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Vegetation degradation trends in the northern Oshikoto Region: IV. The Broad-leafed savannas with associated pans

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Abstract

A proposed rural water supply 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 broad-leafed savannas in the eastern part of the study area are discussed. Degradation is mainly due to the overexploitation of the woody resources for building and fencing material. Although some severely degraded areas were found near settlements, large parts of these savannas in the cattle post area are still in fairly good condition. The pans found in the northern part of the study area have better soils than the surrounding sand plains, thus most of these have been ploughed up for crop production. These pan terraces are thus a threatened habitat.

A classification of the most prominent herbaceous species into Decreaser and Increaser categories is given.

Keywords: Degradation trends; deforestation; desertification; indicator species; Namibia; northern Kalahari

Introduction

The Oshivelo - Omutsegwonime - Okankolo area in northern Oshikoto Region has been identified for a rural water supply scheme (Lund Consulting Engineers 1998). An environmental impact assessment was commisioned in the planning phase of this project (Strohbach 1999). This paper is the fourth in a series, discussing degradation gradients found in the broad-leafed savannas of the deep Kalahari sands, with some notes on the associated pans.

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Study Area

The study area consists of a strip 30 km wide north of the tarred road between Tsumeb and Ondangwa (B1) from 17° East to Okatope, as well as 5 km south of the road. This paper deals with the vegetation of the deep Kalahari sands to the north and east (see Figure 1 in Strohbach 2000a), also giving some notes on the vegetation of the associated pans.

Geology, Topography and drainage

This vegetation type is typical of the deep Kalahari sand plateau (Geological Survey 1980). The red-brown sands are windblown sands of a recent age (SACS 1980). The Kalahari sand plateau in the north-east was originally deposited as longitudinal dunes in an east-westerly direction. These longitudinal dunes, with associated *omuramba*'s, form the agro-ecological zone KAL 8 (de Pauw *et al.* 1998/99). The drainage to the north of the Mangetti (north-east of Oshivello) is still in an east-westerly direction (the "Akadhulu" or "Akazulu"). These fossil dunes do not show a great difference in relief (compared to southern Kavango and north-eastern Grootfontein districts), probably because of erosion and thus a general flattening of the topography.

As these remnant dunes flatten out completely, the rivers "Akadhulu" and "Niipele" turn south towards the Etosha pan. Roughly 80 % of the study area, to the east of Onankali - Okankolo, falls within these fairly flat sand plains, as part of the KAL 3-3 (de Pauw *et al.* 1998/99). It consists of a sand drift plain with a general slope range of 0-2 % (i.e. flat), very low relative relief (< 10 m), with no preferred drainage orientation. The dominant soils are haplic Arenosols associated with ferralic Arenosols (sandy soils with a very poor nutrient-retaining capability). Strohbach (1999) describes a mini soil profile pit at relevé 87126 as follows:

Top 5 cm:	Humus enriched, bleached yellow-grey sand
Below 5 cm:	Undifferentiated pure red sand

Drainage in the sand plateau is mainly vertical (downwards). This has resulted in the formation of numerous pans in the north-western parts of the study area, spreading out up to Eenhana in the north (the KAL4 according to de Pauw *et al.* 1998/99). The vertical movement of water leads to increased mineralisation of the sands, thus forming finer textured, more fertile soils in these pans. Both the more fertile soils and the shallow ground water in these pans has resulted in the settling of people along these pans in the area around Okankolo and Onyaanye in the study area. At one of these pans, a mini soil profile pit was dug at relevé 87138. The soil profile looked as follows:

Top: 1-2 cm bleached white sand (could be the deposit of erosion from further up).
A-Horizon: 30 cm deep, dark grey loamy sand.
B-Horizon: below 30 cm, yellow grey sandy loam, very sticky to the touch. (Strohbach 1999).

The broad-leafed savanna falls within growing period zone 3 (de Pauw *et al.* 1998/99).

Vegetation

This vegetation type is typical of the "Forest savanna and woodland (northern Kalahari)" (Giess 1971). This is described as a species-rich vegetation dominated by deciduous trees like *Burkea africana, Terminalia sericea, Lonchcarpus nelsii, Baikiaea plurijuga, Pterocarpus angolensis, Ochna pulchra, Combretum* species and *Grewia* species.

Cunningham *et al.* (1992) descibe the vegetation in this areas as being woodlands. A map of the vegetation is included, describing the vegetation as being "Croton gratissimus / Lonchcarpus 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.

Various forms of broad-leafed savannas exist here, ranging from shrubland with some dispersed *Acacia erioloba* trees, to bushland with a mixture of *Combretum* species, both in a tree and shrub form, to woodland with *Burkea africana* and *Baikiaea plurijuga*. The dominant tree and shrub species, however, stay constant, and the composition of the herb layer is virtually the same.

Typical trees are *Terminalia sericea*, *Combretum collinum*, *Lonchocarpus nelsii*, *Burkea africana* and *Acacia fleckii* and the shrubs *Combretum engleri*, *Acacia ataxacantha*, *Bauhinia petersiana, Ozoroa schinzii*, *Grewia flava, G. flavescens* and *G. bicolor* as well as *Commiphora angolensis*, *C. africana* and *C. glandulosa*. In KAL 8 (Omuramba-Dune association) north of King Kauluma school some *Baikiaea plurijuga* were encountered on a dune. Although this popular timber species had only a DBH of 20 cm (thus far from exploitable), some of these trees were found chopped down in this remote area. In the north-eastern cattle post areas some *Baphia massaiensis* were found.

Typical perennial grass species are *Stipagrostis uniplumis, Anthephora pubescens*, *Brachiaria nigropedata*, *Digitaria seriata*, *Schmidtia pappophoroides* and *Eragrostis trichophora*. Rare perennial species occurring here are *Panicum kalaharense* and *Aristida meridionalis*. The annual *Aristida stipitata,* which is often dominant in the commercial farming areas in similar sands, was found twice only - at very low cover. *Megaloprotachne albescens* (a palatable annual grass) was found in a few relevés in the cattle post areas. Common annual grasses are *Urochloa brachyura* and *Schmidtia kalahariensis*. The latter is typical of trampled areas.

Methods

A detailed description of the survey and data processing methods is given in Strohbach (2000a). In this vegetation type 44 relevés were sampled, with an additional four relevés on the slopes of the pan terraces.

Results

Degradation gradient

The scatter diagram of the DCA axis 1 and 2 is presented in Figure 1. Field observation revealed that the condition of the veld in the north-eastern cattle post areas and the Mangetti block is in pretty good shape, with various climax grasses being present and little to no harvesting of the woody vegetation. These all showed a low value on Axis 1 of the ordination results (Photo 1). Three known degradation gradients have been plotted. Each of these started as semi-degraded, and ended in a poorer state (Photos 2 and 3). The biplot in Figure 2 indicates that disturbances have a strong influence on the vegetation to the right of Axis 1, whilst undisturbed veld (to the left) is characterised by higher shrub cover, higher herbaceous biomass (expressed as the height of the herbaceous layer) and also a larger number of species. In this way it had thus been established that Axis 1 represents the degradation gradient. This axis has an Eigenvalue of 0.716, which means that the axis roughly

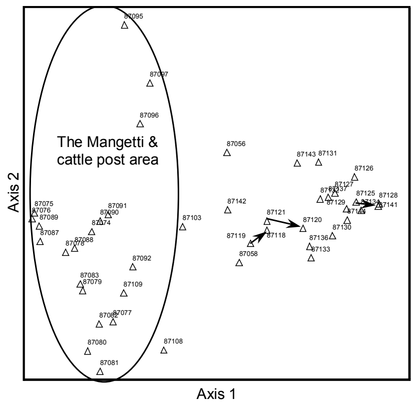

Figure 1: DCA ordination scatter diagram, with known degradation gradients indicated (compare to Photos 1, 2 and 3).

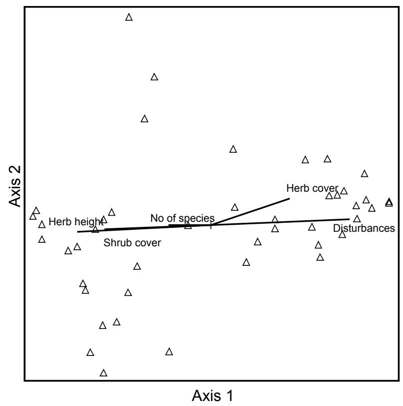

Figure 2: Biplot of the DCA ordination, indicating the influence of some vegetation characteristics, as well as disturbances, on the diversity.

represents 67 % of the variation in the data set (compared to Axis 2 with an Eigenvalue of 0.226, which represents roughly 21 % of the variation). Axis 2 represents an unidentified habitat gradient.

Photo 1: Broad-leafed savanna in good condition. Relevé 87096 in the north-eastern cattle-post area.

Photo 2: Broad-leafed savanna in mediocre condition. Note the short coppicing shrubs in the foreground. Relevé 87131 north of Onyuulaye.

Photo 3: Broad-leafed savanna in poor condition north of Onyuulaye (relevé 87128). Note that a few trees do remain, as well as the extremely low grass cover.

Species reaction to degradation

These savannas are mainly shrublands, occasionally bushland (*sensu* Edwards 1983), with a fairly low tree cover (up to 20 % cover, but normally no more than 5 % cover) (Figure 3a). The highest tree cover occurs more or less in the middle of the degradation gradient. The shrub cover, however, decreases from well over 60 % cover to less than 2 % cover over the degradation gradient (Figure 3b). The shrub in the Mangetti block area was so dense, that these areas could actually be classified as bush encroached. This is probably the result of the current land-use of the area, which is semi-commercial cattle farming on fairly small units. Thus the degradation gradient seems to stretch across the two opposites of degradation from encroached to deforested. For the purpose of this paper the "encroached" veld will be regarded as being in good condition.

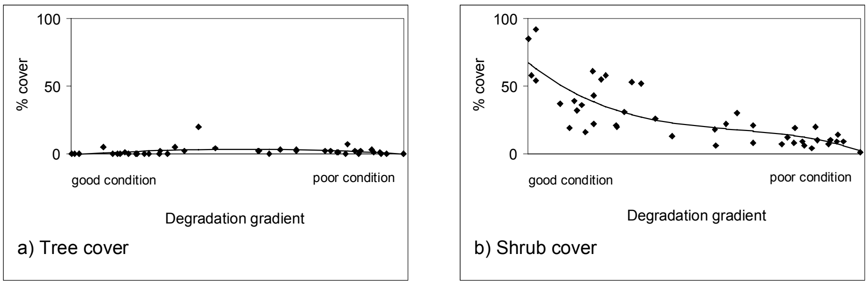

Figure 3: Cover trends of the woody plants across the degradation gradient.

Typical encroaching species are *Acacia fleckii, Bauhinia petersiana, Combretum engleri, Commiphora angolensis, Croton gratissimus, Dichrostachys cinerea* and *Terminalia sericea* (Figure 4b, f, j, l, n, o and x respectively). *Croton gratissimus* and *Terminalia sericea* are, however, fairly resistant to the degrading factors, persisting for a while along the grazing gradient. Also associated with this group are browse species like *Baphia massaiensis, Boscia albitrunca, Grewia bicolor, Grewia flava* and *Grewia flavescens* (Figure 4e, g, p, q and r respectively). The abundance of these species, being regarded as good fodder species, is drastically reduced as degradation progresses. None of these (with the possible exception of *Grewia flavescens*) attains a high abundance and can thus not really be classified as encroaching species. Interestingly enough, *Baphia massaiensis* does not occur in the densely encroached area – and can thus be regarded as not being a strong competitor for growing space. The same is true for *Ozoroa schinzii* (Figure 4v). The tree species *Burkea africana* and *Combretum collinum*, as well as the shrub *Mundulea sericea,* occur at peak abundancies lower down the degradation gradient (Figure 4h, i and u respectively). Of interest here is that some trees of *Combretum collinum* remain right through to the most degraded state. Why these are not also harvested is unclear. Also of note is that *Combretum collinum*, once harvested, has a weak coppicing ability – short branches with a dense leaf mass are formed, but no long, usable coppicing branches have been observed in the area. *Pechuel-Loeschea leubnitziae* shows a weak tendency to increase under degraded conditions (Figure 4w), never attaining a high abundance compared to the more loamy soils of the *Hyphaene petersiana* plains and the *Colophospermum mopane* shrublands (Strohbach 2000 a & b).

The general reaction of perennial grasses is as Decreasers (Figure 5a), whilst the annual grasses actually form two peaks – one as Increaser II, and one as Increaser IV (Figure 5b). Typically *Anthephora pubescens, Digitaria seriata* and *Stipagrostis uniplumis* react as Decreasers (Figure 6a, c and f respectively). *Schmidtia pappophoroides* and *Aristida meridionalis* react as typical Increaser II's (Figure 6b and e respectively), whilst *Eragrostis trichophora* reacts rather indistinctly to the degradation gradient. One peak occurrence of five percent under poor conditions suggests a tendency towards Increaser III for this species (Figure 6d). The annual grass species fall into two broad groups: *Megaloprotachne albescens* and *Urochloa brachyura* react as typical Increaser II's, being palatable species (Figure 6i and l respectively). The other annual grass species, *Aristida stipoides, Eragrostis dinteri, Schmidtia kalihariensis* and *Tragus berteronianus*, all react as Increaser IV's (Figure 6g, h, j and k respectively). Note: *Eragrostis dinteri* was not positively identifiable in the veld (no inflorescences yet), as the surveys were done too early in the season. The growth habit, however, suggested that this particular grass could be *Eragrostis dinteri*, which generally occurs on deep sandy soils under degraded conditions. *Schmidtia kalahariensis* provides the bulk of the grass cover (and thus a large part of the total vegetative cover) under degraded conditions. This species is regarded as a valuable grazing species in the southern Kalahari and could also provide a large part of the standing biomass here during the dry season.

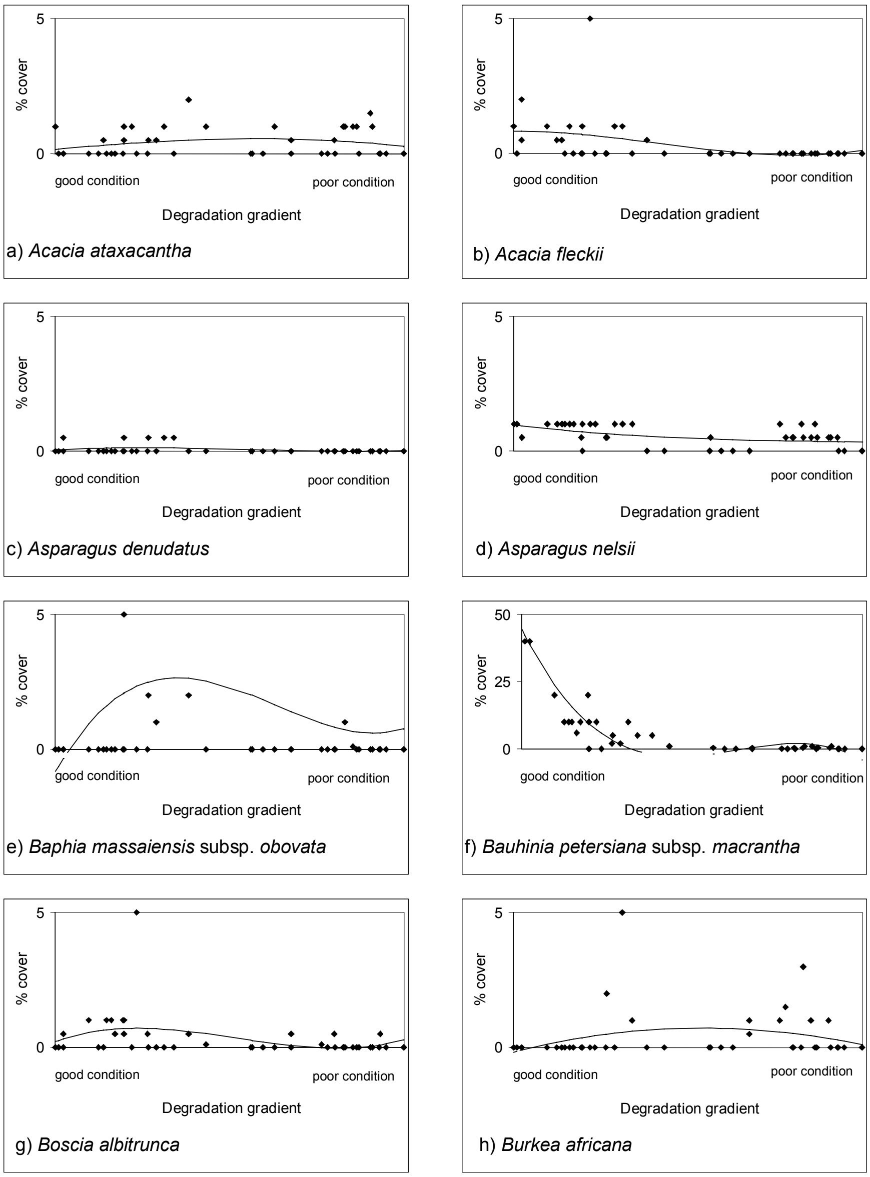

Figure 4: The reaction of various woody species to the degradation gradient.

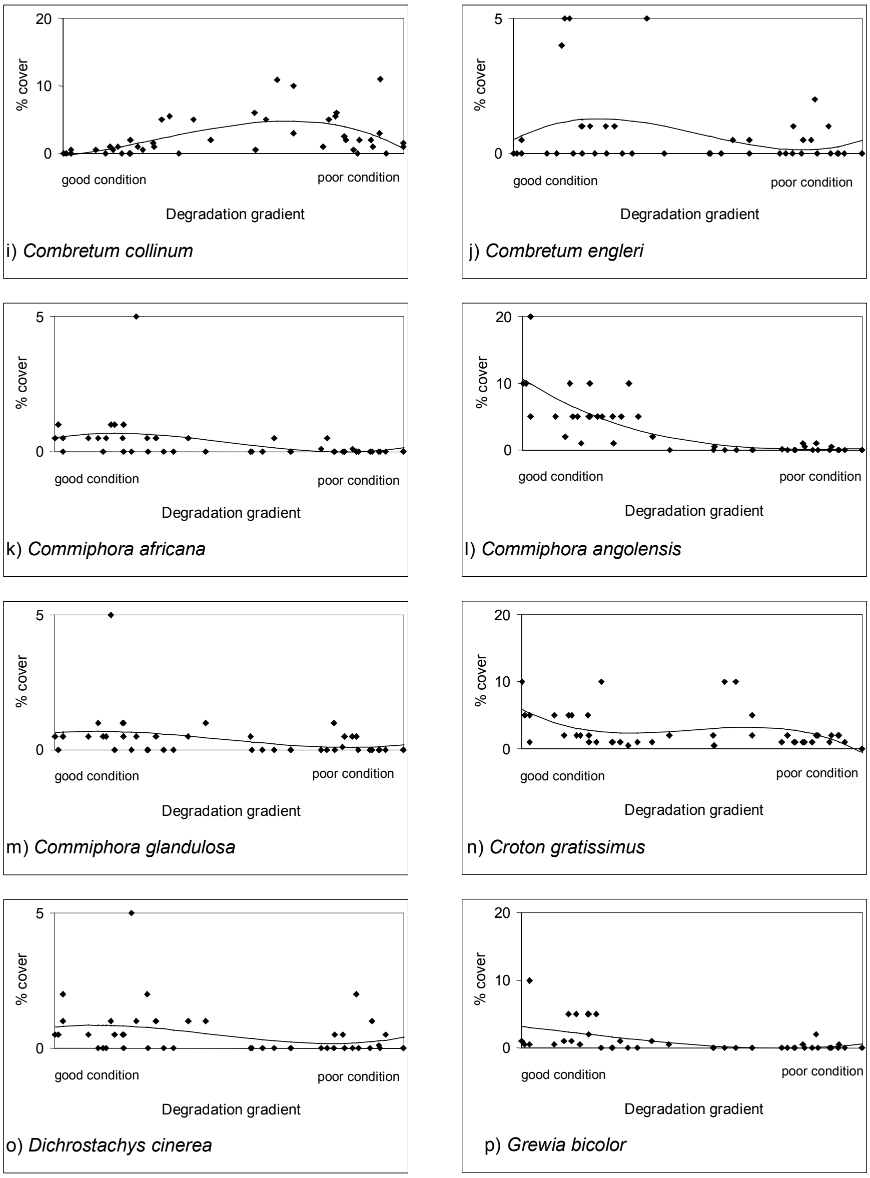

Figure 4 (continued): The reaction of various woody species to the degradation gradient.

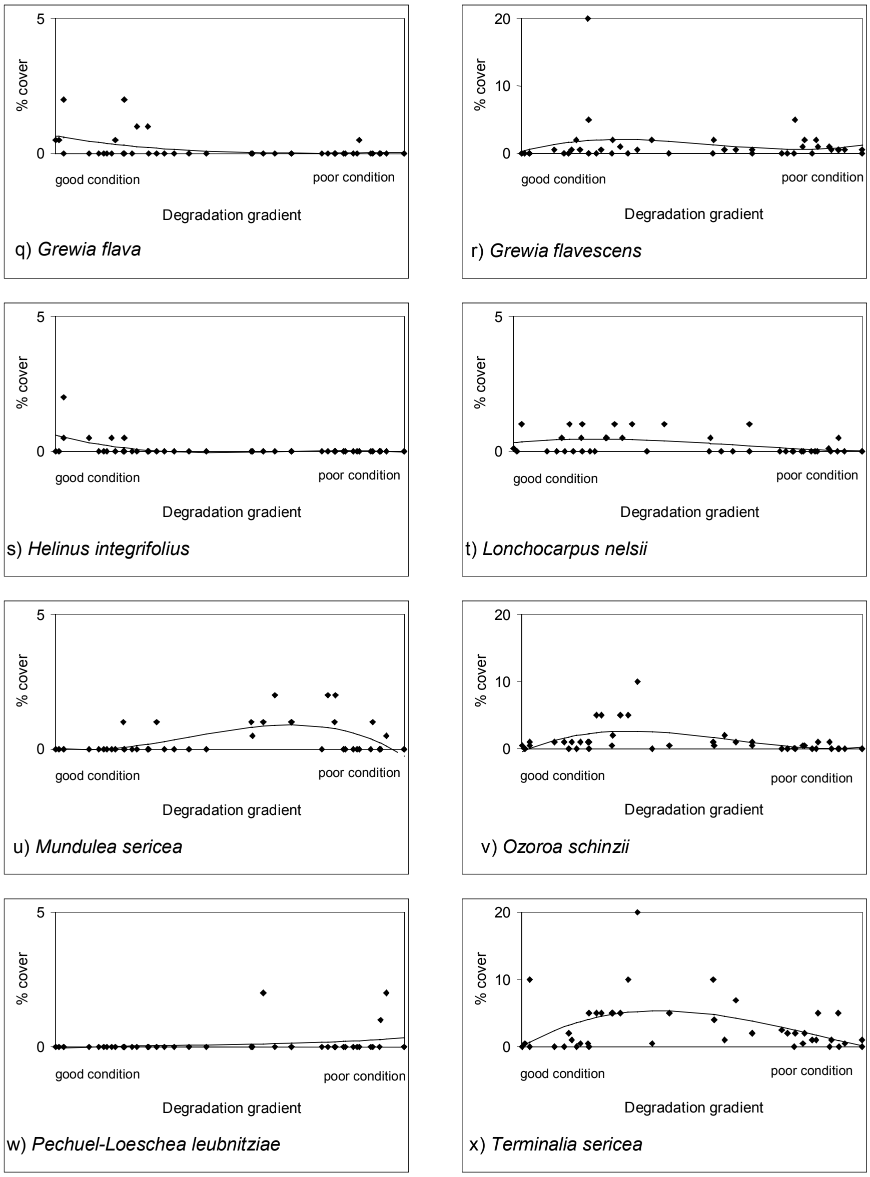

Figure 4 (continued): The reaction of various woody species to the degradation gradient.

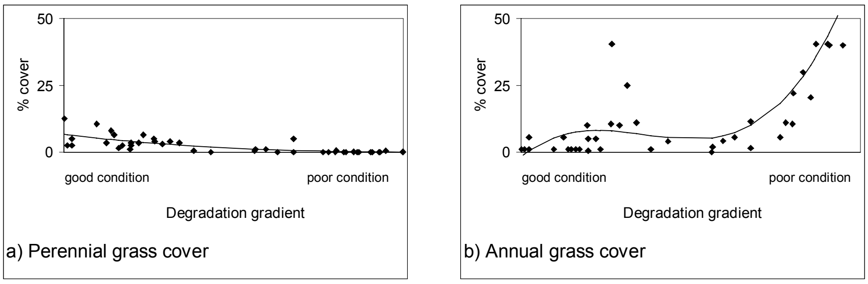

Figure 5: Cover trends of the grasses across the degradation gradient.

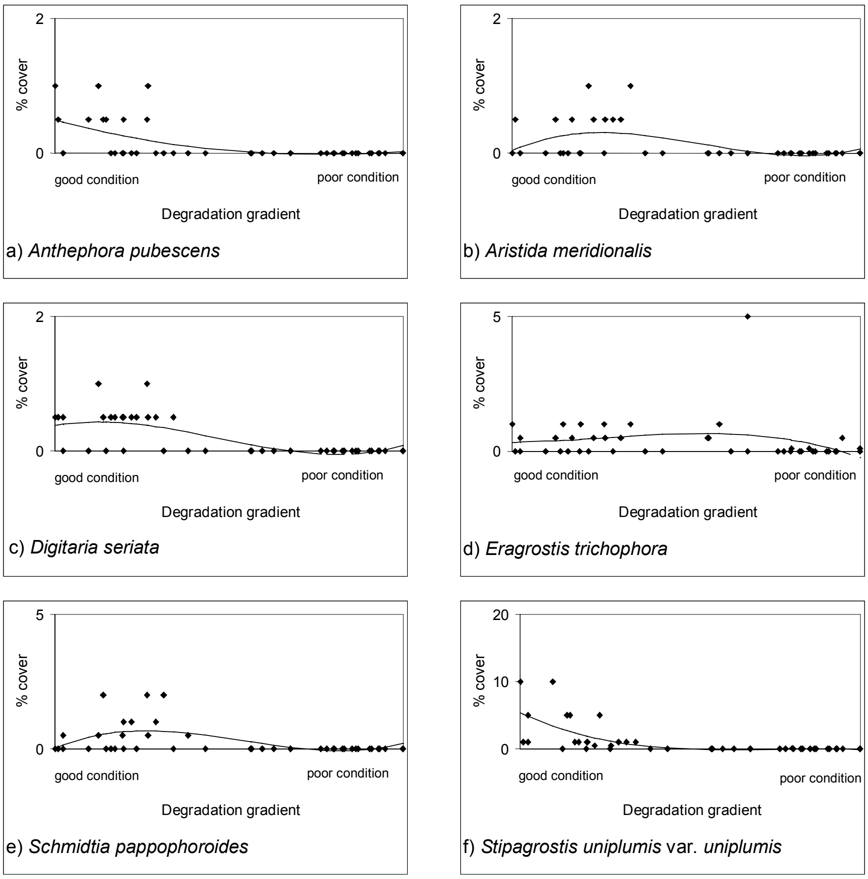

Figure 6: The reaction of various grass species to the degradation gradient.

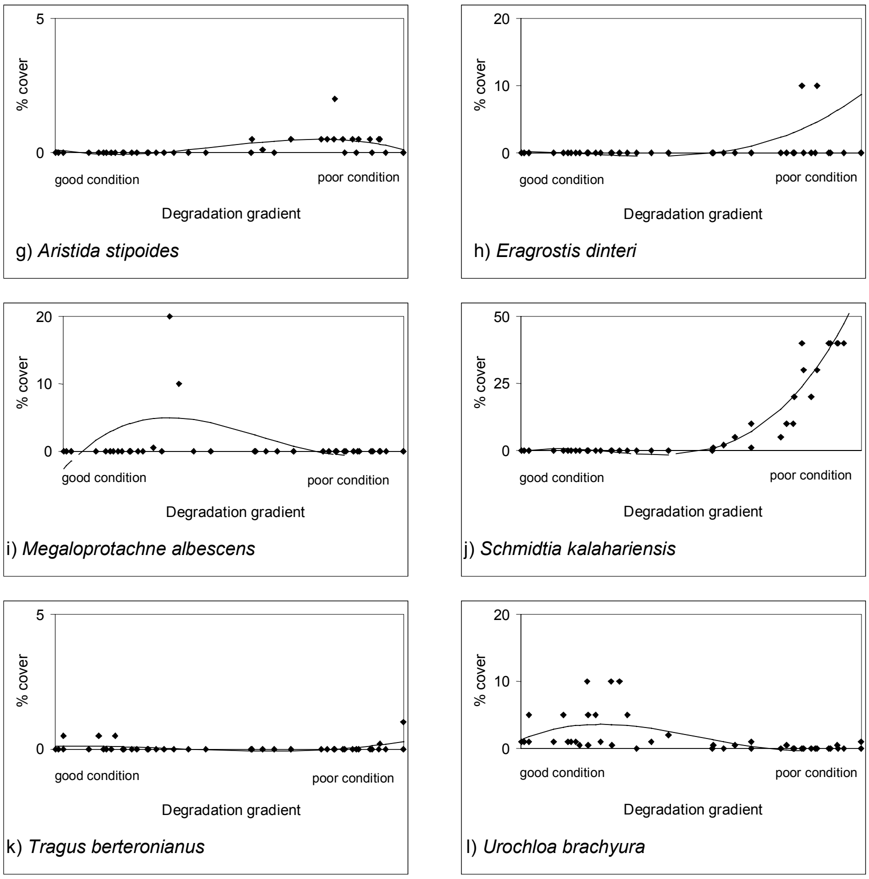

Figure 6 (continued): The reaction of various grass species to the degradation gradient.

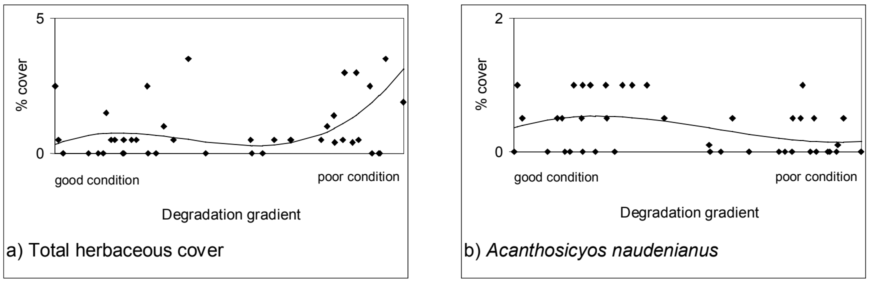

Figure 7: The cover trend of the herbaceous layer (a), and the reaction of individual herbaceous species to the degradation gradient.

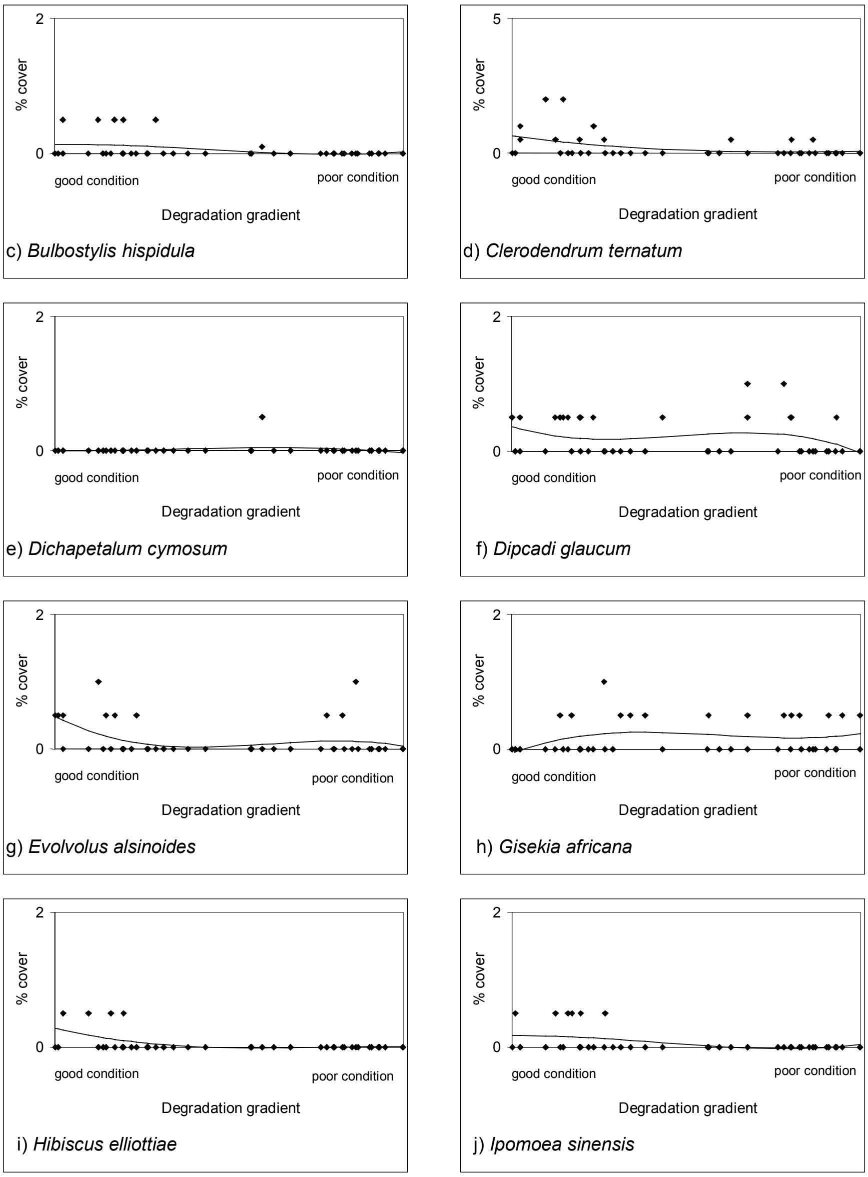

Figure 7 (continued): The reaction of individual herbaceous species to the degradation gradient.

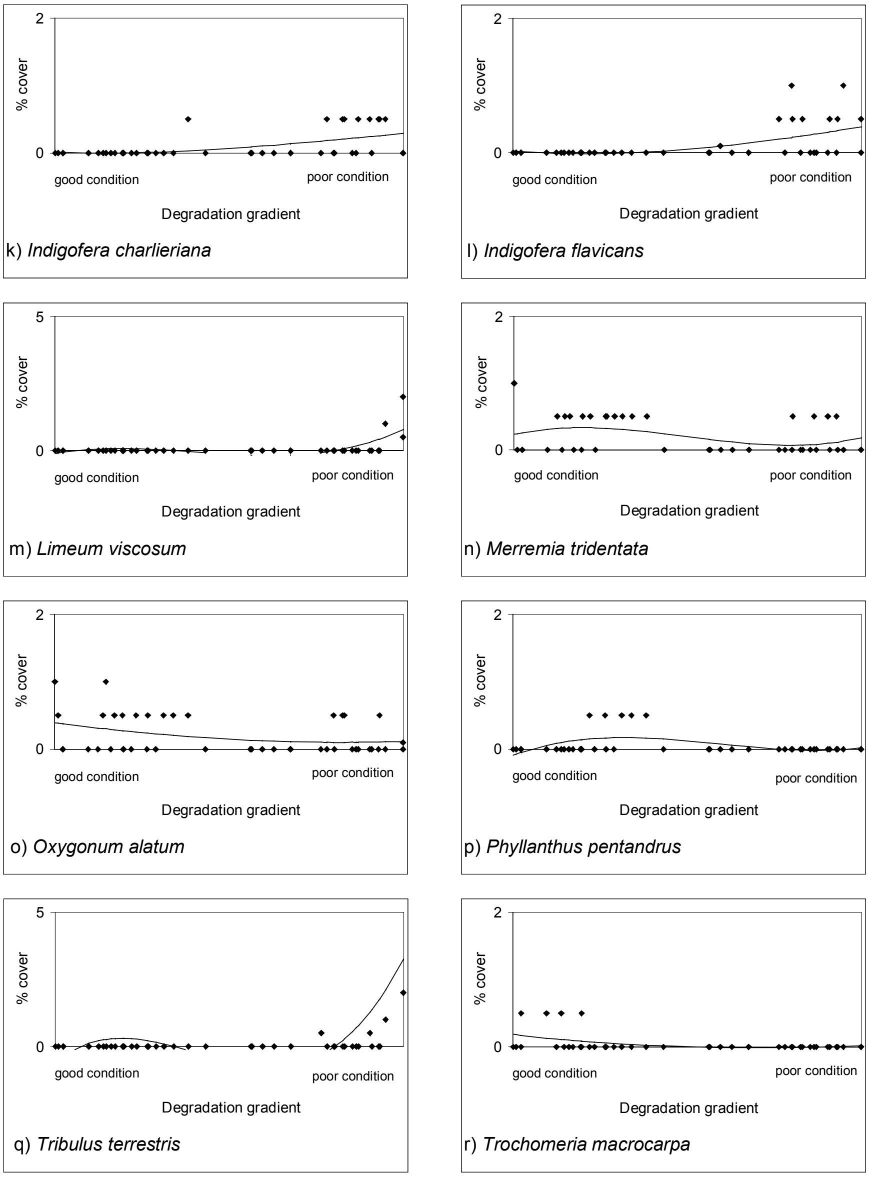

Figure 7 (continued): The reaction of individual herbaceous species to the degradation gradient.

The herbaceous cover also shows two distinct peaks: a lower peak under fairly good conditions (typically Increaser II species) and a major peak under degraded conditions (Figure 7a). Typical Decreaser / Increaser II type herbs include *Bulbostylis hispidula, Clerodendron ternatum, Hibiscus elliotiae, Ipomoea sinensis, Phyllanthus pendrandus,* and *Trochomeria macrocarpa* (Figure 7c, d, i, j, p, and r respectively). Other species typically associated with these broad-leaf savannas also tend to favour the undegraded conditions, but do occur in degraded areas: *Acanthosicyos naudenianus, Dipcadi glaucum, Evolvolus alsinioides, Gisekia africana, Indigofera charleriana, Merremia tridentata* and *Oxygonum alatum* (Figure 7b, f, g, h, k, n and o respectively). Species like *Indigofera flavicans, Limeum viscosum* and *Tribulus terrestris* form distinct peaks as Increaser IV species (Figure 7l, m and q), similar to their reaction in other vegetation types in this region (Strohbach 2000a, b & c). *Dichapetalum cymosum* (Figure 7e) is still a rare plant in this area, having been found once only.

The Pan terrace vegetation

As mentioned earlier, the agro-ecological zone KAL4 is characterised by the inclusion of pans. Most of these pans are used for cultivation; a few pans north of Onyuulaye were found unploughed. In some pans, patches of natural vegetation were also encountered. Overall, it is estimated that less than 20 % of this habitat type is still in its natural condition.

The pan terrace is typically covered by closed shrubland dominated (to the extent of encroachment) by *Acacia arenaria*. Some *Boscia albitrunca* and *Acacia erioloba* trees occur occasionally in such pans (Photo 4). Typical shrubs are *Acacia hebeclada* subsp. *hebeclada* and *Dichrostachys cinerea,* whilst shrubs like *Ehretria rigida* and *Pavetta zeyheri* occur occasionally. The grasses include *Schmidtia pappophoroides, Schmidtia kalihariensis, Brachiaria nigropedata, Eragrostis trichophora* and *Urochloa brachyura*. *Harpagophytum zeyheri* was found in these pans, whilst in one occasion *Eulophia speciosa* was encountered.

The pans form a unique habitat. Due to the fairly dense shrub cover by *Acacia arenaria*, perennial grasses like *Brachiaria nigropedata* and *Schmidtia pappophoroides* find a refuge here. This is also proven by the presence of the rare *Eulophia speciosa.* It is therefore essential that some of these pans should be conserved in their natural state.

During the road building operation of the D3630, about half of one pan (uncropped) was dug up to obtain gravel for the road surface (Photo 5). At present the soil (which is good agricultural soil) is heaped in an unstable heap, prone to erosion.

Photo 4: Typical pan terrace vegetation at relevé 87138.

Photo 5: This pan has been dug up to obtain gravel for road building purposes. The unused topsoil has been dumped in an unstable heap.

Discussion

As with other vegetation types in this area, the degradation threat is largest from wood harvesting, leading to deforestation. Wood is used generally as building and fencing material: even branches and shrubs are used for fencing (Photos 6 and 7). Even more progressive farmers using “modern” wire fences tend to use an extreme amount of droppers for their fencing (Photo 8).

Photo 6: A typical brush fence at relevé 87131 north of Onyuulaye. Compare with Photo 2.

Photo 7: A typical gate has been constructed with loose poles.

New settlements will also threaten the ecosystem: As these people are not only cattle

Photo 8: A “modern” 4-strand wire fence in construction. The average dropper spacing is 20 cm!

breeders, but also plant a variety of crops (especially pearl millet – ‘mahangu’), it is likely that a slash-and-burn situation will ensue. As the soils are nutrient poor, the need will arise to continuously clear new fields as the old fields become unproductive.

The danger exists that shrub is specifically cleared to allow *Schmidtia kalahariensis* to establish and in this way produce a high yield of fodder for cattle. However, due to its weak root system, *Schmidtia kalahariensis* does not persist long, leaving the soil surface denuded and vulnerable, especially to wind erosion during the dry season. Any attempt to manipulate this vegetation type into a degraded state to obtain a higher grass production by *Schmidtia kalahariensis* will be unsustainable in the long-term.

Associated with degradation is the increase of undesirable herbaceous species. Both *Dichapetalum cymosum* and *Dipcadi glaucum* are present in this vegetation type, although still at relatively low abundancies. The latter species already shows a definite tendency to invade degraded areas (Figure 7f). The threat of an invasion by *Dichapetalum cymosum* is real: experience has shown that this species coppices profusely when disturbed (Bester 1989). In the Omaheke region the abundance of this species has already taken disastrous proportions (van Eck 2000).

From the results presented in Figures 6 and 7, herbaceous species showing a distinct reaction to grazing pressure have been classed as Decreasers or Increasers (Table 1).

As a guide to the reliability of the classification the r^2 value, indicating the reliability of the polynomial regression, has been presented.

The relatively low r^2 values can be interpreted as a result of the many null-values (i.e. plots in which the particular species is expected according to the regression curve, but was not found during the survey). Although these results are, i.t.o. the sample size, by far more reliable than those from other vegetation types (see Strohbach 2000a, b & c), the low r^2 values necessitate a word of warning to use these results with caution.

Table 1: Key herbaceous species in the broad-leafed savannas.

Species	Fitted polynomial regression formula	r^2 value
Decreasers		
Anthephora pubescens	$y = 0.496 - (0.00403x) + (0.00000889x^2) - (0.00000000365x^3)$	0.317
Digitaria seriata	$y = 0.379 + (0.00253x) - (0.0000330x^2) + (0.0000000661x^3)$	0.483
Stipagrostis uniplumis var. *uniplumis*	$y = 5.364 - (0.0660x) + (0.000258x^2) - (0.000000325x^3)$	0.439
Increaser II's		
Aristida meridionalis	$y = 0.0423 + (0.00639x) - (0.0000455x^2) + (0.0000000778x^3)$	0.260
Megaloprotachne albescens	$y = -2.632 + (0.157x) - (0.000972x^2) + (0.00000157x^3)$	0.118
Schmidtia pappophoroides	$y = 0.0234 + (0.0156x) - (0.000110x^2) + (0.000000190x^3)$	0.299
Urochloa brachyura	$y = 1.287 + (0.0614x) - (0.000474x^2) + (0.000000839x^3)$	0.319
Increaser III's		
Aristida stipoides	$y = 0.109 - (0.00632x) + (0.0000630x^2) - (0.000000127x^3)$	0.358
Eragrostis trichophora	$y = 0.335 + (0.000369x) + (0.0000212x^2) - (0.0000000751x^3)$	0.0695
Increaser IV's		
Indigofera flavicans	$y = 0.0257 - (0.00116x) + (0.00000828x^2) - (0.00000000619x^3)$	0.286
Limeum viscosum	$y = -0.117 + (0.00624x) - (0.0000610x^2) + (0.000000142x^3)$	0.449
Schmidtia kalihariensis	$y = -0.543 + (0.0668x) - (0.00106x^2) + (0.00000379x^3)$	0.897
Tribulus terrestris	$y = -0.507 + (0.0265x) - (0.000256x^2) + (0.000000593x^3)$	0.367

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