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CHAPTER 1

INTRODUCTION

Chapter Outline

Phytogeography, or the study of the geographic distribution of plants, can be divided into **descriptive** and **historic plant geography** (White 1970, 1971). The descriptive part of plant geography "...is concerned with devising adequate and useful classifications of biogeographical patterns based on known distributions of taxa within the geographical area of interest." (Birks 1987), while historic plant geography "...attempts to explain present-day distributions in terms of historic events..." (White 1971). McLaughlin (1994) refers to descriptive phytogeography as **floristic plant geography,** which he defines as that part of plant geography concerned with global, contemporary patterns in floristic assemblages.

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The two main concepts of floristic plant geography or descriptive phytogeography are **floristic areas** or **regions**, and **floristic elements** (for definitions see Myklestad & Birks 1993; McLaughlin 1994; *Key definitions*, this chapter; and *Numerical techniques*, Chapter 2). In **quantitative descriptive phytogeography** numerical techniques are used to detect patterns in the data in a more or less objective, repeatable way.

This study ventures beyond the descriptive phase of phytogeography by employing numerical techniques to identfiy gradients in the data which can be related to environmental variables. However, no attempt is made to relate patterns in the moss distribution data to historical events.

A. Twentieth Century Milestones in the Taxonomy of Southern African Bryophytes

A sound taxonomic basis is a prerequisite for any phytogeographic study. The taxonomy of tropical bryophytes has generally lagged behind that of the northern hemisphere (Touw 1974, Argent 1979, Richards 1984, O'Shea 1997). However, in contrast to most of Africa, considerable progress has been made in the taxonomy of southern African bryophytes (Buck & Thiers 1989, O'Shea 1997). The following publications stand out as 20th Century milestones in the taxonomy of the bryophytes.

Twentieth Century milestones: the taxonomy of southern African bryophytes.

1. Early checklists of: a) the bryophytes by Sim (1915), and b) the mosses by Wager (1917).

2. *The Bryophyta of South Africa*, the first bryophyte flora for the subcontinent, was published in 1926 by T.R Sim, who might be regarded as the 'father' of southern African bryology (Bayer 1971, Gunn & Codd 1981). This work was prepared in consultation with H.N. Dixon, the well known British bryologist.

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3. The *Hepaticae of South Africa* by S. Arnell (1963), a Swedish bryologist who also collected in South Africa (Martensson 1972), is a comprehensive account of the liverworts of the region.

4. Magill & Schelpe's *The bryophytes of southern Africa. An annotated checklist.* (Magill & Schelpe 1979) provided an up to date list of taxa, recent and selected synonymy, and literature references.

5. The moss *Flora of Southern Africa* is a modern taxonomic treatment of about 80% of mosses on the subcontinent. It currently consists of 3 fascicles: fascicle 1 (Sphagnaceae–Grimmiaceae) published in 1981 (Magill 1981), fascicle 2 (Gigaspermaceae–Bartramiaceae) published in 1987 (Magill 1987), and fascicle 3 (Erpodiaceae–Hookeriaceae) published in 1989 (Magill & Van Rooy 1989).

6. The PRECIS checklists, which started with the *List of species of southern African plants* by Gibbs Russell *et al.* (1984), followed by a second edition which included literature and synonyms (Gibbs Russell *et al.* 1985), and culminating in the *Plants of southern Africa: names and distribution*, which included species distributions by province (Perold 1993, Van Rooy 1993). Updates of these lists were published in *Bothalia* (Van Rooy 1986, 1988, 1989, 1990, 1991). The bryophyte component of these computer generated lists incorporated taxonomic and nomenclatural name changes since the Magill & Schelpe (1979) checklist.

7. The *Checklist of the mosses of sub-Saharan Africa* by O'Shea (1995) includes southern African mosses based on the latest PRECIS checklist (Van Rooy 1993) but incorporating new synonymy and records as well as distribution data.

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8. Wiggington & Grolle's *Catalogue of the Hepaticae and Anthocerotae of sub-Saharan Africa* (Wiggington & Grolle 1996), with extensive synonymy and selected literature references for each country, is largely based on the latest authoritative taxonomic revisions.

9. In *Taxonomic literature of southern African plants*, Perold (1997) and Van Rooy (1997) provide up to date lists of moss and liverwort families and genera as well as literature references most useful in the identification of southern African bryophytes.

10. The first fascicle of the Hepatophyta volume in the *Flora of Southern Africa* series, written by S.M. Perold (1999), has recently been published. It is a taxonomic treatment of the Subclass Marchantiidae of the Marchantiopsida (thallose liverworts).

In addition to the publications listed above there have been many taxonomic monographs, revisions, notes, reports of new taxa and new records, and other papers dealing with bryophytes which occur in southern Africa. Most of these have been cited by Magill & Schelpe (1979), Magill (1981, 1987), Perold (1997), Van Rooy (1997), Magill & Van Rooy (1989), and Perold (1999) while others are listed in Appendix I.

Despite all the taxonomic work on the bryophytes of southern Africa there has never been an analysis of the diversity, endemism or geographic distribution of this plant group. It was therefore decided to present such an analysis for my Ph.D. thesis. As the taxonomy and distributions of southern African mosses will certainly change in future the results obtained here are not definitive but merely a first approximation or an exploratory study of the distribution patterns within the FSA area.

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B. Aims and Objectives

1. The main objective of this study is to identify, classify and describe floristic regions and floristic elements within the *Flora of Southern Africa* (FSA) area by means of repeatable numerical techniques.

2. A secondary objective is to use an indirect gradient or ordination technique to produce hypotheses about possible environmental factors causing the observed gradients in the data.

3. This study also aims to explore how well numerical techniques most commonly used in ecology as well as phytogeography perform in identifying broad-scale patterns and gradients in the distribution data of southern African mosses.

4. Another important objective is to compare the bryogeographic classifications generated in this study, as well as hypotheses about the possible determinants of such patterns, with those proposed for vascular plants of the region.

5. The distributions (MOSS) database (see *Data Compilation* in Chapter 2) has made it possible to include the following objectives:

   - to enumerate diversity and endemism within the moss flora;
   - to identify and describe centres of moss diversity and endemism in the FSA area;
   - to compare these centres with those described for vascular plants;
   - to identify 'hot-spots' in the distribution of southern African mosses.

6. Basic phytogeographic information is increasingly regarded as the theoretical basis for the protection of the worlds plants (Takhtajan 1986; Birks 1987; Siegfried 1989; McLaughlin 1994; Cowling & Hilton-Taylor 1994, 1997). This study therefore aims to contribute to the conservation of southern Africa's rich biodiversity.

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7. It was also felt that a classification of bryogeographic regions of southern Africa would contribute towards a new bryogeographic classification of the world as proposed by Ochi (1973), Lewis (1990) and Schofield (1992).

C. Key Definitions

Inadequate definition and inconsistent use of phytogeographic terms have led to confusion in southern African phytogeography, as will be demonstrated in the chapters to follow. It is therefore very important to provide, right at the start, clear and precise definitions of some of the most important terms used in this study. White (1993), in a synopsis of his chorological work in Africa, explained his interpretation of many of the terms listed here and also referred to other literature on the subject.

1. Centre of diversity

A centre of diversity is an area with a high concentration of taxa (usually species) within the total geographic distribution of a particular flora. The size of the centre may vary from a ¼° grid square (or smaller) to a province, country or subcontinent, depending on the extent of the study.

2. Endemic

A taxon is endemic to a certain area or phytogeographic region when it is only known from that area or region. A southern African endemic, for example, only occurs in the FSA area. A **narrow endemic** is a taxon of very limited geographic distribution, e.g. restricted to particular degree grid square. It all depends on scale as the narrow endemic *Pseudoleskeopsis unilateralis* (Leskeaceae), only known from a single locality in the Dordrecht area of the Eastern Cape Province of South Africa, may also be regarded as endemic to South Africa, and endemic to Africa.

3. Centre of endemism

A centre of endemism is an area with a high concentration of taxa with limited geographic distributions (endemics). A centre of endemism is therefore a

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concentration of taxa (usually at the level of species) in the geographic distribution area of an endemic element, in this case the endemic element of the (moss) *Flora of Southern Africa* (FSA).

A clear distinction should be drawn between this centre of endemism and a phytogeographic region characterised by high endemism, the so called Regional centre of endemism of White (1976, 1983, 1993). Each phytogeographic region has its own endemics (sometimes absent), and might therefore be regarded as a centre of high or low endemism, whatever the case may be. However, unlike a true centre of endemism, a phytochorion such as a Region or Domain is not based on or delimited by endemics only, as sometimes advocated in the literature (White 1983, Linder 1990), but by all taxa in the region or, in other words, by the floristic composition of the area. It can therefore be misleading to include 'centre of endemism' in the name of a phytochorion as was done by White (1976, 1983, 1993), even if a definition of 'centre of endemism' has originally been provided by the author, as a name is often used out of its context. Centres of endemism have also been described within phytogeographic regions, e.g. the centres of endemism recognised within the 'Afrotemperate Region' by Linder (1990). These centres of endemism are determined by the endemic component or element of the flora of a particular floristic region.

Oliver *et al.* (1983) employed numerical techniques to delimit 6 floristic areas or regions within the 'Cape Floral Region'. Unfortunately they called these areas 'elements' and added to the confusion with their statement "On the whole, these centres agree with the centres defined by Weimarck (1941).", when the two are clearly not comparable. Likewise, Hilton-Taylor (1987) described subdivisions of the Karoo-Namib Region, "...below the domain level...", as centres of endemism. Under the same heading he refers to these 'phytogeographic centres' as areas. However, 'centre' is not a recognised category for a floristic area or region (White 1970, Takhtajan 1986, McLaughlin 1994) and has traditionally been applied to areas of high species concentrations within floristic elements (see *Phytogeographic element*).

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As mentioned in the previous paragraph, phytogeographic centres have usually been described within phytogeographic elements, e.g. the 'endem centres' described within the Cape element of Weimarck (1941). If a floristic element is based on endemic taxa only, as in the case of Weimarck (1941) then the centres within that element might be called 'centres of endemism'. However, in this case 'Cape centres of endemism' would probably have been a better name. These centres may or may not coincide with centres of endemism based on all southern African endemics or the endemic element of southern Africa.

A centre of narrow endemism is a concentration of endemics with very limited geographic distributions, for example species restricted to one ½° grid square.

To summarise, 3 kinds of centres are important in this study, and in phytogeography in general:

The phytogeographic centre. This centre represents a high concentration of species in the geographic distribution area of a **floristic element.**

The centre of diversity. A high concentration of species (or taxa of higher rank) in the geographic distribution area of a **flora** is called a centre of diversity.

The centre of endemism. This is a high concentration of species (endemics) in the geographic distribution area of the **endemic element** of a flora.

4. **Hot-spot**

Hot-spots are geographic areas where centres of diversity and centres of endemism overlap. These areas are frequently also centres of family and genus diversity, and centres of narrow endemism (see Rebelo 1994 and Chapter 3). My definition of hot-spots agrees largely with that of Myers (1990) except that the southern African moss hot-spots are not necessarily threatened by habitat modification and transformation.

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5. Phytogeographic (floristic) region

A group of grids (areas) of similar floristic composition. A phytogeographic region (floristic area) can also be described as a natural area with a characteristic flora (McLaughlin 1994). Phytogeographic regions or floristic areas can not overlap geographically but they may share a number of taxa. In phytogeographic regions it is the grids (relévés) or areas which are classified according to their floristic compositions. A phytogeographic region is therefore a geographic area. See also discussion of R- and Q-mode analysis under *Numerical Analysis*, Chapter 2.

6. Phytogeographic (floristic) element

A group of taxa of similar geographic distribution. The distributions of phytogeographic elements may overlap geographically but a taxon (usually species/infraspecific taxa) can only belong to one element. In the case of phytogeographic elements it is the taxa (species) which are classified according to their geographical distributions. A phytogeographic element is therefore a group of taxa (species). See also discussion of R- and Q-mode analysis under *Numerical Analysis*, Chapter 2.

In a phytogeographical analysis of the evergreen forests of Malawi, White (1970) has described a number of elements within his phytogeographic regions. Friis (1990) referred to these elements in a study of the distribution patterns of *Ficus* in tropical north-eastern Africa. It must be realised, however, that these elements described by White (1970) are not subdivisions of his phytogeographic regions and may only exist within a particular phytogeographic region.

Areas of high species concentration within the geographic distribution of floristic elements have traditionally been described as centres and subcentres (e.g. Weimarck 1941, Stuckenberg 1962). These centres or subcentres are not necessarily subdivisions of the elements (see *General Discussion and Conclusions*, Chapter 6).

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7. Phytochorion

A phytochorion is a phytogeographic (floristic) region or area of any rank. A chorion is therefore a geographic area.

D. Layout of the Thesis

The thesis is divided into two main parts: Part 1 comprising the main text, and Part 2 containing the tables, figures and appendices.

Part 1 can be subdivided into three section: 1) the first section consisting of a table of contents, and lists of tables and figures, 2) the core of the study comprising six chapters, each starting with an outline of the contents, and 3) the last section containing an English and Afrikaans summary, a list of literature references, acknowledgements, and a curriculum vitae. The introductory chapter (Chapter 1), which includes a list of Twentieth Century milestones in the taxonomy of southern African bryophytes, the aims and objectives of this study, as well as key definitions, is followed by a chapter on materials and methods of study. This chapter (Chapter 2) describes several aspects of the study area, the data sets, and the numerical techniques employed in the analysis of the moss distribution data. Chapter 3 starts with a short historical review of diversity and endemism studies in southern Africa, followed by an enumeration of moss diversity and endemism. This chapter also includes formal descriptions of moss centres of diversity and endemism as well as 'hot-spots' in the distribution of southern African mosses.

Both Chapters 4 an 5 start with historical reviews of the different phytogeographic classifications of southern Africa. Chapter 4 describes the numerical (TWINSPAN) classification of grid squares and provides a formal classification and description of the bryofloristic Regions and Domains of southern Africa. The chapter includes an analysis of the compositional gradients identified by the (DECORANA) ordination which leads to a hypothesis about the environmental factors causing the observed gradients in the data. Chapter 5 is concerned with the other main concept in floristic plant geography, i.e. floristic (bryogeographic) elements. The distribution patterns of mosses within the FSA

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area are formally classified and described as four bryofloristic Elements, subdivided into eight Subelements. As in the previous chapter, (distributional) gradients in the data are identified and correlated with environmental factors. The last chapter, Chapter 6, is a general discussion and summary of the main conclusions. It also highlights needs and prospects for future phytogeographic research in southern Africa.

In Part 2 of the thesis the tables and figures are followed by three appendices. Appendix 1 is a checklist of all southern African mosses included in the database. This list includes the latest synonymy and selected literature references. Appendix 2 lists the moss species/infraspecific taxa found in each of the bryofloristic Regions and Domains while Appendix 3 lists the species that make up each floristic Element and Subelement in southern Africa.