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Minor Field Study, Oshana Region, Namibia
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EXECUTIVE SUMMARY

Water distribution, grazing intensity and alterations in vegetation around different water points, in Ombuga Grassland, northern Namibia

RESEARCH PROBLEM

In the late 1980s the South African state initiated a Water Borehole Programme directed at the underprivileged communal areas in northern Namibia (Olofsson and Henriksson, 1997). New grazing land previously not accessible could now be used. Systematic changes in vegetation cover in relation to water points are indicative of long term land deterioration (Moleele, 1999). Environmental effects have not been properly investigated in connection with water pipeline network expansions in the redistribution of more water in rural areas (Valdelin et al., 1996).

OBJECTIVES

The objective is to find out if the water pipeline network programme in north central region (NCR) of Namibia, has resulted in a negative change in the ecological resource base around selected waterholes in the communal lands of Uuvudhiya Constituency, Oshana Region, northern Namibia, i. e.:

- Determine if there are pronounced changes in vegetation cover around waterholes and if bare ground areas exposed to erosion have increased in size.
- Examine if areas surrounding some waterholes have managed better than others, due to the influence of factors like seasonal water distribution, livestock intensity, livestock movements, tending, utilisation history of the water point, etc.
- Determine if new man-made water points or taps are a sustainable solution to the water supply problem, regarding livestock production in the area.
- Try to find out if local ecological carrying capacity is exceeded or not.

WATER DISTRIBUTION

All the ephemeral watercourses (oshanas) form a large inland delta, ca 10 000 km^2, which is a very important ecological unit that recharges groundwater aquifers, renews grazing for livestock and provides water for both people and animals. Freshwater lenses are formed during flood events under these channels, which illustrates the importance of these events concerning water availability during the dry season. Traditionally, hand-dug funnel shaped ponds called *omifimas* were constructed in order to get to this freshwater, which was the only source of freshwater in the past until the construction of the pipeline network.

The groundwater table in the Cuvelai-Etosha Basin is very flat with a gradient of only 0.2 ‰. Groundwater flow, increasing age and salinity of the groundwater are all directed towards

Etosha Pan. The Main Shallow Aquifer (MSA) is brackish to saline, situated ca 0-40 m b. g. l. (meters below ground level), with lenses of freshwater directly underneath the oshanas, situated ca 0-20 m b. g. l., resting above the saline water (Christelis and Struckmeier, 2001).

An aquitard is a saturated but poorly permeable geological formation that does not yield water freely to a well or borehole (Christelis and Struckmeier, 2001). However, an aquitard may transmit large quantities of water to and from adjacent aquifers. Under such conditions, it is difficult or impossible to extract the groundwater economically, as is the case in the central oshana area, which also applies to the study area. An unconfined aquifer is an aquifer where the water table is exposed to the atmosphere through openings in the overlying material.

WATER CARRIER SYSTEM

The construction of the pipeline network was prioritised in the years directly following independence (1990), where water is taken from the Kunene River. The aim is to provide clean water at a distance less than 2.5 km away from every household (Marsh and Seely, 1992), but still in the year 2000 about 100 000 people had a longer distance to clean water (Christelis and Struckmeier, 2001). The water is supplied from the Calueque Dam in Angola, led through a canal and pipeline system, via Olushandja Dam in Namibia and further led in a gravity-fed canal to Oshakati, where it also is cleaned by water-purifying plants. Though, the Olushandja Dam is a shallow reservoir with a substantial amount of water being lost by evaporation. The man-made open canals directed in a west-easterly direction, have considerable negative effects on the shallow, mainly north to south directed, low gradient natural oshana drainage system, resulting in that less flooding water nowadays reaches the south and not as far as it did previously. This artificially created water shortage has probably implications for the environment and economic activities in the area, resulting in reduced carrying capacity.

GRAZING INTENSITY

Degradation of rangelands may be defined as a grazing-induced long-term reduction in capacity to produce vegetation cover as a whole, due to high grazing intensity (Pickup and Chewings, 1994). This in turn leads to a decrease in forage availability for livestock at the same time as the pressure on the whole system increases, due to increased pressure on the remaining grass cover caused by continued grazing. The palatable grasses disappear and are replaced by less desirable species, with lower nutritional content. Dahlberg (1996) suggests the use of the term *environmental change,* forcing each user to specify the environmental changes and to discuss whether land degradation has occurred, and if so according to what criteria.

Dryland ecosystems may not be at equilibrium, given that animal and plant population ratios are constantly changing, due to varying weather conditions such as rainfall, and hazards such as fire (Scoones, 1993). These changing conditions make it difficult to predict the status of an ecosystem at a particular point in the future. The systems are operating out of equilibrium most of the time, when controlled by frequent drought perturbations, but when these perturbations is frequent and seem to be dominate events, these disturbances can be considered as a part of the system (Lusigi and Buursink, 1994). Current thinking indicates that pastoralism is an effective response to the uncertainties of a difficult natural environment and eventually will increase the productivity of the land (Scoones, 1993). The carrying capacity concept must be regarded as a very flexible system in the semi-arid area of Ombuga Grassland, following a climate-driven dynamic sort of ecosystem behaviour with a significant change to the system caused by the introduction of the pipeline network, suggesting that overgrazing is now a major problem in the area, instead of water shortage as in the past.

LOCAL CHARACTERISTICS

The study area constitutes a part of the Uuvudhiya Constituency to the north of Etosha National Park (FIG 1), at approx. 1100 m a. s. l. The area is characterised by weakly matured sodic sandy soils (arenosols), with layers of hard crusts or a hardpan close to the surface. The local climate is dry, with prevailing semi-arid conditions and an average annual precipitation of about 350 mm in the south-west and approx. 450 mm in the north-east of the study area.

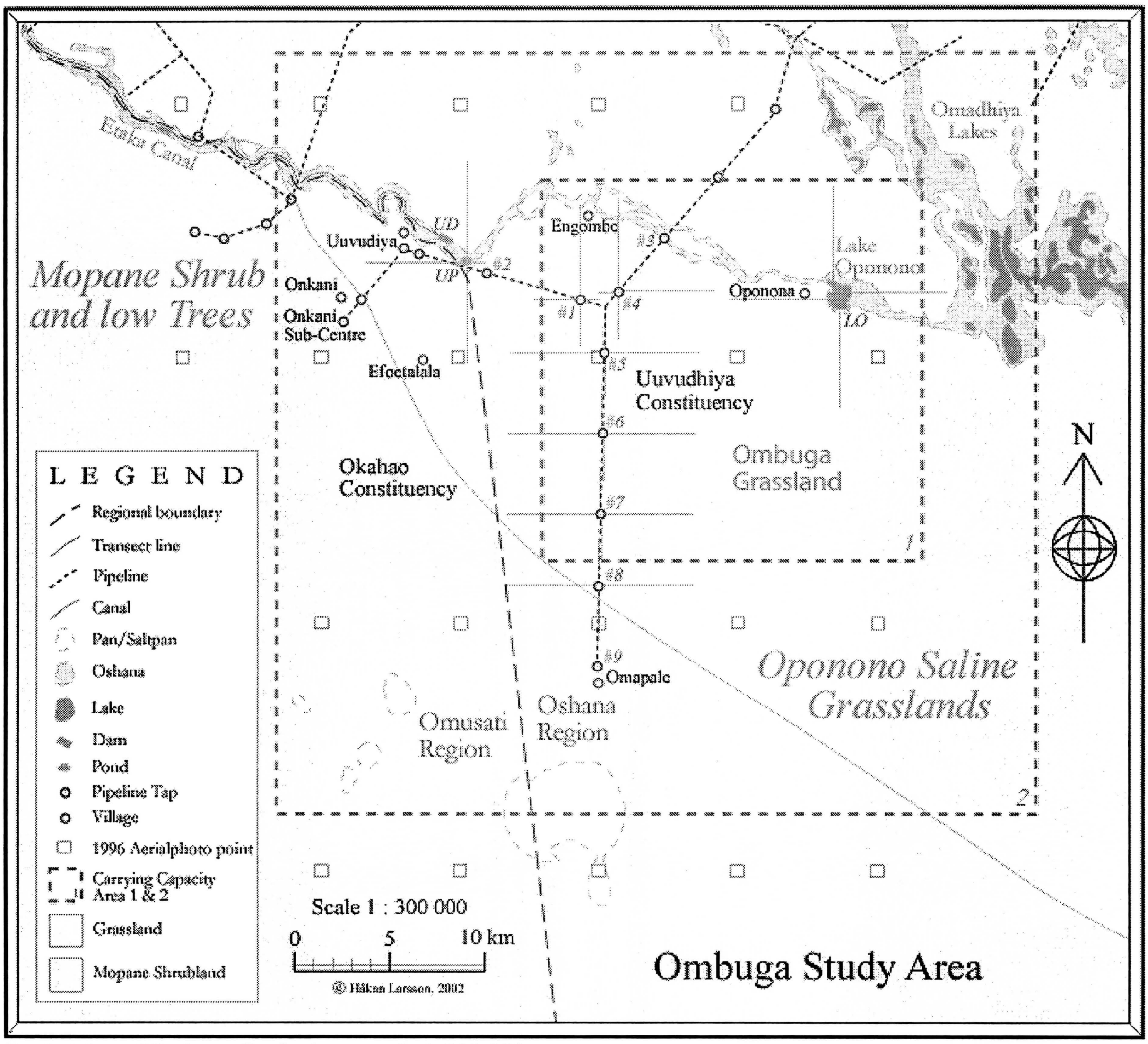

FIG 1: Map of Ombuga Study Area, scale 1:300 000.

Before the late 1960s the region was sparsely populated by semi-nomadic agro-silvio-pastoralists, who migrated between water sources guiding their livestock to rangelands with good grazing opportunities. The first permanent settlement was established in 1968, compared with 107 families (9 persons/family) in the Onkani community in year 2001 (Christelis and Struckmeier, 2001). Human activity has brought significant changes to the area, with large trees and wildlife having disappeared and artificial water points have been constructed.

The in-migration of livestock from other parts of the north-central region is a relatively new phenomenon, started about three years before independence and increased dramatically after independence, coinciding with the pipeline network construction (1992-93). This rapid influx of livestock from other regions also led to the establishment of permanent cattle posts by people from outside the Constituency.

The main water pipeline, Oshakati-Omapale Pipeline, ends in the mopane shrubland close to Omapale (FIG 1). The pipeline is also connected with a branch in the northern part of the study area running westwards to Onkani Sub-Centre (FIG 1). The pipeline taps are spaced approx. 5 km, or less, apart. The Etaka Canal, a major oshana and the area's central drainage channel, dominates the northern part of the fieldwork area, running towards Lake Oponono (FIG 1).

VEGETATION TYPES

This area is conditioned with low moisture and low nutrient availability. The main feature in the study area is the flat Ombuga Grassland, with the *Oponono saline pan and grasslands vegetation type,* and mopane savannah, with its bush vegetation in the south-western part of the study area (FIG 1), *mopane shrub and low trees on loamy sandy soils vegetation type*. The sandy soils is underlain by a salty, impermeable layer of clay and sandstone hardpan that prevent the growth of most woody species and are unsuitable for crop cultivation. Perennial grasses dominate the Ombuga area, but are in decline, especially in the close vicinity of water points. *Eragrostis nindensis* and *Sporobolus iocladus* are examples of desirable grass species in the area and *Aristida stipoides* and *Odyssea paucinervis* of species concerned with a very low forage factor.

WATER POINTS IN THE STUDY

Lake Oponono (LO) has water throughout the year, as well as Uuvudhiya Ponds (UP) with the help of a series of man-dug ca 5 m deep ponds or omifimas. The water in both these sources deteriorates during the dry season, with increasing salinity due to evaporation and fresh water extraction together with contamination. Because of their natural occurrence, they have been used in the traditional nomadic pastoral system. Both of these areas are at present under very heavy utilisation and subsequent high grazing intensity.

Pipeline taps #1 and #4-8 was constructed in 1992-93. In the past, the surroundings along the pipeline through Ombuga Grassland only offered ephemeral water sources. Taps #1 and #4 are situated quite close to the main oshana (FIG 1), and thus the surrounding pasture area here may have been utilised to a larger extent in the past in comparison with the pastures around taps #5-7. Pipeline tap #8 is situated in the mopane shrubland, with a lower percentage grass cover than the grassland vegetation type but, in turn, linked to a different grazing regime because of the availability of mopane dry season fodder, from September and onwards.

FIELD SURVEY METHOD

The study intends to map the area around eight water sources with different utilisation history and situated in various natural settings, using the piosphere approach (Lange, 1969). To find out if grazing gradients have evolved around the foci points and if there are differences between water points with regard to their utilisation history. Gradients evolve due to rapidly decreasing concentration of animal activity, or grazing pressure, with the distance into the surrounding rangeland (Andrew, 1988).

From a centred water source sampling areas (10 x 10 m) are mapped along transect lines, based on vegetation cover (%) and the type of vegetation (according to classification below). Following four 5 km transect lines from each waterhole (to the N, S, E and W), the sampling is carried out at distances of 15, 30, 60, 120, 240, 500, 1000, 2500 and 5000 m from the origin. The increasing distance between sampling areas along the transect line reflects the pattern of animal activity. The 10 x 10 m sampling areas are divided into 1 x 1 m squares, which in turn are subdivided into 10 x 10 cm squares, in order to more easily facilitate the mapping of the percentage vegetation cover, about 2 cm above the ground surface. Types of vegetation and stratification are classified as:

1) Bare ground (BG), 0 m
2) Grazing or grass layer (G), 0-1 m
3) Unpalatable grass layer, *Odyssea* grass (SG), 0-1 m
4) Unpalatable shrub layer, *Grevia* shrub (S), 0.3-1.5 m
5) Browse layer I, *Mopane* shrub (MS), 0.3-2.5 m
6) Browse layer II, bush (B), 1.5-2.5 m
7) Browse layer III, tree (T), 2.5- m

RVA CLASSIFICATION AND TEMPORAL ALTERATION

A *Rapid Veld Assessment* (RVA) classification (Schneider et al., 2001) was carried out concerning the *Grazing or grass layer* (G). The RVA categories 0-5 have been quantified with regard to dry matter (DM) content per m^2 (Riise, 2003). Furthermore, comparisons were made of the present rangeland condition, based on the fieldwork data, with earlier times, in panchromatic aerial photographs from July 1964, preceding the construction of the pipeline network in 1992-93, and in aerial photos from August 1996. Information was also collected in a Landsat TM-scene from the same time as the fieldwork was carried out (17th July 2002).

RESULTS

There are negative systematic changes in vegetation cover or pasture in relation to water points along a 2 km radius (FIG 2). The best pasture condition prevails generally within an interval between approx. 2-2.5 km from the water points. After a 2.5 km distance the situation becomes more diversified; in some places the conditions remain unchanged and homogenous, but in others a decreasing pasture gradient is evident further outwards from the water point, i. e. illustrating a reversed grazing gradient (FIG 2).

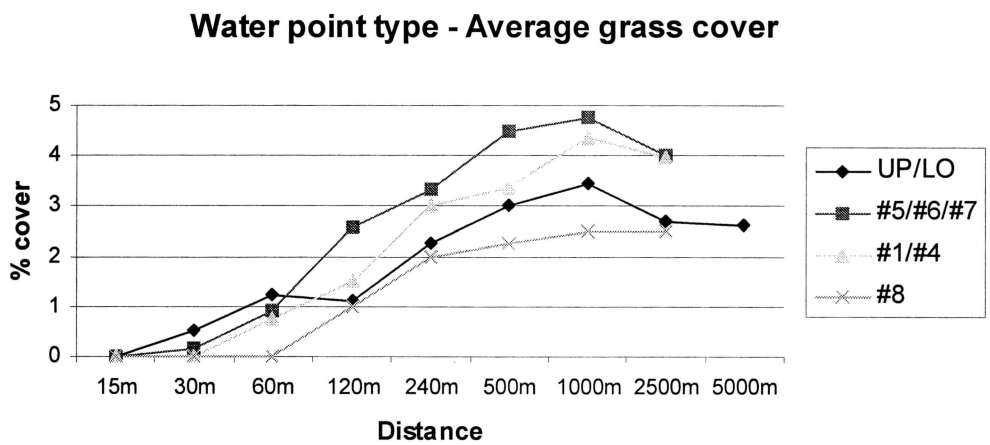

FIG 2: Average grass cover gradients per water point type (in regard to age of utilisation, environmental surroundings and kind of water point). UP – Uuvudhiya Ponds, LO – Lake Oponono and #1-8 – pipeline taps.

Around water sources that have been used for a longer period of time, from the 1960s like the Uuvudhiya Ponds and Lake Oponono, also linked with the highest stocking rate, the rangeland deterioration is more severe in comparison with the pipeline taps #5-7 (FIG 2). Pipeline taps #5-7 have the best surrounding pasture lands, followed by pipeline taps #1 and #4 (FIG 2), where pastoralism has a more intense utilisation history than around the area surrounding #5-7, which in the past was associated with a more pronounced water shortage in the dry season. Pipeline taps #5-7 are also linked with the lowest livestock grazing intensity.

DISTRIBUTION OF ODYSSEA GRASS (SG)

The distribution of the grass species *Odyssea paucinervis,* being almost unpalatable to livestock, reveals an interesting pattern (FIG 3). The *Odyssea* grass occurrence is evenly distributed in all directions from the water sources within a 500 m radius, but then this picture changes. There are relatively high concentrations of this saline tolerant grass species to the south of the oshana channel and especially to the south of Lake Oponono, as well as to the east of pipeline taps #5-7. But along the transect lines in the opposite direction, this abundant halophyte condition does not appear (FIG 3).

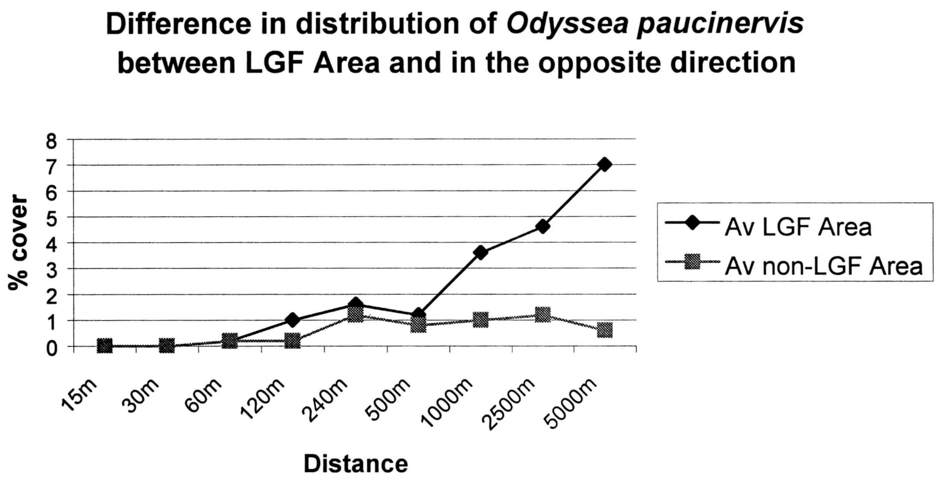

FIG 3: Distribution of unpalatable *Odyssea paucinervis* grass to the south of UP, LO and to the east of #5-7 (Av LGF Area), vs. the opposite direction (Av non-LGF Area). LGF – Local groundwater window/formation.

GRASS COVER AND RVA CLASSIFICATION

In mid July, with more than 3 months left of the dry season, almost all pasture around Lake Oponono is already grazed off. The situation around Uuvudhiya Ponds, pipeline taps #1 and #4 is similar. The pasture availability around pipeline taps #5-7 is still good. The result of the RVA classification reveals that ca 65 % of the sampling points (79 points), located at least 1000 m from the studied water points, belong to RVA-class 1, ca 23.5 % belong to RVA-class 2 and ca 11.5 % to RVA-class 3.

INTERPRETATION OF SURVEY RESULTS

The sampled data support the theory that land degradation is taking place due to overgrazing, showing a gradual negative change in the desirable species composition and percentage vegetation cover with the age of water source utilisation and prevailing livestock pressure. The limiting resource of the area concerning livestock has shifted from water to pasture, but in the case of pasture production the scarce resource is still water. The dynamics of the natural ecosystem was put out of function by the introduction of artificial watering points. A new ecosystem was created, characterised by critical variations in grass production from one year to another. Distribution systems, like this pipeline network with access to new water points, closely located, designed to solve the water problem for livestock production do not seem to be sustainable in the long run on communal land. On communal land anyone is allowed to utilise the pastures, which easily causes overstocking. Reallocation of water resources in this way also diminishes an area's supply of reserve pasture for livestock consumption in cases of drought, thus lowering the region's resilience in times when such events occur.

LOCAL GROUNDWATER WINDOW

The oshana channel and Lake Oponono also seem to affect the groundwater that slowly flows southwards in some way; it is in areas to the south of the surface water system that the unpalatable halophyte specie *Odyssea paucinervis* is thriving better than in areas elsewhere. The northern part of Lake Oponono may emit groundwater to this groundwater window, coming into contact with the atmosphere and through the evaporating effect of sun rays large quantities of the groundwater in the open window are lost, corresponding to the potential evaporation rate, which makes the remaining water mass enriched in salt elements, before the water continues its southward motion as underground water again. However, not even *Odyssea paucinervis* seems able to cope with the high grazing intensity that persists closest to the water sources and ca 500 m outwards from them, but this less desirable grass species is more resistant than the more palatable grasses seems to be.

OTHER FACTORS INFLUENCING RANGELAND

The natural water distribution is seasonal, this factor promotes transhumance in order to reach an optimal range utilisation and is probably the force behind the *reversed vegetation cover gradient* in some areas, approx. 2.5 km away from permanent water points. If the network of man-made watering points can be regulated in a specific scheme and be utilised together with natural water sources in the area, parallel with decreasing numbers of livestock, a long-term sustainable and ecologically optimised rangeland utilisation could be developed.

Over-utilisation of ecological resources by large numbers of livestock can trigger a shift in the precipitation controlled ecosystem to another system depending on water supplied from the pipeline network, with a negative long-term rangeland productivity. Low rain years in Ombuga Grassland may lead to a higher grazing pressure of this kind, due to transhumance from the interior of the Oshana area. Structural changes are difficult to determine, especially when climatic factors are variable, but when a change has become a fact it may be hard to reverse.

CONCLUSIONS

There are pronounced changes in vegetation cover around waterholes in Ombuga Grassland, caused by the construction of the pipeline in 1992/93 that led to a higher grazing pressure.

- Grazing gradients have developed and the vegetation cover is gradually decreasing.
- Bare ground spreading and decreasing vegetation cover in the study area is associated with i) distance from the focal water point, ii) how long the water point has been utilised, and iii) prevailed grazing intensity.
- Lake Oponono constitutes a groundwater window, belonging to the main shallow aquifer (MSA), which has the characteristics of an unconfined aquitard.

- From the RVA calculations and comparisons in aerial photographs, it may be possible to conclude that the average carrying capacity in the study area has diminished from ~18 ha/LSU (Livestock Unit) to ~26 ha/LSU during the last decade.
- In a perspective of ecological rangeland management and sustainable livestock raising, it does not seem to be a sustainable solution to have these many closely located man-made watering points on communal land, as long as the grazing intensity in the area remains high. Nonetheless, the water pipeline is an important and a sustainable solution in supplying rural residential households with fresh water at close range.