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Vegetation degradation trends in the northern Oshikoto Region: I. The *Hyphaene petersiana* plains

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Abstract

A proposed rural water supply scheme in the northern Oshikoto Region will impact on the settlement patterns of the rural population. For this reason an environmental impact assessment was commissioned.

In this paper the degradation gradients found in the oshana system in the western part of the study area are discussed. Degradation is not only due to overgrazing, but also due to an over-utilisation of veld products like building wood. This veld type is seriously degraded with only few less-disturbed areas present.

Although indications are given on various species' reaction to degradation, no definite classification as decreasers and increasers is given due to the fairly small sample size.

Keywords: Communal lands, degradation trends; deforestation; desertification; Namibia; oshana's

Introduction

The Oshivelo - Omutsegwonime - Okankolo area in northern Oshikoto Region comprises 257 800 ha (Lund Consulting Engineers 1998) - some of the few less densely populated, better-conserved areas of the former Owamboland. However, people do live in the area (42 653 persons were counted in 1999 – Lund Consulting Engineers *et al.* 1999), relying on surface water and/or poor quality ground water sources. Piped water supply to the area was identified as one of the development objectives of the Government of Namibia.

In a consultancy report regarding environmental impacts of rural water supply, ARCADIS/Euroconsult (1998) points out that the major impact of water supply in

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unsettled areas will be the permanent settlement of stock owners with their herds, resulting in unsustainable long-term overstocking of the area. Not mentioned in this report is the fact that the people in the area are agrosilvopastoralists, thus not only herding cattle, but cropping fields and needing wood products to do so (B. Mwifi, personal communication[2]). This land use practice will have more extreme environmental impacts on unsettled areas than new permanent-settling cattle owners.

It was thus realised that an influx of new settlers will take place. It is not clear whether such settlers will be subsistence farmers from other, more densely populated areas, absentee land holders (weekend farmers), people temporarily settling in order to graze their animals in this area during dry seasons / droughts or permanent settlers with possibly bigger herds (Lund Consulting Engineers *et al*. 1999). The most likely "source" of such new settlers is the nearby *Oshana* system to the west, which is known to be densely populated to the extent that resources become scarce (Cunningham *et al*. 1992).

In the light of this possibly negative development, a study was commissioned to assess the environmental impact of the proposed rural water supply scheme in the area (Strohbach 1999).

Study Area

The study area consists of a 30 km wide strip north of the tarred road between Tsumeb and Ondangwa (B1) from 17° East up to Okatope, as well as a 5 km south of the road (Figure 1). This paper deals with the western-most part of the study area, the *Hyphaene petersiana* plains of the *Oshana* system.

Geology, Topography and Drainage

The Kalahari deposits, being between 200 m (in the south-east at Oshivelo) and up to 400 m (in the NW near Okankolo) deep (Geological Survey 1980), are formed by various sandstone to clay deposits of the Beiseb formation, the Olukonda Formation and the Andoni formation (all of the Kalahari group). The red-brown sands found in the south-eastern parts are windblown sands of a more recent age (SACS 1980).

The most prominent topographic features of the central northern regions are: the Etosha pan and its surrounding saline plains in the south, the Cuvelai delta feeding into the Etosha pan from the north and the Kalahari sand plateau to the east and west of the Cuvelai delta.

The Cuvelai delta (better known as the *Oshana* system between Ondangwa and Ruacana) was formed by a varying regime of flooding, slow-flowing water, and the

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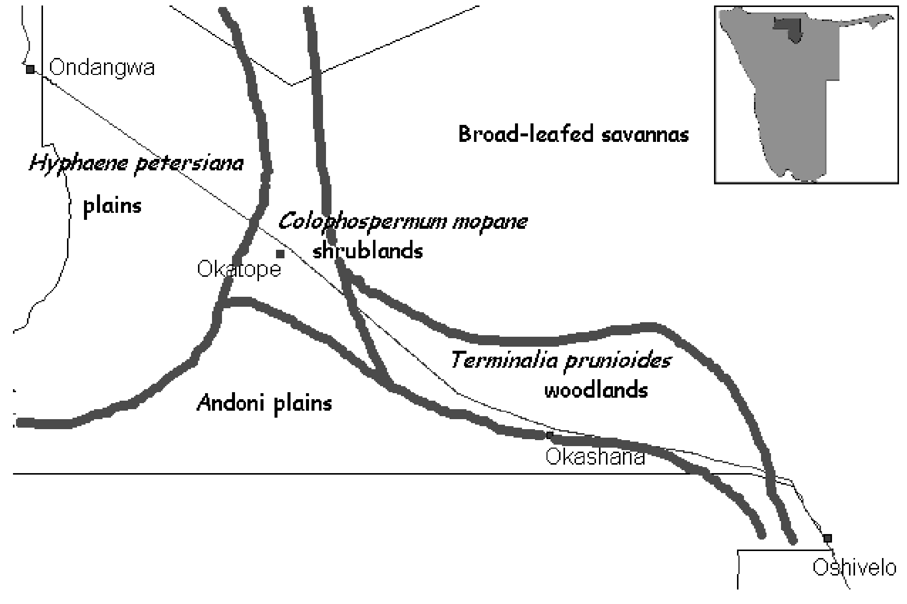

Figure 1: Map indicating the approximate extent of the various vegetation types found in the study area.

depositing of wind-blown sands from the east. In time shallow channels formed the present *oshanas*. The soils are rich in clay and loam, often with a high saline content. The western oshanas are fairly active, flooding annually with the *efundja*. From Ondangwa eastwards, the oshanas are rudimentary channels, which only flood due to local run-off (Cunningham *et al.* 1992).

Agro-Ecological Zones: climate and soils

A first approximation of agro-ecological zones of the country has recently been published (de Pauw & Coetzee 1998/99; de Pauw *et al.* 1998/99). This zonation is mainly based on topographic and climatic divisions, and, for the study area, reflects the above mentioned topographic units.

The growing period is defined as the period in which (a) the precipitation exceeds half the potential evapotranspiration and (b) the daily temperature exceeds 6.5° C (FAO 1978). In the Namibian context, the length of growing period is strongly correlated with rainfall (de Pauw *et al.* 1998/99). For the study area, two growing periods are delimited, being zones 3 and 4.

Zone 3 occurs in the eastern two-thirds of the study area, roughly up to Onankali. Zone 3 is characterised by an average growing period of between 61 and 90 days (average of 83 days), with a dependable growing period of 60 % of the average (52 days). Zone 4 covers the western third of the study area, and essentially the eastern Oshana area. This zone is characterised also by an average growing period of between 61 and 90 days (average of 73 days), has, however, a very short dependable growing period of 6 days only (i.e. the rainfall is very variable). Oniipa (one of the stations used for the calculations of the growing period zones) has an average of 512.8 mm rainfall annually (Namibia Meteorological Services 1997).

The recommended land use practice for both these growing period zones is livestock grazing rather than cropping (even using early maturing crops) (de Pauw *et al.* 1998/99).

The western part of the study area (roughly from Onankali westwards) forms the fringe of the Oshana flood system. Rudimentary oshanas occur only from Okatope westwards. The slope ranges from 0-2 % (flat) to 2-5% (gently undulating), however with a very low relative relief (<10m). Altitude is generally between 1090 and 1100 m.

The agro-ecological zone KAL9-4 falls within the growing period zone 4. The dominant soils are haplic Arenosols (modal sandy soils), with petric Calcisols (soils with high lime concentrations in indurated form in the subsoil), gleyic and haplic Solonetz included (sodic soils with poor drainage, or modal).

Vegetation

The study area overlaps two vegetation types described by Giess (1971). The major part to the north and east falls within the "Forest Savanna and Woodland (northern Kalahari)". Further south, bordering the "Saline Desert with Dwarf Shrub Fringe" of the Etosha pan, extends a tongue of "Mopane Savanna". Giess describes this vegetation type as dominated by *Colophospermum mopane*, which occurs both as a shrubland or woodland (Giess mentions frost damage and soil differences as causing factors).

Cunningham *et al.* (1992) mention 4 major vegetation zones in Owambo, being woodlands, the central drainage system, shrub savanna and the grasslands of southern Owambo. They include a map of the vegetation, describing the vegetation as being "seasonally waterlogged grasslands" and "Croton gratissimus / Lonchocarpus nelsii / Bauhinia petersiana shrubveld integrated with T. prunioides / Acacia luederitzii tree veld". To the north are "dry woodlands on deep greyish sands". No further information is given regarding the composition or dynamics of these vegetation types.

The *Hyphaene petersiana* plains are characteristic of the eastern Oshana plains between Ondangwa and Okatope. *Hyphaene petersiana*, together with the shrubs

Acacia arenaria, Acacia hebeclada subsp. *hebeclada* and *A. hebeclada* subsp. *tristis*, and the grasses *Wilkommia sarmentosa, Sporobolus ioclados* and *Eragrostis trichophora* are characteristic. Typically the vegetation is a shrubland, but can vary between an open woodland (seldom), a bushland, or in degraded situations, a grassland (structure definitions after Edwards 1983). Photo 2 depicts a typical, degraded example of the *Hyphaene petersiana* plains.

In few isolated, protected areas (e.g. graveyards - see Cunningham *et al.* 1992 and Photo 1) some other trees and shrubs can be found, especially *Terminalia sericea, Diospyros lycioides, Elephantorrhiza suffruticosa* and the grass *Odyssea paucinervis*. Due to widespread overutilisation, these species have disappeared in most cases from the landscape. Also occasionally found are some large trees of *Sclerocarya birrea* subsp. *caffra* and of *Schinziophyton rautanenii*.

Soil compacting and sheet erosion is common, indicating the generally resource-poor and degraded condition of these plains.

Methods

Field surveys

The degradation gradient method developed by Bosch (Bosch & Janse van Rensburg 1987; Bosch 1989; Bosch & Gauch 1991; Hurt & Bosch 1991) was applied. This method has been successfully applied by both Strohbach (1992) and Joubert (1997) in Namibian savannas.

The degradation gradient method basically prescribes selective sampling of the vegetation composition on degradation gradients, from well-conserved to over-utilised / trampled / degraded. Important in the application of this method is that only samples of a similar veld type / habitat type are compared (Strohbach 1989; Janse van Rensburg & Bosch 1990). Thus sample sites were selected on various locations nearer to and further from settlements. Fence-line effects were, if possible, also sampled (i.e. inside a protected or semi-cleared fenced area compared to outside in an open-access area). As the *Hyphaene petersiana* plains are only on the fringe of the study area, a total of only 17 plots was sampled.

The sample plots were 20 x 50 m in size (i.e. 1000m^2). The position was taken with a Trimble Ensign GPS, also noting the accuracy of the position by noting the DOP-value. Basic habitat information, following the SOTER (FAO 1993) procedure, was noted. At each relevé, a photo (or more if needed) was taken.

The Braun-Blanquet survey method was adopted as a rapid assessment of the floristic composition of the sample sites. The Braun-Blanquet survey method consists of compiling ‘relevés’, being a description of a sample site i.t.o. locality, habitat and floristic composition. A complete list of species present at a sample site is a prerequisite for a relevé (Mueller-Dombois & Ellenberg 1974; see also Westfall *et al*. 1996). The species abundance's are only estimated crown covers given in percentages.

Unknown, but identifiable plants were collected and pressed for later identification in the National Herbarium of Namibia (WIND). Unfortunately, the survey was done about a month too early in the growing season (3rd & 4th weeks of January 1999). Many species were not yet fully developed, had thus no flowers and are impossible to identify even in the herbarium. It is suspected that some species had not yet emerged.

Data Processing

The relevé data were data-based using the TurboVeg for Windows data base (Hennekens 1996) with the southern African species list (after Arnold & de Wet 1993) as base.

The relevés occurring in this vegetation type were selected using the characteristic species as selection criteria, and exported into separate CEP-format data files. Processing was done according to the method of Bosch & Janse van Rensburg (1987), as used also by Strohbach (1992): The data set was ordened using Detrended Correspondence Analysis (DCA) of the PC-ORD for Windows programme package (McCune & Mefford 1997). This programme was selected rather than the DECORANA programme (Hill 1979) due to the instability problem described by Oksanen & Minchin (1997).

A scatter diagram was prepared of the distribution of relevés on the ordination axes. Relevés known to be in "good" or in "poor" condition, preferable in close proximity of each other (i.e. a known degradation gradient) were plotted on this scatter diagram to identify the axis representing the degradation gradient.

With the degradation gradient identified, the reaction of various components of the vegetation to degradation could be tested. For this purpose, the measurements of these components were put as dependants against the degradation gradient, and a trendline (either calculated by way of an exponential regression or a 2nd or 3rd order polynomial regression - whichever gave the best fit) was fitted.

Results

Axis 1 (Eigenvalue = 0.794) and Axis 2 (Eigenvalue = 0.353) of the DCA-ordination were plotted as a scatterplot. Axis 2 of the DCA-ordination was identified as representing the degradation gradient by plotting two known degradation gradients on the scatter plot (Figure 2) (compare also Photos 1 and 2).

Photo 1: "Undisturbed" veld in a grave-yard near Onyaanya (relevé 87059).

Photo 2: Degraded veld ca 200 m outside the graveyard at Onyaanya (relevé 87061).

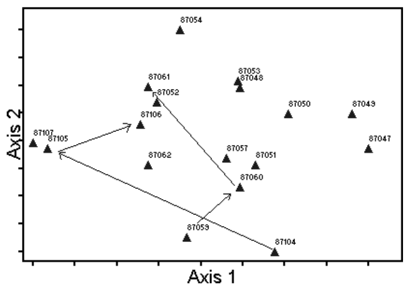

Figure 2: DCA ordination scatter diagram, with two known degradation gradients indicated.

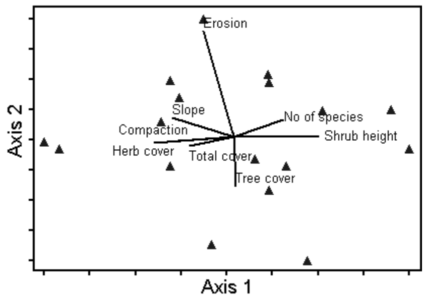

Figure 3: Biplot of the DCA ordination scatter diagram indicating the effect of various environmental factors on the diversity.

The fact that the first axis does not represent the degradation gradient, but rather an environmental gradient, can be attributed to the low sample size (30 to 40 sample are seen as a minimum according to Strohbach 1989) and the high variability of the habitat. When comparing the habitat attributes and some of the vegetation attributes (e.g. cover of the various components) with the scatter diagram by way of a biplot, it becomes clear that the first axis represents a gradient from the slope of the oshana to the top of the sandy ridges between the oshanas (Figure 3). Associated with increasing slopes to the left of ordination axis 1 are also increasing compaction (indicating a higher clay content of the soil) as well as an increase in herb cover. This in turn can be explained by the fact that the lower slopes of the oshana banks become (partially) water-logged, thus supporting the hydrophytic grasses *Sporobolus ioclados* and *Wilkommia sarmentosa*. The mat-forming nature of these grasses, often associated with a mat-forming type of *Eragrostis trichophora*, results in a higher herbal cover and thus also a higher total vegetative cover. A higher number of species and a general increase in shrub height to the right of ordination axis 1 indicate the sandy ridges between the oshanas.

The second ordination axis, although representing only about half as much of the diversity as the first axis, clearly represents the degradation gradient as manifested by the increasing degree of erosion to the top and the increase of tree cover (thus a decrease in the impact of deforestation) to the bottom. Interesting enough, compaction is not associated with increasing degree of erosion, but rather (as explained above) with increasing slopes of the oshana banks. **It must be understood that these axes are a mathematical abstraction of the change in species composition due to an environmental gradient, and cannot be directly related to the intensity/degree of the environmental gradient.**

Species reaction to degradation

The second ordination axis, representing the degradation gradient, is thus used as a numerical representation of the degradation gradient. This representation of the degradation gradient was then used as independent variable to plot the various components as dependant variables. In Figure 4 the grass cover trends are displayed, whilst Figure 5 displays the trends in woody cover as well as the absolute height of the woody vegetation. In Figures 6, 7 and 8 respectively the trends of the individual grasses, woody plants and some prominent herbaceous species are displayed.

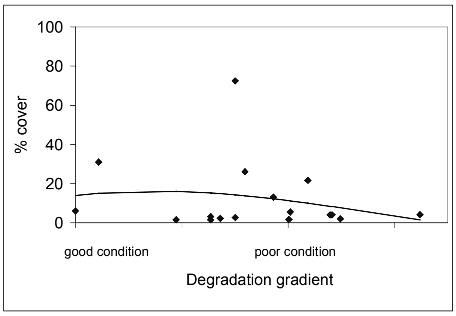

Figure 4: The change in total grass cover over the degradation gradient.

The grass cover displays a slight increase at about the middle of the degradation gradient, due to a strong increase in *Cynodon dactylon*. This species however also disappears towards the end of the degradation gradient. *Cynodon dactylon*, a mat-forming, stoloniferous, perennial grass, is generally associated with disturbed and heavily trampled areas in Africa (Chippendale & Crook 1976; Gibbs-Russel *et al.* 1990). Further indication of the severe degradation state of the veld is the fact that *Stipagrostis uniplumis*, generally regarded as a subclimax grass in the north-east and central parts of the country (Strohbach 1992; Joubert 1997), is limited to a single plot on the sample at the very beginning of the degradation gradient (the "undisturbed" relevé at the graveyard) (Figure 6c). *Eragrostis trichophora*, also regarded as a pioneer species in similar climatic conditions in the Grootfontein district (Strohbach 1992) is here reacting as a typical climax grass (Figure 6a). Also a climax grass in this veld type is the hard, spiky, halophytic grass *Odyssea paucinervis* (Figure 6b). The fact that these partially unpalatable, partially strongly competitive, typical subclimax and pioneer grasses are here reacting as typical

Decreaser species (*sensu* Voster 1982), indicates the degree of degradation of this veld type.

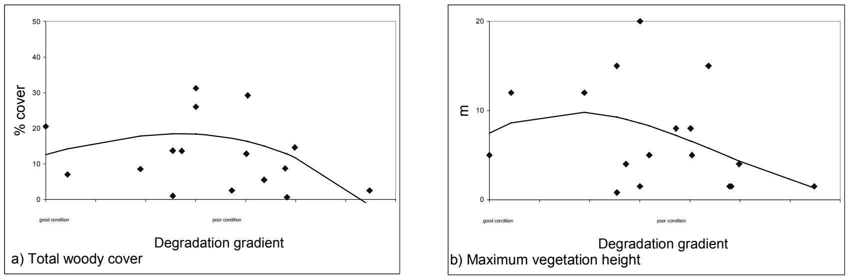

Figure 5: General reaction of the woody vegetation to the degradation trend.

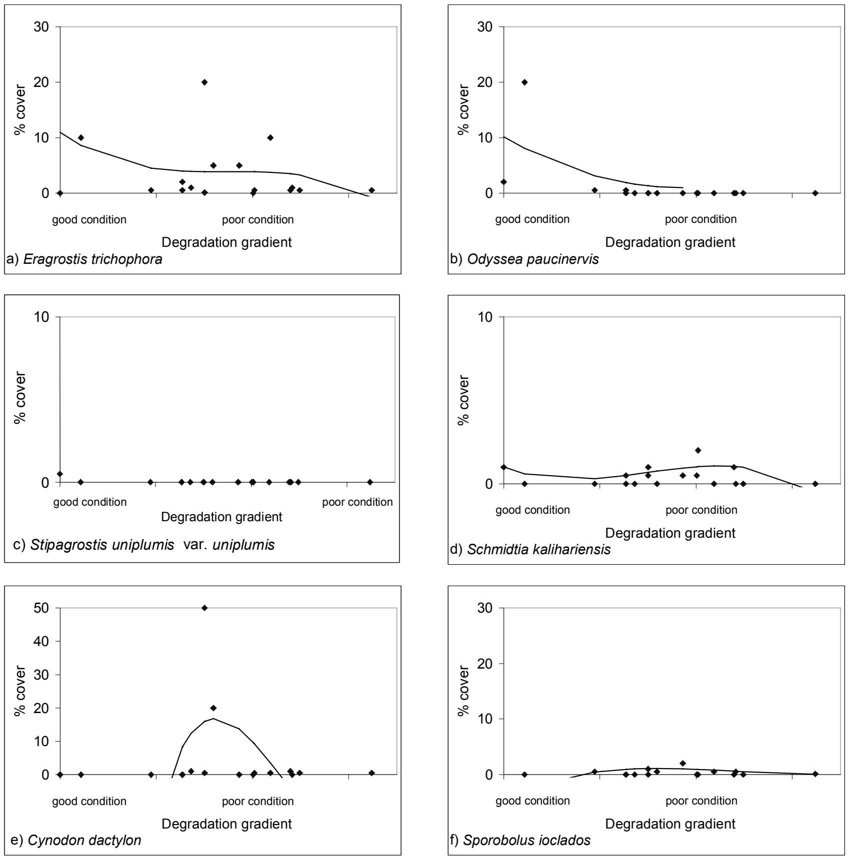

Figure 6: Reaction of various grass species to the degradation gradient.

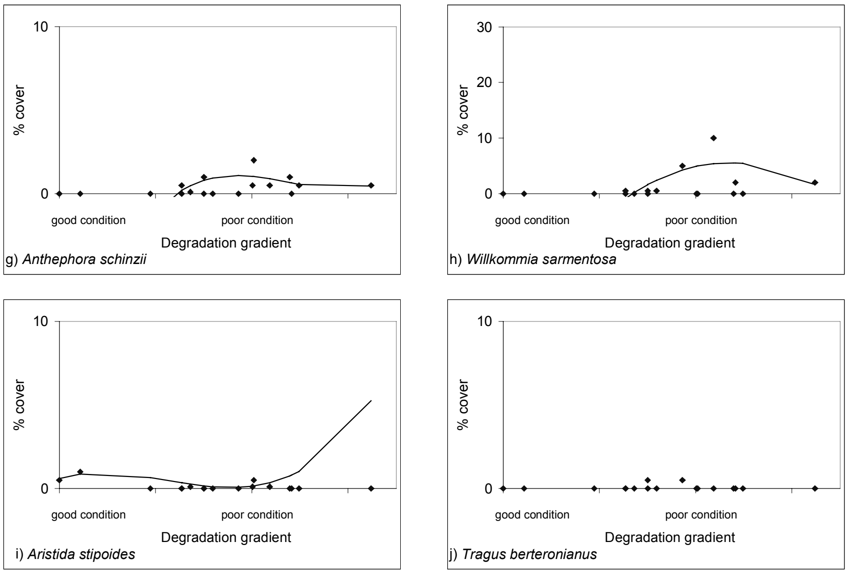

Figure 6 (continued): Reaction of various grass species to the degradation gradient.

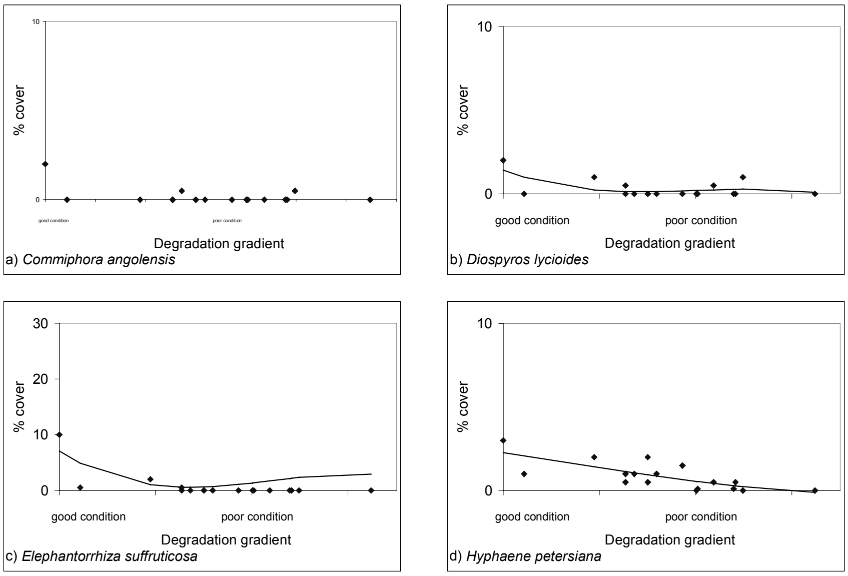

Figure 7: Reaction of various tree and shrub species to the degradation gradient.

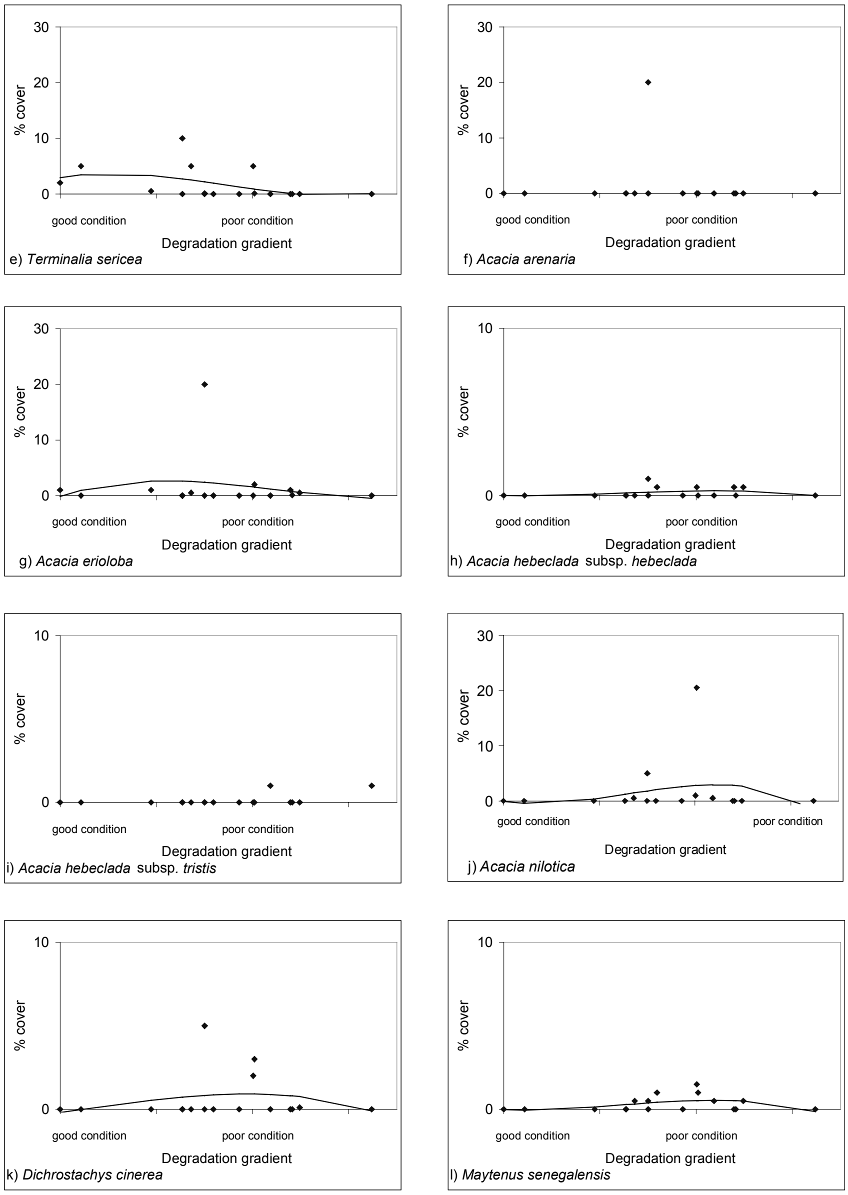

Figure 7 (continued): Reaction of various tree and shrub species to the degradation gradient.

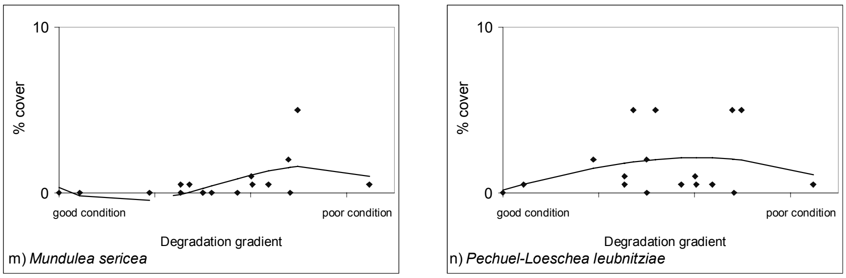

Figure 7 (continued): Reaction of various tree and shrub species to the degradation gradient.

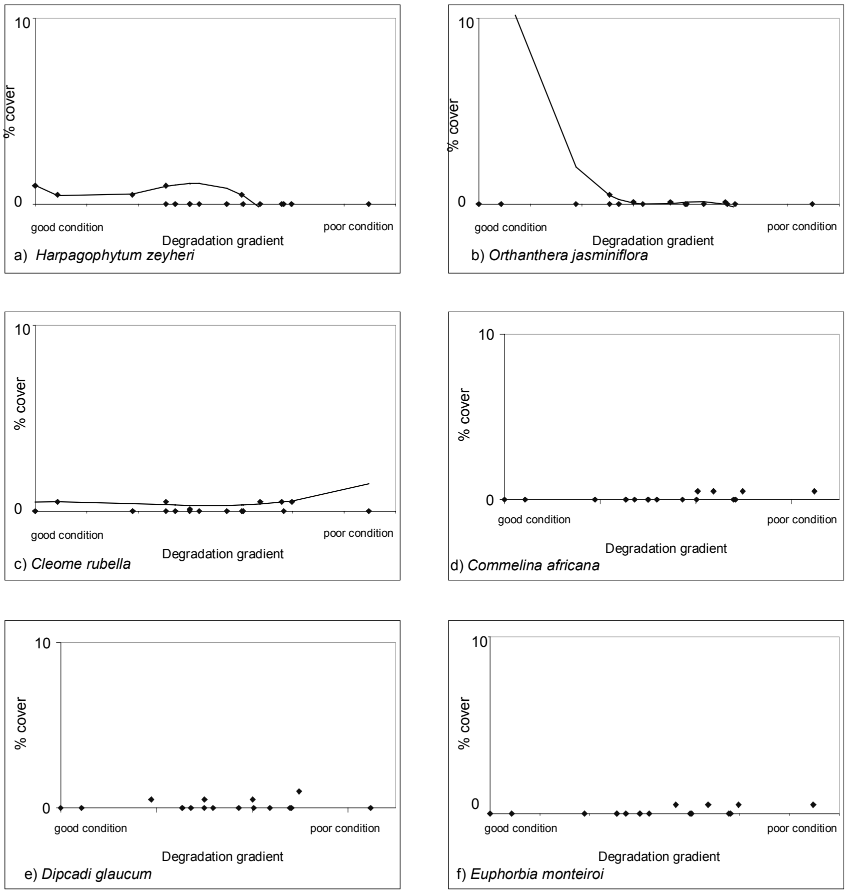

Figure 8: Reaction of various herbaceous species to the degradation gradient.

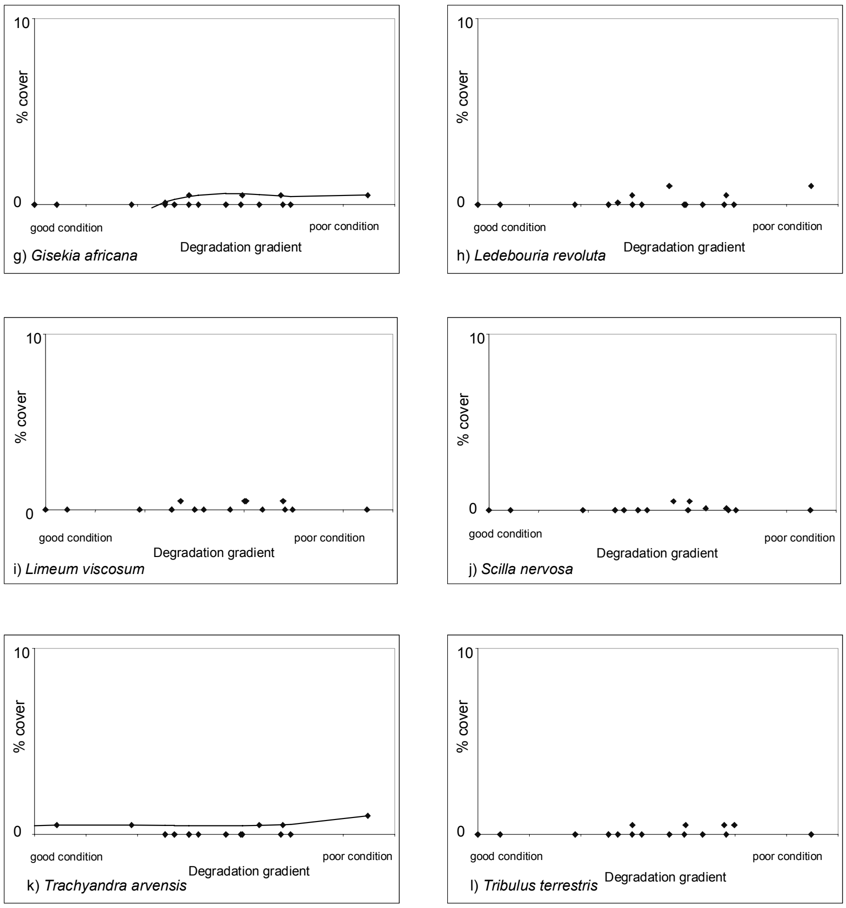

Figure 8 (continued): Reaction of various herbaceous species to the degradation gradient.

Typical subclimax grasses here are *Sporobolus ioclados, Cynodon dactylon* and *Schmidtia kalihariensis*, whilst *Anthephora schinzii* and *Willkommia sarmentosa* react as pioneer species. Of indeterminate reaction are *Aristida stipoides, Tragus berteronianus* and *Urochloa brachyura*, probably due to the relative low sample size.

Total woody cover never reaches more than 57 %, and generally is below 30 %. An increase in woody cover is again experienced in the middle of the degradation gradient, a typical sign of a phase of bush encroachment. This increase is also caused by the increase of various *Acacia* species (Figure 7). Figure 5b depicts the maximum vegetation height, i.e. the height of the woody species. Again, a peak height is experienced in the middle of the degradation gradient. Both graphs however indicate the effect of deforestation: woody cover decreases to about 2.5 % at the end of the degradation gradient, whilst the height of the woody plant species also decreases to 1.5 m.

The woody species also react to the degradation gradient: Species preferred by browsers or utilised in some way are only found in the better patches. Typical are *Diospyros lycioides* and *Commiphora angolensis*, which are browsed, whilst *Terminalia sericea* is browsed as well as utilized for building material (good quality poles, hoe handles, whilst the bark is used as a rope) (Rodin 1985). This species is found as small trees only in the “undisturbed” areas; in more degraded areas it increases in abundance as shrub, later only as juvenile plant. This increase indicates the strong competitive nature of the species, often referred to as an encroacher in the northern Kalahari (Strohbach 1998/99). *Elephantorrhiza suffruticosa* also reacts as a decreaser – it is however not clear whether this species is browsed upon or otherwise over-utilized. *Hyphaene petersiana* gradually decreases over the degradation gradient until it eventually vanishes from the system. This species is extensively used: The leaves are harvested for basketry, trunks are occasionally used as troughs, whilst the growth point is harvested for wine making (Rodin 1985).

The *Acacia* species react as typical encroachers, increasing in abundance about halfway through the degradation gradient. The most prominent is *Acacia arenaria* (Figure 7f), forming fairly dense stands. But also *A. nilotica, A. erioloba*, *A. hebeclada* subsp. *hebeclada, Dichrostachys cinerea* and *Maytenus senegalensis* peak at this stage of encroachment (Figure 7g-l). These species however are either browsed on by goats or utilised as building wood, thus do not persist to the completely degraded condition. Interesting enough, *Acacia hebeclada* subsp. *tristis* occurs nearer to the totally degraded end of the degradation gradient – although only at two relevés (Figure 7i).

Associated with the encroachment of acacias, *Mundulea sericea* increases. This species, known as a poisonous species, persists to the end of the degradation gradient (Figure 7m). The same tendency is shown by *Pechuel-Loeschea leubnitziae*, which occurs more widespread than *Mundulea sericea* (Figure 7n). This weedy, bitter species (Wells *et al*. 1986) however does not become as abundant as in other veld types in the area (Strohbach 2000), and in fact decreases in abundance at the very end of the degradation gradient. This is again an indication of the severity of degradation in this veld type.

Two herbs, *Harpagophytum zeyheri* and *Orthanthera jasminiflora*, react as decreasers. *Harpagophytum zeyheri* is browsed by cattle or goats, whilst *Orthanthera jasminiflora* is used as a wild vegetable by the local population (B. Mwifi, personal communication[2]) (Figure 8a and b). Most other herbaceous species show an indistinct reaction to the degradation gradient (Figure 8c-l), with only *Commelina* *africana, Dipcadi glaucum, Euphorbia monteiroi, Gisekia africana, Ledebouria revoluta* and *Tribulus terrestris* showing a tendency as pioneer species. Of concern is the increase of *Dipcadi glaucum*, which is a poisonous species ("malkopui") (Grant 1988).

Conclusions

The sample size is too small to divide the species conclusively into decreaser and increaser categories (Voster 1982) or even developing index values for other veld condition assessment methods (Bosch & Gauch 1991; Bosch & Kellner 1991). This is also proven by the fact that the second axis represents the degradation gradient as well as the fact that the fitted regression curves have r^2-values of between 0.04 and 0.6 (average 0.4). Thus these results **must** be seen as preliminary and more work is needed in this veld type regarding degradation trends.

Acknowledgements

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