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The herbaceous vegetation of subtropical freshwater wetlands in South Africa: Classification, description and explanatory environmental factors

E.J.J. Sieben [a,*], T. Nyambeni [b], H. Mtshali [b], F.T.J. Corry [d], C.E. Venter [e], D.R. MacKenzie [f], T.E. Matela [b], L. Pretorius [g], D.C. Kotze [c]

[a] Department of Plant Sciences, University of the Free State, Qwaqwa Campus, Private Bag X13, Phuthaditjhaba 9866, South Africa
[b] Department of Plant Sciences, University of the Free State, South Africa
[c] Center for Environment and Development, University of KwaZulu-Natal, South Africa
[d] Freshwater Research Unit, Department of Zoology, University of Cape Town, South Africa
[e] Kyllinga Consultants, Pretoria, South Africa
[f] Plant Specialist Group Mpumalanga, Lydenburg, South Africa
[g] Applied Behavioral Ecology Research Unit, Department of Environmental Sciences, University of South Africa, South Africa

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ABSTRACT

In this paper, the wetland vegetation types of subtropical wetlands occurring in South Africa are discussed. The South African National Wetland Vegetation Database targeted the collation of all available wetland vegetation data consisting of species composition, Braun-Blanquet cover-abundance data and the relevant environmental parameters. A subset of this database that represented subtropical wetlands, was used for analysis by means of clustering and ordination techniques. Forty-nine wetland communities are described and these are summarized into sixteen community groups. The most important factors that account for the variation among these wetlands are the soil clay percentage and associated soil electrical conductivity. Some communities are associated with peaty or sandy soils with a very low soil electrical conductivity on the coastal plain while others that occur more in loamy soils with a high soil electrical conductivity are associated with drainage channels, at the foothills of mountains or the escarpment. A specific group of wetlands is associated with nutrient-poor substrates of the Msikaba group Sandstones in Pondoland or on coastal sands of Maputaland. Subtropical wetlands are particularly vulnerable to degradation due to cultivation as they are found in some of the most densely inhabited rural areas of South Africa.

Introduction

In their comprehensive vegetation atlas of South Africa, Mucina and Rutherford (2006) note that they were the first authors to include azonal vegetation such as wetlands into the vegetation map of South Africa. Historically, vegetation mapping in South Africa has focused on terrestrial vegetation, and its management aspects were informed by correlation of vegetation with climatic factors or large-scale environmental impacts such as grazing and fire (Rutherford and Westfall, 1986; Tainton, 1999). Wetlands often form only small portions of a landscape, and if they already were included in large-scale vegetation studies they were rarely regarded as separate entities. Recently, however, it has been recognized that wetlands play a disproportionate role in large-scale ecological processes (Mitsch and Gosselink, 2000; Keddy, 2004; Schlesinger and Bernhardt, 2013) and they provide many ecosystem services important to rural development (Kotze et al., 2008). In the last two decades, wetlands have become some of the most intensively managed parts of the rural landscape in South Africa and they feature as important elements in strategic plans for water resource management (Driver et al., 2011; Nel et al., 2011). They also represent heavily utilized parts of the landscape in rural areas where people are directly dependent on the resources and services that nature provides. Therefore, the wise use of wetland resources is often promoted and it is certainly desirable to obtain more information about their species composition, ecology and distribution.

Wetland vegetation differs significantly from upland vegetation, as plants in areas that are inundated for at least part of the year have to cope with very specific stresses (Cronk and Fennessey, 2001; Keddy, 2004). Inundation of soils creates anaerobic conditions in the soils which lowers the redox potential and drastically changes the biochemistry of soils (Schlesinger and Bernhardt, 2013). Many reduced compounds in such soils are toxic to plant growth and plants require specific physiological adaptations to deal with them. But most of all,

* Corresponding author at: Department of Botany, University of the Free State, Qwaqwa Campus, Private Bag X13, Phuthaditjhaba 9866, South Africa.
E-mail address: siebenej@ufs.ac.za (E.J.J. Sieben).

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plants need adaptations to manage their own energy needs in the root zone. Respiration in the root zone requires oxygen and therefore oxygen is transported from the surface to below the soils in specialized tissues called aerenchyma (Cronk and Fennessey, 2001). Different habitats in the wetland have different inundation regimes during the course of a year and in most cases, wetlands can be subdivided into habitats that are temporarily, seasonally or permanently wet. These habitats can be recognized by means of their soil hydromorphic features (Kotze et al., 1996).

Plants are often adapted to germinate in periods when the water level drops (Shipley et al., 1989) but they may form extensive mats by the time the water level rises again. Many wetland plant communities are dominated by clonal dominant matrix species with interstitial species in between (Boutin and Keddy, 1993). For this reason, it is generally easy to recognize and classify wetland plant communities as most communities have a distinct dominant species.

Wetlands of warm tropical and subtropical areas are among the most productive ecosystems in the world and most African wetlands fall into this category (Thompson and Hamilton, 1983). In South Africa, such wetland ecosystems are only present in the northern provinces and along the coast at the lower altitudes. This large number of wetlands contains a wide variety of vegetation types linked to specific environmental conditions such as soil type, wetness and nutrient contents.

In this paper, we provide an overview of vegetation types of subtropical wetlands in South Africa, following the definition of Azf6 (subtropical freshwater wetlands) by Mucina and Rutherford's (2006). This includes those wetlands in the northern and eastern provinces of South Africa between altitudes of 0 and 1400 m, that are covered by medium short to tall reeds, sedges or rushes. Many of the widespread wetland vegetation types, such as those dominated by Kweek (*Cynodon dactylon*), Common reed (*Phragmites australis*), *Imperata cylindrica* or *Leersia hexandra* are also found in subtropical wetlands, either extensively or in small patches, but they have not been dealt with in the current paper. These vegetation types and their connection to subtropical wetland vegetation are discussed in the report by Sieben et al. (2014). The aims of this study are to present a classification based on vegetation composition, that is useful for conservation planning and management, as well as to understand and differentiate the communities on the basis of environmental factors that determine the distribution and abundance of the plant species that make up these communities.

Methods

The standard method for collecting vegetation data in South Africa is the Braun-Blanquet method (Westhoff and Van der Maarel, 1978; Brown et al., 2013). This involves sampling vegetation in representative quadrats in terms of species composition and each species' relative abundance. These data can then be entered into a database programme such as Turboveg (Hennekens and Schaminée, 2001), where it can be made available for different kinds of analysis. The data that were already available in this format was brought together and combined with new data from areas that were under-represented in historical wetland vegetation studies, which was nearly everywhere in the subtropical areas except for Maputaland. The overall effort to combine wetland vegetation data from historical studies and supplement it with new data gave rise to the South African National Wetland Vegetation Database (Sieben et al., 2014). Subtropical wetland vegetation is represented by 1112 vegetation plots, of which 388 plots were newly collected. The source of the other data, from historical studies, is indicated in Table 1. The datasets indicated in grey contribute only a very small number of plots to the overall dataset of the current study.

For the new data that was collected, a standardized sampling protocol was developed so that the Braun-Blanquet vegetation data could be supplemented by standardized environmental data, which has relevance for wetland habitats (Table 2). Additionally, in at least one plot per wetland for the new data, a soil sample from the topsoil (the rooting zone of the vegetation) was collected and analysed to provide additional explanatory variables. The environmental data that were used for the analysis are summarized in Table 2, together with their methods of measurements. The data that were not available for all vegetation plots are indicated with an asterisk. In those vegetation plots where no soil data was collected, some general environmental characteristics were assessed on site. Analyses that required the most detailed explanatory data (ordination analysis) were restricted to a subset of the total database where all data fields were complete. Two important environmental characteristics listed in Table 2 are the Hydrogeomorphic Unit and the Hydroperiod. The Hydrogeomorphic (HGM) Unit refers to the position of the wetland in the landscape and indicates the reason why that position in the landscape has a net surplus of water (for at least part of the year) or an impeded drainage. This kind of wetland classification has been discussed in detail by Ollis et al. (2013). Within the current study, all sites have been classified either as Floodplain, Depression, Seepage, Valley bottom or Channelled Valley Bottom wetlands, depending on the main types of water inflows and outflows that occur in these wetlands. The second most important environmental character is the Hydroperiod, which is the time period of the year in which the area is inundated or saturated. Unfortunately, it is not possible to obtain detailed measured data on this variable on a large scale; it has to be inferred from the soil hydromorphic features, following Kotze et al. (1996).

Table 1
Historical studies that were included in the compilation of a database for subtropical wetland vegetation in South Africa.

Publication/dataset	Area	Comments	No. of plots
Furness (1981)	Pongola floodplain	Vegetation plots 10 × 10 m	17
Schoultz (2000)	Mkhuze Swamps	Plots on transects, no wetness data	73
Taylor (2000)	Mdlanzi Pan, Zululand	Plots on transects, no wetness data	51
Neal (2001)	Mkhuze floodplains	Plots on transects, no wetness data	127
Goge (2002)	Eastern shores Lake St. Lucia		130
Venter (2002)	Mfabeni Swamp, Eastern shores	One large wetland sampled	189
Sieben et al. (2006)	Wetlands South of Richards Bay	Unpublished consultancy	11
Grobler (2009)	Swamp Forest Kosi Bay	Limited number of sedgeland plots, various stages of succession	5
Corry (2011)	Western Cape lowlands	Soil data and many other variables available for most plots	42
Pretorius (2011)	Wetlands Nothern Maputaland	Masters thesis, soil data not yet available	46
Sieben et al. (2014)	Catalina Bay, KwaZulu-Natal	Vegetation sampled twice in permanent quadrats	25
Coetzee, Bredenkamp & Van Rooyen (1994)	Wetlands of Heidelberg, Witbank, Pretoria area		2
Perkins et al. (2000)	Southern KwaZulu-Natal		1
Kareko (2002)	Middelvlei Wetland, Stellenbosch		1
Sieben, Kotze & Morris (2010)	Maloti-Drakensberg Transfrontier Park		2
Cowden, Ellery, Kotze, & Sieben (2014)	Rehabilitated wetlands in KwaZulu-Natal		1
Collins (2011)	Free State pans and Valley bottoms		1