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MANAGING DESERT ENVIRONMENTS FOR SUSTAINED HUMAN BENEFITS

Lessons from Namib Desert Research

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Abstract. A scientific understanding of processes determining the distribution, abundance and habitat dependence of desert organisms including humans and the source of their energy and water resources may be used to substantially manage desert environments. Thirty years of Namib Desert studies show that life systems there depend upon unpredictable heavy rainfall events, advective fog and linear oases formed by ephemeral rivers crossing the desert. The contribution of the coastal Namib Desert to the Namibian economy is based primarily on tourism, urban cities and resorts. Benefits to Namibia from coastwise agricultural settlements are outweighed by losses of landscape appearance values (98 words).

Deserts provide obvious examples of the relationship of ecological principles to environmental processes (*Noy-Mier 197x, Seely & Louw 198x). As such, they provide guidelines for the sustainable management of arid landscapes (Seely and Jacobson 199x). In Namibia, a country composed of 97% arid and semi-arid land, over thrty years of desert research results (*TM Monograph) are now being applied to natural resource management issues (*e.g. Hines, Marsh and Seely 199x) in this newly independent, developing country.

Time scales of natural processes in deserts and arid lands are protracted, far more so than are those of more mosic environments. Long-term studies may eventually accommodate these extended intervals. In addition, examination of the historical record provides insights into the functioning of arid ecological systems. This record is particularly well suited to the study of desert environments because the record is often preserved and be accessible for study in the form of biological and geomorphological deposits (*Ward, Lancaster and Seely 1989).

Here we identify the relationship of basic research studies of the Namib Desert to management of this desert and other deserts and arid lands. We do so by illustrating the application of relevant climatic, landscape, biotic and human interrelationships to information needs and management guidelines. Some of these suggestions are broadly applicable to arid lands in general, but we confine our attention to the Namib Desert west of the 1000 m contour and the 100 mm rainfall isohyet (*Kock 1962). Although the same basic principles apply to management issues elsewhere such as the relationship of agriculture to arid lands, especially that of domestic livestock grazing to maintenance of viewscapes, management implications of agricultural impacts on fragile substrates are not addressed here. This additional aspect of arid lands management is considered elsewhere (*e.g. March and Seely 199x, Scoones 1996).

We discuss the contribution of basic research to sustainable use of the Namib Desert environment, not simply to conservation or preservation of a natural condition. In deserts, fragility of the substrate and the certainty of aridity and non-equilibrial conditions necessitate application of results from region-specific or even site-specific research to formulate and implement plans and policies for sustainable resource use. Two key aspects of desert conservation and sustainable use, the importance of viewscapes and the ease with which low economic gain activities can eliminate the potential for high economic gain use, are considered. The contribution of research is particularly relevant in Namibia where tourism, in large part based upon the attractions of the desert environment, is the fourth largest income sector of the economy following mining,

agriculture and fisheries. Mining is based upon finite natural resources and agriculture and fisheries are in decline, leaving tourism a significant and growing role to play.

Issues, management responses and recommendations

Issue 1: Climate, rainfall variability and aridity

A salient feature of all arid environments is the high variability of rainfall. Episodic Namib Desert rainfall drives biological processes, resulting in infrequent and unpredictable explosions of primary productivity. Highly variable Namib Desert rainfall events are complemented by the more regular occurrence of advective fog (*Lancaster, Lancaster & Seely 198x, Seely in Polic 199x). The coastal fog-based ecosystem, while producing biological diversity of great interest to biologists and tourists, supports low primary productivity unsuited to agricultural activity (*Seely.Shell). The fundamental differences between these two systems, one driven by fog, the other by rainfall, require alternative but complementary guidelines for management. Table 1 summarises the results of a variety of studies and observations of the response of the Namib desert biota to these two moisture sources. An understanding of the relationships of these difference components to the desert environment is essential for adequate management.

Table 1. Response of plants and herbivores to alternative moisture sources in the Namib; use by indigenous and domestic animals of plants sustained by these moisture sources.

Indigenous plants
Indigenous animals
Domestic livestock

Fog
Sustains established growth of adapted perennial plants
Many species take up fog directly/Consume plant materials
Do not use fog/Plants not used; not generally available

Low rainfall
Germinates annual plants
Local or long-distance movements in response to temporarily increased biomass
Local destruction of local/long distance movements

High rainfall
Germinates annual plants and germinates and establishes perennial plants
Population growth in response to increased biomass
Herd increase

Threshold levels of rainfall are essential for germination and development of vegetation, smaller amounts for annuals than for perennials. In the Namib, rainfall and vegetation increase along a gradient extending from the coastal fog belt to more mesic inland environments (*Seely 1976/gradient). Long-term studies show that infrequent, major rainfall events in the arid Namib Desert produce extensive plant production effects which may endure for several decades (*Seely & Louw 1980). The widespread 1976/78 rainfall episode produced perennial vegetation which remains the nutrient base for the functioning of the current (1997) dunes ecosystem twenty years later.

At the higher inland end of the rainfall gradient, more frequent, but still irregular rainfall events provide sufficient productivity to sustain flourishing natural ecosystems and temporary livestock grazing. The rainfall schedule is inadequate to produce sustainable large-scale agricultural operations. In these areas bordering the Namib desert core, the natural rainfall variability is interpreted by land users as resulting in frequent drought.

The current management response to this natural gap between pulses of high plant production by importing stock feed as drought relief.

Natural variability of the rainfall in deserts and arid environments ensures that they are non-equilibrial systems (*Behnke et al. 1993, Scoones 1994). In Namibia, long-term data from the Namib Desert permits a comparison of the functioning of a low energy, quasi-equilibrial system based on fog with that of a higher energy, non-equilibrial system based upon far more variable rainfall (Seely and Louw 198x). Management implications for non-equilibrial systems are particularly pertinent in developing countries such as Namibia where the usual management responses as grazing to fixed carrying capacity and rotational grazing are inappropriately based on equilibrial systems (*Scoones 1994). Consideration of the climate issue leads to the recommendation that the variable climate and its manifestations should be the basis for all policy, planning and management decisions.

Issue 2 Landscape and habitats

A salient feature of desert landscapes is the limited and isolated nature of most key resources. Oases, formed by springs, seeps and ephemeral rivers, provide water and support more diverse and abundant vegetation than surrounding areas. These limited and isolated key resources, water in particular, allow wildlife and domestic stock to use the surrounding lower quality forage. As a consequence, maintaining the integrity of these isolated oases is essential for tourism and to sustain traditional domestic livestock practices. These key resources require specific guidelines for their effective management (*Jacobson et al. 1995). And the integrity of these isolated oases is essential for tourism and to sustain traditional domestic livestock understanding of the relationships of these varied components to the desert environment as a whole is necessary if adequate management is to be practiced.

Other important landscape elements are widespread in extent although some are fragile in nature. (*e.g. Daneel 198x, Hamilton & Seely unpublished). Many of the widespread landscape elements in desert environments provide high viewscape values (e.g. Tarr 199x). In that portion of the Namib Desert we consider here, these viewscapes support low primary productivity, but are highly attractive to tourists. Sand dunes, gravel plains and isolated inselbergs are good examples of elements contributing to attractiveness of the Namib Desert for tourists. Differing management approaches are required for such different habitats as desert dunes and gypsum plains (Schieferstein 199x) but in all cases casual traffic, whether for exploration for minerals, adventure, or for any other reason , should be limited and closely regulated.

2.1 Oases and water

Ephemeral rivers cross the Namib aridity gradient, creating linear oases and, at their termini, small flood plains (J.J and S 199x). Riparian vegetation generated by occasional flooding is a major source of nutrients for large desert mammals (Hamilton et al 1976?; Viljoen and Bothma, 1990) and supports pastoral settlements (*Ward, 199x, Seely et al 197x (Buskirk etc). These relatively productive rivers are also central places, refugia and water sources for large mammals and some of the birds that range outward from them, in some cases covering the entire desert area (*Hamilton et al 1975, Viljoen 1979). Springs, seeps and isolated perennial wetlands along the course of ephemeral rivers play a complementary role. Dependence of such a great part of the functioning of natural life systems upon the oases places their use in direct conflict with the small populations of humans who depend upon the associated vegetation to support their livestock herds (J..J.S 199x).

In addition, extraction of upstream water from the ephemeral rivers consumes surface and subsurface water flows, reducing productivity and mortality of vegetation downstream (J J S 199x, *Dauseb et al. 1996). Unsustainable use of ephemeral river water, particularly if it competes with wildlife, livestock and human domestic consumption, is unwise (Dewdney 1996).

While oases are inviting places to settle, tourism and agricultural potential and sustainable use of desertic regions is compromised by such settlements. Fencing, development pf homesteads and privatisation preclude communal use by all in multiple use areas and prevent access by wildlife. In addition, concentration of people and livestock intensify the grazing gradient and preclude seasonal use of surrounding grazing, making travel to water sources less productive. National or regional policy should be to exclude private use of and settlement at oases. Ground water usage for all purposes should be limited to sustainable yields. Since linear oasses in arid regions often pass through lands under mixed ownership and management regimes, a catchment approach to planning and management of water usage is desirable (e.g. JJS). Because of their sensitive nature, key resources such as seeps, springs, oases and man-made wells should be managed so as to maintain their productive functioning indefinitely.

2.2 Dunes and plains

The southern Namib Desert dune sea is relatively invulnerable to destruction. However, the touristic attractiveness of these dunes is determined by the dunes landscape, associated with interdunes valleys and other geomorphological features particularly susceptible to permanent scarring by off road vehicle use. To date, the use of these dunes has been adequately controlled.

In the northern Namib, barchan dunes and other sand formations, produced by the replication of rivers and sand formations lying to their north, has created spatial arrangements favourable for speciation of substrate dependent species (*Griffin and Seely 198x). The northern Namib, because it is narrow, relatively small and more accessible, is relatively vulnerable to destruction. To date, there has been a policy of no off road vehicle usage in the northern Namib dunes and the relatively pristine character of these dunes persists (*Tarr 199x). The success of this early policy shows the value of establishing agreed upon management policies before problems arise. It also seems to show that there is broad community support for an aesthetic value that could not initially be identified as being economically important. Sometimes we as naturalists discover settings, determine their naturalistic value before others have arrived, and later find that our value judgements about the value of these sacred places was both anticipated and followed. (This is bullshit and needs to be erased – just thinking out loud)

2.3 Biota

Desert biota feature unusual physiological and behavioral adaptions by many endemic species and widespread movements of some of the larger mammals and birds. Variability or uniformity of the habitat influences distribution and speciation of many specialised species (*Griffin/Seely 198x). The Namib Desert in particular supports a high diversity of invertebrates (*Seely JAE 198x) as a result of its two moisture sources, long-narrow shape and apparent longevity of the desert conditions (*Ward, Lancaster and Seely 198x). As a result, the condition of habitat is a primary consideration in maintaining the integrity of desert diota. Many specialised and unusual adaptions, particularly of smaller organisms, result in high touristic and educational value of the biota but limit its attractiveness because of scarcity and difficulty of observation. As a consequence, sustainable use of the desert biota , particularly in support of tourism and education, requires well publicised results of a variety of basic research endeavours over a broad range of topics strongly supported by materials including videos, local information centers and well trained guides.

The productive capacity of arid lands sustains only a minor fraction of that of more mesic lands (table 2). Thus, while the productivity of various Namib Desert habitats fluctuates dramatically according to the vagarics of rainfall incidents, the overall capacity of this environment to support grazing and especially browsing depends upon rainfall intensity and duration. In the desert where elephants depend upon riparian retreats, browsing up to 90 km from water during 4-day sorties (Viljoen 1979), plant productivity will inevitably limit abundance unless hunting holds population increases in check. First ecological principles dictate management of these herds at sustainable levels.

Table 2 Plant productivity of Namib Desert environments and habitats compared with that of other more mesic habitats elsewhere.

Habitat
Rainfall
Sustainable stocking

Namib

Elsewhere

Issue 3 Landscape values

One of the most important values of desert areas accessible for use on a sustainable basis is the viewscape or landscape value offered by the environment. Recreational use of the desert surface also has high economic value and offer the potential for sustainable development. In contract, mining has the potential for high economic gains over a relatively short time span while grazing domestic stock provides intermittent income dependent on variable rainfall. Policies, planning and management approaches require consideration of how the short term gains can be realised without compromising sustainable, long-term use of the desert environment.

3.1 Barren but fragile landscapes

A variety of research activities implemented in the Namib Desert have identified the value of and potential impacts on apparently barren but fragile landscapes. These studies have approached the question of fragility of the land directly and indirectly. Following directions established in the southwestern United States, Hamilton and Seely (198x) investigated the persistence of tracks from a variety of vehicle types and use patterns on the gravel substrate. Their research results have been incorporated into a variety of vehicle use policies and guidelines applied through the Namib Desert. More recently, Daneel (199x) addressed the impact of vehicular traffic on gypsum surfaces. By examination of the subsurface environment, she documented the compression of crystalline gypsum and long-term alteration of the subsurface soil formations. Her results have been incorporated into policies and guidelines particularly applicable to prospecting and mining activities along the coastal Namib. Both projects directly examining the impact of vehicle tracks on the desert surface also investigated the longevity of tracks made at random during the past decades and of experimental tracks laid down during the study. From these studies and other research observations (e.g. Watson 197x, other geomorphologists), it is clear that maintaining a pleasing viewscape on the Namib Desert plains requires knowledge and understanding of the potential impacts of alternative land use activities and policies as well as guidelines to minimize negative impacts.

3.2 Lichens, animals small and large

Gravel and gypsum plains, lichen fields and open viewscapes occupy extensive areas in the Namib Desert. Numerous studies of the lichen fields of the coastal Namib Desert (e.g. Schieferstein 198x, Hale 197x, Lange

199x) focus on the importance of maintaining the integrity of the habitat to support the broad diversity of lichens occurring in the Namib Desert. Many of these lichen fields are dependent on an intact gypsum surface where off-road vehicle damage is particularly noticeable. These extensive formations are associated with a mainly endemic fauna and flora (e.g. Seely 198x Shell) which constitute one of the major touristic attractions in the Namib Desert. This fauna and flora would not be of touristic interest, however, without the extensive basic research into their unusual, varied adaptations which has been undertaken (e.g. Viljoen 198x, Seely 198x, Hamilton 198x) and the interpretation of these adaptations for the tourist industry (e.g. Seely 198x, Craven and Marais 198x). Interpretation of the geological history and the lanscape attributes also plays a major role in the regard. (e.g. Ward 198x, Goudie 197x, Selby 198x).

3.3 Desertification

The term desertification, as currently defined and understood, describes loss of productivity caused by change in climate and/or human activity (Desertification convention). In the Namib Desert, loss of productivity can be caused in a variety of ways, for example, by off-road vehicle use, mining of water from subsurface riparian aquifers, reducing woody plant productivity, or over grazing on ephemeral grasslands (Seely and Jacobson 199x, 199x, Wolters 1994). Any loss of productivity in desert environments reduces their capacity to sustain wildlife, to marginally sustain domestic livestock, and to support active tourism.

In Namibia, basic research contributing to an understanding of ecosystem system structure and functioning in arid environments has made a major contribution toward combating desertification throughout the country (e.g. Seely and Louw 198x, Jacobson et al 199x). In particular, results leading to the understanding of climatic variability and the non-equilibrial nature of the productivity base have been of great value (e.g. Wolters, 1994). These research results have contributed not only to an understanding of arid system functioning but also to interpretation of these results for use by planners, policy makers and managers of natural resources (e.g. Jacobson et al 199x, March and Seely 199x, du Toit 199x). Since desertification in Namibia is causing great monetary losses to the government and individuals alike (Quan et al 1994), further research particularly contributing to the understanding of the processes and the associated economic loss is essential.

Issue 4 Land use planning

Effective management and sustainable use of the Namib Desert and arid lands in general should be based on appropriate land use planning. Deserts, despite their low productivity, have relatively high viewscape values. Land use planning should consider the relationship of use of primary productivity for domestic livestock to that of alternative uses. Human populations are growing rapidly in the drylands of the world, with much of the growth based upon pastoralism and dryland agriculture. While there may be some margin for further increases in the numbers of people and the bioass of stock in low primary productivity areas of desertic Namibia, a wise national policy, one in harmonious response to long term observations of rainfall vagarics and of the recurring natural regulation of the numbers of plants, animals and human populations, will call for limits upon further development before the relatively small resource base and its consumers become unbalanced. We view calls for drought aid in domestic areas as evidence that management has been unsuccessful and that a new management paradigm based upon sustainability within contraints offerd by aridity and its root cause, low and erratic rainfall, be adopted.

Large scale environmental planning requires environmental policy and law and the willingness of governments to plan for sustainable future – relationship to zoogeography.

4.1 Farming
4.2 Tourism

Given the essential assumption of sustainability there is no prospect for substantial resource-dependent increase in human population in Namibia's coastal zone. Limited productivity of the most arid regions should be allocated to essential industry such as fishing, domestic consumption and maintenance of ecosystem functions, not to additional industrial and mining schemes unless they fit into the desert environment (i.e. avoid those only looking for space and water, focus on those that must be located in or near the desert – e.g. fisheries and tourism).

Recommendations

Based upon our analysis of the relationship of scientific studies to management of the Namib Desert we find several genral principles applicable to deserts in general:

Land use planning and mapping including zoning are necessary.

Basic ecological studies should continue or be initiated. Time has demonstated their utility in identifying targets, specific and general, for effective management of arid environments.

To maintain viewscape values, relatively unprofitable disturbances disrupting more profitable conditions should be avoided. Needs work .....