8. METHODS

8.1 PHYTOSOCIOLOGICAL METHODS

A judicious selection of scale is an important aspect when initiating vegetation surveys. All studies are limited by time and finances available, thus an approximate minimum amount of relevés necessary to be sampled to reach the objectives of the study should be set *a priori*. Guidelines for scale-related sampling intensity have been proposed by Westfall *et al*. (1996) who recommend using a stand, i.e. a circular area with radius equal to stand denominator to account for the scale when sampling. Further, a minimum of four stands should be sampled to adequately characterise a plant community (Westfall *et al*. 1996). For the initial map scale of 1:250 000 used in this study, a stand would have a 500 m diameter, which is too big to be practical in the thornbush-savanna. To deal with this, a series of at least 4-6 subplots or relevés were sampled (with equal distance from each other) within a landscape type, following the guidelines of Strohbach (2001) for the Namibian Vegetation Mapping Program.

A reconnaissance trip was undertaken throughout the study area in early April 2001, during the peak rainy season, when especially herbs and lower shrubs were in flower and could be collected for positive identification. At this time, only notes were taken on major vegetation structures and types encountered, and a priority-list of areas (commercial farms) to be investigated compiled.

For the purposes of the study, The German Remote Sensing Data Centre of the German Aerospace Centre (DLR) acquired satellite maps of LANDSAT-7-ETM for the study area. The study area was covered by images 178/74 and 178/75 (Numbers indicating Path and Row of the satellite), for May 2000 and again May 2002. From these images, a false-colour composite image of bands 4/5/3 (maps 1 and 2, Appendix 4) was used to refine the priority-list of the reconnaissance survey, ensuring that all major vegetation types occurring within the study area would be adequately sampled. It was estimated that a minimum of 250 - 300 sample sites should be sufficient to sample the vegetation types. Of course, once being in the field, this number rose as different variations of vegetation types were also regarded large enough to warrant a separate characterisation. In total, 425 relevés were recorded during the main growing seasons (Mid-February to Mid-May) of

2001 and 2002. A set of 42 relevés was added to the data set from the BIOTA Observatories situated on the farms Erichsfelde and Omatako-Ranch (Austermühle 2001) and forming part of the vegetation transect. Keeping with BIOTA sampling procedures and limited by time, sampling was strictly kept to the plains, occasional inselbergs within the study area were left out.

In accordance with the standardisation of methods for BIOTA as well as the Namibian Vegetation Survey, the size of relevés was pre-set at 1000 m^2, measuring 20 x 50 m. Samples were laid out in an W-E direction, unless where topography or other landscape features such as relatively narrow riverine vegetation made this impractical, to ensure the homogeneity of the sampling area. Bearing in mind the pixel size of the satellite imagery (30 x 30 m), relevés on narrow strips of distinct vegetation types were always placed in a manner to avoid going below this pixel size.

For every sampling site, a relevé with the following data was produced (see standard data sheet (Strohbach 2001) in Appendix 3):

- GPS reading, with the GPS set to the Schwarzeneck Map Datum. Additional information on locality includes region, district, farm- or locality name, and short description of sampling site.

- Habitat information including slope, terrain type, aspect, stone cover estimation, parent material (lithology) where visible, erosion severity, disturbances and surface sealing/crusting. Following the "Feel Method" (Figure 11) (Foth *et al.* 1980, Arbeitsgruppe Boden 1996), soil texture was determined.

- The NARIS database (AEZ 2001) was used to derive long-term mean annual rainfall and major soil types for each relevé. Similarly, geological substrata and formations were derived from the Geological Map of Namibia (Geological Survey 1980).

- Vegetation information recorded: a full list of species present. Unless geophytes could be positively identified, not much attention is given to them (following Strohbach 2001). Herbarium specimens with corresponding collection data were collected for all unknown species for subsequent identification at the National Botanical Research Institute in Windhoek.

- Each species was recorded according to height class, following Edwards (1983) together with major growth form - tree, shrub, grass, and herb. Cover abundance for species in every height class was estimated using crown cover, recorded as actual percentage cover. For the purpose of developing skills in estimating crown cover, the Plant Number Scale methodology of Westfall & Panagos (1988) was used initially, and was also compared to estimates of co-workers of BIOTA whenever possible.

- Each sampled relevé was photographed to document landscape as well as vegetation structure at the time of survey.

The TURBOVEG PC package (Hennekens 2000) was used for data entry. The Megatab-function of this package was further used to execute a TWINSPAN (Hill 1979) classification on the data set. The TWINSPAN classification with refined by combining small TWINSPAN groupings into definable vegetation associations. Further, within each association species order was re-arranged to have a better overview of common, dominant and diagnostic species (see TWINSPAN Tables in Appendix 1.2.).

The main environmental factors responsible for the distribution of the defined species associations were determined by subjecting the divided data-set (divided into the groups of the first TWINSPAN separation - see Figure 16 under Section 9.2) to both PCA and DCA ordination, using PC-ORD (McCune & Mefford 1995).

Plant communities identified by the TWINSPAN program were combined into associations, which can be regarded as management units (see introduction) following the approach of Acocks (1988). The International Code of Phytosociological Nomenclature, (Weber *et al.* 2000) was followed for the naming of the associations after their most characteristic species. However, a formal classification and naming of plant communities and associations was beyond the scope of this study, as it only covered a strip of larger vegetation types and needs to be verified in future studies for the entire vegetation type. This would also make it irrelevant to select type relevés, which would be required to formerly name such plant communities or associations (Weber *et al.* 2000).

To Start:

take a small handful of soils and add water until the soil is plastic and molable like moist putty

↓

does soil remain in a ball when squeezed? no ↓ yes→	SAND

form a ribbon of uniform width and thickness with the soil and push up between thumb and forefinger

↓

does soil form a ribbon? yes ↓ no→	LOAMY SAND

allow the ribbon to extend over the forefinger, breaking from its own weight

↓

ribbon weak and less than 2.5 cm long before breaking yes ↓ no→	ribbon medium strength and 2.5 - 5 cm long before breaking yes ↓ no→	ribbon strong and >5cm before breaking yes ↓

excessively wet a part of the soil and rub between fingers

↓

SANDY LOAM	does soil feel very gritty ←yes no ↓	SANDY CLAY LOAM	does soil feel very gritty ←yes no ↓	SANDY CLAY	does soil feel very gritty ← yes no ↓
SILT LOAM	does soil feel very smooth ←yes no ↓	SILTY CLAY LOAM	does soil feel very smooth ← yes no ↓	SILTY CLAY	does soil feel very smooth ← yes no ↓
LOAM	neither grittiness or smoothness predominates ←	CLAY LOAM	neither grittiness or smoothness predominates ←	CLAY	neither grittiness or smoothness predominates ←

Figure 11: determining soil texture by the "Feel Method", adapted from Foth *et al.* (1980)

8.2. IMAGE PROCESSING OF SATELLITE DATA TO ASSESS THE DISTRIBUTION OF THE MAJOR VEGETATION TYPES OF THE STUDY AREA

All image processing was done at and with the assistance of staff of the DLR in Porz, Germany. All processing was done using the ERDAS PC package (ERDAS 1997).

8.2.1 Pre-processing of the satellite image

For the classification process, LANDSAT-7-ETM images 178-74 and 178-75, both taken on 17 May 2000, were used. Both images were previously spectrally enhanced and geo-rectified. Image classification is based on the same process as vegetation classification - taking all samples (here pixels) of a data set (here the entire image) and assigning them to a vegetation class. Looking at the false-colour composite images (and confirmed by rough unsupervised classifications of the entire scene), on the image there are several vegetation types which are not represented in the study area, thus not sampled, and it would be unrealistic to include these in a classification. Further, as sampling was limited to plains only, including the reflectance of the few inselbergs present would lead to further misclassifications. Hence, an AOI (Area of Interest) was defined for both images, which extracted the image of the study area only, while Inselbergs were removed from the scene using an elevation model. These AOI's were used for further image processing.

8.2.2. Image Classification process

i. For every region on earth, ideal projection-parameters have been set for geographic data - this has been set according to the path the satellites follow, as well as the curvature of the earth in relationship with the scanned image, ensuring a correct projection of remotely-sensed data onto a map. For Namibia, maps are projected according to the Schwarzeneck map-datum - which is used when e.g. collecting reference points with GPS on the position of a sample. Unfortunately, ERDAS can convert data back into Schwarzeneck, but has problems working with Schwarzeneck data, as the system does not have this map datum as an option. As the classification process is a relatively exact science, relying on the correct assignment of single pixels to a vegetation group, all GPS reference points were first converted to WGS 84, before being transformed into lat.-long data which could be placed onto the satellite image.

ii. Starting with the mapped GPS reference points and going back to field notes, where it was recorded in which direction the sample was laid out (and hence more homogenous vegetation could be found), training sites were selected manually around every point. The basic operation compares the similarity of surrounding pixels to the "model pixel" according to a predefined similarity-limit, and then marks the pixels as a polygon-class, which can be used in the classification process. A minimum of 4, but preferably 8-12 pixels were considered desirable for a training site. Some samples could not yield enough pixels for a training site - meaning the vegetation is too heterogeneous to be used in a satellite classification, and were removed from the classification.

iii. As every vegetation association is still relatively diverse, especially when looking at the typical shrub/grass structure of savannas - a rough classification may lead to over-generalisation errors in the classification. For a successful satellite-image classification, spectral signatures of a class must be as "clean" as possible, thus should follow nearly identical peaks and curves. To speed up the signature-selection process, the original classification-classes of TWINSPAN (53 in total, see Dendogram Figure 16 under Section 9.2.) were used to assign the training sites to, thus obtaining preliminary classes of training sites.

iv. For all classes of training sites, the spectral signatures were viewed - combined into higher classes when they were very similar, but usually subdivided further where definite groups of signatures could be identified. A minimum of 3-4 similar signatures were considered sufficient to define a signature-class, samples with single very different signatures were discarded from the classification.

v. A supervised classification was done using the signature-classes defined above, and the print-out of this classification was compared to field notes to assess accuracy as well as interpret possible reasons for differences in spectral signatures - usually a result of differing vegetation structure and density.

vi. This classification was repeated until the author was satisfied that classes identified by ERDAS were representative of the vegetation on the ground. Subsequently, these “subclasses” were simply combined using the same colour-coding for the different classes into the vegetation associations defined by the phytosociological classification to view the distribution of these associations throughout the study area.

vii. For a first approximation of mappable vegetation types (on a scale of 1:250 000 and smaller), vegetation associations were grouped together based on vegetation data as well as comparisons to previous vegetation descriptions (e.g. Giess 1971). Again, associations were combined into “approximate vegetation types” by assigning the same colour coding to the associations of a vegetation type.