Vegetation survey in a swamp forest of Mpumalanga, South Africa

View of upstream riverine vegetation in the Sand River catchment

Olivier Flores

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Contents

1 Introduction

Wetlands are particular terrestrial ecosystems essentially dependent on soil waterlogging. Among these, riparian formations occur along streams and are strongly influenced by flood regime (Kingsford, 2000; Richter and Richter, 2000). Riverine ecosystems have high conservation value since they buffer flooding, provide habitat to numerous species (Darveau et al., 2001) and serve as corridors for animal movements (De Lima and Gascon, 1999). In South Africa, swamp forest cover 4834 ha over the 1.2 million square kilometres of the total area of the country. Very little literature exists on swamp forest in South Africa and these ecosystems remain weakly known.

The aim of the present project was to study of the composition and organisation of a swamp forest in the Mpumalanga province in South Africa. This work was realized in collaboration with the governmental *Working for Water* programme. The first aim was to draw up an inventory of species present in a river catchment being rehabilitated by the programme. In order to present the context and content of the project, this report is divided in two parts. In the first part, a presentation deals with the purpose of *WfW* in South Africa. The second part presents a field survey of riverine vegetation in the upper Sand River catchment area, part of the Sabie River catchment in Mpumalanga. The data obtained from this survey concerns sampling of occurring plant species from which diameter distributions of woody species and species assemblage are studied. While surveying species, I also characterized species response to four qualitative environmental variables in order to investigate their influence on species distribution. Comparisons are drawn with a similar study done in the Santa Lucia Lake area (Kwazulu-Natal, South Africa, Wessels, 1991).

2 Presentation of the *Working for Water* programme

2.1 The issue of invasive plant species in South Africa

In South Africa, one hundred and sixty one species have been identified as invasive. They cover around 10% of the area of the country (Fig.1.a). Their ability to spread and establish in sensible ecosystems is a serious threat to South African biodiversity, whereas the country is one of the hotspors with regard to the world biodiversity (Myers et al., 2000). Invasive species can increase fire frequency due to the addition of natural combustible, especially under dry conditions which are common in South Africa. They also cause trouble in terms of water management: infested catchment show severe decrease in runoff due to water use by invading species. Water loss from invasive species in South Africa has been estimated to 7% of the total water ressources. Agriculture is also affected since the land needs to be cleared before being suitable. Each year, billion of dollars are spent on fighting biological invasions. Left uncontrolled, effect of these invasions are supposed to double within twenty years or less.

2.2 What is the *Working for Water* programme?

WfW is a multi-departmental programme of the South African government. It was launched in 1995 in order to tackle the problem of invasive species and unemployment in South Africa. The map on figure 1 displays the locations of about three hundred projects run by *WfW*, as well as level of infestation by invasive species. The goal of the programme are multiple:

- Ecological aims
  The principal activity of the programme is the clearing of invasive species in order to improve the sustainability of water ressources and protect the biodiversity of the country. Different methods are employed: hand-cutting, herbicides, ring-barking to kill trees without cutting them, and biological control using predators and pathogens of invasive species.

- Social aims
  The programme acts on a social ground to create jobs for people from the local communities and improve water supply conditions. Projects are conducted in the nine South African provinces. In each province, area managers are responsible for a given part of the territory. Each manager employs local contractors from the communities and each contractor is responsible for a team of twenty people chosen by himself. Among the 42,000 workers employed by *WfW* at its peak, 54% were women, 26% were young people, and 1% were disable people. Created jobs essentially include alien plants clearing and rehabilition of stream catchments, but the programme also developps secondary industries such as crafts from alien wood.

  Environmental awareness as well as disease prevention against cholera and AIDS are also conducted among the local contractors and private owners.

2.3 *WfW* in Mpumalanga and the *Save the Sand* project

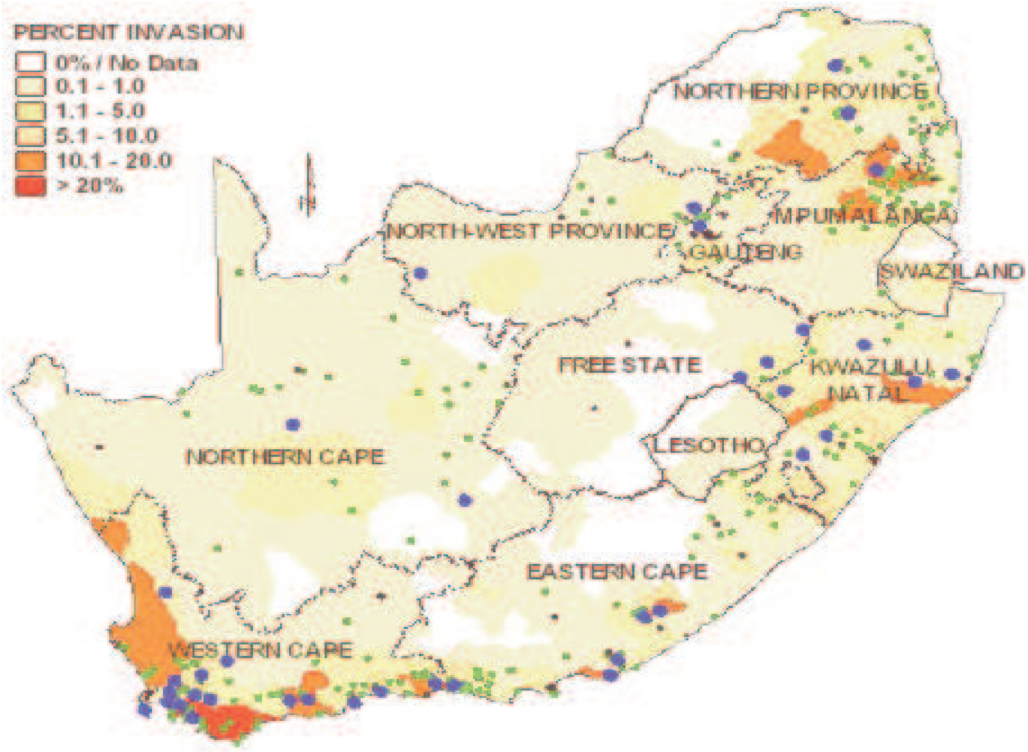
In Mpumalanga, *WfW* is implied in the rehabilitation of the Sand River sub-catchment which is part of the more important Sabie River catchment (Fig.1). The Sabie River catchment (SRC) covers around 7,000 km^2 at the border between South Africa and Mozambique. Included in this area, the Sand River sub-catchment (SRSC) which represents 27% of the SRC (1910 km^2. The Sand River contributes up to 20-23% of the Sabie River runoff, depending on estimations, and over 336,000 people depend on the SRC for their water supply. In the SRC, population density, estimations range from 176 to less than 2 people per km^2, depending on wether the total area or only residential areas are considered.

These physical and demographical conditions make water management a critical issue in this area. Among other things, the *Save the Sand* project include maintenance of access roads and stream management in the SRSC.

3 Vegetation survey in a swamp forest of the srsc

3.1 Ecological features of the srsc and presentation of the forest

The SRSC lies eastward of the Drakensberg escarpment (Fig.1.b). The climate in the region of SRSC is sub-tropical and strongly influenced by topography with altitudes varying from over 1700 m westward to 200 m above sea-level eastward. The precipitation pattern shows a strong eastward gradient in annual rainfall decreasing from 2000 mm to 550 mm per year over a distance of 80 kms. Due to this pattern, the upper part of the SRSC provides water to the rest of the catchment: 50% of the Sand a.



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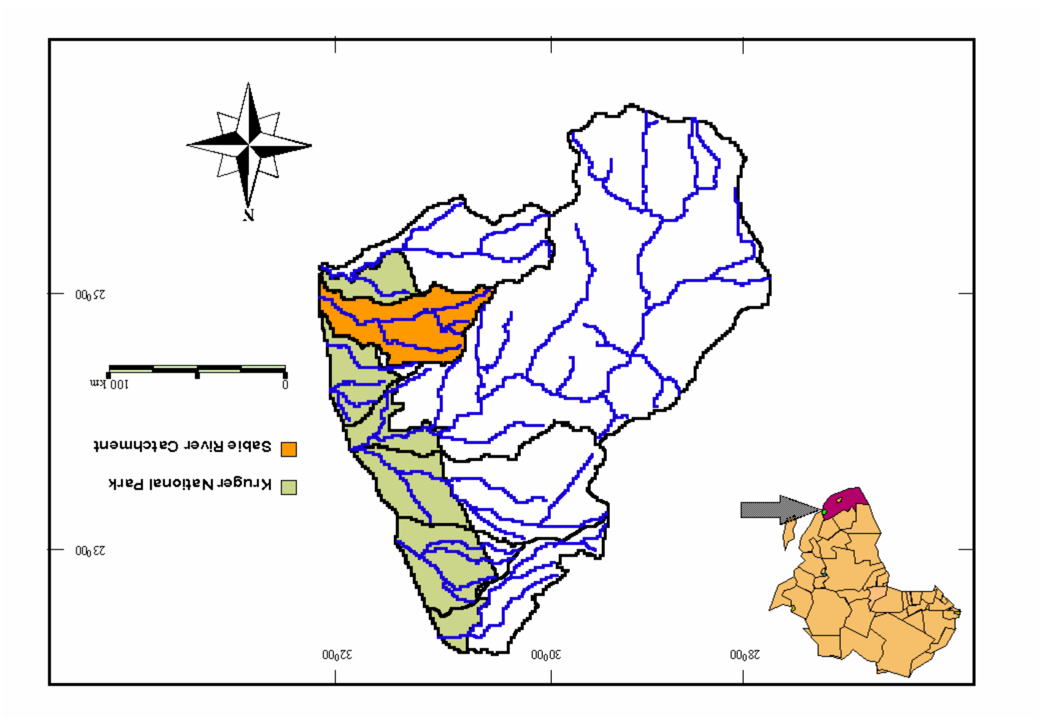


Figure 1: a. Infestation level by invasive species in South Africa and locations of *WfW* projects (circles). b. Localization of the Sabie River Catchment (SRC).

River runoff is actually generated on 25% of the catchment area. Precipitations are highly seasonal and mainly occur during summer, with 75% of the annual amount falling between October and March.

The studied swamp forest occurs in this upper part of the catchment along river streams including the Sand River and its tributaries. Pine plantations also occur in this part of the catchment above the 1100 mm isohyet. Three state-owned plantation cover about 3% of the catchment area, among which the Welgewonden forestry where the survey was conducted. In this area, plantations sometimes a common edge with the indigenous fores. The width of the swamp forest (across the drainage line) ranges from 5 m on each side up to 100-200 m. The forest cover is fragmented by open areas. These areas may occur naturally or correspond to highly perturbated areas (clearcut forestry). Slopes in the forest are low (<5%) except in the very upper part of the catchment.

The studied forest shows evidence of use by the local communities. Two main types of usage occur in the forest. The forest provides food for cattle and timber. Timber is essentially extracted daily for firewood. Plants are also used as food for people or medicines.

The aim of the vegetation survey in the SRSC was first to draw an inventory of occurring species and to determine wether species distribution could be linked with environmental and human-induced conditions.

3.2 Methods

3.2.1 Vegetation sampling

Species present in the forest vegetation were sampled on 400 m^2 circular plots. I randomly chose thirty-eight plots along river banks in the forested area. Plots were limited with a rubber tape and positioned at random distance on each side of a stream. Sampling sites were always under tree cover and never in a completely open area.

Vouchers were collected, referenced for each present species and identified by local botanists. I distinguished three vegetation strata following the classification of (Wessels, 1991): a canopy layer, a shrub layer and a ground layer. The canopy stratum included all trees above 5 m high. In this layer, species were recorded by number of stems. Most of the time, one tree counted for one stem, but some individuals showed several stems just above ground level: they counted for more than stem. Trees DBH were also recorded (Diameter at Breast Height).

In the shrub stratum, shrubs and saplings between 0.4 and 5 meters were also recorded on a density basis. Herbs and seedlings occur in the ground layer. Species of this stratum were recorded on a presence–absence basis. This classification suffers some exceptions: due to variability in its development, a herbaceous species may be more than 40 cm high, meanwhile all sorts of creepers were recorded in the herbaceous layer with the same method. Following this classification, trees can be present in the three strata.

Some species were observed in the Welgevonden forest but not recorded. They were either rare species (*Aloe dyare*, *Cussonia spicata*), or invasive species in South Africa. The most problematic species in the studied area were Bugweed (*Solanum mauritianum*), Mauritius thorn (*Caesalpinia decapetala*), Guava (*Psidium guajava*), Granadilla (*Passiflora edulis*) and *Senna septentionalis*.

3.2.2 Site characterization

A qualitative characterization of sampling sites was realized regarding four variables: soil hydromorphy, human-induced disturbance, upstream distance and distinction between location regarding either the main stream bed or secondary stream beds. I chose these environmental variables in order to test their possible influence on species distribution. This choice was partly arbitrary and partly influenced by observations in the forest: for instance, most of the individuals of *Breonardia microcephala*, one of the most abundant woody species, were observed near the main stream. Invasion by alien plants was another type of disturbance that may affect the composition of the forest and the distribution of species within the forest. Yet, this possible effect was not taken into account at this stage.

Evidence of human-induced disturbance in the forest consisted in evidence of grazing, pathways for cattle with varying use frequency, stumps and evidence of harvesting. Disturbance was evaluated on a four-level scale:

1. no disturbance,
2. weak disturbance,
3. strong disturbance,
4. very strong disturbance.

Every sampling site showed evidence of human use. Among the two main types of use in the forest, harvesting mainly affected the canopy layer, while cattle mostly influenced the ground and shrub layer. Yet, effects of these two factors were not distinguished.

Soil hydromorphy was estimated on a six-level scale, from 1 for very dry sites to 6 for sites with flooded soils and running water, either as a small stream or more diffusively.

Sampling sites were also characterized by an arbitrary distance class, the most downstream site being in class 1 and the most upperstream in class 15.

3.2.3 Data analysis

I conducted two types of ordination analyses with the software ADE4. Relationships between species and sites were analyzed through a Canonical Analysis (CA, Gauch, 1982). This method groups co-occurring species and sites with similar composition and finds relationships between the two sets. The ordination is based on calculated scores on axes defined to maximise scores variability. Relationships between species composition and qualitative variables were estimated through a Canonical Correspondence Analysis (CCA, Gauch, 1982). The method is often used after a CA in order to estimate to which extent existing axes in species composition can be explained by descriptive environmental variables.

Rare species were defined as species occurring in only one sampling site and excluded from the analysis. Species were initially sampled on an abundance basis in the two upper vegetation strata and on a presence-absence basis for the lower stratum. Yet, ordination analysis only deals with homogeneous data. Densities in the two upper strata were then transformed into presence–absence data. I conducted analyses in two different ways referred as "overall" when species were treated without distinction between vegetation strata and "detailed" when the three strata were distinguished. In the second case, a tree species could be recorded three times on a single sampling site.

Identification	Life-form					Total	%
	Trees	Shrubs	Ferns	Creepers	Herbs		
Species	30	27	18	20	27	122	72
Gender	0	1	0	5	15	21	12
Unidentified	30	28	11	18	37	100	
%	18	17	11	18	37	100	

Table 1: Identification level, life-form and species richness in the Welgevonden area.

	Woody	Ferns	Creepers	Herbs	Total
Welgevonden	58 *(35)*	10 *(11)*	30 *(18)*	62 *(37)*	168
Santa Lucia	47 *(54)*	11 *(14)*	13 *(15)*	16 *(18)*	87

Table 2: Composition of species richness across life-forms between the Welgevonden area (this work) and the the Santa Lucia lake area (Kwazulu-Natal). In brackets: proportion of total.

3.3 Results

3.3.1 Species identity and status

One hundred and sixty-eight species were sampled during the study (see Table 3 in appendix). Among these, twenty-one species (12%) were identified were identified at gender level and 25 (15%) were unidentified. On average, thirty nine species were present per sampling site. I characterized species status in the forest, either common or scarce, by an index of scarcity defined as the proportion of sites where a particular species occurred and, for woody species, a mean abundance defined by the number of individuals by hectare. No distinction in vegetation strata was used for this characterization.

3.3.2 Life forms

Trees and shrubs were the most common life forms and represented 35% of the species as compared to 54% in the Santa Lucia Lake area (Tables 1 and 2). Ferns and creepers represented almost the same proportions in both areas. In the Welgevonden area, remarkable species included *Cyatea dregei*, a tree fern usually rather uncommon under forest cover, and Acliantum philipense which was recorded for the first time in South Africa (J. Burrows, pers. com.). On the other hand, herb species were more abundant in the Welgevonden area than in the Santa Lucia lake area.

3.3.3 Overstorey composition and diameter distribution

Thirty species were recorded in the canopy layer. Among these, nine species accounted for 90% of all individuals present in this stratum (Fig.2.a) and eight species had individuals over 60 cm DBH (Fig.2.c). The forest overstorey was largely dominated by Waterberries (*Syzygium cordatum*) which represented 39% of all tree records and 45% for trees with DBH over 60 cm. Four other species were also abundant in this stratum but at lower densities (*Anthocleista gradiflora, Breonardia microcephala, Ficus sur* and *Bridelia micrantha*, Fig.2).

Diameter distributions are presented in annex 3. Tree numbers reflected differential densities and the large dominance of *Syzygium cordatum*. The biggest trees were recorded for *Breonardia microcephala* which tended to be concentrated on the banks of the main stream of the area where flooding is the most frequent. Diameter distribution of a given species somehow indicates local intraspecific dynamics. On one hand, high numbers in low diameter classes indicates effective recruitment and regeneration of the species. This feature was evidence in the case of *Syzygium cordatum* and to a lower extent for *Ficus sur*. On another hand, low values in those classes compared to intermediate and high diameter classes tend to indicate poor regeneration and thus an aging population. This trend was visible for *Breonardia microcephala, Bridelia micrantha, Masea lanceolata, Anthocleista grandiflora* and *Erythrina lysistemon*. However, for the last three species, this trend may be a sampling effect because of low densities.

3.3.4 Ordination analyses

Results for ordination analyses are displayed in figures 4 et5. Labels are shown for the best discriminated species with scores greater than 1 or lower than -1. Numbers correspond to sites in sampling order: low numbers correspond to downstream sites. For each analysis, the first three axes are presented, depending on whether species are treated in either one or three strata.

Species ordination

Overall analysis: The total inertia of the analysis, *i.e.* the variability in species and sites ordination, was 2.48. On the whole, the analysis detected continuous associations rather than particular species assemblages at a community level (Fig.4). Yet, at a more detailed scale, some associations may occur. For instance, it seems that the two species *Arthropteris monocarpa* and *Rumex sagitatia* (*A.mo.(f)* and *R.sa.(c)* on Fig.4) occur at similar locations and therefore may have the same ecological requirements.

Detailed analysis: In this case, the total inertia was 2.96. The comments of the overall analysis also apply to this analysis. The distinction between three layers allow to distinguish between life-stages for trees. For instance, the species *Apodytes dimidiata* had different scores in the shrub and the tree layers (*A.di.(sh)* and *A.di.* on Fig.5), which may indicate different requirements between the two life-stages and particular establishment conditions for this species.

Species response to qualitative variables CCA allows linking between observed patterns in the CA analysis and environmental variables. In the analysis, variables can be represented by vectors whose directions indicate with which axes they are more related whereas their lengths indicate the level of correlation. Therefore, correlations between variables can also be observed graphically. The amount of explained variability in the floristic composition is given by the ratio $\frac{Inertia_{CCA}}{Inertia_{CA}}$. In our case, chosen environmental variables 19.7% of the total variability in the overall analysis and 18.4% in the detailed analysis, the first axis accounting for respectively 52% and 48% of these quantities.

Overall analysis: Axis 1 was correlated with the variable *distance* (Fig.5). This result was in agreement with the fact that regarding sampling sites, low numbers (downstream sites) had low scores on the first axis whereas high numbers (upstream sites) had high scores. Therefore, the first gradient observed in species composition related well with a downstream-upstream location. In the CA analysis, species were organized following a gradient that corresponded to axis 1 (Fig.4). The variability of species scores changed on other axes: low scores on the first axis correspond to little variability of scores on axis and high variability on axis 3. This trend was reversed for high scores on the first axis.

The variable "water" was equally correlated with axes 1 and 2 and also negatively correlated with the variable "distance" indicating that the most flooded conditions occurred downstream. The variable "river" was correlated with axis 2, with high scores corresponding to sites near the main river stream) and discriminated the sites numebered 3, 7, 8 and 9 from the others. The variable "perturbation" had low influence on observed patterns and was more related with axis 3. Species composition seemed rather insensitive to the type and intensity of the disturbance being characterized.

Those relationships allow to assess ecological requirements for particular groups of species. Hence, among ferns, a group of species seemed to occur in conditions of high waterlogging (*Lunathyrium japonicum (L.ja.(f)), Cyathea dregei (C.dr.(f))* and *Arthropteris monocarpa (A.mo.(f))*), whereas *Polypodium polypodioides (P.pl.(f)), Pleopettis macrocarpa (P.ma.(f))* and *Asplenium aethiopicum (A.ae.(f))* occurred in drier conditions.

Detailed analysis: The relationships described for the overall analysis could also be observed in a more detailed fashion (Fig.5). In this case, the variable "perturbation" had a higher weight in the construction of the axis 3 (the associated vector was longer than in the *overall* case). This higher influence of the variable derived from the inclusion of different life-stages of tree species in the analysis. Therefore, it seemed that some species showed more sensibility than others at particular life-stages. For instance, the position of *Halleria lucida* was opposed to the variable "perturbation" in the shrub layer (*H.lu.(sh)*) and therefore may be particulary sensible to the type of disturbance identified.

4 Discussion – Conclusion

4.1 Conservative value of the swamp forest in the Welgevonden area

This survey of the upper part of the SRSC showed the relatively high diversity of species in the riverin vegetation compared to that occurring in the Santa Lucia lake area in a similar type of forest (Wessels, 1991). Species richness was particulary high regarding the numbers of herbaceous and fern species. On the opposite, the overstory composition was largely dominated by *Sysygium cordatum* and few other tree species. Moreover, the composition of the herbaceous layer may be unrelated to that of the overstorey (Sagers and Lyon, 1997). In the upper part of the SRSC which is mainly planted with forestry, the swamp forest also provides natural habitat to many animal species among which Vervet monkeys (*Cercopithecus aethiops*) and baboons (*Papio ursinus*), observed during the survey.

4.2 Species response to environmental variables

Conducted ordination analyses highlight the importance of the location on a downstream-upstream gradient on floristic composition. However, this variable is complex and may only summarise the effects of other possibly related variables, such as elevation slope, or substrate conditions occurring at lower scales. Waterlogging conditions are also important in the distribution of species as commonly regarded in the literature on riverine vegetation ( ). This emphasises the need for managing riverine vegetation in order to maintain sufficient flooding levels to sustain a diverse vegetation. Vegetation might then act as a buffer on flood regimes. On the another hand, species seem rather insensitive to human disturbance except when different layers are considered in the vegetation. Anyway, this kind of survey needs to be repeated, may be at a larger scale in order to provide reliability to this type of results.

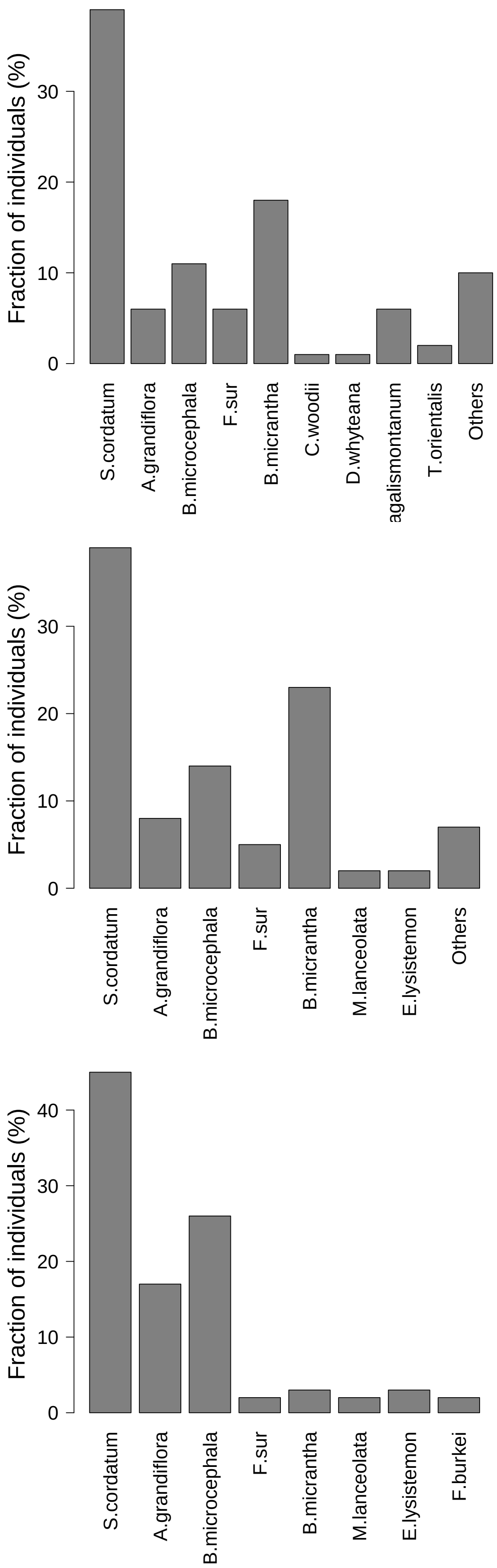
On the whole, chosen environmental variables explain only little amount of the observed floristic composition (around 19%). Some more variables could be tested such as the level of infestation by alien species, measured by the density and the nature of those species. Human disturbance could be addressed more accurately by distinguishing between different uses of natural resources. Lateral distance aside from a stream could also be tested although this is difficult when width of the forest is highly reduced or when runoff is diffused.

4.3 About this work

This work was conducted in collaboration with a governmental programme aiming on ecological and social grounds. *WfW* is unique worldwide and highly rewarded with regard to the work done on those different aspects This shows, if needed, that ecological and social issues can be assessed together quite successively, and also with less applied scientific aspects.

Acknowledgements

I would like to thank people who helped and were present during this work, all the people of the *Working For Water* program in White River (Mpumalanga), in particular Tony Poulter who made this project possible, and John Burrows and Mervyn Lotter from Lydenburg (Mpumalanga) who helped for botanical identification of vouchers.



a.

b.

c.

Figure 2: Species composition of the canopy layer. a. All trees included, b. Trees with DBH ≥20 cm, c. Trees with DBH ≥60 cm.

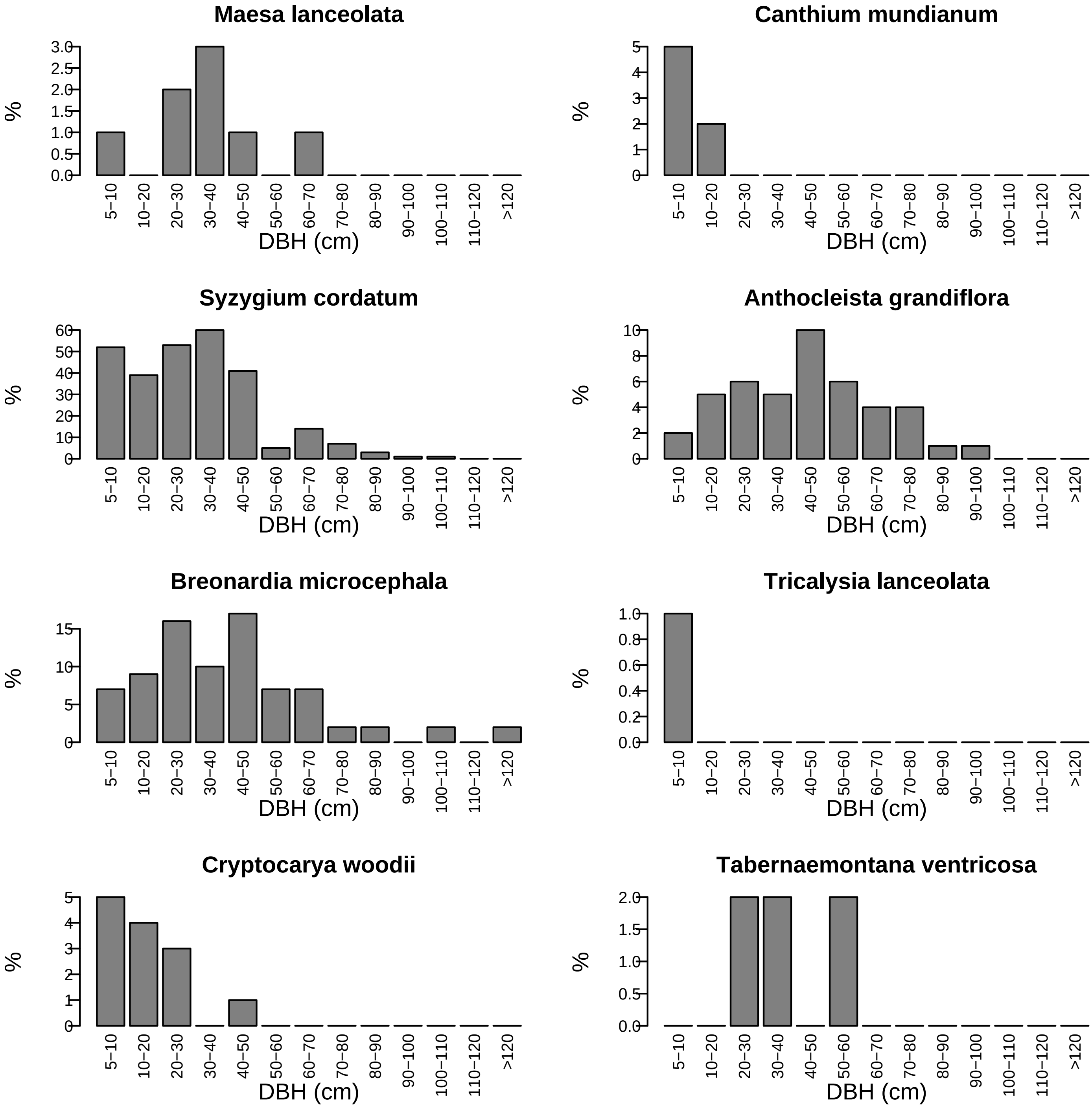


Figure 3: Diameter distribution of the most abondant species in the overstorey.b. Localization of the Sabie River Catchment (SRC).

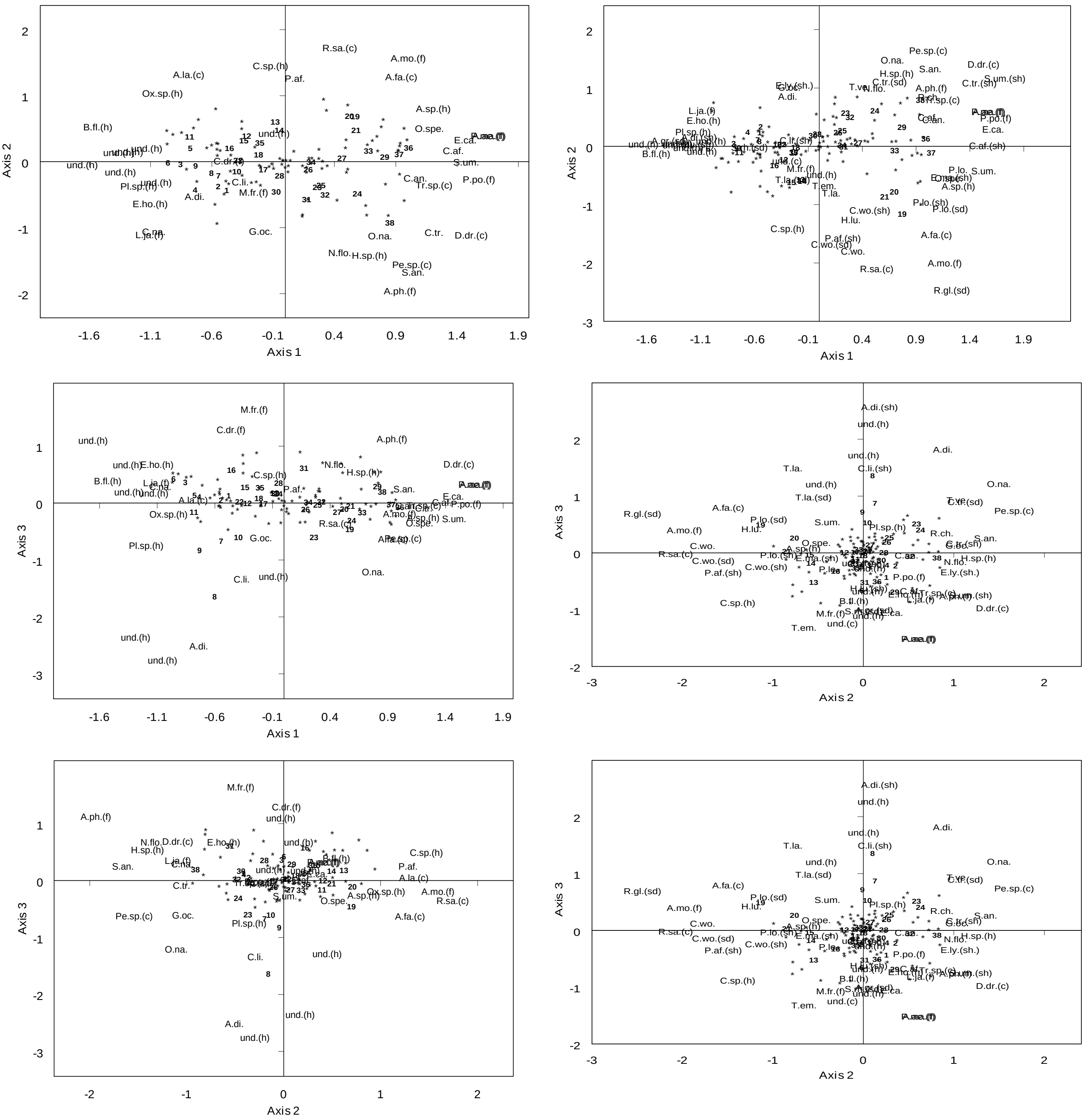


Figure 4: Factorial maps of Canonical Analysis (CA) on species presence – absence. **Left**: *overall* analysis without layer distinction. **Right**: *detailed* analysis of presence – absence in three vegetation strata. Numbers refer to sampling sites. Labels are initials of scientific names for species with scores higher than 1 on one axis. (sh) shrubs, (se) seedlings, (c) creepers, (f) ferns, (h) herbs.

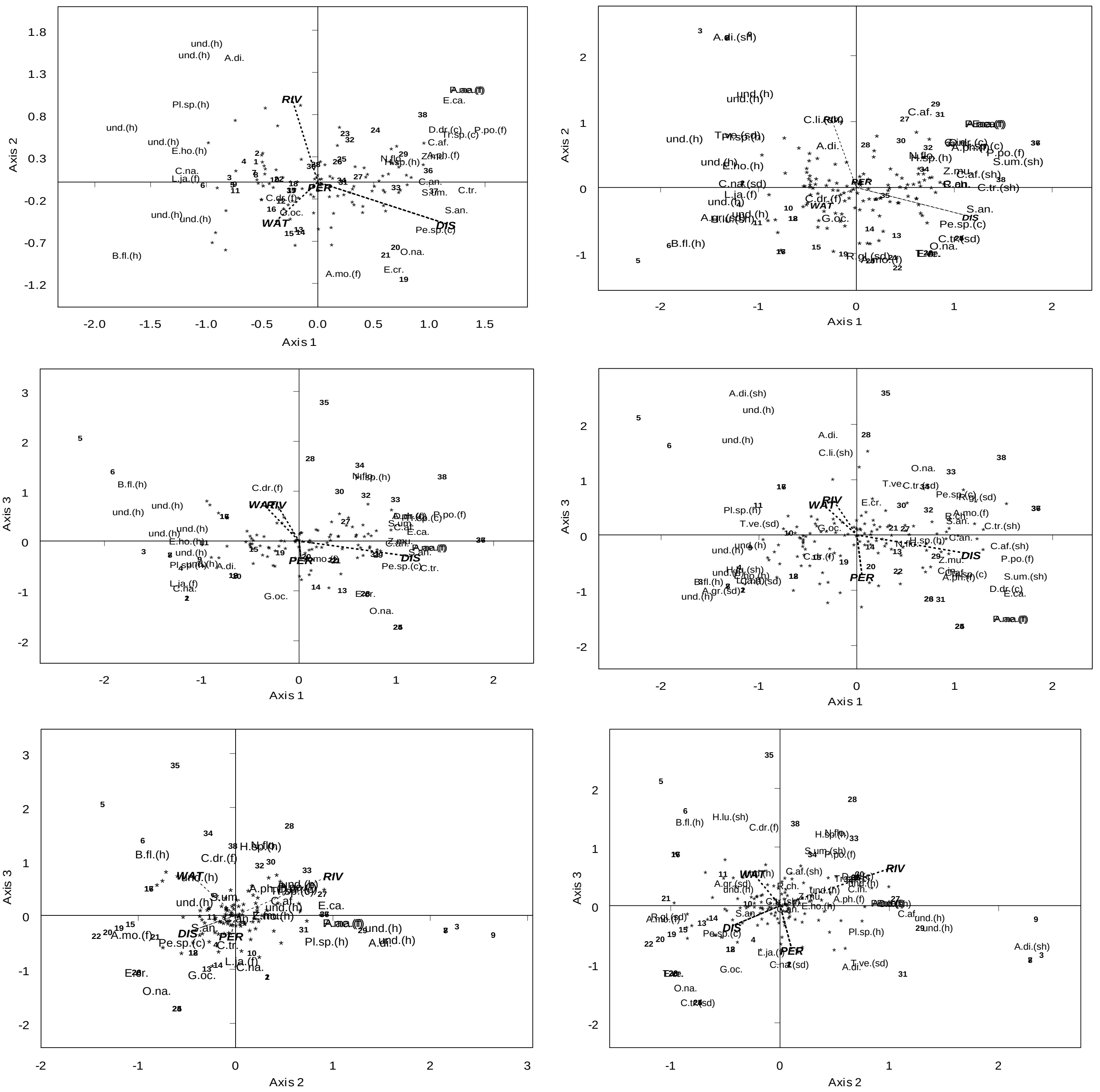


Figure 5: Factorial maps of Canonical Correspondance Analysis (CCA) on species presence – absence. **Left**: *overall* analysis without layer distinction. **Right**: *detailed* analysis of presence – absence in three vegetation strata. Variables are: ***WAT***, water, ***PER*, perturbation, *RIV*, river**. Numbers refer to sampling sites. Labels are initials of scientific names for species with scores higher than 1 on one axis. (sh) shrubs, (se) seedlings, (c) creepers, (f) ferns, (h) herbs.

References

Darveau, M., Labbé, P., Beauchesne, P., Bélanger, L., and Huot, J. (2001). The use of riparian forest strips by small mammals in a boreal balsam fir forest. *Forest ecology and Management*, 143(95-104).

De Lima, M. and Gascon, C. (1999). The conservation value of linear forest remnants in central amazonia. *Biological Conservation*, 91:241–247.

Gauch, H. (1982). *Multivariate analysis in community ecology*. Cambridge Studies In Ecology. Cambridge University Press.

Kingsford, R. (2000). Ecological impacts of dams, water diversions and river management on floodplains wetlands in australia. *Austral Ecology*, 25:109–127.

Myers, N., Mittermeier, R., Mittermeier, C., da Fonseca, G., and Kent, J. (2000). Biodiversity hotspots for conservation priorities. *Nature*, 403:853–858.

Richter, B. and Richter, H. (2000). Prescibing flood regimes to sustain riparian ecosystems along meandering rivers. *Conservation Biology*, 14(5):1467–1478.

Sagers, C. and Lyon, J. (1997). Gradient analysis in a riparian landscape: contrasts among forest layers. *Forest ecology and Management*, 96:13–26.

Wessels, N. (1991). The syntaxonomy and synecology of swamp forests in the lake st lucia area. Technical report, Department of Water Affairs and Forestry (South Africa).

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Appendix

Table 3: Checklist of sampled species in the Welgevonden area with names and status. Scarcity: number of sites where the species occurs over total. Abundance: mean abundance over sampling sites.

Scientific name	Family	Common name	Scarcity	Abundance
Trees and shrubs				
Anacardium occidentale	Anacardiaceae		0.03	1
Anthocleista grandiflora	Loganiaceae	Forest fever tree	0.66	49
Apodytes dimidiata	Icacinaceae	White pear	0.11	4
Argyrolobium tomentosum	Fabaceae		0.18	25
Brachylaena transvaalensis	Compositae	Wild silver oak	0.03	5
Breonardia microcephala	Rubiaceae	Matumi	0.61	72
Bridelia micrantha	Euphorbiaceae	Mitserie	0.95	107
Canthium inerme	Rubiaceae	Turkey-berry	0.18	14
Canthium mundianum	Rubiaceae		0.24	28
Celtis africana	Ulmaceae	White stinkwood	0.18	17
Cephalanthus natalensis	Rubiaceae	Tree strawberry	0.03	1
Citrus limon	Rutaceae	Lemon tree	0.16	22
Clausena anisata	Rutaceae	Horsewood	0.29	14
Combretum krausii	Combretaceae	Forest bushwillow	0.21	11
Cryptocarya transvaalensis	Lauraceae		0.08	5
Cryptocarya woodii	Lauraceae	Cape laurel	0.29	38
Dracaena aletriformis	Agavaceae		0.03	1
Dyospyros whyteana	Ebenaceae	Bladder-nut	0.82	325
Ekebergia capensis	Meliaceae	Cape ash	0.08	3
Englerophytum magalismontanum			0.32	42
Erythrina lysistemon	Papilionoideae	common coral tree	0.16	10
Euclea crispa	Ebenaceae	Blue guarri	0.05	2
Ficus burkei	Moraceae	Common wild fig	0.08	7
Ficus sur	Moraceae		0.61	45
Grewia occidentalis	Tiliaceae	Cross-berry	0.05	1
Halleria lucida	Scrophulariaceae	Tree-fuchsia	0.16	9
Heteropyxis natalensis	Myrtaceae	Lavender tree	0.03	1
Keetia guenzii			0.58	54
Kiggelaria africana	Flacourticeae	Wild peach	0.03	1
Maesa lanceolata	Myrsinaceae	Maesa	0.58	94
Maytenus undata	Celastraceae	Kokoboom	0.03	1
Monanthotaxis caffra	Annonaceae	Dwaba-berry	0.03	6
Nuxia floribunda	Loganiaceae	Forest nuxia	0.08	5
Ochna natalita	Ochnaceae	Natal plane	0.05	3
Oxyanthus speciosus	Rubiaceae	Wild loquat	0.13	7
Pavetta gardeniifolia	Rubiaceae	Common bride's bush	0.21	13
Peddiea africana			0.11	17
Prothorus longifolia	Anacardiaceae	Red beech	0.26	18
Psycothria capensis	Rubiaceae	Cream psychotria	0.03	1
Rhus chirindensis	Anacardiaceae	Bostaaibos	0.18	6
Rhus pyroides	Anacardiaceae	Common taaibos	0.11	4
Rothmannia globosa	Rubiaceae		0.18	38
Rubus sp.	Rubiaceae		0.03	1
Sapium ellipticum	Euphorbiaceae	Jumping seed tree	0.13	5
Schfflera umbellifera	Araliaceae	Bastard cabbage tree	0.08	6
Sida rhombifolia			0.50	51
Solanum anguivii	Solanaceae		0.05	1
Solanum panduriforme	Solanaceae		0.13	13
Syzygium cordatum	Myrtaceae	Water berry	0.92	289
Tabernaemontana ventricosa	Apocynaceae	Forest toad tree	0.42	28
Toddalia asiatica			0.39	16

Table 3: *(continued)*

Trema orientalis	Ulmaceae	Pigeonwood	0.08	3
Tricalysia lanceolata	Rubiaceae	Rock alder	0.66	76
Trichilia emetica	Meliaceae	Natal mahogany	0.03	1
Trimeria grandiflolia	Flacourtiaceae	Mulberry-leaf trimeria	0.08	5
Zanthoxylum davyi	Rutaceae	Knobwood	0.03	1
Ziziphus mucronata	Rhamnaceae	Buffalo-thorn	0.18	11
Ferns				
Acliantum philippense			0.11	
Anemia dregeana			0.05	
Arthropteris monocarpa			0.05	
Asplenium aetheiopicum			0.05	
Cheilanthes viridis var. macrophylla			0.66	
Cyatea dregei			0.05	
Diplazium zanzibarum			0.08	
Doryopteris concolor			0.03	
Lunathyrium japonicum			0.05	
Marattia fraxinea var. salicifolia			0.05	
Microlepia speluncae			0.26	
Pleopettis macrocarpa			0.05	
Polypodium polypodioides			0.55	
Pteridium aquilinum			0.18	
Pteris friesii			0.03	
Thelypteris confluens			0.03	
Thelypteris dentata var. buchananii			0.55	
Thelypteris interrupta			0.68	
Creepers				
Abrus laevigatus			0.05	
Acacia ataxacantha			0.32	
Asparagus falcatus			0.08	
Cissampelos torulosa			0.66	
Cyphostema sp.			0.03	
Dalbergia armata			0.32	
Desmodium repandum			0.03	
Diosorea dregeani			0.05	
Domatia villosa			0.03	
Hibiscus calyphyllus			0.34	
Mikania spicata			0.32	
Momordica sp.			0.11	
Peniplocoea sp.			0.08	
Rhoicissus rhomboides			0.08	
Rhoicissus tomentosa			0.45	
Rhynchosia caciber			0.18	
Rhynchosia caribia			0.03	
Rumex sagitatia			0.05	
Secanoni sp.			0.18	
Smilax anceps			0.68	
Stephania abyssinica			0.24	
Tragia sp.			0.05	
Herbs				
Ageratum houstonianum			0.21	
Alocasia sp.			0.03	
Asclepia fructicosa			0.03	
Asparagus sp.			0.16	
Bideus pilosa			0.03	
Bradypodium flexum			0.08	
Carex pseudoleptocladum			0.13	
Centella sp.			0.05	

Table 3: *(continued)*

Commelia africana	0.61
Commelia benghualensis	0.66
Cyathula cylindrica	0.76
Desmodum repandum	0.92
Dissotis canescens	0.03
Equisetum ramosissimum	0.13
Eulophia horsfallii	0.16
Gallium sp.	0.18
Helichrysum sp.	0.03
Hemizgia sp.	0.03
Hibiscus sp.	0.08
Impatiens sylvicola	0.47
Justicia sp.	0.87
Kalanchoe rotundifolia	0.03
Oplismenus sp.	0.95
Orchidacea sp.	0.03
Oxalis sp.	0.05
Pennisetum clandestinum	0.03
Persicaria puchrum	0.29
Phragmites mauritianus	0.16
Plectranthus fructicosus	0.55
Plectranthus laxiflorus	0.76
Plectranthus sp.	0.13
Plectranthus verticillaris	0.32
Richardsia sp.	0.03
Selaginela mittenii	0.50
Senecio pandaniforme	0.03
Senecio polyanthemoides	0.29
Senecio sp.	0.68
Setaria megaphylla	0.71
Solanum nigrum	0.21
Triumphetta sp.	0.37
Verbena brasiliensis	0.05
Xanthium strumarium	0.03