# CHAPTER 8

# DISCUSSION

## 8.1 Introduction

This study adopted a broad approach in Vegetation Science. The viability of a proposed method to treat large vegetation data sets was tested upon the Mopaneveld vegetation in southern Africa. During the progress of the study, general limitations in the methodology and within vegetation science in southern Africa were identified. This discussion will therefore be of value to any scientist who attempts to treat large vegetation data sets, or to undertake a vegetation study in a relatively unexplored area such as the Mopaneveld in southern Africa.

Apart from the identification and discussion of limitations and general constraints, valuable ideas were born from the synthesis of the southern African Mopaneveld. These ideas are captured in the discussion of the results and are certainly of value to future research projects, not only in the vegetation science, but also in ecosystem dynamics.

Hence, this chapter comprises a discussion not only on the results of this study, but also on observations made during all different processes of the study.

## 8.2 Methodology

### 8.2.1 Introduction

It is important to note that this study was the first attempt to propose a method for the synthesis of a large data set of which all data were not fixed in syntaxa yet. The method was tested upon the Mopaneveld of southern Africa. Many limitations, already during the preparation of data for analysis, were identified. These limitations are discussed and possible alternatives in the methodology are stipulated.

### 8.2.2 Vegetation data surveying and capturing

The basic fundamentals of a sound phytosociological synthesis are adequate, comprehensive, comparable, uniform vegetation data. The very first step of this study was therefore to collect and collate vegetation data sets, which possibly could contribute to the synthesis of Mopaneveld vegetation in southern Africa. The criteria being used for data selection (Chapter 4) comprised minimum parameters for vegetation sampling for the purpose of vegetation classification, therefore stipulating basic needs for the identification of plant communities. Considering the wide distribution of Mopaneveld in southern Africa and the immense area of land occupied by this extensive vegetation type, it was unsatisfactory how little adequate vegetation data were available for a comprehensive phytosociological synthesis over the entire area. Du Plessis (2000) identified limitations in adequate vegetation data in the savannas of southern Africa (with special reference to the Mopaneveld) as a result of insufficient information being recorded during field surveys. The implementation of common standards for vegetation sampling in southern Africa was proposed in order to create a sound vegetation database for future reference.

Time restriction is a common constraint in any scientific study. The selection and capturing procedure was set to be finished before the end of 1998 for satisfactory progress in the study and to limit the project size. It was however hard to accumulate all existing vegetation data and relevant information within the time frame since data had to be collected from several different African countries. Constraints and delays in many attempts to capture vegetation data also caused difficulties in keeping within the time appointed for the pre-analysis phase of the study.

As a consequence of limited adequate vegetation data in the study area, every single data set that could contribute to the classification was considered for capturing. Many of the vegetation data sets which conformed to the requirements, were however only accessible in published format. Data of such studies had to be captured from the published Braun-Blanquet tables. Although the software package TURBOVEG (Hennekens 1996a) includes a valuable option to capture data directly from phytosociological tables, it remains a time-consuming process with a probability of parallax mistakes, especially when the phytosociological table was not subdivided into its larger vegetation units. After data capturing, the data had to be correlated with the hard copy. Data capturing from published tables eludes floristic detail because species that were downweighted during refinement are usually not printed for publication purposes or for submission to a dissertation, thesis or report. This floristic detail is however of lower significance for the phytosociological study although this floristic information might have been of great value in attempted future floristic studies. Furthermore, it may include data on the distribution of rare and endangered species.

Some data sets were accessible in CEP-format (e.g. the species names are summarised in 4-3 codes ACAC KAR for *Acacia karroo*). The corresponding species name had to be selected for the code, creating possible "misplacement" of species. Species had to be verified according to all the plant species listed by the author, which is a time-consuming process.

Data captured from the original field sheets were fairly compatible, except that a few species were not identified at the time of vegetation surveying. Those species had to be searched for in the published tables.

Many of the selected data sets comprised historical data (i.e. vegetation information being captured more than twenty years ago). These historical data sets were however of valuable contributions to the study. Due to the dynamic character of vegetation, one is not always comfortable in analysing historical data for present-day use. It is however evident that the complete picture remains stable to some extent.

Many vegetation studies conducted in southern African savannas include only species of the woody component for vegetation classification, which consequently limited the number of sound, total floristic vegetation data sets to be considered for the synthesis. In certain target areas for vegetation surveying, the only studies of contribution are those on which classification is based on satellite images. Since only the woody component could be stratified on the image, classification was based upon the woody component. Although these studies did not necessarily need to contain herbaceous surveying to conform to the objectives of the study, it would have been extremely valuable if all vegetation layers were included for classification. The description of these woody communities is of value, but a deductive method should be applied to the data to get significant results. An attempt was however made to relate communities, which were identified according to the classification of the woody component (referred to as woody communities), to the communities which were identified according to all vegetation layers. This attempt was paused due to time limitation and also due to uncertainties on the subjective method.

One of the limitations in capturing vegetation data was the general lack of available habitat data. The option in TURBOVEG to import habitat data in a database would have been of great contribution if habitat data were captured in electronic format by the author. Habitat information, if sufficient, therefore had to be summarised according to the descriptions of communities in the published format or in unpublished theses, dissertations and reports. This procedure was also time-consuming although of utmost importance for clear explanation of results.

Unpublished data lack substantial reference, which in turn constitute difficulties in terms of entering species names and habitat information. Published data should have been a prerequisite (an additional criterion for data selection), but being left with an unsatisfactory number of phytosociological data sets, unpublished data sets could not be ignored.

The above list of limitations regarding vegetation data in southern Africa is of significant motivation for the area to be targeted for future vegetation research. The southern African savannas, in particular the southern African Mopaneveld needs to be assessed in terms of vegetation classification.

### 8.2.3 The proposed method to classify large data sets

Unlike other attempts to treat large vegetation data sets, the pre-selected vegetation data were used in its raw form for phytosociological analysis.

The two-step method of Van der Maarel *et al.* (1987) and the prolonged three-step method of Bredenkamp and Bezuidenhout (1995) could not be applied to the data set due to insufficient information on the data itself. A new method for treating large vegetation data sets in the savannas of southern Africa was therefore proposed. The method followed basic procedures in the phytosociology, but still remained an immense task due to the extensive dimensions within the data set.

The proposed method failed in several ways for being the finest approach in which large data sets can be classified. However, the method was tested on a large vegetation data set and results were sufficient. New computer tools have evolved in the meanwhile, e.g. JUICE (Tichý 2001), which also address and evade common problems in treating large vegetation data sets.

#### 8.2.3.1 Notes on the limitations of the methodology

Strict criteria for data selection were initially thought to be appointed because unfaithful, unpublished data usually evoke uncertainties in the applicability of a method. For the purpose of this study, it would have been impossible to follow strict criteria since the study area was almost unexplored in terms of vegetation data sampling.

During the analysis of a large vegetation data set, information that seems to be of low significance in the holistic view of a system is usually being ignored while its contribution to vegetation knowledge of that system should not be denied. In a study area such as the southern African Mopaneveld where only a limited area has been sampled, omitting relevé data might result in the ignorance of samples probably representing an undersampled community. It is therefore suggested that the Mopaneveld is a too diverse and a too unexplored study area to omit relevé data from classification. Still it was thought necessary to exclude those relevés from the data for the sake of handling the large data set.
A synoptic table was constructed to facilitate refinement procedures (Step 8). The refined synoptic table was used to identify major vegetation units within the Mopaneveld. The synoptic table was however refined according to frequency values and not according to general abundance of plant species. After examining the DECORANA scatter diagram (Figure 19) it was however evident that, despite the identification of major units within Mopaneveld from frequency values, it could be supported by the distribution of types along environmental gradients.

The synoptic table containing 29 clusters and 1 465 species was reduced to 10 clusters and 329 species (Step 11) for easier reference to species composition within the identified major vegetation units of the southern African Mopaneveld. This step in the methodology seems to be subjective. A synthesis is however a subjective study since it is needed to philosophise on all information based upon objective classification results. No matter which method is used in a phytosociological synthesis, the outcome of the analysis does not present all facets of the input. It is therefore needed to summarise the outcome of a synthesis in such a way that it is representative of the input of information by several authors.

### 8.2.4 Concluding remarks on the methodology

- Time was a common constraint in the study due to the data collection attempts over a large study area and due to attempt to make all adequate data electronically accessible for analysis.
- The proposed method is complex, but at least stipulates many general limitations for future attempts in treating a large vegetation data set based on raw data material.
- Although at times subjective, the methodology is based upon information accumulated from objective classification results.

## 8.3 Can the dynamics of Mopaneveld vegetation be explained by non-equilibrial models?

In Chapter 7, a detailed discussion on the dynamics of the Mopaneveld is presented. This discussion basically concludes what is discussed in Chapter 7.

The attempt to separate azonal and intrazonal vegetation from the complete data set by applying TWINSPAN on a single division level resulted in speculations on the dynamics of Mopaneveld vegetation. After relevés representing azonal and intrazonal vegetation were removed from the data set, the single division revealed two major groups within zonal Mopaneveld. After clear examination of the results, it was evident that the separation was induced by frequency values of perennial climax grass species rather than being a geographically separation between arid Western Mopaneveld and semi-arid to moist Eastern Mopaneveld, or any other possible major Mopaneveld types.

In the Mopaneveld, and of course other semi-arid savannas as well, temporal **and** spatial shifts in dynamics have relevance. Temporal change in vegetation is obvious in any ecosystem (i.e. change in plant species composition over time although the outcome of species composition is not clear in non-equilibrial systems). Vegetation change can also be presented on a spatial scale.

The Mopaneveld of southern Africa is geographically widespread and certain plant communities within this extensive vegetation type are thought to be too isolated to be related to each other. The opposite is proved during the attempt to identify the vegetation types and major plant communities within Mopaneveld. The distribution of the *Enneapogon scoparius – Colophosphospermum mopane* vegetation type could not be related to a specific locality. Relevés from Namibian Mopaneveld as well as from the Eastern Mopaneveld represent the vegetation type. After investigating plant species composition and relevant habitat information for each relevé present in the vegetation type, it became evident that the relevés from the Eastern Mopaneveld were surveyed under extreme drought conditions. The drought event altered the herbaceous species composition to such an extent that it relates to species composition of arid Namibian Mopaneveld. The two ecosystems represent different states in vegetation change, with the relevés from the Eastern Mopaneveld representing a transition state after the drought event whereas relevés from Namibian Mopaneveld represent a climax (stable) state. These results indicate spatial shifts in vegetation composition and emphasises the need for holistic approaches in Vegetation Science.

Non-equilibrial (disequilibrium) models to explain vegetation dynamics were thought to be applicable to the dynamics of the Mopaneveld. Abiotic influences, especially rainfall events drive vegetation change of especially the herbaceous component. The woody component is more resistant to the stochastic rainfall events and therefore is suggested to follow a different dynamic pattern of vegetation change. Examples of vegetation dynamics studies following sustained drought conditions in the Mopaneveld, revealed that palatable, perennial grass species die back, while species such as *Stipagrostis uniplumis*, being a climax species in the arid regions, but a sub-climax in the eastern savannas, survive these extreme conditions. From this example it became evident that after an event, such as sustained drought, the herbaceous species composition change in such a way that it correspond to the species composition from a different ecosystem. Keeping in mind the polythetic divisive character of TWINSPAN, this species relation with other ecosystems supported the grouping of relevés which, according to locality should have been separated. It is therefore clear that some data from which results were obtained represent transition states of vegetation change. The state-and-transition model (Westoby *et al.* 1989) is thought to describe vegetation dynamics in Mopaneveld best.

Non-equilibrial models however cannot explain all systems within Mopaneveld. If a transect is considered through southern African savannas, from the desert in the West, to the East Coast it is speculated that a gradient of vegetation dynamics follow the transect line, with event-driven systems representing the western savannas, and stable state dynamics representing the eastern savannas. Considering the location of Mopaneveld along this transect it is furthermore suggested that, not only stochastic events drive system dynamics to non-equilibrial explanations for vegetation change, nor do stable states explain vegetation dynamics of the Mopaneveld. The Mopaneveld itself can be explained as a transition between non-equilibrial models and stable state models to explain vegetation change!

## 8.4 Synthesis of the southern African Mopaneveld

### 8.4.1 Evaluation of the study

Cole (1986) defined a satisfactory classification of savannas by giving three basic guidelines, which include the following:

1) it should accommodate vegetation types for which the term savanna is used
2) it should comprise different levels of ecological detail
3) it should be able to be presented on different mapping scales

The value of this synthesis was determined according to the above criteria. The following were concluded:

- Despite the limitations within the data and within the method, sufficient results were obtained from the attempt to conform to the guidelines for a savanna vegetation classification given by Cole (1986). Vegetation types within the southern African Mopaneveld could be derived from classification results (criterium 1).
- Unexpected results however evoked uncertainty, but could be explained sufficiently. It was of valuable experience that unexpected results could stimulate further research focus in the study area, e.g. the dynamics of the Mopaneveld. The study therefore comprised not only a presentation of results, but an explanation and understanding the system, hence comprising different levels of ecological detail (criterium 2).

- Although no attempt has been made during this synthesis to present the communities on different mapping scales (criterium 3), it would be possible to do so.

### 8.4.2 Small-scale versus large-scale vegetation studies

Vegetation classification according to the Zurich-Montpellier School is a relatively new concept in southern Africa. Since the introduction of the Braun-Blanquet (BB) approach to South Africa by Werger in 1972, the use of this method for phytosociological research was proven successful in several attempts to describe vegetation (e.g. Van der Meulen 1979; Van Rooyen *et al.* 1981a; Van Rooyen *et al.* 1981b; Van Rooyen *et al.* 1981c; Westfall *et al.* 1985; Bredenkamp & Theron 1990; Bredenkamp & Theron 1991; Bredenkamp *et al.* 1993; Coetzee 1983; Nel *et al.* 1993; Schmidt *et al.* 1993; Bredenkamp & Deutschländer 1994; Bredenkamp & Deutschländer 1995; Brown *et al.* 1995a; Brown *et al.* 1995b; Brown *et al.* 1996; Dekker & Van Rooyen 1995; Bezuidenhout 1996; Visser *et al.*). The application of the BB-method to vegetation classification is however limited in other African countries, which consequently limits the possibility to completely understand ecosystem functioning in southern Africa on a scale larger than the association. The need and the essential value of small-scale studies in southern Africa are not being denied, although it is suggested that vegetation scientists should attempt to assess vegetation on a scale larger than the association. This study therefore aimed to highlight the need for adequate vegetation studies in southern Africa in order to investigate vegetation on a broader scale.

*Why the need for vegetation studies on a regional scale?*

The whole of a system is worth more than the sum of its parts. Fragments of data cannot be analysed separately to produce a holistic view of a subject. The information captured within the data can however be analysed and interpreted, and even if analysis can be described as subjectivity of method, the holistic picture is likely to appear. The sum of all vegetation classifications within the Mopaneveld (if ever the complete area had been classified) would not represent the holistic picture of the vegetation within the Mopaneveld. It surely would represent only fractions of the truth! Local-scale studies do not attempt to understand the position of a particular plant community in time and space. Plant communities identified and defined from a local-scale study may "disappear" when data from a larger area are classified, while other communities, not previously recognised, become apparent. This is due to the lack of knowledge species composition and variability over its entire distribution range. This became apparent in this study, where relevés classified in a single community in previous studies are now allocated to different communities. This is exactly why earlier phytosociologists, e.g. Werger (1974) warned against compiling a formal syntaxonomy too early, before adequate data over larger areas were available.

**Key questions**:

- What about ecotone plant communities? In local-scale studies ecotone vegetation is being ignored already during stratification. Isn't it time that ecotone vegetation types deserve unique management status?
- Do we understand ecosystem dynamics if we only study vegetation as it is today? Phytosociological studies never need to explain ecosystem dynamics. Phytosociological synthesis on a regional scale however can depict vegetation changes if the data comprise amongst others, historical information. It is important to note that the classification and hence the description of plant communities should not regard the plant communities as being static. Plant communities are indeed dynamic entities, but the overall composition tends to be relatively stable.
- Vegetation mapping often depends on clarity on treating extensive vegetation information. Major mapping projects in southern Africa are however based on extrapolation of localised knowledge rather than classifying and synthesising extensive raw data material. Wouldn't borders in mapping units be clearer if units were identified by analysis rather than by extrapolation? Considering the vast number of relevés a mapping project is encountered with, no current numerical analysis can treat so many samples in an area of such high species diversity, e.g. South Africa.

Nature can produce complex structures even in simple situations, and can obey simple laws even in complex situations (Goldenfeld & Kadanoff 1999). From the above it becomes evident that we are living in a chaotic world. How can we understand complex systems if studies focus on the situation on a local-scale as it prevails today?

### 8.4.3 Discussion on Mopaneveld vegetation

One of the primary objectives of the study was to define all major vegetation types within Mopaneveld, southern Africa. Limitations in adequate Braun–Blanquet vegetation data in the African countries engendered a less detailed definition of Mopaneveld vegetation types. Major types along a climatic gradient from the eastern, semi-moist Zimbabwean Mopaneveld to the arid western Namibian Mopaneveld however, could easily be identified from the pre-selected data.

Despite the extensive distribution of the Mopaneveld along environmental extremes and their geographical discontinuity, the vegetation types are to some extent related to each other (Table 5). The relation between the first four vegetation types and the relation between vegetation types 6 and 7 can primarily be ascribed to similar geological parent material they occur on, and secondary to soil moisture availability (Madams 1990). Vegetation types 1, 2, 3 & 4 represent the Eastern Mopaneveld of less arid conditions in comparison to the semi-arid to arid Western Mopaneveld (vegetation types 6 & 7).

The *Digitaria milanjiana – Colophospermum mopane* vegetation type representing the southeastern part of Zimbabwean Mopaneveld is a distinct vegetation unit, although the Zimbabwean Mopaneveld is far more extensive than is presented in this study. Comprehensive vegetation studies in Zimbabwean Mopaneveld need to be included for a more detailed picture of the entire southern African Mopaneveld.

The *Croton megalobotrys – Colophospermum mopane* vegetation type is associated with large rivers of the Eastern Mopaneveld, showing no relation to the Western Mopaneveld. No adequate data of the vegetation along large rivers in the Western Mopaneveld were available at time of data acquisition. The Mopaneveld along large rivers in Namibia is restricted to the upper clayey soils where the rivers are deeply incised. Shallow rivers tend to dry out seasonally, which consequently gives *C. mopane* the ability to inhabit these dry, sandy washes. In the Cuvelai Delta, northern Namibia, isolated patches of Mopaneveld are often associated with upland islands within the broad sandy, calcareous shores. Although adequate vegetation data from the Cuvelai Delta contributed to the identification of vegetation types in the Western Mopaneveld, TWINSPAN did not separate those relevés as being representative of riverbank Mopaneveld. It is however envisaged that local-scale studies on the northern Namibian Mopaneveld will separate the discontinuous Mopaneveld patches within the Cuvelai Delta.

High frequency values of *C. mopane* in the *Croton megalobotrys – Colophospermum mopane* vegetation type were first thought to be controversial since *C. mopane* is known as a terrestrial species occupying dry soils. This vegetation type rather seems to represent an ecotone between upland Mopaneveld on clayey alluvium and deep alluvium adjacent to the watercourse.

The *Cissus cornifolia – Colophospermum mopane* vegetation type is more diverse in terms of plant communities than is presented in the results. Therefore, a separate analysis of this vegetation type was undertaken. A detailed discussion on the results appears in Chapter 6. Representing the Mopaneveld of the South African Lowveld, this vegetation type hosts at least four different major plant communities on different geological substrates. The general ecology of Mopaneveld vegetation (variation in plant communities on different geology, physiognomical variation and vegetation dynamics) can be well observed in the Kruger National Park, South Africa. The first identified vegetation type, the *Terminalia sericea – Colophospermum mopane* major plant community already evoked curiosity on the Lowveld Mopaneveld due to its sandy component – an unusual association with *Colophospermum mopane*. A detailed discussion on the *Terminalia sericea – Colophospermum mopane* major plant community as well as an explanation of its ecology is given in Chapter 6. Born from the synthesis of the South African Lowveld Mopaneveld it is suggested that ecotone plant communities such as the *Terminalia sericea - Colophospermum mopane* major plant community should be studied in more detail in future vegetation studies. Other plant communities where *Colophospermum mopane* occurs in lesser dominance with plant species adapted to deep sandy soils, include amongst others the *Combretum* woodland thicket on colluvium and sandstone in Zimbabwe (Timberlake *et al.* 1993) and the *Terminalia sericea* deciduous tree savanna on medium and low altitude (Wild & Barbosa 1967). In Botswana many *Colophospermum mopane* communities occur on aeolian Kalahari sand. The soil profile to which these communities are confined consists of a considerably shallow, but sandy A-horizon and a clayey B-horizon. It is thus speculated that where the basalt opens, aeolian sand filled up the soil profile, resulting in a patch of deep sand which species such as *Terminalia sericea, Lonchocarpus nelsii*, *Baphia massaiensis* etc. inhabits.

The *Ptycholobium contortum* – *Colophospermum mopane* vegetation type, which represents the Mopaneveld north of the Soutpansberg in South Africa is related to the *Cissus cornifolia* – *Colophospermum mopane* vegetation type of the South African Lowveld Mopaneveld. This vegetation type also represents the most arid conditions of Mopaneveld in South Africa, explaining its strong relation to the Western Mopaneveld. Despite strong relations with other vegetation types, this type hosts a more diverse floristic composition, especially in the woody component. A detailed local-scale study on the vegetation and flora of the area north of the Soutpansberg is envisaged to emphasise its conservation value.

The *Enneapogon scoparius* – *Colophospermum mopane* vegetation type represents seral communities within the Mopaneveld. No specific location could be determined for this vegetation type. After a literature study on the vegetation dynamics of semi-arid savannas, it is suggested that this vegetation type represents transitions between stable states in the dynamics of the Mopaneveld. These transitions are temporal shifts in vegetation composition following an event. The event by which vegetation change was driven, is probably sustained drought conditions in the separate relevés representing this vegetation type. The identification of a seral vegetation type provides substantial motivation for vegetation dynamics studies in the southern African Mopaneveld. Being a seral vegetation unit, it may be questioned whether the *Enneapogon scoparius* – *Colophospermum mopane* carry sufficient value to be treated as a vegetation type on its own. On a scale as large as the southern African Mopaneveld, it certainly would be valued as a vegetation type since it is likely to occur over any time period, although it might not always follow the same spatial variation.

The Western Mopaneveld is represented by the *Boscia foetida* – *Colophospermum mopane* vegetation type and the *Bauhinia petersiana* – *Colophospermum mopane* vegetation type. The former is generally associated with shallow gravel or calcrete tolerating harsh environmental conditions, whereas the latter is commonly found on aeolian Kalahari sand. These two vegetation types are strongly associated with each other despite their difference in habitat preferences. Their relation could possibly be ascribed to similar climate conditions which is in general low rainfall or low soil moisture availability. Other than the *Asparagus nelsii* – *Colophospermum mopane* major plant community (6.2), the *Lonchocarpus nelsii* – *Colophospermum mopane* major plant community (7.1) shows affinity to the Eastern

Mopaneveld and to the *Boscia foetida* – *Colophospermum mopane* vegetation type. The environmental conditions of the *Asparagus nelsii* – *Colophospermum mopane* major plant community are different from any other vegetation type or major plant community. Although it represents the moister north-eastern Namibian Mopaneveld, moisture conditions are still low and erratic, which probably relate it to the *Lonchocarpus nelsii* – *Colophospermum mopane* major plant community. The combination of deep, sandy soils and limited moisture conditions on which the *Asparagus nelsii* – *Colophospermum mopane* major plant communty occurs, prevent this community from being highly related to the Eastern Mopaneveld. Although moisture limitations are much more significant in the *Lonchocarpus nelsii* – *Colophospermum mopane* major plant community than in the Eastern Mopaneveld, similarities in soil conditions might relate these communities to each other.

### 8.4.4 The South African Lowveld Mopaneveld

The synthesis of the South African Lowveld Mopaneveld (SALM) also follows a holistic approach. The vegetation data from the SALM (e.g. Gertenbach 1976; Van Rooyen 1978; Gertenbach 1987; Purchase 1997; Swart 1998) that contributed to the identification of the *Cissus cornifolia* - *Colophospermum mopane* were stored in a separate working directory in MEGATAB as a raw data matrix. The identification of major plant communities by the application of TWINSPAN came therefore independently from the results of the separate studies. It was expected that the synthesis of the raw data would confirm the existence of all plant communities which were previously described. Many of these plant communities could be identified from the synthesis, although the relevé composition within these plant communities often differed! Many relevés were not located within the same community as for the local-scale study. Extra plant communities were also identified by this procedure. These extra plant communities probably represent ecotonal plant communities or small, mosaic plant communities which were probably too small to be recognised as a separated vegetation unit during the local-scale studies.

This "misplacement" of relevés by TWINSPAN emphasises the need for a holistic approach in vegetation classification. The vegetation of the South African Lowveld Mopaneveld therefore does not represent the sum of all the plant communities that have been described earlier.

### 8.4.5 The need for floristic studies of the southern African Mopaneveld

The Mopaneveld is floristically far more extensive than presented in Table 5. Vegetation types represent broader units which usually represent variation in environmental conditions. Variation in environmental conditions constitutes different habitats occupying different plant communities of lower rank. Certain species are confined only to these plant communities (habitats), though will not have any influence on a synoptic table, as these communities are all consolidated into the single synrelevé. Such species of limited distribution often have very low frequency values and may not be included in the synoptic table. The vegetation types may therefore be floristically and environmentally much more diverse than indicated in the table and descriptions. A floristic analysis of the southern African Mopaneveld therefore needs attention in the nearby future.

Some key questions (and possible answers) on the floristics of the Mopaneveld evolved with the synthesis of the southern African Mopaneveld:

- What is the plant species diversity of the southern African Mopaneveld? Because *C. mopane* often totally dominates the woody layer and the herbaceous layer being sparse most of the year, the general feeling is that the diversity within this extensive vegetation type is low. Considering its distribution over an expanded area underlain by the different geological parent material, isn't its flora being eluded by Botanists?
- Is *Colophospermum mopane* the only woody savanna species that can tolerate such extreme environmental conditions? *Terminalia prunioides* is the only other woody species that occurs frequently in the Eastern Mopaneveld in mesic conditions and in the Western Mopaneveld often being recorded with *Welwitschia mirabilis*! *T. prunioides* can therefore probably withstand the same environmental conditions as *C. mopane*, although *C. mopane* probably will out-compete *T. prunioides* under stress conditions.
- Considering *C. mopane* and the miombo species *Julbernardia* and *Brachystegia*: are their some relation to their gregarious character and the family they belong to (Caesalpiniaceae)?

- What is the floristic relation between the *Terminalia sericea – Colophospermum mopane* major plant community in the South African Lowveld to the sand forests of northern Kwa-Zulu Natal? And what are their floristic relation to the Miombo in the adjacent north-eastern African countries?
- Which plant species are endemic to the Mopaneveld of southern Africa?
- Which plant species share endemicity with the above-mentioned sand forests?

It is envisaged that a detailed floristic analysis of the southern African Mopaneveld will provide answers to the above key questions.

## 8.5 Future research

Phytosociology is one of the major keys for understanding ecological processes. It is however not clear yet whether phytosociology is simply an independent collection of vegetation data to understand ecological systems on a local scale. From the synthesis of the southern African Mopaneveld the value of sound, adequate local-scale phytosociological studies were appreciated. These local-scale studies provide basic vegetation knowledge although the sum of various local-scale phytosociological studies will not provide in the understanding of the ecosystem as a whole. It is therefore suggested that local-scale phytosociological studies should be undertaken in all areas of Mopaneveld that are unexplored in terms of sound vegetation surveys. It is envisaged that such studies will contribute to a second, complete attempt to synthesise the vegetation of the southern African Mopaneveld. Furthermore it is of utmost importance that standards of vegetation surveying are set for future vegetation studies. Vegetation is a complex phenomenon that needs to be studied, not only to conform to the objectives of a specific study, but for future reference and use. It is therefore suggested that basic, minimum parameters for vegetation sampling should be identified for public domain. These minimum parameters should include detailed physical environmental information.

The southern African Mopaneveld is ecologically far more extensive than could be explored in this study. A detailed study on the physical environment of the southern African Mopaneveld was not included due to the enormous dimensions of the study. A proper study on the physical environment and possible relations between the physical environment and the vegetation is therefore suggested.

The dynamics of southern African savannas are currently under examination. Vegetation dynamics of the Mopaneveld in particular needs to be assessed in nearby future.

One of the most apparent shortages in a clear synthesis of the southern African Mopaneveld is the limitations in adequate vegetation data. Several vegetation data sets however could be of significant contribution to the knowledge of Mopaneveld vegetation, although these data sets usually include only information on the woody component. A deductive approach to incorporate this information in a database that could possibly be linked to the Mopaneveld database is suggested.

Research concerning specific and infraspecific diversity in the Mopaneveld is necessary to determine conservation priorities within this extensive vegetation type. The Convention on Biological Diversity states in its preamble that the contracting parties should recognise the dependence of local communities on biological resources (Geneva Executive Centre 1994). For future research to be holistic, the people inhabiting the southern African Mopaneveld and especially their traditional dependence on the vegetation of the region, should be taken into consideration. The recognition of the human component is relevant to the conservation and sustainable use of biodiversity (Siebert 1998).

To summarise suggested future research on Mopaneveld: studies should attempt to:

- fill all gaps in local-scale phytosociological research in southern African Mopaneveld;
- identify and set basic, minimum parameters for vegetation sampling in southern African savannas;
- examine the Sandveld areas of the South African Lowveld for representing a separate vegetation class;
- correlate the physical environment (specifically the geology and climate) of the southern African Mopaneveld to the distribution of vegetation types on a detailed scale;
- understand the vegetation dynamics of the Mopaneveld;

- correlate existing vegetation information which is based on the woody component with results obtained from the synthesis of the southern African Mopaneveld, and
- assess the specific and infraspecific plant diversity of the southern African Mopaneveld in order to prepare strong conservation priorities for the study area.

# CONCLUSIONS

The aims for this study were successfully achieved:

a) The gregarious character of *Colophospermum mopane* gives the impression of a relatively homogeneous area. Representing the strong climatic, edaphic and topographic heterogeneity within the Mopaneveld, seven vegetation types and six major plant communities were derived by phytosociological criteria. The following is a list of all plant communities at various hierarchical levels in the Mopaneveld of South Africa, southeastern Zimbabwe and Namibia:

- *Digitaria milanjiana* – *Colophospermum mopane* vegetation type
  - *Justicia flava* – *Colophospermum mopane* major plant community
  - *Setaria sphacelata* – *Colophospermum mopane* major plant community
- *Croton megalobotrys* – *Colophospermum mopane* vegetation type
- *Cissus cornifolia* – *Colophospermum mopane* vegetation type
- *Ptycholobium contortum* – *Colophospermum mopane* vegetation type
- *Enneapogon scoparius* – *Colophospermum mopane* vegetation type
- *Boscia foetida* – *Colophospermum mopane* vegetation type
  - *Eragrostis viscosa* – *Colophospermum mopane* major plant community
  - *Leucosphaera bainesii* – *Colophospermum mopane* major plant community
- *Bauhinia petersiana* – *Colophospermum mopane* vegetation type
  - *Lonchocarous nelsii* – *Colophospermum mopane* major plant community
  - *Asparagus nelsii* – *Colophospermum mopane* major plant community

b) Despite limitations in adequate vegetation data from the study area, these major vegetation units represent Mopaneveld vegetation along environmental gradients, which is apparent in the ordination results.

c) None of the previous methods to treat large vegetation data sets could be applied for the purpose of a synthesis of Mopaneveld vegetation, since many data sets were not fixed into associations yet. A new method to treat large vegetation data sets was therefore proposed. This method attempts to classify a large vegetation data set according to its basic component, the vegetation relevé. The data are therefore classified by using raw data material. Although not the ultimate approach in meta-analysis, the method was successfully applied to the data set. Results of this synthesis adequately revealed the identification of the above vegetation types and major plant communities within the Mopaneveld.

d) A separate synthesis was conducted on the South African Lowveld Mopaneveld, which was identified as the *Cissus cornifolia* – *Colophospermum mopane* vegetation type. Four distinct major plant communities were identified from TWINSPAN classification:

- *Terminalia sericea* – *Colophospermum mopane* major plant community
- *Acacia nigrescens* – *Colophospermum mopane* major plant community
- *Euclea divinorum* – *Colophospermum mopane* major plant community
- *Combretum apiculatum* – *Colophospermum mopane* major plant community

These syntaxa are related to the most dominant geological substrates of the South African Lowveld Mopaneveld, namely sandstone, gabbro, basalt, Ecca-shale, granite and gneiss.

Only the *Terminalia sericea* – *Colophospermum mopane* and the *Acacia nigrescens* – *Colophospermum mopane* major plant communities are described in this synthesis.

e) Furthermore, this study also provided a better understanding of the ecological processes within the Mopaneveld. From the first results obtained from the synthesis, it became evident that non-equilibrial models for vegetation change is most likely to describe the vegetation dynamics of the Mopaneveld. Further dynamic studies are however suggested for clarity on the speculations.

f) Literature studies on the Mopaneveld vegetation in southern Africa, along with classification results, contributed to the knowledge of this extensive vegetation type.

The hypotheses of this study were met by holistic views in the approach of the study. The knowledge gained from this study will contribute to a better understanding of the ecology of the Mopaneveld.