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Determining carrying capacities in highly variable and unpredictable environments - A Namibian perspective

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Abstract
Based on available national-level information, this paper proposes an approach to livestock status assessment in Namibia. Although there is no consensus on the appropriateness of equilibrium versus non-equilibrium models in arid rangeland science, planning tools are badly needed in developing countries where the majority of the population rely on livestock farming. The proposed map of stocking status in Namibia incorporates elements of both, conventional (equilibrium) concepts of range science in the form of carrying capacity, but also includes a measure of unpredictability of the environment (risk of farming), thus an element of non-equilibrium models. This map provides a planning tool for directing further field assessments and rangeland research in Namibia.

Key words: desertification, equilibrium, livestock, rangeland, resource management, Southern Africa

Introduction
Adapting livestock numbers to what the land can support sustainably is of pivotal importance in arid and semi-arid rangelands. This is particularly so where livestock farming is often the only means for the rural population to make a living, such as in many parts of Namibia. Rangeland degradation is evident in Namibia (Seely *et al.* 1995; Zimmermann 2010) and there is debate on whether or not equilibrium or non-equilibrium models apply to Namibian rangelands, as elsewhere in arid rangelands (e.g. Ellis & Swift 1988; Mentis *et al.* 1989; Westoby & Noy-Mei, 1989; Gillson & Hoffman 2007).
While there is no consensus on the appropriateness of either concept (Cowling 2000), planning tools are badly needed as an important step towards reversing rangeland degrading processes and to guide national initiatives such as the government's resettlement programme (Falk *et al.* 2010). One such planning tool has been compiled on a national level in Namibia in a comprehensive publication of environmental data (Mendelsohn *et al.* 2002). The "Atlas of Namibia" includes a suggestion for determining the status of stocking rates by combining a map of carrying capacity with stocking density. Carrying capacity was based on the assessment of the Agro-Ecological Zoning project of the Ministry of Agriculture in Namibia and a UNDP

report (1998). The resulting composite map illustrates areas that are overstocked and those that have potential for more stock (Mendelsohn *et al.* 2002, p. 151). Although the explanatory text makes reference to the debate on determining carrying capacity, the composite map carries the risk that, if used in isolation, it may convey misleading information for development planning. However, the authors also provide a nation-wide assessment of risk of farming, based on average and variation in rainfall and plant productivity (Mendelsohn *et al.* 2002, p. 152). The purpose of this paper is (1) to suggest a transparent method for combing these two maps, and (2) to review the resulting "stocking status" against published information from the field. The resulting map would provide a planning tool for rangeland management which also incorporates a measure of environmental variability, thereby incorporating elements of equilibrium and non-equilibrium rangeland theory.

Materials and Methods

A transparent process to combine the quantitative data of the livestock density minus carrying capacity map (referred to as "composite map") (Figure 1) with the qualitative data of the "risk of farming map" (Figure 2) is required. In order to align the values of the composite map with the seven qualitative classes of the risk map, intervals of 10 were used and values were assigned to seven classes in the risk map in a reverse order (i.e. high = 60, low = 0). The reverse order would match the range of values on the positive (understocked) side of the composite map scale (Table 1). The values of the risk map were then subtracted from those of the composite map for each resulting mapping unit. The same class interpretations as in the composite map were used in the resulting map of stocking status (Table 1). However, while the composite map is based on real values (kg livestock weight / unit area), the livestock status map generated relative values, as it was not possible to convert the risk of farming to livestock-related field data.

Table 1. *Class intervals and median of composite (livestock density minus carrying capacity; values reversed from classification of Atlas of Namibia to indicate positive for potential for more stock) and risk of farming map; and class intervals for stocking status map (there were no polygons in the class ranges -80 to -60 and -100 to -80, and these have thus been omitted from the map).*

Livestock density minus carrying capacity (kg/ hectare)		**Risk of farming**		**Stocking status**	**Interpretation**
Existing class	**Median**	**Existing class**	**Median**	**Class**	
More than 60	70	1 (high)	60	More than 60	potential for more stock
40 to 60	50	2	50	40 to 60	
20 to 40	30	3	40	20 to 40	
-20 to 20	0	4	30	-20 to 20	near carrying capacity
-20 to -40	-30	5	20	-20 to -40	
-40 to -60	-50	6	10	-40 to-–60	overstocked
-60 to -80	-70	7 (low)	0	Less than -100	
-80 to -100	-90				
Less than -100	-110				

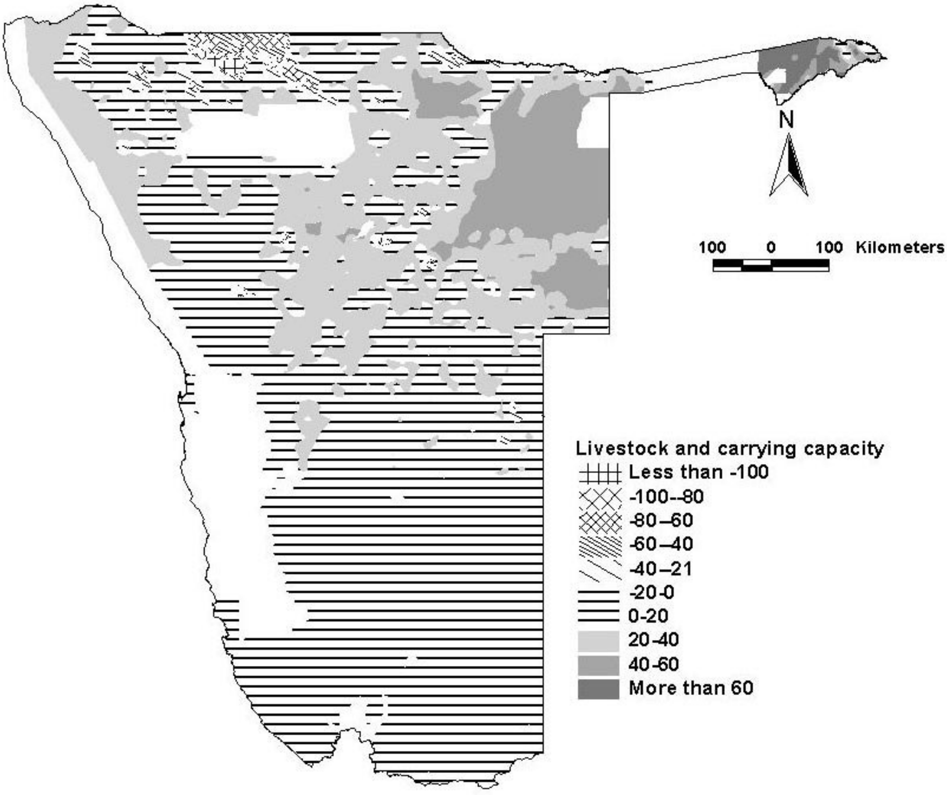

Figure 1: *Composite of stocking rates minus carrying capacity (kg/ha) (white = protected areas) (after Mendelsohn et al., 2002; values are reversed to indicate positive for potential for more stock).*

Results and Discussion

The resulting map of stocking status (Figure 3) showed a similar pattern to the composite map (Figure 1), but areas showing potential for additional stock are approximately 50 % reduced due to the high risk of farming in half of the country. This is particular evident in the western, arid regions, which also experience the highest variability in rainfall and resulting plant production. Areas with potential for more stock (all shaded areas in Figure 3) are now only found in the higher rainfall areas in the north-east of the country with extensions into the central area. The inclusion of "risk of farming" has eliminated all areas in the arid west that were depicted on the composite map as having potential for more stock (Figure 1).

Does the resulting map of livestock status provide a better reflection of areas that may have potential for more stock than the composite map? Although field assessments in all resulting mapping units are required to verify these maps, assessments available in the literature give

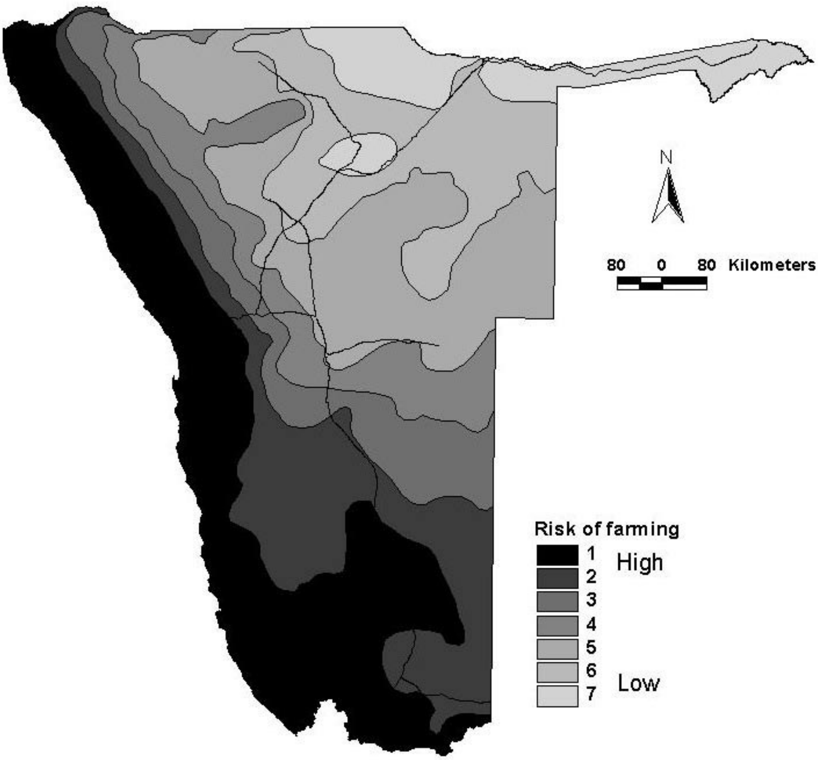

Figure 2: *Risk of farming (after Mendelsohn et al., 2002).*

some indication. Some of the areas depicted on both maps as suitable for more livestock, for example in parts of the Caprivi and Kavango Regions, have indeed been evaluated in field assessment to be able to absorb more livestock (Hines & Burke 1997; Burke 1998; Directorate of Rural Water Supply 2000). However, similar assessments for the Kunene Region in areas depicted on the composite map with potential for more livestock (Figure 1), but now with no further potential for additional livestock once risk of farming was incorporated (Figure 3), report degradation in many of these areas (Schulte 2002) and a reduction in livestock numbers has been called for (Directorate of Rural Water Supply 2001). Similarly rangelands in the central west of Namibia (Erongo Region) are stocked under the nationally recommended carrying capacity due to a shortage of available grazing, despite an abundance of water points (Burke 2004). Many areas in the south of Namibia, depicted as stocked to capacity on the composite map (Figure 1), are degraded, particularly in the communal areas (e.g. Dreber & Falk 2010). The stocking status map shows these now as negative, thus no more potential for absorbing more livestock (Figure 3).

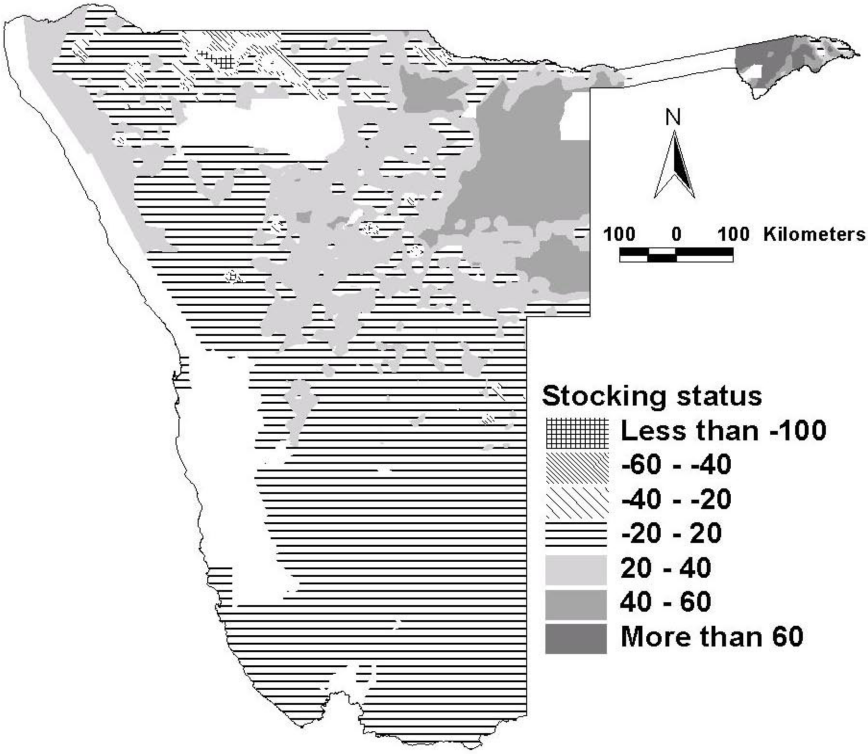

Figure 3: *Stocking status based on composite map incorporating risk of farming (white = protected areas; shaded areas indicate potential for more livestock).*

Although the new map of stocking status provides a tool at the national level, and appears to provide a more realistic reflection of the status of Namibian rangelands, some aspects have to be kept in mind when using this map. (1) The level of detail in the underlying base data determines the final outcome of the composite and stocking status maps. Maps of carrying capacity in Namibia vary widely (van der Merwe 1983; Sweet 1998; Ministry of Agriculture 1998), and the choice of map integrated in this process will determine the outcome of the synthesised maps. (2) Although the stocking status map was based on a mathematical procedure and long-term data, there are different ways to combine these data. The values in the stocking status map have no direct correlation to livestock-related field data and this map only provides a relative measure. In a field situation, for example, a high risk of farming does not necessarily require the subtraction of 60 kg/hectare from established carrying capacities. (3) A national level assessment cannot incorporate the detail expressed in topography and resulting vegetation types on the ground. Large mapping units show variation in usage, particularly where topography is varied (Directorate of Rural Water Supply 2001). Animals do not graze or browse homogeneously over vast areas (DeSimone & Zedler 1999), and as elsewhere in arid rangelands (Milchunas & Noy-Meir 2002), grazing impacts in Namibia are higher in level areas than on slopes (Joubert 1997), and in certain vegetation types (Burke 1997; Strohbach 2000). Forage quality differs significantly between vegetation types. For example, *Burkea* savannah in the north-east of Namibia (Burke 2002) which is depicted as understocked (Figures 1 & 3), is a very nutrient poor vegetation type with many unpalatable species, slow regrowth and thus poor resources for herbivores (Byrant *et al.* 1989). Carrying capacity, numbers of livestock and farming risk cannot provide an indication of the condition of the rangeland. Hence all areas depicted with potential for more stock (Figure 3) will require detailed field assessments prior to development (e.g. water points or resettlement), particularly with regard to status of the rangeland and grazing management. This map provides guidance at the national level, but the status of the rangeland needs to be determined in the field and at the scale of the proposed development.

Conclusion

The developed map of stocking status in Namibia provides a planning tool for rangeland research and management and appears to indicate a realistic assessment of stocking status in areas where information from the field has been published.

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References

Burke, A. 1997. The impact of large herbivores on floral composition and vegetation structure in the Naukluft Mountains, Namibia. *Biodiversity & Conservation* 6: 1203-1217.

Burke, A. 1998. Vegetation resources of Nolidep pilot communities – Fumbe, Kavango Region. Report for Northern Regions Livestock Development Programme.

Burke, A. 2002. Present vegetation in the Kavango Region. *Journal of the Namibia Scientific Society* 50: 133-145.

Burke, A. 2004. Range management in arid Namibia - What can livestock numbers tell us? *Journal of Arid Environments* 59: 387-408.

Byrant, J.P., Kuropat, P.J., Cooper, S.M., Frisby, K. & Owen-Smith, N. 1989. Resource availability hypothesis of plant antiherbivore defence tested in a South African savanna ecosystem. *Nature* 340: 227-228.

Cowling, R.M. 2000. Challenges to the "new" rangeland science. Trends in Ecology and. *Evolution* 15: 303-304.

Desimone, S.A. & Zedler, P.H. 1999. Shrub seedling recruitment in unburned Californian coastal sage scrub and adjacent grassland. *Ecology* 80: 2018-2032.

Dreber, N. & Falk, T. 2010. Ecological impacts of communal farming in southern Namibia: an interdisciplinary case study. In: Hoffman, M.T., Schmiedel, U. & Jürgens, N. (eds) Biodiversity in southern Africa 3: Implications for landuse and management. pp. 101-104. Klaus Hess Publishers, Göttingen & Windhoek.

Directorate of Rural Water Supply 2000. Caprivi Region – Rural Water Supply Development Plan. Windhoek Consulting Engineers, Windhoek.

Directorate of Rural Water Supply 2001. Kunene Region – Rural Water Supply Development Plan. Windhoek Consulting Engineers, Windhoek.

Ellis, J.E. & Swift, D.M. 1988. Stability of pastoral ecosystems: alternative paradigms and implications for development. *Journal of Range Management* 41: 450-459.

Falk, T., Kruger, B., Lohmann, D. *et al.* 2010. Economic and ecological indicators of landreform projects in eastern Namibia. In: Schmiedel, U. & Jürgens, N. (eds) Biodiversity in southern Africa 2: Patterns and processes at regional scale, pp.200-206. Klaus Hess Publishers, Göttingen & Windhoek.

Gillson, L. & Hoffman, M.T. 2007. Rangeland ecology in a changing world. *Science* 315: 53-54.

Hines, C. & Burke, A. 1997. Vegetation survey of NOLIDEP pilot communities. Report for Report for Northern Regions Livestock Development Programme.

Joubert, D.F. 1997. Grazing gradients in the Highland Savanna vegetation of Namibia. *Dinteria* 25: 69-86.

Mendelsohn, J., Jarvis, A., Roberts, C. & Robertson, T. 2002. Atlas of Namibia. David Philip Publishers, Cape Town. URL for data: http://www.the-eis.com

Mentis, M.T., Gossman, D. Hardy, M.B., O'Connor, T.G., O'Reagain, P.J. 1989. Paradigm shift in South African range science, management and administration. *South African Journal of Science* 85: 684-687.

Milchunas, D.G. & Noy-Meir, I. 2002. Grazing refuges, external avoidance of herbivory and plant diversity. *Oikos* 99: 113-130.

Ministry of Agriculture, Water and Rural Development 1998. Agro-ecological zoning project. Ministry of Agriculture, Water and Rural Development, Windhoek.

SEELY, M., HINES, C. & MARSH, A.C. 1995. Effects of human activities on the Namibian environment as a factor in drought susceptibility. In: Coping with aridity (Eds. R. MOORSOM, J. FRANZ & M. MUPOTOLA). Brandes and Apsel Verlag, Frankfurt.

STROHBACH, B.J. 2000. Vegetation degradation trends in the northern Oshikoto Region: I. The *Hyphaene petersiana* plains. *Dinteria* 26, 45-62.

SWEET, J. 1998. A rainfall model for estimating carrying capacity. Ministry of Agriculture, Water and Rural Development. Northern Regions Livestock Development Project, Windhoek.

SCHULTE, A. 2002. Stabilität oder Zerstörung? Veränderungen der Vegetation des Kaokolandes unter pastoralnomadischer Nutzung. In: Kaokoland - Interdisziplinare Perspektiven zu Kultur- und Landschaftswandel im ariden and semiariden Nordwest Namibia (Eds. M. BOLLIG, E. BRUNOTTE & T. BECKER). Kölner Geographische Arbeiten Heft 77, 101-118.

UNDP 1998. Namibia: human development report. United Nations Development Programme, Windhoek.

VAN DER MERWE, J.H. 1983. National Atlas of South West Africa. National Bookprinters, Goodwood.

WESTOBY, M.B.H. & NOY-MEIR, I. 1989. Opportunistic management for rangelands not at equilibrium. *Journal of Range Management* 42: 266-274.

ZIMMERMANN, I. & SMIT, G.N. 2010. Impact of landuse at landscape level, using fenceline contrasts and best-practice case study. In: SCHMIEDEL, U. & JÜRGENS, N. (eds) Biodiversity in southern Africa 2: Patterns and processes at regional scale, pp.214-221. Klaus Hess Publishers, Göttingen & Windhoek.