# Short-term vegetation change on rehabilitated peatland on Rietvlei Nature Reserve

**C.E. VENTER, G.J. BREDENKAMP and P-L. GRUNDLINGH**

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Natural peatlands occur on the Rietvlei Nature Reserve. Before the Pretoria City Council acquired the land, these peatlands were mined by private land-owners. Ditches were constructed to drain the area for mining and the peatlands became desiccated. Later the area was proclaimed as a nature reserve and has since then been managed as such. Rehabilitation of the drained peatland on Rietvlei Nature Reserve first started in 2000 as a Working for Water project. The aim of the rehabilitation was to close the ditches and rewet the peatland, to enable possible revival of the peatland. A baseline vegetation survey was undertaken during the summer (March to April) of 2001 to determine the nature of the pioneer communities that established on the rehabilitated area. This survey was repeated during the summer (March to April) of 2002 to detect changes in the vegetation. The same sample plots were used on both occasions. The initial pioneer vegetation was mostly composed of weedy annuals.

Three communities were identified from the 2001 data set using the classification algorithm TWINSPAN. DECORANA ordination showed a clear distinction between the community on the mined and the communities on the drained areas. A specific pioneer community dominated by *Persicaria* species established on the rehabilitated ditches. *Phragmites australis* reed communities, with *Phytolacca octandra*, were prominent on the least disturbed sites. *Cyperus* dominated communities, without reeds (*Phragmites australis*), occurred on areas that were mined extensively, but not rehabilitated. The 2002 floristic data was added to the baseline data and the ordination procedure as performed on the 2001 data set was repeated on this new data set. The results indicate that within a single year the vegetation already started to change in the direction of the climax communities.

Key words: vegetation survey; peatland; succession; rehabilitation.

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## Introduction

Wetlands are very important in nature, because they form unique habitats for certain aquatic and hydrophilic plant species and also result in an increase in the number of waterfowl and other fauna typically associated with wetlands. Wetlands lessen the devastating effects of floods and are responsible for clearer and healthier surface water. They act as a filter for debris and certain toxic substances, such as heavy metals, and absorb large quantities of water that are eventually released over time into natural drainage channels (Hey & Philippi 1999). Wetlands in South Africa do not have high plant species diversity but some of the species that do occur in wetlands are restricted to these habitats (Bloem *et al.* 1993; Myburgh *et al.* 1995; Eckhardt *et al.* 1993; Smit *et al.* 1995). Additional to these functional and biological values, wetlands also have consumptive uses, e.g. they provide water to man and animals, they generate energy and can be used for fish farming. Non-consumptive uses include recreation, tourism and transport (Rand Water Scientific Services 1998).

The goal of a rehabilitation project may be to a particular species, or may include the rehabilitaion of a whole ecosystem or landscape, or to restore the ecosystem functions (Ehrenfeld 2000). South Africa ratified the Ramsar convention (Cowan & Marneweck 1996) and are therefore under an obligation to conserve wetlands. The rehabilitation of wetlands play an important role in wetland conservation, as mentioned in the Ramsar convention.

When rehabilitating wetlands it is important to understand wetland functions and to give the system time to react. Some rehabilitation projects may take up to 50 years before rehabilitation has been accomplished (Middleton 1999; Mitsch & Wilson 1996). A wetland ecosystem is not a stable system, because many disturbances such as flood pulsing, fire and herbivory occur naturally in many wetlands (Middleton 1999; Mitsch & Wilson 1996), especially in a country such as South Africa with its high frequency of thunder storms, fire-prone grasslands and large variety of large herbivores. A restored wetland should be able to deal with these kinds of disturbances.

Only a few peatlands have been rehabilitated in South Africa and information is limited. In 1995 it has been proposed that the Orange River Mouth salt marsh should be rehabilitated (Marneweck 1995), but in 1998 almost no progress has been made and many problems were experienced with the project (Dini 1998). Another similar project was the rehabilitation of Blesbokspruit (Dini 1998). In 1996 the Free State Department of Environmental Affairs and Tourism and Rand Water started the rehabilitation of the Seekoeivlei as well as other wetlands in the north- eastern Free State (Collins 1998). The rehabilitation of the Wilge River started as a Rand Water and Working for Water project in the same year (Rand Water & Working for Water Programme 1998). These projects take time and it is therefore difficult to determine if the projects have been successful. The Orange River Mouth, Blesbokspruit and Seekoeivlei are Ramsar sites (Cowan & Marneweck 1996). On the contrary, there is much information available on the rehabilitation of European peatlands, but those are completely different ecosystems, which developed under very different climatic conditions.

During peat mining operations in the past on Rietvlei Nature Reserve, ditches with sharp edges were constructed to drain the peatland. Some of the water was used for irrigation of farms in the area. There are four dolomite springs on the Reserve. The water from these springs is piped to the Rietvlei Water Works. A large amount of water was therefore drained from the peatland, which subsequently became dry and resulted in the vegetation being altered.

Rehabilitation of the Rietvlei peatland started as a "Working for Water" project. The aim of the rehabilitation project was mainly to rewet the peatland to allow hydrophytic vegetation to re-establish. The sharp edges of the main channel were sloped and gabions were placed in the main channel to stop the peat from rapidly drying out and to allow floodwater to easily overspill onto the adjacent peatland, thus enhancing the rewetting process. The peat recovered from the sloping process was used to fill some of the smaller ditches. Soil and straw gabions were placed in the ditches to stabilise them and to retain the water. Rock filled gabions were placed in the main channel to slow the flow, increase the flooding frequency and duration and to promote the deposition of sediment.

It was necessary to conduct a baseline vegetation survey to determine the pioneer plant communities that established naturally on the rehabilitated peatland. The communities closer to the climax, that occur on areas with less disturbance, were also surveyed, to gain knowledge on the potential climax vegetation.

## Study area

The Rietvlei Dam Nature Reserve is located at about 25º50'S and 28º20'E. The reserve became established as a result of the Rietvlei Water Scheme to provide drinking water to the people of Pretoria. The Rietvlei Dam is

located in the northern portion of the reserve and the peatland is located upstream from the dam in the southern portion of the reserve.

The City Council of Pretoria acquired the farm in 1929. The dam was built in the Ses Myl Spruit during the Great Depression and it was completed in 1934. The catchment area of the Ses Myl Spruit is to the south of Pretoria, towards Kempton Park. The area was declared the Rietvlei Game Reserve in 1937. In 1948 it became the Rietvlei Reserve for Game and indigenous Flora. In 1954 the area became the Van Riebeeck Nature Reserve and in 1992 the name was changed again to the Rietvlei Nature Reserve (Culture and Recreation Department 1997).

To drain the peatland, a deep ditch was dug through it, and this now forms part of the Ses Myl Spruit main channel. The main channel has been severely eroded and the water flows very fast, with high energy levels. The main channel and the peatland on the western side of the main channel have been rehabilitated. Certain portions of the peatland, on the eastern side of the main channel, were extensively mined and almost all the peat was removed. This area has not been rehabilitated. The underlying clay soil was exposed. On the western side of the main channel deep deposits of peat still remained intact, but they were severely disturbed by drainage ditches. The vegetation was disturbed during the construction of the ditches and the ditches altered the hydrological regime of the peatland.

## Methods

The peatland area was stratified into the following units: ditches filled with peat; ditches filled with soil; sloped main channel edges; reed areas on old peat-deposits; and the mined area east of the main channel.

During the summer of 2001, 22 sample plots of 4 m x 4 m were placed randomly in these different units. The exact locality of each plot was recorded using a Global Positioning System (GPS). In each plot all plant species present were listed and each assigned the approriate Braun-Blanquet cover-abundance value (Werger 1974). Some aspects of the habitat were also noted such as soil type (peat or clay), degree of disturbance and rehabilitation measures.

The floristic data were entered into the TURBOVEG data basis (Hennekens 1996a) and the data were subjected to classification and ordination procedures to identify plant communities. TWINSPAN (Hill 1979b) was used for the initial classification of the vegetation, and the result was refined by using MEGATAB (Hennekens 1996b). The final classification is presented in a phytosociological table. The procedure of Detrended Correspondence Analysis was performed by applying the DECORANA software (Hill 1979a). This ordination was used to indentify environmental gradients responsible for plant species distribution, and hence the occurrence of plant communities.

To determine a probable change in vegetation (path of succession) after one year, the floristic survey was repeated during the summer of 2002 on the same sample plots as 2001. The data of the two surveys were pooled and to determine the direction of change in vegetation, the ordination was re-applied to the pooled data set.

## Results

### *Classification*

The result of the classification is presented in the phytosociological table (Table 1).

The classification of the plant communities found in the baseline survey (2001 data set) is as follows:

1. *Amaranthus hibridus* - *Setaria ustilata* Community on filled ditches.
   - 1.1. *Cynodon dactylon* - *Solanum sisymbrifolium* Sub-community on soil filled ditch.
   - 1.2. *Persicaria* species - *Amaranthus hibridus* Sub-community on peat filled ditch.

2. *Phytolacca octandra* - *Solanum nigrum* Wetland Community.
   - 2.1. *Phytolacca octandra* - *Datura stramonium* Disturbed Wetland Sub-community.

Table 1

*Phytosociological table of pioneer vegetation on the rehabilitated peatland at Rietvlei Nature Reserve*

| **Plant communities** | **1** | | | | | | | **2** | | | | | | | | **3** | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **1.1** | **1.2** | | | | | | **2.1** | | | **2.2** | | | | | **3.1** | | **3.2** | | |
| | | | | | | | | | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 |
| Relevé nr. | 7 | 1 | 2 | 3 | 4 | 5 | 6 | 8 | 9 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 8 | 0 | 2 | 7 | 9 | 1 | 1 |
| **Species group A** | | | | | | | | | | | | | | | | | | | | | | | |
| *Persicaria* species | + | 3 | 4 | b | 5 | 5 | r | . | . | + | + | . | . | + | . | . | . | . | . | . | . | . | |
| *Amaranthus hybridus* | 1 | 4 | 1 | 3 | 1 | . | 5 | + | . | + | + | . | . | 1 | . | + | . | . | . | . | . | . | |
| *Bidens pilosa* | 1 | . | . | a | r | r | + | . | . | a | . | . | . | . | . | . | . | . | . | . | . | . | |
| *Setaria ustilata* | + | + | + | 1 | + | + | + | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | |
| **Species group B** | | | | | | | | | | | | | | | | | | | | | | | |
| *Cynodon dactylon* | b | . | . | 1 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | |
| *Hibiscus trionum* | 1 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | |
| *Cyperus esculentus* | 1 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | |
| **Species group C** | | | | | | | | | | | | | | | | | | | | | | | |
| *Urochloa panicoides* | . | a | a | 1 | . | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | |
| *Eleusine coracana* ssp. *africana* | . | . | . | + | + | r | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | |
| *Verbena brasiliensis* | . | r | . | + | r | r | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | |
| *Pennisetum clandestinum* | . | + | . | + | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | |
| *Cyperus pulcher* | . | . | . | + | + | + | . | . | . | . | . | . | . | b | . | . | . | . | 1 | . | . | . | |
| *Agrostis lachnantha* | . | r | . | . | + | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | |
| **Species group D** | | | | | | | | | | | | | | | | | | | | | | | |
| *Phytolacca octandra* | . | . | . | . | . | . | . | 5 | 5 | b | + | b | + | + | + | . | . | . | . | . | . | . | |
| *Solanum nigrum* | . | . | . | . | . | . | . | 1 | + | + | + | . | + | a | 3 | 1 | . | . | . | . | . | . | |
| **Species group E** | | | | | | | | | | | | | | | | | | | | | | | |
| *Phragmites australis* | . | + | 5 | . | . | . | 1 | . | . | + | 3 | 5 | 5 | b | b | + | . | . | 5 | . | . | . | |
| *Veronica anagallis-aquatica* | . | . | . | . | . | . | . | . | . | . | . | . | . | a | . | . | . | . | . | . | . | . | |
| *Physalis angulata* | + | . | . | . | . | . | . | . | . | . | + | + | + | . | . | . | . | . | . | . | . | . | |
| *Oxalis corniculata* | . | . | . | . | . | . | . | . | . | . | . | . | . | 1 | . | . | . | . | . | . | . | . | |
| *Hypochaeris radicata* | . | . | . | . | . | . | . | . | . | . | . | . | . | 1 | . | . | . | . | . | . | . | . | |
| **Species group F** | | | | | | | | | | | | | | | | | | | | | | | |
| *Datura stramonium* | 1 | 1 | 1 | . | r | . | r | + | b | a | . | + | + | 1 | . | + | . | . | . | . | . | . | |
| *Solanum sisymbrifolium* | b | . | . | . | . | . | . | 1 | . | . | . | . | + | . | . | r | . | . | . | . | . | . | |
| *Chenopodium album* | r | + | . | + | . | . | + | . | . | + | + | b | + | + | 1 | 4 | . | . | . | . | . | . | |
| **Species group G** | | | | | | | | | | | | | | | | | | | | | | | |
| *Tagetes minuta* | + | . | . | + | r | . | + | + | . | 1 | + | . | . | + | . | . | . | + | . | . | . | . | |
| *Paspalum dilatatum* | + | + | . | . | . | + | . | . | . | . | . | . | . | . | . | . | . | 3 | . | . | . | . | |
| **Species group H** | | | | | | | | | | | | | | | | | | | | | | | |
| *Cyperus* species | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 5 | b | 4 | . | b | 4 | |
| *Cirsium vulgare* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | r | 1 | . | 1 | . | + | |
| *Oenothera rosea* | . | . | . | . | . | . | . | . | . | . | . | . | . | + | . | . | 1 | a | a | r | 1 | 1 | |
| *Berkheya radula* | r | . | . | . | . | . | . | . | . | . | . | . | . | + | . | 1 | + | 1 | . | . | + | . | |
| **Species group I** | | | | | | | | | | | | | | | | | | | | | | | |
| *Typha capensis* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 4 | 5 | . | |
| *Epilobium hirsutum* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 1 | 1 | . | |
| **Species group J** | | | | | | | | | | | | | | | | | | | | | | | |
| *Persicaria lapathifolia* | . | 1 | . | + | + | 1 | a | 1 | + | . | + | + | . | + | . | . | . | . | . | + | + | 1 | |
| *Cyperus fastigiatus* | . | b | 1 | . | + | + | . | . | . | . | . | . | . | . | . | . | . | . | . | 3 | 1 | b | |
| *Verbena bonariensis* | . | . | . | 1 | . | + | . | . | . | . | . | . | . | . | . | . | . | + | 1 | . | + | . | |
| *Rumex crispus* | . | . | . | . | . | r | . | . | . | . | . | . | . | + | . | . | . | . | . | . | 1 | . | |

Table 1
*(continued)*

| The following species were encountered in the peatland, but were not of any significant value to the phytosociological table |
|---|
| *Hyparrhenia hirta* |
| *Setaria verticillata* |
| *Alisma plantago-aquatica* |
| *Schoenoplectus corymbosus* |
| *Bidens formosa* |
| *Panicum schinzii* |
| *Hemarthria altissima* |
| *Digitaria sanguinalis* |
| *Askidiosperma albo-aristatum* |
| *Ranunculus multifidus* |
| *Cyperus eragrostis* |
| *Sambucus nigra* |
| *Helichrysum* species |
| *Trifolium africanum* |
| *Sisymbrium thellungii* |
| *Pseudognaphalium* species |
| *Xanthium strumarium* |

2.2. *Phragmites australis* - *Chenopodium album* Wetland Sub-community.

3. *Cyperus* species - *Oenothera rosea* Wetland Community on clay.

3.1. *Cyperus* species - *Paspalum dilatatum* Moist Wetland Sub-community on clay.

3.2. *Typha capensis* - *Cyperus fastigiatus* Wet Wetland Sub-community on clay.

A hierarchical and habitat interpretation of the recognised plant communities is given in Fig. 1.

*Community description*

1. *Amaranthus hibridus* - *Setaria ustilata* Community on filled ditches.

The plant community occurs on the ditches that were filled with peat or soil during the rehabilitation of the peatland. The vegetation represents a pioneer stage, which established directly after the new disturbance caused by the rehabilitation. The vegetation is short, mostly below 0.5 m, and young. Some parts of the community have a dense vegetation (aerial) cover (80 %) while other parts have open patches with bare peat. The community is characterised by species group *A. Persicaria* species is dominant and *Amarathus hibridus* and *Setaria ustilata* are conspicuously present. All these species are annual weeds, common in disturbed areas and are indicators of disturbance. A total of 38 species were noted in the community and an average of 14 species per relevé.

1.1. *Cynodon dactylon* - *Solanum sisymbrifolium* Sub-community on soil filled ditches.

The sub-community is located on soil (not peat) filled ditches at the edge of the wetland. This habitat is much drier that the rest of the wetland. The vegetation is open (about 30 % aerial cover) with large patches of bare soil surface visible. This sub-community is characterised by species group B. The stoloniferous perennial grass *Cynodon dactylon* is the dominant species and the annual weeds *Solanum sisymbrifolium* and *Datura stramonium* are conspicuous in this sub-community. Both these weeds occur in disturbed areas. *Cynodon dactylon* occurs in disturbed places on all soil types and is often found in damp areas (Van Oudtshoorn 1999). An average of 15 species per relevé and a total of 15 species were found in this sub-community.

1.2. *Persicaria* species - *Amaranthus hibridus* Sub-community on peat filled ditches.

This sub-community is located on old drainage ditches filled with peat during the rehabilitation. The aerial cover of the vegation is about 50 %. Species group C characterises this sub-community and the dominant species is *Persicaria*. Furthermore *Amaranthus hibridus*, *Persicaria lapathifolia* and *Cyperus fastigiatus* are also conspicuous. *Phragmites australis* is starting to establish within this sub-community. *Persicaria lap-*

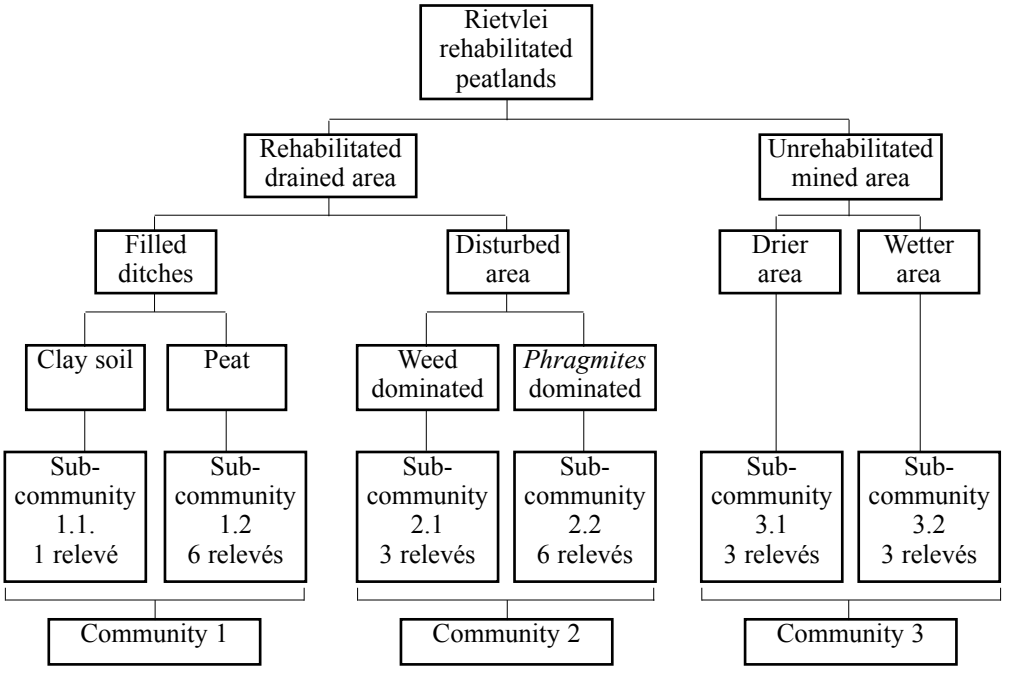


Fig. 1. Dendrogram showing the hierarchy of TWINSPAN divisions for the vegetation data of the rehabilitated peatlands on Rietvlei Nature Reserve on the 2001 dataset.

*athifolia* is a weed that often occurs in wet areas and *Amarathus hibridus* is common in disturbed areas (Van Wyk & Malan 1988). A total of 32 species were noted in this sub-community with an average of 14 species per relevé.

2. *Phytolacca octandra* - *Solanum nigrum* Wetland Community.

This is a weedy community on peat, probably representing a further stage in the succession. It is closer to the main channel and is moister than community 1. The community is characterised by species group D and shares species group F with community 1. The dominant species is *Phytolacca octandra*, which is a tall-growing annual weed (>2 m) restricted to disturbed areas (Van Wyk & Malan 1988). The community has a species diversity of 26 and an average of nine species per relevé.

2.1. *Phytolacca octandra* - *Datura stramonium* Disturbed Wetland Sub-community.

The sub-community has been disturbed and the vegetation consists mainly of weeds. The vegetation is dense, with an aerial cover of almost 100 % and up to 2.5 m tall. This sub-community is characterised by the absence of species group E. The dominant species are *Phytolacca octandra* and *Datura stramonium*, while *Persicaria lapathifolia* and *Solanum nigrum* are also very conspicuous. *Phytolacca octandra* is a weed restricted to disturbed areas and *Persicaria lapathifolia* is a weed that often occurs in wet areas (Van Wyk & Malan 1988). The sub-community with 13 species is relatively poor in species

composition, probably due to the shading effect of the dominant species. Seven species on average were found in each relevé.

### 2.2. *Phragmites australis* - *Chenopodium album* Wetland Sub-community

The sub-community represents a further successional stage, probably close to the reed dominated climax. It is located close to the main channel and is quite wet. Species group E characterises the sub-community. *Phragmites australis* is the dominant species and the weedy annuals *Chenopodium album* and *Solanum nigrum* are often present. *Phytolacca octandra* is present, but is relatively small in size in this sub-community, probably due to the competition from *Phragmites australis*. A total of 23 species were noted in this sub-community with an average of nine species per relevé.

### 3. *Cyperus* species - *Oenothera rosea* Wetland Community on clay.

This community is restricted to the eastern side of the main channel. The community is on a part of the wetland where the peat was mined extensively, and where the mined area is relatively flat without any drainage ditches. All peat was removed and the community is therefore on a clay soil. This area was not actively rehabilitated. Species group H characterises the community and the dominant species is *Cyperus* species. *Oenothera rosea* is a weed that occurs in moist disturbed areas and is an indicator of the past disturbance that occurred at the site (Van Wyk & Malan 1988). Only 14 species were recorded in this community with an average of six species per relevé.

### 3.1. *Cyperus* species - *Paspalum dilatatum* Moist Wetland Sub-community on clay.

This sub-community is drier than sub-community 3.2, because is is on slightly higher ground, and the vegetation is shorter, mostly lower than 1 m. The sub-community is characterised by the absence of species group I and it is dominated by *Cyperus* species. *Oenothera rosea* and *Cirsium vulgare* are conspicuous in the vegetation. *Paspalum dilatatum* occurs mostly on clay and loam soil and in wet areas and is often a weed in disturbed areas (Van Oudtshoorn 1999). *Cirsium vulgare* also occurs in moist disturbed areas (Van Wyk & Malan 1988). These species are indicators of the past disturbance, as well as the moist clayey soil. The sub-community has an average of six species in each relevé and a species diversity of only nine species. This is the sub-community with the lowest species diversity.

### 3.2. *Typha capensis* - *Cyperus fastigiatus* Wet Wetland Sub-community on clay.

The sub-community occurs on moist clay soil and is located in a lower area of the wetland. The vegetation is about 2 m tall. Species group I is characteristic of the sub-community and the dominant species is the perennial *Typha capensis*. *Epilobium hirsutum*, *Persicaria lapathifolia*, *Cyperus* sp., *Cyperus fastigiatus* and *Oenothera rosea* are conspicuously present. *Typha capensis* occurs in wet areas and *Epilobium hirsutum* occur in moist grassland and are often found in vlei areas (Van Wyk & Malan 1988). These species are indicators of the wet soil. The sub-community has 10 species and an average of seven species per relevé.

### Ordination

In the ordination on the 2001 data set (Fig. 2), the separation of communities 1 and 2 on the drained, rehabilitated side of the channel and community 3 on the mined side of the channel is clear. Most of the relevès in a sub-community are close together but there are a few exeptions where the relevès are in a state of transition between two communities. Although relevè 2 is still in Sub-community 1.2 it is also close to Sub-community 2.2. It is therefore closer to the climax (Sub-community 2.2) than the other relevès in Sub-community 1.2. The environmental gradient from dry to wet can be seen in the ordination as well as the gradients from the pioneer community to the two different close-

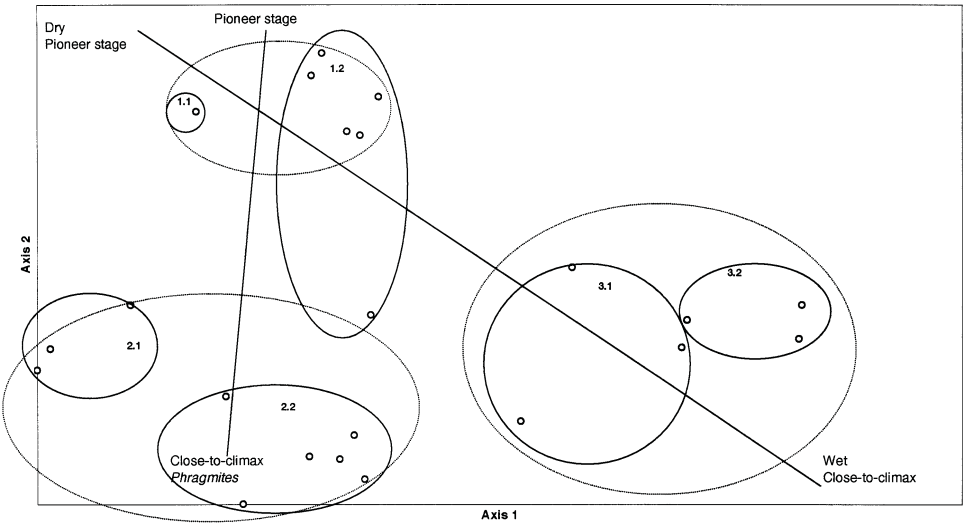


Fig. 2. Scatter diagram of a DECORANA ordination illustrating the difference between the communities along an environmental gradient using the 2001 dataset. Axis 1 was plotted against Axis 2.

to-climax communities. These communities occur in the areas with less recent disturbance and are more similar to climax vegetation than the pioneer communities. The succession of community 1 will be to either one of them. The one close-to-climax community should not change to become like the other close-to-climax community.

*Monitoring vegetation change*

The following is the result of the ordination as performed on the pooled data set for the specific purpose to monitor vegetation change from 2001 to 2002. The ordination (Fig. 3) indicates that the vegetation of sub-community 1.1 moved away (to the top left in the diagram) from the other communities. This is probably because it is situated at the edge of the wetland and has more terrestrial species than wetland species and is becoming more terrestrial, like the adjacent grassland community.

The vegetation of sub-community 1.2 changed (moved downwards in the diagram) in the direction of the of the reed-dominated community 2.2. This is probably an indication of succession form a pioneer community towards the climax *Phragmites australis* dominated vegetation.

The vegetation of Sub-community 2.1 stayed almost the same and although reeds are present it is dominated by the tall weed *Phytolacca octandra*. It does however share a lot of species with the reed-dominated sub-community 2.2. Relevé 11 moved closer to 2.1 and it therefore seems that it has degraded, due to later disturbance by the floods.

Sub-community 2.2 represents the close-to-climax vegetation dominated by *Phragmites australis*. This vegetation stayed almost the same, however, the vegetation of sample plots 14 and 15 seems to have degraded, and moved towards sub-community 1.2, which is an earlier successional stage.

Community 3 stayed almost the same, but the vegetation at relevé 22 moved towards the more reed-dominated group. This may be because it is the only relevé in community 3 with *Phragmites australis*. Relevé 20 in community 3 was probably more disturbed

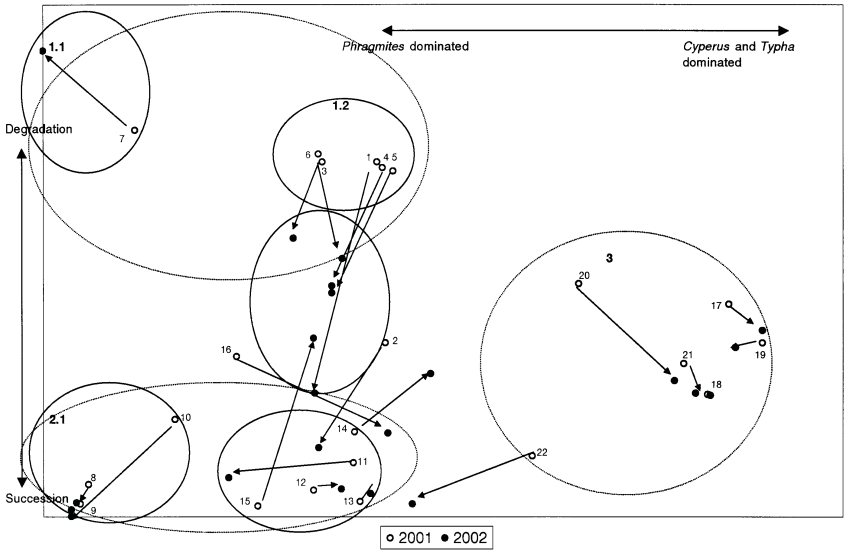


Fig. 3. Scatter diagram of a DECORANA ordination illustrating the change of the vegetation of the communities after one year using the pooled dataset of the 2001 and 2002 data. Axis 1 was plotted against Axis 2.

than the rest, because it is close to the rehabilitation area and has been trampled. It moved closer to the rest of community 3. The two sub-communities in community 3 seem to become more similar, since it is more difficult to distinguish them from the ordination diagram.

## Discussion

### *The baseline survey*

The first division of TWINSPAN on the 2001 baseline data separated the un-rehabilitated, mined areas and areas disturbed by the rehabilitation. The rehabilitation disturbed the sites because of trampling, the construction of gabions and the movement of peat from one site to another. The mined area is on the eastern side of the main channel and the disturbed rehabilitated area is on the western side. These communities differ largely and have few species in common. These species are in species groups G and J and include *Persicaria lapathifolia*, *Tagetus minuta* and *Cyperus fastigiatus*, mostly pioneer, annual species. The DECORANA ordination diagram also shows significant separation between these plant communities. There are two communities on the western, rehabilitated, side of the main channel and each of these have two sub-communities. There is only one community on the eastern side, with two sub-communities. Each community and sub-community occurs on a particular habitat.

Community 1 is on the filled ditches that were rehabilitated recently and the weedy pioneer plant species of the two sub-communities are mostly the same. Most of the pioneer species are exotic weeds. The vegetation of sub-community 1.1 differs from 1.2, due to the dominance of the perennial stoloniferous grass *Cynodon dactylon*, while the annual weedy *Solanum sisymbrifolium* is very conspicuous in 1.1. *Persicaria* species and *Amaranthus hibridus* are more dominant in sub-community 1.2 and the annual grass *Urochloa panicoides* occurs in this sub-community. *Phragmites australis* is becoming established in sub-community 1.2, but not in 1.1. The differences in the vegetation of the

two sub-communities are probably a result of the difference in soil. Sub-community 1.1 is on relatively dry clay and sub-community 1.2 on moist peat.

The two sub-communities of community 2 differ in the dominant vegetation and probably the degree of disturbance. The vegetation of sub-community 2.1 consists mainly of tall growing weeds, mostly *Phytolacca octandra*. The vegetation of sub-community 2.2 is dominated by *Phragmites australis* which includes the older, well developed stands, probably closer to the climax vegetation, as well as the recently sloped area next to the river. The older and pioneer sub-communities are floristically therefore combined in a single community. Sub-community 2.2 occurs on both peat and clay. It seems that a community completely different from the filled ditches (community 2.1) is therefore developing on the sloped area (part of community 2.2). The difference in disturbance may be responsible for the difference in sub-communities 2.1 and 2.2. Another possibility may be that they are at different successional stages, or moving towards different new climaxes. Reeds were established on the sloped areas before and the reeds are growing back rapidly. This may explain the separation of community 2.2 from community 1.

Community 3 on the eastern side of the main channel is completely different from the communities on the western side. The area was mined and the peat removed and not rehabilitated. The community occurs on exposed clay, that was previously underlying the peat. The community that established is dominated by *Cyperus* species. This may be an example of a climax, or close to climax, community dominated by *Cyperus* and Typha. The wetter (slightly lower) sub-community (3.2) is dominated by *Typha capensis* and the drier sub-community (3.1) is dominated by *Cyperus* species.

There are very few general species. Communities 1 and 2 share some species, but they do not share many species with community 3. Community 1 has the highest species richness and community 3 has the lowest species richness. The pioneer communities therefore contribute more to species diversity than the close-to-climax communities, which are dominated by tall groups of reeds or sedges, with few other species present. Community 3 is already stable and there is probably more competition between dominant species, while community 1 is a pioneer community with many weeds and open spaces for plants to establish. Few individuals of these weeds occur in the established communities and they should disappear in time. In contrast, the flood regime of the wetland may cause sufficient disturbance for the weedy species to persist in the pioneer communities for some time. Wetland species are adapted to these disturbances, but they need time to establish in a disturbed wetland and the flooding regime still need to stabilise.

### *Vegetation change*

The study was conducted over a short period with only two data sets one year apart. This is important to take into consideration, since wetlands take a long time to rehabilitate. The study is at the start of rehabilitation and it is difficult to predict what the vegetation will look like after a few years. This study will hopefully give us some indication.

After the flooding disturbance at the end of the year, that destroyed most of the pioneer vegetation, the peat was wetter. This flooding was caused by the rehabilitation measures. It seems that the rehabilitation was successful and that succession is taking place towards the climax vegetation, even after only a single year. Sub-community 2.1 may be a problem, because it does not seem to advance towards a reed-dominated community, but stays the same. This is a problem because this community are dominated by weeds. It would be interesting to see if this community would change over a longer period of time. Further monitoring would confirm whether the changes in vegetation is of a permanent nature, or whether the vegetation is merely fluctuating due to yearly changes in the moisture regime. The moisture regime is changing due to the rehabili-

taion, but yearly fluctuations in the amount of rainfall also plays a role. Although it seems as if the peatland is recovering the time frame of the study is to short to confirm this as a fact.

Other disturbances in the peatland are grazing, by the animals occuring in the reserve as well as trampling by the buffalo. Any of the disturbances could have caused the degeneration of some of the relevés, for example relevé 15.

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