6. PHYTOGEOGRAPHY AND DIVERSITY

Phytogeographical or phytochorological units are usually based on the flora of the zonal habitats of a region. Unless the entire region consists predominantly of mountainous or other extreme features of topography or soil, the floral units characterised are found on the plains, reflecting the full effect of the regional climate on the vegetation (Jürgens 1991).

The evolution of present-day southern African plant communities started during the quaternary, when shifts in biomes were the result of large fluctuations in temperature, precipitation and seasonal distribution patterns of moisture, brought on by an uplifting of large tracts of the continent (Axelrod & Raven 1978, Scott *et al.* 1997). Fossil records indicate a strong cyclic change of vegetation patterns within the savanna biome, ranging from woodland savanna during warm interglacial phases to cool and open grassland with fynbos elements during glacial maxima. The semi-arid thornveld savanna probably evolved during the late Pleistocene to Holocene, with the contemporary savanna structure developing as recently as 1000 yr. BP (Scott *et al.* 1997).

Different authors provided a general characterisation or description for the study area, even though the information from which such description was derived is only based on observations or photographs; actual baseline surveys with quantitative information for the study area is extremely limited (Volk 1966b, Giess 1971, Werger 1978 quoting White, Troupin and Monod, Werger & Coetzee 1978, Huntley 1982, Gibbs Russel 1987, Jürgens 1991, Irish 1994, Rutherford & Westfall 1994, Strohbach 2001).

Volk (1966b) proposed a more accurate delineation of the Nama-Karoo and the Sudano-Zambezian floral region in Namibia, using distribution data of key species. Irish (1994), following the approach of Rutherford and Westfall (1994), subdivided the Namibian Flora into major biomes. According to his classification the study area falls entirely within the savanna biome, with phanerophytes and hemicryptophytes the dominant life form, corresponding with other general vegetation descriptions (see Huntley 1982, Rutherford and Westfall 1994, Rutherford 1997 and Scholes 1997). A typical diagnostic characteristic of the savanna biome is that hemicryptophytes within the biome are mostly comprised of the C_4 type of graminoids (Huntley 1982, Rutherford and Westfall 1994). Following Huntley (1982) and Scholes (1997), the savanna of the study area can be further described

as an arid, fine-leafed savanna, with most of the dominant trees having leaves of less than 1 cm^2 in surface area and also tending to be predominantly spinescent. Cowling and Hilton-Taylor (1997) have a somewhat different approach in dividing the savanna into the Zambezian Regions, which covers northern and north-eastern Namibia, while the remainder of the savanna is classified as the Kalahari-Highveld Transition Zone. They characterise this zone as consisting of residual Zambezian tree flora (mainly *Acacia* spp.), with an overall relatively low species diversity and few endemics. However, as Scholes (1997) rightly points out, any definition and delineation of savanna is to a large degree arbitrary, as savannas are a continuum of arid shrublands, lightly wooded grasslands, deciduous woodlands and dry forests.

The nature of the African savanna has been defined as being a seasonal ecosystem with a continuous herbaceous, usually graminaceous layer and a discontinuous layer of trees and/or shrubs, varying from sparse to 75% canopy cover (Edwards 1983, Frost *et al.* 1986, Rutherford & Westfall 1994, Scholes 1997). It is believed that local savannas owe their existence to the impact of fire and large herbivores rather than climate alone. Fires in this system are the result of seasonal water availability, which leads to an accumulation of dry, easily ignited fuels, which may potentially lead to annual (in moist savannas) or one in 10 years or more (in arid savannas) major fire events (Scholes 1997). Savanna plants in general are well adapted to withstanding fire, which is demonstrated by a mortality rate of often less than 10% after an "average" surface fire. Phanerophytes may experience top-kill during such a fire event, but will resprout from the base. Dominant life forms of savannas are equally well adapted to drought, although woody plants usually have a higher resistance than graminoids. High grazing pressure exerted on graminoids during drought usually leads to the weakening of this layer, creating favourable conditions for seedling emergence of the woody layer (Knoop and Walker 1985, Rutherford & Westfall 1994), but also leading to erosion which will affect the soil moisture balance (Walter & Volk 1954). Savannas thus overall are highly dynamic event-driven systems, in which temporal as well as spatial changes are caused in the short- and long term by changes in climate, e.g. poor vs. good rainy seasons, adding to the effects of soil nutrient content, fire regime and herbivory (Walker 1987, Skarpe 1992).

Westoby et al. (1989) described the state-and-transition model, which is highly applicable to savanna ecosystems: Transitions of a stable vegetation state occur as

a result of often long-term climatic conditions and accompanying management practices. Climatic circumstances can be either opportunistic or hazardous. Management practices should therefore adapt to a continuous state of non-equilibrium, taking advantage of opportunities and avoiding hazards (e.g. by timely de-stocking).

Giess (1971) in his "Preliminary Vegetation Map" of Namibia presented the most comprehensive vegetation classification for Namibia available up to date. According to his map (Figure 8), the study area stretches over the following vegetation types: Mountain Savanna and Karstveld, Thornbush Savanna (also referred to as Tree and Shrub Savanna) as well as bordering on Tree Savanna and Woodland (also referred to as Northern Kalahari). The majority of the study area falls within the Thornbush Savanna. Giess (1971) characterises this vegetation type as being dominated by *Acacia* species, of which *Acacia mellifera* ssp. *detinens* is the most prominent, leading to various degrees of bush encroachment. Further typical *Acacia* species here are *A. reficiens*, *A. hebeclada*, *A. erubescens*, *A. fleckii* and occasionally *A. tortilis* ssp. *heteracantha* and *A. erioloba*. *Boscia albitrunca* and *Ziziphus mucronata* are found throughout the vegetation type, although in relatively low densities. *Lonchocarpus nelsii* is common on the more sandy areas, while *Combretum apiculatum* may predominate on rocky outcrops or limestone.

The report on "Relatively Homogenous Farming Areas" (Dept. Agricultural Technical Services 1979) further divides the Thornbush Savanna from south to north into Okahandja Thornbush Savanna, Osire Sandveld, Etjo-Catchment Area, Otjiwarongo Thornbush Savanna, Otjenga Plains and the Namibian Maize Triangle. A vegetation description *per se* is not provided, rather a limited list of common shrubs and trees, or a list of edible/browsable shrubs and trees. More important, although not standardised, is a brief description of valuable grasses present in "original" veld, somewhat degraded "succession-state" veld as well as degraded veld. The report also occasionally indicates which areas are prone to degradation, and which are already extensively degraded - be it affected by bush encroachment or poor grazing remaining - all as observed in the 1970's. This report, despite being very basic, does enable some comparison between "what was" and "what is". Specific studies on such long-term dynamics are sparse, but show for example that in some areas valuable grasses such as *Brachiaria nigropedata* have entirely disappeared (Strohbach & Austermühle, in prep).

The Mountain Savanna and Karstveld, which occurs mostly in the northern regions of the study area, is relatively diverse, covering a largely mountainous region. The plains between the mountains are typically covered with shrubs and small trees such as *Combretum apiculatum*, *Dichrostachys cinerea* - which is the major bush encroacher in this area - as well as species of *Croton* and *Acacia*. The tree stratum of the plains and low rocky ridges consists of *Kirkia acuminata*, *Olea europaea* ssp. *africana*, *Sclerocarya birrea* ssp. *caffra* and *Peltophorum africanum*. *Combretum imberbe* is found on outcrops of recent surface limestone, in the study area usually in the form of dolomite. Sandveld patches support trees such as *Lonchocarpus nelsii*, *Terminalia sericea* and *Acacia* species. A species common throughout this vegetation type and also leading to bush encroachment is *Terminalia prunioides*. According to the Giess (1971) map, this vegetation borders on the northern fringes of the study area. As some of the defined Homogenous Farming Areas in the Otavi-Region overlap both Thornbush Savanna and Karstveld, it has been expected from the onset that a transition zone of Karstveld into Thornbush Savanna may occur throughout the northern half of the study area, roughly from around Otjiwarongo.

The Thornbush Savanna of northeastern regions of the study area merges into the Northern Kalahari, which in itself is a very complex vegetation type. According to Giess (1971) the southern parts of this vegetation type are characterised as open savanna with *Combretum imberbe*, *Acacia mellifera* ssp. *detinens*, *Peltophorum africanum*, *Lonchocarpus nelsii*, *Acacia reficiens*, *Combretum apiculatum*, *Tarchonanthus camphoratus*, *Ziziphus mucronata*, *Catophractes alexandri* and *Combretum hereroense*.

An interesting observation made by Irish (1994) is that small outliers of Nama-Karoo are found within the Savanna Biome. He defines these outliers as being dominated by *Catophractes alexandri*, and regards such areas as "marginal savanna". Although Irish (1994) did not list such outliers within the study area, on a first glance such patches of *Catophractes*-dominated vegetation occasionally do occur.

A factor limiting the characterisation and description of the majority of vegetation types of and their delineation within Namibia is that they have been derived from isolated case studies, very basic field observations and photographs only (Burke and Strohbach 2000). The larger part of this categorisation, including the study area, remains to be substantiated with more quantitative field data.

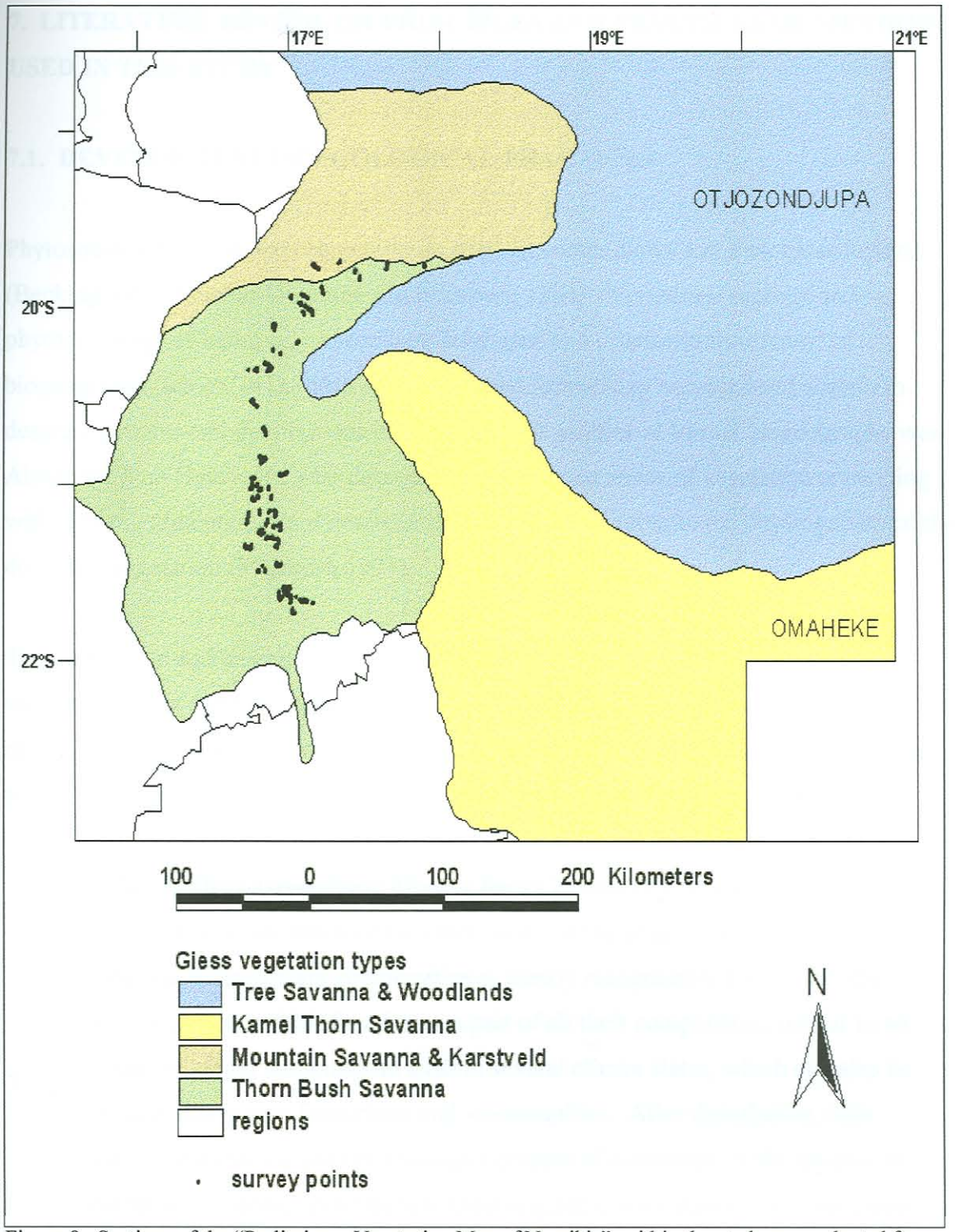

Figure 8: Sections of the "Preliminary Vegetation Map of Namibia" within the study area, adapted from Giess (1971).