REPORT TO THE WATER RESEARCH COMMISSION

WETLAND-USE: A WETLAND MANAGEMENT DECISION SUPPORT SYSTEM FOR THE KWAZULU/NATAL MIDLANDS

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PREFACE

This document is one of a series arising from a project designed to improve the management of wetlands in KwaZulu/Natal. The project includes the following documents:

KOTZE D C, BREEN C M, and KLUG J R, 1994. A project to improve the management of wetlands in the KwaZulu/Natal Midlands: an overview. WRC Report No 501/1/94, Water Research Commission, Pretoria.

KOTZE D C, BREEN C M, and KLUG J R, 1994. WETLAND-USE: a wetland management decision support system for the KwaZulu/Natal Midlands. WRC Report No 501/2/94, Water Research Commission, Pretoria.

KOTZE D C, and BREEN C M, 1994. Agricultural land-use impacts on wetland functional values. WRC Report No 501/3/94, Water Research Commission, Pretoria.

KOTZE D C, HUGHES J C, BREEN C M, and KLUG J R, 1994. The development of a wetland soils classification system for KwaZulu/Natal. WRC Report No 501/4/94, Water Research Commission, Pretoria.

KOTZE D C, BREEN C M, and KLUG J R, 1994. A management plan for Wakkerstroom vlei. WRC Report No 501/5/94, Water Research Commission, Pretoria.

KOTZE D C, BREEN C M, and KLUG J R, 1994. A management plan for Ntabamhlope vlei. WRC Report No 501/6/94, Water Research Commission, Pretoria.

KOTZE D C, BREEN C M, and KLUG J R, 1994. A management plan for Mgeni vlei. WRC Report No 501/7/94, Water Research Commission, Pretoria.

KOTZE D C, 1994. A management plan for Blood River vlei. WRC Report No 501/8/94, Water Research Commission, Pretoria.

KOTZE D C, 1994. A management plan for Boschoffsvlei. WRC Report No 501/9/94, Water Research Commission, Pretoria.

OELLERMANN R G, DARROCH M A G, KLUG J R, and KOTZE D C, 1994. Wetland preservation valuation, and management practices applied to wetlands: South African case studies. WRC Report No 501/10/94, Water Research Commission, Pretoria.

WETLAND-USE (a **wetland**[1] management decision support system) has been developed as a tool to assist agricultural and nature conservation extension personnel provide wetland management and land-use planning guidelines. This document has two parts:

* Part 1, describing:

  a. the conceptual design of WETLAND-USE;

  b. the agro-ecological, soil wetness and hydrogeomorphological classification systems used by WETLAND-USE; and

  c. the primary assumptions on which the system is based; and

* Part 2, comprising the decision support system and data sheet for the information required in the assessment.

The emblem on the cover depicts the various features accounted for by the model namely: the surrounding catchment and associated land-uses, the wetland and its hydrological and ecological values (represented by the wattled crane and the person benefiting from the water respectively), and the direct use that is made of wetlands (represented by the cow). The central problem addressed by the system is: how does one allow for the user to benefit from the wetland but at the same time minimize the impact of such use on the wetland's hydrological, erosion control and ecological values?

Although not essential, it is preferable when using WETLAND-USE to make reference to the accompanying document: *The impacts of agricultural land-uses on wetland functional values* (WRC Report No 501/3/94). This is a comprehensive review outlining the effects that all those land-uses considered by WETLAND-USE (i.e. crop production, planted pasture production, natural grazing by stock, burning, mowing and damming) have on the functional values of wetlands. It is recommended that users read the relevant sections of this document before using WETLAND-USE.

Caution will be required in using WETLAND-USE because such techniques are open to mis-use by users with expectations that are too high. In such cases, insufficient consideration is usually given to the limitations and unsubstantiated assumptions of the model. Furthermore, when applying WETLAND-USE to problems, it should be remembered that no guidelines, however comprehensive they may be, are a substitute for a multi-disciplinary approach in planning for the use and/or development of wetlands. It is unreasonable to expect a system, such as WETLAND-USE, to provide the final answer as to whether a given land-use is acceptable or not in a particular situation. What it does do, however, is assist the user/s in arriving at a final decision, by ensuring that adequate information on the wetland and its surrounding landscape is collected, the relevant questions are asked, and the likely environmental impact of different land-use alternatives is predicted. WETLAND-USE also provides a means of structuring the collection of data for wetland management plans.

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[1] All terms first appearing on boldface are defined in the glossary.

EXECUTIVE SUMMARY

Introduction

Presently, wetland use tends to be planned from the restricted perspectives of individual landowners with specific interests (e.g. livestock grazing). Little attention is given to the effects on wetland functional values (e.g. water quality improvement) which benefit society. Also, there are very few guidelines available for the management of wetlands in South Africa. Thus, a wetland management decision support system, termed WETLAND-USE was developed to assist agricultural and nature conservation extension workers in providing sound land-use advice for wetland areas. The study area chosen for developing the system is in KwaZulu/Natal and includes Bioclimatic Groups 3, 4, 6 and 8 (Phillips, 1973).

Agro-ecological zones and hydrogeomorphological classes used by WETLAND-USE

In order to make informed wetland management decisions it is important to zone wetlands into land capability units which are as homogeneous as possible. The hydrological regime is generally the most important factor accounting for zonation within wetlands. Ideally, long term hydrological data should be obtained, but this is lacking for most South African wetlands. Consequently, the best surrogate measure possible: soil morphology, is used. A provisional three class system for determining the degree of wetness of wetland soils using soil morphological features (e.g. colour of the soil matrix) was developed. The characterization of soils is a very important component of WETLAND-USE because it forms the basis for land-use planning.

A four class system based primarily on vegetation has been developed for assisting with categorizing the zones within a wetland. The four classes, open water, marsh, wet meadow and wet grassland, are associated with degree of soil wetness, making them meaningful from an agricultural and ecological point of view. They are thus termed agro-ecological zones.

A simple hydrogeomorphological classification of wetlands was also included in WETLAND-USE because of the important influence that geomorphology has on wetland functioning. This classification system has two parameters: landform setting and terrain type.

The conceptual design of WETLAND-USE

WETLAND-USE has three main components: (1) INFO-COLLECT, which prompts the user to collect the appropriate information about the wetland, its catchment and the downstream service area; (2) ENVIRONMENT-ASSESS, which assists in selecting appropriate land-use alternatives for a given wetland area by predicting the likely impacts of the proposed land-uses on the functional values of the wetland area; and (3) LAND USE-RECOMMEND, which recommends how the wetland area be managed for the chosen land-use.

INFO-COLLECT comprises four sub-components:

1. WETSITE-INFO, which poses questions regarding the wetland site (e.g. landform setting, distribution and extent of agro-ecological zones, wetland dependent threatened species and current and past use of the wetland) and would be useful when conducting a wetland inventory over a broad area;

2. CATCHMENT-INFO, which poses questions relating to the wetland catchment (e.g. percentage occupied by the wetland and current and past uses);

3. DOWNSTREAM-INFO, which is concerned with the extent of water use and floodable properties in the downstream service area of the wetland; and

4. IMPACTSITE-INFO, which requests more detailed information (e.g. the erosion hazard of the site) than WETSITE-INFO, is concerned with that part of the wetland to which the proposed land-use is to be applied. The user is also requested to determine certain derived descriptors concerning cumulative wetland loss, pollutant input and downstream water use by synthesising information already collected.

ENVIRONMENT-ASSESS predicts the environmental impact of the chosen land-use by assessing the likely effects on the hydrological (water purification, flood attenuation and baseflow augmentation), erosion control and ecological (habitat provision) values of the wetland area. The severity of impact on the hydrological and erosion control values is assessed using the following criteria:

1. the extent to which the water table will need to be lowered in order to carry out the proposed land-use in an average rainfall year;

2. the extent to which the roughness coefficient of the wetland is decreased, either by smoothing out microtopographical surface irregularities such as hummocks or by replacing the natural vegetation with new vegetation that offers less resistance to water flow because of it being shorter, softer, less dense, and/or less perennial;

3. the degree to which the soil organic matter content is likely to decrease as a result of a lowered water table leading to a less anaerobic environment;

4. the degree to which soil subsidence is likely to occur;

5. the degree to which the soil is disturbed; and

6. the extent to which wetland area is lost.

Hydrological and erosion control values are considered together in assessing impact because any loss of erosion control value will also detract from the hydrological values.

The severity of impact on the ecological value of a wetland is assessed by determining the extent to which the land-use changes affect biological integrity and populations of threatened (i.e. rare, vulnerable or endangered) wetland dependant species. Due to a lack of knowledge for South Africa, the assessment of biological integrity by WETLAND-USE only accounts for obvious changes such as wetland drainage. Since an excess of water is the dominant factor affecting the plant and animal communities in a wetland, a general assumption can be made that the greater the disruption of the hydrological regime, the greater will be the loss of ecological value. Thus, where land-use activities detract from the hydrological values of a wetland, they will usually also detract from the ecological values.

WETLAND-USE assesses the acceptability of different land-uses using primary and then secondary acceptance criteria. Primary acceptance criteria encompass the first screening process to safeguard against the likelihood of large/obvious impacts. Essentially, the primary criteria are "threshold levels" for key descriptors (e.g. erosion hazard) beyond which a significant loss to society is likely unless adequate mitigation measures are undertaken. Secondary acceptance criteria deal with situations considered to have a lesser impact, and attempt to capture the trade-off between benefits derived by the user and those lost by society at large.

LAND USE-RECOMMEND provides recommendations to minimize the hydrological, erosion control and ecological impacts, while at the same time maximising the land user's benefit. For crops and planted pastures, the recommendations are aimed primarily at minimizing the impact of such activities as fertilizer application on the hydrological values of the wetland. For the grazing of natural wetlands, the recommendations are concerned primarily with regulating the stocking rate and timing of grazing in accordance with the nature of the wetland. Burning recommendations concern timing and frequency of fires as well as measures designed to influence fire behaviour.

The degree to which the model's assumptions are backed by documentation from the literature

The assumptions on which WETLAND-USE is based are clearly stated. While the general primary assumptions of the system are well substantiated in the literature, many of the assumptions concerning the individual land-uses have little literature support and are based largely on expert opinion.

Concluding remarks

When using WETLAND-USE it is important that adequate consideration be given to its limitations. These include that it uses arbitrary cut-off points and qualitative reasoning and that it applies to a limited geographical area and to a limited number of land-uses. Nevertheless, WETLAND-USE, by accounting for the functional values of wetlands, will assist in attempts to use wetlands in a manner which is in keeping with the intrinsic environmental and ecological features of individual wetland areas. This will contribute to allocating appropriate land-uses to different wetland zones and to making ongoing management decisions for different land-uses (e.g. timing and frequency of burning). Consequently, WETLAND-USE is likely to improve individual site assessments undertaken by agricultural and nature conservation extension workers, as well as contributing towards policy formulation and regional planning for South African wetlands.

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Louisiana State University, Centre for Wetland Resources
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PART 1: INTRODUCTION AND OVERVIEW

1.1 Introduction

Despite legislation directed at **wetland** conservation, considerable loss of wetlands has occurred in South Africa, primarily due to agricultural development (e.g. drainage and pasture production) and poor land use practices leading to erosion. In the Mfolozi catchment, for example, Begg (1988) estimated that 58% of the original wetland area had been lost. **Wetland functional values** (e.g. water purification) have tended to be undervalued because of their *indirect* benefit to society, but recently, as the amount of wetland remaining has steadily declined, increased recognition is being given to these values and to the cost to society when they are lost.

Nevertheless, wetland use still tends to be planned from the restricted perspectives of individual wetland users or landowners with specific interests (e.g. livestock grazing). Little attention is usually given to the effects on those wetland functions which benefit society. Clearly, there is a need for a system that, using the best information currently available, would assist in making trade-offs between benefits derived by the individual wetland user and benefits derived by society. For this reason, the development of this wetland management decision support system, termed WETLAND-USE, was undertaken. The knowledge-base of the system was derived from the literature, components of existing wetland evaluation systems (notably WET: Adamus *et al*, 1987) and consultation with experts. WETLAND-USE attempts to encourage users to take adequate account of wetland functional values when planning the use of wetlands. In so doing, it will contribute to rational land-use decisions for wetlands. The functional values considered are:

1. hydrological values (water purification, flood attenuation, water storage and streamflow regulation);

2. erosion control value; and

3. **ecological value** (maintenance of biotic diversity through the provision of habitat for wetland-dependent fauna and flora).

The land-uses included in WETLAND-USE were confined to some of those most commonly applied to wetlands in the study area, namely: (1) grazing of natural wetlands by livestock, (2) burning, (3) mowing, (4) planted pasture-production, (5) crop production and (6) damming. The study area for which the decision support system was developed includes wetlands located in **Bioclimatic Groups** 3, 4, 6 and 8 (Phillips, 1973).

1.2 Agro-ecological zones and soil wetness classes used by WETLAND-USE

In order to make informed wetland management decisions, wetlands should be zoned into land capability units as homogeneous as possible. A four class system based primarily on vegetation has been developed for categorizing the zones within a wetland (Fig. 1.1, Table 1.1). The four classes are closely associated with degree of soil wetness, making them meaningful from an agricultural and ecological point of view. They are thus termed agro-ecological zones. An identification guide for the plant species common to the wetlands of the study area is given in Appendix 1.

Although dominant vegetation types are convenient for stratifying wetlands into agro-ecological zones, they cannot be relied upon for land-use assessment. Ideally, long term hydrological data should also be obtained, but this is lacking for most South African wetlands. Consequently the best surrogate measure possible: soil morphology, is used, combined with additional observations of features such as drainage channels and flood lines. If the long term hydrological regime is rendered less wet, through either natural or human-induced causes, the morphology of the soil retains many features indicative of the water regime under which it was formed. Such soils, which are referred to as relict hydric soils (Wetland Training Institute, Inc., 1989), do not serve as indicators of the current degree of wetness, but may be very useful in situations where the previous extent of wetlands needs to be determined in an artificially drained area. A provisional three class system for determining the degree of wetness of wetland soils using soil morphology has been developed (Table 1.1). The characterization of soils is a very important component of WETLAND-USE because it forms the basis for land-use planning.

Table 1.1 A provisional three-class system based on soil morphology, for determining the degree of wetness of wetland soils

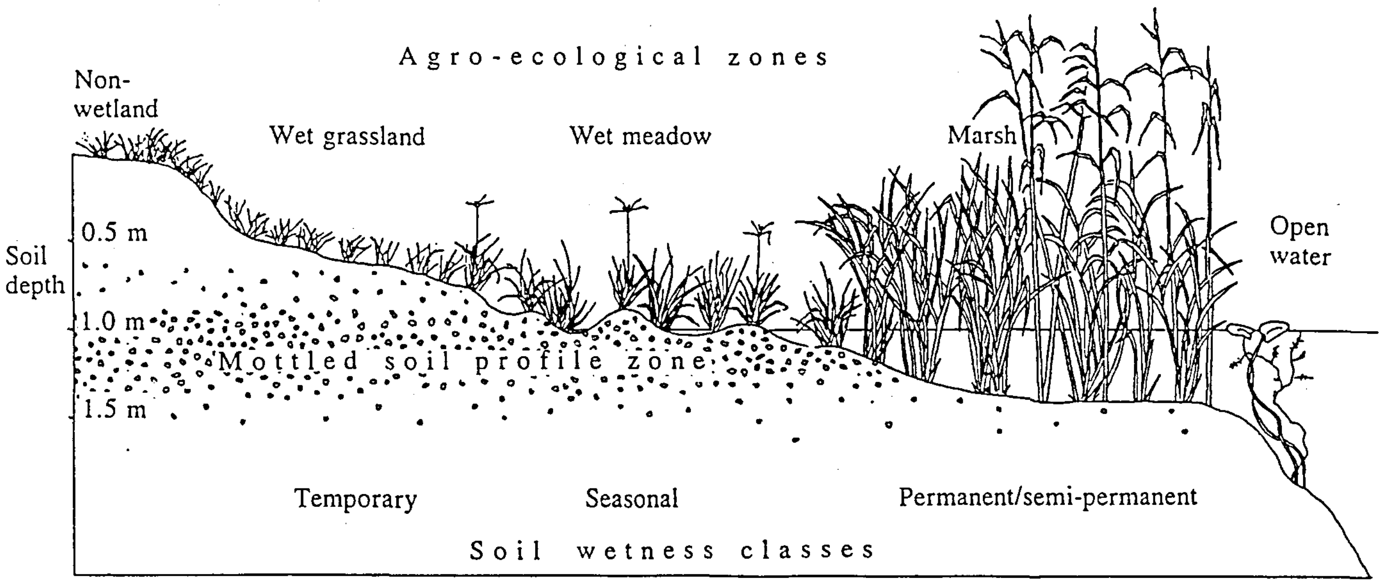
	DEGREE OF WETNESS		
SOIL	Temporary	Seasonal	Permanent/Semi-permanent
Soil depth 0-10 cm	Matrix chroma: 1-3 Few/no mottles Low/ intermediate OM Nonsulphidic	Matrix chroma: 0-2 Many mottles Intermediate OM Seldom sulphidic	Matrix chroma: 0-1 Few/no mottles High OM Often sulphidic
Soil depth 30-40 cm	Few/many mottles Matrix chroma: 0-2	Many mottles Matrix chroma: 0-2	No/few mottles Matrix chroma: 0-1
VEGETATION	Predominantly grass species	Predominantly sedges and grasses	Predominantly reeds, sedges and/or bulrushes

Key to Table 1.1:

High OM: soil organic carbon levels are greater than 5%, often exceeding 10%

Low OM: soil organic carbon levels are less than 2%

Sulphidic soil material has sulphides present which give it a characteristic "rotten egg" smell.



The wet grassland zone is temporarily wet and usually dominated by a mixture of plant species which also occur extensively in non-wetland areas, and hydrophytic plant species which are restricted to temporarily and seasonally wet areas.

The wet meadow zone is seasonally wet and dominated by hydrophytic plant species (usually sedges and grasses < 1 m tall) which are restricted to seasonally or temporarily wet areas.

The marsh zone is usually dominated by tall emergent herbaceous plants such as reeds (*Phragmites australis*) (usually > 1 m tall) and is permanently or semi-permanently wet.

The open water zone lacks emergent plants and is permanently or semi-permanently flooded.

Fig. 1.1 Agro-ecological zones used by WETLAND-USE.

The soil water regime scheme requires that certain problematic soils be accounted for. The water regimes of certain soil types are very difficult to determine through the direct application of the scheme. These problematic soil types, described below, include:

1. **hydric soils** which lack hydromorphic features because of factors such as being recent formation; and

2. non-hydric soils with apparent hydromorphic features, such as low chromas, that did not develop under hydromorphic conditions.

* **Mollisols (the Willowbrook form) and vertisols (the Rensburg form)**

Mollisols are dark coloured, base-rich soils typically having dark topsoil layers and low chroma matrix colours to considerable depths (Wetland Training Institute, Inc., 1989). A high calcium concentration in the soil, as often occurs in these soil types, results in Ca-humate formation, which, in turn, coats the soil particles black (Hughes, 1993, pers. comm.). Thus, even if the organic matter content is relatively low, it imparts a low value and chroma to the soil. Consequently, the low chroma colours of Mollisols are not necessarily due to prolonged saturation. Particular caution, therefore, needs to be exercised in making wetland determinations in these soils (Wetland Training Institute, Inc., 1989). Most vertic horizons in South Africa have a black or very dark colour caused by the same properties that give the melanic A horizon its dark colour (Soil Classification Working Group, 1991), and the same degree of caution must be exercised in wetland determination in these soils.

* **Soils with humic A horizons**

The humic A horizon refers to a freely draining topsoil horizon with low base status, that has accumulated high amounts of humified organic matter under moist, cool or cold climatic conditions. It differs from organic horizons in that both site and profile drainage is good (Soil Classification Working Group, 1991). Humic A horizons may be particularly thick if they occur on protected south-facing valley slopes receiving little direct radiation. Humic A horizons are characterized by low chromas, and if they are deep, this may lead to the soil's being mistakenly identified as hydric.

* **Entisols**

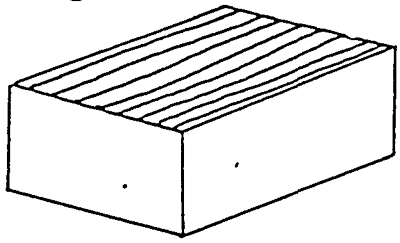
Entisols are recently formed soils that have little or no evidence of pedogenically developed horizons, e.g. soils of the Oakleaf form. Some hydric entisols are easily recognised, but others pose problems because they do not possess typical hydric soil field characteristics. Hydric entisols (with loamy fine sand and coarser textures in horizons within 50 cm of the surface) may lack sufficient organic matter and clay to develop hydric soil colours. When these soils have a hue between 10YR and 10Y, and distinct or prominent mottles, a chroma of 3 or less is permitted to identify these soils as hydric (Wetland Training Institute, Inc., 1989).

1.3 Hydrogeomorphological classes used by WETLAND-USE

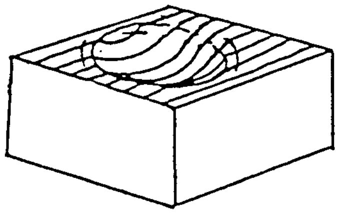
A simple hydrogeomorphological classification of wetlands was included in WETLAND-USE because of the important influence that geomorphology has on local surface and groundwater movement patterns and the degree to which wetlands are open to lateral exchanges of sediments, nutrients and other pollutants. The geomorphological classification system has two parameters: landform setting, which incorporates components of the wetland-habitat classification system of Semeniuk (1987), and terrain type, which is a modification of the system used by the Land Type Survey Staff (1986) (see Table 1.2 and Fig. 1.2).

Table 1.2 Classification of landform settings used in WETLAND-USE

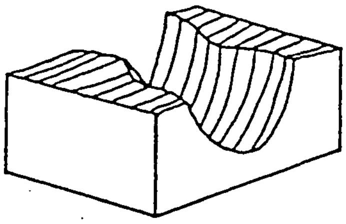
Flats have a slope of <1%,little or no relief and diffuse margins.



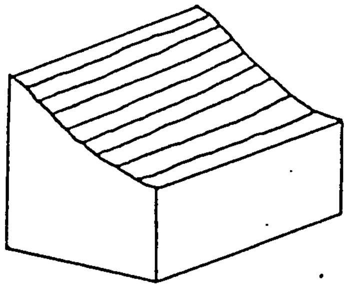
Depressions are depressed basin-shaped areas in the landscape with no external drainage. Depressions may be shallow or deep and may have flat or concave bottoms. They usually do not have clearly defined margins.



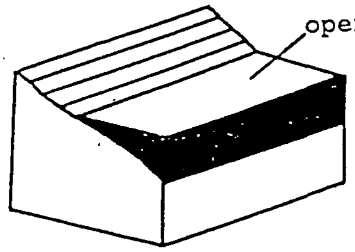
Channels refer to any incised water course. Channels may be shallow or deep but always have clearly defined margins.



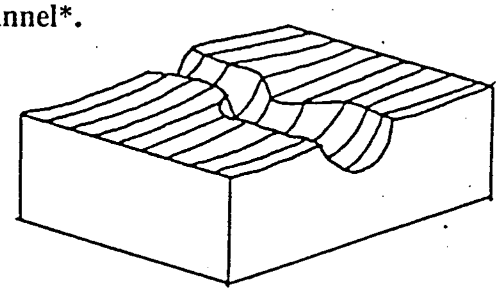
Slopes are areas with a gradient of greater than 1%, which may be concave or convex.



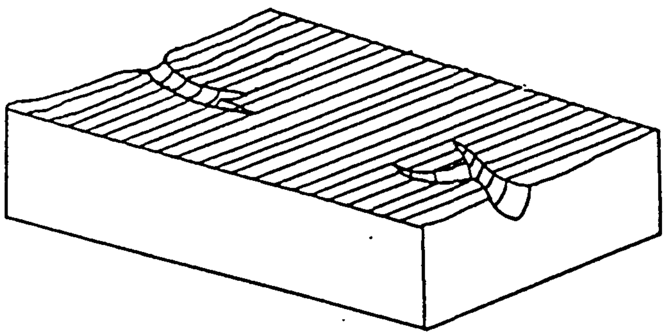
Fringes refer to areas on the edges of open water, such as that provided by lakes or dams.



Channelled flats comprise a flat incised by a channel*.



Channel-disrupting flats comprise a flat which is fed and drained by a channel*.



* Secondary landform settings

KEY

1	crest	5	valley bottom	
2	scarp		5a	valleyhead
3	midslope		5b	young valley
4	footslope		5c	mature/old valley

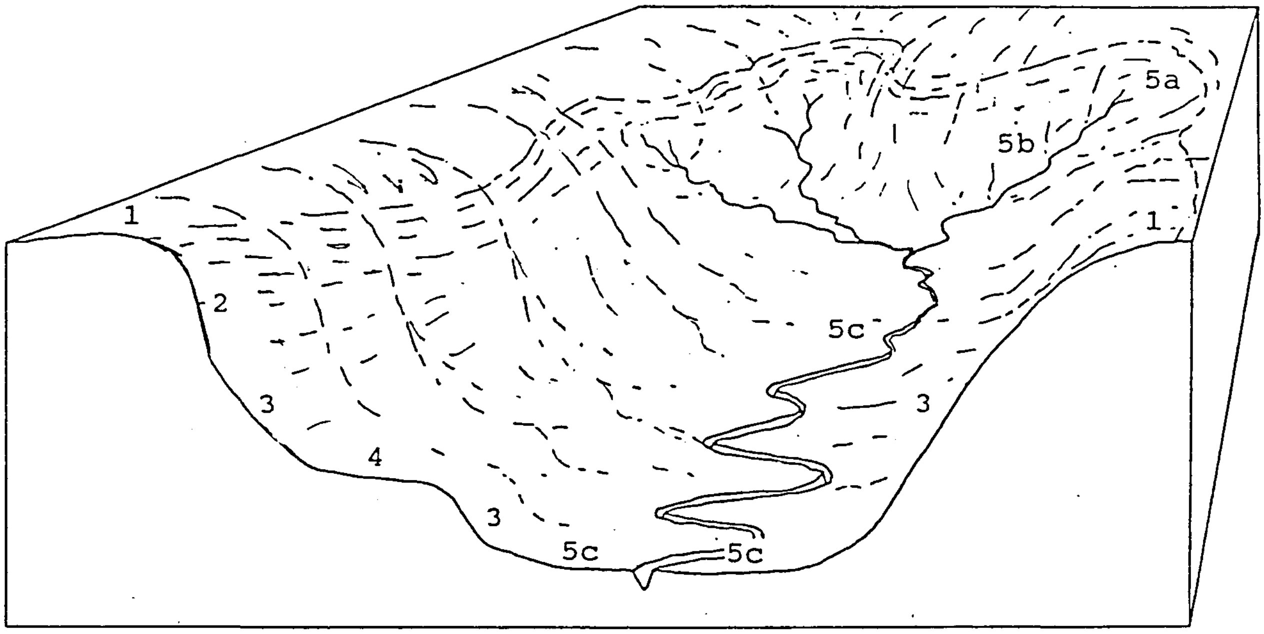


Fig. 1.2 Terrain units used by WETLAND-USE.

1.4 The conceptual design of WETLAND-USE

WETLAND-USE (included as Part 2 of this document) is a simple **rule-based model** with a conceptual design having three main components (Fig. 1.3).

INFO-COLLECT prompts the user to identify the wetland zones, record the proposed land-use information, and collect and record appropriate information on the wetland, its catchment, and downstream area.

LAND USE-ASSESS assists in selecting an appropriate land-use alternative for a given wetland area by predicting the likely impacts of the proposed land-use (e.g. pasture production) on the functional values for that area (e.g. water purification). An "interrogation process" is involved whereby the decision support system uses recorded information from INFO-COLLECT to "interrogate" the proposed land-use.

LAND USE-RECOMMEND recommends how the wetland in question should be managed for the chosen land-use. For example, if the chosen land-use is stock production from a natural (undeveloped) wetland then the model provides information concerning such factors as stocking rate and timing of grazing.

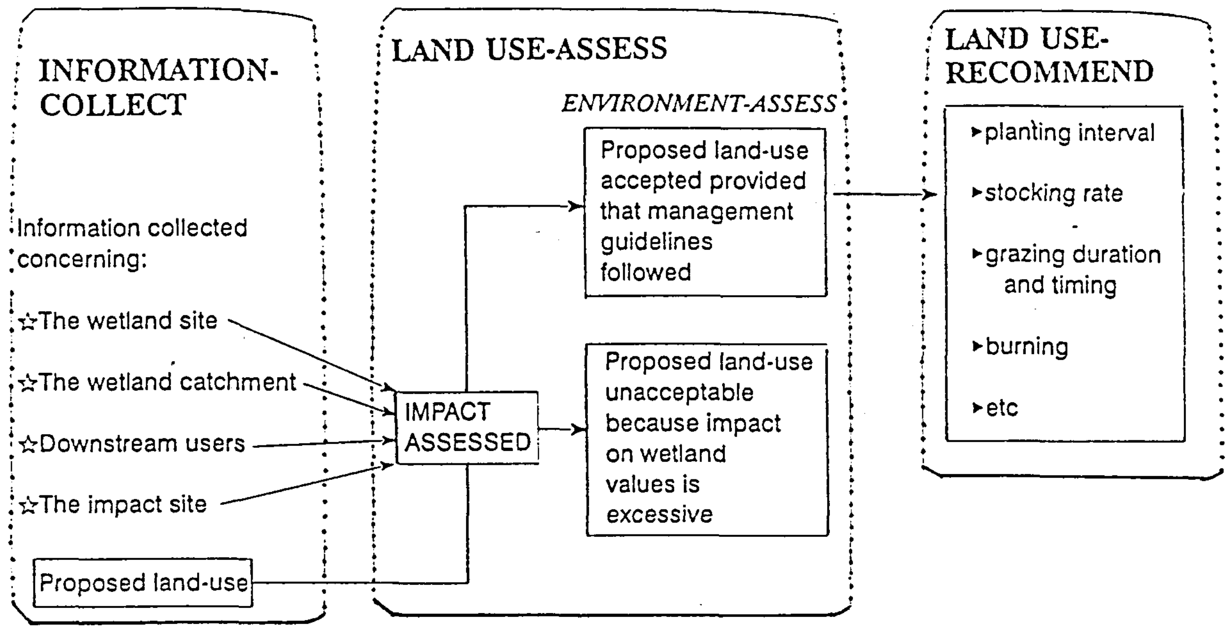


Fig. 1.3 The conceptual design of WETLAND-USE

1.4.1 INFO-COLLECT (Information concerning the wetland site, wetland catchment, downstream service area, impact area and proposed land-use)

In INFO-COLLECT, general questions are first posed by the four sub-components: WETSITE-INFO, LANDSCAPE-INFO, CATCHMENT-INFO and DOWNSTREAM-INFO in order to determine the wetland **descriptor** values (a wetland descriptor is a measurable characteristic considered useful in predicting how a wetland's functional values will be affected by management actions). The wetland descriptors concern the entire wetland, the extent and cumulative loss of wetlands in the surrounding landscape, the wetland catchment and potential downstream significance of the wetland respectively. More specific questions are posed by IMPACTSITE-INFO concerning the proposed land-use and **impact site** (that part of the wetland site to which the proposed land-use will be applied). Although the impact site may include the entire wetland, it generally consists of a portion under a single management authority, usually a farmer.

While it is preferable to obtain accurate descriptor values, this is often not possible due to time and resource limitations. In order to account for this, the user is given the option of choosing the level of detail for obtaining certain descriptor values, the level being dependent on the time and resources available. For example, in describing the distribution and extent of the agro-ecological zones, the user is provided with the following options:

1. indicate the ranked abundance of the agro-ecological zones occurring in the wetland;

2. estimate the approximate percentage contribution of each zone and sketch the approximate boundaries onto the wetland map; or

3. map the boundaries of the different zones and calculate their percentage contribution from the map.

1.4.2 WETSITE-INFO (General details concerning the wetland site)

Questions in this component, which may be used when conducting a wetland inventory over a broad area, concern:

* geographical location and altitude;
* wetland surface area;
* average slope in the direction of surface water flow;
* surface flow characteristics and hydrological disruption of the wetland;
* wetland-dependent rare and endangered species;
* current and past use of the wetland; and
* distribution, extent and degree of dispersion of agro-ecological zones.

1.4.3. LANDSCAPE-INFO and CATCHMENT-INFO (Wetland catchment information)

Questions about the surrounding landscape deal with the extent and cumulative loss of wetlands in this area. Questions relating to the wetland catchment, an area which has considerable influence on wetland functioning, are asked concerning:

* **Bioclimatic Group** (Phillips, 1973);
* Veld Types (Acocks, 1953);
* surface area;
* percentage of the wetland catchment occupied by the wetland;
* topography;
* soils; and
* current and past uses of the catchment.

1.4.4 DOWNSTREAM-INFO (Downstream information)

Questions in this section relate to the extent of water use and floodable properties in the downstream service area of the wetland. The purpose of DOWNSTREAM-INFO is to establish the current levels of benefit that would be derived if the wetland were effectively attenuating floods and purifying water. For example, if many people were dependent on potable water from the downstream area, the potential benefit would be high. It is independent of the opportunity afforded a wetland for carrying out a given function, and the effectiveness with which it does so.

The conceptual basis of this component is based on the assessment criteria used by WEM (US Army Corps of Engineers, 1988). However, an important change has been made to the means of attaching a semi-quantitative value to the potential for flooding. An assumption is made by WEM that the level of impact decreases from a purely urban area to a row crop/small grains area. However, in order for this to be true the proportion of the floodplain that is used would have to be the same for all sites. This will often not be so. For example, there may be some urban areas with little floodable property in the flood area and agricultural areas with many floodable properties in the flood area. It also does not specify the width of the area of influence and this may lead to confusion. WETLAND-USE employs the 1 in 50 year flood line. Although this is also open to confusion, it is likely to be more repeatable. In addition, WEM does not consider the current potential benefit that is derived from water quality improvement. However, it has been included in WETLAND-USE because of its potential importance.

1.4.5 IMPACTSITE-INFO (Information concerning the impact area and proposed land-use)

The user is requested to describe the impact site, which includes:

* estimating the maximum slope of the impact area; and

* describing the soil in the impact area in terms of (1) the Taxonomic System for South African (Soil Classification Working Group, 1991), and (2) wetness class and (3) *n* value (Soil Survey Staff, 1992). The *n* value is helpful in predicting the degree of subsidence that will occur after drainage and can be approximated in the field by squeezing the soil in the hand; and

* information about the land-use (e.g. pasture type) and the user (e.g. their possible alternatives to using the wetland).

The user is also requested to determine the value of certain derived descriptors (to be used directly in ENVIRONMENT-ASSESS) concerning cumulative wetland loss, pollutant input and downstream water use by synthesising information already collected (see Section 1.4.6).

1.4.6 ENVIRONMENT-ASSESS (Predicted impact of the chosen land-use)

The environmental impact of the chosen land-use is predicted by assessing the likely effects on the hydrological (water purification, flood attenuation and baseflow augmentation), erosion control and ecological (habitat provision) values of the wetland area. The severity of impact on the hydrological and erosion control values is assessed using the following criteria:

1. the extent to which the water table will need to be lowered in order to carry out the proposed land-use in an average rainfall year;

2. the extent to which the **roughness coefficient** of the wetland is decreased, either by smoothing out microtopographical surface irregularities such as hummocks or by replacing the natural vegetation with new vegetation that offers less resistance to water flow because it is shorter, softer, less dense, and/or less perennial;

3. the degree to which the soil organic matter content is likely to decrease as a result of a lowered water table leading to a less anaerobic environment;

4. the degree to which soil subsidence is likely to occur (soils with high *n* values and/or organic contents are most susceptible);

5. the degree to which the soil is disturbed; and

6. the extent to which wetland area is lost.

Hydrological and erosion control values are considered together in assessing impact because any loss of erosion control value will also detract from the hydrological values. The reverse is not necessarily true. For example, application of fertilizers to enhance crop production detracts from the hydrological value of the wetland by decreasing the wetland's water purification capacity. However, it does not directly detract from the erosion control value. Even wetland drainage, which would certainly detract from the hydrological value of the wetland, may have a small effect on the erosion control value, if it is carried out on a wetland with a low erosion hazard, and using soil conservation principles, and if perennial vegetation is maintained. However, it should be noted that many wetlands are areas of sediment accretion, and in the above example where drainage does not lead to a net loss of soil, it *would* decrease the net gain of soil trapped by the wetland. The example given of sustainable agricultural production on a drained wetland raises the point that it is possible to utilize the soil resource of a wetland on a sustainable basis, in the medium term at least, but this will detract from the values of the wetland to society.

The severity of impact on the ecological value of a wetland is assessed by determining the extent to which the land-use changes affect **biological integrity** and populations of threatened (i.e. rare, vulnerable or endangered) wetland-dependent species. It is evident from the literature on South African wetlands that there have been no attempts to measure between-system or within-system diversity and to understand the mechanisms regulating diversity (Breen and Begg, 1989). For this reason, the assessment of biological integrity by WETLAND-USE will account only for obvious changes such as wetland drainage. Since an excess of water is the dominant factor affecting the plant and animal communities in a wetland (Cowardin *et al.*, 1979) it may be assumed that the greater the disruption of the hydrological regime the greater will be the loss of ecological value. Thus, in most cases where land-use activities detract from the hydrological values of a wetland, they will also detract from the ecological values. Known threatened wetland-dependent species occurring within the study area include:

Barbus pallidus (goldie)
Leptopelis xenodactylus (long-toed tree frog)
Grus carunculata (wattled crane)
Dasymus incomtus (water rat)
Poecilogale albinucha albinucha (African striped weasel)
Cacosternum striatus (striated caco)
Tyto capensis (grass owl)
Sarothrura ayresi (white-winged flufftail)
Felis serval (serval)

When dealing with wetland values, it is important to clarify what category of value is being referred to. WETLAND-USE accounts for this by recognizing three main categories of value and specifying which is being referred to. These categories are:

1. the effectiveness with which a wetland carries out a function (e.g. a wetland may be of value because it is effective in purifying water);

2. the opportunity afforded a wetland for carrying out a given function (e.g. a wetland may be of value because it receives waste water and has ample opportunity to purify water); and

3. the current potential benefit that might be derived if the wetland were effectively carrying out a function (e.g. if there were many potable water users downstream, the potential benefit derived if the wetland were effectively purifying water would be very high).

WETLAND-USE assesses the acceptability of different land-uses using primary and then secondary acceptance criteria. Primary acceptance criteria embody the first screening process to safeguard against the likelihood of large/obvious impacts. Essentially, the primary criteria are "threshold levels" for key descriptors (e.g. erosion hazard) beyond which a significant loss to society is likely to occur unless adequate mitigating measures are used. Secondary acceptance criteria deal with situations considered to have less impact, and attempt to capture the trade-off between benefits derived by the user and those lost by society. Development orientated land-uses tend to have a greater impact on wetland functional values than non-development orientated land-uses. Their acceptability is based on both primary and secondary acceptance criteria, whereas the acceptability of non-development orientated land-uses is based only on primary acceptance criteria.

In order to explain the interrogation process involved in assessing the acceptability of a land-use, one land-use is chosen: planted pastures. This is dealt with by PASTURE-ASSESS (Fig 1.4). PASTURE-ASSESS begins the interrogation by determining what agro-ecological zone the impact area occupies. If it is open water or marsh, the user is informed that pasture production is unacceptable because the hydrological and ecological impacts are likely to be too high. If the zone is wet meadow then pasture production is considered acceptable provided all the conditions specific to the zone are met. If any of these conditions is not met, the proposed land-use is considered to be unacceptable unless satisfactory mitigating measures are taken. If all the conditions are met then planted pastures is considered to have met the primary acceptance criteria. The user is then instructed to see if the land-use meets the secondary acceptance criteria.

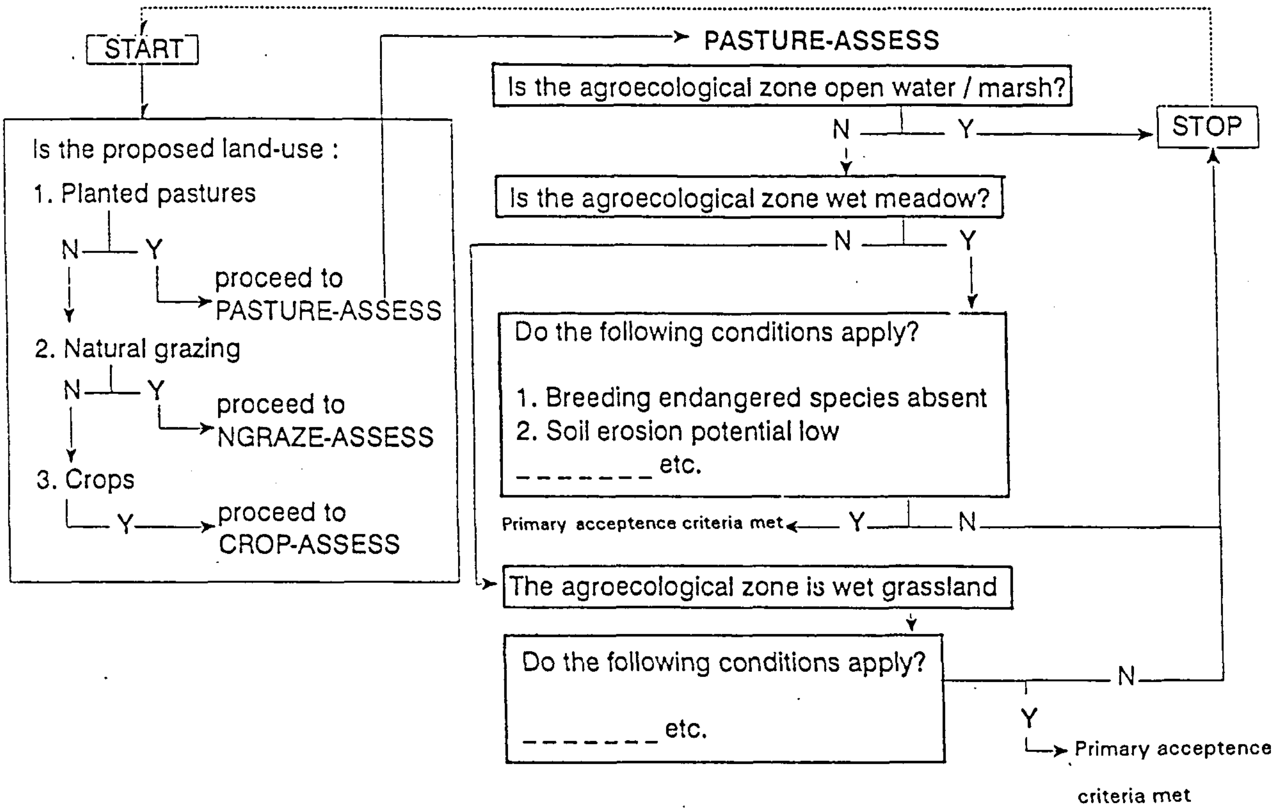


Fig 1.4 An algorithm illustrating the interrogation process of WETLAND-USE.

The rationale behind all stages of the interrogation process is revealed by the system. Much of the space is occupied by details ensuring clarity and consistency and the adequacy of the logic display function. Lay-out makes comparison of descriptor rules and values difficult, but there is a "checksheet" (see Section 2.4) where these are summarised.

1.4.7 LAND USE-RECOMMEND (Management recommendations concerning the chosen land-use)

In essence, all the recommendations in LAND USE-RECOMMEND are designed to minimize the hydrological, erosion control and ecological impacts, while at the same time maximising the land user's benefit. For crops and planted pastures, the recommendations are aimed primarily at minimizing the impact of such activities as fertilizer application on the hydrological values of the wetland. For the grazing of natural wetlands, the recommendations are primarily concerned with regulating the stocking rate and timing of grazing in accordance with the nature of the wetland. Burning recommendations concern timing and frequency of fires (Fig. 1.5) as well as measures designed to influence fire behaviour.

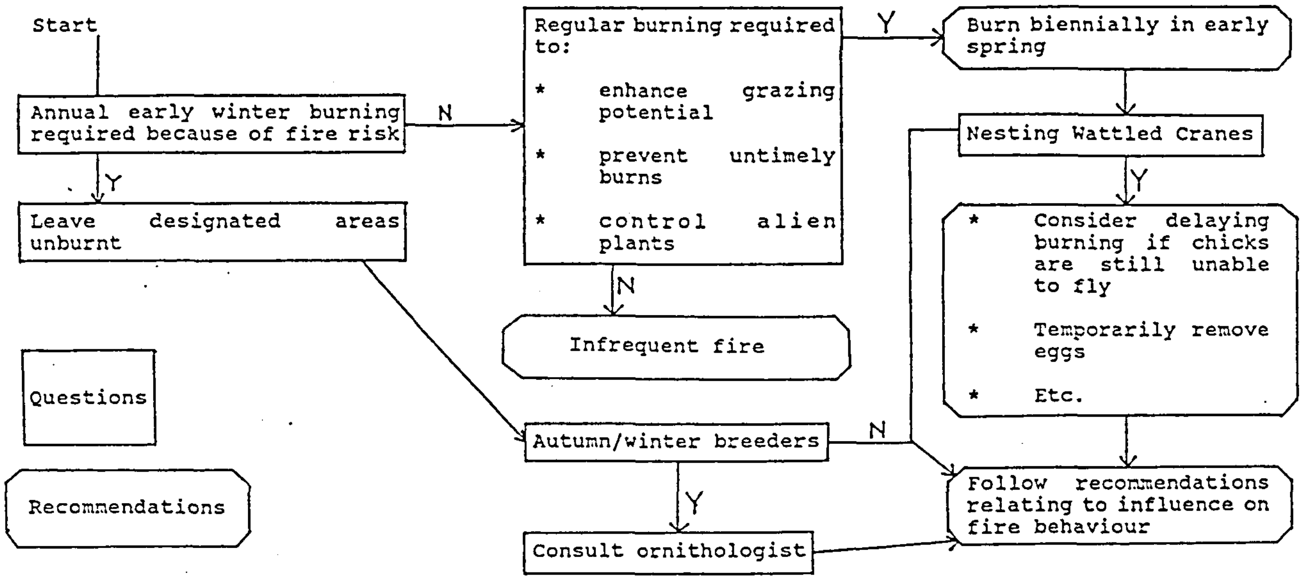


Fig. 1.5 An algorithm illustrating wetland burning frequency and timing recommendations

1.5 The degree to which the model's assumptions are backed by documentation from the literature

While a model based on assumptions not demonstrated to be technically correct may not necessarily be inaccurate, greater confidence can be placed in the predicted accuracy of a model with assumptions that are well substantiated in the literature. Because the knowledge base of WETLAND-USE was created, to a large extent, from the literature, one would expect its assumptions to be supported. However, the strength of support is variable.

1.5.1 Primary assumptions of LAND USE-ASSESS

1. The greater the reduction in the degree of wetness through hydrological modification, the greater will be the impact on all the wetland's functional values[1]. This is well supported in the literature as a general principle (e.g. Goode *et al.*, 1977; O'Brien, 1977; Lavesque, *et al.*, 1982; Brinson, 1988; Ingram, 1991). However, the specific relationships are likely to depend on the nature of the particular site. For example, the relationship between level of drainage and the loss of value of a wetland for improving water quality is likely to vary according to the site.

2. The greater the reduction in surface roughness of the wetland, the greater will be the impact on the hydrological and erosion control values, because the wetland area will become less effective in slowing down the rate of water flow. This has been clearly shown in the literature (e.g. Reppert *et al.*, 1979; Adamus *et al.*, 1987).

[1] All assumptions of WETLAND-USE have been italicised

3. *The greater the reduction in total surface area, the greater will be the impact on all the wetland's functional values.* This is well supported in the literature (e.g. Adamus *et al.*, 1987; Brinson, 1988; Preston and Bedford, 1988).

4. *The greater the extent to which the soil is disturbed, the greater will be the loss of water purification and erosion control values.* This is clear from the literature (e.g. Willrich and Smith, 1970; Miles and Manson, 1992).

5. *The greater the occurrence of soil subsidence, the greater will be the impact on the wetland's hydrological values.* Few references explicitly supporting this assumption were found, but it may be taken that subsidence leads to a decrease in the volume of soil subject to anaerobic conditions, the negative effects of which have been demonstrated (e.g. Ingram, 1991).

6. *The greater the extent to which soil organic matter levels are lowered, the greater will be the impact on the hydrological and erosion control values.* This has been well shown in the literature (e.g. Ingram, 1991; Miles and Manson, 1992).

7. *The more biological integrity and population numbers of valued wetland-dependent species are reduced, the greater will be the impact on the wetland's ecological (biotic diversity) value.* This assumption is based on the proposal of Preston and Bedford (1988) that the effect on valued species and ecological integrity be used for assessing impact on biotic diversity.

1.5.2 Assumptions concerning the erosion hazard index and individual land-uses

* **Erosion hazard index**

The three most important (readily measured) parameters which relate to the wetland site and which influence the susceptibility of an area to erosion (resulting from use by stock) are: (a) soil erodibility, (b) slope, and (c) landform.

The effect of soil erodibility and slope on erosion susceptibility have been shown in the literature (e.g. Anon, 1976). However, the slope limits employed by WETLAND-USE are not based on findings in the literature but were arbitrarily chosen in consultation with soil conservation workers from the Department of Agriculture.

Little evidence has yet been found in the literature to support the assumption that landform has an important influence on susceptibility to erosion. However, this assumption is supported by empirical evidence from wetlands in KwaZulu/Natal (e.g. Kotze 1994a and b; Kotze *et al.* 1994b, c and d). For example, wetlands in depression settings show less evidence of erosion than those in channel settings.

* **Burning**

1. *Provided that the burning recommendations (given in Part 2) concerning burning timing, frequency and influences on burning behaviour are adhered to, burning usually enhances the habitat value of wetlands.* Although there is a lack of reported work on the effect of burning, some studies have clearly demonstrated the advantages of burning to wetland-dependent species (e.g. Vogl, 1973; Smith and Kadlec, 1985).

2. *Provided the burning recommendations concerning burning timing and influences on burning behaviour are adhered to, biennial burning does not significantly detract from the ecological value of wetlands in the study area.* This assumption is based on the fact that biennial burning has not been shown to be detrimental to any valued wetland-dependent species in the study area. However, there are many species for which fire investigations have not been undertaken. Some of these species may well require a fire return frequency of

more than 2 years.

3. *When a wetland area is burnt, other wetland area/s nearby should be left unburnt to provide adequate cover for wetland-dependent species.* No evidence in the literature was found for or against this assumption and it is based on the intuitive logic of species specialists (e.g. Dr. D Johnson, Natal Parks Board, Pietermaritzburg and Mr. B Taylor, Zoology Department, University of Natal, Pietermaritzburg).

4. *Late winter/early spring burning has the least impact on the ecological value of a wetland because it occurs when the fewest species are breeding.* This is based on well-researched information on the life histories of wetland-dependent species, primarily birds.

5. *Fire is an important cause of chick mortality in wattled cranes.* This has been substantiated in the literature (Johnson and Barnes, 1991).

6. *Burning generally does not have a negative effect on the soil provided extensive sub-surface fires do not occur.* This is supported by some literature findings (e.g. Schmulzer and Hinkle, 1992).

7. *Fire may be used to control alien plants effectively.* Although published evidence for this is lacking, empirical evidence, obtained by making comparisons between unburnt and regularly burnt portions of numerous wetlands in South Africa, supports this assumption (Otter, 1992; Kotze *et al.*, 1994c).

8. *From a water storage point of view, a late winter/early spring burn is preferable to an early winter burn because the wetland is left exposed (due to removal of standing dead material) for a shorter period. As such, evaporative loss is lower.* This is supported by studies (e.g. Donkin *et al.*, 1993) which show that evapotranspirative loss of water from wetlands with standing dead material is less than loss from open water.

* **Grazing**

1. *If the veld condition in wet grasslands is poor, the stocking rate should be decreased to account for the lower production potential, and to allow the veld to recover.* It has been shown for non-wetland areas that veld in poor condition has a lower grazing potential than veld in good condition (Edwards and Tainton, 1984). Although this is assumed to hold true for wetland areas as well, no such studies have been undertaken in wetlands. There is also no published support for the arbitrarily chosen reduction factors to account for veld condition. These were chosen in consultation with Prof. N M Tainton, Grassland Science Department, University of Natal.

2. *Wetlands should be rotationally grazed.* There is some published support for the merits of rotational grazing for natural non-wetland areas in South Africa (e.g. Anon, 1951). It is also widely recommended by veld management specialists (e.g. Edwards and Tainton, 1984). Although no studies of rotational grazing in wetlands have been undertaken, it is assumed that the results obtained from non-wetland areas are applicable, particularly to wet grasslands.

3. *Animals should be moved out of rotationally grazed wetland before it has been grazed to a specified height.* Even for non-wetlands there is no literature to support a prescribed level of use as this is affected by numerous variables (e.g. climatic variation). However, the specified height given in WETLAND-USE was based on intuitive logic, results from defoliation studies of individual species, and consultation with Prof. N M Tainton.

4. *Grazing wetland areas when the soil is wet is more likely to result in erosion and/or compaction than grazing when the soil is dry.* This assumption is based on a report by Wilkins and Garwood (1986).

* **Hay making/mowing**

1. Mowing does not significantly detract from the ecological value of wetlands provided that not more than 30% of any agro-ecological zone in a wetland is cut at a given time. There is virtually no literature concerning the effect of hay cutting on wetland fauna. Although there are a number of European studies (e.g. Bakker, 1989) which show that cutting enhances plant species diversity, and indications that it has a short term negative effect on fauna by reducing cover (Bryan and Best, 1991; Kotze *et al.*, 1994c), there are no local studies and the 30% threshold was arbitrarily chosen.

2. Cutting with machinery when the soil is wet is more likely to result in soil erosion than cutting when the soil is dry. (see Grazing Assumption 4).

* **Pasture production**

1. Perennial species are preferable to annuals because they require that the soil be disturbed less often. This assumption is supported by the fact that soil disturbance has negative effects such as organic matter depletion and increased susceptibility to erosion (Miles and Manson, 1992).

2. Species with a high wetness tolerance are preferable to those with a low wetness tolerance because they require less lowering of the water table. See the reasoning for Primary assumption 1.

3. Intensive pastures, particularly those in drainage lines, may contribute to a deterioration in the quality of runoff waters. This general assumption is well supported (e.g. Amberger, 1983; Canter, 1986; and Miles and Manson, 1992). However, it is important to note that the effect of intensive pastures depends on several variables (e.g. fertilizer application rates and soil type), and may be negligible.

4. Measures should be taken to minimize fertilizer leaching losses from planted pastures. The measures recommended by WETLAND-USE for minimizing leaching losses from pastures are based primarily on those recommended by Amberger (1983) and also on those of Miles and Manson (1992).

* **Crop production**

1. Crop production is generally considered to have one of the severest agricultural impacts on wetlands. The high impact associated with wetland drainage and conversion to cropland has been well demonstrated (e.g. Willrich and Smith, 1970).

2. The recommendations and associated assumptions concerning minimizing drainage requirements and nutrient leaching from planted pastures are also applicable to crops.

3. Ley cropping should be implemented to reduce the impact. The benefits (e.g. reduced organic matter depletion) that accrue from ley cropping have been clearly demonstrated (Wardle, 1961; Lockhart and Wiseman, 1988).

* **Damming**

The loss of habitat that follows flooding by dams and the negative effect that dams have on the downstream biota due to the altered flow regime are well documented (e.g. Davies and Day, 1986; Bruwer and Ashton, 1989; Conley, 1992; Masinga, 1992). The decreased runoff that results from evaporation from dams has been clearly shown (Schulze *et al.*, 1989; Mallory 1992).

1.6 Concluding remarks

The description of soil wetness classes and agro-ecological zones employed in WETLAND-USE will contribute towards a workable means of delineating the boundary between wetland and non-wetland areas and between different zones within wetlands in the study area. The delineation of wetlands is very contentious in the USA and is bound to become more so in South Africa as the demand for land and water resources increases. Thus, the potential value of these classification systems for the purposes of land-use planning and management is apparent.

It can be concluded that WETLAND-USE, by accounting for the functional values of wetlands, will assist in attempts to use wetlands in a manner in keeping with the intrinsic environmental/ ecological features of individual wetland areas. This should assist in the following areas of wetland management:

* allocating appropriate land-uses to different wetland zones; and

* making ongoing management decisions for different land-uses (e.g. timing and frequency of burning).

WETLAND-USE should improve individual site assessments undertaken by agricultural and nature conservation extension workers, and should help with policy formulation and regional planning for the wetlands of KwaZulu/Natal. Although the development of wetland management guidelines (as is being undertaken by WETLAND-USE) is considered an important part of any wetland conservation strategy (Dugan, 1992; Williams, 1992), there are very few of these guidelines available for South African wetlands. It may be worthwhile to expand the approach used in WETLAND-USE by including a wider geographic area and more land-uses, with the eventual aim of including the whole of South Africa.

Although the expert system approach to problem solving is a valuable management tool, it does not replace the expert. Caution will be required in using WETLAND-USE because such techniques are open to mis-use: as emphasised in the Preface, it is unreasonable to expect a system, such as WETLAND-USE, to provide the final answer as to the suitability of a given land-use in a particular situation. What it does, however, is assist the user in arriving at a final decision, by ensuring that adequate information on the wetland and its surrounding landscape is collected, the relevant questions are asked, and the likely environmental impact of different land-use alternatives is predicted. In addition, it ensures that a record is kept of the decision making process.

Based on an evaluation of the important assumptions of the model and the extent to which they have been substantiated in the literature, the most important knowledge gaps were identified. The knowledge gaps were mainly concerned with the effects of natural stock grazing, and of burning and satisfactorily describing the biotic diversity of the study area's wetlands and how this is affected by different land-uses. An evaluation of the limitations of WETLAND-USE revealed that:

* it uses arbitrary cut-off points and qualitative reasoning;

* some of its assumptions are not adequately supported in the scientific literature;

* it fails to consider certain interactions and cumulative effects in space and time;

* it is an oversimplification of the field situation; and

* it applies to a limited geographical area only and to a limited number of land-uses.

While all these criticisms are valid, wetland management decisions are at present being made with little or no consideration for the loss of wetland functional values. Any improvement, therefore, should be beneficial. Optimal use needs to be made of the best available information, even if this is qualitative and if arbitrary cut-offs need to be chosen. The structure of WETLAND-USE is open and can be refined later by incorporating more detailed information, as it becomes available, and/or supplementing the system with new components. In this regard, it is important to note that the building of a decision support system, or any environmental model, is never completed in the strict sense as there are invariably some components which can be improved or supplemented.

In South Africa (and in many other countries) there is growing dissatisfaction among resource managers concerning the contribution that research is making toward the enhancement of resource management (Breen, 1992). Thus, with the objective of identifying the key management issues and characterizing the decision-making process in wetlands, it is hoped that WETLAND-USE will not only contribute towards improving the current management of wetlands, but will also assist in designing relevant research programmes that enhance resource management by focusing on the most important knowledge gaps.

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1.8 Glossary

Animal unit (AU): an animal unit is defined as an animal with a mass of 450 kg and which gains 0.5 kg per day on forage with a digestible energy percentage of 55%. Other types of animals are related to such a unit according to the relationship between the three-quarter power of the mass of such animals and a similar function of the mass of a 450 kg animal, i.e. an animal with a mass *m* constitutes:

$$\frac{m^{0.75}}{450^{0.75}} \text{ of an animal unit}$$

Aquic moisture regime: a reducing regime virtually free of dissolved oxygen because the soil is saturated. Some soil horizons, at times, are saturated with water while dissolved oxygen is present (as may occur if the water is moving). The required **soil saturation** duration is not known (and depends on site factors such as soil texture and temperature), but must be at least a few days (Soil Survey Staff, 1992).

Bioclimatic Groups: Phillips (1973) classified the extremely varied natural resources of KwaZulu/Natal into 11 Bioclimatic Groups based primarily on climatic parameters. These groups provide convenient natural resource classes in terms of which management guidelines can be formulated.

Biological integrity: the fauna and flora that characterise an area (i.e. the area's "naturalness").

Capillary fringe: the zone just above the water table (zero gauge pressure) that remains almost saturated. In a sandy soil this zone may be only 10 cm. In loamy or clayey soil that does not shrink or swell appreciably, the thickness may be 30 cm or more, depending on the size distribution of the pores (Soil Survey Staff, 1992).

Chroma: the relative purity of the spectral colour, which decreases with increasing greyness.

Descriptor: a measurable characteristic considered useful in predicting how a wetland's functional values will be affected by management actions.

Dominant plant species: the overstory species that contribute most cover to the area, compared to other overstory species (Barbour, Burk and Pitts, 1980).

Ecological value: the value of the wetland in maintaining the biotic diversity of the area. Biotic diversity can be measured at many different levels, and it is almost impossible to prescribe a standard method of describing it. Its assessment may be simplified by determining the degree to which management is affecting biological integrity and populations of valued species.

Groundwater: subsurface water in the zone in which permeable rocks, and often the overlying soil, are saturated under pressure equal to or greater than atmospheric (Soil Classification Working Group, 1991).

Groundwater table: the upper limit of the groundwater.

Horizon: see soil horizons.

Hydric soil: soil that in its undrained condition is saturated or flooded long enough during the growing season to develop anaerobic conditions favouring the growth and regeneration of hydrophytic vegetation (vegetation adapted to living in anaerobic soils).

Hydrophyte: any plant that grows in water or on a substratum that is at least periodically deficient in oxygen as a result of soil saturation or flooding; plants typically found in wet habitats.

Hue: the dominant spectral colour (e.g. red).

Hydrogeomorphological setting: the landform setting (which influences the surface water flow pattern and is given by the landform class) and the position relative to other landforms in the wider landscape (as given by the **terrain unit class**).

Hydrology: the study of water, particularly the factors affecting its movement on land.

Impact site: that part of the wetland site to which a proposed land-use is to be applied.

Marsh zone: a wetland zone dominated by emergent herbaceous vegetation (usually taller than 1 m), such as the common reed (*Phragmites australis*). Some marsh zone areas are seasonally wet but most are permanently or semi-permanently wet.

Mottles: soils with variegated colour patterns are described as being mottled, with the most abundant colour being referred to as the matrix and the other colour/s as mottles.

***n* Value:** the relationship between the percentage of water under field conditions and the percentage of inorganic clay and humus. It can be approximated in the field by a simple test of squeezing the soil in the hand. It is helpful in predicting the degree of subsidence that will occur after drainage (Pons and Zonneveld, 1965; Soil Survey Staff, 1992).

Open water zone: permanently or semi-permanently flooded areas characterized by the absence (or low abundance) of emergent plants.

Peraquic moisture regime: an aquic moisture regime where the where the ground water is always at or very close to the surface (Soil Survey Staff, 1992).

Perched water table: the upper limit of a zone of saturation in soil, separated by a relatively impermeable unsaturated zone from the main body of groundwater.

Poaching: this occurs when soils are wet, and refers to the disruption of soil structure caused by the repeated penetration of hooves into the soil (Wilkins and Garwood, 1986). The poaching of soils should be avoided because besides decreasing herbage production, it also greatly increases the susceptibility of the soil to erosion.

Physiognomy: the outer appearance of the vegetation; a function of the architecture of the different canopy layers and the life form of the dominant plants.

Red Data species: all those species included in the categories of endangered, vulnerable or rare, as defined by the International Union for the Conservation of Nature and Natural Resources (Smithers, 1986).

Roughness coefficient: an index of the roughness of a surface; a reflection of the frictional resistance offered by the surface to water flow.

Rule-based model: a model which represents knowledge in the form of IF-THEN statements. The IF part contains a condition or premise and the THEN part contains a result, conclusion or consequence.

Soil horizons: layers of soil that have fairly uniform characteristics and have developed through pedogenic processes; they are bound by air, hard rock or other horizons (i.e. soil material that has different characteristics).

Soil profile: the vertically sectioned sample through the soil mantle, usually consisting of two or three horizons (Soil Classification Working Group, 1991).

Soil saturation: the soil is considered saturated if the water table or **capillary fringe** reaches the soil surface (Soil Survey Staff, 1992).

Stocking rate (SR): the number of AUs per unit of land for a specified period of time; it may be expressed in terms of number of land units per AU.

Terrain unit classes: areas of the land surface with homogenous form and slope. Terrain may be seen as being made up of all or some of the following units: crest (1), scarp (2), midslope (3), footslope (4) and valley bottom (5) (Fig. 1.2).

Wet grassland zone: a wetland zone which is usually temporarily wet and supports a mixture of: 1) plants common to non-wetland areas and 2) short (< 1m) hydrophytic plants (predominantly grasses) also common to the wet meadow zone.

Wetland: land where an excess of water is the dominant factor determining the nature of the soil development and the types of plants and animals living at the soil surface (Cowardin *et al.*, 1976).

Wetland catchment: the area up-slope of the wetland from which water flows into the wetland and including the wetland itself.

Wetland functional values: wetland functions (e.g. the trapping of sediment) which are of value to society. Wetland functions refer to the many physical, chemical and biological processes that take place in wetlands.

Wet meadow zone: a wetland zone which is usually seasonally wet and dominated by short (usually < 1.5 m) hydrophytic sedges and grasses common to temporarily or seasonally wet areas.

1.9 Address list

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Pretoria
(012) 3103701

Department of Water Affairs and Forestry
Private Bag X9029
Pietermaritzburg
3200
(0331) 428101

Institute of Natural Resources
University of Natal
Private Bag X01
Scottsville
3209
(0331) 68317

KwaZulu Bureau of Natural Resources
Private Bag X23
Ulundi
3838
(0358) 202713

Natal Parks Board
P O Box 662
Pietermaritzburg
3200
(0331) 471961

Plant protection Research Institute
Cedara Weeds Laboratory
Private Bag
X9059
Pietermaritzburg
3200
(0331) 33371

University of Natal
Private Bag X01
Scottsville
3209
(0331) 2605911

Wildlife Society (Natal)
100 Brand Road
Durban
4001
(031) 213126

PART 2: THE DECISION SUPPORT SYSTEM

2.1 INFO-COLLECT

Note:

1. Those ***descriptors*** *marked with a # are not essential to the assessment of the acceptability of individual land-uses and for making ongoing management decisions but, if they can be readily obtained, they may enhance the assessment and are likely to be useful for formulating an overall wetland management plan.*

2. Those descriptors which are underlined (e.g. <u>A7</u>) are referred to as derived descriptors and do not require gathering of information. Instead, they are derived from other descriptors.

3. Section 2.4 contains the data sheet for recording the information requested in Section 2.1.

4. If any of the data requested is not available indicate this with an "NA".

2.1A WETSITE-INFO (Information concerning the wetland site)

Requirements:

* 1 :50 000 topocadastral maps and/or 1:10 000 orthophotos, both available from the Surveyor General. Airphotos, available from the Chief Director: Surveys and Mapping, would also enhance the assessment, particularly if comparisons could be made to detect change, using a recent set and the earliest set available;

* a planimeter or other means of measuring surface area;

* at least one site visit;

* Bioclimatic Groups according to Phillips (1973);

* veld types according to Acocks (1953); and

* the relevant surface Water Resources of South Africa publication, e.g. Pitman *et al.* (1981).

Attempt to answer all the following questions concerning the wetland:

	month	year
Date of the site visit/s.	.....	......
	.....	......

A1. Wetland name ....

A2. Geographical coordinates ......° ......'S .....° ......'E

A3.1# inlet/maximum altitude (m) ....
A3.2# outlet/minimum altitude (m) ....

<u>A3.3</u># Average altitude (m) ....

Note: the inlet and outlet altitudes can be obtained from orthophotos and the average wetland altitude is taken as: (A3.1 + A3.2)÷2.

A4. Bioclimatic Group (according to Phillips, 1973) ....

A5# Mean annual precipitation (mm) ....

Note: if data are unavailable for A6 and A7 then these may be obtained from Phillips (1973).

A6# Annual potential evapotranspiration (mm) ....

A7. Indicate ...... (a or b) if the Bioclimatic Group (Descriptor A5) is:

a. humid to sub-humid (Bioclimatic Groups 1-6); or
b. mild sub-arid (semi-arid) to arid (Bioclim. Groups 7-11).

A8# Veld type (according to Acocks, 1953) ....

A9# Dominant soil form/s (according to Soil Classification Working Group, 1991) occurring in the wetland. ....

A10. Underlying geology ....

A11. Wetland surface area (ha) ....

Note 1: this does not refer to the area that is wet at the time of the assessment but to the area supporting wetland soils and/or vegetation (see Section 1.2). Temporary wetlands may be wet for only a few weeks in the year, or may even not be wet at all in dry years. Thus, vegetation and soils, in particular, should be used as the primary criteria for delineating wetland areas, unless long-term water regime records exist.

Note 2: although locating wetland boundaries is clearly defined, designating individual wetlands is often an arbitrary choice. As a very general guide, if a wetland area constricts to less than 3 m wide then the areas on either side of the constriction are considered as separate wetlands.

A12# Average width (m) of the wetland perpendicular to flow. ....

Note: to calculate the average width of the wetland, divide the wetland (perpendicular to the direction of flow) into 5 segments of equal length, and measure the width of each segment (at their centres and perpendicular to the direction of flow), then calculate their average by dividing their sum by 5.

A13# Length of the wetland from the outlet to the inlet (m). .....

Note: this refers to the distance that diffuse water flow would travel from the inlet to the outlet. If the wetland were curved or twisted, the wetland length would be longer than the straight line distance from the inlet to the outlet.

A14# Calculate the average slope of the entire wetland (%). ....

Note: $A14 = 100 \times (A3.1 - A3.2) \div A13$.

A15. Distribution and extent of agro-ecological zones (defined in Section 1.2). Depending on the time and resources available:

i) indicate the ranked abundance of the agro-ecological zones occurring in the wetland (1= most abundant, 2= second most abundant, 3= third most abundant and 4= fourth most abundant);

ii) estimate the approximate percentage contribution of each zone (a-l) and sketch the approximate boundaries onto the wetland map; or

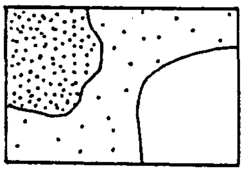
iii) map the boundaries of the different zones and calculate their percentage contributions from the map.

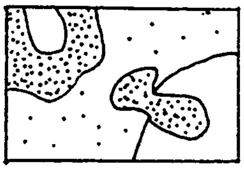
		i) rank (1-4)	ii) estimated abundance	iii) calculated abundance (%)
1.	open water	....	....	....
2.	marsh	....	....	....
3.	wet meadow	....	....	....
4.	wet grassland	....	....	....

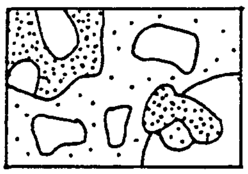
Note:	*a. <0.01%*	*d. 11-20%*	*g. 41-50%*	*j. 71-80%*
	b. 0.01-3%	*e. 21-30%*	*h. 51-60%*	*k. 81-90%*
	c. 4-10%	*f. 31-40%*	*i. 61-70%*	*l. 91-100%*

A16 If data for plant species occurring in the different wetland zones are available, complete the species data sheet at the end of Section 2.4.

A17# Indicate which horizontal pattern of agro-ecological zones (A-C) best describes the condition in the wetland ....

A  Relatively homogenous areas supporting a single zone with little or no interspersion between these homogenous areas.

B  Intermediate between A and C.

C  A highly interspersed mosaic of relatively small areas (not less than 10 m^2) which support different zones.

A18. Indicate (a-f) which landform setting/s (described in Section 1.3) best describes that of the wetland ....

a. Flat b. Depression c. Channel d. Slope e. Channelled flat f. Channel disrupting flat

Note: if a wetland includes more than one landform setting, indicate this by recording the landform settings in the order of their occurrence in the direction of flow, separated by commas (e.g. a wetland comprising a channel at its upstream end, followed by a channelled flat, should be recorded as: c,e)

A19. If the landform setting is a channel, indicate (Y or N) if emergent vegetation extends through the channel bed rather than being confined to the channel banks. ....

A20. If the landform setting is a channel disrupting flat, indicate (a-d) the prevalence of depressions within the flat (expressed as a percentage of the total area). ....

a. < 3% b. 3-10% c. 11-30% d. >30%

A21. Indicate (a-f) on which terrain unit/s (described in Section 1.3) the wetland occurs. ....

a. Crest
b. Midslope
c. Footslope
d. Valleyhead
e. Valley bottom (young)
f. Valley bottom (mature/old)

A22. If the wetland setting is a channel disrupting flat, identify the flow concentration area and demarcate it on the wetland map. Indicate the slope (%) of the flow concentration area. ......

Note: the flow concentration area, sometimes called the "keypoint", refers to that part of the wetland where predominantly diffuse flow becomes channelized. This is usually associated with an increase in slope and is often the most erosion-prone part of the wetland. When undertaking a site visit, check this area for signs of erosion (see A40).

A23# If the wetland setting is a channel, channelled flat or channel disrupting flat, indicate (a-d) the stream order of the primary input channel. ......

a. first order b. second order c. third order d. fourth order or more

A24# Where flow in the wetland is channelled (naturally or artificially) indicate (a-d) the meander ratio. .....

a. < 1.10 b. 1.11-1.30 c. 1.31-1.50 d. > 1.50

Note: the meander ratio is calculated by dividing the distance from one point on a stream to another point on the stream (at least 500 m downstream) via the channel by the straight line distance between the same two points.

A25. List all recorded **Red Data** (threatened) plant species occurring in the wetland. Indicate their status (E= Endangered, V= Vulnerable and R= Rare) and, if possible, indicate in which zone/s they occur (O= Open water, M= Marsh, W= Wet meadow, G= Wet grassland)

	Status	Zone/s
1.	......	....
2.	......	....
3.	......	....

4. Total number of Red Data plant species ....

Note: a single site visit is not sufficient to identify all Red Data plant and animal species as some are very difficult to observe and are not identifiable or are absent during certain seasons. Consult the Natal Parks Board or approach The Wildlife Society for advice.

A26. List all recorded Red Data (threatened) animal species occurring in the wetland, indicate their status (E= Endangered, V= Vulnerable and R= Rare) and, if possible, indicate in which zone/s they occur (O= Open water, M= Marsh, W= Wet meadow, G= Wet grassland).

	Status	Zone/s
1.	......	....
2.	......	....
3.	......	....

4. Total number of Red Data animal species ....

A27. List any valued wetland-dependent species (e.g. species of direct economic importance) occurring in the wetland other than those that are threatened and, if possible, indicate in which zone/s they occur (O= Open water, M= Marsh, W= Wet meadow, G= Wet grassland).

Other valued wetland-dependent species	**Zone/s**
1.	....
2.	....
3.	....
4.	....
5.	....

Note: valued wetland-dependent species are defined in Section 1.4.6.

A28# List those valued wetland-dependent species which are known to occur in the wetland but not in neighbouring wetlands (i.e. localized species).

1. ....
2. ....

A29. Indicate (Y or N) if the wetland is known to be of a type, or to include habitat types, which are threatened or which are regionally scarce or rare ..... and if Y, name the particular type/s ....

Note: The wetlands of South Africa are very poorly described, and the information required for this descriptor is generally lacking. This descriptor will increase in importance for wetland assessments in time, as information on wetlands becomes available.

A30 Indicate (a-c) the wetland's importance for supporting migratory/nomadic birds. ....

a. negligible b. moderate (ca 100-1000 birds) c. high (> ca 1000 birds)

Note: the wetland may be important for only a few weeks each year or even less frequently but, nevertheless, would still be important. It may be necessary to consult an ornithologist regarding A30 and A31.

A31 Indicate (with a Y) if the wetland is considered to be an important duck/heron breeding site. ......

A32. Indicate (a-d) the current timing of wetland fires. ....

a. winter b. early spring c. summer d. autumn

A33. Indicate (a-e) the current fire frequency. ....

a. annual b. every 2nd year c. every 3rd year
d. every 4th to 7th year e. greater than a 7 year interval

A34. List any alien invasive plants in the wetland, and if possible, record whether infestation levels for the overall wetland are: (a) high (occurs in >30% of the wetland area), (b) moderate (occurs in 5-30%

of the wetland area) or (c) low (occurs in <5% of the wetland area).

i) Alien invasive plant species list	ii) Level of infestation (a-c)
1.	....
2.	....
3.	....
4.	....
5. Total combined infestation level	....

Note: if the wetland is infested with alien plants, the local agricultural extension officer or The Plant Protection Institute should be consulted regarding alien plant control, as invasion by alien plants may pose a serious threat to the wetland.

A35. Indicate (a-f) what percentage area of the wetland has been inundated by damming. ....

a. <1% b. 1-5% c. 6-15% d. 16-30% e. 31-60% f. 61-100%

A36. Indicate (a-f, see A35) what percentage area of the wetland has been altered by drainage channels. .....

Note: a wetland area is considered to have been altered by drainage channels if its degree of wetness has been reduced. This may be deduced through airphoto comparison or on-site observation of drainage channels and soils (the soil tends to retain indicators of the previous natural water regime, see Section 1.2). Drainage channels vary in effectiveness, depending on their depth and slope and the physical characteristics of the soil. If the effect of the drains needs to be determined accurately, it may be necessary to consult a hydrologist or soil conservation officer. Generally speaking, drainage of wetlands detracts substantially from the functional values of wetlands (see Section 2.3C2, p65). Thus, the rehabilitation of drained wetlands should be given consideration, particularly if the drainage channels are not being used to increase production potential (e.g. if the area is an abandoned pasture).

A37. Indicate (a-f, see A35) what percentage area of the wetland has been altered by erosion in historical times. ......

Note: alteration due to erosion includes both the direct loss of soil and the reduction in degree of wetness caused by erosion gullies which act as drains. Functional values are lost in eroded wetlands, and it is important that these areas be rehabilitated as far as possible, particularly if erosion is severe and there has been an increase in the extent of eroded areas in the wetland (see Rule C1 Note, Section 2.2C, p51, concerning the rehabilitation of wetland areas).

A38. Through comparison of recent and past airphotos, indicate (a-f) the percentage increase over the last 20 years in the amount of area altered by erosion. ....

a. <0% b. 0% c. 1-30% d. 31-80% e. 81-150% f. >150%

Note 1: <0% denotes that the extent of the eroded area has decreased.

Note 2: due to the fact that erosion may substantially detract from the functional values of wetlands, particularly if it occurs in the flow concentration zone of the wetland (see A40), it is important that rehabilitation measures be undertaken (see the Rule C1, p51). Besides measures taken within the wetland to combat erosion, it is also important to modify land-uses contributing to the erosion in, and surrounding the eroding area, to reduce their impact.

A39. Indicate (a-d) the severity of erosion in the eroded area. ......

Severity of erosion: a. negligible erosion visible

b. mildly severe (predominantly rill erosion but shallow [< 1 m deep] gullies may occur)

c. severe (predominantly shallow gullies)

d. very severe (deep gullies [> 1 m deep])

Rills refer to small intermittent water courses, usually less than 3cm deep.

A40. If a flow concentration area (defined in A22) is present and eroded, indicate (a-d) the severity of erosion in that particular area. .....

A41# Indicate the total length of roads or rail-roads passing through the wetland (m). ....

A42# Indicate (with a Y) if any obvious downstream flow concentration effects caused by road or rail crossings are discernible and sketch these on the wetland map. ....

A43# Indicate (with a Y) if any obvious upstream damming effects caused by road or rail crossings are discernible and sketch these on the wetland map. .....

Note: flow concentration and damming effects may be observed during the site visit or detected by comparing recent and past airphotos.

A44. Current use of the wetland. Depending on the time and resources available:

i) indicate (with a Y on Table A1) which land-uses occur in the wetland;

ii) estimate the percentage area of each land-use, record this on Table A1 (a-k) and sketch the approximate boundaries onto the wetland map; or

iii) map the boundaries of the different land-use areas and determine the percentage contribution of the different land-uses from the map.

Table A1 Current land-uses in the wetland

		i)	ii) area (a-k)	iii) area (%)
1.	nature conservation	....	....	....
2.	natural vegetation stock grazing	....	....	....
3.	hay cutting	....	....	....
4.	planted pastures	....	....	....
5.	crops	....	....	....
6.	forestry	....	....	....
7.	urban or industrial	....	....	....
8.	mining	....	....	....
9.	other:	....	....	....
10.	....	....	....	....

Note:
a: 0-2%
b: 3-10%
c: 11-20%
d: 21-30%
e: 31-40%
f: 41-50%
g: 51-60%
h: 61-70%
i: 71-80%
j: 81-90%
k: 91-100%

A45. Depending on the available time and resources:

i) indicate (with a Y on Table A2) which natural resources (not covered in A44.) are used in the wetland; and

ii) indicate on Table A2 the level of use (a-d) for each resource used. If payment is derived from use of any of these resources, indicate this with a P directly after the level of use (e.g. cP).

Note:	*Level of use*	*Birds shot per year*	*Man hours spent collecting per year*	*Water volume used (m^3 per year)*
	a.	*0*	*0*	*0*
	b.	*1-20*	*1-100*	*1-10 000*
	c.	*21-100*	*100-500*	*10 001-100 000*
	d.	*>100*	*>500*	*>100 000*

Table A2 Wetland natural resources

		i)	ii) (level of use)
1.	birds (hunting)	....	....
2.	reeds, sedges and bulrushes	....	....
3.	water	....	....
4.	others:	....	....
5.	....	....	....
6.	No use made of the wetland	....	

A46. Depending on the time and resources available:

i) indicate (with a Y) which recreational activities are practised in the wetland; and

ii) for each activity, score the level of use (a-c). Indicate (with a P) if payment is derived from the visitors.

		i)	ii)	
1.	bird-watching	....	....	*Note: a= 1-10 visitors per month*
2.	water sports	....	....	*b= 11-50 visitors per month*
3.	fishing	....	....	*c= >50 visitors per month*
4.	other/s (........................)	....	....	

A47# Indicate (Y or N) if the wetland is part of, and essential to, an ongoing long term environmental research/monitoring programme. ....

A48# Indicate (Y or N) if the wetland is the closest wetland to any environmental education centre, school, university or similar education facility and is within 500 m of a public road with available parking. ....

A49. Distribution and extent of land ownership types. Depending on the time and resources available:

i) indicate the ranked abundance of the land ownership types occurring in the wetland (1= most abundant, 2= second most abundant, 3= third most abundant and 4= fourth most abundant);

ii) estimate and record the approximate percentage contribution of each landownership type and sketch the approximate boundaries onto the wetland map; or

iii) map the land ownership type boundaries and calculate their percentage contribution from the map.

		i) rank	ii) estimated abundance (a-k)	iii) calculated abundance (%)
1.	privately owned	....	....	....
2.	government owned land leased out	....	....	....
3.	declared conservation land	....	....	....
4.	state forest	....	....	....

Note: *a. 0-2%* *b. 3-10%* *c. 11-20%* *d. 21-30%* *e. 31-40%* *f. 41-50%* *g. 51-60%* *h. 61-70%* *i. 71-80%* *j. 81-90%* *k. 91%*

A50. Indicate (Y or N) if there is evidence of high nutrient concentrations entering the wetland (e.g. algal blooms or actual measurement of high concentrations). ......

A51. Indicate (Y or N) if there is evidence of waterborne toxicants entering the wetland (e.g. fish kills or actual measurements of hazardous concentrations). ......

A52. Indicate (Y or N) if inflow entering the wetland is turbid following even small storm events (i.e. < 10 mm in an hour). ......

2.1B LANDSCAPE-INFO (Information concerning the extent, and cumulative loss, of wetlands in the surrounding catchment)

Indicate (a-h) the extent of wetlands in:

B1. the wetland catchment .....;
B2. the downstream service area .....; and
B3. a 10 km radius around the wetland (excluding the wetland catchment and wetland service area). ......

Extent of wetland area in the surrounding landscape (expressed as a percentage of the total area):

a. 0- 0.05%
b. 0.06- 0.5%
c. 0.6- 1.0%
d. 2.0- 5.0%
e. 6.0- 10.0%
f. 10.0- 25.0%
g. 26.0- 50.0%
h. >50.0%

Depending on which data are available, indicate (a-d) the extent of wetland loss (in the last 50 years) within:

B4. the wetland catchment .....;
B5. the wetland service area ......; and/or
B6. a 10 km radius around the wetland (excluding the wetland catchment and wetland service area) ....

Extent of wetland loss in the surrounding landscape:

a. Nil
b. 1-30%
c. 31-60%
d. >60%

Note: a wetland area is considered to be lost if it has been developed or degraded to the point where it has lost a significant amount of its functional values, as would occur if it was severely eroded, dammed or drained and planted to crops or pastures. Wetland loss can be estimated by comparing recent airphotos with those taken before 1950.

2.1C CATCHMENT-INFO (Wetland catchment information)

The "wetland catchment" refers to the area up-slope of the wetland (from which water flows into the wetland) and includes the wetland itself. The wetland catchment of channelled flat settings consists of the "wetland catchment proper" and the "flood catchment". All surface water draining the wetland catchment proper passes through the site. However, surface water from the flood catchment passes through the site only when runoff events are great enough to result in streambank overspill. In other words, the size of the effective catchment for channelled flat settings increases during sufficiently high runoff events. In all other wetland settings the effective catchment remains constant. The "surrounding catchment" of all setting types refers to the entire wetland catchment but excluding the wetland area itself (see Fig. C1).

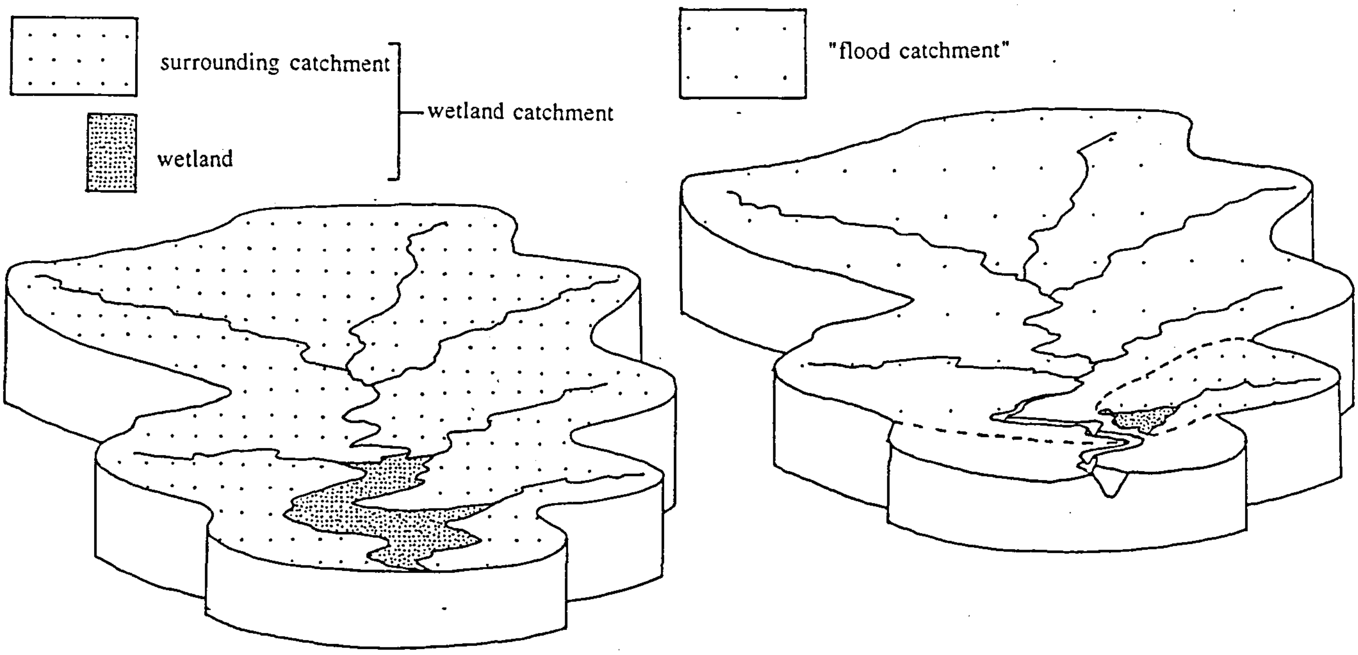


Fig. C1 Diagrammatic representation of the wetland catchment

Attempt to give the following information relating to the wetland catchment.

C1. Bioclimatic Group/s (according to Phillips, 1973) in order of decreasing contribution to the total catchment area ....

C2. Veld type/s (according to Acocks, 1953) in order of decreasing contribution ....

C3. Surface area of the wetland catchment (ha) ....

C4. Percentage of the wetland catchment occupied by the wetland ....

C5. Percentage of the "flood catchment" occupied by the wetland (for channelled flat sites only) ....

C6. Mean annual runoff generated by the catchment ....

Note: if measuring weir data are unavailable, the runoff generated by a wetland's catchment may be approximated very roughly using mean annual runoff data which have been estimated for quaternary catchments (e.g. Pitman et al., 1988). If, for example, a wetland's catchment occupies 40% of a quaternary catchment which has an estimated mean annual runoff of 54 x 10^6 then the estimated mean annual runoff from the *wetland's catchment would be: $54 \times 10^6 \times 0.4 = 22 \times 10^6$. If a greater level of accuracy is required for runoff estimation, predictive models which require inputs concerning the nature of the catchment (e.g. ACRU: Schulze et al., 1989) may be used. However, runoff estimation using such techniques will obviously involve considerably more time and expertise.*

C7. Current use of the surrounding catchment. Depending on the time and resources available:

i) indicate (with a Y on Table C1) which land-uses occur in the surrounding catchment; and

ii) estimate the approximate area under each land-use and record this on Table C1.

Table C1 Current land-uses in the surrounding catchment

	i)	ii) area (ha)
1. conservation	.....	......
2. livestock grazing of natural vegetation	.....	......
3. natural vegetation mowing	.....	......
4. planted pastures	.....	......
5. crops	.....	......
6. urban	.....	......
7. industrial	.....	......
8. mining	.....	......
9. other:	.....	......
10.	.....	......

C8. Indicate the total number of dams in the surrounding catchment ....

C9. Indicate the total area (ha) occupied by dams in the surrounding catchment ......

C10# Depending on the data availability, indicate according to season (a-f) the approximate percentage area of the catchment which is irrigated:

1. Spring ..... 2. Summer .... 3. Autumn ..... 4. Winter ......
5. Total for the year ......

a. <0.5% b. 0.5-2.9% c. 3-8% d. 9-20% e. 21-50% f. >50%

C11 Based on the extent of land-uses in the catchment that reduce runoff (i.e. damming, irrigation and afforestation (see Descriptors C7 to C10) subjectively rate the extent to which the natural runoff is being reduced (a-d). If a greater level of accuracy is required see Schulze *et al.* (1984).

a. negligible b. moderate c. large d. very large

C12. If water quality data are available, give details below and indicate the level of nutrient/toxicant and sediment input for C13 and C14, based on these data. Nutrient/toxicant data should preferably be measured during low flow periods and sediments during high flow periods.

....
....
....

Note 1 concerning C13 and C14: if there are no water quality data, the level of nutrient/toxicant and sediment input into the wetland should be estimated based on observations of land-uses in the catchment (see C7).

Note 2 concerning C13 and C14: a given pollution source in the wetland catchment is more likely to contribute pollutants to the wetland if it is close by than far away, particularly if it is in a drainage line. In order to account for this on a very simplified level, the primary and secondary input zones are defined. The primary input zone is taken as that defined by Adamus et al. (1987) as the area extending 100m upslope of the wetland/non-wetland boundary and including a 100 m wide corridor on either side of all tributaries that enter the wetland, extending a distance of 30 m up the tributaries for each 2.5 m of the tributary channel width at its entry point to the wetland. The secondary input zone includes the rest of the catchment. Pollutant sources in the secondary catchment are less likely to affect the wetland because of the greater distance that pollutants have to travel, thereby increasing the buffering effect of the surrounding catchment. Thus, when considering pollutant sources for Descriptors C13 and C14, consideration should be given to whether they are in the secondary or the primary input zone.

C13. Indicate (a-c) the likely level of sediment input into the wetland. Sources contributing sediments in the wetland catchment include: stormwater outfalls, irrigation return waters, surface mines or areas (>0.5 ha) containing exposed soils associated with agriculture, gullies (dongas) or severely eroding stream or road banks. ......

a. negligible/low　　b. intermediate　　c. high

C14. Indicate (a-c) the likely level of nutrient/toxicant input into the wetland. Non-point sources in the wetland catchment that may contribute pollutants include areas (>0.5ha) of fertilized crop or pasture land; areas (>0.5 ha) where the density of houses with septic tank systems exceeds 6 houses per ha; mines; pesticide treated areas; oil runoff sites. Point sources in the wetland catchment that may contribute pollutants include sewage or industrial outfalls or feedlots. As a very general rule, assuming compliance with wastewater discharge standards:

a. if wastewater input contributes <5% of the streamflow into the wetland then point source input is likely to be low;

b. if wastewater input contributes 5-20% of the streamflow into the wetland then input is likely to be intermediate; and

c. if wastewater input contributes >20% of the streamflow into the wetland then input is likely to be high.

However, if standards are not met, nutrient inputs may be high even though wastewater inputs contribute <10% of the streamflow.

<u>C15</u>. Based on the descriptor values for C13 and C14, indicate whether the combined sediment and nutrient/toxicant input is likely to be low (a), intermediate (b), or high (c). ....

IF: C13=c or C14=c or (C13=b and C14=b) or A50=Y or A51=Y
THEN: C15=c

ELSIF: (C13=b and C14=a) or (C13=a and C14=b)
THEN: C15=b

ELSIF: C13=a and C14=a
THEN: C15=a

2.1D DOWNST-INFO (Information concerning the current potential downstream significance of the wetland)

Service values are functional values which have a well-defined off-site delivery area, referred to as the service area (Adamus *et al.*, 1987). Service values include water purification and flood attenuation. Baseflow augmentation is also a service value but is considered with water purification because water users deriving benefit from water purification are also likely to derive benefit from this function. Ability of a wetland to influence water quality and attenuate floods diminishes with increasing distance downstream of the wetland outlet, particularly for flood attenuation. Thus, the following guidelines, adapted from the U.S. Army Corps of Engineers (1988) and Adamus *et al.* (1987), have been adopted.

If the wetland catchment is <5000 ha then:

* the service area for water quality influence is taken as ending 20 km downstream of the wetland; and
* the service area for flood attenuation is taken as ending 8 km downstream of the wetland.

If the wetland catchment is >5000 ha then:

* the service area for water quality ends 40 km downstream of the wetland; and
* the service area for flood attenuation ends 16 km downstream of the wetland.

Loss of a given wetland's water purification value would result in downstream wetlands having to contend with increased pollutant loads. If the catchment were intensively used and pollutant loads were already high, this may significantly lower the efficiency of downstream wetlands. Thus, although no current beneficiaries may be present in the downstream service area, the effectiveness of other wetlands present in the service area would be improved. The wetland would be of indirect value to potential beneficiaries in the service areas of other wetlands lower in the catchment. Consequently, the effective downstream distance of influence would be greater than had cumulative effects not been accounted for. In addition, some nutrients and fine sediments are likely to be carried further than 20 km, particularly if input levels are high. However, from an assessment point of view it becomes increasingly impractical to assess downstream influence as downstream distance increases and, for the purposes of assessment, a practicable cut-off has been chosen. It should be emphasised that there are several interacting factors determining the wetland's distance of influence, including the size of the wetland and the influence of tributaries entering downstream. These are considered to be beyond the scope of this system.

D1. Using the above guidelines, indicate the water purification service distance. ....

D2. Using the above guidelines, indicate the flood attenuation service distance. ....

Note concerning D3 to D10: if time and resources are very limited, the downstream significance of water purification and flood attenuation may be estimated superficially by answering questions D3 and D4. Otherwise, they should be estimated using comprehensive data collected by answering questions D5 to D9.

D3. On the basis of the present level of water use by people in the wetland's water quality service area, indicate (a-d) the current significance that the wetland would have if it was effectively purifying water. Refer to D5, D6 and D7 as a reference against which the rating should be made. ....

a. nil b. low c. moderate d. high

D4. On the basis of abundance of floodable property in the wetland's flood attenuation service area, indicate (a-d) the significance that the wetland would have if it were attenuating floods effectively. Refer to D8-

D10 as references against which the rating should be made. ....

a. nil b. low c. moderate d. high

D5. In the water purification service area, rate (0-3) the current importance of the stream for:

1. Potable water users, which includes individuals (in most cases poor rural people) who extract water directly by hand for daily domestic use. ......

   0= Nil users 1= 1-3 users/km 2= 4-50 users/km 3= >50 users/km

2. Piped water users, which includes individuals (predominantly urban dwellers) and commerce and industry who purchase piped water extracted from an impoundment for domestic and industrial use. ....

   0= No extraction 2= 11-100 million m^3 extracted annually
   1= 1-10 million m^3 extracted annually 3= >100 million m^3 extracted annually

3. Recreationists who use the water on site for fishing, bathing and/or water sports (expressed on a per km per month basis) ....

   0= No users 1= 1-3 users 2= 4-10 users 3= >10 users

4. Stock farmers (both subsistence and commercial) that require water for stock watering. ....

   0= No stock watering 2= 11-30 AU's per km
   1= 1-10 **animal units** (AU's) watered per km 3= >30 AU's per km

5. Crop/pasture farmers (in most cases commercial farmers) who extract water themselves (usually free of charge) for irrigation purposes. .....

   0= No extraction 2= 31-200 ha of land irrigated per km
   1= 1-30 ha of land irrigated per km 3= >500 ha of land irrigated per km

and 6# rate the sensitivity of the downstream biota to increased levels of pollutants. .....

   0= low 1= intermediate 2= high 3= very high

Note: It is difficult to predict the effect of water quality change on stream biota without undertaking a thorough investigation, which is clearly beyond the scope of WETLAND-USE. Biological systems are, however, considered valid users of water. Thus, a descriptor has been included to superficially account for this, and if adequate information is available, it may be included in the final score.

D6. Calculate the total current water use score (D6) .... using the following formula: D6= D5.1 + D5.2 + D5.3 + D5.4 + D5.5 + D5.6

D7. Now determine the total current significance of water purification in the downstream area of influence

(D7) ..... using the following rules:

if D6= 0 then significance = nil (a)

elseif (otherwise if) D6 <or=4 and >0 then significance = low (b)

elseif D6 <or=8 and >4 then significance = moderate (c)

elseif D5.1 >1 or D6 >8 then significance = high (d)

Downstream flood damage potential:

The benefit derived from flood reduction in a floodable zone below a wetland would obviously increase with increasing abundance of floodable property. In WETLAND-USE, floodable property is expressed in terms of Floodable Units (FU's), where 1 FU is equivalent to 1 house or 20 ha of cropland. Other features of biological, social or economic value should be subjectively allocated FU scores. A riverine forest, for example, while possibly requiring some measure of flooding, may be negatively affected by a marked increase in flood peaks that could result from wetland destruction.

In order to account for the diminishing flood attenuation influence, divide the service distance into 4 reaches (each 2 km if the wetland catchment is <50 km^2 and each 4 km if the catchment is >50 km^2).

D8. To the end of reach 4, determine the current abundance of FU's occurring within the 1 in 50 year flood line for each reach, and using Table D1 then determine the score for each reach.

Note: in most cases the 1: 50 year flood line has not been mapped and will have to be estimated from a site visit, historical records and/or hydrological modelling.

Table D1 Downstream flood damage scores

	0 FU	1-10 FU	10-30 FU	>30 FU	
REACH 1	0	4	8	16	a. ....
REACH 2	0	3	6	12	b. ....
REACH 3	0	2	4	6	c. ....
REACH 4	0	1	2	3	d. ....

D9. Calculate the total score (D8), where:
D9= D8a + D8b + D8c + D8d TOTAL (D8) .....

D10. Now determine the total current significance of flood reduction in the downstream area of influence ....

TOTAL SCORE (D8)	0	1-10	11-19	>20
CURRENT SIGNIFICANCE	Nil	Low	Intermediate	High

2.1E IMPACTSITE-INFO (Information concerning the impact area and proposed land-use)

Requirements:

* As for WETSITE-INFO but Soil Classification: a taxonomic system for South Africa (Soil Classification Working Group, 1991) is also required.

Note: If the impact area includes more than one agro-ecological zone type, the assessment should be carried out separately for each zone.

E1. Indicate on the wetland map, the area to which the proposed land-use will be applied and indicate (a-f) which of the following land-uses is being considered? ....

a. natural vegetation for wildlife and/or fire breaks
b. natural vegetation for stock grazing
c. mowing
d. planted pastures
e. crops
f. dams

IF: E1=a
THEN: answer questions E6 to E9 and then proceed to Section 2.3B

ELSEIF: E1=b
(Otherwise if:)
THEN: answer questions E6 to E18 and then proceed to Section 2.2C

ELSEIF: E1=c
THEN: answer questions E6 to E18 and then proceed to Section 2.2D

ELSEIF: E1=d
THEN: answer questions E2 and E6 to E40 and then proceed to Section 2.2B.

ELSEIF: E1=e
THEN: answer questions E3 and E6 to E40 and then proceed to Section 2.2A.

ELSEIF: E1=f
THEN: answer questions E4 to E40 and then proceed to 2.2E.

E2 Indicate the intended pasture type ....

E3. Indicate the intended crop type ....

E4. Indicate (Y or N) if an outflow control is intended for inclusion in the dam wall ....

E5. Indicate (a-e) the intended use/s of the dam ....

a. irrigàtion b. waterfowl hunting c. stock watering d. watersports e. fishing

E6. Indicate which of the land ownership types given in A49 occur in the impact area (1-4). ....

E7. Determine the surface area of the impact area (ha). ......

E8. Calculate the percentage of the wetland occupied by the impact area. ....

E9. Indicate (a-f) which landform setting (described in Section 1.2) best describes that of the impact area ....

a. Flat	b. Depression	c. Channel
d. Slope	e. Channelled flat	f. Channel disrupting flat

E10. Estimate the slope of the proposed area. ....

E11. Using *Soil Classification* (Soil Classification Working Group, 1991) determine:

(1) the soil form ....

(2) the soil family ....

E12. Estimate (using Table E1) and indicate (0.5-0.15) the erosion hazard (i.e. the K value) of the soil ....

very high: 0.5	moderate: 0.3	very low: 0.15
high: 0.4	low: 0.2	

If soil erodibility values are not available then the following very general assumption can be made:

	K value
Humid to sub-humid (Bioclimatic Groups 1-6):	0.3
Mild sub-arid (semi-arid) to arid (Bioclim. Groups 7, 8, 9, 10, 11):	0.5

Note: The assumption concerning Bioclimatic Groups is based on the observation that wetland soils in humid to sub-humid regions tend to have a lower susceptibility to erosion than those in mild sub-arid to arid regions. This is borne out by the fact that erosional degradation of wetlands has been considerably higher in the latter regions than in the former.

E13. Determine and indicate the erosion hazard index (EH) for the site ....

EH = K x S x F where EH = Erosion hazard index
K = Soil erodability (Descriptor E12)
S = Slope factor (Descriptor E10)
F = Landform setting factor (Descriptor E9)

Note: bracketed descriptors refer to those descriptors used for deriving the factor.

Table E1 Hydrologic information for soil forms and series common to the wetlands of KwaZulu/Natal (adapted from Schulze *et al.*, 1989)

Soil Form	Code	Soil Series	Typical Textural Class	Interflow Potential	Erosion Hazard Rating
CHAMPAGNE	Ch 11	Champagne	SLm	O	High
D	Ch 21	Ivanhoe	SClLm	O	High
	Ch 10	Mposa	SLm	O	High
	Ch 20	Stratford	SClLm	O	High
KATSPRUIT	Ka 10	Katspruit	SCl	O	Mod
C/D	Ka 20	Killarney	SCl	O	High
RENSBURG	Rg 10	Phoenix	Cl	X	High
D	Rg 20	Rensburg	Cl	X	High
WILLOW-BROOK	Wo 21	Chinyika	SCl	O	High
D	Wo 10	Emfuleni	SClLm	O	High
	Wo 20	Sarasdale	SClLm	O	High
	Wo 11	Willowbrook	SCl	O	Mod
ESTCOURT	Es 20	Assegaai	LmS/SClLm	XX	V.High
D	Es 11	Auckland	LmS/SLm	XX	V.High
	Es 22	Avontuur	S/SClLm	XX	V.High
	Es 35	Balfour	LmS/SClLm	XX	V.High
	Es 40	Beerlaagte	LmS/SClLm	XX	V.High
	Es 37	Buffelsdrif	SCl/Cl	XX	High
	Es 42	Darling	S/SClLm	XX	V.High
	Es 13	Dohne	SLm/SClLm	XX	V.High
	Es 31	Elim	LmS/SLm	XX	V.High
	Es 33	Enkeldoorn	SLm/SClLm	XX	V.High
	Es 36	Estcourt	SClLm/SCl	XX	High
	Es 14	Grasslands	SLm/SClLm	XX	V.High
	Es 41	Heights	LmS/SClLm	XX	V.High
	Es 10	Houdenbeck	LmS/SLm	XX	V.High
	Es 21	Langkloof	LmS/SClLm	XX	V.High
	Es 30	Mozi	LmS/SLm	XX	V.High
	Es 12	Potela	S/SLm	XX	V.High
	Es 16	Rosemead	SClLm/SCl	XX	High
	Es 32	Soldaatskraal	S/SLm	XX	V.High
	Es 34	Uitvlugt	SLm/SClLm	XX	V.High
	Es 15	Vredenhoek	LmS/SClLm	XX	V.High
	Es 17	Zintwala	SCl/Cl	XX	High
KROONSTAD	Kd 17	Avoca	SClLm/SCl	XX	High
C/D	Kd 16	Bluebank	SClLm/SCl	XX	High
	Kd 22	Katarra	S/SClLm	XX	V.High
	Kd 20	Koppies	LmS/SClLm	XX	V.High
	Kd 13	Kroonstad	SLm/SClLm	XX	V.High
	Kd 14	Mkambati	SLm/SClLm	XX	V.High
	Kd 10	Rocklands	LmS/SLm	XX	V.High
	Kd 15	Slangkop	LmS/SClLm	XX	V.High
	Kd 12	Swellengift	S/SLm	XX	V.High
	Kd 18	Uitspan	SClLm/SCl	XX	V.High
	Kd 21	Umtentweni	LmS/SClLm	XX	High
	Kd 11	Velddrif	LmS/SLm	XX	V.High
	Kd 19	Volksrust	SCl/Cl	XX	Mod
LONGLANDS	Lo 22	Albany	SClLm	XX	Mod
C	Lo 32	Chitsa	SClLm	XX	Mod
	Lo 21	Longlands	SLm	XX	High
	Lo 10	Orkney	LmS	XX	High
	Lo 30	Tayside	S	XX	High
	Lo 31	Vaalsand	SLm	XX	High
	Lo 20	Vasi	LmS	XX	High
	Lo 11	Waaisand	SLm	XX	High
	Lo 12	Waldene	SClLm	XX	High
	Lo 13	Winterton	SCl	XX	Low
WESTLEIGH	We 10	Chinde	LmS	X	High
	We 32	Davel	SClLm	X	Mod
	We 22	Devon	SClLm	X	Mod
	We 20	Kosi	LmS	X	High
	We 30	Langkuil	S	X	High
	We 31	Paddock	SLm	X	High
	We 12	Rietvlei	SClLm	X	Mod
	We 13	Sibasa	SCl	X	Low
	We 11	Westleigh	SLm	X	High
	We 21	Witsand	SLm	X	High

Legend

A - low runoff potential
B - moderately low potential
C - moderately high potential
D - high runoff potential

O - no/low interflow potential
X - some interflow potential
XX - high interflow potential

l - leaching
t - texture
w - water table
c - crusting

Cl - clay
S - sand
Lm - loam

Slope	S value	Slope	S value
<0.2%	1	3.1-10.0%	2.8
0.2-0.9%	1.6	10.0-20.0%	3.2
1.0-3.0%	2.2	>20%	3.6

If the landform setting is a channel or includes the channelled portion of a channelled flat or channel disrupting flat then F=2, and if it is a depression then F=0.75, otherwise F=1. If the channel is abandoned (i.e. it no longer acts as the streamcourse) then F=1.

An example of a wetland site with an extremely high erosion hazard is one with an Estcourt form, in a channel setting with a slope of 24%, where:

$$EH = 0.5 \times 3.6 \times 2$$
$$= 3.6$$

An example of a wetland site with a low erosion hazard is one with a Katspruit form, Lammersmoor family, on a flat setting with a slope of 0.1%, where:

$$EH = 0.3 \times 1 \times 1$$
$$= 0.3$$

E14. Using Fig. 1.1 and Table 1.1 (Section 1.2) determine the agro-ecological zone based on soil morphology. ....

a. open water/marsh: permanently wet (waterlogged) soil
b. wet meadow: seasonally wet soil
c. wet grassland: temporarily wet soil
d. wet grassland/non-wetland mosaic: temporarily wet/non-wetland soil

E15. Estimate the *n* value by squeezing a handful of soil. Observe how easily it flows between the fingers and indicate this .... (a-c). The soil should be taken at 10 cm below the surface and the test should preferably be conducted during the wet season and not in a drought year.

a. very high (flows easily) b. high (flows with difficulty) c. intermediate or low (does not flow)

Note: the n value refers to the relationship between the percentage of water under field conditions and the percentages of clay and humus. It is helpful in predicting the degree of subsidence that will occur after drainage and whether the soil may be grazed by livestock or will support other loads (Pons and Zonneveld, 1965; Soil Survey Staff, 1992).

E16. Indicate ..... (Y or N) if any Red Data species (Descriptors A25 and A26) occur in the impact area, and which species they are. ....

E17. Indicate ...... (Y or N) if the impact area includes any threatened or regionally scarce wetland habitat type/s recorded for the wetland (Descriptor A29) and which species they are. ....

<u>E18.</u> Indicate (Y or N) if the cumulative loss of wetlands is less than 60% (i.e. Descriptors B4, B5 or B6 do not have the value d). .....

E19. Indicate (Y or N) if the water use is nil or low in the downstream service area (i.e. Descriptors D3 or D7 have the values a or b) .....

E20. Indicate (Y or N) if the pollutant (nutrient/toxicant and sediment) input is low or absent (i.e. C13, C14, C20 or C24 do not have the values c or d and A50 and A51 both have the value N). ....

E21. Indicate (Y or N) if the wetland is in a catchment where further damming is considered undesirable and which has been designated as an area where no further dam permits will be issued by The Department of Water Affairs. ......

E22 Indicate (a-e) the extent to which the water table will need to be lowered. ......

a: 0 cm b: 1-10cm c: 11-20 cm d: 21-40 cm f: >40 cm

E23. Indicate the severity of erosion within the impact area (a-d) (see A39 Note concerning levels of severity). ......

E24 Indicate the percentage of the impact area that is eroded ....

E25. Indicate the percentage of the impact area that is already developed (i.e. planted to crops or pastures or dammed) ....

E26. Indicate (a-c) the roughness coefficient of the impact area ('N' is Manning's roughness coefficient). .....

a. Tall, dense emergent vegetation (e.g. reed marsh): N= 0.08
b. Moderately dense/tall emergent vegetation: N= 0.06
c. Short and sparse emergent vegetation: N= 0.04

E27. Estimate the soil texture class (1-11). If time is limited, the typical textural class taken from Table E1 may be used, otherwise a finger assessment may be conducted in the field (Figure E1) or a particle size analysis conducted in the laboratory. It is important to note that a high organic carbon content (ca>10% organic carbon) generally renders a finger assessment unreliable. ....

1. Clay
2. Loam
3. Sand
4. Loamy sand
5. Sandy loam
6. Silty loam
7. Sandy clay loam
8. Clay loam
9. Silty clay loam
10. Sandy clay
11. Silty clay

E28# Estimate the runoff potential (A, B, C, or D) from Table E1 and indicate this. ....

Manipulate about a heaped teaspoonful of soil with sufficient water to a state of maximum stickiness and plasticity, working out all the lumps before applying these tests.

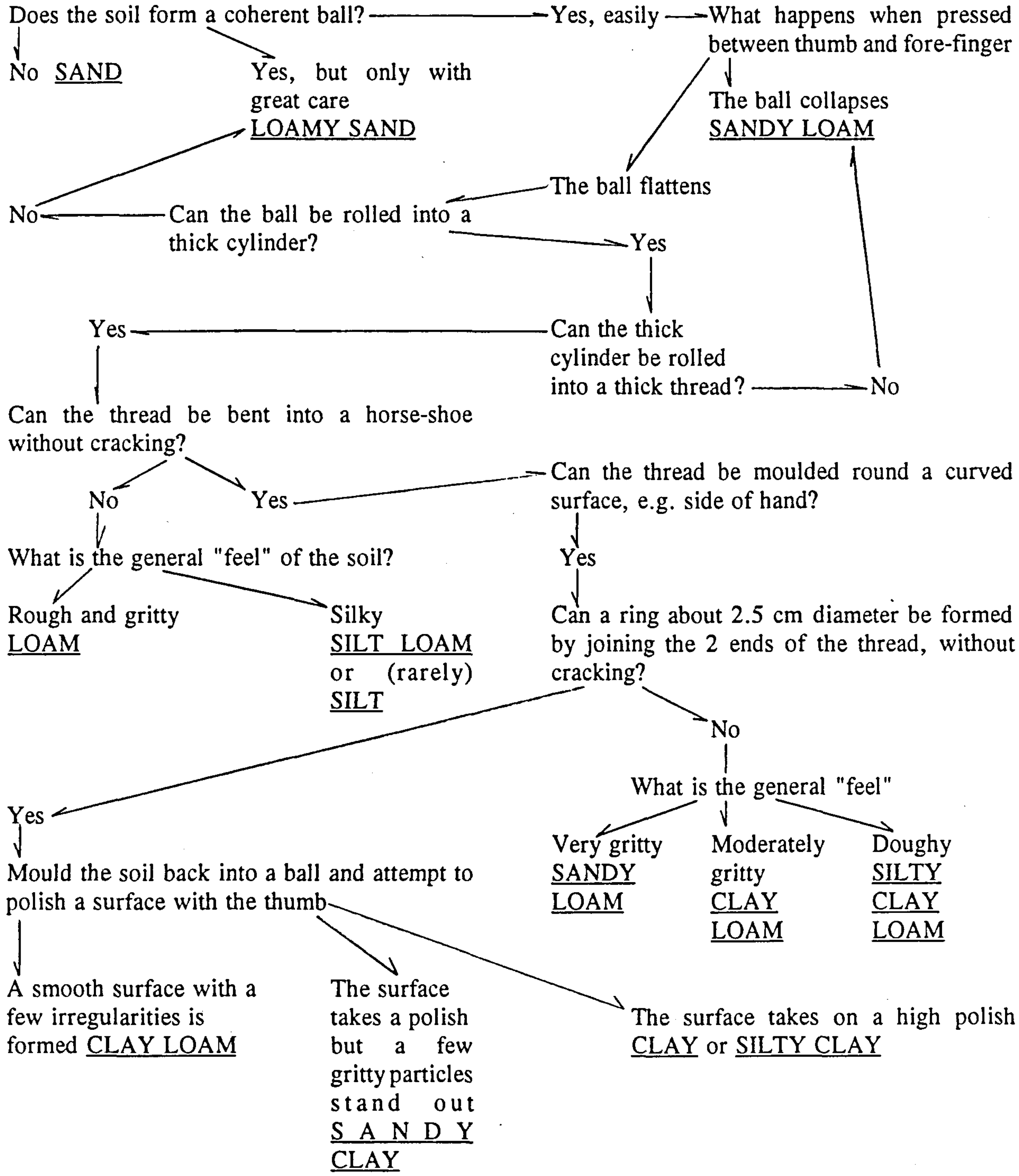


Fig. E1 Finger assessment of soil texture (from Soil Science Practical Course, Soil Science Department, Reading University).

Note concerning E29 to E40:
Descriptors E29 to E40 are required to determine whether the development orientated land-uses meet the secondary acceptance criteria. Indicate (with a 1, 2 or 3) the level of Descriptors E29 to E40 (Descriptors E35 and E36 apply to damming only). Descriptors E37 to E40 deal with socio-economic factors. These are highly complex and require a high level of subjectivity in their assessment. Even if the user is unable to make an assessment of these descriptors, it is important that he/she recognizes that they may be important considerations.

E29. Area of wetland to be developed. ....

1: small (<0.1 ha) 2: intermediate (0.1-1 ha) 3: large (>1 ha)

Note: Development refers to crop production, pasture production and damming. See Descriptor E7 giving the size of the impact area.

E30. Level to which the impact area is already developed and/or degraded due to drainage, erosion or flow concentration by a road. .....

1: high ([E24 + E25] > 60% of the impact area)

2: intermediate ([E24 + E25]= 20-60% of the impact area)

3: low ([E24 + E25] < 20% of the impact area)

Note: the loss to society that would occur with development of a wetland which has already lost its ecological integrity is obviously less than that which would otherwise occur if the wetland's integrity had been maintained. This has not been included as a primary criterion because wetlands can be rehabilitated, the expense of the operation depending on the degree to which the wetland has been eroded or developed.

E31. Availability of alternative sites with less important habitat (i.e. habitat which is less threatened, regionally scarce or rare). ....

1: low 2: intermediate 3: high

Note: this information will often be unavailable, in which case it is important that the Natal Parks Board be consulted for expert opinion.

E32. Importance for wetland-dependent birds (especially migratory, nomadic or breeding birds). ....

1: unimportant 2: moderately important 3: important

Note: if the impact area does not affect any areas used by migratory, nomadic or breeding birds then ignore this question.

E33. The cumulative loss of wetlands in the surrounding landscape (B4, B5 or B6). .....

1: < 10%   2: 11-40%   3: >40%   *Note: see Descriptors B4-B6.*

E34. Roughness coefficient of the impact area. .....

1: N= 0.04   2: N= 0.06   3: N= 0.08   *Note: see Descriptor E26.*

E35. Extent to which the proposed area to be flooded by a dam will have shallows. ....

1: extensive   2: moderate   3: limited

Note: shallows refer to areas with water <1.5 m deep when the dam is full. From a habitat provision perspective, shallows are desirable. However, for water storage, shallow water is undesirable because for a given volume of water, evaporative loss increases with decreasing depth. Thus, if the provision of water from the wetland's catchment is considered particularly important then this criterion may be ignored.

E36. Importance of the wetland for movement of aquatic species. ....

1: unimportant   2: moderately important   3: important

Note: if an adequate "fish ladder" or a gently sloped spillway allowing movement of aquatic species is provided, this criterion may be ignored.

E37. The wetland user's need for the development. ....

1: large   2: intermediate   3: small

Note: assessment of a wetland user's personal need for development requires a high level of subjectivity. As a guideline, consideration should be given to financial state. Take potential user A, who requires to develop the wetland portion of his/her farm in order to maintain the farm as a viable economic unit. In contrast, potential user B, whose farm is already a viable unit, need not do this (i.e. user B's need is less).

E38. Existence of an alternative (to development) for the potential user. ......

1: large 2: intermediate 3: small

Note: as for the above Descriptor, this is subjective. As a guideline, consider the example of potential users X and Y who, both needing to fill critical gaps in the fodder flows of their farms, may either develop the wetland portions of their farms or purchase feed. Potential user X is a great distance from any reasonably priced feedsource, making the purchasing option prohibitively expensive due to the high transport costs. In contrast, user Y is close to a reasonably priced feed-source and has less need to develop the wetland.

E39. Indicate the contribution that the development will make to society, particularly to the poor. ....

1: large 2: intermediate 3: small

Note: this is even more difficult to assess than the above two Descriptors. Such factors as the provision of jobs and access to resources must be considered.

E40. Indicate the level of direct benefit (e.g. reed harvesting) that is being derived from the impact area in its natural state.

1: small 2: intermediate 3: large

Note: refer to Descriptors A45 and A46.

2.2 ENVIRONMENT-ASSESS: PREDICTED IMPACT OF THE CHOSEN LAND-USES

The impact on functional values caused by various land-uses included in WETLAND-USE differs. For this reason, the acceptability of the various land-uses according to agro-ecological zones has been summarized (Fig. E2). Further factors such as Red Data species and downstream water use must also be considered in determining acceptability. Thus, when a land-use is being considered, these factors should be accounted for by proceeding to the specific land-use sections (given below) which deal with the primary acceptance criteria.

a. Crop and annual pasture production: Go to 2.2A
b. Perennial pasture production: Go to 2.2B
c. Natural grazing by domestic stock: Go to 2.2C
d. Hay production: Go to 2.2D
e. Damming: Go to 2.2E

Burning is not a land-use *per se* and is dealt with in Section 2.3B

Note: annual pastures are considered together with crops because, although providing better cover once established, they involve considerably more frequent disturbance of the soil than do perennial pastures. In addition, commonly grown annual pastures tend to have lower wetness tolerances than the commonly grown perennial pasture species: Festuca arundinacea (see Section 2.3C).

```
                         | WET GRASSLAND      WET MEADOW       MARSH
CROP PRODUCTION          |
high erosion hazard      |
low erosion hazard       | ---------
PASTURE PRODUCTION       |
high erosion hazard      |
low erosion hazard       | ================----------------
HAY PRODUCTION           |
high erosion hazard      | ---------------
low erosion hazard       | =================-----------------------
NATURAL GRAZING          |
high erosion hazard      | ----------------------------------------------
low erosion hazard       | =============================---------------
```

KEY:

=== The land-use is acceptable provided that the other conditions (e.g. those pertaining to Red Data species) are met and the guidelines given in Section 2.3 are followed.

------- The land-use is acceptable provided that the other conditions are met and the guidelines given in Section 2.3 are followed, but particularly stringent restrictions apply.

Fig. E2 The acceptability of different land-uses according to agro-ecological zone and the erosion hazard of the wetland site.

2.2A CROP-ASSESS (CROP PRODUCTION RULE)

RULE A

IF: 1) the impact area comprises a mosaic of wet grassland interspersed with patches of non-wetland;

and 2) the erosion hazard index of the impact area is < 1.0 and the severity of existing erosion is low;

and 3) the water table owering requirement is $<$ 10 cm;

and 4) no rare or endangered species have been known to occur at or near the proposed site;

and 5) the wetland is not known to be of a type or include habitat type/s which are threatened or which are regionally scarce or rare;

and 6) the soil n value is intermediate or low;

and 7) the cumulative loss of wetlands in the surrounding landscape is $<60\%$;

and 8) water use is nil or low in the downstream service area;

and 9) pollutant (i.e. nutrient/toxicant and sediment) input is low or absent;

THEN: the primary acceptance criteria for cropping are met. Check whether the secondary acceptance criteria are met (Section 2.2F, p56).

ELSEIF: any of the conditions 1-8 are not met:

THEN: cropping is unacceptable, unless mitigation measures are implemented which will compensate entirely for the effects of the proposed land-use. For example, extra soil conservation measures may be used on a site that has an erosion hazard which would otherwise be considered too high for development. The loss of important habitat at the impact site may be mitigated by restoring an equivalent area of wetland in the surrounding landscape. If mitigation measures are being considered then refer to the secondary acceptance criteria descriptors (E29 to E40) to determine what further effects need to be accounted for.

Note: mitigation measures should not be seen as a "loop-hole" but rather as means of accounting for those instances where a potential wetland user is genuinely able to mitigate the effects of the proposed land-use such that the threshold conditions given in the rule are not violated. This will obviously require expert advice and need to be followed up by regular monitoring.

Reasoning:

* Because of the potentially severe impact of crop production, this land-use is considered acceptable only in wetland areas which are transitional between wetland and non-wetland (i.e. a mosaic of wet grassland

and non-wetland). In areas wetter than this, the hydrology would have to be altered significantly, detracting from the hydrological and ecological values of the wetland area. Besides frequent disturbance of the soil, crop production also involves the application of fertilizer, further detracting from the hydrological value. In addition, crop plants are less perennial and, in many cases, have a lower surface roughness than wetland vegetation. As such, the hydrological value may be lowered significantly when converting wetland to cropland.

* Crop production is not considered acceptable on sites which have intermediate, high or very high erosion hazards because it requires that the soil surface be frequently disturbed, detracting from the erosion control and hydrological values of the wetland.

* If any important wetland dependent species occur in, or adjacent to, the proposed site, draining and producing crops in the area is likely to alter the habitat completely rendering it no longer suitable for these species.

* If the wetland is of a type or includes habitat type/s which are threatened or regionally scarce or rare, the loss would obviously be greater than if this were not so. Conservation of biotic diversity encompasses more than species conservation: other considerations such as the maintenance of biological integrity are involved (see Glossary).

* Drainage, followed by the regular application of fertilizers, detracts from the water purification value of wetlands. If water is being used for human consumption in the downstream area, the conversion of the wetland to cropland could potentially detract from this benefit.

* Should the wetland be disturbed and its hydrology altered, this may cause the accelerated release of pollutants already trapped in the wetland sediments, and may detract from the wetland's future water purification potential.

* If the *n* value is high then the likelihood of soil subsidence occurring following drainage is high.

* If wetland areas have already been lost adjacent to the impact site or in the surrounding landscape, the proposed loss is likely to have a greater impact than if no loss had already occurred.

2.2B PASTURE-ASSESS (PLANTED PASTURES RULE)

RULE B

IF: 1) the proposed area is in a wet meadow zone;

and 2) the area is non-hummocked and the water table lowering requirement is <20 cm, or the area is hummocked and the water table lowering requirement is < 10 cm;

and 3) the erosion hazard of the site is <1.5

and 4) conditions 4-9 in the CROP-ASSESS Rule are met;

OR: 5) the proposed area is in a wet grassland;

and 6) the water table lowering requirement is <20cm;

and 7) the erosion hazard index of the impact area is <2.0;

and 8) conditions 4-9 in the CROP-ASSESS Rule are met;

THEN: the primary acceptance criteria for pasture production are met. Check whether the secondary acceptance criteria are met (2.2F).

ELSEIF: any of the conditions given in the above rule are not met

THEN: planted pastures is unacceptable, unless mitigation measures are implemented which will compensate entirely for the effects of the proposed land-use (see RULE A concerning mitigation). If mitigation measures are being considered then refer to the secondary acceptance criteria descriptors (E29 to E40) to determine what further effects need to be accounted for.

Reasoning:

* Converting wet meadow to planted pastures involves flattening of the area if any hummocks are present, thereby reducing surface roughness and lowering the hydrological value. Thus, more stringent water table lowering limits are set for hummocked than for non-hummocked wet meadow.

* see the reasoning applicable to the acceptability of crop production in wet grassland (Rule A).

* judiciously managed perennial pastures generally constitute less of an erosion hazard than does crop production. As such, the erosion hazard limitations are less stringent than for crop production.

2.2C NGRAZE-ASSESS (RULES FOR NATURAL GRAZING FOR DOMESTIC STOCK)

RULE C1

IF: 1) erosion of the impact area is severe or very severe;

OR: 2) the erosion hazard index of the site is >2.8;

THEN: stock grazing is unacceptable and should be excluded from these areas. Erosion control structures may also need to be erected. Measures must be taken to curb erosion if the region is sub-humid or semi-arid, as wetlands in these areas are prone to erosion. If the amount of eroded area in the wetland has been increasing over the years then this adds to the urgency with which rehabilitation should be undertaken.

ELSE: stock grazing is likely to be acceptable provided the guidelines given in Section 2.3A and 2.3B are followed and the grazing of marsh areas when wet is not intended. If the grazing of marsh areas under wet conditions is intended, proceed to Rule C2.

Note: incorrectly designed and/or positioned erosion control structures may cause further damage and an agricultural extension or soil conservation officer should be consulted. Users are also referred to the Renfreight Wetlands Campaign document: Assessment, Management and Rehabilitation of South African Wetlands (Wyatt, 1993).

Reasoning: Erosional degradation resulting from grazing stock mismanagement is a major source of wetland loss, particularly in sub-humid and semi-arid regions, and should be taken into account.

RULE C2

IF: moderate to heavy grazing pressure is to be applied to marsh areas in order to enhance the ecological value by reducing reed density and height and/or increasing the extent of exposed liquid mud and short vegetation patches;

THEN: 1) the chosen area should have a slope of <0.2% and be positioned as far away as possible (preferably >100 m) from the wetland outlet and channels within the wetland, so that the maximum area of wetland downstream will buffer the impact of reduction in the water purification function of the wetland;

and 2) not more than 30% of the agro-ecological zone should be subject to this treatment in a given year;

and 3) the chosen area should be routinely monitored;

and 4) a wetland specialist/hydrologist should be consulted.

Reasoning:

* It has been widely shown that the habitat value for certain species such as the Ethiopian Snipe (*Gallinago nigripennis*) is improved by having cattle grazing on areas which would otherwise have tall emergent vegetation. However, if this occurs over a large proportion of the wetland, it would be

detrimental to those animals, such as flufftails, which require tall, dense emergent vegetation cover.

* Soils which have been subjected to poaching, as would occur when marsh areas are grazed when wet, become susceptible to sediment loss and possible erosional degradation. Thus, stringent limits are set concerning the slope and distance from channels of marsh areas to be grazed by cattle so as to safeguard the hydrological and erosion control values of the wetland. Nevertheless, even if these constraints are met, such use of wetlands may still constitute an erosion risk. Consultation with a wetland specialist/hydrologist and regular monitoring are advocated.

2.2D HAY-ASSESS (MOWING RULE)

RULE D1

IF: 1) no drainage channels are required;

and 2) the agro-ecological zone is not marsh;

and 3) no Red Data species are present which would be adversely affected by mowing;

and 4) the erosion hazard index of the impact area is not >2.0;

and 5) the soil *n* value is intermediate or low.

THEN: Mowing **may** be acceptable provided that the guidelines given in Section 2.3E are adhered to;

ELSEIF: Conditions 1 to 5 are not met;

THEN: the primary acceptance criteria are not met and mowing is unacceptable, unless cutting is by hand or mitigation measures are undertaken to compensate entirely for the effects of the proposed land-use (see Rule A concerning mitigation). If mitigation measures are being considered then refer to the secondary acceptance criteria (Descriptors E29-E40) to determine what further effects need to be taken into account.

Reasoning:

* Most marsh areas are inaccessible to farm machinery, even in dry years, but wet meadow areas may be accessible during drier periods in the wet season. In wet years, even wet grasslands are often inaccessible during the wet season.

* By removing cover, mowing may detract from the value of wetlands for providing habitat for wetland-dependent species requiring vegetation cover.

* The cutting of hay by machinery constitutes an erosion risk. As such, it is not considered an acceptable land-use on sites with a high erosion hazard index.

RULE D2

IF: 1) drainage channels are required to improve accessibility for mowing;

and 2) all the conditions given for planted pastures (Section 2.2B, Rule B) are met;

THEN: Mowing **may** be acceptable provided that the guidelines given in Section 2.3E are adhered to.

ELSEIF: Conditions 1 and 2 are not met;

THEN: the primary acceptance criteria are not met and mowing is unacceptable, unless cutting is by hand or mitigation measures are undertaken to compensate entirely for the effects of the proposed land-use.

Reasoning: see 2.2B and 2.2D above.

2.2E. DAM-ASSESS (RULES FOR DAMMING WETLANDS)

RULE E

IF: 1) no Red Data species are present which would be adversely affected by damming;

and 2) the wetland is not known to be of a type or to include habitat type/s which are threatened or which are regionally scarce or rare;

and 3) the cumulative loss of wetlands in the surrounding landscape is <60%;

and 4) pollutant input is not high (this is particularly important when downstream use is intermediate or high);

and 5) the wetland is not in a catchment where further damming is considered undesirable and which has been designated as an area where no further dam permits will be issued by The Department of Water Affairs. This is particularly important where extraction is planned from the dam and/or the dam is in a semi-arid region, where evaporation is high;

THEN: the dam satisfies the primary acceptance criteria. In order to determine whether it satisfies the secondary acceptance criteria proceed to 2.2F.

ELSEIF: any of the conditions 1-5 are not met;

THEN: the dam fails to meet the primary acceptance criteria and is unacceptable, unless mitigation measures are undertaken to compensate entirely for the effects of the proposed land-use (see Rule A concerning mitigation). If mitigation measures are being considered then refer to the secondary acceptance criteria (Descriptors E29-E40) to determine what further effects need to be taken into account.

Reasoning:

* Although a dam may improve the habitat provided by a wetland for certain common species such as the spur-winged goose (*Plectropterus gambensis*), the flooding of a wetland by a dam usually makes it unsuitable for specialized and threatened wetland-dependent species (e.g. the white-winged flufftail: *Sarothrura ayresi*).

* If the wetland is of a type or includes habitat type/s which are threatened or which are regionally scarce or rare then the loss would obviously be greater than if the wetland type was not scarce or rare. Conservation of biotic diversity encompass more than species conservation but also includes other considerations such as the maintenance of biological integrity.

* If wetland areas have already been lost from the surrounding landscape, the proposed loss is likely to have a greater impact than if this loss had not already occurred, when considered at a landscape level.

* Although dams perform many of the hydrological functions of wetlands (e.g. flood attenuation and sediment trapping), they are not as efficient in the removal of nutrients, particularly nitrogen. As such, the water quality constraints on dams, although accounting for situations where nutrient inputs are high, are not as stringent as for planted pastures and crops.

* Due to evaporation from dams, runoff is reduced in catchments which are dammed. This is particularly so in catchments where evaporation is high and which have a high percentage area occupied by dams. If users need to determine the extent to which runoff is likely to be decreased, they are referred to ACRU (Schulze *et al.*, 1989).

It is more difficult to set norms for dams than for the other land-uses because individual dams vary greatly with respect to:

1. depth;

2. nature of the outlet; and

3. shape and occurrence of features such as islands.

Furthermore, the use that is made of dams varies greatly, and includes: (1) irrigation (ranging from extraction of a small percentage of the stormflow to extraction of well in excess of the stormflow); (2) stock watering; (3) fishing; (4) waterfowl hunting; and (5) watersports. As such, it is even more difficult to prescribe acceptance criteria than for the other land-uses, and many of the criteria considered in determining the acceptability of dams are included in 2.2F.

2.2F SECONDARY ACCEPTANCE CRITERIA

IF: most of the answers to the secondary criteria questions (i.e. E29-E40) were 1's then the land-use may be acceptable provided that the guidelines for ongoing management outlined in Section 3 are adhered to.

ELSEIF: most of the answers to the secondary criteria questions were 2's and 3's then the land-use is unacceptable, unless mitigation measures are undertaken which will compensate entirely for the effects of the proposed land-use (including those effects revealed by both primary and secondary criteria questions).

Reasoning: see Notes for Descriptors E29-E40.

2.3 LAND USE-RECOMMEND: MANAGEMENT GUIDELINES FOR THE INDIVIDUAL LAND-USES

From the sections given below which deal with ongoing management guidelines for the particular land-uses, proceed to the section which deals with the land-use/s of interest.

Burning:	go to 2.3B
Natural grazing for domestic stock:	go to 2.3A and 2.3B (if burning is also applied)
Production of planted pastures:	go to 2.3C
Crop production:	go to 2.3D
Hay cutting:	go to 2.3E and 2.3B (if burning is also applied)
Dams:	go to 2.3F

2.3A NGRAZE-RECOMMEND (MANAGEMENT GUIDELINES FOR THE GRAZING OF NATURAL WETLANDS BY DOMESTIC STOCK)

Stocking rate

1) Establish in which Bioclimatic Group the impact area occurs (Descriptor A5);

2) Determine the potential grazing capacity for wetlands in the Bioclimatic Group (Table 3A1);

3) Adjust the potential grazing capacity by taking into account veld condition (Table 3A2) and the relative amounts of wet grassland, marsh and wet meadow to determine the Recommended Stocking Rate (RSR); and

4) Adjust the RSR to account for erosion hazard of the site (Table 3A3).

Fencing (camping) and grazing system

Consider the practicality of fencing off the wetland area as a special use pasture.

IF: the area has been (or will be) fenced off as a special use pasture;

THEN:
Apply the recommended rest-rotation grazing system with the proviso that animals are withdrawn if the soils are subjected to poaching;

ELSE:
Take alternative measures to reduce area selective grazing.

2.3A1 Stocking rate

Bench-mark sites, which represent areas considered productive and stable veld, have been described for all the Bioclimatic Groups of KwaZulu/Natal (Edwards and Tainton, 1981). The potential grazing capacities for these bench-marks have also been estimated (Table 3A1). Through personal observation and consultation with farmers at various wetlands in KwaZulu/Natal, it appears that the grazing capacity of natural wet grasslands is usually 1.5-3 times greater than that of the surrounding non-wetland veld. There are wet grassland areas, in Memel Vlei and Franklin Vlei for example, that are utilized at stocking rates of over 2 AU ha^{-1} on what appears to be a sustainable basis and with no obvious hydrological impacts. However, until these differences have been quantified in field studies, the grazing capacity of wet grasslands will conservatively be assumed to be 1.5 times that of the surrounding veld. This conversion figure is likely to be particularly conservative for arid and semi-arid regions because the difference in production between wetland and non-wetland is likely to increase with increasing aridity.

A widely applied method for recommending an appropriate stocking rate for an area is to conduct a veld condition assessment and to use the condition score to adjust the potential grazing capacity relevant to the Bioclimatic Group in which the area occurs. In order to determine veld condition, the species composition of the sample area is compared against that of the bench-mark for the region. Veld which is in poor condition generally has a lower potential productivity and soil protection capacity than good condition veld. Thus, the stocking rate needs to be reduced by an amount proportional to the condition score (i.e. the lower the veld condition score, the greater will be the required reduction in grazing capacity) (Edwards and Tainton, 1981).

Table 3A1 Potential grazing capacities of bench-mark sites for the different Bioclimatic Groups of KwaZulu/Natal (from Tainton *et al.*, 1980) and adjusted for wet grassland areas

Bioclimatic Group	Minimum $haAU^{-1}$ Non-wetland	Wet grassland
1	1.4	0.9
2	1.4	0.9
3	1.0	0.7
4	1.0-1.4	0.7-0.9
5	5.0	3.3
6	1.6	1.1
7	5.0	3.3
8	2.5	1.7
9	5.0	3.3
10	5.0	3.3
11	8.0	5.3

Unfortunately, bench-marks have not been described for the wetland areas within the different Bioclimatic Groups. A simplified system to be applied to wet grassland areas is proposed, whereby the recommended stocking rate is reduced by an amount proportional to the relative abundance of Increaser II species present (Table 3A2). Increaser II species have low palatability and/or perenniality, and increase in mis-managed veld where grazing pressure is heavy. *Eragrostis plana* is the most commonly occurring Increaser II species in the wetlands of the study area (see Appendix 1). A veld condition assessment should be conducted by randomly placing a point 200 times in the wet grassland zone and at each point recording whether or not the closest species is an Increaser II.

Table 3A2 Stocking rate adjusted to account for veld condition (RSR)

Percentage of Increaser II species	Stocking rate (expressed as a percentage of the potential grazing capacity for wetlands in the given Bioclimatic Group)
0- 30%	100%
30-60%	85%
>60%	70%

In the mid and late grazing season, domestic stock select strongly for wet grassland, less strongly for wet meadow, and avoid marsh. If a given wetland area were stocked without consideration for agro-ecological type then the effective stocking rates in the wet grassland areas would be considerably higher than the RSR. The stocking rate needs to be based on the proportion of wet grassland relative to wet meadow and marsh.

The extent to which marsh and wet meadow areas should be excluded in the calculation of stocking rate would be determined by the degree to which these areas are selected against. If it can be demonstrated for the given wetland area that during early spring, livestock do not show a strong preference for wet grassland then it is recommended that wet meadow and marsh areas be included in the stocking rate calculations for the early grazing season only. Stocking rates of $1haAU^{-1}$ are recommended for wet meadow and marsh in the early growing season. However, these areas should be used opportunistically under conditions that will not lead to **poaching** (the disruption of soil structure caused by the repeated penetration of hooves into the soil) (Wilkins and Garwood, 1986) (see Section 2.3A3, p60).

The stocking rate recommendations described above have been made for sites with a low erosion hazard. Thus, if the potential for erosion control value loss is high, because the wetland has a high erosion hazard, the maximum stocking rate restriction should be decreased (Table 3A3). The erosion hazard (EH) of the site is given in Descriptor E13.

Table 3A3 Stocking rate correction factors to account for erosion hazard of the site (expressed as percentages of the recommended stocking rate) and to calculate the adjusted stocking rate (ASR)

Sites with an intermediate erosion hazard (EH= 1.5-2.2):	80%
Sites with a high erosion hazard (EH= 2.3-2.7):	60%
Sites with very high erosion hazard (EH> 2.7):	exclude grazing

Provided that the recommended rest-rotation grazing system outlined in Section 2.3A3 is adhered to, and the wetland area is rested for a full year every fourth year, then wet grasslands may be grazed at the adjusted stocking rate (ASR).

2.3A2 Fencing of wetland areas and other means of reducing area selective grazing

Because wetlands have special management requirements, they should be fenced off as special use camps. However, this is often impractical. For example, wetlands in slope settings generally occur as many small areas (often < 0.5 ha) interspersed in a matrix area of predominantly non-wetland. If fencing is impractical, the following guidelines aimed at reducing the grazing pressure on wetlands should be considered:

1. herd those animals which are managed under herding away from wetland areas into under-utilized non-wetland areas;

2. ensure water availability in adjoining non-wetland sites so as to reduce animal numbers and time spent in wetland areas. This is particularly relevant to slope wetlands which often provide the only water

source in the surrounding landscape;

3. place supplementary feed in non-wetland areas where grazing is desired and minimize its location near and within wetland areas;

4. assure accessibility for livestock into non-wetland areas to be grazed, and provide stock trails and accessways over difficult terrain;

5. provide shade or shelter at strategic locations away from the wetland area; and

6. cut herbage for hay or green chop, mow old grasses, or strategically burn (in the non-growing season only) to attract more grazing to otherwise under-utilized areas away from wetland areas.

If the stocking rate for the overall area is excessive there will be few under-utilized areas in the landscape, diminishing the effectiveness of these measures. This, again, emphasises the importance of maintaining reasonable stocking rates.

2.3A3 The grazing system

In rotationally grazing a wetland area, a farmer may adopt one of two systems:

1. a fixed rotational system, with a cycle of 14 days in and 28 days out of the wetland, for example, and a full 12 months' rest every 4 years; or

2. a flexible rotational system, whereby the area is grazed until a predetermined level of use or disturbance has occurred, beyond which continued use of the wetland is likely to begin detracting from the hydrological and ecological values of the wetland and, in many cases, its current production potential. A full 12 months' rest is included every 4 years. It is very difficult to prescribe a threshold level of use, as it will depend on the vegetation type and climatic conditions. A suggested level is when the sward has been grazed to an average height of 8 cm, and/or when the favoured plants have been grazed to 4 cm high, and/or when most of the tufts of the favoured species have been grazed.

If the expertise of the manager is high and it is possible to check regularly on camps being grazed to monitor the effect of the animals, a flexible system is defenitely preferable. If, however, the manager's expertise is low and/or regular checking is impossible, the fixed system may be preferable.

Rotational grazing, be it fixed or flexible, should be discontinued if the soil becomes flooded or wet to the surface, at which stage it is recommended that grazing livestock be removed until the area dries out again. When wet,.soils, particularly those with a high clay content, are more susceptible to compaction and poaching. The poaching of soils should be avoided because it decreases herbage production, and increases the susceptibility of the soil to erosion (Wilkins and Garwood, 1986).

The exclusion proviso based on soil wetness may appear to be over-conservative and unjustifiably deny the farmer valuable grazing. However, it is important to note that when the need for grazing to supplement drought-limited non-wetland grazing is high then grazing of the wetland is usually permissable. This is because it generally corresponds to times when the wetland soils are least susceptible to erosion and are acceptably dry for use. In contrast, when the use of the wetland is likely to have the greatest impact, as a result of being wet to the surface, then the need for wetland grazing is likely to be low because it usually corresponds with wet periods when non-wetland forage production is high.

2.3B BURN-RECOMMEND (MANAGEMENT GUIDELINES FOR BURNING)

There are two main groups of fire management decisions. The first concerns the time of year to burn and the frequency of burning. The second concerns the steps that can be taken to influence fire behaviour (e.g. if a low intensity fire is required, burning should not take place when the air temperature is high).

2.3B1 Recommendations concerning the timing and frequency of burning

IF: the wetland falls within an afforested area and is not burnt at all (usually because it is very small/narrow and surrounded by trees) or is burnt annually in early winter because of the fire risk to surrounding trees;

THEN: Go to 2.3B1.1 (p62)

ELSEIF: the wetland does not fall within an afforested area and regular burning is required to:

* enhance grazing potential;
* promote plant vigour and control alien plant infestation;
* enhance the habitat for wetland-dependent fauna and/or flora; or
* to prevent the build-up of exceedingly high fuel loads;

THEN: Goto 2.3B1.2 (p63)

ELSE: Goto 2.3B1.3 (p63)

2.3B1.1 Wetlands in afforested areas

* Wetlands in afforested areas that are very seldom burnt

Small/narrow wetlands in afforested areas but not within fire-breaks are often very seldom defoliated by burning and/or grazing. This causes the accumulation of standing dead and loose surface litter which, in turn, reduces the vigour of the vegetation, increasing its susceptibility to invasion by alien plants. In addition, runoff reduction caused by the planted trees reduces the degree of wetness of these wetland areas, making them more vulnerable to invasion by alien plants which would otherwise not have been able to tolerate the water regime of the unaltered wetland area. Often trees are planted very close to the wetland, and the wetland areas are shaded. Furthermore, plantations often harbour large populations of alien plants and provide a source for invasion into the wetland.

In such situations, it is recommended that nature conservation and/or extension officers be consulted about the various options available to increase the vigour of the natural wetland vegetation (e.g. through grazing), moving the afforested areas back from the edge of the wetland, and controlling alien plants.

* Wetlands burnt annually in early winter because of fire risk

From an ecological and hydrological impact point of view, an early winter burn is more destructive than a late winter/early spring burn, particularly if it is annual. In marsh, where the water table remains close to the soil surface through most of the winter season, absence of loose surface and standing plant litter (removed by the fire) for the entire winter is likely to result in a significant increase in the evaporative loss of water from the wetland. However, in wet grassland where the water table drops well below the soil surface, removal of plant litter is unlikely to have this result. This is because loss is already being limited by the upper dry soil layers. The increased evaporative loss from wet meadow is likely to be higher than in wet grassland because the upper soil layers remain wet for longer into the dry season, but this is not as prolonged as in marsh. Thus, the extent to which early winter burns increase evaporative loss will depend on the relative proportions of marsh, wet meadow and wet grassland. Little can be done to minimize the hydrological impact of early winter burning, other than to protect marsh and wet meadow areas where possible. Early winter burning may detract from the grazing resource if large numbers of herbivores are attracted to the winter flush (Tainton, 1993. pers. comm.). Grazing of these areas should preferably commence only in the following season.

Measures taken to minimize the impacts of early winter fires on the ecological values of wetlands are primarily aimed at winter breeding species. One of the rarest species that may still be breeding in early winter is the grass owl (*Tyto capensis*), a late summer to early winter breeder. Other less rare species which may also be breeding at this time are the African marsh harrier (*Circus ranivorus*) and the marsh owl (*Asio capensis*). In order to cater for the needs of these species it is recommended that the areas in which they breed be burnt rotationally. An ornithologist should be asked to identify localized areas which, if rotationally burnt, would most benefit the winter and autumn breeding species.

Wetlands may be burnt rotationally through strip burning or block burning. Strip burning is probably best achieved by preparing a burning trace, using a herbicide that kills only the aerial portions (e.g. Gramoxen). Wetland areas usually comprise "tongues" within the afforested landscape. Where these wetland tongues are wide (ca >300 m), the tongue should be divided into 2 strips and burnt alternately on a rotational basis. In order to account for breeding grass owls (*Tyto capensis*), the following steps should be undertaken:

1. identify those areas used by the grass owl for breeding; and

2. check these areas before burning for currently breeding owls and/or chicks still unable to fly. This may be achieved by having 'beaters' 10 m apart walking through the area and then closely examining all localities where grass owls are flushed (Johnson, pers comm.). Areas where chicks have still not fledged would then be left unburnt for that year, or, if possible, burning for that year could be delayed.

2.3B1.2 Late winter/ early spring burning

If burning is needed to enhance grazing potential or habitat value, or to control alien plants, it is recommended that this be done every second year in early spring: this should have the least hydrological and ecological impact. Occasional late autumn/winter burns (at an average seven-year interval) should also be included to enhance diversity. Early spring burning may result in the death of wattled crane (*Grus carunculata*) chicks or eggs, as the wattled crane is a winter to early spring breeder. Thus, if this species is breeding in the wetland then:

1. consider delaying burning if the chicks are still unable to fly;

2. observe where the chicks are at the time of the burn and burn strategically; and

3. if eggs are present, temporarily remove them and replace them after the burn.

2.3B1.3 Infrequent burning

Wetlands that meet the requirements for infrequent burning should not be burnt more frequently than every five years. As the burning of wetlands, and of the landscape in general, is the norm in the humid and sub-humid grasslands and savannas of KwaZulu/Natal, the assumption is made that most wetlands in the landscape are likely to be burnt regularly. Thus, by promoting the infrequent burning of some wetlands, the diversity of habitat provided by wetlands in the overall landscape will be enhanced.

2.3B2 Recommendations relating to influence on fire behaviour

The following generally applicable recommendations are made, aimed at reducing the extent, intensity and damage caused by fire.

* Burn when the relative humidity is high and the air temperature is low, preferably after rain, in order to keep the fire as cool as possible and increase the likelihood of a patch burn.

* If possible, divide the wetland into two burning blocks and alternately burn each half, leaving the other half unburnt to provide refuges for wetland-dependent animals from which recolonization of the burnt areas can occur. If this is impractical, the entire wetland may be burnt every second year provided there are other wetlands nearby (preferably within 1 km) left unburnt for the year in which the wetland is burnt. Effective fire breaks are often difficult to achieve in wetlands, as fires may easily burn across the break through the loose surface litter on the soil surface, or even below it in the upper organic matter-rich soil layers if they are dry.

* Protect areas known to be important bird breeding areas (e.g. reed marsh areas used by herons or sedge marsh areas used by ducks) but even these may need to be burnt every fourth or fifth year to stimulate new plant growth.

* If conditions are unfavourable for burning (e.g. if the soil is very dry and susceptible to sub-surface fires or if the weather conditions are consistently unsuitable) delay burning until the following year.

* Burn areas with abundant dead (moribund) stem and leaf material that is obviously limiting new growth, preferentially.

* Where wetland plants are being harvested, do this in areas useful for fire breaks, as far as is possible.

* Keep records of management practices, to monitor progress.

* Cattle, by reducing the fuel load and creating puddles, can be used to good effect in promoting patch burns.

* Head fires (burning with the wind) are generally preferable to back fires (burning against the wind). Temperatures at ground level tend to be higher in back fires and consequently the impact on the growing points of plants is greater. Although the fire front advances less rapidly in a back fire, direction is more difficult to predict. Also, because the fire front advances more rapidly with head than with back fires, particularly if the wind speed is high, the fire has less time to spread laterally. Thus, head fires can be used more effectively for burning only portions of the wetland without the use of fire breaks. However, this method of burning portions of a wetland is dependent on many factors outside the managers control, such as wind direction changes, and cannot be relied upon for consistent block burning.

2.3C PASTURE RECOMMEND (MANAGEMENT GUIDELINES FOR PLANTED PASTURES)

2.3C1 Selection of species

Perennial species, such as *Festuca arundinacea* (tall fescue) and *Acroceras macrum* (Nile grass), are preferable to annuals, such as *Lolium multiflorum* (annual ryegrass), as they require the soil surface to be disturbed less frequently. This means that loss of erosion control value is less likely to occur.

Species with a high wetness tolerance, such as *Festuca arundinacea*, are preferable to species with a lower tolerance, such as *Medicago sativa* (lucerne) and L. multiflorum because the greater the wetness tolerance of the species, the smaller will be the need to decrease the degree of wetness of the soil. As such, the loss of hydrological values would be lower.

2.3C2 Drainage channels

Wetland drainage is discouraged by all government and non-government environmental bodies and a permit is required to drain any wetland area. Drainage will almost always detract from the hydrological and ecological values of a wetland, irrespective of how carefully planned it may be. However, an even greater loss may be avoided through careful planning. If a permit is obtained for wetland drainage, which rarely occurs, the Department of Agricultural Development should be consulted with about the final design and placement of the drainage channels. It may also be that an already drained area requires a revised drainage plan because of poor planning earlier, and consultation is strongly advised here.

The objective of wetland drainage is to lower the water table just enough to permit the successful establishment and growth of pasture. Complete control of the ground water elevation should be maintained so that the water regime of the wetland can be returned to its original state at any time (Scotney, 1970). Under no circumstances should the outlet of the wetland be altered, either by the creation of new drainage channels or by the straightening and/or deepening of existing channels. In addition, the area immediately above the outlet should be left under natural vegetation, as should the flow concentration zone of channel disrupting wetlands.

Surface drainage channels usually require regular excavation and disturbance of the soil to remove plants growing in the channels. This means that sub-surface channels are less likely to detract from the water purification function of the wetland. However, although it in no way compensates for the natural habitat lost through development, surface drainage channels provide a small amount of micro-habitat that would otherwise be absent if sub-surface drainage had been used. Thus, sub-surface drainage is likely to detract slightly more from the ecological value of the wetland than surface drainage.

2.3C3 Timing of grazing

As is the case in natural wetlands, grazing should be avoided as far as possible when the soil is saturated, because this is when the soils are most susceptible to erosion and compaction. If the pastures are irrigated, it is important that a co-ordinated irrigation and grazing schedule be devised. Extra care should be exercised in grazing pastures during the first year or two after planting. Older stands, particularly those providing fibrous ground cover, would be at a lower risk than younger stands.

2.3C4 Fertilizer application

Measures should be taken to minimize nitrogen and phosphorus losses into drainage waters as this not only detracts from the economic returns derived from pasture production but also from the water purification function of the wetland.

There are numerous possible measures available for minimizing nitrogen leaching losses (Amberger, 1983; Miles and Bartholomew, 1991), including:

1. limitation and proper timing of mineral fertilizer application according to the special needs of the pasture;

2. multi-cropping with nitrogen-fixing legumes and grasses (which reduces the application requirements) and possibly also mulching with straw (which decreases loss);

3. modern fertilizer technology (e.g. slow release-fertilizers); and

4. avoiding over-irrigation.

There are fewer ways of limiting phosphorus loss. As with nitrogen, the amount applied should not exceed the plants' requirements, allowing for soil fixation. Determination of these requirements involves taking into account such factors as soil texture and pH (see Department of Agriculture and Water Supply, 1987). Although some leaching of phosphorus occurs, it leaches less readily than nitrogen, and the greatest loss generally occurs in association with the loss of soil mineral particles from a pasture. Because of the association of phosphorus loss with soil loss, measures taken to limit soil erosion would also assist in limiting phosphorus loss.

* **Limitation and proper timing of mineral fertilizer application according to the needs of the pasture**

Fertilizer applied should be just enough to meet the requirements of the specific pasture species (i.e. the correct fertilizer dressing should be applied). Theoretically, nitrogen losses could be reduced by perfectly matching nutrient availability with total nitrogen requirements of the pasture, but this is very difficult to achieve under field conditions. Split applications in at least three or four dressings is recommended (i.e. frequent small applications are preferable to infrequent large applications). As an example, Miles and Bartholomew (1991) recommend that if a total seasonal nitrogen (N) rate of 300 kg/ha is required then it should be applied as six equal dressings of 50 kgN/ha rather than as three equal dressings of 100 kgN/ha. Four- to six-weekly intervals are recommended as optimal for N topdressing. Although split-dressings increase labour costs, this may be offset by more efficient nitrogen use and avoidance of possible toxic fertilizer concentrations in the soil solution.

In newly established pastures, nitrogen from decomposed organic matter is likely to meet the initial requirements of the plants. Thus, it is recommended that the first application be reduced or that nitrogen fertilizer be applied only two weeks after establishment.

When applying fertilizer, the seasonal growth patterns of the pasture should also be taken into account. In the highland sourveld (which characteristically has a humid climate) growth in the mid-winter is restricted by low temperatures and not by nitrogen insufficiency. Nitrogen dressings should be drastically reduced (or terminated) in mid-winter and the bulk of the nitrogen applied in spring and late summer/autumn (Miles and Bartholomew, 1991).

*** Intercropping with legumes and mulching**

A mixture of grasses and nitrogen-fixing legumes, provides naturally occurring nitrogen, and the amount of expensive mineral fertilizer required would be reduced. In legume/grass pastures the legume may contribute from 50 to 250 kg N/ha annually to the pasture. However, legumes cannot supply enough nitrogen for maximum grass production: although they usually supply enough for themselves, this is not sufficient to maintain the other pasture species.

An important consideration when using nitrogen fixation by the legume component of a mixed sward, is that nitrogen from the legume is made available to the grass mainly via excreta. Thus, cutting and removing material and having animals deposit their excreta off the pasture is likely to cause nitrogen deficiency and limit grass growth (Miles and Bartholomew, 1991).

Mulching, by mechanically incorporating residual pasture herbage into the soil, can be used to capture fertilizer or manure nitrogen and assimilate it into organic matter through the action of micro-organisms. This would be particularly applicable to annually established pastures and crops. This practice would assist in counteracting the steady decrease in organic matter often associated with cultivation and, in so doing, would have additional benefits such as increasing the soil's moisture holding capacity. From a plant production point of view it is important to note, however, that this biologically blocked nitrogen will not be available to the plants until the organic matter has been broken down, which may take months.

*** Modern fertilizer technology**

Fertilizer particle coatings (e.g. with sulphur) or slow release nitrogen fertilizers (which consist of either sparingly soluble material or organically combined nitrogen) can also improve nitrogen-efficiency by allowing a controlled release of nutrients to the roots. Nitrification inhibitors accumulate ammonia by retarding the nitrification of ammonium to nitrate. Leaching of nitrogen is reduced because nitrate is most prone to leaching. Thus, as in coatings and slow release fertilizers, the roots are continuously supplied with small quantities of nitrogen.

* **Avoiding over-irrigation**

In irrigated pastures, over-irrigation will not only waste costly irrigation water through run-off, but may cause nutrient losses through leaching. Once the soil profile is nearing saturation, the irrigation system should be moved or shut down until the soil has dried out sufficiently to require irrigation again (Macdonald, 1991).

2.3D CROP-RECOMMEND (MANAGEMENT GUIDELINES FOR CROP PRODUCTION)

The development of wetlands for crop production is generally not considered acceptable by conservation and environmental bodies and has never been encouraged. WETLAND-USE lists stringent requirements for the acceptability of wetland cropping, one of which is that the area must be transitional between wetland and non-wetland (see Section 2.2A). Where the conditions are met and permission has been granted for development, caution must be exercised in utilizing these marginal cropland areas.

Recommendations concerning drainage and minimizing the impact of artificial fertilizer applications given for planted pastures are also applicable to crop production (i.e. Sections 2.3C1-2.3C4). In addition, the Universal Soil Loss Equation (U.S.L.E.) should be applied in order to plan contour bank spacing distances, where they are required, and other soil conservation measures (a seventeen page document "Use of The U.S.L.E. in the Natal Region" is available from The Department of Agricultural Development, Natal Regional Head Office, PB X9059, Tel: 33371).

Long ley rotations should also be implemented. In dry years, the moisture conditions in wetland areas are generally more favourable than in drier non-wetland areas. Consequently, they may provide useful alternative dryland crop production areas during drought years but they cannot be relied upon for continuous cropping. A one-in-three year ley is recommended, where for every year the area is cropped, it is left fallow or under perennial pastures for three years. For a ley to serve its purpose (primarily to restore depleted soil organic matter levels) at least three consecutive years for each rotation is required. The most generally applicable system would probably be three years of cropping alternating with nine years of perennial pasture ley.

2.3E HAY-RECOMMEND (MANAGEMENT GUIDELINES FOR HAY PRODUCTION)

Although the restrictions that apply to mowing are largely included in Section 2.2D, some further guidelines are given below.

* Mowing should not be carried out when the soil is wet, because, as with grazing, this increases the risk of soil erosion, particularly if machinery gets stuck.

* Consideration should be given to hand cutting. Although more labour intensive, this harvesting method is less constrained by soil surface conditions and would have less impact on the soil, thereby decreasing the loss of hydrological and erosion control values.

* If the wetland is also being used for domestic stock grazing then not more than 40% of any agro-ecological zone in the wetland should be harvested for hay, because this may detract from the ecological value and would also reduce its flood attenuation value. If the wetland is not being used for grazing then this value may be increased to 60%.

2.3F DAM-RECOMMEND (MANAGEMENT GUIDELINES FOR DAMS)

2.3F1 Construction of the dam wall and spillway

The dam wall and spillway should be built to withstand flooding because the bursting of dams usually has a high environmental impact, increasing flood peaks, sediment loads and streambank erosion. In addition, the spillway should be built to allow for the movement of aquatic species. All dams should also preferably have an outflow control (see 2.3F2).

Consult the local soil conservation officer or an engineer to plan the dam wall and spillway and to check whether it has been built to specifications.

2.3F2 Ongoing management

The main factors within the manager's control once a dam has been built and filled are:

1. water extraction;

2. outflow control; and

3. introduction of species, and harvesting of introduced and/or indigenous species.

* **Extraction of water**

Extraction of water often causes sudden, large fluctuations in the water level of a dam, hindering the establishment and growth of wetland vegetation. Together with wave action, this also contributes to hardening of the soil to produce an armoured shoreline, which decreases the ecological value of the area. In some instances, however, drawdown on shorelines with a soft substratum improves the ecological value as these exposed areas are often good for mud-probing birds. If wattled cranes are breeding on the edge of the dam then winter draw-down should be limited as this is likely to leave the nest exposed and makes the site unsuitable for breeding.

* **Outflow control**

The first wet season flows from a dam's catchment are often retained in the dam because levels are depleted at the end of the dry season. This may affect both the river biota and downstream users negatively (Bruwer and Ashton, 1989). It is important that the outflow from the dam be controlled so that at least 50% of the early season flow entering the dam is released.

* **Introduction of species and harvesting of species (introduced and indigenous).**

If species are to be introduced and/or species are to be harvested, consult the local nature conservation extension officer, because this may detract from the ecological value of the area.

2.4 WETLAND DATASHEET

Section 1 and Section 2.1-2.3 should be referred to so that the data sheet is completed with as much clarity and consistency as possible.

WETLAND SITE INFORMATION

Date of site visit/s ......(mnth.) ......(yr.)
......(mnth.) ......(yr.) ......(mnth.) ......(yr.)

Compilers'name/s.......................................

A1 Wetland name ....

A2 Geographic co-ordinates ....

A3.1 Inlet altitude (m) ....

A3.2 Outlet altitude (m) ....

A3.3 Average altitude (m) ....

A4 Bioclimatic Group ....

A5 Mean annual precipitation (mm) ....

A6 Annual pot. evapotranspiration (mm) ......

A7 Humidity Category (a or b) ....
a=Bioclimatic Grps 1-6; b=Bio Grps 7-11

A8 Veld type ....

A9 Dominant soil form/s ....
....

A10 Underlying geology...........................
....

A11 Total surface area (ha) ....

A12 Average width (m) ......

A13 Length (m) .....

A14 Average slope (%) ....

A15 Agro-ecol. zone abundance (1-4, a-l or %):

A15.1 Open water ......

A15.2 Marsh ......

A15.3 Wet meadow ......

A15.4 Wet grassland ......

abund. ranking: 1=1st 2=2nd 3=3rd 4=4th
a<0.01% b=0.01-3% c=4-10% d=11-20%
e=21-30% f=31-40% g=41-50% h=51-60%
i=61-70% j=71-80% k=81-90% l=91-100%

A16 Species composition: see p76.

A17 Horizontal pattern of zones (A-C) ....
A=low interspersion B=intermediate intrsp.
C=high interspersion

A18 Landform setting (a-f) ......
a=Flat b=Depression c=Channel d=Slope
e=Channelled flat f=Channel disrupting flat

A19 Emergent vegetation in channel (Y/N) .....

A20 Prevalence of depressions (a-d) ....
a<3% b=3-10% c=11-30% d>30%
of total wetland surface area

A21 Terrain unit (a-f) ....
a=Crest b=Midslope c=Footslope
d=Valleyhead e=Valley bottom (young)
f=Valley bottom (mature/old)

A22 Slope of flow concentration zone (%) ....

A23 Stream order ....

A24 Meander ratio ....

A25 Red Data plant species Status Zone
....
....

A26 Red Data animal species Status Zone
....
....

A27 Other valued species ....
....
....

A28 Localized species
....
....

A29 Threatened habitat types ....
....

A30 Migratory/nomadic species (Y/N) ......

A31 Duck/heron breeding site (Y/N) ....

A32 Timing of fires (a-d) .... a=winter
b=early spring c=summer d=autumn

A33 Fire frequency (a-e) ....
a=annual b=every 2 yrs. c=every 3 yrs.
d=every 4th-7th yr. e > a 7 yr. interval

A34 Alien invasive species Infestation level (a-c)

....

....

a >30% of the wetland area infested

b=5-30% infested c <5% infested

Area (a-f) of the wetland altered by:

A35 Dams ....

A36 Drainage channels ....

A37 Erosion ....

a <1% b=1-5% c=6-15% d=16-30%

e=31-60% f=61-100%

A38 Increase in erosion (a-f, see above) ......

A39 Severity of erosion (a-d) ....

a=negligible b=mildly severe

c=severe d=very severe

A40 Severity in the flow conc. zone (a-d) ......

A41 Total length of roads/railroads (km) ......

A42 Flow concentration effect of roads (Y/N) .....

A43 Damming effects of roads (Y/N) ......

Land-uses in the wetland (Y, a-k or % of area):

A44.1 Nature conservation ....

A44.2 Natural vegetation stock grazing ....

A44.3 Hay cutting ....

A44.4 Planted pastures ....

A44.5 Crops ....

A44.6 Forestry ....

A44.7 Urban or industrial ....

A44.8 Mining ....

A44.9 Other (..........................) ....

a=1-3% b=3-10% c=11-20% d=21-30%

e=31-40% f=41-50% g=51-60% h=61-70%

i=71-80% j=81-90% k=91-100%

Natural resources level of use (Y or a-c):

A45.1 Hunting ....

A45.2 Plant harvesting ....

A45.3 Water use ....

Level of use: a=nil b=low

c=intermediate d=high

Recreation level of use (Y or a-d):

A46.1 Bird watching ....

A46.2 Water sports ....

A46.3 Fishing ....

A46.4 Other (.........................) ....

A47 Part of a research programme (Y/N) ....

A48 Close to educational centre (Y/N) ....

A49 Land ownership..........................

A50 High nutrient level in wetland (Y/N) ....

A51 Toxicants in wetland (Y/N) ....

A52 Inflow turbid (Y/N) ......

SURROUNDING LANDSCAPE INFORMATION

Extent of wetlands (a-h) in:

B1 The wetland catchment ......

B2 The downstream service area ......

B3 A 10 km radius ......

a=0-0.05% b=0.06-0.5 c=0.6-1%

d=2-5% e=6-10% f=11-25%

g=26-50% h >50%

Extent of wetland loss (a-d) in:

B4 The wetland catchment ....

B5 The downstream service area ......

B6 A 10 km radius ......

a=Nil b=1-30% c=31-60% d >60%

CATCHMENT INFORMATION

C1 Bioclimatic Group/s ....

C2 Veld Types ....

C3 Wetland catchment size (ha) ....

C4 'flood' catchment size (ha) ....

C5 % catchment occupied by the wetland .....

C6 Mean annual runoff .....

Current land-uses in the catchment (Y or %):

C7.1 Conservation ......

C7.2 Livestock on natural vegetation .....

C7.3 Natural vegetation mowing ....

C7.4 Planted pastures ....

C7.5 Crops ..... C7.6 Urban ....
C7.7 Industrial ..... C7.8 Mining ......
C7.9 Other (..........................) ....
C8 Total number of dams ......
C9 Total surface area of dams (ha) ....
C10 % of catchment irrigated (a-e):
C10.1 (spring) ..... C10.2 (summer) .....
C10.3 (autumn) ..... C10.4 (winter) .....
C10.5 (total) .....
a <0.5% b=0.5-2.9% c=3-8% d=9-20%
e=21-50% f >50%
C11 Runoff reduction (a-d) ....
a=negligible b=moderate c=large
d= very large
C12 Water quality data (append if necessary)
....
....
....
....
....
....
C13 Level of sediment input (a-c) ....
C14 Level of nutrient/toxicant input (a-c) ....
<u>C15</u> Level of combined pollutant input (a-c)
.... a=low b=intermediate c=high

POTENTIAL DOWNSTREAM SIGNIFICANCE
D1 Water purification service distance (km) ....
D2 Flood attenuation service distance (km) ....
D3 Wetland's current potential water purification significance .....
D4 Wetland's current potential flood attenuation significance .....
Current potential importance (0-3) for:
D5.1 Potable water users ....
D5.2 Piped water users ....
D5.3 Recreationists ....
D5.4 Stock watering ....
D5.5 Irrigation ....
D5.6 Downstream biota ....
Importance: 0=nil 1=low
2=intermediate 3=high
D6 Total water use score (0-15) ....
D6=D5.1+D5.2+D5.3+D5.4+D5.5+D6.6
D7 Total current significance (a-d) ....
a: D6=0 b: D6=1-4 c: D6=5-8
d: D6>8 or D5.1>1
D8 Current abundance of floodable units ....
D9 Total current significance (a-d) ....
a: D8=0 b: D8=1-10 c: D8=11-19
d: D8>20

NOTES:...
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INFORMATION ABOUT THE IMPACT SITE

Initial impact site information

E1 Land-use (a-f) ....

a=natural vegetation for wildlife or fire breaks

b=natural vegetation for stock grazing

c=mowing d=planted pastures

e=crops f=dams

E2 Pasture type ....

E3 Crop type ....

E4 Outflow control (Y/N) ....

E5 Uses of the dam (a-e) ....

a=irrigation b=waterfowl hunting

c=stock watering d=watersports

e=fishing

E6 Land ownership ....

E7 Surface area (ha) ....

E8 % of wetland that is impact area ......

E9 Landform setting. ....

E10 Slope ....

E11.1 Soil form ....

E11.2 Soil family ....

E12 Erosion hazard of the soil ....

Primary acceptance criteria checksheet

Use of the checksheet involves checking each row to see if the descriptor values for the site meet the requirements given in the column of the land-use under consideration. If the site column has a value which falls outside the limits set for the land-use for any of the rows then the land-use is considered unacceptable. For example, if in the first row to be checked the impact site had an erosion hazard index of 1.9 then both crop and pasture production would be unacceptable. Similarly, if the soil *n* value was high, crop and pasture production would be unacceptable. A '*' indicates that the land-use may be acceptable but restrictions given in Section 2.3 apply. A blank indicates that no restrictions apply for that particular descriptor and land-use. The acceptance criteria and reasoning behind them are given in Section 2.2.

		Site	Graze	Mow	Dams	Crops	Pastures
E13	Site erosion hazard (0.3-3.6)	.....	<2.8	<2.0		<1.0	<1.5
E14	Agro-ecological zone (a-d)	.....				d	c,d
E15	*n* Value (a-c)	.....	b,c	c		c	c
E16	Red Data species (Y/N)	.....	*	*	N	N	N
E17	Threatened habitat types (Y/N)	.....	*	*	N	N	N
E18	Cumulative wetland loss (%)	.....			<60%	<60%	<60%
E19	Downstream water use	.....	*			N	N
E20	Pollutant input	.....			N	N	N
E21	Catchment unsuitable for dams	.....			N		
E22	Water table lowering (a-f)	.....	-	-	-	<10cm	<20cm
E23	Severity of existing erosion (a-d)	.....	a,b*	a,b*		a	a

E13= FxSxE12

If E9 is a channel or includes the channelled portion of a channelled flat or channel disrupting flat then F=2, and if it is a depression then F=0.75, otherwise F=1.

S value:

Slope (E10)	S value	Slope	S value	Slope	S value
<0.2%	1	0.2-0.9%	1.6	1.0-3.0%	2.2
3.1-10.0%	2.8	10.0-20.0%	3.2	>20%	3.6

E14: a=open water/marsh b=wet meadow c=wet grassland d=wet grassland/non-wetland mosaic

E15: a=very high *n* value b=high *n* value c=intermediate or low *n* value

E22: a=0cm b=1-10 cm c=11-20 cm d=21-40 cm f >40 cm

E23: a-d see A39

Information required for the secondary acceptance criteria and LAND USE-RECOMMEND

E24 Percentage of impact area eroded ....
E25 Percentage of impact area developed ....
E26 Roughness co-efficient ....
E27 Soil texture class ....
E28 Runoff potential ....

Secondary acceptance criteria (1-3 ranking)

If all the primary acceptance criteria are met and most of the answers to the secondary criteria questions (i.e. E29-E40) are '1's then the land-use may be acceptable provided that the guidelines for ongoing management outlined in Section 3 are adhered to. Otherwise, if most of the answers to the secondary criteria questions were '2's and '3's then the land-use is unacceptable, unless mitigation measures are undertaken which will compensate entirely for the effects of the proposed land-use (including those effects revealed by both the primary and the secondary criteria questions). The notes for Descriptors E29-E40 should be referred to see the reasoning behind the ranking.

E29 Area to be developed (ha) ....
1 <0.1 ha 2=0.1-1 ha 3 >1 ha

E30 Level of development/degradation ....
1=(E24 + E25) > 60% of Impact area
2=(E24 + E25)= 20-60% of Imp. area
3=(E24 + E25) < 20% of Impact area

E31 Availability of alternative sites ....
1=low 2=intermediate 3=high

E32 Importance for birds ....
1=low 2=intermediate 3=high

E33 Cumulative loss ....
1 <10% 2=11-40% 3 >40%

E34 Roughness coefficient ....
1: N=0.04 2: N=0.06 3: N=0.08

E35 Extent of shallows ....
1=limited 2=moderate 3=extensive

E36 Aquatic species movement ....
1=unimportant 2=mod. important
3=important

E37 User's need for development ....
1=large 2=intermediate 3=small

E38 Existence of alternatives ....
1=large 2=intermediate 3=small

E39 Contribution to society ....
1=large 2=intermediate 3=small

E40 Level of direct benefit ....
1=large 2=intermediate 3=small

NOTES:..
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APPENDIX 1: SOME PLANT SPECIES COMMON TO THE WETLANDS OF THE KWAZULU/NATAL MIDLANDS

The agro-ecological zones in which the species characteristically occur, as well as their heights, are given in the list below. Diagnostic features are indicated with arrows on the species drawings and in the list.

TYPHACEAE (BULRUSHES)

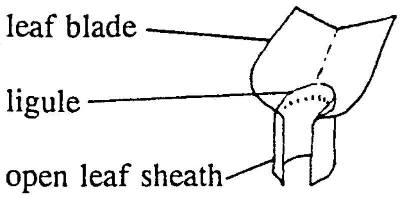
Typha capensis: marsh; 1.5-3m.

POTAMOGETONACEAE

Potamogeton thunbergii: open water, floating.

GRAMINEAE (GRASSES)

Grasses resemble some sedges but, unlike most sedges, all grasses have a ligule and an open leaf sheath.



Phragmites australis: marsh; 1.5-4.5m
Andropogon appendiculatus: wet grassland, wet meadow; 0.3-1m.
Eragrostis plana: wet grassland; flattened leaf base; up to 1m.
Eragrostis planiculmis: wet grassland, wet meadow; resembles *Eragrostis curvula* but hairs are absent from the leaf bases; up to 1.2m.
Leersia hexandra: marsh, wet meadow; 0.3-1.2m.

CYPERACEAE (SEDGES)

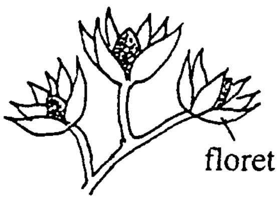
Most sedges lack a ligule and almost all sedges lack an open leaf sheath (i.e. if present, the leaf sheath is closed).

Florets are generally arranged in spikelets, as in grasses.

Carex acutiformis: marsh; 0.6-1.8m.
Carex cognata: marsh; 0.6-1.6m.
Cyperus fastigiatus: marsh 1-2.2m
Eleocharis dregeana: marsh, wet meadow; 0.3-1.4m.
Schoenoplectus corymbosus subsp. *brachyceras*: marsh; 0.6-1.5m.
Scleria welwitschii: wet meadow; 0.4-1m.

JUNCACEAE (RUSHES)

Rushes may be confused with certain sedges but their flowers are distictly different.



Florets with 6 stamens and 6 whorled bracts.

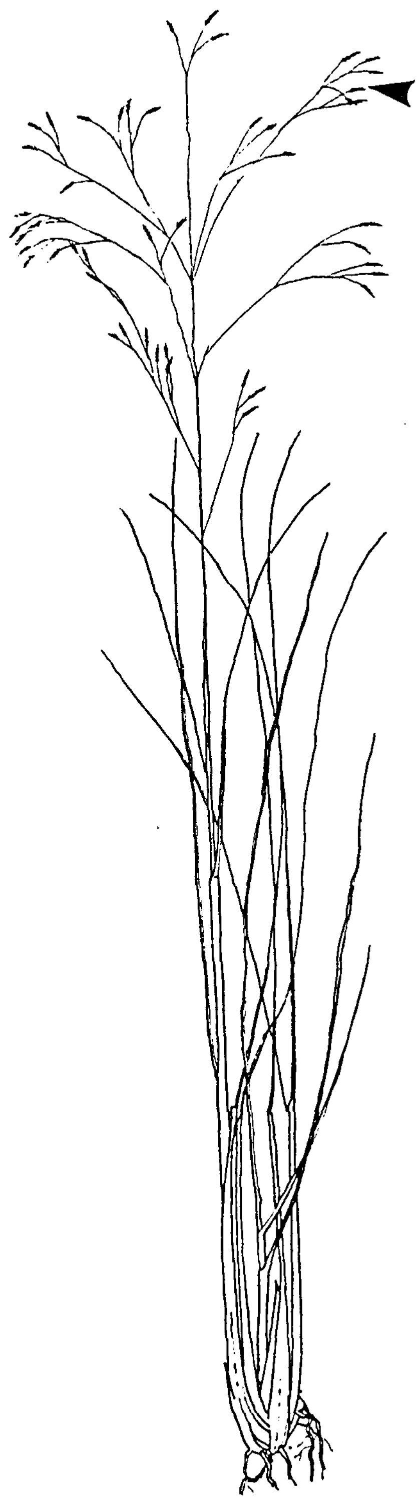
Juncus species have leaves that are round and resemble stems.
Juncus effusus: marsh; 0.8-1.8m.
Juncus oxycarpus: marsh;0.5-1.5m.

POLYGONACEAE

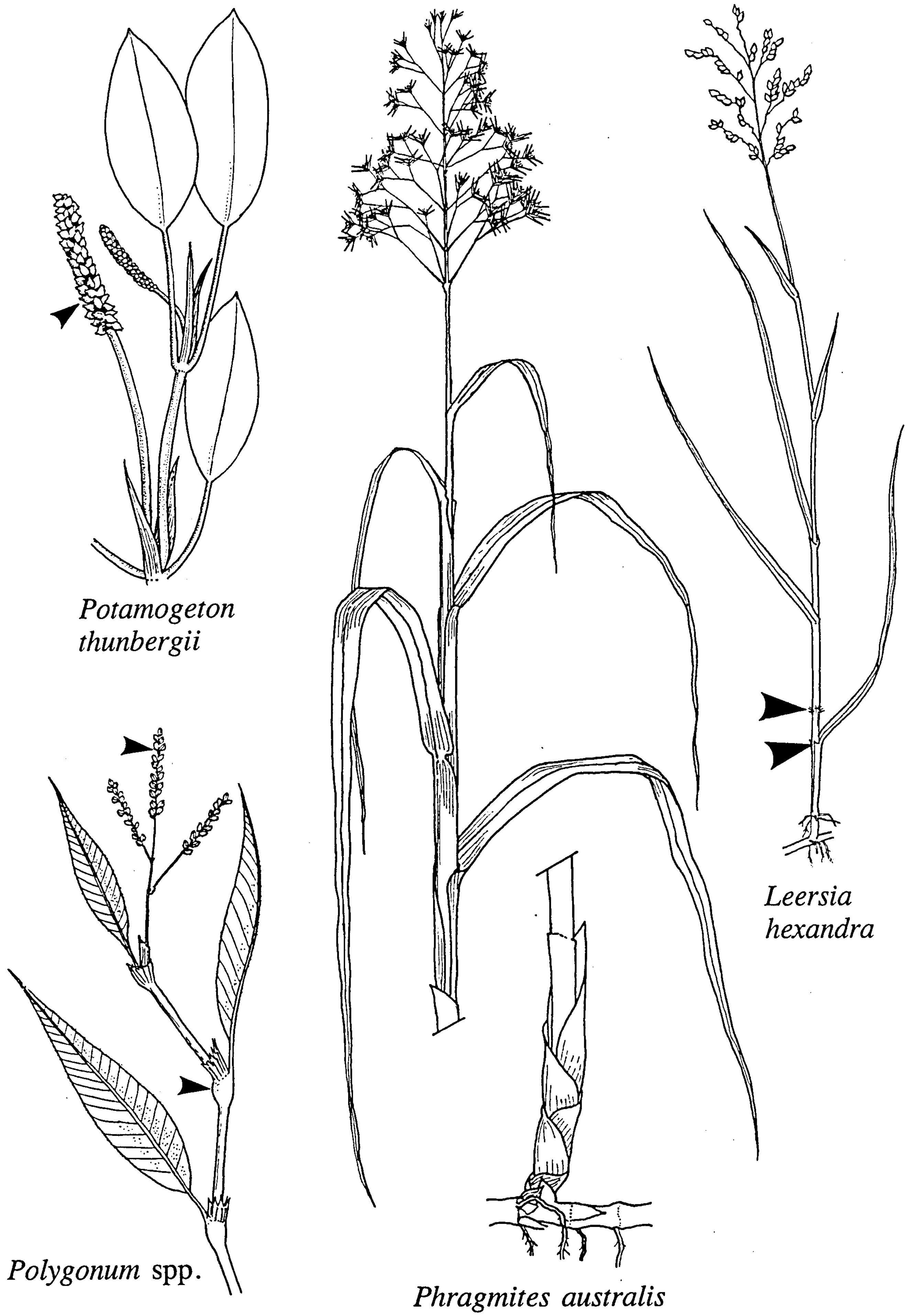
Polygonum spp.: marsh, wet meadow; up to 2m.

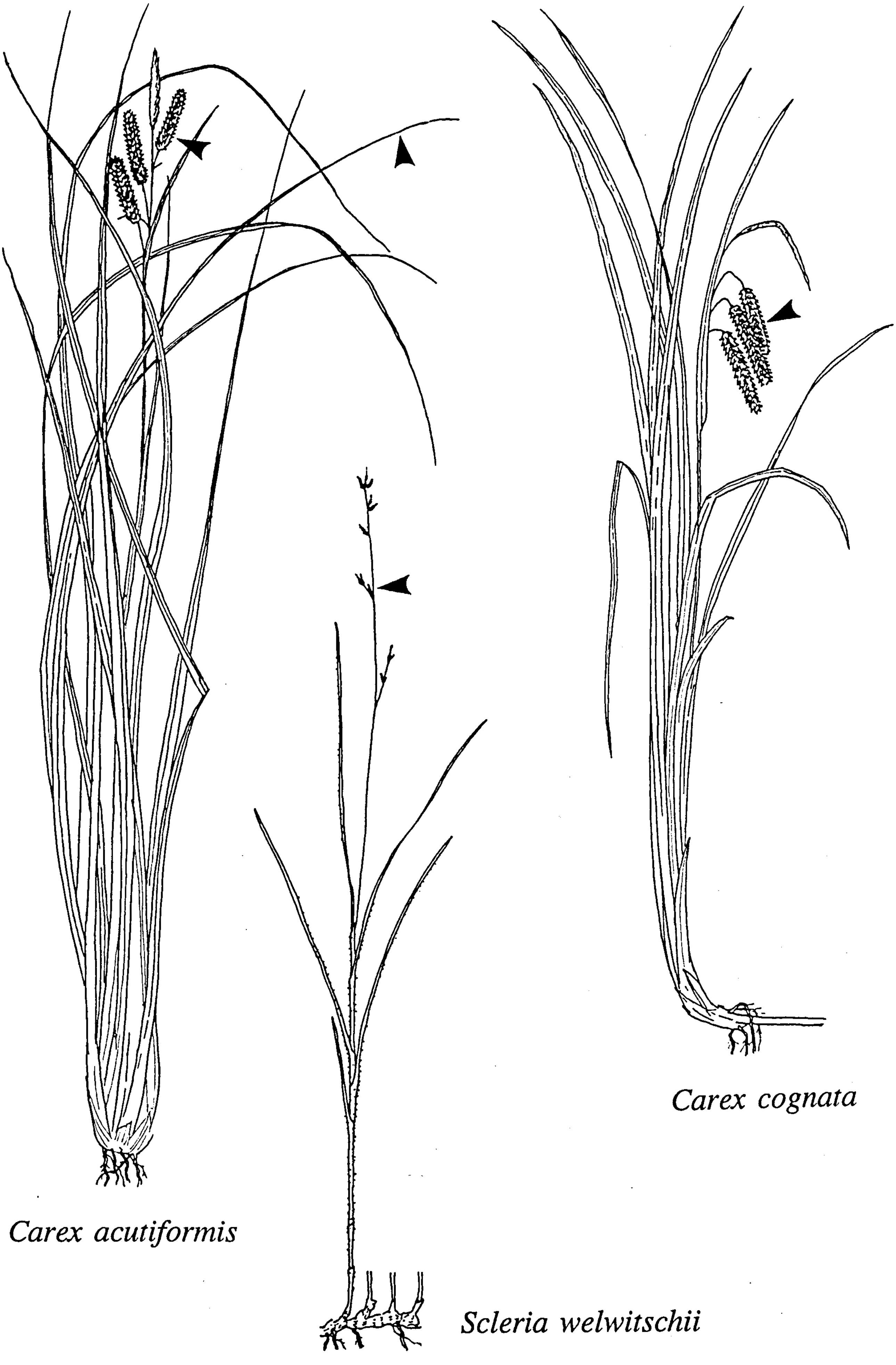
Eragrostis plana

Andropogon appendiculatus



Eragrostis planiculmis

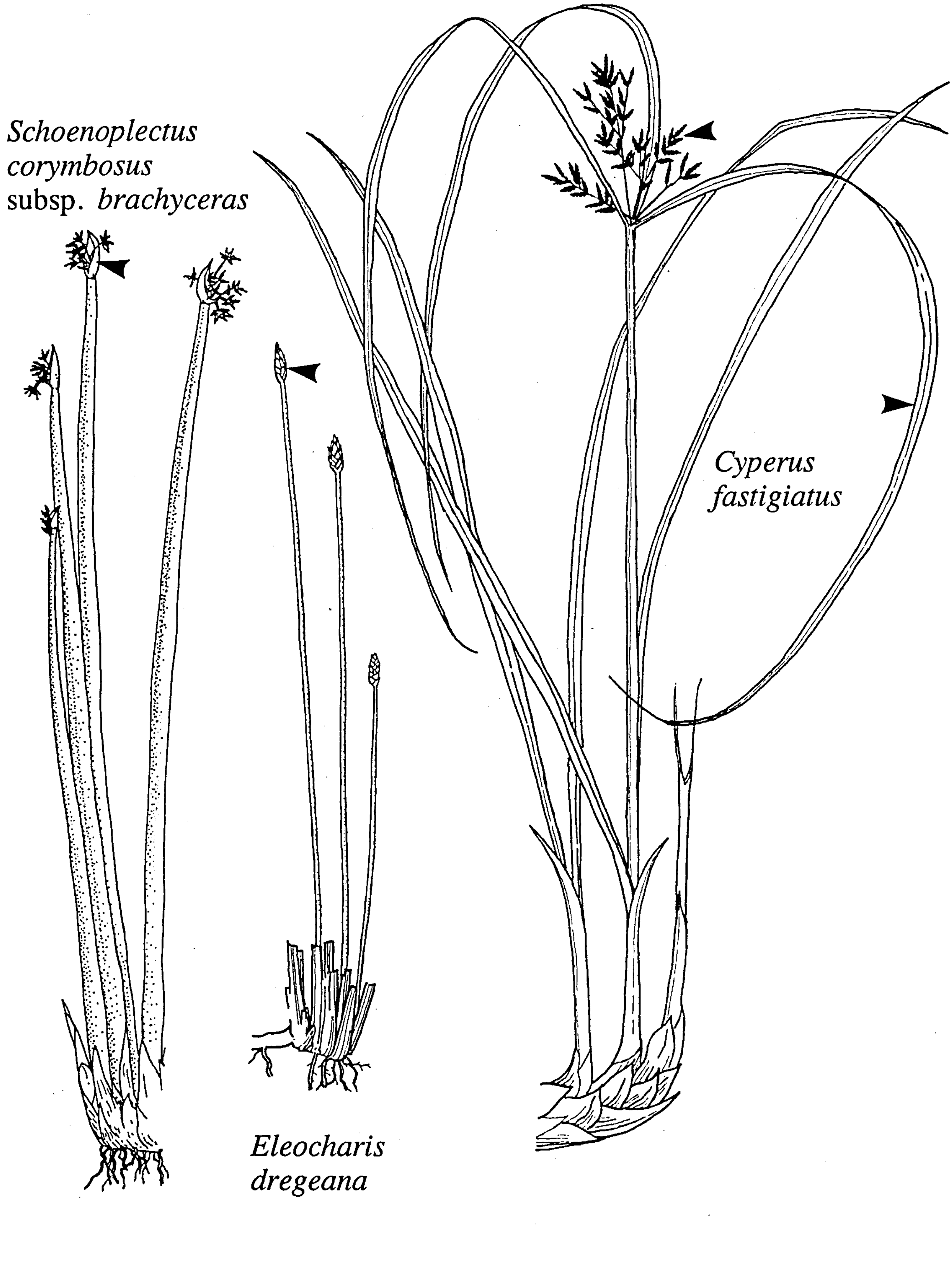

Potamogeton thunbergii
Leersia hexandra
Polygonum spp.
Phragmites australis

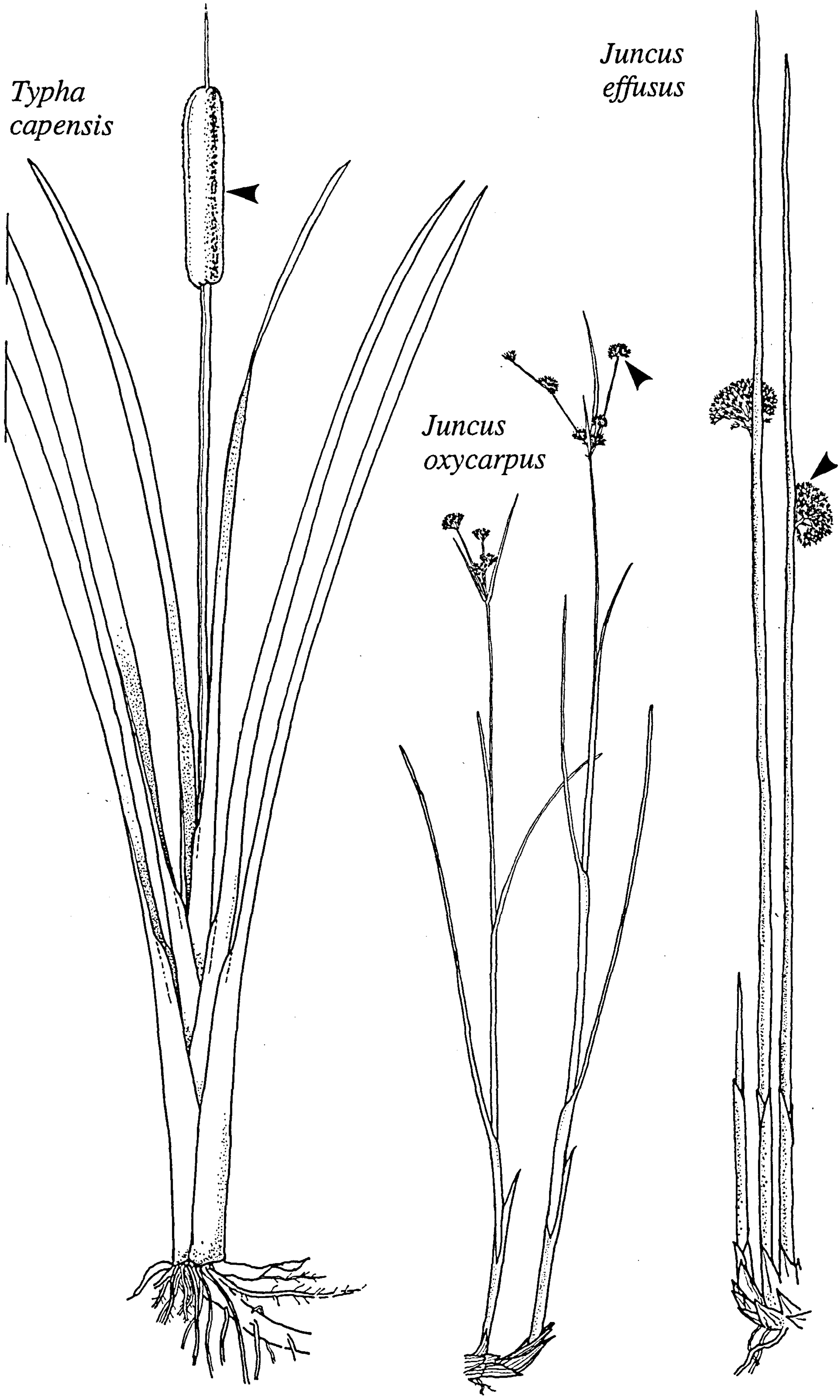


Carex acutiformis

Scleria welwitschii

Carex cognata


Schoenoplectus corymbosus subsp. *brachyceras*
Eleocharis dregeana
Cyperus fastigiatus



Typha capensis
Juncus effusus
Juncus oxycarpus