COMPILING VEGETATION DATA IN WETLANDS IN KWAZULU-NATAL, FREE STATE AND MPUMALANGA, PROVIDING MINIMUM DATA REQUIREMENTS AND A SAMPLING PROTOCOL

Report to the
Water Research Commission

by

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This report emanates from a project titled *Compiling vegetation data in wetlands in KwaZulu-Natal, Free State and Mpumalanga* (WRC Project No. K8/789)

Executive Summary

Rationale

Wetland vegetation types in South Africa are poorly known. The most recent vegetation map of South Africa by Mucina & Rutherford (2006) includes wetland vegetation, but the authors indicate that these vegetation types require much more attention. Detailed vegetation descriptions, together with the correlation between vegetation types and environmental conditions is an essential tool in the management of wetlands across the country. An overview of wetland vegetation data across the country would be useful for the sake of conservation planning, wetland monitoring using indicator species and wetland rehabilitation.

Project aims

The aims for this project as detailed in the research contract with the Water Research Commission (WRC) are to:

1. Initiate a central database for the three eastern provinces in South Africa (Mpumalanga, Free State and KwaZulu-Natal) that is compatible with the research currently in progress on wetland indicator species in the Western Cape.
2. Obtain an insight into the gaps in knowledge in wetland vegetation across the country.
3. Set up a sampling protocol for wetland vegetation that is applicable to wetland vegetation in any part of South Africa.
4. Pursue a classification of wetlands based on the vegetation data that is available for the three provinces

Report structure

The structure of this report reflects the project aims as follows:

Chapters 1 to 3 deal with the rationale for this project and state the need for a comprehensive database on wetland vegetation.

Chapters 4 to 7 deal with the procedures for setting up a central database and the historical data that has been included in that database (Aim 1).

Chapter 8 clarifies the sampling protocol for future studies (Aim 2), while chapters 9 and 10 also deal with the nearby future: databases that will be included in the nearby future and national programmes that will benefit from collaboration with the database project.
Chapter 11 deals with a provisional classification of wetland vegetation types, based on the data that is currently in the database (Aim 4).
Chapter 12 indicates the gaps in vegetation sampling across the country (Aim 3) and this is then used to state the need for further work in the recommendations (Chapter 13).

Wetland vegetation database

Vegetation is the most visible aspect of wetland management. Plant growth and productivity responds relatively quickly to changes in the environment, so vegetation patterns will reflect the environment and hydrology of wetlands and their management quite well. For this reason, the Water Research Commission has been funding research into the use of macrophytes as indicator species for wetland habitat integrity. One of the problems that were encountered during this research is that many wetland vegetation types have only a relatively narrow distribution and an overview of wetland vegetation types in the entire country is lacking.

In order to proceed with research into wetland vegetation in South Africa, an inventory of existing wetland vegetation data needs to be made, to clarify the gaps in knowledge that exist in the present. Because there is no standard sampling protocol for wetland vegetation data, it is expected that environmental data for the vegetation plots is recorded at different levels of detail, even though the vegetation data itself is generally recorded in a standard fashion, according to the Braun-Blanquet method. Consensus about data standards for header data in wetland vegetation studies has been achieved at a workshop organized in 2008 in Phuthaditjhaba. On this workshop it was decided to include a number of fourteen fields as header data in the wetland vegetation database. A standardized vegetation plot in a wetland should contain information about the species composition of the vegetation (Braun-Blanquet method with 9 cover-abundance classes), vegetation structure (stratum and cover), locality (latitude, longitude and altitude), date of recording, slope and aspect, wetland type (Hydrogeomorphic unit following Ollis et al.,

2009), topography (following Ollis et al., 2009), hydroperiod (following Kotze et al., 1996), inundation depth (assessed at the time of recording), soil type (assessments of texture and organic matter contents, soil depth), water velocity (assessed at the time of recording), salinity, disturbance and a reference to the original study. Soil form according to the South African Soil Classification Group, landscape setting (urban, rural, pristine) and nutrient status, more detailed information about hydrology and other variables are regarded as supplementary and optional.

Vegetation data that meets the Minimum Data requirements as it has been decided on by the workshop, has been re-entered in a vegetation database in the programme TurboVeg for Windows. In many cases, wetland vegetation data is available in the public realm, like universities or provincial governments, but in some cases, special permission by the original author had to be requested. A total of 34 studies have been consulted and have been entered into the database, although some datasets have been listed as 'incomplete' when certain data fields were missing. These studies included MSc theses, journal articles, research reports and in many cases, the original data forms had to be consulted. A number of studies have been consulted but not entered into the database because they did not meet the Minimum Data Requirements. A number of PhD and MSc studies that are currently underway comply with the Minimum Data Requirements and can be added in the near future.

The Minimum Data Requirements have been used to design a vegetation data collection form which can be applied in the field for future studies. This data collection form can be used as a sampling protocol, because it will serve to remind wetland vegetation ecologists what data is necessary to collect in any particular wetland. A sampling protocol is essential for future work in wetland vegetation in South Africa.

Classification of vegetation types

A vegetation classification has been made on the basis of the current vegetation database. Sixty-four different community types can be recognized on the basis of the current data. Not all of these vegetation types are well represented by a large number of relevés and

the environmental data is often incomplete. It is clear that there are still a lot of gaps in the vegetation data and that there are many areas and vegetation types that are undersampled. More sampling is necessary particularly in the Eastern Cape, coastal areas of KwaZulu-Natal, the inland parts of the Western Cape, the Mpumalanga lowveld, Limpopo province, and the arid regions of the Karoo, Kalahari and Namaqualand.

Recommendations

The sampling protocol should be used to initiate a Phase 2 for the current project, in which the regions that are undersampled are targeted for a more intensive round of wetland vegetation data collection. The following recommendations are made for such additional sampling.

1. Regions where few vegetation plots are available in wetlands should be targeted specifically.
2. Vegetation types that have no or only a few vegetation plots available in the present database should be targeted specifically.
3. Hydrogeomorphic units from which there are few vegetation plots available in a certain region should be targeted specifically.
4. Large wetlands with a wide range of habitats should be targeted specifically so that a representative range of variation is sampled.
5. Environmental data should be collected systematically according to the sampling protocol with a number of plots targeted for more detailed soil analysis.
6. Training in wetland botany should be provided to various stakeholders within every province while conducting these vegetation surveys, so that there is sufficient expertise in every province to monitor biotic changes in the wetlands in the future.

Acknowledgements

The work presented in this report is by its very nature a collaborative project. Relying on existing literature and work that has preceded my own work on wetland vegetation requires that one gets to know all the other specialists and work with them to bring the data together. For this reason, there are many people that I have to thank for their contribution. Firstly, there are the people attending the workshop on wetlands vegetation that I organized: Nacelle Collins, Mncedi Nkosi, George Bredenkamp, Ina Venter, Retief Grobler, Anton Linström and Ronell Niemand. They helped set the framework and perspective that is followed when setting up the wetlands database. Modise Kganye and Nomadlozi Nhlapo were my student assistants who helped enter the many datasets into a single database. Then, I have to thank the many people who helped me to get access to datasets that were not readily available: George Bredenkamp, Mbali Goge, Donovan Kotze, Fred Ellery, Ina Venter, Willem de Frey, Miranda Deutschländer, Luke Perkins and Johann Du Preez. The valuable discussions that I had, also after the workshop, with Nacelle Collins, Fynn Corry, Donovan Kotze, John Dini and Fred Ellery had an impact on the course that the project took. Geoffrey Mukwanga helped with editing previous drafts of this text.

Contents

1. Introduction

Large parts of South Africa can be categorized as arid country and proper management of the water resources is required. The government has to devote considerable attention to the management and conservation of its water resources if a major water crisis is to be avoided in the future. Protection of wetlands has been stated as one of the factors that has the potential to enhance water resource conservation in South Africa. In the late 1970s and early 1980s it was indicated that wetlands were an ecosystem that had been neglected in terms of conservation and management (Noble and Hemens, 1978; Heeg and Breen, 1982; Begg, 1986). Unfortunately, there has been considerable loss and degradation of many important wetland areas in South Africa. Lately, it has been recognized that wetlands fulfill many social, economic and ecological functions, resulting in an increase in the status of wetlands as important ecosystem. This is evidenced by the designation of 19 Ramsar sites, the designation of specific wetlands as World Heritage sites, and by mentioning them as requiring special attention in the National Environmental Management Act of 1998. In addition, in the National Water Act (Act. No 36 of 1998), ecosystems like wetlands are recognized as requiring a basic amount of water as an ecological reserve. These measures, together with the highly successful Working for Water Programme, in which alien vegetation is cleared to increase runoff in rivers, have raised public awareness of wetlands in South Africa.

The launching of the Working for Wetlands Programme in June 2000 has enhanced this awareness even more and along with it came many environmental education campaigns focusing on wetlands. The partners in this programme are the Department of Water Affairs (DWA), the Department of Environmental Affairs (DEA), the Department of Agriculture, Forestry & Fisheries (DAFF), and the Mondi Wetlands Project. In 2002 the Working for Wetlands Programme financed the restoration of 32 Wetlands in different parts of the country. Most wetland restoration projects are labour-intensive and create jobs that provide skills to rural communities. Restoration activities include the building of gabion structures in order to control erosion, the construction of structures that divert the flow of water or raise the water table, as well as the plugging of artificial drainage channels, and the removal of alien plants.

The success of rehabilitation work is usually assessed by follow-up monitoring in the course of years after the rehabilitation activity. This is why the Water Research Commission is currently sponsoring research into the assessment of wetland health and integrity as a priority, particularly now that rehabilitation methodologies have worked out well (Dada et al., 2007). The development of assessment tools for biological integrity will not only be useful in measuring rehabilitation success, but also in supporting prioritization exercises that determine which wetland types should be selected for rehabilitation.

The vegetation of wetlands is an important indicator of wetland quality and integrity (Cronk & Fennessy, 2001). Wetlands are quite susceptible to alien invasion or terrestrial encroachment when damaged. This is why a macrophyte index will play an important role in the assessment of the overall quality of a wetland. The advantage of using such an index is that changes in vegetation can be readily monitored and if user-friendly field guides are published, the monitoring can be carried out by reserve managers without too much expert knowledge. The vegetation of wetlands gives a characterization of the habitat units within the wetland. Recently a classification of wetland types in South Africa has been carried out and one of the recommendations of this classification is that further classification should proceed up to habitat level (Ewart-Smith et al., 2006). Habitats within wetlands can best be understood as the stresses and conditions that constrain plant growth within the wetland plus the conditions that are created by the dominant plant growth as this also has an impact on ecosystem processed such as stream flow, shading and evapotranspiration.

A habitat based classification will also encourage the development of a freshwater conservation plan, which is of interest to provincial conservation agencies. Freshwater conservation plans ultimately aim to identify wetlands that are irreplaceable and/or representative of freshwater diversity within the province. These plans are not only important in making decisions on the conservation status of wetlands but they also lead to conservation targets that are based on a defendable method. This classification would then be a useful tool in setting conservation targets at a provincial level. In order to understand habitats and the determinants of plant growth in wetlands in a better way it is important to have an inventory of all wetland types, wetland habitats and vegetation types

present in the area under question. As a starting point to achieve such an inventory it is important to compile all vegetation data that is already existent in a single database and to standardize the data collection in such a way that a sampling protocol can be maintained for future use.

It is suggested here that the compilation of this database can start with three provinces (KwaZulu-Natal, Free State and Mpumalanga) where considerable research work in wetlands has already taken place. The Wetland Health & Integrity Programme is underway in Cape Town and this will generate an additional large dataset for the Western Cape coastal lowlands. When vegetation data for the three provinces together with the Western Cape is available in a standardized format it will require only a small effort to expand the protocol to other provinces as well. A central database for wetland data will prove to be a valuable tool for wetland conservation and management.

Bringing data from these three provinces together in one database that is compatible with the database created for the Wetland Health & Integrity in the Western Cape will facilitate future work on monitoring and environmental assessment in wetlands in these areas and also in other regions of South Africa.

2. Need for a database on wetland vegetation

An inventory of existing wetland vegetation data needs to be made in order to see what is available. In vegetation studies, a standardized methodology is mostly used for describing vegetation, which is known as the Braun-Blanquet method (Westhoff & Van der Maarel, 1973). This approach has been widely applied in South Africa. Analysis of vegetation data that has been collected in this way, can lead to a fair comparison between the vegetation and environment from very different localities. In this way, information about rarity, indicator species, species interactions, links between species and environment and the effects of management procedures will be available for a large number of habitat types. When it comes to wetlands, the amount of data that is available in this format across the country is quite limited and the additional data about the environment ('Header data') is available at different levels of detail, even though there are many different environmental factors that play a role in the description of a wetland habitat (Ollis et al., 2009)

A combined database will prove to be a much more powerful tool for wetland conservation planning and management than a large series of small wetland surveys. With a national database, it will become more clear which wetland vegetation types are rare at a national scale, which combinations of environmental factors are rare and which vegetation types can be expected in which situations. All this will provide a very powerful tool for conservation planning. Monitoring of wetlands will be facilitated by the identification of indicator species for certain habitat conditions. Such indicator species can be identified from a dataset once the presence and absence of species in wetland habitats of different kinds is known, so also here, a wetland vegetation database will prove to be very helpful. A pilot study in the Western Cape has been aiming to devise a method to identify such indicator species and this can, at a later stage, be extended to other parts of the country (Corry, 2010). In the end, when lists of indicator species are available for every region in the country, fieldguides can be developed that help conservationists identify indicator species for wetland health and assess the ecological

integrity of a wetland ecosystem based on the presence of these indicator species. Additionally, when wetland restoration requires revegetation, this database may provide some clues as to which dominant matrix species can be expected in a given environment, so which plants should be used for planting.

When bringing together all existing data, undoubtedly, it will become clear that there are still many gaps in the knowledge on wetland vegetation across the country. The database will help in identifying these gaps and provide guidelines for the systematic exploration of wetlands in parts of the country that are not yet covered by the database.

With a group of stakeholders it needs to be decided what data needs to be regarded as Minimum Data Requirements. Wetland Vegetation Data has not been collected in a systematic way, and the available data is from various authors, institutions and research projects and each of these different datasets have had other priorities and research aims. It is clear that if the data 'standard' is going to be set very high, then there is probably not too much data available, whereas the opposite is true if the data standard is set very low, but then the usefulness of these data in analysis is going to be limited.

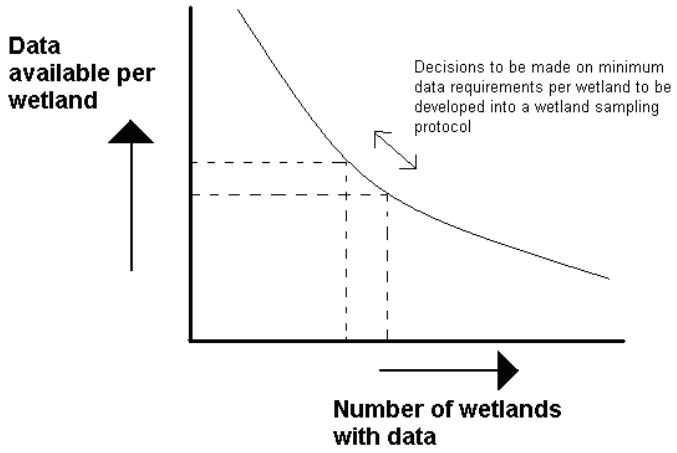

Figure 1. Trade-off between data quality and data availability

In short, the aims of the current project are to:

- Create a central wetland vegetation database for the three eastern provinces in South Africa (KwaZulu-Natal, Free State and Mpumalanga). This database is central to the analysis of correlation between environment and vegetation in this area (Objective 1).

- Determine an overview of the gaps in knowledge regarding vegetation in wetlands. Areas where specific research into wetland vegetation still needs to be carried out will be identified and students will be encouraged to do their Honours or Masters degree in one of those areas (Objective 2).

- Develop a sampling protocol for wetland vegetation which is applicable to wetlands elsewhere in the country. In this way, the database can grow in the future and analysis can be encompassing a wider range of wetlands (Objective 3).

- Create a classification of wetlands based on vegetation types for the three provinces, which will assist in setting up systematic conservation plans for wetlands (Objective 4).

3. Previous literature on wetland vegetation

Wetland vegetation is azonal vegetation, which means that the vegetation responds more readily to localized edaphic factors such as the amount and periodicity of water and salts, rather than to macroclimatic and geological patterns across the landscape that form the basis that dictates vegetation formation elsewhere. The stresses and problems that plant encounter in the wetland environment are so peculiar and in some cases so extreme that only highly specialized species that are sufficiently equipped to deal with those stresses and problems can be found there, forming their own typical vegetation composition (Keddy, 2004).

The scale of patches of vegetation where wetland vegetation is found is generally too small to be included in most vegetation maps produced on a national scale for South Africa. This is why wetland vegetation has generally been ignored in most vegetation mapping exercises (Mucina & Rutherford, 2006).

On the other hand, among wetland ecologists in South Africa, vegetation is regarded mostly as a rather specialized field that is often only described in general terms (‘grasses’, ‘sedges’, ‘reeds’ etcetera.) and only few wetland ecologists have been trained in the sampling of vegetation. This is why it is often difficult to compare wetland vegetation from one site with that of another site.

Since there is a need for more detailed information on wetland vegetation, for monitoring, rehabilitation and management, a database on wetland vegetation with the exact species composition, linking the species to the environmental conditions at the site, is desirable. This would be in much more detail than the information on vegetation that is available for terrestrial vegetation but this reflects the management priorities, the intensity of management procedures and the funds allocated to wetland management on a national level.

Much progress has been made in the mapping of vegetation types in South Africa. The most recent vegetation map of South Africa by Mucina & Rutherford (2006) provides a

clear oversight on vegetation types across the country and is a powerful tool for conservation planning. Azonal Vegetation like wetlands has been mostly ignored during previous rounds of vegetation mapping in South Africa, but has now been introduced for the first time with a separate chapter in Mucina & Rutherford (2006). However, the vast majority of wetlands are small in size and they are therefore still ignored because their size does not allow them to be mapped at a scale of 1:1 000 000. Also, within a wetland there are large differences in vegetation types since there is such a large diversity of habitats, whether it is in terms of substrate type, sediment deposition or erosion and hydroperiod. It can be argued that, with respect to wetlands, it is much more valuable to map wetland vegetation in environmental space, than it is to map it topographically. This would allow conservationists to understand which wetland vegetation types exist under which environmental conditions.

Mucina & Rutherford (2006) list the following vegetation types that could be found in wetland habitats. In brackets the code by which they are indicated on the Vegetation Map of South Africa is indicated. A more extensive literature review on which these vegetation types have been based can be found in Mucina & Rutherford (2006), but many of these articles have also been consulted for the present report.

Freshwater wetlands

Cape Lowland Freshwater Wetlands (AZf1)
Cape Vernal Pools (AZf2)
Eastern Temperate Freshwater Wetlands (AZf3)
Drakensberg Wetlands (AZf4)
Lesotho Mires (AZf5)
Suptropical Freshwater Wetlands (AZf6)

Alluvial Vegetation

Fynbos Riparian Vegetation (Aza1)
Cape Lowland Alluvial Vegetation (AZa2)
Lower Gariep Alluvial Vegetation (AZa3)

Upper Gariep Alluvial Vegetation (AZa4)
Highveld Alluvial Vegetation (AZa5)
Albany Alluvial Vegetation (AZa6)
Subtropical Alluvial Vegetation (AZa7)

Inland Saline Vegetation
Namaqualand Riviere (AZi1)
Namaqualand Salt Pans (AZi2)
Southern Kalahari Mekgacha (AZi3)
Southern Kalahari Salt Pans (AZi4)
Bushmanland Vloere (AZi5)
Southern Karoo Riviere (AZi6)
Tanqua Wash Riviere (AZi7)
Muscadel Riviere (AZi8)
Cape Inland Salt Pans (AZi9)
Highveld Salt Pans (AZi10)
Subtropical Salt Pans (AZi11)

Estuarine Vegetation
Arid Estuarine Salt Marshes (AZe1)
Cape Estuarine Salt Marshes (AZe2)
Subtropical Estuarine Salt Marshes (AZe3)

Azonal Forest Vegetation
Swamp Forest (FOa2)
Mangrove Forest (FOa3)

As Mucina & Rutherford (2006) point out in their chapter on Azonal vegetation, the wetlands have not been dealt with in sufficient detail for effective conservation planning. Accordingly, they recommend further research into these and other azonal vegetation types. As noted by Mucina & Rutherford (2006), most wetland types that have been

listed above are actually intrazonal vegetation types. For example, it is clear that the Drakensberg Wetlands (AZf4) are to be found in the Drakensberg region. However, a detailed study of wetlands in the Drakensberg region (Kotze et al., 2006) reveals that there are many different vegetation types to be found in the wetlands of the Maluti-Drakensberg, and that some of these are exclusive to this area whereas others are widespread. Some of the variation within the vegetation types listed above is acknowledged by Mucina & Rutherford (2006), where there are several subheadings under the floristic description of the Drakensberg Wetlands, indicating species to be expected in 'drainage line grasslands & herblands', 'marshes & seeps' etc. In reality, a lot of the species mentioned in these lists are clonal dominants that are mutually exclusive and will not occur together in a community.

Detailed vegetation surveys on wetlands, such as the ones from which Mucina & Rutherford (2006) have drawn their information, have been scarce and scattered. Most wetland vegetation data has been collected in studies that targeted a broader area of terrestrial vegetation with some wetlands embedded within it. In those cases, the detailed information about the wetland is often missing. In other cases, wetlands have been surveyed for hydrological and sedimentological purposes but the wetland vegetation has only been described in a superficial manner.

Another complication arises from the fact that 'Alluvial vegetation' can refer either to river-associated wetlands such as floodplains and valley bottom wetlands, or riverbank vegetation. River banks often do not have wetland characteristics since the factors that are most fundamental in their formation is the stream power and the disturbance by violent floods, not so much the anoxia in the soil.

So when wetland delineation methods of the Department of Water Affairs are applied or when a close look is given to the soil hydromorphic features, the areas on a riverbank should not be regarded as 'wetland' vegetation, although in most vegetation studies, this distinction has not been made that clearly.

The distinction of different wetland habitat types is missing in most historical vegetation studies. This is a major problem where vegetation data has to be used in wetland

conservation planning and monitoring. It is not only that ‘wetland’ vegetation has often been lumped with ‘riparian’ vegetation, the description of the habitat at the exact location of the relevé is mostly missing and this is where the current development of a wetland classification can greatly support wetland vegetation studies.

Data quality also plays an important role when considering the compilation of wetland vegetation data. Vegetation is not always the main aim of a wetland research project and not all wetland vegetation studies have been carried out by qualified botanists.

An overview over the datasets that have been used to draw up this first national wetlands database can be seen in chapter 6, whereas the many databases that have not been included are listed in chapter 7.

4. Resolutions from workshop on wetland vegetation

On August 8th 2008 a workshop was organized between various wetland specialists to discuss the Minimum Data requirements for wetland vegetation data. The resolutions that were made on this workshop are presented in this chapter. The resolutions involve the format that is expected for wetland vegetation data in order to be included in the database in future studies and the decisions about inclusion of old datasets that should be included.

Data format

Vegetation description should follow the Braun-Blanquet method and record all species in the plot, and the plot size needs to be recorded.

Software for Database: The main program to enter the vegetation data (which has already been opted by the Water Research Commission) is TurboVeg, where data is entered based on the Braun-Blanquet method. The advantage of this database programme is that it is also the database in which the National Vegetation Database is stored and the programme is not commercial so newer versions will always be compatible with older versions. Turboveg has many import- and export possibilities and there won't be any serious problems with transfer from one data format to another.

Plot Size: exact requirements about plot size will not be necessary. It is just important that the plot consists of homogeneous vegetation. In narrow zones (for example the edge of pans), vegetation bands will be sampled in rectangular plot, for example only 1 meter wide. Data should not be rejected on the basis of plot size, a note should be made if plot size is not mentioned. Recommended plot sizes should be 10 x 10 meters for savanna and for swamp forest and 4 x 4 meters for grasslands. Most sedge-dominated wetlands can be sampled in areas smaller than 4 x 4 meters.

Species list: It is recommended to have a complete species list, but data that only sampled specific taxa (for example only grasses/sedges) will be accepted, but a note of it should be made. Unvegetated parts should also be recorded in a database, since the absence of vegetation is also an indicator for environmental conditions.

Cover-abundance: It is recommended that cover-abundance data is present, many cover-abundance scales can be easily transformed into each other. Presence/Absence data will be accepted, but it is not recommended. The recommended data type will be the Braun-Blanquet scale (new).

Meta-Database: It is important to keep track of data and its original authors in the form of a 'meta-database'. Here the amount of data, the original author and the extent in which the minimum data requirements are met will be noted.

The Braun-Blanquet data standard for vegetation studies

One of the founders of the study of Vegetation Ecology in Europe was Josias Braun-Blanquet, who published the book *Pflanzensoziologie* in 1928. This book was to become very influential among fellow European vegetation ecologists and the methods of setting out a quadrant, the criteria that are applicable to a representative vegetation plot, the recording of the species and the estimation of cover-abundance scale have become the standard in vegetation studies worldwide. A good reference that more or less summarizes the approach of the Braun-Blanquet method is Westhoff & Van der Maarel (1978). The database-programme TURBOVEG (Hennenkens, 1996) makes use of this standard and assists in storing vegetation data that was collected in the Braun-Blanquet method in a digital form. In South Africa, the National Vegetation Database is stored in TURBOVEG that is housed at SANBI in Cape Town.

Header data

In order to interpret wetland vegetation it is important to record certain environmental variables in each wetland vegetation plot. The final list of environmental variables consists of a set of 14 variables which should be available for every vegetation plot and another smaller subset of variables that are often recorded but are not regarded as compulsory.

Wetland type: most dependent on hydrology and geomorphology. The shape of the water-holding 'container' and the major source of water determine the 'Hydrogeomorphic Unit' which should be included in the header data. The Freshwater Research Unit at UCT is presently involved in a wetland classification study that also described HGM Units in considerable detail and even continues up to the Habitat Unit (Ollis et al., 2009). It is necessary to make use of the same standards.

On June 29th there was a workshop in Pretoria dealing with the classification of different HGM Units in wetlands. This classification system is accepted by this meeting and the different levels have been discussed in order to see how much of the minimum data requirements are already incorporated in this system. 'Spring' should be recognized as a separate category within seepages, as these are often very distinct areas for plant growth and springs have a distinct flora. Some springs are in flat landscapes, such as Wonderkrater in Limpopo and the 'eyes' in the Free State.

The link between wetland typology and vegetation typology is regarded as important and a protocol for sampling an entire wetland can be set up, in which each vegetation unit , as recognized in the wetland classification has at least one vegetation relevé and the bigger units several.

Location: Old data often does not have GPS coordinates. Much of that can be derived from maps if there is a good description of the location. It is recommended that GPS coordinates in WGS format are used for future relevés. Altitude should be measured in meters. Transferring data into different projections on a map is not part of this project.

Topography: The Soil Classification Book has an appendix where topography is mentioned. Topography was also mentioned in the Wetland Classification Workshop on June 29th in Pretoria. It should be included in the form top, crest, slope, foot, valley bottom. The topography should be indicated as the location where the entire Hydrogeomorphic unit is located within the larger landscape.

Wetness / Hydroperiod: It is decided that the method used for assessing the hydroperiod, based on hydromorphic characters in the soil, will be based on Kotze et al. (1996). Even though there are other methods and hydroperiod is all based on assessment, it is recognized that some assessment methods are more reliable than others.

Inundation depth: In situations where there is inundation, the inundation depth at that moment (which will most likely be the wet season, when the vegetation is green) will be measured in cm. Categorizing different inundation depths into classes can be developed at a later stage. Seasonality of inundation is not assessed.

Soil: Soil characters can go in much detail and there is some data available that records soil characters in great detail and assigns a Soil Form according to the Soil Classification Handbook (Soil Classification Working Group, 1991). In the end, it is suggested to keep

soil data simpler, as this data will not be available in most cases. Soil Form is regarded as additional and not as an obligate field in the database. The only soil texture that is recorded is from the topsoil (where plants are rooted), soil depth up to 50 cm (in case of shallow soils), organic matter contents (three classes, with the highest class peaty soils) and some distinct features such as the presence of a clay layer under a sandy layer or a saltcrust that has a direct impact on drainage and wetland properties.

Hydrology: The source of water is mostly already incorporated in 'wetland type'. Assessments of how much water originates from overland flow, deep groundwater etcetera are regarded as additional data and not as minimum data requirements. Hydrology can also change seasonally

Water velocity: This changes in the different seasons and water is mostly flowing only very locally within a wetland. It does have an impact on vegetation though. Water velocity is recorded as belonging to three different categories: stagnant, slow flowing (a leaf floating on the surface can be followed just by walking), fast flowing (you have to run to keep up with a leaf floating on the surface). In most cases when it is not recorded it can be assumed that the water is stagnant. There are seasonal aspects when it comes to water velocity but it is only recorded at the time of sampling.

Salinity: In some cases, salinity can be recorded in the form of the presence of a salt-crust. There will be two fields, one which contains measured data which is not obligatory and one with an assessment which just mentions two categories 'fresh' or 'saline'. No subdivisions into hypersaline or brackish are made, as this cannot be reliably assessed. This assessment is regarded as a minimum data requirement. A tickbox will indicate whether there are detailed measurements yes or no.

Nutrient status: This is not regarded as an obligate field, but a tickbox will be provided in which you can record whether there are detailed measurements.

Slope / Aspect: Can be assessed by using certain classes. Measurements are not necessary. The classes that are used in WetHealth will be used for the assessment of slope. Aspect will use eight classes (N, NE, E, SE, S, SW, W, NW) and will only be recorded if slope is not zero.

Vegetation structure: Definition of tree, shrub and herb layer. The same standards that are used in vegetation science and the system as it is provided in TurboVeg will be

employed for wetland vegetation. Vegetation height is measured from the soil level in case of inundation.

Other header data: Grazing, fire regime, will only be noted in cases that something is going on. A field will be provided whether there is a photo yes or no. The original field number will also be recorded in a separate field and a reference to the study where the original data is to be found. A separate field will record the extent of modification of the landscape: urban, rural, natural etc. This will be regarded as additional data, but it can often be inferred at a later stage. Date of a sample is important, especially with regards to seasonal effects.

It was urged not to throw away 'incomplete' data and it is suggested that for every record an assessment of that completeness needs to be indicated: either a record is complete (all required datafields are known), nearly complete (one or two datafields are missing and can be checked quite easily by an extra field visit, look on the map, or an estimate), or incomplete (the Braun-Blanquet method was not used or many datafields are missing).

In some cases, data has not been collected directly, but assumptions can be made, based on other information elsewhere in the article or in the original dataset. For example, if water velocity has not been recorded, it can still be assumed that in a pan, water is stagnant. In this way, missing data or 'gaps' can be filled in. The reason why certain assumptions have been made in a particular dataset needs to be recorded.

If data can really not be 'assumed' and it requires another field visit to collect the missing information, that vegetation plot has to be recorded as 'nearly complete'. This means that at one stage, this data field can be obtained, from an extra field visit or maybe from a good look at a detailed map, but this has not been part of the present project. Information that can be collected from looking up the wetland in Google Earth can easily be incorporated in the database.

If there are many fields missing or if the vegetation data itself is not in the Braun-Blanquet format (or assessed only at a very inaccurate scale), data can still be incorporated into the database, but it will just have to be recorded that the data is incomplete. Data that is more complete will however have priority when it comes to entering data into the database.

Minimum data Requirements for Wetland vegetation		
1	**Vegetation description**	Complete Braun-Blanquet cover data with cover-abundance classes in 9 categories
2	**Vegetation structure**	Assessment of height and cover of different vegetation strata
3	**Locality description**	GPS coordinates in WGS system and altitude
4	**Date of recording**	Important for assessing seasonal aspects
5	**Slope and aspect**	Slope in categories Flat (0-0.5%), Slight (0.5-1%), Very Gentle (1-2 %), Gentle (2-3%), Moderate (3-10%), Steep (> 10%), Aspect in categories N, NE, E, SE, S, SW, W, NW
6	**Hydrogeomorphic unit (wetland type)**	Level 3 of wetland classification system (Ewart-Smith et al. (2006))
7	**Topography**	Position in the landscape (floor, foot, slope, top, plain)
8	**Hydroperiod**	Three classes assessed on Hydromorphic features in soil, see Kotze et al. (1996)
9	**Inundation depth**	Assessed at time of recording
10	**Soil type**	Texture of topsoil, assessed in seven categories: Bedrock, Sand, Clay, Loam, Peat, Silt/Mud, Saltcrust. Includes soil depth, up to 50 cm, the presence of impermeable layers below like a clay lens and the amount of organic material in three categories: Mineral, Humic/Dark and Peaty
11	**Water velocity**	Three classes (stagnant, slow-flowing, fast-flowing), recorded at time of survey
12	**Salinity**	Saline Yes/No
13	**Disturbance**	If applicable, write notes about disturbance, grazing, fire etc.
14	**Reference**	Field number and reference to original study
	Additional data	
15	**Soil Form**	Soil Form according to the Soil Classification Working Group
16	**Nutrient status**	If chemical analysis of soils has been carried out, supply a reference to that study
17	**Hydrology**	Source of water and assessments of the contribution to water in the wetland
18	**Landscape**	Natural landscape, Agricultural landscape or Urban landscape

5. Setting up the database

The recommendations for the database that came out of the Workshop on August 8th have been implemented when setting up the database.

The wetland vegetation data that was found in the many literature references consulted for this report correspond in different degrees with what are regarded as the Minimum Data Requirements. It requires some effort to unify all datasets into this format and in many cases references to the original study need to be made if additional information is available. In some cases, information can be inferred from other information (for example, a pan does not have flowing water, velocity is stagnant). The level of completeness is recorded in a separate field and has three categories: 1. 'Complete', 2. 'Nearly complete' and 3. 'Incomplete'. In some cases, a small number of data fields remain empty and they can be recorded at a later stage with a minimal effort. In this case, the data is regarded as 'nearly complete'. In other cases, when a large part of the header data is missing, when the vegetation data exists only in the form of presence/absence data or when species lists are not complete, the data will not prove to be very valuable for data analysis. In this case, the data will be recorded as 'incomplete' and the plot will have to be redone at some stage in the future.

Turboveg has a few fields that are standardized in the header data. To some extent these fields have been used, but quite a number of additional fields have been added, in order to comply with the Minimum Data Requirements as suggested at the Workshop.

The fields that were already present were:

Cover-abundance scale:

This is the scale that has been used for recording species abundances. The standard scale that is chosen for all plots is Braun-Blanquet (new). If the original data was in another scale, it has been transformed before entering in the current database.

Country Code:

All vegetation plots are from South Africa, with maybe a few from Lesotho or Swaziland.

Biblioreference:

This is a field which indicates a number that refers to a literature reference. The literature references are listed as the papers, reports, theses and research projects that the data was taken from.

Reference code	Authors	Year	Study	Published
1	Coetzee, Bredenkamp & Van Rooyen	1993	Report on wetlands in Belfast-Barberton-Wakkerstroom-Piet Retief	Unpublished
2	Kotze, Sieben & Morris	2006	Wetlands in Maloti-Drakensberg Transfrontier Park	Bothalia
3	Goge	2002	Wetlands of Eastern Shores St Lucia	Thesis UKZN
4	Perkins, Bredenkamp & Granger	1997	Wetlands Southern KwaZulu-Natal	Bothalia
5	Cleaver, Brown & Bredenkamp	2004	Springs of Kamanassie Mountains	Koedoe
6	Cilliers & Bredenkamp	2006	Pans in Northwest	Bothalia
7	Venter	2002	Mfabeni Swamp	Thesis UP
8	Sieben, Ellery, Garden & Grenfell	2006	Wetlands of Zulti South	Unpublished
9	Guthrie	1996	Vegetation of Hlatikulu Vlei	Thesis UKZN
10	Fuls	1992	Grasslands Northern Free State	Thesis UP
11	Wessels	1995	Swamp Forests South Africa	Thesis UPE
12	Eckhardt, Van Rooyen & Bredenkamp	1993	Wetlands Northeastern Free State	Memoirs museum Bloemfontein
13	Eckhardt, Van Rooyen & Bredenkamp	1996	Wetlands of Northwestern KwaZulu-Natal	South African Journal of Botany
14	Bloem, Theron & Van Rooyen	1992	Vegetation of Verlorenvlei	South African Journal of Botany
15	Sieben	2008	Didima	Unpublished
16	Sieben	2006	Agulhas Plain	Unpublished
17	Sieben	2006	Goukou Wetland	Unpublished
18	Sieben	2008	Eastern Free State	Unpublished
19	Sieben et al.	2009	Eastern Free State, student data	unpublished
20	Sieben & Ellery	2007	Catalina Bay	Unpublished
21	Sieben	2006	Western Cape various	Unpublished
22	Smit, Bredenkamp, Van Rooyen, Van Wyk & Crombrinck	1997	Witbank Nature Reserve	Koedoe
23	Furness	1981	Pongola Floodplain	Thesis UKZN
24	De Frey	1996	Southeastern Mpumalanga	Thesis UP
25	Venter, Bredenkamp & Grundlingh	2000	Rehabilitated peatland in rietvlei	Koedoe
26	Coetzee, Bredenkamp & Van Rooyen	1994	Wetlands of Pretoria-Witbank-Heidelberg area	South African Journal of Botany
27	Sieben, Boucher & Mucina	2004	Fens and Restio marshlands of Hottentots Holland Mountains	Bothalia
28	Cilliers, Schoeman & Bredenkamp	1998	Wetland plant communities in Potchefstroom	Bothalia
29	Van Zinderen Bakker & Werger	1974	Bogs in Lesotho	Vegetatio
30	Bezuidenhout	1995	Graspan-Holpan in Vaalbos National Park	Koedoe
31	Siebert, Van Wyk, Bredenkamp & Duplessis	2002	Sekhukhuneland	Bothalia
32	Malan	2003	Cookes Lake Recreational Area in Mmabatho	South African Journal of Botany
33	Burgoyne, Bredenkamp & Van Rooyen	2000	Northeastern Sandy Highveld, Mpumalanga	Bothalia
34	Janecke, Du Preez & Venter	2003	Soetdoring Nature Reserve	South African Journal of Botany

Nr of table in publication:

This has not been filled in. Most publications only contain a single table.

Nr. of relevé in table:

This has not been filled in, a separate field has been included that indicates the field number

Project Code:

This has not been filled in. Information on this can be found in the Biblioreference.

Author Code:

This has not been filled in. Information on this can be found in the Biblioreference.

Date (year/month/day):

The exact day that a plot was made was not always available, but at least the month is always indicated.

Syntaxon code:

This has not been filled in as it is not relevant at the current stage.

Relevé area:

The size of the quadrat in which species abundances have been estimated.

UTM_grid_system_code:

This has not been filled in. The Coordinates have been given in additional fields which are given as latitude and longitude in the WGS'84 system.

Altitude:

Altitude given in meters.

Aspect:

Direction of the downward slope if such a slope is present, given in compass degrees. 0 = North, 90 = East, 180 = South, 270 = West.

Slope:

Slope in degrees. An attempt is made to record very slight slopes in detail as this plays a major role in wetland sedimentological processes, but data at this accuracy is often not available.

Cover total:

An estimate of the overall cover. Not always available but can be inferred.

Cover tree/shrub/herb/moss layer:

The cover of the different strata has not always been recorded separately, but in most cases, only a herb layer is present, so then this is equal to the total cover.

Cover lichen/algae/litter/open water/open rock layer:

These cover estimates have most often not been made, but could be made in the future more accurately.

Height trees high / low:

Estimate of the average height of the tree layer. Only first value filled in, because no separate strata within the tree layer are recognized. In many swamp forest sites this data is not available, except in very general terms

Height shrubs high / low:

Estimate of the average height of the shrub layer. Only first value filled in, because no separate strata within the shrub layer are recognized. Also here, most of the time, this data is not available, except in very general terms.

Height herbs high / low / maximum:

Estimate of the average height of the herb layer. Only first value filled in, because no separate strata within the herb layer are recognized. In many cases, a value can be given here, but absent in a number of studies.

Height cryptogams:

Estimate of the average height of the moss layer. Generally not applicable.

Mosses identified:

General answer is NO. But this could be included in future studies.

Lichens identified:

General answer is NO. No lichens are to be expected in wetland sites.

Remarks:

A large field that can be used to make some notes about disturbance or about the locality. Filled out in many of the original studies, but not so much in the final database.

A range of other variables has been added to specify the wetland habitat more accurately.

Lat_deg, Lat_min, Lat_sec:

Latitude in degrees, minutes and seconds, derived from the original dataform or from Google Earth.

Lon_deg, Lon-min, Lon_sec:

Longitude in degrees, minutes and seconds, derived from the original dataform or from Google Earth.

Wetland type:

Description of the Hydrogeomorphic unit of a wetland: lowland river, foothill stream, mountain stream, slope seepage, valleyhead seepage, spring, floodplain flat, floodplain

depression, valley bottom with a channel (valley bottom w c), valley bottom without a channel (valley bottom), endorheic flat (flat), exorheic flat (flat w o), endorheic depression (depression), exorheic depression (depression w o).

Topography:

Location in the landscape where a wetland is found: footslope, valley bottom, slope, crest or top. In case of a more complicated setting it can indicate: floor on top, or floor on slope.

Wetness:

Hydroperiod in six classes: 1 = no wetland, 2 = temporary wet, 3 = temporary/seasonal, 4 = seasonally wet, 5 = semi-permanent, 6 = permanently wet.

Inundation:

Inundation depth in centimeters at the time of recording.

Soil_Form:

Soil form as described according to the Soil Classification Working Group. Not an obligatory field, but quite often this data is available or can be derived.

Soil_Texture:

Texture of the topsoil as allocated to one of the following classes: Sand, Loam, Clay, Bedrock, Peat, Saltcrust

Soil_depth:

Soil depth recorded, only if it is shallower than 50 cm, otherwise it gets the standard value of 50 cm.

Soil_ref:

Tickbox that needs to be indicated as YES if there is more detailed information on soils (for example clay contents) is to be found in the original reference.

Organic:

Organic matter contents as assessed in the field. 1 = mineral soils, 2 = dark humic or melanic soils, 3 = peaty soils.

Organic_ref:

Tickbox that needs to be indicated as YES if there are more detailed measurements on organic matter in the original reference.

Velocity:

Assessment of the speed of water flow. 1 = stagnant, 2 = slow flowing, 3 = fast flowing

Salinity:

Assessment of salinity. 1 = not saline, 2 = saline

Salin_ref:

Tickbox that needs to be indicated as a YES if there are more detailed measurements on salinity to be found in the original reference.

Nutrients:

Quick assessment of whether the medium for plant growth is eutrophic, oligotrophic or mesotrophic, based on real measurements.

Nutr_ref:

Tickbox that needs to be indicated as YES if there are detailed measurements of soil chemistry to be found in the original reference.

Landscape:

Indicating the general context of the landscape in which the wetland is found: URBAN, RURAL or PRISTINE.

Study:

Field duplicating the Biblioreference field. Not filled in in most relevés

Field No.:

Number indicating the original field number that was given to the plot in the original study.

Hydr_soil:

Assessment of the fraction of the water in the wetland that is originated from seepage in the soil.

Hydr_surf:

Assessment of the fraction of the water in the wetland that is originated from surface runoff.

Hydr_atm:

Assessment of the fraction of the water in the wetland that is originated from rainfall in or immediately around the wetland.

Hydr_deep:

Assessment of the fraction of the water in the wetland that is originated from deep aquifers.

Disturbance:

Indicating in a few words whether there has been a recent disturbance in the wetland, like grazing or fire.

Completeness:

Indicating whether the original data meets the Minimum Data Requirements that have been decided upon for this project. 1 = complete, 2 = nearly complete, 3 = incomplete.

Deeplayer:

Indicating whether there is a layer below the topsoil between 0 and 50 cm depth that has an impact on the hydrology, like a clay lens.

6. Datasets that have been included

A search for datasets has been conducted, mostly on the basis of already existing literature surveys on wetland vegetation in South Africa (Mucina & Rutherford, 2006). With every dataset, it was investigated whether it matched the Minimum Data Requirements as they were suggested in the Workshop on Wetland Vegetation on August 8th 2008. Most datasets were not complete in this respect, but they were included in any case, with some notes on which data fields are lacking.

In the end, it became clear that really most of the Wetland Vegetation Data in the country is from the three eastern provinces, Free State, KwaZulu-Natal and Mpumalanga. If data was found that originated in other provinces (mostly Western Cape and Northwest Province), it was included in the database but it still remains a minority of all the data available.

The information that is indicated in the paragraph below is also part of a meta-database which is given in Appendix A.

The following datasets have been included in the database

Kotze, Sieben & Morris (2006): Wetlands of the Maloti Drakensberg

This is a report that was carried out for the Maloti-Drakensberg Transfrontier Park. The project was focused on wetlands and they have been sampled across the entire altitudinal range in six transects across the Eastern Cape, KwaZulu-Natal and Free State. The wetlands have also been selected across as wide a range of hydroperiods and hydrogeomorphic units as possible. The data is reasonably complete since the focus was on wetlands and their management and description, but soil data has not been collected systematically and was often only described in short terms.

This dataset contains 263 vegetation plots, all according to the Braun-Blanquet method.

The data has been noted down as complete, except in individual cases where soil variables were missing. A paper with the original vegetation table will come out in 2010.

Cillers & Bredenkamp (2003): Endorheic pans of Northwest Province

This is a paper that appeared in Phytocoenologia 33. It does not include soil data and the coordinates of the plots had to be found back in Google Earth. The paper includes 78 vegetation plots, according to the Braun-Blanquet method. The plots have been noted down as 'nearly complete', because some soil variables had to be induced.

Venter (2003): Vegetation of Mfabeni Swamp, Eastern Shores, St. Lucia

This is a thesis from the University of Pretoria. Vegetation tables do not include header data per plot and most data has been induced from the data that is given for each 'cluster'. The original data was requested from the author. GPS- coordinates are also not available per plot. The plot size was 1 x 1 meter which is smaller than recommended, but 10 x 10 meters for Swamp forest.

This dataset contains 214 vegetation plots, which have been sampled according to the Braun-Blanquet method.

Sieben, Ellery, Garden & Grenfell (2006): Zulti South, Richards bay

This is a consultancy report delivered to Richard Bay Minerals, describing a couple of wetlands in the coastal dunes between Richard's Bay and Mtunzini. The data was quite complete but some wetlands were quite disturbed and not in a really good condition. The plot size used was 2 x 2 meters and the vegetation data was generally very complete, except in the Swamp Forest which was not included as a proper vegetation sample.

The dataset contains 19 vegetation plots, which have been sampled according to the Braun-Blanquet method. Header data could not be found back in some cases.

Guthrie (1996): Hlatikulu, Highmoor and Ntabamhlophe Vleis

This is a thesis for the University of KwaZulu-Natal and it has an extensive survey over the wetland of Hlatikulu Vlei in the Drakensberg Foothills. In the thesis, this wetland is compared to Ntabamhlope and Highmoor wetlands which have comparable vegetation types but are slightly further to the north. For these two sites, the vegetation data is present, but no maps are available with the localities of the individual sample sites. No structural data is available and another problem arises out of the fact that the only data

entries into the vegetation tables are '1', '2' and '3', which makes it clear that, although in the text it was mentioned that the Braun-Blanquet method was used, in reality some of the information went lost. The problem was resolved by interpreting '1' as either 'r', '+' or '1', so it was entered as a '+', '2' as either '2m', '2a' or '2b', so it was entered as '2a' and '3' as either '3', '4' or '5', so it was entered as '4'. In this case, some information went lost and the resolution of the cover data is not really very precise. The vegetation was sampled in plots of 5 x 5 meters.

The dataset for Hlatikulu contains 100 vegetation plots, but if Highmoor and Ntabamhlophe are included, another 76 vegetation plots can be added.

Goge (2002): Mfabeni Swamp

This is a thesis for the University of KwaZulu-Natal and it was possible to get hold of the original data with the author who is still active in wetland work. The thesis was carried out for the Department of Geography (Environmental Science) and the botanical input is not really of high quality as many species were left unidentified. The vegetation samples were carried out in transects and even though exact hydrological measurements (height of the water table etc.) are given, it was in some cases it difficult to 'translate' this into the hydroperiod classes as they are used in the database. The vegetation data does not include vegetation structure. Several other theses have been written about wetlands from this Department in the Maputaland area, but the original data has not been found back in most cases.

This dataset consists of 262 vegetation plots.

Fuls (1992): Northern Free State

This is a dataset that was developed for an MSc study at the University of Pretoria and it deals with all grasslands, not just wetlands, and most likely the wettest parts of the wetlands have not been included in the study. The sampling size is 10 x 10 meters and it is possible that there is some heterogeneous riverbank vegetation among the vegetation plots. The original field forms have been acquired and from these field forms, soil characteristics and wetness have been derived. Soil form is often indicated on the field form and this gives an indication for organic matter contents, wetness and texture of the

topsoil. Many relevés are indicated as 'Alluvial' so in these plots, the soil data cannot be provided in detail. Altitude had to be derived from the GPS coordinates using Google Earth. An article came out detailing the vegetation of the wetlands in the northern Free State and the vegetation table in this article has been used in the entry of the data. The vegetation table originally contained 52 vegetation plots, but for not all of them the original dataform was found.

Eckhardt, Bredenkamp & Van Rooyen (1992): Northeastern Free State

This is another dataset that was developed for an MSc study at the University of Pretoria, using more or less the same framework as the previous study by Fuls, and filling out data on the same field form. The study focused on grasslands not just wetlands. The gaps in the dataset are more or less the same as in the study by Fuls(1992) and the sampling size was 10 x 10 meters. The original field forms have been acquired and soil characteristics have been derived from Soil form, which was entered on the original field form. In some cases, relevés are indicated as being made on 'Alluvial' soil, and when they are very rocky, this suggests heterogeneous riparian plots.

This dataset consists of about 40 vegetation plots and most of these have been entered into the database.

Eckhardt, Bredenkamp & Van Rooyen (1996): Northwestern KwaZulu-Natal

This dataset is the result of Holger Eckhardt's PhD thesis in the northwestern parts of KwaZulu-Natal. The dataset focuses on grasslands not just wetlands, sampled in plots of 10 x 10 meters, but contains important data on the biggest wetlands in that area, such as the Blood River wetlands. The gaps in the dataset were similar to those of Eckhardt's MSc thesis and the original field forms have been acquired. Soil data was derived from Soil Form that was indicated on the original field forms. Some plots are indicated as 'Alluvial' and in this case soil data is mostly lacking and suspicion arises that these are actually heterogeneous riparian plots. The wetlands have been published separately in a paper in Bothalia.

The dataset consists of 96 plots and from most of these plots the original field form has been found back and the plot is included in the database.

Perkins, Bredenkamp & Granger (2000): Southern KwaZulu-Natal

This dataset is the result of an MSc thesis at the University of Pretoria. The dataset does not deal with wetlands alone, but an article exclusively on the wetlands in the area was published in Bothalia, although a lot of riparian vegetation types were included in this article. The field forms that belong to this study have not been found back, but GPS data on the location of the plots is available in Appendix 4 of the thesis. Community descriptions give an indication of environmental variables, but the exact environmental variables are entered in the TURBOVEG grassland Data Base in the University of Pretoria, which was not consulted. The localities of the plots are given in an index which could be consulted with the help of the original author.

The dataset contains 184 vegetation plots which are unfortunately not complete when it comes to the header data.

Wessels (1996): Swamp forests of South Africa

This dataset was produced as part of an MSc thesis at the University of Port Elisabeth, now Nelson Mandela Metropolitan University. The study looked at the distribution of swamp forests along the eastern coast of South Africa, the extent and changes in land area covered by swamp forest and an assessment of the conservation status of swamp forests. A limited survey of swamp forest vegetation was carried out in order to have a closer look at the typology and environmental characterization of different swamp forest types. Localities were not noted per plot and had to be inferred: most plots were made in Mfabeni Swamp on the Eastern shores of Lake St. Lucia, but there are a few plots that were made further to the South. Unfortunately, the vegetation data includes only tree species and herbaceous species have only been listed in an overall species list for the study, but not including their cover data for every plot. This is a major shortcoming but since data on swamp forest is very scarce, this data has been included in the database in any case, with the note that it is not complete.

The dataset includes 33 vegetation relevés which are not complete.

Furness (1982): Seasonally flooded areas in Pongola River Floodplain

This dataset was produced for a PhD study at the University of KwaZulu-Natal with a specific focus on Cynodon dactylon communities on floodplains. An article has been published about these communities. The dataset includes many different communities which may not all be actual wetlands. The exact GPS coordinates of the plots cannot be found back in the thesis but a vegetation map has been provided as an appendix in the thesis. Most plots have been linked to a polygon on that vegetation map with the help of the text in the thesis in order to get the exact coordinates per plot.

Bloem, Theron & Van Rooyen (1993): Verloren Vallei Mpumalanga

This is a journal article in South African Journal of Botany. Unlike in most journal articles, the header data is presented well and most environmental data is available from the article itself, so that original field forms did not have to be sought for. All plots are from a single wetland with different habitat zones, so that also facilitates the interpretation of the data.

This dataset contains 47 vegetation plots which are nearly complete.

De Frey (1999): Southeastern Mpumalanga

This is a dataset resulting from an MSc Thesis that conducts a detailed study of the grasslands of Southeastern Mpumalanga. Wetlands are included but they are mostly confined to wet grasslands. Maps are given in the thesis, but it is not clear which plot belongs in which locality. The original header data has been traced with the original author who also provided an unpublished report by Coetzee from the same region. Soil form was indicated on the original header data but the dataset contained many terrestrial soils. Hydrogeomorphic unit and hydroperiod has been inferred from landscape ecological fields in the dataset.

This dataset contains 51 vegetation plots, which are nearly complete. A mistake occurred when copying and a part of the vegetation table is missing and needs to be traced back from the original.

Coetzee, Bredenkamp and Van Rooyen (1994): Southwestern Mpumalanga

This is an article that was derived from an MSc thesis describing the grasslands of Southwestern Mpumalanga and bordering Gauteng. The thesis did not focus on wetlands alone but the article dealt with wetlands specifically. The original dataforms had to be found in order to derive a better description of the habitat, such as hydroperiod, hydrogeomorphic type and landscape position. Soil form was present on the original dataform and from this texture, wetness and organic material could be derived.

The dataset contains a number of 40 vegetation plots, but from 2 of them the original dataform could not be found back.

Burgoyne, Bredenkamp and Van Rooyen (2000): Dullstroom, Lydenburg

This is an article that came out of an MSc thesis, but the original MSc thesis was not consulted. The article is accompanied by a map but individual plots are not indicated on that map. Localities of the wetlands are in a confined enough area to infer an 'average' latitude and longitude, and in some cases, the altitudinal range in which was sampled gave a range of where the vegetation plots were sampled. Original dataforms could not be found so header data was inferred from community descriptions, which was in sufficient detail to describe most data fields. Vegetation plots were sampled in a 200 m^2 area which is exceptionally large compared with most other plots. Vegetation plots were sampled in some very wet areas. The quality of the data is dubious and it seems that some plots are heterogeneous as they contain too large a number of species for a supposedly permanently wet area.

The total number of vegetation plots in this dataset is 39 which are nearly complete, but where locality has been inferred. Nine of these plots have not been entered into the new database as they seem to be exact duplicates of other plots (!).

Coetzee, Bredenkamp and Van Rooyen (1993): Central Mpumalanga

An additional dataset on wetlands from the central parts of Mpumalanga that was never published has been found together with the thesis of Willem de Frey. This dataset contains 56 vegetation plots on wetlands in Barberton-Belfast-Piet Retief-Wakkerstroom area of Mpumalanga. Only 23 of these are actual wetlands, The original header data

could not be traced and can only be derived from community descriptions in the article, but also the coordinates are missing. It is assumed that most plots were made in the 'Lake district' of Chrissiesmeer, and the locality data has been inferred. Several environmental data fields could be inferred from the community description and figures in the article.
This dataset consists of 23 vegetation plots which are not complete.

Venter, Bredenkamp and Grundlingh (2000): Rietvlei Gauteng

This is a paper in Koedoe that was published after monitoring of a rehabilitated peatland in Rietvlei in Gauteng. All plots were made in more or less the same location and the same wetland, so much header data could be inferred from the general wetland description. The description of the communities also describes the environmental data in sufficient detail so that a lot of environmental data could be inferred from the community descriptions. This dataset is interesting because it contains many pioneer communities, which are generally lacking in most other studies.
This dataset consists of 22 vegetation plots which are nearly complete.

Bezuidenhout (1995): Vaalbos National Park

This vegetation study of the Graspan – Holpan section of the former Vaalbos National Park describes a few communities from wetlands in the arid zone of the country, and are very valuable in this respect. The environment is described for each community, not for every vegetation plot separately so environmental factors had to be inferred. Location is also not very clear as it is clear that there are two major pans in this area so this was also partially inferred
This dataset contains 16 vegetation plots which are nearly complete.

Sieben, Boucher & Mucina (2004): Hottentots Holland Mountains, Western Cape

This is a paper that is partially derived from a PhD thesis on riverine ecosystems in the Hottentots Holland Mountains. It describes the communities in association with their environment and all environmental variables are indicated in an Appendix with the paper. They describe unique communities that have largely been ignored, namely the wetlands that are embedded within mountain fynbos.

This dataset contains 35 vegetation plots which are complete.

Siebert, Van Wyk, Bredenkamp and Duplessis (2002): Sekhukhuneland

This is an article that was derived from a PhD thesis and it describes the wetlands shortly. It is mostly the montane wetlands of the Sekhukhuneland Centre of endemism that were described in this paper, but the exact locality of the wetlands is not known from the article. The original author was contacted but the original header data could not be found back any more. Environmental description had to be inferred from the community descriptions in the paper.

This dataset contains 17 vegetation plots which are nearly complete.

Van Zinderen Bakker & Werger (1974): Bogs in Lesotho

This is one of the oldest datasets that have been included in the database and was produced by two Dutch phytosociologists trained in the Braun-Blanquet method of vegetation ecology, which was not yet very popular in South Africa at that time. Strictly speaking, these are not South African wetlands, but of course they are unique ecosystems that occupy a unique place among Southern Africa's wetlands, so it is better to include them in the database. Locality is described as '30 km Northwest of Mokhotlong' and environmental variables had to be inferred from community descriptions. Species names have to be updated according to current nomenclature.

This dataset contains 28 vegetation plots in the wetlands which are nearly complete.

Cleaver, Brown & Bredenkamp (2004)

This is a study into the threat of springs drying out because of groundwater abstraction in the Kamanassie Mountains in the Eastern Cape, resulting in a publication in Koedoe. It is one of the few journal articles found that actually provides a map with coordinates for all vegetation plots that were done. Most environmental data can be derived from the community descriptions, but some vegetation types are actually more riparian than wetland.

This dataset contains 51 vegetation plots which are nearly complete.

Cilliers, Schoeman & Bredenkamp (1998): Potchefstroom Municipal Area

This is a dataset that has been produced for an article in Bothalia and for the Municipal planning for MOSS. The study focuses entirely on wetlands and describes these wetlands reasonably well. Localities can be derived quite easily because the whole study area is relatively small. Further header data needs to be derived from the community descriptions.

This dataset contains 102 vegetation plots which are nearly complete.

Malan (2003)

This is a dataset that was produced for a South African Journal of Botany article. It contains a series of relevés from the Cookes Lakes area in Mmabatho. The data on habitat descriptions has been derived from the average of the community descriptions. The whole study area is relatively small, so the coordinates have been derived from a single locality.

The dataset contains 56 vegetation plots which are nearly complete.

Janecke, Du Preez & Venter (2003)

This is a dataset that originated in an article for the South African Journal of Botany. It contains several relevés from the Soetdoring Nature Reserve near Bloemfontein. The data originates from only two pans within the reserve but it is not indicated which data is from which pan. Overall it is from a relatively small area and the two pans are quite close to one another. Data on habitat descriptions and environmental variables has been induced from the community descriptions that are given in the text.

The dataset contains 59 vegetation plots which are nearly complete.

Unpublished data Erwin Sieben

Several small datasets have been collected by Erwin Sieben when working with Fred Ellery on the Wetland Research Programme: These have mostly been carried out in the Western Cape (Agulhas Plain, Goukou Wetland) and KwaZulu-Natal (shores of Lake St. Lucia). At a later stage, when testing the new vegetation field form, this form has been applied to various wetlands in the Eastern Free State, and the Drakensberg mountains.

This data is mostly very complete, as the Minimum Data Requirements for wetland vegetation have been taken into account when the relevés were made.

In the end, this dataset contains 14 vegetation plots in the Agulhas plain, 20 in Goukou wetland near Riversdale, 4 plots scattered throughout the Western Cape, 12 plots in the high Maloti-Drakensberg, Didima area, 21 plots throughout the Eastern Free State, mostly collected by third years students, and 35 plots on the lakeshores of Lake St. Lucia.

7. Datasets that have been left out

In some cases, datasets were found, but it was decided not to include them because of specific reasons of compatibility or accessibility. For some of these datasets it may still prove to be possible to trace the original data with the author, but for the moment, they have been left out.

Kotze & O'Connor (2000)

This is a dataset that resulted as part of a PhD thesis, and it has very detailed environmental data but not very good vegetation data as only graminoids have been included. A paper in Plant Ecology was published out of this dataset. It deals with a large range of wetlands in the KZN Midlands area and the surroundings of Vryheid, and most of these wetlands are dominated by graminoids, but the total proportion of graminoids is not indicated.

Schoultz (2000)

This dataset is an MSc Thesis on hydrological and vegetation gradients through the Mkhuze Swamps in Northern KwaZulu-Natal. The thesis only provides vegetation descriptions and the original vegetation data needs to be traced with the original author who could not be found. It would be a valuable study to add, since it contains Papyrus wetlands, which is an important wetland type that has not been sampled extensively within the country.

Musil (1972)

This is an old dataset produced for an MSc study in the Pongola River floodplain. An article came out of this study as well, but vegetation sampling was carried out with a non-standard method. The study looked mainly at aquatic vegetation.

Malan (1997)

This is a PhD thesis on the vegetation of the Southern Free State, but it does not contain any header data nor coordinates of where the original plots were made. The dataset has

been left out but can be included if the header data is traced with the original author in the future.

Moll (1965)

This is an MSc thesis that deals with the vegetation of the KwaZulu-Natal midlands. No vegetation data was used and wetlands are only described in very general terms

Downing (1966)

This is an MSc thesis on Ntabamhlophe Vlei, but it does not contain any relevé data and only describes the wetland in very general terms. Later on, Guthrie (1995) provided Braun-Blanquet vegetation data on this wetland.

Matthews (1991)

This is an MSc thesis dealing with the grasslands of the escarpment area in Northeastern Mpumalanga. No original dataforms were found and the coordinates of the plots are missing.

Robbeson (1995)

This is an MSc thesis that was carried out in the Northwest of KwaZulu-Natal. The header data on the original dataform was very poor and since there is an overlap with Holger Eckhardt's PhD thesis, it was decided to leave this thesis out for the moment.

Deysel (2005)

This is a dataset produced by GDACE that was encountered when visiting a grasslands conference. It was not found back after enquiring with several people from GDACE.

8. Sampling protocol for future studies

A data standard has been accepted by representatives of the provincial Departments of Environmental Affairs that visited the workshop in Phuthaditjhaba on Wetland Vegetation and it is a data standard that has been implemented in the database for the three Provinces of KwaZulu-Natal, Free State and Mpumalanga.

In future studies, more direction needs to be given to the systematic sampling of wetland vegetation, where soil and hydrological data are collected in a way that makes comparison across the country possible. One way of doing so is to ensure a complete oversight of all the data that is required to be collected in the field by means of a dataform which is specifically applicable to wetlands. This approach leads to a standardized protocol for collecting data in wetlands and the data can be used for classification and environmental characterization of wetlands.

Recently, there has been a lot of debate between different provinces about wetland characteristics and a standardized protocol for classifying Hydrogeomorphic units, delineating wetlands or determining the hydroperiod is now well-known to most people that are doing research in wetlands in the country (Ewart-Smith et al., 2006; Ollis et al., 2009; Kotze et al., 1996)

A standardized protocol for large wetlands will first require an overall map of the wetland in question that indicates the location of all different habitat units and vegetation units. Such a map can be created in the framework of a classification of hydrogeomorphic units following Ollis et al. (2009). In each vegetation unit that is recognized on such a map a vegetation sample can be made in a plot of a suitable size (4 x 4 meters in grassland and 10 x 10 meters in forest). It is recommended that wetland vegetation surveys focus on such large wetlands as the whole range of natural variation can best be observed in large wetlands. Soil samples should be collected for a selection of vegetation relevés to supplement the minimum amount of environmental data and make more detailed ecological analysis possible. Small wetlands should be targeted mostly when they contain special vegetation types, or when large wetlands of that hydrogeomorphic type do not occur in the region.

Concerning the vegetation data, another problem is formed by the differences in the quality of species identification. Wetland surveys have not always been carried out by qualified botanists and training in field botany for wetland practitioners would be an important step forward. Until good field guides on wetland botany in South Africa are published, it will remain necessary to collect plants, press them and identify them in one of the National herbaria. Taxonomists who are dealing with plants that grow in aquatic environments are very few in the country so some effort needs to be made to obtain the correct names. Collaboration with taxonomists is necessary as many additional distributional records of these species can be expected in and some families may require real specialist input, particularly the difficult families such as Cyperaceae, Restionaceae and Chenopodiaceae.

South African Wetland Vegetation Survey - Field Dataform

Releve number:		Date:	Area / Study
Surveyor(s):		Latitude: Longitude:	Wetland name: Slope
Plot size:		Altitude:	Aspect

Vegetation structure:

Layer:	Cover:	Av. Height	Dominants	Growth form
Total cover:				

Wetland and habitat description:

HGM Unit: Landscape setting: Urban/Rural/Pristine	Hydroperiod: Inundation depth: Groundwater table:	Water velocity: Salinity: Water source:
Disturbance		Geology:

Soil description:

Texture of top soil Colour of top soil: Soil form:	Mottling present: Soil depth: Deep layer:	Soil sample taken: yes/no

Braun-Blanquet cover-abundance scale

r = 1-2 ex, **+** = 3-10 ex, **1** = 11-100 ex, **2m** = > 100 ex, <5%, **2a** = 5 - 12.5%, **2b** = 12.5 - 25%, **3** = 25 - 50%, **4** = 50 - 75%, **5** = 75 - 100%

Vegetation sample:

Species	Layer	Cover	Coll. Number	**Species**	Layer	Cover	Coll. Number
				Total number of species:			

Notes:

9. The near future: some more datasets for inclusion

Historically, wetlands have been included in vegetation studies, but have never received much attention in their own right. Recently, with the better attention that is now given to wetlands and the launch of wetland restoration projects by Working for Wetlands, some recent vegetation studies have addressed wetlands in their own right. This means in most cases also that environmental data has been collected in much more detail, using standardized protocols more frequently than in previous studies. These studies, some of which are near completion and ready to become incorporated into the present database will be discussed below:

Nacelle Collins: Wetlands of the Free State

Wetlands play an important role in conservation planning issues in the Free State province. The province has been active in obtaining detailed wetland vegetation data across the province. This has resulted in an elaborate and detailed database of vegetation and soil data which forms a good template for the entire country to emulate. This study is turned into a PhD thesis with the University of the Free State and is restricted to pans and valley bottom wetlands across the entire province.

Fynn Corry: Indicator species in the Western Cape Coastal Forelands

This was a study conducted for the Wetland Health and Integrity programme in the Western Cape and focuses mostly on the question whether plants can be used as indicators for ecosystem health. Most of the vegetation data that was collected for this project is not used for answering this research question raised in this report but provides a very valuable supplement to wetland vegetation data in this province. The dataset is very complete since it focused on a detailed description of the wetland environment. This dataset is the first extensive study into wetlands in that part of the country.

Retief Grobler: Swamp Forests of Kosi Bay

Swamp forest is an important and severely threatened ecosystem in South Africa. A new study of this ecosystem has been made by Retief Grobler for his MSc study. This study will be a valuable addition to the existing data on Swamp Forests. Previously, most data on Swamp Forest was lacking detail in terms of stratification and particularly the composition of the herb layer. Also, in previous studies, many species went unnamed.

Althea Grundling: survey of wetlands of Maputaland

This study is looking into groundwater level fluctuations in the coastal plains of Maputaland. Plant community composition is not the main focus of the study, but George Bredenkamp has become involved to determine whether plants can be used as wetness indicators in this difficult area. There may be some useful data produced from this work that can be added to the database.

Jacques Gerber: Aquatic communities of the Northern Highveld

This is a PhD thesis from the university of Pretoria on aquatic communities in permanent pans on the Highveld. Aquatic communities are lacking mostly in the current database, so this would be a valuable addition to the current database.

Andri van Aardt: Floodplains of the Vet River, Western Free State

Vegetation ecological studies at the University of the Free State are encroaching more and more into the wetter parts of the terrain and the MSc thesis of Andri van Aardt is focusing on the banks and floodplains of the Vet River in the Western Free State. This dataset will not consist entirely of wetland data, but data from the floodplains and floodplain depression will surely form an addition to the wetland vegetation data for the country. Andri's supervisor, Prof. Johann Du Preez is involved in several smaller studies in the Western Free State as well, such as dealing with specific salt pans or rock pools on mountain koppies.

Several people have indicated that they want to engage in landscape-wide surveys of wetlands in the near future. These studies have not started yet, but it is important that people initiating new studies in the future are informed about the Minimum Data

requirements as soon as possible so that these requirements will be implemented and the resulting datasets will be compatible with the data that already exists. Examples of such initiatives are Piet-Louis Grundling's initiative to start up a wetland survey of Kruger National Park and Ronell Niemand's intended project on the Lake District of Mpumalanga.

10. Links with other National Programmes

National Wetland Inventory

The National Wetland Inventory is a project run from the South African National Biodiversity Institute (SANBI) that aims to develop an overview over all wetlands of South Africa. It does so by creating a map of all wetland areas in South Africa on a 1:50 000 scale, which is referred to as the Advanced Wetland Layer. Originally, this wetland map was derived from the National Land Cover 2000 data, which is based on multi-season Landsat imagery from 2000/2001. The criteria of how to identify wetlands from satellite imagery have gradually been refined over the years and several versions of the wetland map have been produced, and currently, SANBI is working on its third version. When they are being mapped from satellite imagery, it is also possible to already classify wetlands into several types. For this reason, the National Wetlands Inventory also spurned research into Wetland Classification. This resulted in a couple of workshops among wetland specialists that discussed the terminology and classification of wetlands in South Africa, based on the hydrogeomorphic approach. The results of these workshops have been laid down in two research reports by Ewart-Smith et al. (2006) and Ollis et al. (2009). The present project has a link with the National Wetland Inventory because data is collected on the ground that feeds into the database that is being built on a national level. The National Wetland Inventory takes a top-down approach, whereas the vegetation database takes a bottom-up approach. These two databases reinforce each other and an inventory of wetland vegetation types can also help in groundtruthing the Advanced Wetlands Layer of SANBI.

Wetland Classification Protocol

The National Wetland Inventory also participated in the workshops that were organized to construct a National Wetland Classification System. During the workshops, it was ensured that the proposed classification system was not only useful for the top-down approach that is followed by the National Wetlands Inventory, but also for the bottom-up approach that is taken by wetland researchers in the field collecting ecological data

(vegetation or otherwise). The wetland classification system that is used in the header data of the vegetation data forms has to match the classification system applied in the National Wetlands Inventory, so that the link can be made between vegetation type and wetland type. The datafields 6 and 7 (Wetland type and Topography) of the database presented in the current report have now been integrated in the National Wetland Classification System on levels 3a and 3b. Finer scales in the classification also elaborate on issues such as soil type, hydroperiod and vegetation structure, which are also relevant for future vegetation studies in wetlands.

Wetland Health & Integrity

In recent years, the Water Research Commission funded research in the Western Cape that was looking into the question whether aquatic macrophytes can be used as indicators for measuring the status of ecosystem health. Because of the unavailability of historical data in the Province , this project aimed at collecting its own data and was restricted to the Western Cape forelands. A method has however been devised to decide on indicator values for particular species. This approach can be applied at later stages of the project when a vegetation database is more complete. When the national database is more complete, the identification of indicator species can be carried out for different regions.

NFEPA

The National Freshwater Ecosystem Priority Areas project aims at conservation planning around wetland areas in the country. When this project was initiated in 2009, it was soon found out that the data available on wetland vegetation was inadequate and that it was difficult to predict what the conservation value of a certain type of wetland is, by just looking at a map. In the end it was decided to adopt with the DWAF level 1 ecoregions and the bioregions according to the vegetation map of South Africa (Mucina & Rutherford, 2006) in which the wetlands are embedded. A number of wetland ecologists were invited to brainstorm about the issue of attaching a conservation value to wetlands without access to large databases, even though the need for such a database was emphasized in this project.

National Vegetation Database and Vegetation map

The South African National Biodiversity Institute (SANBI) was instrumental in developing a vegetation map for South Africa which culminated in the publication of the vegetation atlas for South Africa (Mucina & Rutherford, 2006). After the publication of the book, a committee was set up in order to meet annually to discuss updates and refinements to the current vegetation map. The national vegetation database, which contains the large number of vegetation studies on which the vegetation map was initially based, is also stored at SANBI. Classification of wetland vegetation data will provide a new impetus into the existing vegetation map. The new vegetation database will provide a national classification for different types of wetland habitats, based on actual field data. So far, this has only been achieved for forest vegetation.

Calculation of Environmental Reserve and other Resource Directed Measures

The Natural Water Act in South Africa ensures that enough water is allocated to the people of South Africa as well as to the natural ecosystems. For that reason, the Department of Water Affairs (DWA) has made efforts to calculate the Reserve in aquatic ecosystems in South Africa, because water in excess of that Reserve can be considered the 'total allocatable resource'. To ensure proper management of wetlands, especially those that are connected to riverine ecosystems, it must be known how much water of aquatic ecosystems are necessary to maintain the basic functioning of the ecosystem, so that water allocation to users in a catchment can be carried out in a fair and equitable way. The methods for calculating environmental flow requirements for rivers have been in use for some time now, but the development of systems to calculate the ecological reserve for wetlands is still in its initial stage. The link between wetland vegetation and hydroperiod can be an important parameter in the development of such methods.

11. Provisional classification of wetland vegetation types in South Africa

A provisional classification of wetland types has been made to provide an oversight over the different vegetation types within wetlands across the country that can be recognized so far. This classification can not to be regarded as the final classification, as many types are missing, but it provides a good guidance when the database is growing in the future.
Currently, the dataset has been classified when there were 1100 plots in the dataset. This classification will be carried out again when several more datasets will be available for inclusion. At this moment there are 64 vegetation communities, but a number of 156 vegetation plots are left unclassified.
For each community an assessment of the completeness of sampling can be made based on the number of vegetation plots present in this community and the quality of the data present.
The following terms are used:

Term	Explanation / Criterion
Poorly represented	There are less than 5 plots with good quality data or less than 10 plots with poor quality data.
Reasonably represented	between 5 and 10 plots with good quality data, or all data present is of poor quality
Well represented	More than 10 vegetation plots present with good quality data.
Good quality data	Completeness is 1 or 2
Poor quality data	Completeness is 3

For most of these community types, there will be significant improvements after the data from the studies presented in chapter 9 has been added. Some community types are not represented at all, for example Papyrus wetlands and many wetland types from the Western Cape.

Many vegetation samples are not placed in a community yet, either because they are transitional and cannot be placed easily or because they belong to a unique vegetation type that cannot be placed with any other plot. In any case, in large datasets of this nature, a large amount of 'noise' is to be expected and during later and more complete classifications, a thorough analysis of the unplaced plots should be in place.

Wetland vegetation types that can be recognized so far are:

1. *Chenopodium glaucum* – saline flats

These are vegetation samples from saline pans in the Northwest province. They are dominated by Chenopodium glaucum with a very sparse cover. At present they are the only inland saline pan vegetation that is represented in the database. This will be improved when Nacelle Collins' database will be added.

This vegetation type is for now poorly represented.

2. *Prionium serratum* – riverine peatlands

These are wetlands dominated by Palmiet (*Prionium serratum*) from the Western Cape, mostly occurring in riverine peatlands. A lot of variation exists within this system but the amount of data as present is limited so most of this variation is not covered. Two vegetation types that are associated with Palmiet-wetlands are covered next.

This vegetation type is for now reasonably represented.

3. *Cliffortia strobilifera* – riverine peatlands

Some parts of the Palmiet-wetlands are actually dominated by the shrub *Cliffortia strobilifera*, but what environmental factor is the cause of this difference is not known from the limited amount of data that is currently in the database.

This vegetation type is for now poorly represented.

4. *Isolepis prolifer – Juncus capensis* – wetlands

These are actually more the pioneer situations found in Palmiet wetlands and also along rivers edges in the Western Cape, dominated by two small sedges *Isolepis prolifer* and *Juncus capensis*.

This vegetation type is for now poorly represented.

5. *Cyperus textilis* – wetlands

These are wetlands from the Western Cape that are mostly growing on loam and that are dominated by the tall sedge *Cyperus textilis*, which grows very dense.
This vegetation type is for now poorly represented.

6. *Chondropetalum tectorum* – saline flats

The coastal flats in the Southern and Southwestern Cape which have a slight saline deposition during summer are dominated by the tall restio Chondropetalum tectorum, but with a large array of smaller species in between. When Fynn Corry's data is added to the current database, this type will be better represented.
This vegetation type is for now poorly represented.

7. *Sphagnum* moss blankets

Peatlands dominated by the moss *Sphagnum truncatum* are found in Mfabeni Swamp, but it is not known how widespread they are in the rest of the country. Occurs with several sedges.
This vegetation type is for now well represented.

8. *Rhynchospora holoschoenoides* – peatlands

These are sedge-dominated peatlands in Maputaland, dominated by the species *Rhynchospora holoschoenoides*, but co-occurring with a large number of other sedges, among them the much larger *Rhynchospora corymbosa*.
This vegetation type is now well represented.

9. *Cladium mariscus* – wetlands

In some cases in coastal wetlands, the wetland becomes dominated by the tall sedge *Cladium mariscus*. This wetland type is actually widespread as it was also found by Fynn Corry in the Western Cape (not yet part of the current database).
This vegetation type is for now poorly represented.

10. Eleocharis dulcis – Nymphaea nouchali – ponds

Deeper water in the Maputaland region is dominated by the sedge *Eleocharis dulcis*, which grows for the main part under water and the floating-leaved *Nymphaea nouchali*.
This vegetation type is now well represented.

11. Ficus trichopoda – swamp forest

Swamp forests from the Maputaland coastal region can be dominated by several tree species. *Ficus trichopoda* is impressive as it has large stilt roots. Vegetation data from this type is generally of poor quality and it is worth collecting more data on swamp forest and this type in particular.
This vegetation type is now reasonably represented.

12. Barringtonia racemosa – swamp forest

A second type of swamp forests, mostly expected in conditions that are slightly brackish is dominated by Barringtonia racemosa in the canopy. This is an attractive tree with large leaves and the forest is rich in other species as well.
This vegetation type is now reasonably represented.

13. Syzygium cordatum – swamp forest

A third type of Swamp Forest, dominated by the common tree *Syzygium cordatum*, which can grow very tall in Swamp Forest. This type is characterized by the climbing fern *Stenochloa tenuifolia* that is very common.
This vegetation type is now reasonably represented.

14. Ischaemum fasciculatum – Centella asiatica – sandy flats

Sandy interdune flats in the Maputaland region are often very wet and contain a large variety of wetland types. The most common ones are dominated by the grass *Ischaemum fasciculatum* and the creeping herb *Centella asiatica*. This type is rich in species with many other grass species present. This is a type that can be difficult to recognize as a wetland as the sand drains very quickly and the vegetation intergrades with terrestrial vegetation.

This vegetation type is now well represented.

15. Scleria sobolifer – Abildgaardia hygrophylla – sandy flats

This is another wetland type that is commonly found on sandy depressions in Maputaland. *Ischaemum fasciculatum* is still present, but the dominant species here is *Scleria sobolifer* and sometimes *Abildgaardia hygrophylla*. These are probably slightly wetter than the wetlands in the previous type.

This vegetation type is now well represented.

16. Cyperus prolifer – interdune wetlands

This is a wetland type from wet areas in interdune flats and it is dominated by *Cyperus prolifer* and *Eleocharis limosa.* This type of wetland is relatively common along the coast of KwaZulu-Natal.

This vegetation type is now well represented.

17. Eleocharis limosa – wetlands

Often associated with *Cyperus prolifer* wetlands, there are the coastal wetlands with *Eleocharis limosa* dominant. Towards the inland regions this species is replaced by the very similar *Eleocharis dregeana*.

This vegetation type is now reasonably represented.

18. Scleria poiformis wetlands

This is a wetland on sandy seepage lines that often consists of the giant sedge *Scleria poiformis*, which is very conspicuous. It is often found in the wettest part of the sandy interdune valleys.

This vegetation type is now reasonably represented.

19. Juncus kraussii – brackish wetlands

These brackish wetlands are particularly common in coastal areas as they were found all along the coast down to the Cape. They are dominated by the sedge *Juncus kraussii*,

which is a stiff species which can occur in combination with a large array of other species.
This vegetation type is now well represented.

20. Sporobolus virginicus – saline wetlands

Saline wetlands near the coast are often dominated by *Sporobolus virginicus*, which is quite common all along the South African coast, and can occur on dry dunes as well.
This vegetation type is now poorly represented.

21. Sarcocornia natalensis – hypersaline wetlands

In hypersaline flats, for example in estuarine lakes where sea water evaporates, vegetation dominated by the halophyte shrub *Sarcocornia natalensis* can be found. There are several other species of *Sarcocornia* present that are not all represented in the database.
This vegetation type is now reasonably represented.

22. Cyperus laevigatus – brackish wetlands

On muddy estuarine flats, the trailing sedge *Cyperus laevigatus* can become dominant. This is a sparse vegetation type that can probably be expected everywhere along the Eastern coastline.
This vegetation type is now poorly represented.

23. Isolepis fluitans – wetlands

These are saline flats that can be inundated with fresh water temporarily, whereas they can also turn into hypersaline flats. The trailing sedge *Isolepis fluitans* is coping with this extreme fluctuation in habitat conditions and is the obvious dominant in this vegetation type. It is probably that there are several types with Isolepis fluitans dominant as this is a widespread species with a high range of tolerance and it can be found under very different conditions.
This vegetation type is now reasonably represented.

24. Haplocarpha nervosa – Athrixia fontana dicot lawns

These wetlands occur in wet boggy areas at high altitudes and are dominated by short lawn grasses and forbs. It is often difficult to delineate these wetlands as they extend up slopes where the borders become unclear. These wetlands are rich in forbs within a matrix of low grasses and sedges.

This vegetation type is now well represented.

25. Isolepis angelica – dicot lawns

A slight variation of the high altitude dicot lawns is the type that is dominated by the short sedge Isolepis angelica. This wetland type is a bit poorer in herbaceous species and has a few more grass and sedge species present.

This vegetation type is now well represented.

26. Kniphofia caulescens – seepages

This is another high-altitude wetland type dominated by the conspicuous species *Kniphofia caulescens*. It often occurs in seepages and the central part of valley bottom wetlands at high altitudes.

This vegetation type is now poorly represented.

27. Carex cognata – seepages

Often occurring as a community directly bordering the *Kniphofia caulescens* wetlands is a vegetation type dominated by the sedge *Carex cognata*.

This vegetation type is now well represented.

28. Gunnera perpensa – seepages

This is a community of seepages and valley bottom wetlands that often occurs at high altitudes, but extending down to mid-altitudes. The broad-leaved *Gunnera perpensa* is dominant, but in some cases this species is co-dominated by grass and sedge species.

This vegetation type is now reasonably represented.

29. Festuca caprina – Carex austro-africana – hygrophilous grasslands

This is a wetland community found in some of the bigger wetlands of the lower Drakensberg – Natal midlands area. It has dominance of both *Festuca caprina* with *Carex austro-africana* often co-dominant.
This vegetation type is now well represented

30. Andropogon appendiculata – Aristida junciformis – hygrophilous grasslands
Hygrophilous grasslands in the KwaZulu-Natal throughout the Grassland Biome are often dominated by *Andropogon appendiculatus* with a high presence of *Aristida junciformis*.
This vegetation type is now well represented.

31. Carex austro-africana – wetlands
A few wetlands in the KwaZulu-Natal midlands area are actually entirely dominated by the sedge *Carex austro-africana*.
This vegetation type is now poorly represented.

32. Andropogon appendiculatus – mixed grasslands
A variation to type 30, with *Andropogon appendiculata* dominant but with a rich mix of herbaceous species represents another type of hygrophilous mixed grasslands.
This vegetation type is now reasonably represented.

33. Fimbristylis complanata – wetlands
The sedge *Fimbristylis complanata* is widespread but there have been only a few occasions where it is actually dominant in a wetland. It mostly occurs together with the grass *Andropogon appendiculatus*, but it probably occurs in wetter patches.
This vegetation type is now poorly represented.

34. Merxmuellera macowanii – seepages
This is another type of seepage that can be found at the higher altitudes in the Drakensberg, and it is dominated by the stiff and unpalatable grass *Merxmuellera macowanii*. In one case a similar vegetation type was dominated by its relative *Merxmuellera drakensbergensis*.

This vegetation type is now well represented

35. Carpha filifolia – seepages

This is an apparently rare type of montane wetland that is entirely dominated by the short sedge *Carpha filifolia*. It is quite rich in species and has been found mostly in the Southern parts of the Maloti-Drakensberg area.

This vegetation type is now poorly represented.

36. Kyllinga pulchella – wetlands

This is a vegetation type that is quite common in very small-scale wet patches in the lower Maloti-Drakensberg area, but has not been sampled extensively yet. It is dominated by the short sedge *Kyllinga pulchella*.

This vegetation type is now poorly represented.

37. Themeda triandra – hygrophilous grasslands

These are common hygrophilous grasslands that are often not very conspicuous as being a part of the wetland, as most of the surrounding vegetation is also dominated by *Themeda triandra*. This species is a very palatable grass species and grows in conditions that are optimally grazed.

This vegetation type is now well represented.

38. Scirpus ficinoides – seepages

Seepages occurring in the high Maloti-Drakensberg area are often dominated by the unpalatable sedge *Scirpus ficinioides*, but it has many species from the surrounding grasslands as well.

This vegetation type is now well represented.

39. Miscanthus capensis – wetlands

The tall grassland with a dominance of *Miscanthus capensis* represents the drier edges of wetlands in the Drakensberg area.

This vegetation type is now well represented.

40. Restio zuluensis – interdune depressions

Edges around pans in the Maputaland area are often dominated by the only subtropical restio species, *Restio zuluensis*. This species occurs in sandy areas, often at the edge of wet areas.

This vegetation type is now poorly represented.

41. Cyperus marginatus – wetlands

Seasonal wetlands in the Maloti-Drakensberg area are sometimes dominated by the sedge *Cyperus marginatus*, which is widespread and extends down the Cape as well as throughout East Africa. However, not enough samples have been taken to represent the regional variation in this vegetation type.

This vegetation type is now reasonably represented.

42. Fuirena pubescens – wetlands

A reasonable number of wetlands in the Grassland Biome are dominated by the sedge *Fuirena pubescens*. This sedge often represents areas that are seasonally wet.

This vegetation type is now well represented.

43. Eragrostis curvula – Helichrysum aureonitens – hygrophilous grasslands

This vegetation type represents those hygrophilous grasslands that are slightly overgrazed, which stimulates the growth of the grass *Eragrostis curvula* as well as the forb *Helichrysum aureonitens* in most patches.

This vegetation type is now well represented.

44. Arundinella nepalensis – wetlands

A large number of wetlands in the grassland biome are dominated by the grass Arundinella nepalensis, which is often associated with river banks but can also be found in valley bottom wetlands and floodplains.

This vegetation type is now well represented.

45. Cyperus denudatus – mixed sedgelands

This is a mixed grass / sedgeland with a very prominent presence of the sedge *Cyperus denudatus*, but with also *Eragrostis plana*, *Eragrostis planiculmis*, *Rhynchospora brownii*, *Eleocharis dregeana* and *Hemarthria altissima* present. It is often a seasonally wet part of the wetland where this combination is found.

This vegetation type is now well represented.

46. Eragrostis plana – wetlands

In some cases, the grass *Eragrostis plana* becomes the most prominent species in the wetland. This is mostly in the temporary wet zone in the grassland biome.

This vegetation type is now well represented.

47. Eragrostis planiculmis – wetlands

The grass *Eragrostis planiculmis* usually grows in wetter areas than *Eragrostis plana*, but both species are quite variable in this respect.

This vegetation type is now well represented

48. Kyllinga pauciflora – Pennisetum thunbergii – wetlands

This is a wetland type that is found in seepage areas, mostly on mid-altitudes in the grassland biome. *Kyllinga pauciflora* is dominant, but the grass *Pennisetum thunbergii* is often present as well.

This vegetation type is now poorly represented.

49. Eleocharis dregeana – wetlands

This is a very common vegetation type in the grassland biome, particularly in pans and on top of mountains. There is a subtle 'switch' towards the next vegetation type as the dominant *Eleocharis dregeana* often co-occurs with the grass *Leersia hexandra*, but it is not clear what triggers the dominance of either species.

This vegetation type is now well represented.

50. Leersia hexandra – wetlands

This can be regarded as a 'variant' of the previous vegetation type, as *Leersia hexandra* is dominant here. This species and thus this community is however more widespread than *Eleocharis dregeana*.

This vegetation type is now well represented.

51. Cyperus fastigiatus – wetlands

Another very widespread and very variable species in wetlands across South Africa. It is mostly growing in very wet areas on floodplains and in valley bottom wetlands. *Cyperus fastigiatus* is a tall sedge and very variable across its distribution range.

This vegetation type is now well represented.

52. Schoenoplectus brachyceras – wetlands

This is a community that often occurs in small patches in wetlands, often in combination with the previous communities. The sedge *Schoenoplectus brachyceras* becomes dominant in the wettest parts, or along streams and channels within a wetland.

This vegetation type is now reasonably represented.

53. Typha capensis – wetlands

This is one of the most familiar wetland vegetation types to most wetland practitioners and the dominant species *Typha capensis* is known to grow in heavily polluted waters and to take up heavy metals in its tissues.

This vegetation type is now well represented.

54. Hemarthria altissima – wetlands

This is a common vegetation type in many wetland types, as the dominant species, the creeping grass *Hemarthria altissima*, is a very widespread species that is found both on the coast and on the Highveld. It is usually found on the edge of pans and it can cope with very dry conditions as well.

This vegetation type is now reasonably represented.

55. Eragrostis plana – Agrostis lachnantha – wet grasslands

This is a mixed grassland that mostly represents disturbed wetlands as the alien species *Paspalum dilatatum* is very dominant. The grass *Agrostis lachnantha* is prominent but never achieves dominance.

This vegetation type is well represented.

56. Agrostis lachnantha – mixed grasslands

Another disturbed wetland vegetation type with a larger mix of species that generally become taller, such as *Miscanthus junceus* and the alien species *Paspalum urvillei*.

This vegetation type is well represented.

57. Phragmites australis – reedbeds

Another very familiar wetland vegetation type is represented by reedbeds with *Phragmites australis* dominant. Although this is a common species, its conservation value is considered to be high as there are many birds species that nest in these habitats. In subtropical areas, this species is often replaced by its relative *Phragmites mauritianus*, but no vegetation plots of this species are present in the datasets so far.

This vegetation type is now well represented.

58. Carex acutiformis – wetlands

Often associated with reedbeds are sedgelands dominated by the sedge *Carex acutiformis*. This sedge is typical for temperate climates and is mostly common in the Highveld area.

This vegetation type is now well represented.

59. Schoenoplectus decipiens – wetlands

Wetlands dominated by the sedge *Schoenoplectus decipiens* are common in the drier areas of the country but are not that much present in the moist parts of the Grassland Biome, where most wetland vegetation studies have been done so far. It will probably be better represented after the vegetation data from Nacelle Collins is added to the database.

This vegetation type is now poorly represented.

60. Hyparrhenia dregeana – grasslands

The tall grass *Hyparrhenia dregeana* is often dominant in temporarily wet areas, for example on floodplains.

This vegetation type is now poorly represented.

61. Pycreus polystachyos – coastal wetlands

The sedge *Pycreus polystachyos* does never achieve full dominance but mostly occurs mixed with several grasses and sedges in seasonally wet grasslands in the coastal areas. It is usually the most conspicuous species present.

This vegetation type is now reasonably represented.

62. Thelypteris interrupta – wetlands

The swamp fern *Thelypteris interrupta* can become a very prominent species in a wetland community, particularly in coastal wetlands. Its sister species, Thelypteris confluens, has also been seen growing in Drakensberg wetlands, but this vegetation type has not been sampled yet.

This vegetation type is now poorly represented.

63. Leptochloa fusca – pans

The species *Leptochloa fusca* is a very common and widespread species, particularly in the drier parts of the Highveld. The species is extremely variable and can grow as low-growing species in dry pans, swimming in permanently wet conditions, tuft-forming in dry pans and it has even been found as a reed-like tall grass in Maputaland. Considering this variation, it should be sampled much more extensively.

This vegetation type is now reasonably represented.

64. Cynodon transvaalensis – pans

Cynodon transvaalensis is a low-growing, creeping grass that is typically found in dry pans. There are various other species that are to be expected in this type of areas, mostly of the genus *Sporobolus*.

This vegetation type is now poorly represented.

The knowledge of the vegetation types that can be recognized so far in combination with the geographical spread of sampling plots across the country provides a good guideline in order to strategize future vegetation sampling across the country. Communities that have many plots already present in the current database can probably be ignored to a large extent in future sampling, but it is important to also provide some geographical spread in the sampling of widespread vegetation types, such as *Phragmites australis* reedbeds.

When looking at Fynn Corry's database, which is already available, another 26 well established communities can be added, many of them restricted to the Western Cape or to coastal areas in general. Classification of the dataset is probably an exercise that is good to carry out at regular intervals when the database is growing, in order to keep an oversight.

12. Gaps in vegetation sampling across the country

For the main part, wetland vegetation data has been collected in the Grassland Biome in South Africa. Wetlands are in most cases a conspicuous element in the vegetation of the Grassland Biome, especially in high rainfall areas such as the eastern parts of the Highveld and KwaZulu-Natal. Most large scale studies on grassland such as MSc and PhD theses had a separate chapter or journal article dedicated to on wetlands and riverine vegetation. In areas where wetlands are less of a conspicuous element, smaller in scale or rare, wetlands have mostly been ignored in vegetation studies. Also, in the Western Cape, where there are large numbers of wetlands, wetlands have mostly been ignored in vegetation studies, because there have been other conservation issues that have attracted more attention, such as rare fynbos types or renosterveld. Most of the Eastern Cape, the dry regions of the country and the far north of the country, have been ignored in vegetation studies on wetlands.

The main gaps, together with the expected wetland vegetation types in all provinces of South Africa are discussed below.

KwaZulu-Natal

Even though KwaZulu-Natal has received relatively high interest in wetland and vegetation studies, there are still significant gaps in knowledge on wetland vegetation in the province. Maputaland is very rich in wetlands and one of these wetlands, Mfabeni Swamp, has had three MSc studies conducted on it and a present PhD study ongoing on the hydrology. The other wetlands in Maputaland have been largely ignored. This is particularly the case with the Mkhuze Swamps, which are dominated by Papyrus. Another wetland-rich area in KwaZulu-Natal, the KwaZulu-Natal midlands, has barely received attention at all. Other gaps are mainly along the coast, Zululand, and the upper Tugela valley, although not many wetlands are to be expected in the last two areas.

Free State

The Free State is the most adequately studied region in terms of wetland vegetation. When Nacelle Collins concludes his vegetation study on pans and valley bottom wetlands in the province, the whole province will have been covered, except for floodplains and seepage wetlands. However, these types of wetlands are much less common in the Free State, and the province can be regarded as very well covered.

Mpumalanga

This province has been well covered with respect to vegetation studies in the Grassland Biome, which for a large part include wetlands. Unfortunately, the areas in the province that are expected to have a more distinct wetland vegetation are not well represented, for example the Escarpment area near Lydenburg and Dullstroom, and the Lowveld in Kruger Park. Also, the Chrissiesmeer area in central Mpumalanga has not yet been covered in great detail yet.

Gauteng

Even though many Environmental Impact Assessments have been conducted in Gauteng, not many wetland vegetation studies have been conducted in this province. A few small studies have been carried out in the nature reserves of the province, and the provincial government is compiling a list of all the wetlands in the province, but for the most part, Gauteng can be regarded as a gap in wetland vegetation studies.

Northwest Province

Vegetation studies in wetlands in this province have mostly been restricted to a few localities: the Potchefstroom area and the Barberspan area. The drier parts of the Province have mostly been ignored in wetland vegetation studies.

Limpopo

This province has largely been ignored in terms of wetland botany. A few studies are available, mainly from Sekhukhuneland. A vegetation study of the Nylsvley Nature

reserve (Coetzee et al., 1976) conspicuously left out the wetlands. For the rest, the whole province still needs to be studied to a much larger extent.

Eastern Cape

This province is not well covered in wetland vegetation surveys. The Drakensberg area was surveyed by Kotze et al. (2006), so the northeastern part of the province is reasonably well covered. Besides this area and areas around the springs in the Kamanassie Mountains, this province has not been covered by wetland vegetation studies at all.

Western Cape

This province has been studied to a reasonable extent, but it is also the province with the highest diversity of wetland types and much is still to be done. The mountainous areas are a big gap and contain many rare and endemic wetland species but also the lowlands still need to be studied. The West Coast and the Western part of the Overberg have been covered reasonably well, but the rest of the lowlands still require more research.

Northern Cape

No vegetation studies in wetlands have been carried out in this province and the entire province can be regarded as a big gap in the knowledge on wetland vegetation.

13. Recommendations

To proceed with an overview of wetland vegetation types and plant species in South Africa, it is important to keep up with the present developments and incorporate the latest data from the more recent wetland research, as mentioned in Chapter 9. At the same time, a nation-wide research project should be launched in which the areas that have been neglected in terms of wetland research are sampled according to a standard protocol. This project needs to be as collaborative as possible, while simultaneously providing training in wetland botany to wetland stakeholders in each region.

The large wetland inventory involved requires collaboration with several other ongoing projects in the country.

Mostly, it needs to keep track of developments in the National Wetland Inventory. The wetland vegetation database can be fed into a GIS database where sampling plots can be entered as point data that can overlay the national wetland database. Wetlands, wetland types and wetland bioregions that have been neglected so far will become more obvious and planning for field trips to collect more representative data needs to be carried out in collaboration with the National Wetland Inventory.

The knowledge that is gathered in this way will help greatly in monitoring wetland habitat integrity across the country. A field guide for common wetland plants is currently being developed and it is expected that wetland botany may become more popular with the availability of such a field guide. This means that lay people or wetland practitioners will be able to contribute significantly to the monitoring of wetland health and integrity in their area, provided that knowledge on the ecological relevance of certain species is available.

Another way to popularize the subject and help wetland practitioners interpret vegetation changes in their wetland, is to subdivide the plants into characteristic 'functional types' that are easily identifiable, such as 'tall tuft-forming grasses' or 'dwarf shrubs'. When wetland practitioners and stakeholders have adequate information available it becomes easier for them to monitor or assess the quality and progress in the wetlands in their

particular areas. This means that more stakeholder involvement can be ensured, thus contributing to the overall success of the Working for Wetlands Programme and to more awareness of water issues around the country. It will also help in keeping track of the influence of climate change on South Africa's scarce water resources and help raise awareness for a wide range of environmental issues affecting the nation's water resources.

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APPENDIX A:

Meta-database of all datasets that have been consulted and included in the current database of Wetland Vegetation.

Study	Authors	Area	Year	Number of relevés	Wetlands only?	Completeness	BB-method	Data found	Notes	Included
Aquatic macrophytes Pans of Pongola River floodplain	Musil	Pongola River Floodplain	1972	62	Yes	No locality data available	No, different sampling system used	Thesis found at UKZN, also paper published	Only aquatic samples	No
Bogs in Lesotho	Van Zinderen Bakker & Werger	Eastern highlands of Lesotho	1974	28	Yes	Localities had to be induced as they are described only as '20 km northeast of Mokhotlong'. Environmental variables also induced	Yes, but small plot sizes, less than 1 x 1 meter	Paper in Vegetatio	One of the oldest publications, strictly speaking not in South Africa	Yes
Seasonally flooded areas in Pongola River Floodplain, PhD Thesis	Furness	Pongola River Floodplain	1981	106	Yes	Localities inferred from vegetation map. Other environmental variables not complete	Yes	Thesis found at UKZN		Yes
MSc thesis grasslands Mpumalanga Escarpment	Matthews	Escarpment area Northeastern Mpumalanga	1991	20?	No	Few plots only, with no environmental and locality data	Yes, 10 x 10 meters	Thesis found at University of Pretoria	Possibility to consult the original author	No
Wetlands of Northern Free State	Fuls	Northern Free State	1992	52	No for thesis, yes for paper in Bothalia	2 plots without environmental data. Soil data inferred, coordinates from Google Earth	yes. 10 x 10 meter	Article in South African Journal of Botany. Original field forms were found as well	Translated from Afrikaans, includes rivers and riverbanks	Yes
Verlorenvlei	Bloem, Theron & Van Rooyen	Verlorenvlei, Northern Mpumalanga	1992	47	Yes	Overview in table with article	yes, 10 x 10 meters	Paper in South African Journal of Botany		Yes
Northeastern Orange Free State, Ea land Type	Eckhardt, Van Rooyen, Bredenkamp	Memel area	1993	22	no	Assumed to be covered in paper below as well	Yes, 10 x 10 meters	paper in Bothalia 23,1	Header data found in University of Pretoria	No
Ba Land type in Western Transvaal grassland	Bezuidenhout, Bredenkamp & Theron	Central Northwest province	1994	16	no	No coordinates available, spanning large area	Yes	paper in SAJB 60(4)		No
MSc thesis grasslands Mpumalanga	Coetzee, Bredenkamp & Van Rooyen	Witbank, Heidelberg,	1994	40	No for thesis, yes for paper in Bothalia	Localities found on original dataforms, most environmental data inferred	yes, 10 by 10 meters	paper in Bothalia, original dataforms found at University of Pretoria		Yes
Wetlands of Northeastern Free State	Eckhardt, Van Rooyen, Bredenkamp	Memel area	1995	19	yes	Wetland type, hydroperiod had to be inferred from header data	Yes, 10 x 10 meters	paper in Navorsings Museum in Bloemfontein	Header data found in University of Pretoria	Yes

Study	Authors	Area	Year	Number of relevés	Wetlands only?	Completeness	BB-method	Data found	Notes	Included
Vaalbos National Park, The Graspan-Holpan section	Bezuidenhout	Vaalbos National Park	1995	16	no	Most environmental data is inferred from community descriptions	Yes	Paper in Koedoe 38/2		Yes
Unpublished data Petri Coetzee	Coetzee, Bredenkamp & Van Rooyen	Central Mpumalanga	1995	23	yes	Localities not known exactly	Yes, 10 x 10 meters	Received from Willem de Frey	Unpublished study that supported MSc study	Yes
MSc thesis grasslands NW KwaZulu-Natal	Robbeson	Northwestern KwaZulu-Natal	1995	100?	No	Poor header data	Yes, 10 x 10 meters	Thesis found at University of Pretoria together with header data		No
Vegetation of Hlatikhulu Vlei, MSc Thesis	Guthrie	Hlatikhulu Vlei, (Ntabamhlope, Highmoor?)	1996	176	Yes	Veg structure is missing and plots from Ntabamhlophe and Highmoor are not with exact GPS coordinates	Yes, but scale is only in three classes, 5 x 5 meters	Thesis found at UKZN	Would still be better to find original cover data, as it contains only three cover classes at present.	Yes
Agrostis lachnantha – Eragrostis Plana wetlands Northern KZN	Eckhardt, Van Rooyen, Bredenkamp	Newcastle/ Vryheid / Utrecht area	1996	93	yes	Wetland type, hydroperiod had to be inferred from header data	Yes, 10 x 10 meters	paper in SAJB 62(6)	Header data found in University of Pretoria	Yes
Witbank Nature Reserve	Smit, Bredenkamp, Van Rooyen, Van Wyk, Combrinck	Witbank	1997	9	no	Coordinates have been inferred from vegetation map in paper	Yes, 10 x 10 meters	Paper in Koedoe 40/2		yes
Swamp Forests in South Africa	Wessels	Maputaland, swamp forest areas only	1997	60	yes	No complete species lists available, only trees and without data on stratification. Localities had to be inferred	Yes, but only trees are recorded	Thesis of Port Elizabeth, copy available	Information about extent as well, but no detailed vegetation plots and exact localities	Yes
Southern Free State	Malan	Wetlands in Southern Free State	1997	100?	No	Locality data and environmental data could not be found	Yes, 10 x 10 meters	Thesis found at University of the Free State	Possibility to consult the original author	No
MOSS study in Potchefstroom	Cilliers, Schoeman & Bredenkamp	Wetlands in and around Potchefstroom	1998	102	Yes	Localities induced but spans only a small area. Environmental data induced from cluster averages	Yes, 16 m^2	Paper came out in Bothalia	Study carried out for municipal planning (MOSS)	Yes

Study	Authors	Area	Year	Number of relevés	Wetlands only?	Completeness	BB-method	Data found	Notes	Included
Unpublished data Willem de Frey	de Frey	Gauteng, Mpumalanga	1999	51	No	Complete	Yes, 10 x 10 meters	Header data obtained from original author	From MSc thesis	Yes
Wetland vegetation of southern KwaZulu-Natal	Perkins, Bredenkamp, Granger	southern KwaZulu-Natal	2000	215	yes	Most header data is missing, but coordinates were obtained from original author	Yes, 10 x 10 meters	paper in Bothalia 30,2	Coordinates were requested from original author	Yes
Eastern portion of the Mkhuze Swamps	Schoultz	Mkhuze Swamps, Maputaland	2000	115	yes	Vegetation data was not found in thesis	Yes	Raw data not yet found	Data in transects across wetland	No
Study on graminoids on wetland and altitude gradient	Kotze & O'Connor	KZN Midlands & Vryheid area	2000	100?	Yes	Good header data available	No, only graminoids sampled	Part of a PhD thesis, published in Plant Ecology	No data on total cover found	No
Sekhukhuneland Centre of Plant Endemism, PhD Thesis	Siebert, Van Wyk, Bredenkamp, Duplessis	Sekhukhuneland	2002	17	no	Exact localities and environmental data was not found back any more	Yes, 10 x 10 meter	Paper in Bothalia 32,2	Quite heterogeneous. Some plots may be more like riverbanks	Yes
Endorheic Pans of Northwest	Cilliers & Bredenkamp	4 Pans around Barberspan, Northwest	2003	83	yes	Soil data induced, coordinates from Google Earth	Yes	Paper in Phytocoenologia 33 (2-3)		Yes
MSc Thesis Mfabeni Swamp	Venter	Mfabeni Swamp, St Lucia	2003	214	yes	Not all data with exact GPS coordinates	Yes, 1 x 1 meters (10 x 10 for swamp forest)	Thesis and raw data obtained from author		Yes
Wetlands of Greater St. Lucia National Park	Goge	Eastern shores lake St. Lucia	2003	262	Yes	Vegetation data without structure, many species unidentified, wetness has been inferred	Yes, 3 x 5 meter	Original data obtained from author	Data in transects across wetland, groundwater tables measured along those transects	Yes
Rehabilitated peatland on Rietvlei Nature Reserve	Venter, Bredenkamp & Grundling	Rietvlei in Gauteng	2003	22	yes	Complete as most data has been inferred from community and wetland description	Yes, 3 x 3 meter	Paper in Koedoe 46/1	Sampled in a single wetland, so header data inferred from data on that wetland	yes
Cookes Lake area in Mmabatho	Malan	Wetlands southeast of Mmabatho	2003	56	Yes, but some quite on the edge	Environmental data induced from cluster averages	yes, 10 x 10 meters	Paper in South African Journal of Botany		Yes
Vegetation of pans in Soetdoring Nature Reserve	Janecke, Du Preez & Venter	Soetdoring Nature Reserve near Bloemfontein	2003	59	Yes	Locality data refers to only two pans in the reserve	Yes, 4 x 4 meters	Article in South African Journal of Botany.		Yes

Study	Authors	Area	Year	Number of relevés	Wetlands only?	Completeness	BB-method	Data found	Notes	Included
High altitude fens and restio marshlands	Sieben, Mucina, Boucher	Hottentots Holland Mountains	2004	35	Yes	Complete	yes	paper in Bothalia 34,2		Yes
Springs of the Kamanassie Mountain	Cleaver, Brown & Bredenkamp	Kamanassie Mountain	2004	51	No (also streambanks)	Not clear whether they are all wetlands	Yes, but variable plot size	paper in Koedoe 47/2		Yes
Maloti-Drakensberg Transfrontier Park	Kotze, Sieben & Morris	Six transects across Maloti Drakensberg	2006	278	yes	Some relevés missing soil data	Yes, 4 x 4 meters	In possession of author	12 relevés added after report came out, paper came out only in 2010	Yes
Zulti South Lease Area Richard Bay Minerals	Sieben, Ellery, Garden & Grenfell	Coastal area between Richards Bay and Mtunzini	2006	19	yes	Some relevés no GPS data and environmental data could not be found back	Yes, 2 x 2 meters	In possession of author	Commercial report for Richard Bay Minerals	Yes
Catalina Bay Coastline	Sieben & Ellery	Catalina Bay, Lake St. Lucia	2006	28	Yes	Complete, data on water quality available	yes	Not yet Published	In transects with notes on vegetation dynamics	Yes
Unpublished data Erwin Sieben	Sieben	Agulhas, Goukou, Cape Flats	2006	44	yes	Several datasets, environmental data generally complete	yes, 3 x 3 meters	Raw data still in possession of author	supporting research on wetland restoration ecology.	Yes
Provincial dataset GDACE	Deysel	Marievale Bird Sanctuary	??	20?				Not found at GDACE		No
Free State, Pans and Valley bottoms	Collins	Entire Free State	2009?	> 300	yes	All environmental data has been included and more	yes	Restricted to pans and valley bottoms, entire gradient of wetness covered	thesis yet to come out	No
Indicator species for macrophyte vegetation	Corry	Western Cape Lowlands	2009?	> 300	yes	Complete as many more environmental data have been collected	Yes	Thesis, to come out soon	Aimed towards an analysis of indicator species	No
Kosi Bay Swampforest, MSc Thesis	Grobler	Kosi Bay, Swamp forest only	2009?	??	yes	Not yet seen	Yes	thesis to come out soon		No