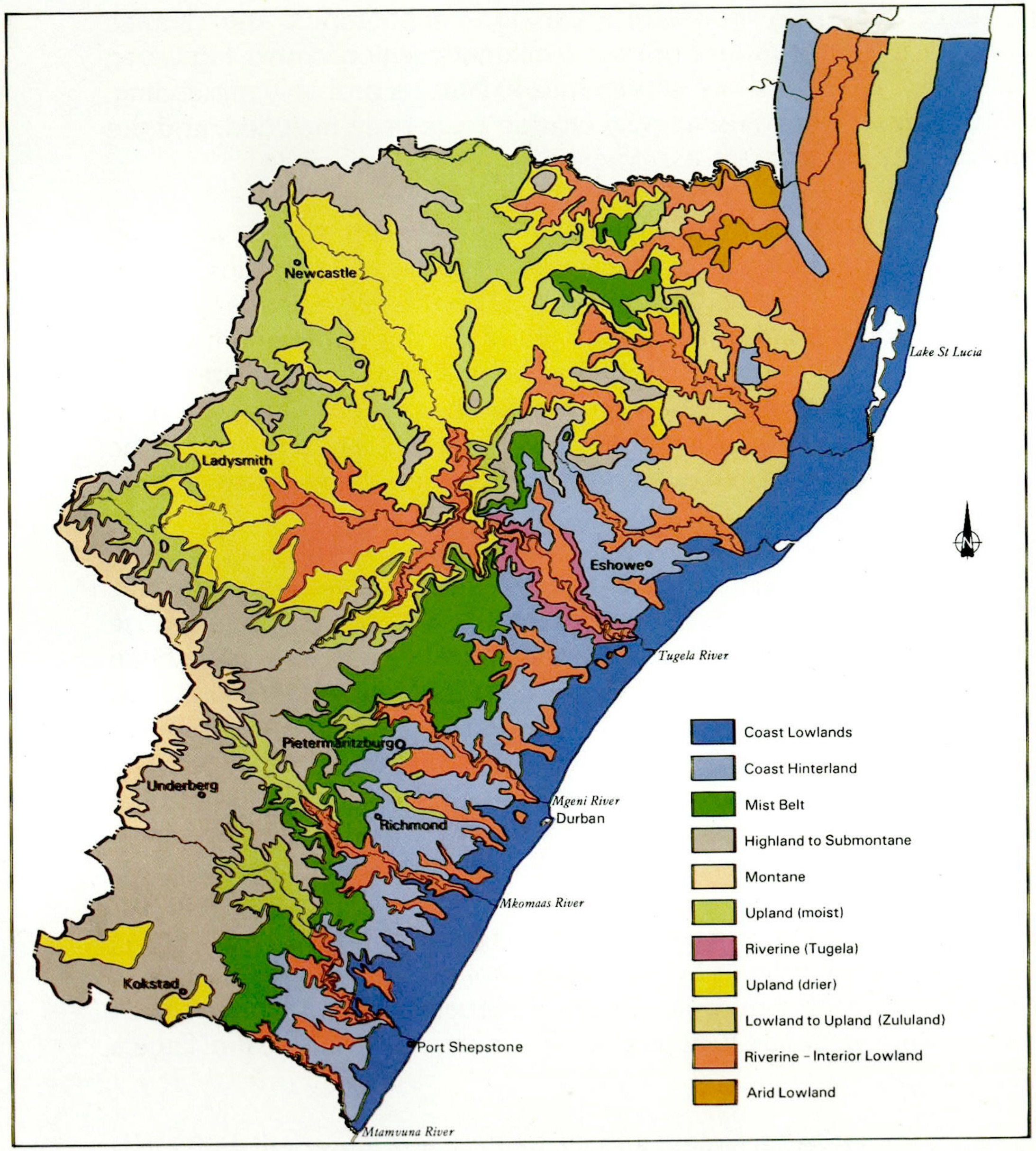
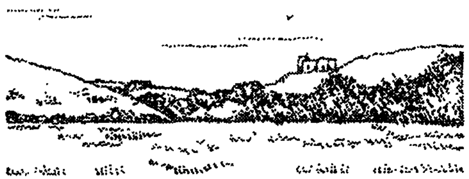


Fig. 10 The bioclimatic regions of Natal
After Phillips (1969)



The data clearly reflect that, in response to a variety of topographic and climatic influences, the extent of wetlands varies from one bioclimatic region to next. However, the suggestion that there are 8 101 km^2 of wetlands in Natal is probably misleading, because wetlands degraded by extensive gully erosion have been included, and the truth of the matter is that no accurate assessment has ever been made.

An accurate assessment of the distribution and extent of wetlands in Natal is regarded as the most important requirement of the research program that lies ahead (Chapter 8). Having gone to some length to describe the role of wetlands in Natal, (Chapter 3) the reasons for allocating such a high priority to this requirement should be clear. However, the most important is that it has been shown that the amount of wetland in a catchment is a relationship that is crucial for the rational management of Natal's water resources. In addition, one cannot hope to formulate a policy for the utilization of wetlands without knowing where these areas lie, or how much of each catchment comprises wetlands.

The key to obtaining these data lies in the mapping of soils, because hydromorphic soils constitute the basis of what is meant by a wetland (see Chapter 2), and because they are readily discernible from aerial photography. In Natal, soil maps have been compiled for different purposes by numerous independent organisations but the largest single area ever mapped (occupying 30% of Natal) is the Tugela Basin (181). No other data exist which have thrown so much light on the subject of wetland distribution in so large an area of Natal, and these have proved invaluable for the purposes of this study. They have provided an overview of wetland distribution, from which extrapolations can be made as to the likely situation in other catchments.

By reducing the scale of these maps from 1:100 000 to 1:500 000, and extracting only information on the distribution of hydromorphic soils (Fig 11), it can be shown that before man's influence became a significant destructive determinant of their structure and functioning, wetlands occupied 4 741 km^2 (or 16,5%) of the Tugela Basin (Table 7).

Mapped in this way it is clear that most of these wetland lay in the interior of the Tugela

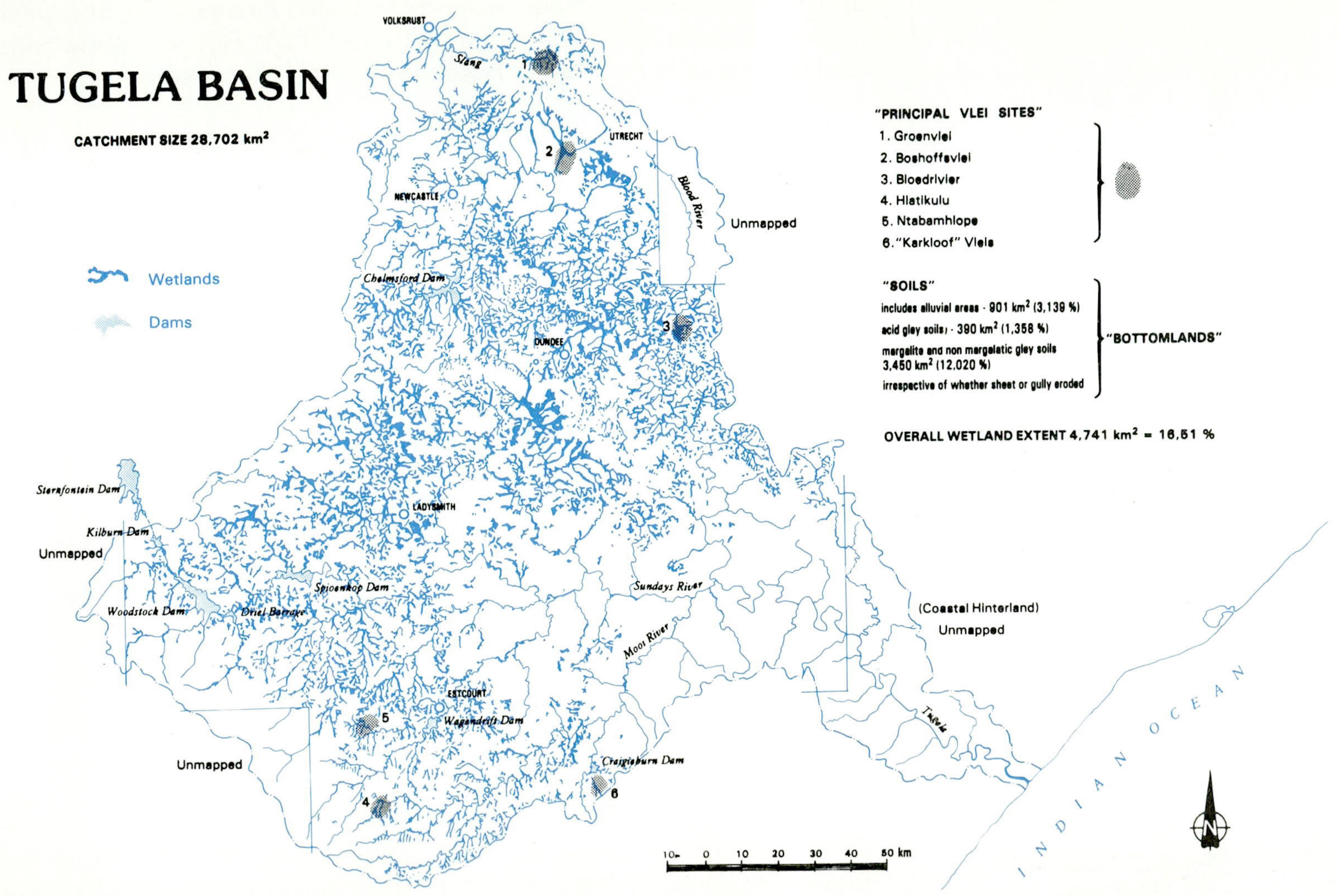
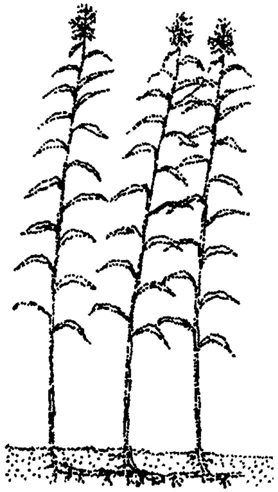
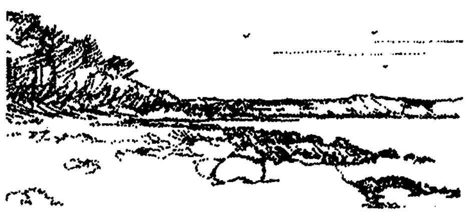


Fig. 11 The distribution of hydromorphic (bottomland) soils in the Tugela Basin, prior to man's influence as a destructive determinant of their structure and functioning.





Basin. However, what Fig. 11 does not reveal is that at the time of the survey approximately 34% of these wetlands had been destroyed by overgrazing and sheet erosion or drained by gully erosion (156, 181, 178). But now, some twenty years later, wetland losses in the Tugela Basin are probably far greater.

Table 7: The former extent of hydromorphic (bottomland) soils in the Tugela Basin, after Van der Eyk *et al.*, (1968).

Wetland Soil Type	Extent (km^2)	% of Tugela Basin*
Alluvial areas	901	3,1
Acid gley soils (e.g. Katspruit form)	390	1,4
Margalitic and non-margalitic gley soils (e.g. Rensburg form)	3 450	12,0
TOTAL	4 741	16,5

(*The total catchment area being 28 702 km^2).

In the process, irreparable damage has been done to the region's natural resources. In other words, by increasing run-off, inland areas of the Tugela Basin now experience periods when water is in increasingly short supply. Furthermore, the poor quality of the water can be accounted for; the rate of soil loss, estimated to be 375 tons/km^2/yr (146); the damage created by floods; and last, but not least, the diminishing carrying capacity of the land. With the reduced detention of sediment in the watershed, and its consequent transport downstream, it is well known that with a 100-fold increase in sediment yield, the depth of the Tugela estuary has become reduced from a system deep enough to permit the entry of British gunboats at the turn of the 19th century, to one which is less than a metre deep to-day (23).

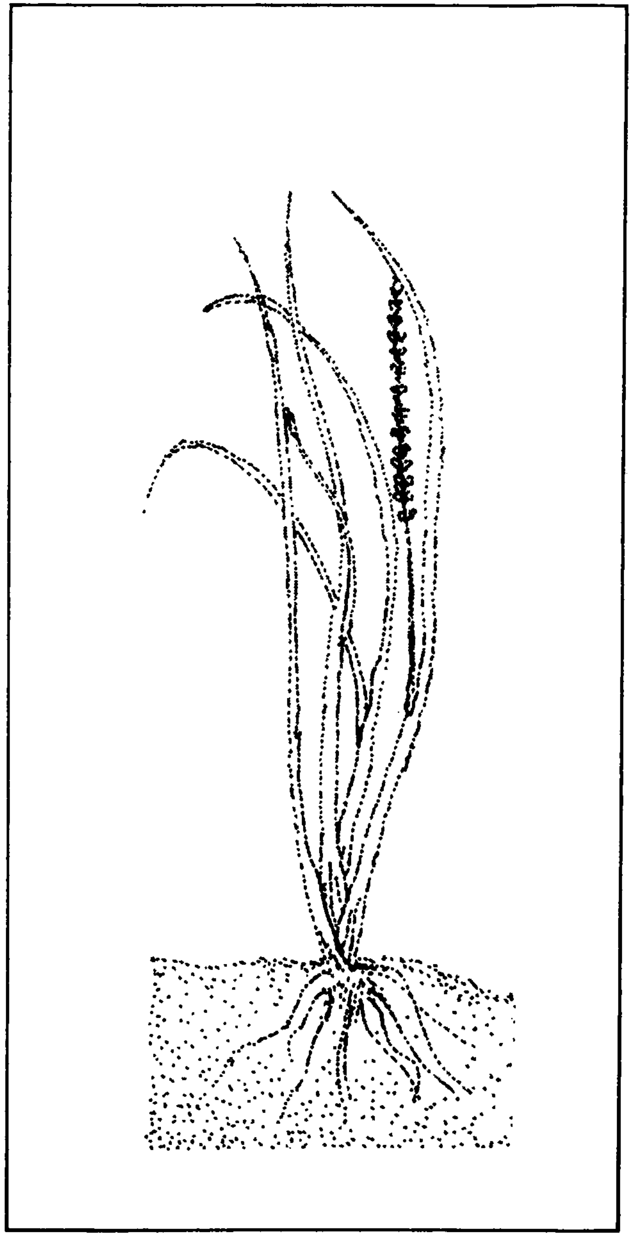
When one considers that each of the wetlands shown in Fig. 11 had the potential of acting as a store of water influencing to some degree the pattern of run-off below it, and the quality of the water, the overall significance of having 16,5% of the catchment buffered in this way becomes apparent. Indeed, scattered in the form of a mosaic of wetlands of various sizes throughout the Tugela Basin, one can also appreciate that the collective influence of these systems, on hydrological stability alone, must have been considerable. Regrettably, this is no longer the case today.

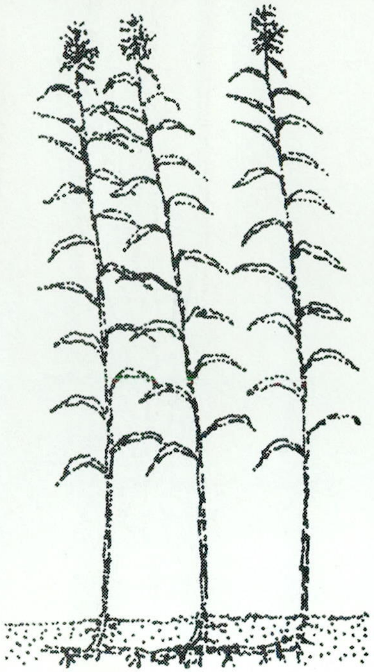
With the exception of the Mozambique coastal plain (Maputaland), it is highly likely that the distribution and extent of wetlands in the Tugela Basin (Fig. 11) is similar in most other catchments of Natal. Scrutiny of the soil maps compiled of the "Howick Extension Area" (154), which lies adjacent to the Tugela catchment, confirms this point of view (Fig. 12). The reason for this is that most of the major catchments in Natal lie tilted between the Drakensberg mountains and the Indian Ocean, in terrain similar to that in the Tugela Basin. Whether the proportion of wetlands lost in the Tugela Basin is also in the order of 34% has yet to be discovered, but at first sight this does not appear to be the case.

Over most of Natal, wetlands are distributed in a linear manner consistent with the incised pattern of drainage from each catchment. However, the reason Maputaland was singled out above is that this unique area of Natal is made up of gently undulating, sandy plains. This area is studded with wetlands, many of which lie between dune slacks, but enormous tracts of land are also included, which comprise the largest wetland systems in Natal (Fig. 13).

Anyone that may have flown over the Mkuze swamp for example, would not fail to be impressed by the size of this wetland. It is the largest single wetland in Natal (Table 8), and after the Okavango, probably one of the most important wetlands in Southern Africa.

The subject of wetland distribution in Natal is clearly linked to wetland status (Chapter 5), because where wetlands were once known to occur 20 — 30 years ago (or even 2 — 3 years ago, in some cases) they no longer exist today. This means that until their





distribution has been mapped on a catchment by catchment basis, and their conservation status determined by ground-truth verification, the question "how much wetland is there in Natal?" cannot be answered.

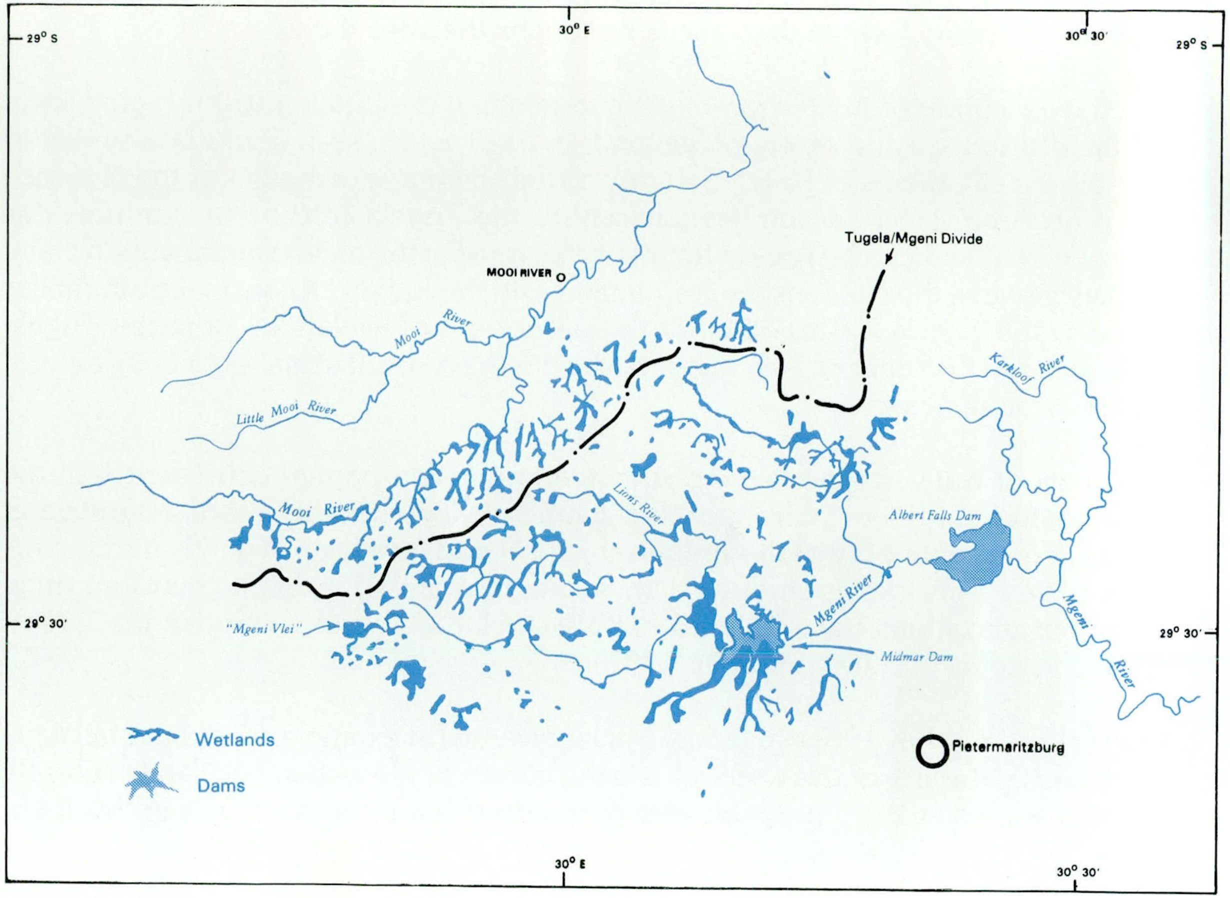


Fig. 12 The distribution of hydromorphic soils in the Howick extension area

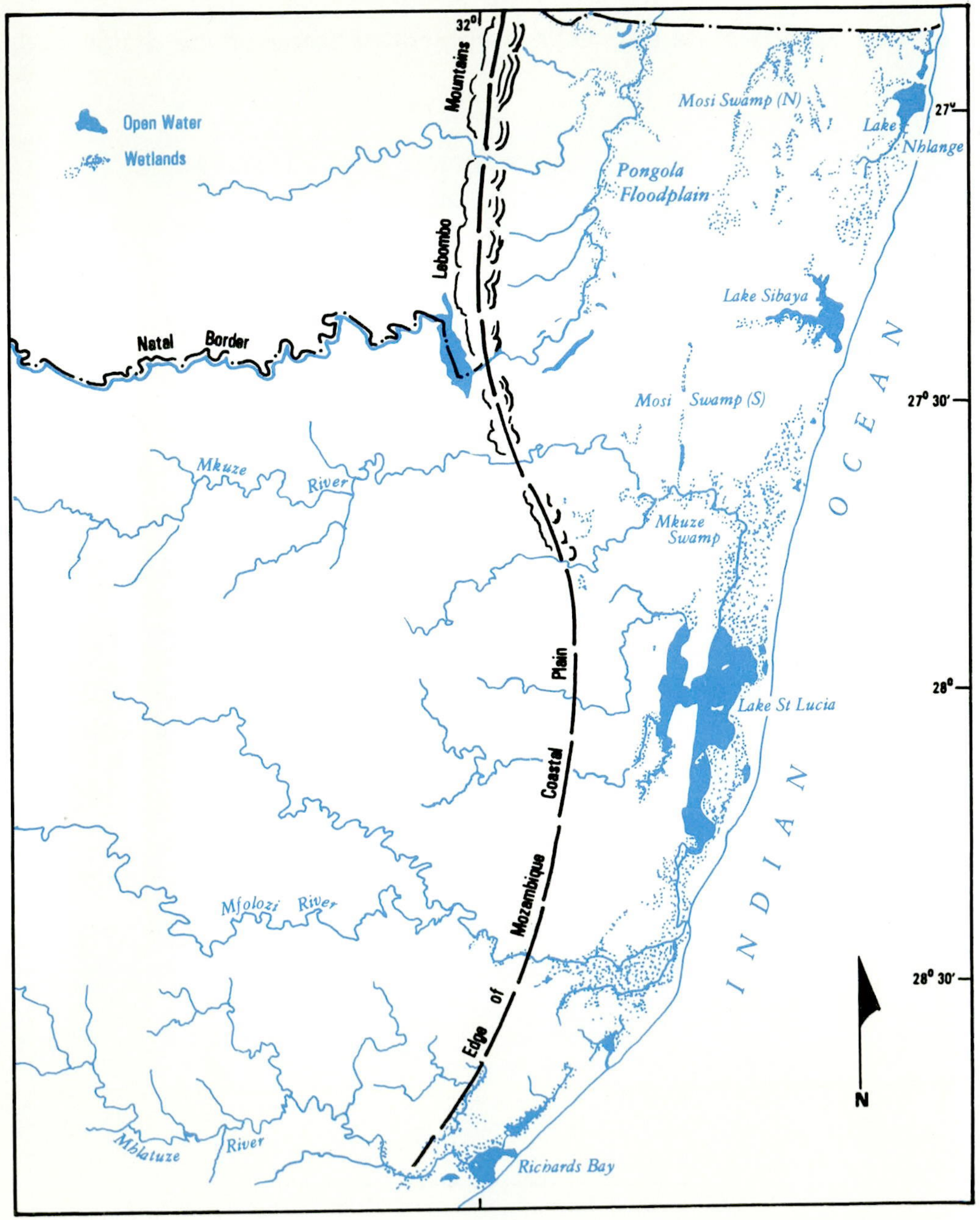


Fig. 13 The approximate distribution of wetlands in Maputaland, partially drawn from maps made available by the Department of Geological Survey *(Wolmerans, pers. comm.)* showing the distribution of alluvium.

Table 8: The approximate size (where known) of some of the major wetlands in Natal.

Wetland Name	Approximate size (ha)	Data source
Pongola Floodplain*	13 000	Heeg & Breen, (1982)
Mkuze Swamp*	10 500	Taylor (1982, b)
Franklin Vlei	2 500	Scotney & Wilby (1983)
Mgeni Vlei	1 200	Scotney & Wilby (1983)
Bloodriver Vlei	775	Colvin (1985)
Mosi (South) swamps	296	Cunningham (1985)
Ntabamhlope vlei	100	Downing (1966)

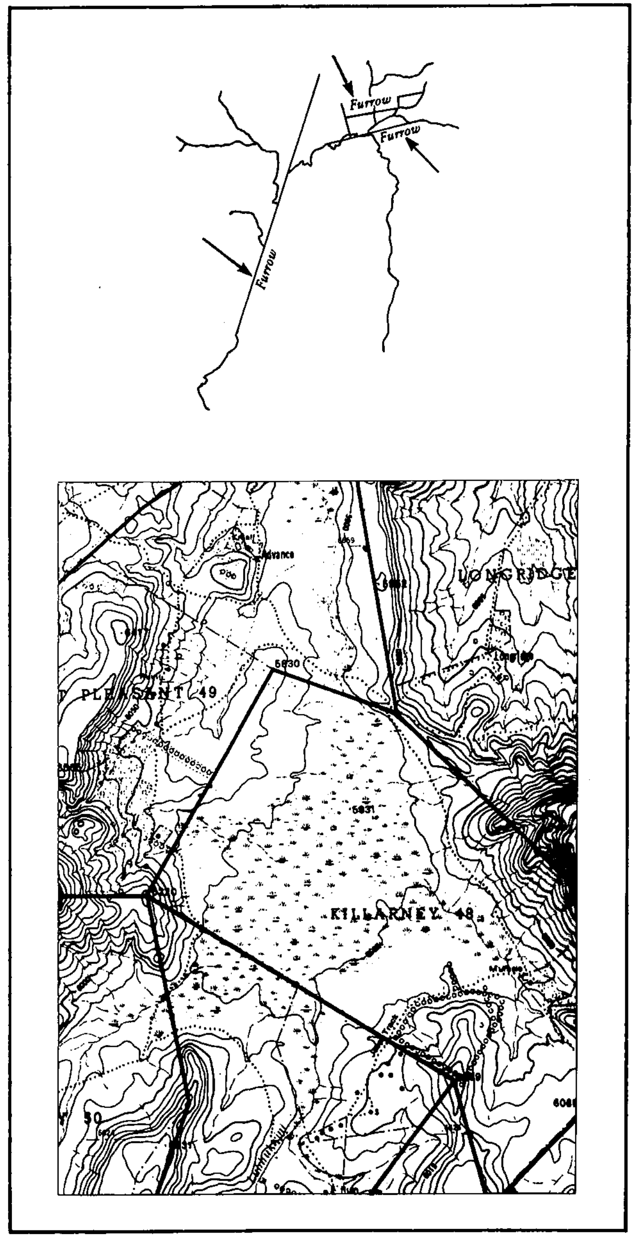
(* wetland mosaics)

It can be concluded from Chapter 5 that wetlands are being rapidly degraded, but since they have never been adequately mapped the historic record is being lost with them. The courses of action required are quite clear:

- halt or retard the rate of wetland destruction (Chap. 6).
- assemble the relevant information on wetland distribution and status (Chap. 8).
- develop and implement a wetland management policy for Natal.

Chapter 5

The present status of wetlands in Natal



The overall status of wetlands in Natal cannot be established until the distribution and extent of wetlands (Chapter 4) is known. However, for the purposes of an overview and impression of the status of wetlands in Natal can be obtained from maps, aerial photographs, field observations and literature.

To begin with, the declining status of wetlands in Natal is apparent from the 1:50 000 topocadastral maps that are currently in use throughout the Province. For example, the existence of furrows and drains are commonplace in many low-lying areas, and especially in the Midlands region of Natal. These are positive signs that portions of the landscape have been deliberately transformed from a wet condition into a less-wet, or dry condition by drainage. This is generally done to facilitate agricultural development.

Secondly, if recently updated and reprinted maps of a particular area are compared with the original maps of the same area, a marked reduction in areas depicted (in blue) as "marshes, swamps and vleis" is generally noticeable. This means that in the intervening years, areas formerly discernible as wetland from aerial photographs were no longer recognisable as such when the maps were redrawn. The reasons are various, and inlcude dam construction, afforestation and urbanization for example, but the most significant form of land use in these areas is agriculture. There is a high degree of correlation between areas shown as "cultivated land" and terrain that is otherwise identifiable as "bottomland". Being low-lying and flat in nature, it is here that wetlands naturally form, and very often the name of the place (the "Mfolozi flats";

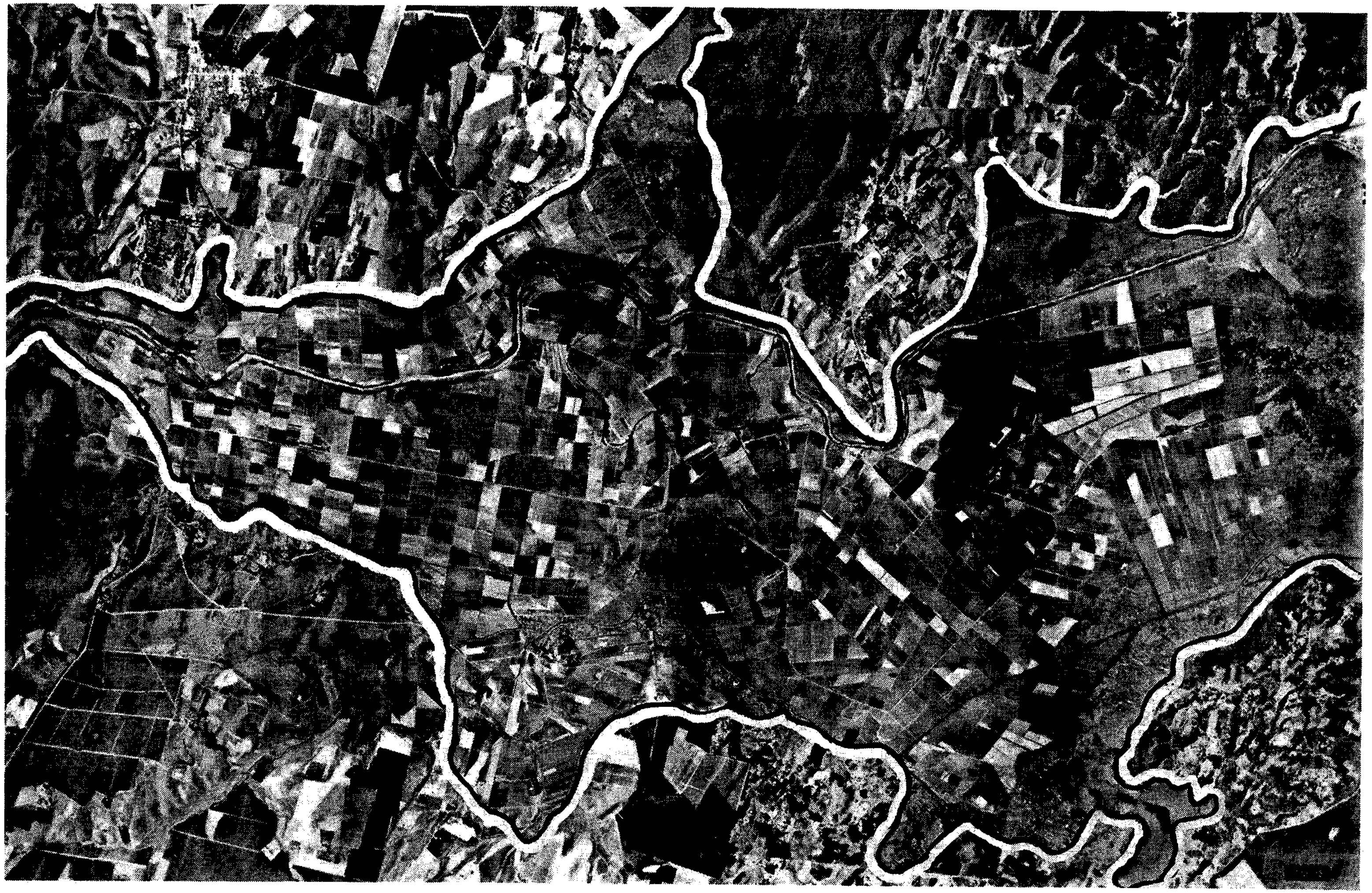


Plate 3 Exploitation of the "Mfolozi Flats" as a prime example of agricultural useage of an area formerly comprised of wetland. The edge of the flood plain is outlined in white. (Photo provided by the Sugar Industry Central Board.)

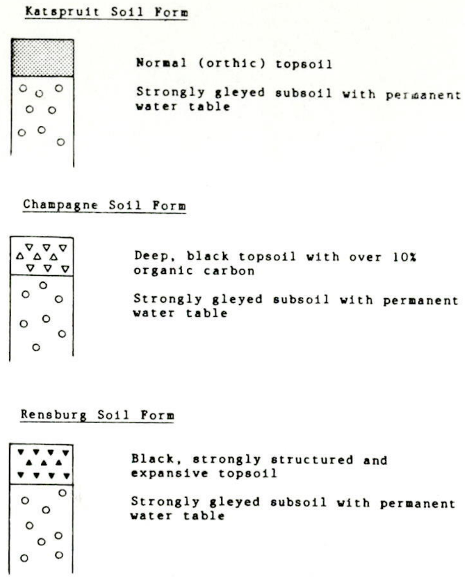
the "Cedarville flats"; or "Compensation flats") speaks for itself. The problem is that these were by their very nature important wetland areas, but today are regarded simply as prime agricultural lands (Plate 3).

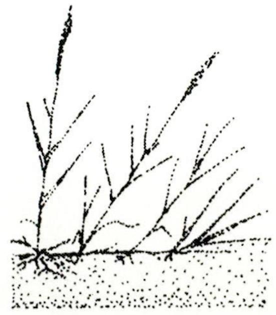
On many 1:50 000 maps cartographers in the offices of the Surveyor-General have also indicated the state of soil erosion, and particularly where this takes on an obvious form, such as gullies. This is a further indication of the status of wetlands in Natal, because gully erosion often arises in heavily utilized wetland sites, and rapidly destroys the system by lowering the water table. In portions of the Tugela Basin for example, it has been estimated that up to 90% of wetlands have been lost in this way (156) (see Plate 1).

Soil maps are another excellent source of information for determining the distribution of wetlands, and their status. For example, those of the Tugela Basin (181) not only reflect the state of soil erosion in wetland sites, but can also be used to show the original extent of wetlands in this area, compared with their extent today. In the same way, if soil maps of the Kokstad/Cedarville area (157) are prepared as an overlay and superimposed over the 1:50 000 sheets of this area, it can be shown that the size of Franklin Vlei, for example, has been reduced by agricultural development from 2 500 ha to 1 060 ha. Furthermore, several other wetlands (although much smaller) have been completely transformed (Fig. 14).

Because they have been so radically altered by mankind, many wetlands are no longer recognisable (especially to the untrained eye), without the aid of soil maps. Prepared as overlays these maps show how a single wetland, that may extend over several farms, has been used for different purposes depending on the attitude of the individual farmer. For example, portions of the same wetland may have been left undisturbed, whilst other parts of it used for crop production, a dam or the establishment of trees.

Aerial photographs can also be used to extremely good effect for assessing the status of wetlands in certain areas (185, 194). For example, a most effective way of assessing the extent to which wetlands have been altered in the last 50 years, is to refer to the earliest (1937) vertical aerial photography of Natal.





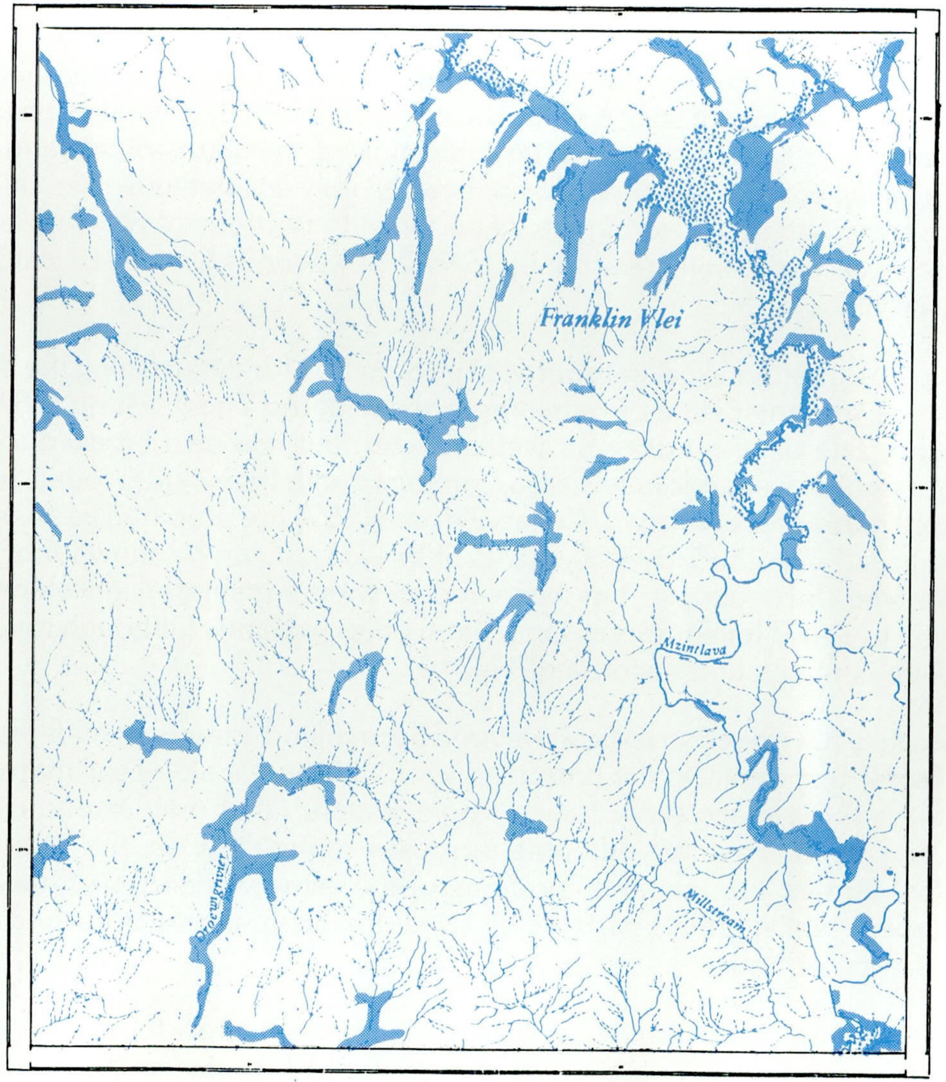
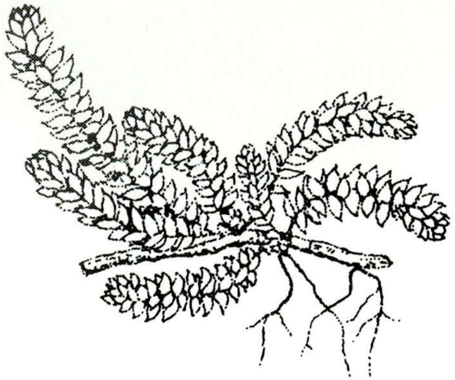


Fig. 14 The distribution and extent of hydromorphic soils, or wetlands (in light blue) on sheet "3029 AD, Franklin". When compared with the "Marsh Areas" shown on the standard topo-cadastral map of the area (dark blue), the advantages of using soils as a surrogate data source for locating wetlands are clear.

In the small (15 km^2) Siyaya catchment for example, (which lies just south of Mtunzini) aerial photography reveals that bottomlands throughout the catchment were undisturbed in 1937 (Fig 15). They were comprised of reedbeds, papyrus swamps and forest communities, that provided a protective belt of vegetation along all the major drainage lines. By 1966 approximately 93% of the area occupied by these communities had been transformed through the planting of sugarcane. In their place a network of herring-bone drains, and stream courses (straightened to form open furrows) appeared, and even in areas where patches of swamp forest remained uncleared, canalization ensured that water retention was reduced to acceptable levels for agricultural development.



At the discharge of the catchment, the area of open water in the Siyaya lagoon was reduced through reed encroachment from 6,4 ha to 4,5 ha over the same period of time (121). Today, after the lapse of a further 20 years, there is no evidence of open water in the original lagoon at all.

It is alarming to think that the pattern of events briefly described for this small catchment probably reflects the situation in many others in Natal. Of equal concern, is the fact that although the consequences were forseeable, being a controversial issue no-one apparently had the courage to enforce the legislation protecting these sites.

In this case, an assessment of temporal changes in the status of wetlands has been relatively easy to make, because the catchment is small enough to be covered by four aerial photographs. However, if it were accepted that a change of attitude towards wetland utilisation was desirable, then, given the time and the resources, similar analyses could be done without any difficulty for any catchment in Natal (see Chapter 8).

Even without aerial photographs there is an abundance of evidence to suggest that the status of Natal's wetlands is rapidly declining. The condition of Natal's rivers (the quality of the water, the flow regime, and the amount of sediment transported) are all expressions of catchment ailments that can generally be traced back to wetland misuse.

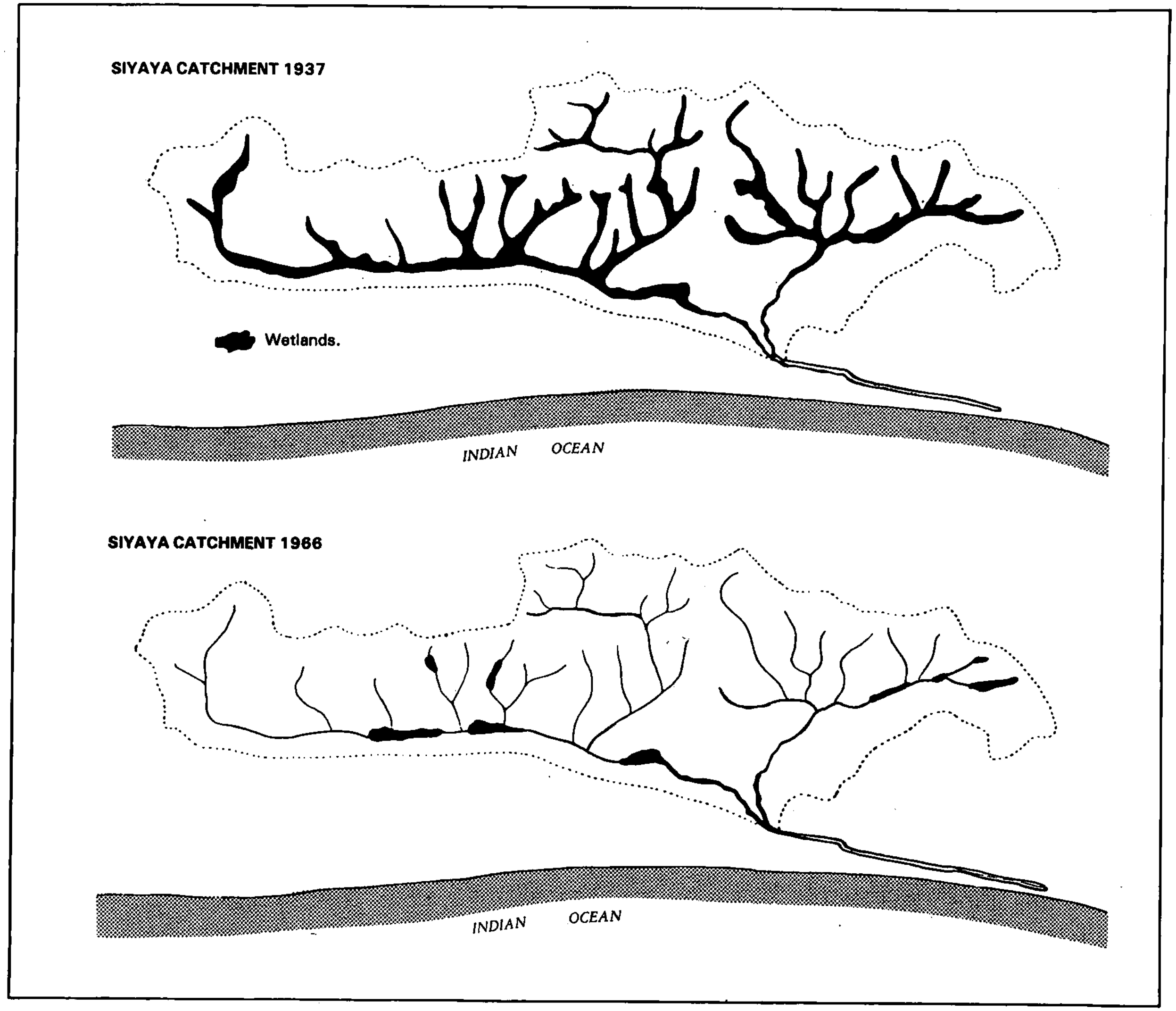


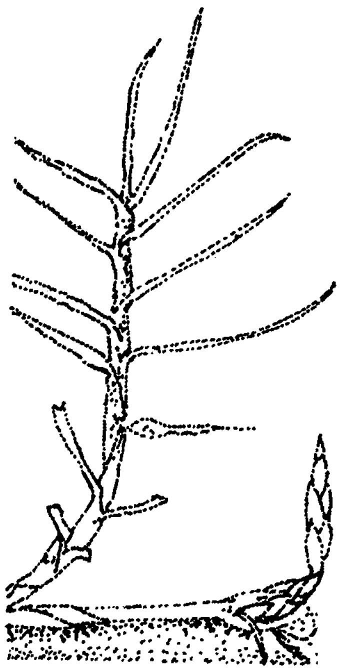
Fig. 15 A comparison between the distribution and extent of wetlands in the Siyaya catchment in 1937 and 1966 (as revealed by aerial photography), to serve as an indication of their declining status in the region as a whole.

Plate 4a

The disposal of gypsum in the papyrus swamps of the Mhlatuze floodplains epitomizes the current thinking that "wetlands are wastelands", and fit for little else than reclamation.

Plate 4b

The disposal of municipal refuse in wetlands alongside the Lovu estuary is being done in the interests of reclaiming the area for sportsfields.



There are also more blatant signs than these. To name a few, the "reclamation" of marchland through the disposal or gypsum at Richards Bay (Plate 4a); the disposal of municipal refuse in the reedswamps of the Lovu Estuary (Plate 4b); the construction of Louis Botha Airport and of Phoenix Industrial Park outside Durban, all serve as examples of different ways in which the insidious loss of wetlands can occur. Sometimes, the scale of these losses differs, but it is clear that the process of wetland degradation has yet to be halted.

The regulation of streamflow, and the construction of dams also has dramatic effects on wetland ecosystems. To begin with, the discharge point of the wetland is often selected as the site for a dam wall for geological reasons; the 'water balance' upstream and downstream of the site alters; wetlands downstream of the dam often dry up; and the run-off from adjacent irrigated lands can be polluted. On the other hand, inundation of the wetland area through impoundment of the water can be compensated for by the development of wetland habitats around the edge of the dam, and the fact that dams perform similar roles to wetlands when it comes to silt attenuation and water storage. However, not all the functions are performed as well as in a normal wetland. The phenomenal growth in dam building since 1920 (67) therefore gives ample grounds for concern, if for no other reason than wetland sites are almost always implicated. This is particularly true of small farm dams in Natal (Cook, pers. comm.), the impact of which need careful evaluation.

Most people do not appreciate the multiple effects of wetland degradation. For example, the deliberate draining of a wetland often starts off a chain reaction, which begins with lowering of the groundwater table, and the drying out of what was formerly a permanently saturated area. This adversely affects water storage in the catchment and, because crops are established that require fertilization, the run-off from cultivated lands can adversely affect water quality. If channel flow accompanies the change, it is probable that bank erosion will develop due to the increased water velocity. Furthermore, sediment and nutrient retention will decline because of the reduced residence time of the inflowing water (Table 9).

Another activity which can have drastic effects on the ground water in wetlands, is the

Table 9: Simplified overview of the negative consequences of man-induced modifications in wetland ecosystems.

Form of wetland disruption ↓ / Expected environmental effect →	Reduced interception	Less infiltration	Reduced winter flow	Increased run-off	Increased stream velocity/flood damage	Reduced run-off	Reduced water storage	Lowered water table	Elevated water table	Deterioration in water quality	Desertification/dessication	Substrate disruption	Silt transport/soil loss	Bank erosion	Gully erosion	Lowered productivity	Wildlife disruption/habitat losses
Channelization/excavation	*	*	*	*	*		*	*		*		*	*	*			*
Over-drainage	*	*	*	*	*		*	*		*	*	*	*				*
Crop production	*	*	*	*	*		*	*		*	*	*	*			*	*
Pasture production							*	*		*							*
Over-grazing	*	*	*	*	*		*	*		*	*	*	*		*	*	*
Burning	*	*	*	*			*	*			*					*	*
Afforestation	*		*		*	*	*	*					*				*
Road Construction									*			*					*
Dam Construction			*			*			*								*
Water Abstraction			*			*	*	*		*	*						
Waste Disposal										*						*	*

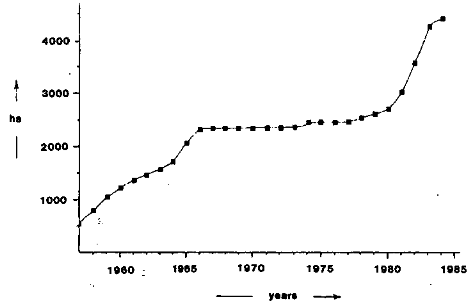


Fig.16 The rate of afforestation with pine trees on the eastern shores of St. Lucia over the last 28 years.

practice of burning. For example, at the Grasslands Research Station in Zimbabwe it has been shown that the groundwater level drops after burning. This was caused through the heavy moisture losses incurred through evaporation from the blackened surface of the wetland, and regeneration of the vegetation. Regular burning is also associated with a gradual decline in organic matter in the wetland soil, and this leads to lower productivity and less moisture retention (196).

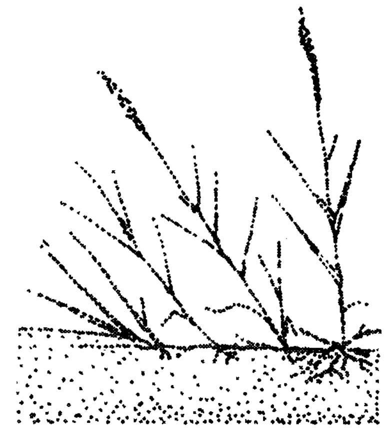
The afforestation of wetlands has adverse effects on the water yeild of a catchment, and yet in Natal many wetlands have been planted with gum, pine and poplar trees. For example, 90% of the 3 000 ha of poplar trees grown in Natal, have been established in wetland areas (158). Furthermore, in certain areas such as the eastern shores of St. Lucia, the Directorate of Forestry have seen fit to more than double the area of pine plantations in recent years (Fig. 16). The conculsions of the Commission of Enquiry (106) (see Chapter 3, Sect. 3.2.3) on the afforestation of wetlands; opinions on water balance on the eastern shores (179); and the known dubious economic return from pine trees grown in nutrient-deficient soils (and only harvested after 20—25 years), all seem to have been overlooked.

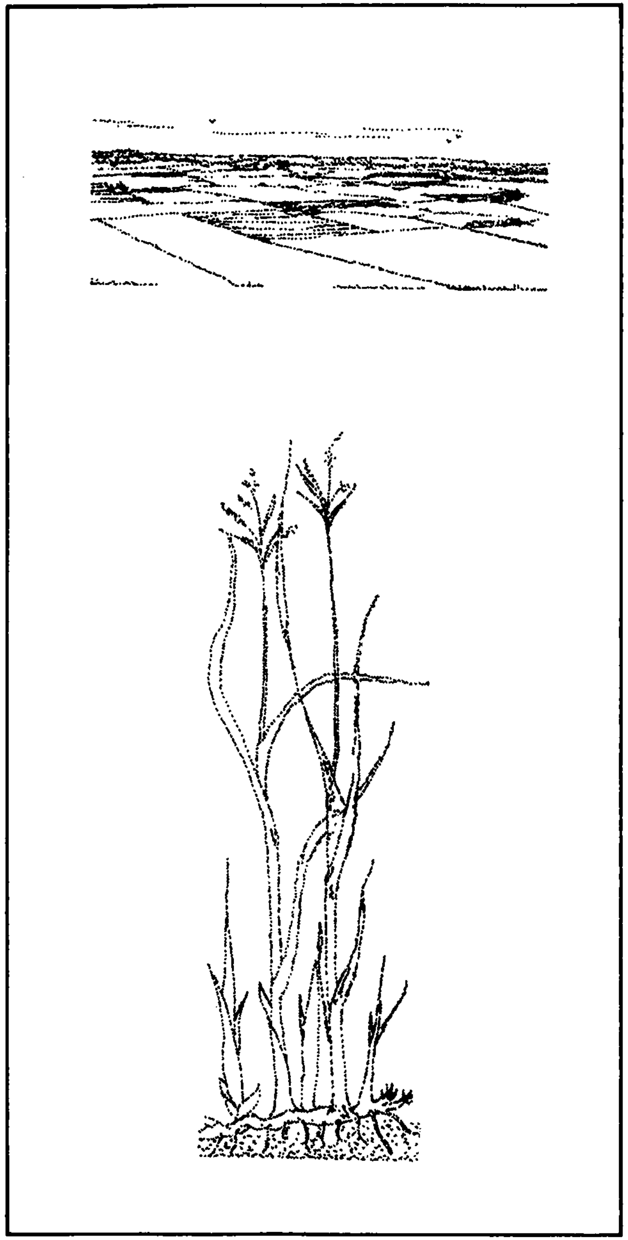
The mosaic of wetlands on the eastern shores of St. Lucia has been transformed in the process, with the result that habitat diversity has declined, and in times of drought, it is likely that important seepage of fresh water from the eastern shores towards the lake will similarly diminish. This state of affairs illustrates that divergent and myoptic attitudes at a decision-making level to the management of a multi-purpose area such as the eastern shores of St. Lucia, contribute to the declining status of wetlands in Natal. Another example is the establishment of industries such as saw-mills and paper-mills to stimulate the economy of certain regions. This appears to be being done without consideration for the wetlands (and water resources) that will be lost in the process, when vast areas of land have to be planted with trees in order to supply these industries with raw materials. At the moment, 10 000 ha of wetland-rich land south of Sodwana is said to be threatened by this very situation.

When one considers that the "art" of road building lies in the selection of low-lying areas in which to place "fill" that has been "cut" from higher ground, wetlands are particularly vulnerable during road construction, simply because they occur in low-lying terrain. Road building has led to the disruption of many wetlands in Natal, but particularly those within the coastal lowlands (23). On the other hand, in some areas where drainage has become impeded by road building materials, small wetlands have been inadvertently formed. In other cases bridge design has not taken account of ecological requirements, with the result that plant communities, intolerant of permanent inundation, have died. The mangrove swamps alongside the Mgobezeleni estuary provide an example (40), as do the swamp forests surrounding Lake Shazibe and parts of Lake Nhlabane (see end map for locations). The solid causeways that are built across floodplains to serve as the approaches to bridges, invariably infill wetlands and disrupt drainage patterns. Thus, the process of wetland degradation takes many different forms.

Apart from activities such as these, which have already had an adverse effect on the status of wetlands in Natal, various impending developments also threaten their future. For example, cultivation of the Mgeni Vlei has often been considered despite the knowledge that thousands of people in Pietermaritzburg and Durban depend upon an assured yeild of potable water from this catchment. Aquaculture and the growing of rice in the Mosi Swamps (see Fig. 13) is being contemplated in certain circles, and an increased demand upon Franklin Vlei for irrigation purposes is developing. In each case further disruption of Natal's existing wetland resources are implied, and further problems are likely to materialise downstream.

To make matters worse, it is well known that very few of Natal's wetlands are in State ownership (158), although in relatively recent times the Natal Parks Board has taken over the control of Stillerust Vlei (near Kamberg), half of the Mvoti Vlei (near Greytown), "the Swamp" (in the Pevensey area), a series of four wetlands (in the Coleford Nature Reserve), a small wetland area near Himeville (94), and a number of wetland — dominated nature reserves on the coast; such as the Mhlanga Lagoon and the Beachwood Mangrove Reserves. They have also partially secured the safety of wetland sites in the 78 nature conservancies of Natal (109), and are exploring the prospect of taking control over Bloodriver Vlei (46) (see Fig. 11).





The conservation status of wetlands in Maputaland (see Fig. 13) seems, on the whole, to be good, despite the fact that most of the Mkuze swamps are included in the S.A. Defence Force missile range. Although a fire swept through part of the swamps on one occasion, missile testing does not seem to have done any harm, except to disturb the breeding of colonial waterbirds at certain times. In fact, by excluding people from the area, "military protection" of the Mkuze swamps, has probably benefitted the system as a whole. Of far greater significance is a 13,5 km canal dug through the Mkuze swamps in 1971 (173) in an attempt to by-pass the swamps, and take water from the Mkuze river directly into the lake at a time when freshwater inflows were so low that the lake was hypersaline. In retrospect, it is clear that the canal has had no benefit at all. Instead, it has created severe bank erosion problems below Mpempe pan (its point of offtake), and a degree of human reliance upon it (for stock-watering) that will be difficult to remedy in the future.

Thus the status of wetlands in Natal is far from secure and their ultimate fate needs to be decided, but the tragedy is that so much of this has already been said before (Table 10). In other words, it is quite clear from what has already been written about wetlands in Natal, that the gravest of concern about their declining status exists. Furthermore, the views expressed emanate from a wide variety of sources, but they all seem to have been ignored.

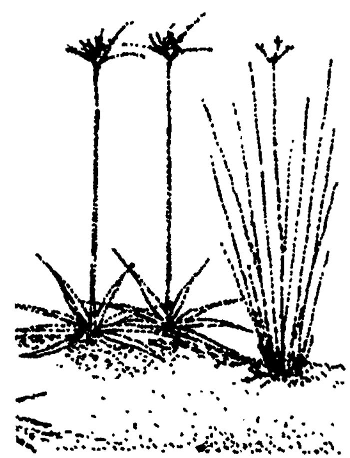
These range from an official Commission of Enquiry into Water matters (106), to Government organizations concerned with the formulation of legislation (61, 168), to academic institutions concerned with hydrological (151) and water quality matters (38), to consultants (31, 197), to ornithological institutions (113) and various other organisations deeply concerned about the conservation of natural resources (7, 95, 206).

One would like to think that there was no better way open to these persons of communicating their concerns than by writing about them, and yet their impact seems to have been negligible. Unfortunately, the same can also be said for various conferences held in Natal to discuss the future of wetlands, if all the signs of wetland degradation between the "Vlei Symposium" held in 1970 (155), and the "Wetland

Table 10: The status of soil and water conservation in each bioclimatic region of Natal, as seen by the Department of Agriculture (Natal Region) in 1972 (55). The terms 'vlei' and 'bottomlands' adopted throughout Table 10 mean wetland.

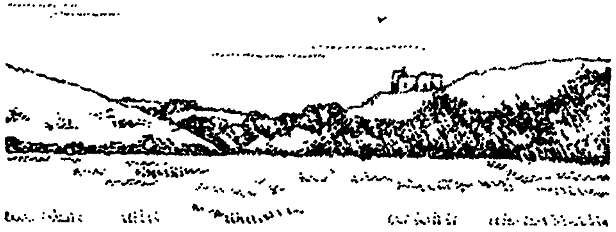
Bioclimatic Region*	Soil & Water Conservation Status in 1972
1	Cultivation of fertile bottomlands (river alluvium and vleis) without planning has led to erosion, changes in drainage channel features and damage to crops.
2	Water resources are inadequately planned.
3	Development of water resources needs planning.
4	Vleis have been extensively developed for the establishment of pastures. Little is done about conservation because of dubious economic returns.
5	Careful protection, conservation and control of water resources should be given high priority.
6	The vlei areas require careful management and protection.
7	General management and conservation status of this area is poor.
8	Vleis should be completely protected and those eroded, reclaimed.
9	Development of water supplies require careful planning.
10	Over 90% of the vlei areas have been severely gully eroded. Bottomlands should be totally protected, and reclamation of denuded areas given high priority.
11	Erosion is widespread in many parts, especially the bottomlands (vlei areas).

*see Fig. 10.



Symposium" held in 1983 (89), are taken as an indication of progress in the last 15 years. Clearly, there is still much to be achieved in South Africa before wetlands can enjoy the status of those in Switzerland for example, where, during the course of constructing Zurich Airport, instead of infilling the wetlands affected, a program of wetland transplantation was implemented (100).

In conclusion, stemming the process of wetland degradation, at this late stage, is no easy matter. This is because many forms of wetland exploitation that have been shown to be harmful in the long term have acquired a semi-legitimate status amongst wetland regulators, despite the practice being forbidden by law (168), and the warnings sounded above.



'A time will come when nature will take vengeance on human beings for their unreasonable attitude towards it."

(F. Engels)

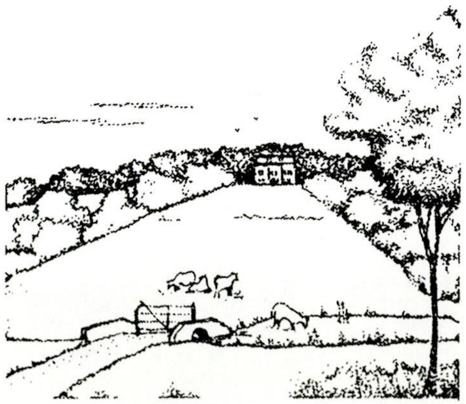
Chapter 6

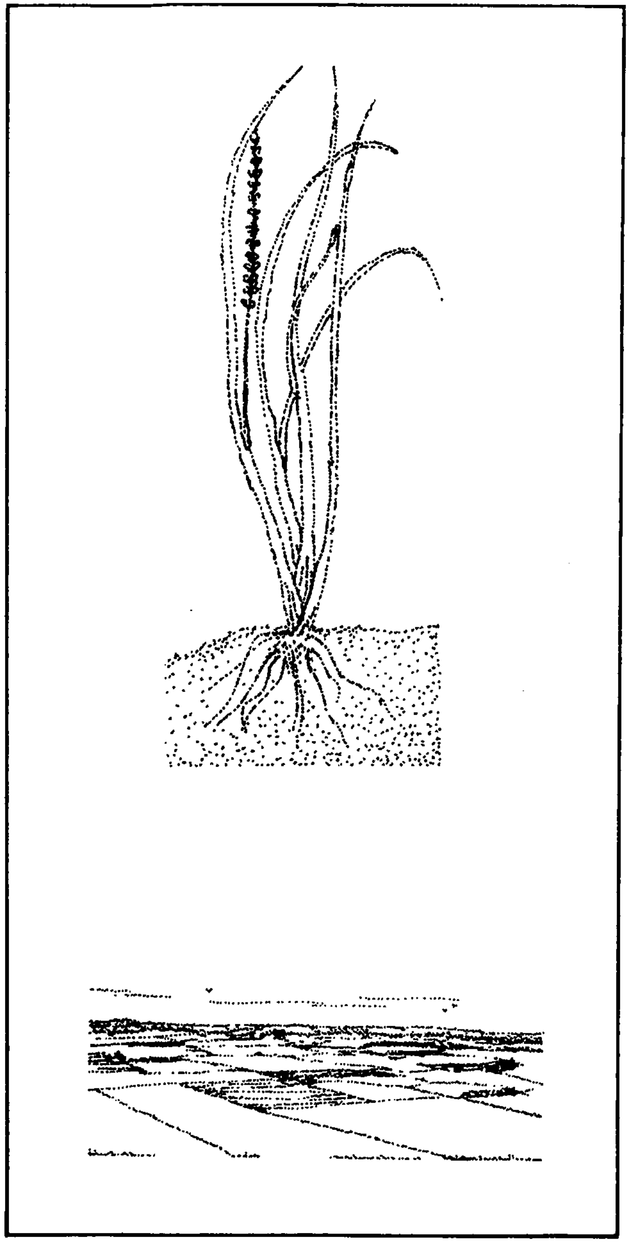
An interim strategy for wetland protection

It has been repeatedly stressed in this report that "development" in its various forms has taken little cognisance of the many and varied attributes of wetlands. Although many people have done their best to take these into account, the fact remains that wetlands are not only poorly understood systems, but also complex, because of the numerous factors governing their structure and functioning. It is understandable therefore that, due to this misunderstanding, poor decisions are inevitable. What is worrying is that the consequences of continued wetland mismanagement are now considerable. This is because wetlands are interlinked systems, and the cumulative effects arising from their mismanagement in a catchment are rapidly compounded. As a result the ultimate aim of this study is, above all else, to formulate a management strategy for the wetlands of Natal.

The development of a wetland policy statement and management strategy is contingent upon the reciprocal understanding of the needs of potential users, and the impacts of their actions (37). In view of this, the task requires the compilation of an extensive data base (including information on the distribution, structure, range, functioning and use of wetlands in Natal), and the passage of some 6 — 8 years before the conceptual programme is complete (Chapter 8). The problem is, that in the interim, an enormous amount of damage can be inflicted upon Natal's dwindling wetland resources, many of which have already been severely affected (Chapter 5).

Indeed, judging from the situation in certian parts of the country it is possible that, by the time a policy statement has been formulated, it could well be too late. Clearly,





some sort of interim strategy must be devised to improve the degree of protection currently afforded to the wetlands of Natal, irrespective of their location, size, structure or function.

In recent years, the IUCN have been faced with exactly the same predicament, but have correctly perceived that the most effective way of promoting the conservation of wetlands lies in the development of a publicity campaign (205).

A wide variety of strategies can be employed, including the preparation of posters, leaflets, booklets, audio-visual slide programmes, and the use of media such as newspapers, radio and television. All of these should be pursued to make the general public more aware of the need for wetland conservation, and of the threat to their own welfare if wetland mismanagement continues. Public opinion and ecological consciousness is a powerful instrument that still needs to be used for wetland conservation in South Africa. In principle, once society come to understand and to appreciate the value of wetlands as a common resource (using the above advertising media), wetland degradation should then become perceived as "antisocial". Public opinion is also soon felt in those quarters where decisions are being made, and so greater governmental involvement is likely to follow.

To date, no wetland conservation measure carried out by the State, or any other organisation on an *ad hoc* basis, appears to have had the required impact. If this was the case, the signs of wetland degradation mentioned in Chapter 5 would not have been as evident. The reason seems to be that the plight of wetlands is still poorly understood by the general public. Furthermore, there is widespread ignorance of wetland functions, and of legislation that exists relating to the protection of wetlands. As a result, the damage being done to wetlands is, generally speaking, inadvertent.

A way of remedying this situation lies initially in making a direct appeal to every farm owner in Natal, for the conservation of wetlands.

This suggestion is not as impractical as it may first appear to be.

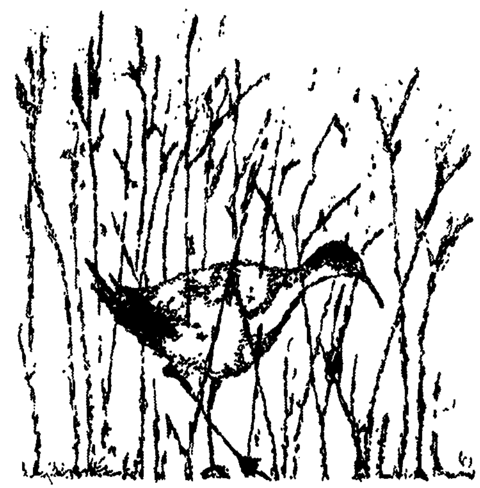
- To begin with, as a result of the "Agri-quest" survey conducted by the Government in recent times, the name and address of every farm owner in Natal is already known, and is computer retrievable. In all, 8 714 persons are involved.

- Secondly, legislation relating to the protection of wetlands has recently been revised, having only come into operation in May 1984 (see Chap. 7). Many persons are probably unaware of the revisions contained in the new Conservation of Agricultural Resources Act, No. 43 of 1983, and would welcome being advised of their existence.
- Thirdly, this study of Natal's wetlands, aimed at the formulation of a management strategy, has commenced. This would be an opportune time to inform the general public of its objectives.
- Finally, the year spent in writing this report should be put to maximum advantage by preparing a brochure on the wetlands of Natal. This could emphasize the role of wetlands, the various threats to their welfare, could mention their declining status, and, for those that may be interested, where a copy of this report could be obtained.

Therefore until such time that a provincial policy statement has been formulated, it is proposed that an information package be assembled, and distributed to every registered farmer in Natal by the Department of Agriculture and Water Supply. This package should contain:

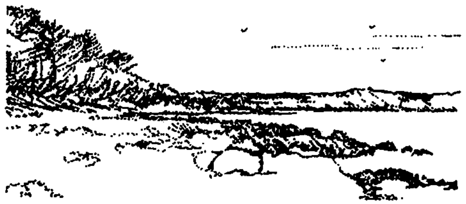
- a letter of appeal from the Director
- a copy of the latest legislation relating to the protection of wetlands, and
- a promotional pamphlet relating to the significance of wetlands in our environment. (see footnote).

Handled in the right way, this could be an effective way of accomplishing the interim protection that Natal's wetlands need. However, time must also be devoted to the holding of meetings and seminars to provide a broad and balanced view about wetlands within both agricultural communities and government agencies seeking to



Footnote: A copy of this brochure is contained in an envelope at the back of the report.

regulate wetland use. In time to come, once the different properties and management needs of Natal's wetlands have been formulated, more appropriate measures will be adopted. These could include refining of the procedural aspects to be followed before development is allowed, and experimentation with wetland rehabilitation to establish whether the regional benefits to be derived from these vital resources could be restored.



Chapter 7

Legislation for wetland protection

At present there are seven major Acts and two Ordinances relevant to the management and control of wetlands in Natal.

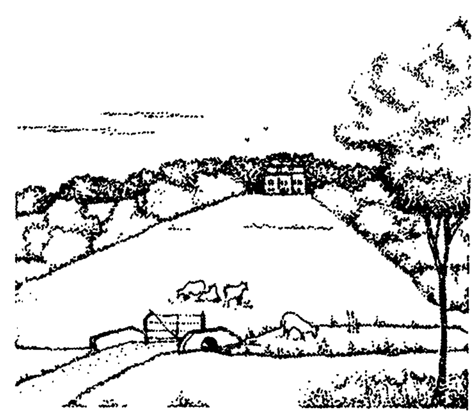
7. 1 Conservation of Agricultural Resources Act, No. 43 of 1983.

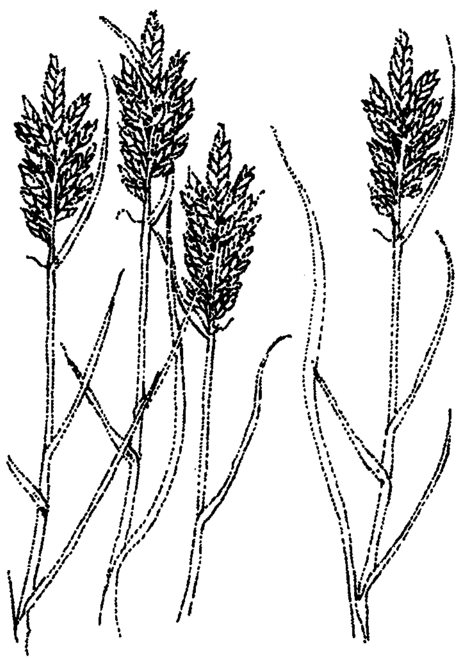
This Act, which is administered by the Department of Agricultural Economics and Marketing, came into operation on the 26 May 1984, and superseded the Soil Conservation Act, No. 76 of 1969 (168). Among the various amendments made were those relating to the protection of wetlands, since the only former provisions in this regard were appended to Act, No. 76 of 1969 as "guidelines". However, in Act No. 43 of 1983, these guidelines became modified and embodied into the text of the new Act.

Regulation 7 (3) of the present Act specifically provides for the "utilisation and protection of vleis, marshes, water sponges and watercourses". It reads:
"except on authority of a written permission by the Executive Officer, no land user shall

a) drain or cultivate any vlei, marsh or water sponge or portion thereof on his farm unit,
b) or cultivate any land on his farm unit within the flood area* of a watercourse, or within 10 m horizontally outside the flood area of a water course".

(*defined as the 1:10 year flood line)





The Act also says (in sub-regulation 4) that providing there are no signs of excessive soil erosion within these areas, the above prohibition shall not apply where wetlands or flood areas of a watercourse that have already been drained, or were under cultivation on the date of commencement of these regulations.

Indications such as these suggest that the Government presently recognizes wetlands as a multiple-use resource, and are firmly committed to their conservation. For example, heavier penalties (of up to R10 000 or 4 years imprisonment) now apply for contravention of these measures. The present legislation also provides for some of the damage that has already been inflicted in wetland and flood prone areas to be remedied.

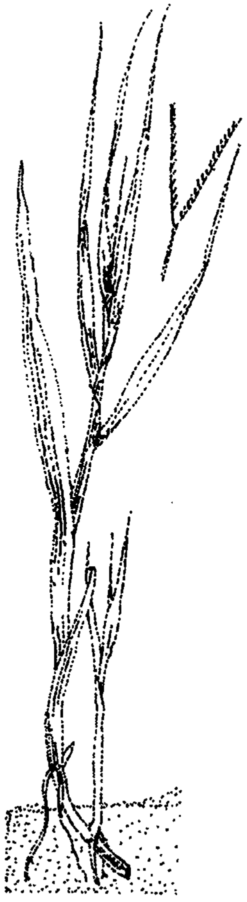
New regional procedures have also been adopted, to deal with applications for the cultivation of wetlands, because prior to this, many wetland areas were developed without Governmental approval or knowledge. A greater measure of control is now seen as a prerequisite by the Department. Its declared policy is that "only under exceptional circumstances will development be permitted", but this remains to be seen.

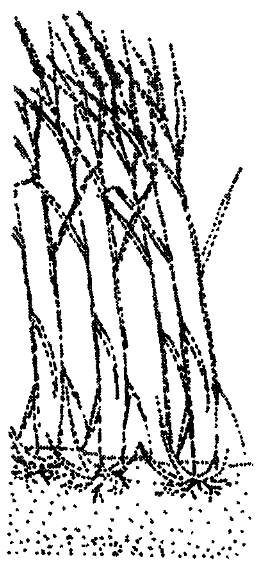
In theory, the legislation exists which should ensure that any person wishing to drain or cultivate an area of undisturbed wetland on his farm or engage in such activities within 10 m of the 1:10 year flood line of a watercourse, has to apply for permission through the Department of Agriculture and Water Supply. A soil conservation officer would then examine the site (in his executive capacity) to decide whether this activity should or should not be permitted. As advised by Scotney (154), the officer would presumably determine the purpose of the drainage system, the outlet depth, the ruling gradient, the topsoil and subsoil characteristics, the crops to be grown, examine the topography of the catchment and sources of seepage.

In practice however, difficulties arising from the interpretation of the legislation exist. Witness to this is the recent excavation of a 3m deep drain through 400m of Franklin Vlei, in East Griqualand (Plate 5). Although no permission was given to the farmer concerned to excavate this trench, there is at present no proof that it has caused lateral drainage of the soil (Wilby, pers. comm.)

This situation demonstrates that the act of digging a trench through a wetland without permission is still not necessarily a contravention of regulation 7 (3) of the Act. The reason for this is because the word "drain" has not been defined. One would presume a dictionary would be used for this purpose ("to draw liquid off or away by a conduit; to dry land by withdrawing moisture; to carry off superfluous water") but then, the wording "a vlei, marsh or water sponge", would also need to be defined before a case would stand up to cross examination in court. In passing, it should be noted, however, that the word "cultivate" in Act 43 is said to mean "to mechanically disturb" (168), and so the act of digging a trench through Franklin Vlei could be regarded as mechanical

Plate 5 A view of the controversial 3m deep trench dug without reference to anyone through 400m of Franklin Vlei.
(Photo: C. Wright pers. comm.)





disturbance. Preparing the foundations for a dam wall could also be regarded as mechanical disturbance, however, the purpose of highlighting this is to show how difficult it is to apply the legislation, as well as to show that these difficulties are symptomatic of the inadequacy of our basic understanding of wetland ecosystems.

Another area of the Act open to misinterpretation is in regulation 7 (2), which stipulates that:

"every land user shall remove the vegetation in a watercourse on his farm unit to such an extent that it will not constitute an obstruction during a flood that could cause excessive soil loss as a result of erosion through the action of water".

The rationale behind the insertion of this requirement is debateable, but the problem is that it allows a farmer the right to remove vegetation in potentially wet and flood prone areas. In fact, use of the word "shall" makes it obligatory to do so, but activities of this nature would be environmentally damaging because of the downstream consequences of removing this vegetation. Furthermore, the passage of water through the dense plant mass associated with wetlands is crucial for the attenuation of silt and flood water, and for the wetland to perform its natural hydrological functions (see Section 3.1).

There is no specific provision in the Act to control grazing in vleis, and yet this can be a major reason for the degradation of wetlands (196). However, it should be noted that sub-regulation 7 (1) states "no land user shall *utilise* the vegetation in a vlei . . . ." in such a way as to cause the deterioration of, or damage to, agricultural resources. This could cover the problem of over-grazing.

Regulations within the Conservation of Agricultural Resources Act 43 of 1983, which do have a potential to influence the conservation status of wetlands are:

- Regulation 2 (1) which reads:

  "Except on authority of a written permission by the executive officer, no land user shall cultivate any virgin soil . . . ."

Just like any other form of undisturbed land, wetlands can be regarded as virgin soil, and thereby afforded 'blanket protection' from cultivation by the application of this particular regulation.

- Regulation 8 (5). This reads:

  "no land user shall remove or alter any obstruction in the natural flow pattern of run off water on his farm unit, if such removal or alteration will result in excessive soil loss due to erosion . . . .".

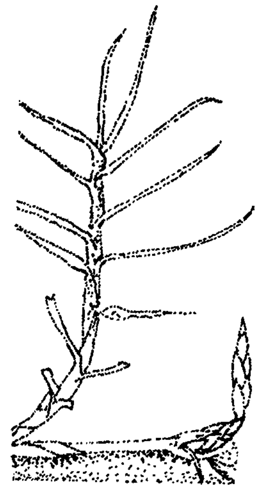
  More often than not, wetlands are areas in which drainage has been impeded by a natural obstruction, such as a dyke, or a sill across the flow path of a stream. The removal of these natural barriers would greatly alter the physical condition of the wetland, as well as its functioning (Section 3.4), and so the above regulation is seen as a potential means of preventing this from happening.

- Regulation 12 (1) also reads:

  "Except in authority of a written permission by the executive officer, no land user shall —

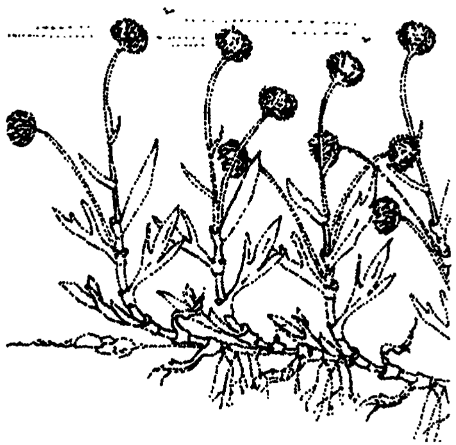
  a) burn any veld on his farm unit.

Although "vlei burning" is a traditional veld management practice on many farms, there is evidence to suggest that this can be harmful in the long term (Chap. 5). Further research is required (Chap. 8), but in the interim, it seems that the means by which the indiscriminate burning of wetlands can be prevented by legislation, do exist. Whether they are implemented, or not, is another matter.



7. 2 Forest Act, No. 122 of 1984

This Act, which is administered by the Department of Environment Affairs came into operation on the 29 August 1984 (169) and superseded the Forest Act 72 of 1968. Prior to this the (then) Department of Forestry's in-house policy was that no afforestation should be allowed "in or within 20 m of the edges of vleis, marshes and swamps", but there is nothing in the present Act which gives specific protection to



these areas. Regulation 8 (1) provides for the prohibition of tree planting or reafforestation within certain areas (which have to be defined by the Minister by notice in the Gazette) as "necessary for the protection of any natural source of water".

However, this requirement relies heavily upon the judgement of the forest officer appointed by the Minister to assess whether a specific area constitutes a natural source of water. He is expected firstly to decide whether the area concerned is a wetland; secondly, to evaluate its hydrological significance; and thirdly, to judge the distance from the wetland to which afforestation could be allowed.

The ability of each Officer to make these sort of decisions will vary from one person to the next. Thus, as in the previous case where Extension Officers from the Department of Agriculture were similarly implicated, the suggestion to compile an inventory of Natal's wetlands, as an aid to State officials in the field, could be an invaluable product of the envisaged research program (Chap. 8).

It has been claimed that at present the Forest Act is again under revision and, that amongst the changes being considered, is provision for the removal of trees in wetland areas (Owen, pers. comm.).

7.3 The Mountain Catchment Areas Act, No. 63 of 1970

Administered by the Department of Environment Affairs, the above Act is there to provide for the conservation, use, management and control of land situated within declared "mountain catchment areas". Particular emphasis is placed on the prevention of soil erosion, and the protection of natural vegetation through the control of fire (166).

Despite the fact that water yield is not mentioned in the Act as one of the reasons for its existence, the Mountain Catchment Areas Act is an important piece of legislation. This is because of the significance of the water which mountain areas generate, and the fact that the pattern of flow and water quality of rivers, is dependent to a large extent, upon the integrity of high altitude wetlands.

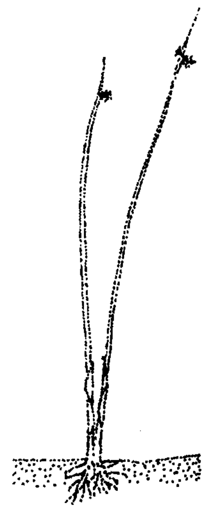
At present, there is no land declared as "mountain catchment areas" in Natal, but this is because virtually the whole of the Drakensberg is State-owned (Table 11). Apart from melting snow, those rivers that rise in the Drakensberg are fed by the springs, bogs and sponges that form on the slopes of these mountains. These in turn, owe their permanence to the high rainfall (on average 700 — 1 800 mm per annum) which falls in the Drakensberg, due to the effect these mountains have on rain-producing air masses that move inland from the sea.

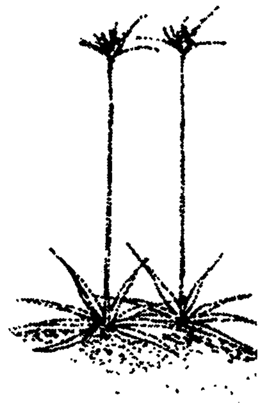
The Drakensberg mountains were singled out as a water production area of national importance as long ago as 1940. It is the area of highest precipitation in Natal, and therefore a major source of water. The need to protect the mountain slopes led to the production in 1974 of the Drakensberg Policy Statement.

Table 11: State ownership of the Drakensberg in Natal, up to the edge of the administrative catchment boundary.

Controlling Authority		Area (ha)
Department of Environment Affairs		168 773
Natal Parks Board		48 278
KwaZulu		60 450
Private*	ca.	19 000
Total		296 501

(* To be purchases shortly by the State)
(Data provided by D. MacDevette, pers. comm.)





This defined the location of water production areas, restricted human activity to research and hiking, restricted agriculture and silviculture and resulted in acquisition of the mountains (if necessary, through expropriation) by the State. At present, the Department of Environment Affairs administers the land according to accepted policies which have the goals of maximising vegetal cover, of de-afforestation, rehabilitation of degraded areas, and reducing agriculture pressures on the land.

State ownership of the Drakensberg means that the headwaters of some of the largest river systems in Natal (Mzimkulu, Mkomazi, and Tugela) are protected, but the headwaters of Natal's smaller rivers receive no such benefit. The Karkloof Mountains on the divide between the Mooi and the Mgeni catchments; and the Ingele Mountains, at the headwaters of the Mtamvuma, serve as examples.

One of the failings of the Act is that the protection it could potentially afford to wetlands ends at the prescribed "administrative catchment boundary". In other words, although this Act recognises the need to protect the headwaters of streams and rivers, there is still no defined policy for river systems or entire catchments as a whole.

Another problem is that mountain catchment areas must have a low agricultural potential before they can be declared as such.

Thus, for important rivers such as the Mgeni and Mvoti for example, which have their headwaters in the Natal Midlands, no protection could be afforded to them by the Mountain Catchment Areas Act.

7.4 Water Act, No. 54 of 1956 and Water Amendment Act, No. 96 of 1984

These Acts which are administered by the Department of Water Affairs, regulate the utilisation of public water, and a number of authorities such as Irrigation and Water Boards exercise this control (164).

Three specific regulations within these Acts have potential to influence the conservation status of wetlands. They are:

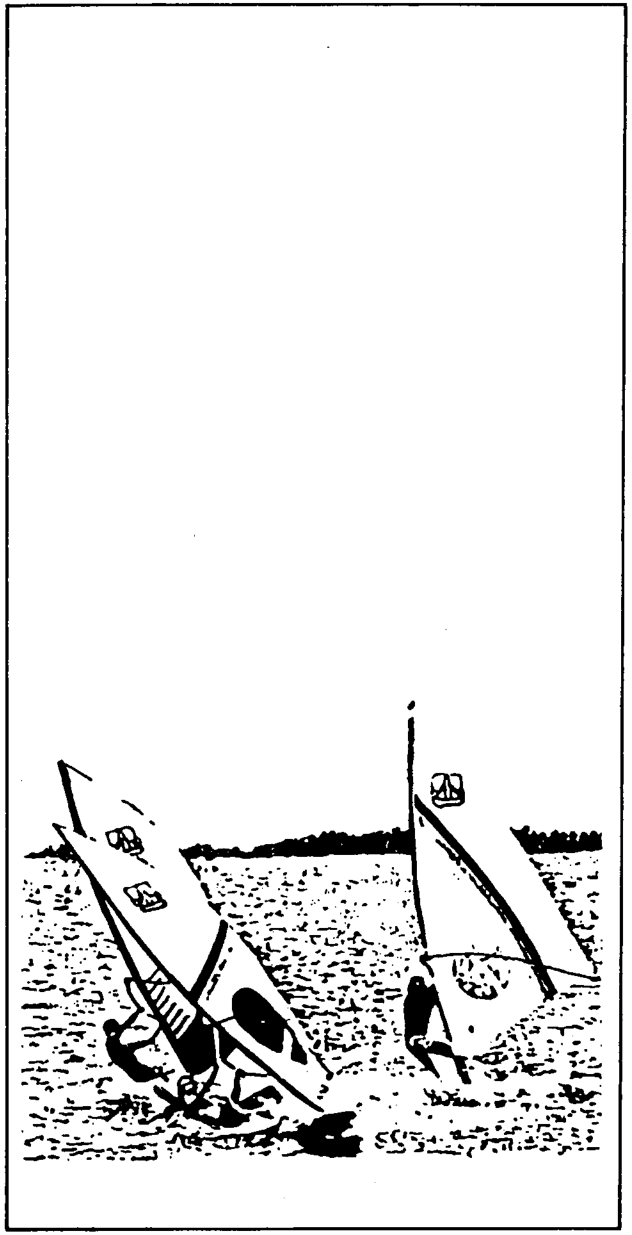
> Sect 28 of Act No. 54, relating to the proclamation of "subterranean water control areas" (aimed at controlling the abstraction of water *naturally existing* underground).
>
> Sect 59 of Act No. 54, relating to the protection of *any portion* of the catchment area of a public stream. This entitles the Governor-General to declare the channel of any public stream, together with land on either side, or any other area situated within the catchment.... to be a "catchment control area", if for example this is seen to be necessary to prevent flood damage and control silt. Clearly, wetlands should be given high priority in this regard.
>
> Sect 10 of Act No. 96, and Sect 20 of Act No. 54, both of which make provision for altering the course of a public stream without the permission of the Minister of Environment Affairs.

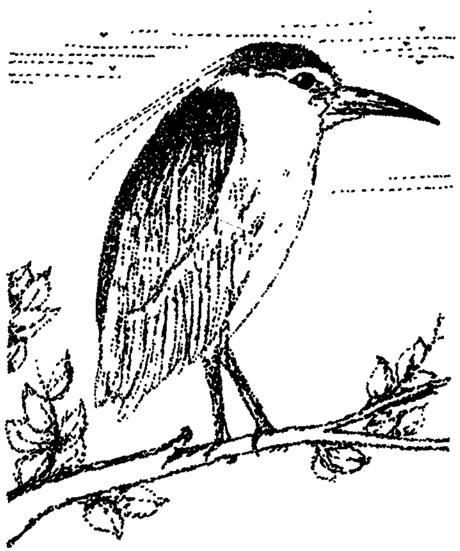
At present there are 31 Irrigation Boards in Natal, the objectives of which are to build up the storage capacity of dams for irrigation purposes, through the regulation of river flow. The legislation entitles water users (such as farmers) to abstract up to 110 litres of water per second from rivers and build dams with a total storage capacity of less than 250 000 m^3 without requiring a permit.

7. 5 Lake Areas Development Act, No. 39 of 1975

From the point of view of wetland conservation the above Act has relevance because it is aimed at the control of development in land comprising or adjoining tidal waters. It also affects land comprising or adjoining a natural lake or river (or any part thereof) in the immediate vicinity of such tidal waters (167) within a proclaimed lake area.

Once declared a lake area in terms of the above Act, extensive control of land use





practices within the proclaimed area becomes possible. Although this Act affords a degree of protection to wetland ecosystems in declared Lake areas, no lake areas have yet been delcared along the Natal coast.

Therefore, no coastal wetlands (such as reedswamps, mangrove swamps and various sedge communities) have derived any protection from the Act to date, despite their great significance in the productivity of estuaries and lagoons throughout Natal. The reason is because the Natal Provincial Administration have opted for cohesive control of the entire coastline, rather than fragmenting control of the coastline by declaring portions of it lake areas.

7. 6 Physical Planning Act, No. 88 of 1967

After consultation with a variety of Departments and administrative bodies, this Act enables the Minister of Constitutional Development and Planning to reserve land as a nature area. This means "any area which could be utilised in the interests of, and for the benefit and enjoyment of the public in general; and for the reproduction, protection or preservation of animal life . . . ." (165).

The Physical Planning Act could therefore, in certain circumstances, be utilised for the ptotection of wetlands. It could be used for example to protect the Mkuze swamps at the northern end of Lake St Lucia, because these wetlands presently lie in an area under the jurisdiction of three different authorities (173). These are the Natal Parks Board, KwaZulu and the Department of Environment Affairs, each of whom have a different attitude to wetland conservation.

7. 7 Natal Nature Conservation Ordinance, No. 15 of 1974

The Natal Nature Conservation Ordinance 15 of 1974 is administered by the Natal Parks Board, but only regulations 1 and 2 of Section 136 have any bearing on wetlands and wetland conservation (67). This arises through the opportunity riparian owners have of forming themselves into an association known as a *river* conservancy. This means that the affected landowners concern themselves with all matters related to water in these districts. By the term "water" is meant . . ." any stream, river, (lagoon) or creek which is not tidal . . .", and as well as ". . . the foreshore or banks of such waters". This last provision therefore, offers a significant degree of protection to riparian wetlands in areas declared as river conservancies.

The "conservancy movement" in Natal has been an outstanding success, and is something that the Natal Parks Board have every right to be proud of.

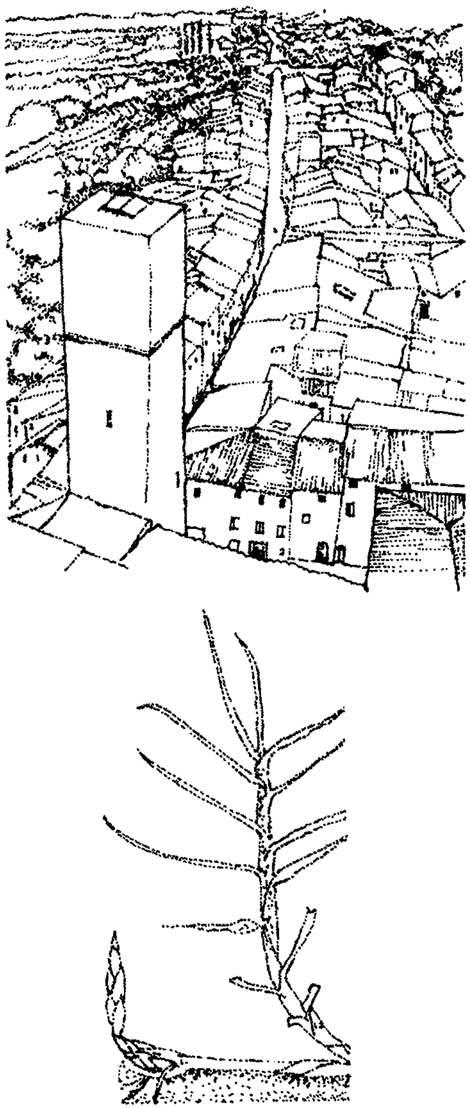
At present there are 78 conservancies in Natal spread over 6547 km^2 of land (109). Plans for each farm in a conservancy are prepared which pruposely demarcate wetland areas. This is done to highlight their significance from a conservation point of view, and to warn of their environment sensitivity. In many respects, therefore, conservancies represents one of the best form of protection presently available to wetland sites in Natal.

The following "vlei (i.e. wetland) management aims" are promoted by the Natal Parks Board (108):

- to prevent any further shrinkage of vlei systems
- to prevent any erosion taking place in the catchment areas above vlei systems
- to restrain domestic stock from entering vlei systems
- to minimize any disturbance in the immediate vicinity of vlei systems, and
- to prevent pollutants (such as fertilizers) from entering vlei systems.

The only problem with these "aims" lies with their wording, because phrased in this manner, they are unachievable. This can be easily remedied by use of the word 'control' instead of 'prevent', but a more difficult problem is that the conservancy system depends upon voluntary compliance. Thus, with a change of ownership the attitude of the farmer can change, and hence the protection afforded to wetlands.

The total area of wetlands in each conservancy differs from one to the next, but one of



the most significant aspects of these developments is the fact that sometimes entire catchments are involved. For example, in the Seaview Conservancy the entire catchments of the Zolwane, Sandlundhlu and Kuboboyi rivers are included, and these incorporate approximately 84 ha of wetlands (110).

7. 8 Town Planning Ordinance, No. 27 of 1949

Many of the provisions in the above ordinance can be used to advantage in Natal's campaign for the protection of wetlands. Most town planning schemes in Natal have adopted the policy of setting aside "river reserves" for aesthetic, ecological, and recreational reasons. The notable "green belt" policies in the Pietermaritzburg and Durban region are examples, in that they are aimed at limiting urbanization and the conservation of watercourses. The tree-lined watercourses around Richards Bay are another example of where town planning policies have been used to environmental advantage.

Finally, virtually all of the policy statements prepared by the Natal Town & Regional Planning Commission (for the eastern shores of St Lucia, the Drakensberg and Natal's estuaries) make provision for wetland protection. Theoretically therefore, both the Administrator of Natal and local authorities have the rights to prevent certain forms of development if natural amenities, such as wetlands, are to be adversely affected.

7. 9 Wetland legislation in KwaZulu and Transkei

In the Transkei the only legislation affording protection to wetlands is the Soil Conservation Act, No. 76 of 1969, which was inherited from South Africa when the Transkei became independent in 1976 (Proctor, pers. comm.). Therefore, the inherent weaknesses of this Act, which necessitated its revision in 1983 (see Sect 7.1) in South Africa, would still pertain to portions of the Umzimkulu catchment presently under the jurisdiction of the Transkei government.

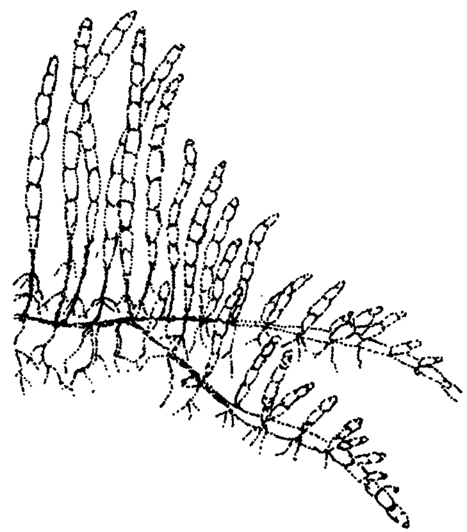
In KwaZulu, the current legislation adopted by the South African government is meant to apply.

7. 10 Concluding remarks

Having briefly reviewed the relevant legislation currently applicable to the conservation of wetlands in Natal, it is clear that numerous factors have prevented this from being particularly effective. These include the granting of executive powers to district Committees unwilling to enact laws amongst themselves; fragmented control; departmental independence; sectional interests; and more recently, sudden changes of responsibility brought about by the present era of "rationalisation" amongst State departments. The "Franklin vlei case" (Sect. 7.1) serves as a good example, because the inflexibility of human attitudes is often regarded as the major cause of wetland degradation (205). However, in the Franklin vlei case it would seem that departmental attitudes also need to change. Wetland management will require a holistic approach to policy making, and at the moment no cohesive policy exists. As a result, fragmented control over resources such as Franklin vlei are a major reason for its present state of disrepair.

So as to capitalise on their valuable hydrological role (see Sect. 3.1) in water purification, water storage, stream flow regulation and flood attenuation, the Water Act needs to make specific reference to wetland protection. The Forest Act needs to do the same thing. When one considers that one of the Departments delegated to administer the Agricultural Resources Act is now the Department of Agriculture *and Water Supply*, the protection of wetlands on hydrological grounds needs to be built into Act No. 43 of 1983. Furthermore, there are two schools of thought as to the manner in which these laws should be applied.

The first of these is voluntary compliance, as the favoured form of approach by Government authorities. Voluntary compliance is based on the belief that public acceptance and support in favour of wetland conservation can be achieved without the enforcement of regulations. Education and persuasion are seen to be key factors

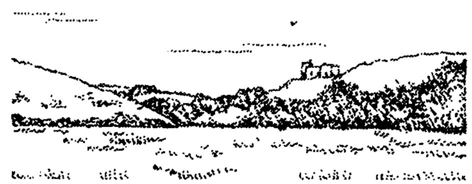


in this process.

However, if the state of confusion over wetland functions, and the degraded condition of Natal's wetlands, are taken as indicators of success in this respect, then one can only conclude that this policy has failed to arouse public consciousness over the last 30 — 40 years.

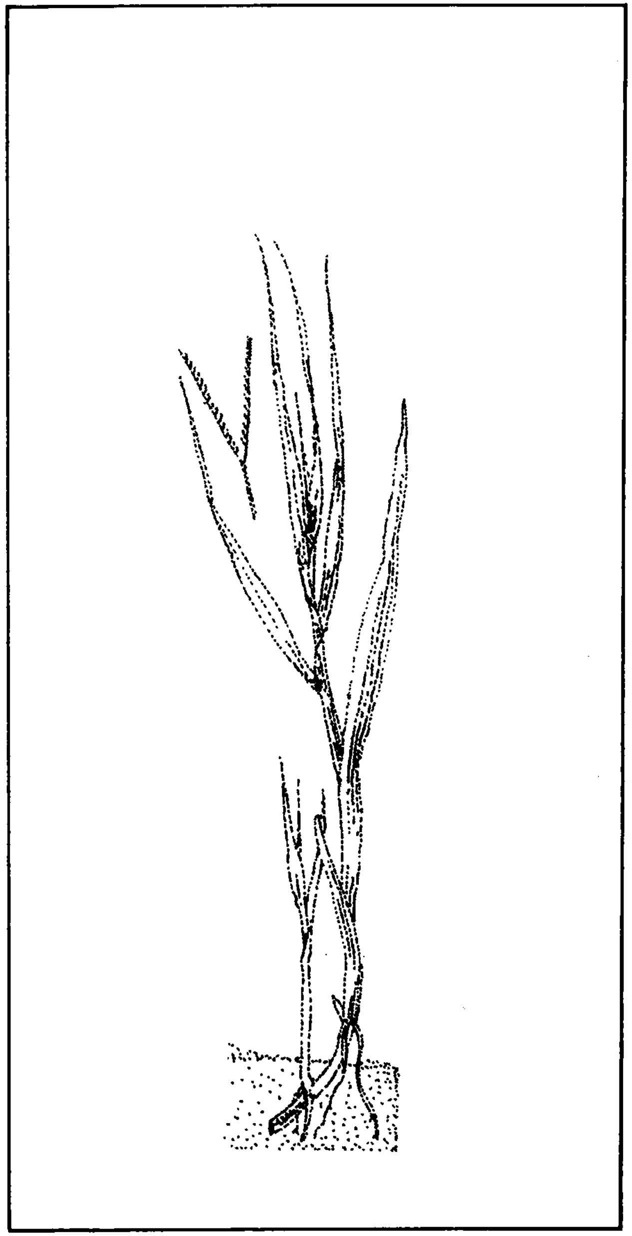
The alternative approach is coercion. This relies upon the enforcement of legislation as a deterrent, and in the circumstances, with so few of Natal's wetlands still functional, seems to be the only option open to the Government. Furthermore, a point that is not generally appreciated by the public is that any individual is entitled to bring transgressions of wetland legislation to the attention of the relevant Government Department. Participation by the public in this way could help enormously in the difficult task of law enforcement (Scotney, pers. comm.). However, the most important requirement of all is more motivated people with a sense of commitment in the extension arena to implement the legislation, and to foster an understanding of wetland functions in the eyes of the public at large. This in turn means that more money needs to be spent on employing such people and on the dissemination of proper advice.

For this reason many people respect the stance adopted by Jimmy Carter for example, when President of the United States of America, who, acting in the best interests of the Nation and, by virtue of the power vested in him, issued an 'executive order' in May 1977 for the protection of wetlands. This was done "in order to avoid the long term and short term adverse impacts associated with the development or modification of wetlands . . .". The point is that the wetlands of South Africa are no less important than those in America, and one can only hope that, in time, similar pronouncements in South Africa may be made.



Chapter 8

Research requirements

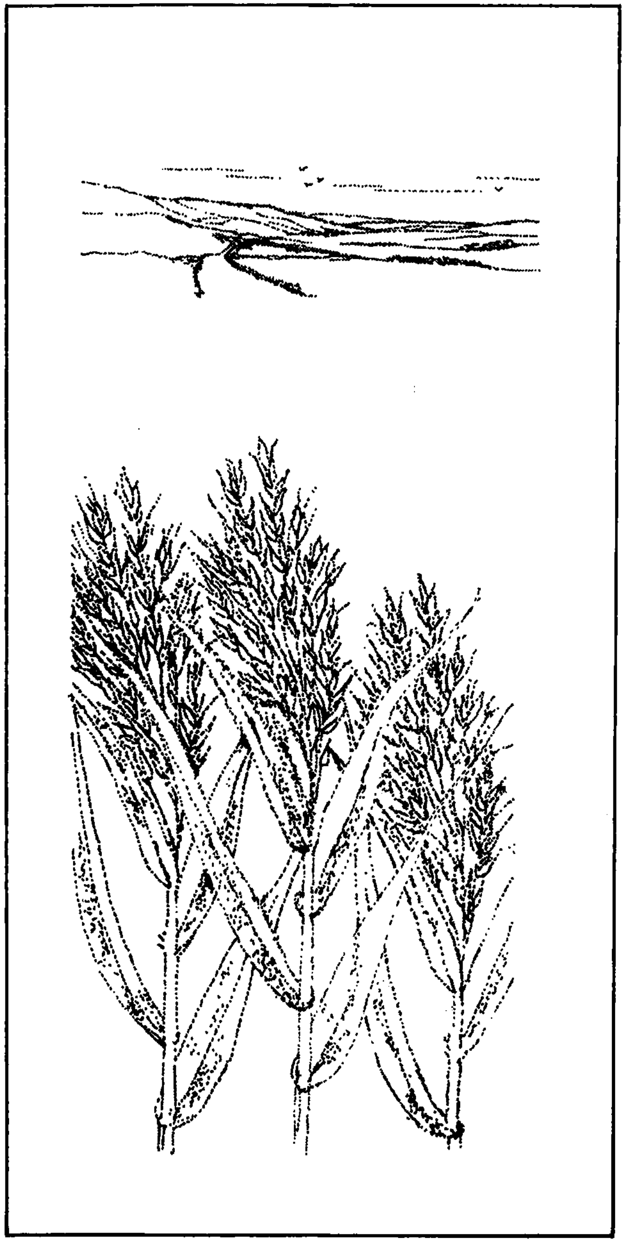


A glance at the list of references (Chapter 9) which accompanies this report, should be enough to demonstrate that little research on wetlands has been conducted in Natal.

It is of paramount importance to remedy this state of affairs, because the temptation to borrow results measured elsewhere can be full of pitfalls, and the prospect of producing a wetland management policy is out of the question without the benefit of this understanding.

This does not mean to imply, however, that the prevention of further wetland deterioration need await the completion of further research. It is infinitely preferable to apply what is already known (193), and simultaneously conduct research that will reinforce or test these conclusions. Considering the "blind eye" that seems to have been turned towards so many persons that have been warned of the long-term consequences of wetland abuse in the past, this is an important point.

The "Master Research Programme No. NW 1" drawn up by Professor P J C Vorster as a "white paper" in 1962 (83), and presented to the Secretary of Water Affairs, is one such reminder. The research objectives and justification for this program are as valid today as they were 23 years ago. The tragedy is that these research aims were only partially fulfilled. Many of them have therefore been resurrected, and purposely embodied in the program proposed below.



8. 1 Inventory

The need to compile an inventory of Natal's wetlands is the most pressing research requirement of all. This has been called for by many persons in the past (155, 174, 122), but for the program specified below will require interdepartmental commitment of adequate resources and manpower (Fig. 17) for approximately 8 years.

A proper inventory of Natal's wetlands should systematically document, on a "drainage region by drainage region" basis (Fig. 18) the present distribution, extent and status of wetlands throughout the Province. The program should include:

a) The mapping of wetlands, using soils as a surrogate data base.
b) Evaluating the present status of each wetland.
c) Evaluating the proportion of wetland cover in each watershed, and the linking of this to assessments of erosion status.
d) The ranking of each wetland in terms of its relative importance in the area under consideration.
e) Collation of the available information on each wetland.
f) The formulation of guidelines which would set out appropriate means of managing wetlands in the future.

In recognition of the widely differing climatic, hydrologic, and topographic influences operative in wetland sites, and the likelihood that each site will perform different roles in the environment, a wetland classification is the second-most important research need in Natal.

8. 2 Classification

A proper classification (177), will serve as the key to determining what sort of wetlands will need to be strictly preserved in the future, as well as which could be used gainfully

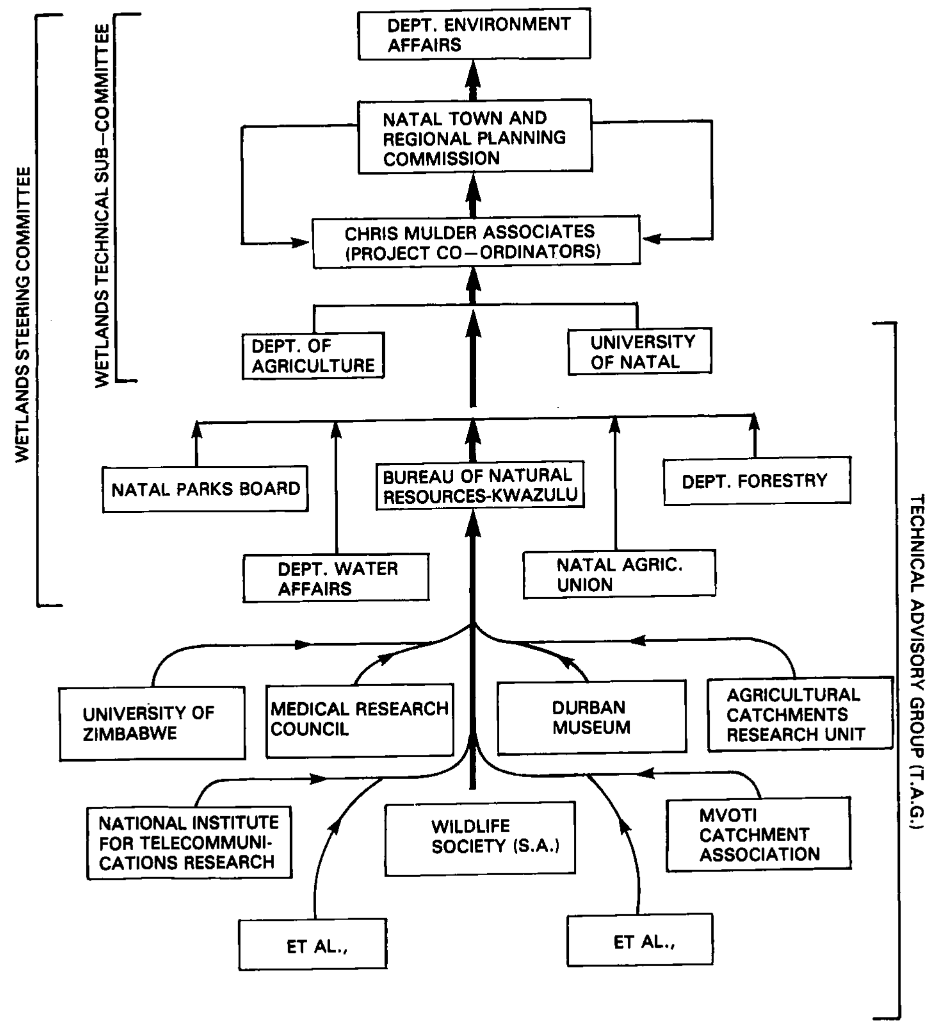


Fig. 17 Organizational diagram of Natal wetland study

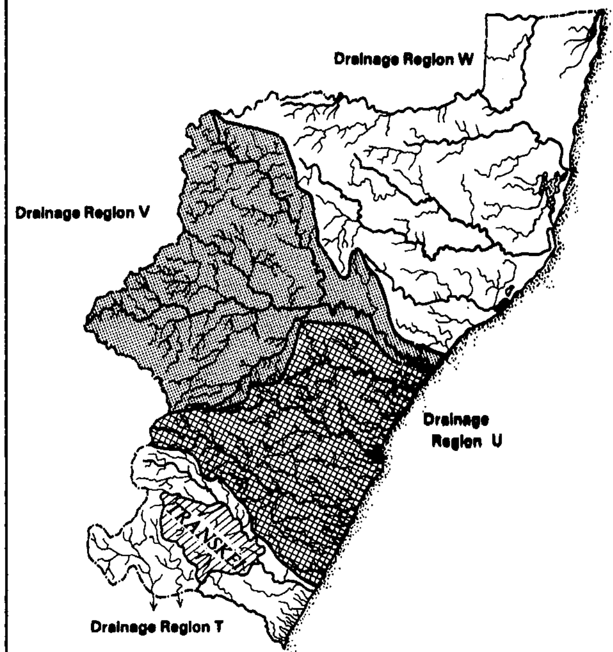
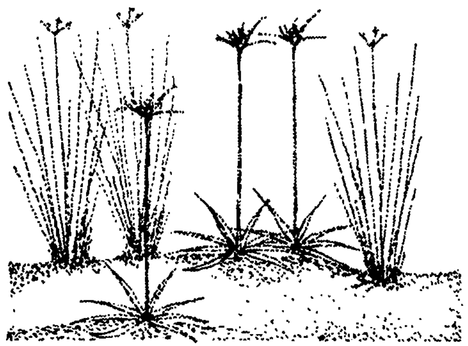


Fig. 18 The sub-division of Natal into four drainage regions, in accordance with the system adopted by the Dept. of Water Affairs.



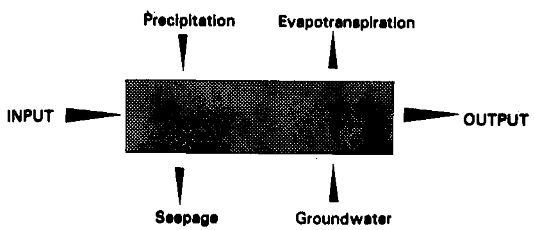


Fig. 19 A conceptual model of the "water balance" operative in a wetland.

for some specific economic purpose. It would thus be of tremendous assistance in the formulation and implementation of a wetlands policy statement.

In the belief that plant community structure is an outward reflection of the physical and chemical processes operative in wetlands (76) the research program will, of necessity, require:

a) The gathering of data on vegetational differences between wetlands.
b) The gathering of basic data such as soils, soil moisture, micro-climate, and slope.
c) A multi-variate approach to the analysis of these data.

This research will provide the means for monitoring change in the future, and evaluating the sensitivity of wetlands to cetain forms of perturbation.

8. 3 Hydrology of wetlands

In a country as deficient in water as South Africa, decisions on the uses of water should not be made lightly, or without proper factual information. Therefore, in order to strengthen the present understanding of the hydrological processes operative in Natal's wetlands, the following research topics deserve high priority. Most of these relate to quantification of the water balance in wetlands (Fig. 19), and will require the installation of instruments designed to measure stream flow and climatic conditions.

The program should make provision for the collection of data on:

a) Evapotranspiration.
   - from natural wetland vegetation
   - from commercial crops established in wetland sites
b) Soil moisture relationships in wetland sites.
c) Inflow around the perimeter of wetlands.

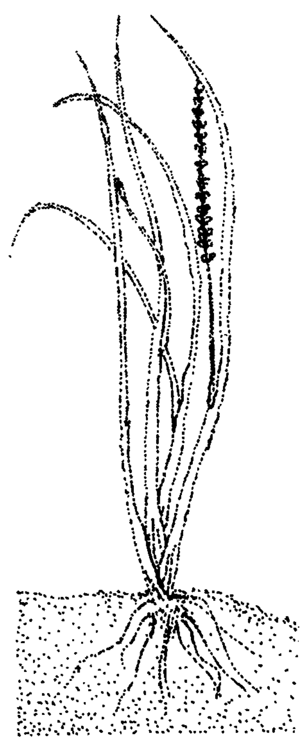
d) Stream flow into and out of wetlands.
e) The macroclimate and microclimate of wetlands.
f) The hydrologic effects of intensified agriculture in wetland sites.
g) The hydrologic effects of afforestation in wetland sites.
h) The comparative hydrology of disturbed and undisturbed wetlands.
i) The effectivity of wetlands in flood attenuation.
j) The influence of wetlands on streamflow regulation.

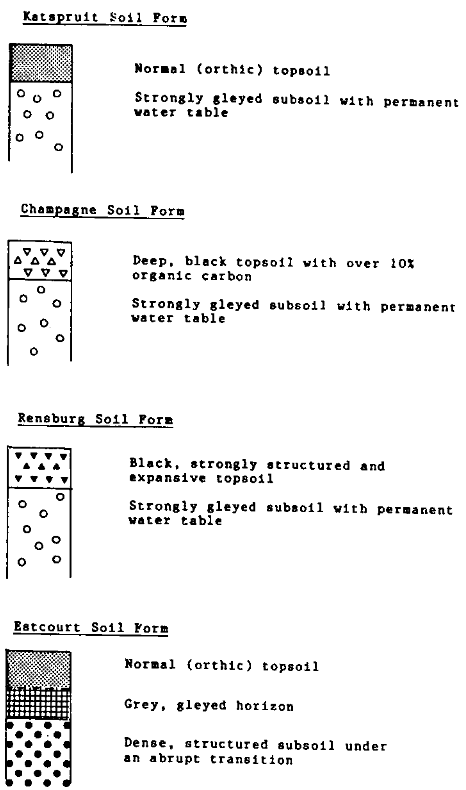
8. 4 The effects of wetlands on water purification

Wetlands are known to be natural water purifying systems with a capacity that cannot be simulated by man-made treatment schemes (Section 3.1.4, Chap. 3), and yet there are few locally-derived data to support this point of view. With diffuse pollution becoming increasingly difficult to control, and potable supplies of water becoming an increasingly important issue in rural areas, research directed towards demonstrating the water cleansing properties of wetlands warrants immediate attention. For similar reasons, research aimed at quantifying the optimum wetland cover for specific catchments would also be essential.

The program should include:

a) Studies of the chemical transformations taking place within wetlands representative of the types revealed by classification (see 8.2).
b) Comparative studies of the water quality of wetlands in which the residence time differs.
c) Studies on the removal efficiency of wetlands, with particular reference to sites receiving sewage laden effluents.
d) Assessments of the downstream effects on water quality of intensified agriculture in wetland sites, and especially where irrigation is involved.





e) Comparative studies of water quality in 'wetland-poor' and 'wetland-rich' watersheds, ideally located adjacent to one another.

8. 5 The effects of wetlands on sediment accretion

Wetlands are known to play a crucial role as intercepting agents in any catchment prone to soil loss (see Section 3.1.4.2, Chap. 3). Since soil erosion and siltation are acute problems in Natal, research that would demonstrate the role that wetlands play in attenuating these processes should be encouraged.

The envisaged program should include:

a) Measurements of the grain size distribution of the deopsited material in wetlands.

b) Measurements relating to the effect of the size of wetlands as a function of the mean annual runoff.

c) Measurements of the rate of sediment accretion, and of any changes in the functioning of the system, relating to this process.

d) Determinations of the ratio between wetland size and mean annual runoff on the siltation rate.

e) Comparative studies of accretion rates in wetlands of varying land use.

f) Comparative measurements of the sediment yield in 'wetland rich' and 'wetland poor' catchments.

g) Geological and geomorphological studies of wetland sediments to account for their origins, and to explain their dynamics.

h) Elucidation of the consequences of sediment accretion for wetland hydrology.

8. 6 Cost-benefit analysis

Considering the present economic returns derived from the exploitation of wetlands (Section 3.2, Chap. 3), there is an urgent need for a more holistic view to be taken of the actual environmental costs and benefits (in monetary terms) attributable to these activities.

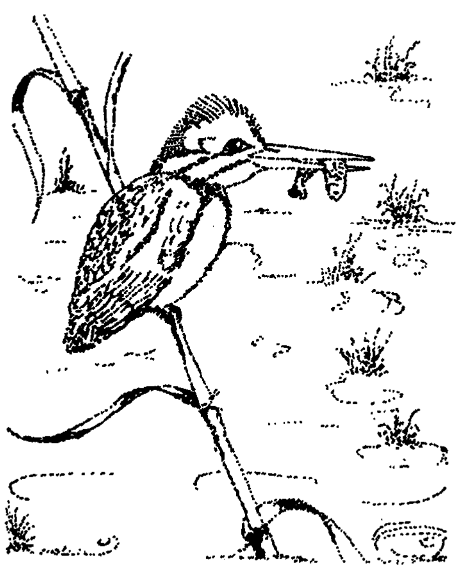
For example, the return (to the individual) from maize grown in wetland sites, or from fodder crops that can be fed back to cattle, is not the sole basis upon which to evaluate or justify wetland development. This is because wetland sites, in a undeveloped condition, have certain regional functions and values that can be measured in monetary terms.

To establish the real costs and benefits of wetland development therefore, there is a need to evaluate:

a) the initial capital costs of wetland development
b) the maintenance costs
c) the potential return from crop, timber or pasture production
d) the potential costs of having to counteract effects such as freshwater diminution, flood damage or diminished water quality downstream
e) the value of the undeveloped resource.

Similar studies could also be made of the cost-benefits of artificially creating wetlands. If conducted upstream of certain areas, the downstream socio-economic benefits of wetland protection could be evaluated. In fact, analyses similar to these undertaken in the United States (205), have shown that:

- the *public* value of wetlands has been calculated to be up to five times the value of the area to a private owner
- that each hectare of marsh along the coast of Georgia is worth 5 — 12 times as much as prime farmland



- that the draining of wetlands (often at the taxpayer's expense) usually leads to the loss of vital public benefits, which then have to be paid for or replaced (also at the taxpayer's expense).

Development of the "Mfolozi Flats" (see Plate 4) would make a classical cost-benefit analysis, which in all likelihood, would endorse the above conclusion. However, it should be recalled that in South Africa, with its localised third world character, wetland values are usually not replaced, and the consequences for rural communities are disastrous. In fact, this situation eventually leads to the need for massive subsidy by the state in the form of aid for water resource development (boreholes) and agrarian reform.

8. 7 Ecosystem structure and functioning

Wetlands are inherently difficult areas to work in, because of logistical problems in sampling, and making observations or measurements. Despite this, a better understanding of biological responses to degradational processes is an important area of study that requires attention.

The sort of research needed includes:

a) Studies of the relationship of wetland vegetation (and specifically, indicator species) to soil moisture and microclimate.

b) An assessment of the ecosystem responses to burning. These would include:
- responses of the fauna and flora
- responses of the groundwater
- the effects of fire on organic accretion
- its effects on the nutritional qualities of the wetland vegetation
- the effects of the grazing of cattle on infiltration

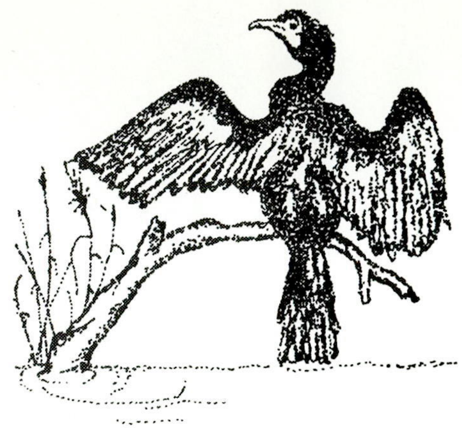
c) The study of wetland types and their function as wetland habitats.

d) Studies on the environmental implications of farm dam construction in wetland sites.

e) Studies of the life histories and environmental requirements of wetland dependent animals. (Most of these will be birds or amphibia, and threatened species will obviously warrant some sort of priority).

f) Studies of wetland sediments are needed to elucidate the role of microbiota in the transformation of polluted water.

g) Studies on the burrowing fauna of wetlands are needed, to shed light on their role in processes such as infiltration and recycling, and to further evaluate the effects of wetland cultivation.



8. 8 Causes of wetland degradation

The threatened status of Natal's wetlands has already been highlighted in Chapter 5 of this report, but further studies are needed which will reveal the full extent of the damage done to wetlands in the last 50 years. The most effective way (see Fig. 15) is through the analysis of early aerial photography (dating back to 1937), by giving specific attention to bottomland utilization.

To complement the intial studies done of this nature, in areas such as the Siyaya catchment for example, it is recommended that an effort be made to acquire the relevant aerial photography of the Mhlali catchment (dominantly influenced by sugarcane cultivation), and selected sub-catchments of the Mgeni (such as the Lions River), and Mzintlava (such as the Krom Rivier) watersheds, to determine whether similar impacts are discernible.

In conclusion, there is a wide range of wetland-related research topics that require to be undertaken in Natal, but common to them all is concern about the causes and consequences of wetland degradation. This has accounted for the problem-orientated nature of the envisaged research program, which has been done purposefully, so as to be of the maximum value to those charged with the responsibility of managing wetlands in Natal and KwaZulu.

Chapter 9

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Chapter 10

Glossary of terms

ABSORPTION	The entry of water into the soil by all natural processes, including infiltration and gravity flow from streams into valley alluvium.
ALLUVIUM	Silt of fine sedimentary materials from which floodplains are formed.
ANAEROBIC	Lacking in, or devoid of oxygen.
ANOXIC	(Synonymous to anaerobic).
BASE FLOW	Stream discharge comprised of sub-surface run-off.
BED LOAD	That portion of the total sediment load which is being "rolled" along (or carried by) the stream bed. The grain size/immersed weight of the material being transported depends mainly on the velocity of the water and the traction force on the stream bed.
BILHARZIA	A common trematode parasite *(Schistosoma)* which is spread through contact with water in which the intermediate soil host lives. Together with malaria, one of the two most prevalent diseases on earth.
BIOCLIMATIC REGION	"A region differentiated by an interplay of climatic factors and biotic phenomena, so integrated as to permit the development of the biotic community to a mosaic of climax stages in equilibrium with the climate" (132).
BIOGEOCHEMICAL	The environmental end-product created by the interplay of the geological, chemical and biological processes that are operative in wetlands.
BIOLOGICAL DIVERSITY	The number of species (plant or animal) and the number of individuals of these species.

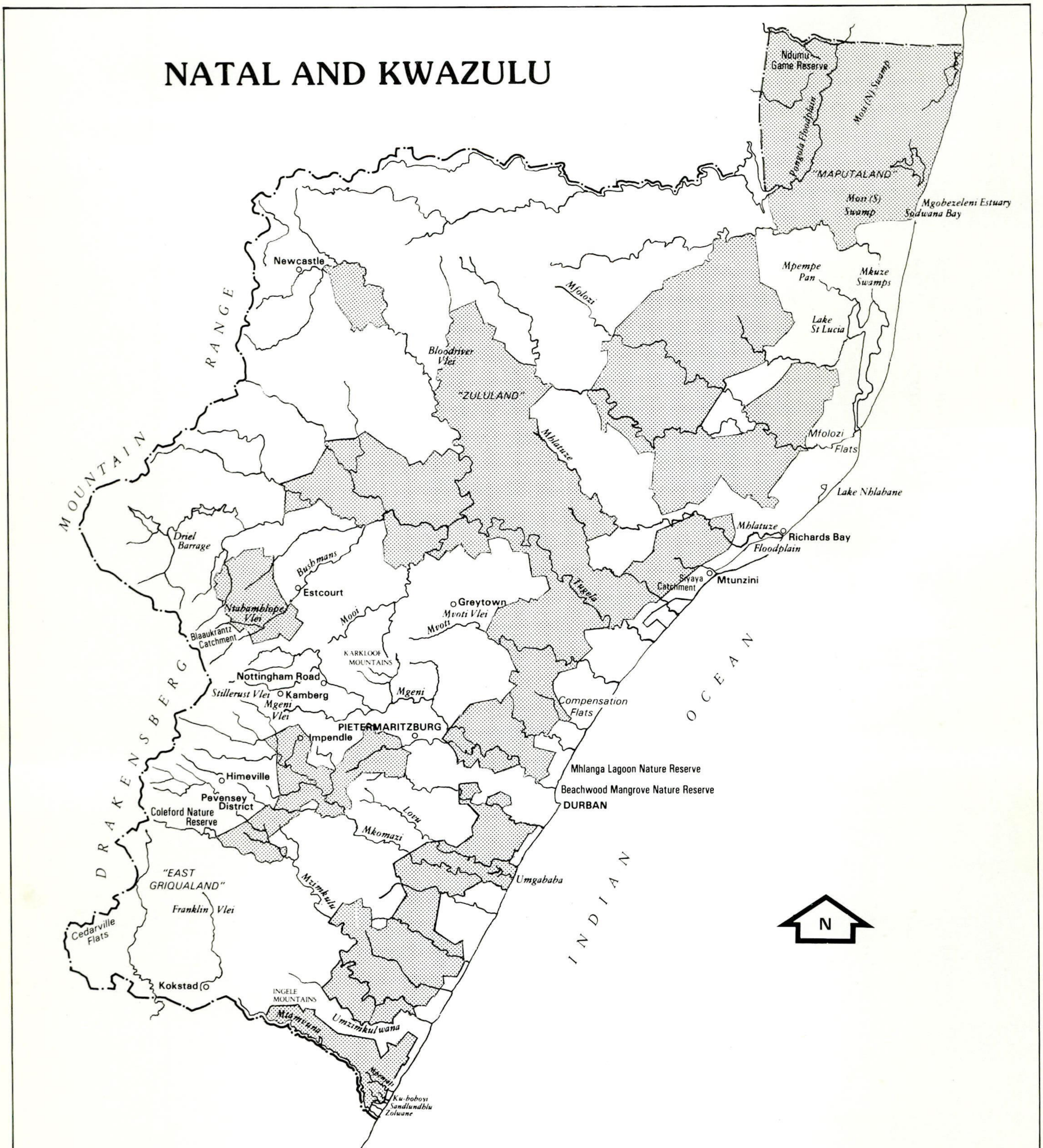
BIOMASS	Total weight of all living organisms in a community or in a given area.
BIOTA	The plant and animal assemblage of a biological community.
BOG	A type of wetland generally characterised by peat deposits (i.e. dead plant material) and acidic water. Bogs often owe their existence to springs in headwater situations. Dominant plants include mosses and sedges.
CHANNEL FLOW	Water flow confined between the banks of a river or stream.
CATCHMENT AREA	A basin-shaped area from which rainfall is collected and concentrated into stream flow.
COLIFORMS	Members of a particularly large, widespread group of bacteria normally present in the gastro-intestinal tract of mammals.
COMPACTION	A process by which the porosity of the soil is decreased, and major factor limiting infiltration.
DECOMPOSITION	The breakdown of non-living organic matter, and its conversion into simpler substances.
DETRITUS	An "aquatic compost" comprised of organic debris from decomposing plants and animals.
DRAINAGE BASIN	Synonymous to catchment area.
ECOLOGY	The science which deals with the relationship between plants and animals, and their environment.
ECOSYSTEM	A system which includes the organisms of a natural community functioning together with their environment.
ENVIRONMENT	The sum of all the external conditions and influences (both biotic and abiotic) which affect the development and life of organisms.
EUTROPHICATION	The process by which a body of water becomes enriched by the addition of certain nutrients such as nitrogen and phosphorus. The high productivity associated with nutrient enrichment means all swamps, for example, would be eutrophic, but in impoundments or lakes which are over-enriched adverse effects can result.

EVAPORATION	The process by which water is withdrawn by radiation from a moist land area, or water surface, and passes into the atmosphere as vapour.
EVAPOTRANSPIRATION	The process by which water is withdrawn from a land area by both transpiration and evaporation.
FAUNA	The animal life characteristic of a particular region or environment.
FLORA	A collective term for the plant life characteristic of a particular region or environment.
FOOD WEB	A "Chain" of organisms through which energy is transferred. Each link feeds on and obtains energy from the one proceeding it. The various components of one link collectively form a trophic level.
GENETIC	Of, or relating to, biological inheritance.
GENETIC DIVERSITY	The variation of genetic material within and between species and subspecies of plants and animals.
GEOMORPHOLOGY	The study of landform or topography.
HABITAT	The locality, or niche (i.e. living place) of a plant or animal, and normally within a particular kind of environment.
HEAVY METAL	A metal of high density.
HYDROLOGY	The science that underlies the development and control of water resources. In view of the extensiveness of the hydrological cycle (Fig. 2) hydrology is a very broad science, involving the study of water and expecially the factors governing its movement on land.
HYDROMORPHIC SOIL	Soils in which water logging becomes the dominant factor determining its physico-chemical characteristics.
HYDROPHYTIC PLANTS	Water-loving plants.
HYGROPHILOUS PLANTS	Moisture loving plants which can live where there is an abundant supply of available water.
INDIGENOUS	Species, that have originated naturally in a particular region or environment.

INFILTRATION	The passage of water through the surface of the soil via pores or small openings. It is governed by the permeability of the soil profile, and non-capillary porosity of the soil surface.
INTERCEPTION	Precipitation which does not reach the soil, being retained for some period, however short, amongst the plant/organic material above the soil surface.
INTERSTITIAL WATER	Water occupying the small intervening spaces and crevices between soil particles.
LIFE SUPPORT SYSTEMS	The main ecosystems involved in providing food, health, water and shelter for human survival and sustainable development.
MALARIA	A disease transmitted by the bites of infected mosquitoes.
MARGINAL LAND	Land of low potential for agriculture, which is often susceptible to degradation.
MARSH	A particularly moist form of wetland dominated by herbaceous plants (such as reeds *(Phragmites)* and rushes *(Typha* and various Juncaceae) which often develop in shallow depressions or along river margins.
MICROBIAL	Flora and fauna composed of microscopic organisms.
NATURAL RESOURCE	Any raw material, either living or non-living renewable or non-renewable, obtained from nature.
NICHE	A term used to describe the status of an animal in its community, i.e. its biotic and trophic relationships.
NUTRIENT	An element or compound that is an essential raw material for organism growth and reproduction.
OPTIMUM YIELD	The amount of material that can be removed from a population or given area that will maximize growth on a sustained basis.
ORGANIC MATTER	Carbon containing matter, usually derived from living organisms.
ORGANISM	Any individual plant or animal.
OVERLAND FLOW	That part of streamflow which orginates from rain which fails to infiltrate the soil, and flows over the land towards channels.
PATHOGENIC	Disease producing.

PESTICIDE	Any chemical designed to kill animals or plants that humans consider to be undesirable.
pH	Hydrogen ion concentration, synonymous to acidity.
PERCOLATION	The passage of water under hydrostatic pressure through the interstices of a soil or rock.
POLLUTION	Destruction or impairment of the purity of the environment.
POTENTIAL EVAPOTRANSPIRATION	The total amount of evaporation which would take place from a vegetated surface where moisture was not a limiting factor.
REMOVAL EFFICIENCY	A measure (expressed as a percentage) of the natural ability of wetlands to remove suspended materials (such as silt, or pathogenic bacteria) or dissolved materials (such as nutrients) from water during its passage through the system.
RILL EROSION	The soil losses associated with the flow of water down the network of diminuitive rivulets that form over the surface of exposed land.
RIPARIAN	Occurring on the banks of rivers or streams.
SHEET FLOW	The form that run-off takes in flat areas (such as swamps), where the terrain, dictates that water spreads over a wide area. In the process its velocity and erosivity is greatly reduced.
SOIL MOISTURE	The amount of water stored in the soil. Of tremendous benefit to man, since soil-water supplies the largest fraction of fresh water that benefits man, through the production of non-irrigated crops.
SORPTION	The physico-chemical binding of naturally occurring elements and inorganic (e.e. clay), or organic matter.
SUSPENDED LOAD	That part of the sediment load (generally the finer material) being carried in a semi-suspended state by the water. Sometimes also referred to as the wash load, the quantity (immersed weight) usually increases with an increase in flow.
SUSTAINED YIELD	The principle of managing a plant or animal population in which there is a balance between those individuals removed and those replaced by natural growth, so that the population is not depleted.

SWAMP	Wooded wetlands with standing, or gently flowing water. Typical species include *Barringtonia racemosa, Syzygium cordatum* and *Ficus hippopotami.*
TRANSPIRATION	The process by which water in plants is transferred to the atmosphere as water vapour.
VECTOR	The carrier of pathogenic organisms, and any agent (such as a snail) transferring a parasite (such as bilharzia) to a host (such as man).
VLEI	Wetlands of a slightly drier form than marshes, but also occurring in depressions dominated by non-woody plants. Instead of reeds, these include sedges (such as *Carex, Leersia* and *Cyperus* spp.) and terrestrial grasses (Gramineae) such as *Hemarthria, Aristida, Andropogon* and *Monocymbium* spp.
WATERSHED	The divide separating one drainage basin from another.



The study area showing all the place names mentioned in the text. (KwaZulu areas shaded).

Care for Wetlands

.... your future may depend on them!

Wetlands throughout the world have long been recognized as key habitats for biological, hydrological and economic reasons. However, they are also regarded as being amongst the most threatened of habitats in the world. For this reason 1985 was declared internationally as the "Year of the Wetland".

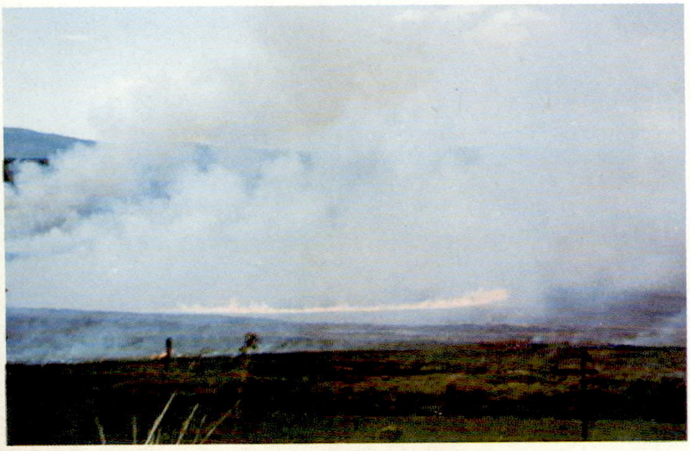
Undisturbed wetlands are a valuable natural resource, contributing substantially to the requirements of wildlife. Many species of birds rely entirely on productive but fragile wetlands.

In South Africa the most commonly used term to describe a wetland is "vlei" which, together with allied terms such as marsh, bog and swamp, denote areas where the soil is water-logged often enough for distinctive plants such as reeds and sedges to grow .

Many farmers regard these areas as unproductive land, being too wet to drain; an obstruction to the movement of their livestock and farm machinery; and as the source of liverfluke in their cattle. Others have attempted to develop them for pastures or cropland; have burnt them for grazing at the end of the dry season; have established dams where wetlands once occurred, or have planted them with gum or poplar trees. True, *some* wetlands can be used for more productive purposes, but what is the worth of an undisturbed wetland?

Wetlands are not wastelands. The vleis that we see around us play surprisingly important roles in our lives. These include:

- water storage
- stream flow regulation
- drought relief
- flood damage protection
- soil erosion protection
- water purification
- wildlife protection
- recreational opportunities and
- raw materials.



The localized burning of wetlands on a regular basis is a short-sighted act of destruction which ultimately can cause regional problems. Wetlands can be gradually degraded by burning to the point that they no longer benefit society.

Wetlands are integral parts of river systems. When wetlands are drained indiscriminately the results are serious and predictable. Downstream flooding becomes more severe in the rainy season and rivers stop flowing in the dry season; the water table will be lowered and people will be less able to support themselves off the land.

Living in the country, farmers are closely affected by all of these issues. No-one needs to explain that "water means life", but perhaps the farming community does not always appreciate the broader *public value* of wetlands. In other words, the transformation of privately owned wetlands can insidiously lead to the loss of the above benefits, all of which are of vital public significance.

Thus the decision to drain a vlei may inadvertently create problems downstream. These can include a deterioration in water quality, flood damage, reduced winter flows and increased bank erosion. Vlei burning and

In certain parts of the Tugela Basin the structure and functioning of 90% of its wetlands have been altered by gully erosion.

desiccation by the planting of trees and the abstraction of water can also be shown to have adverse long term effects. In fact, the current view of many agronomists is that further extension of annual cropping into wetlands is not always profitable; and that hydrological and ecological benefits may, in the long term, be greater than those derived from increases in acreage. They believe that better management of existing lands may give high yields at lower costs.

This change in attitude can be attributed to the growing realization that for a country to survive, let alone develop, it needs a healthy, natural resource base. It also calls for a new approach to evaluating wetlands, and means that

Wetlands are ecosystems where the dominant factor is a regular or seasonal abundance of water. The retardation of run-off by dense vegetation and low gradients enables flood peaks and sediment loads to be dramatically reduced.

every farmer in Natal has a vital and positive contribution to make in trying to accomplish this regional goal.

At present there are seven major Acts and two Ordinances relevant to the management and control of wetlands in Natal. The most important of these is the Agricultural Resources Act 43 of 1983. In essence, this Act demands that any person wishing to alter a wetland area by drainage or cultivation, has first to apply for permission to do so from the Department of Agriculture and Water Supply. The reason is because the widespread exploitation and modification of wetlands has far-reaching consequences, which are often evident far beyond the boundary of an individual farming unit.

Natal and KwaZulu have an international responsibility to maintain resources whose importance transcends political boundaries. The management of wetlands is a prime example.

The Natal Town and Regional Planning Commission, funded by the Department of Environment Affairs, has also started to take positive steps towards developing a regional policy for wetlands by commissioning a report on the "Wetlands of Natal".

The first of this report series, which will be available in early 1986, is being written to foster a greater interest in the welfare of wetlands at a strategic level, and to convince people that we can no longer afford to overlook the public value of wetlands. It aims at defining the term wetlands, at clarifying their role, and quantifying their extent in Natal. The report also describes the manner in which wetlands are presently being used and recommends what should be done to protect them, until such time that a management policy has been formulated. It evaluates the current legislation relating to the protection of wetlands, and identifies what further research is needed to ensure the proper management of these vital resources.

Should you be interested in receiving a copy, the report is available from the offices of the

Natal Town & Regional Planning Commission
Private Bag 9038
Pietermaritzburg
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