The impact of stock along a defined stretch of the Lower Kuiseb River, Central Namib Desert: A first attempt at quantification

Martin Gabriel

Abstract

During a four-month stay at the Desert Ecological Research Unit (DERU) of Namibia, Central Namib Desert, an approximately 30 km long stretch of the Kuiseb River was monitored to assess the impact caused by the domestic stock owned by the indigenous Topnaar people. By estimating the conditions of the most common tree species in the area, *Tamarix usneoides*, *Euclea pseudebenus*, *Salvadora persica* and *Acacia albida*, the impact could be quantified for the first time.

Assigning "Impact Indication Points", permitted a quantification of the impact on individual tree species, as well as providing an overview of the varying extent of impact along the monitored stretch of the river.

This paper presents the results of the survey and also discusses the method in question in terms of its applicability.

Contents

1. Introduction

Amongst the ephemeral rivers of Namibia, the Kuiseb River is of particular importance, as its course in the Central Namib Desert marks the border between the southern Sand Sea and the gravel plains in the North.
The water table below the riverbed and floodplain which is usually replenished by the annual floods, is a precondition for the growth of the riparian forest. The latter is composed of several woody species which are able to reach the ground water.
In the Lower Kuiseb, the most important tree species are *Acacia albida, Acacia erioloba, Tamarix usneoides, Euclea pseudebenus* and *Salvadora persica*. In addition the "Narra", *Acanthosicyos horrida* can be found at some localities, as well as individual specimens of *Acacia tortilis, Ficus sycomorus* and *Maerua schinzii* (van Wyk et al. 1985, Theron et al. 1980 and 1985).
The Kuiseb River - a linear oasis - supports the desert fauna as a food and water source, but also allows non-desertic or partially adapted species to extend their range into the true desert (Seely et al. 1981). This explains the vital importance of the Kuiseb River for the Central Namib Desert.
The "Topnaar", an indigenous tribe of Nama People, have inhabited the banks of the Kuiseb River for at least 300 years (Budack 1977). Their numerous settlements were originally scattered along the banks of the river, each consisting of a small number of people, while the river provided nearly everything they required to meet their daily needs.
Today they still live along the Kuiseb, but since coming into contact with the modern economy of Walvis Bay, many of them have given up their traditional way of life. As a result, the total number of settlements has decreased, with the inhabitants now living on a semi-permanent basis at the remaining localities (Seely at al. 1981).
The present situation: As opposed to the original settlements there are now large numbers of domestic stock present in every Topnaar village. These include donkeys, sheep, cattle and goats. Some hundreds of the latter are to be found in certain villages like Oswater and Homeb. Goats represent the most important domestic animal of the Topnaar people.
Every morning the animals are let out into the fertile river region where they feed on *Acacia* pods, leaves etc. (cf photo 4 and 6). As the animals are dependent on a daily water supply, they return to their villages (waterholes) every evening. Along stretches of the Kuiseb which are visited regularly by stock, the following observation is immmediately apparent: Several tree species show a partially well-defined browseline, the usually strong silt-crust in the riverbed has been crushed to fine dust, and the herb layer has been largely destroyed (cf photo 2). This gives rise to the assumption that the large numbers of domestic stock have a severe effect on the Kuiseb ecosystem, not only in the form of the abovementioned effects, but also as an impact which is not immediately visible. This could mean an influence on the composition of species in the riparian forest, the removal of microhabitats in the silt layer, impact on the regeneration rate of the forest, etc..

2. Objectives

During a four-month stay (October 1992 until January 1993) at DERU of Namibia, an investigation was conducted to assess the impact of domestic stock on the Kuiseb-ecosystem. At the time of initiating the survey, qualitative or quantitative data relating to the impact of

stock on the ephemeral Kuiseb River were not available. Such data would provide fundamental information with regard to an objective estimation of the present ecological situation in the Kuiseb River. This was the reason for conducting the survey in question. It aims to quantify the extent of impact on a stretch of the Kuiseb approximately 30 km long. The survey was conducted by applying a method especially developed by the author for that particular purpose. In turn, the suitability of the method itself could be judged in view of its application. The primary objective was not to state the actual consequences of the impact of stock on the ecosystem or on the affected vegetation itself.

3. The survey area (cf appendix, map of survey area)

The survey area is a stretch of the Lower Kuiseb River, approximately 30 km long. It stretches from DERU at Gobabeb in the west, to a point about 10 km upriver of Homeb in the east. The area was divided into 30 survey points about 1 km apart, which were named after the respective distance east or west of the nearest Topnaar village. The survey point "N3e" e.g. therefore indicates the point located **3** km **e**ast of **N**atab.

4. Methodology

4.1. Fieldwork

To facilitate a quantitative evaluation of the survey area, comparable parameters had to be found first. This was done by comparing affected areas with unspoilt ones: Some of the most common tree species were assessed to provide the most suitable indicators for a comparative study:

- *Tamarix usneoides*
- *Euclea pseudebenus*
- *Salvadora persica*
- *Acacia albida*

These species were chosen as they occur at virtually each monitored point, permitting a direct collection of data without necessitating special equipment or laboratory analysis. Although *Acacia erioloba* is a common species in the survey area, it could not be taken into account, as this species occurs only in some individuals along the edge of the riverbed; it is more common further out in the actual floodplain.
The trees provided the following parameters (cf appendix, questionnaire for full details):

- status of browseline or general condition
- browseline-height
- damage to bark
- amount of *Acacia albida* pods on the ground

The parameters mentioned were considered to be suitable for a quantitative assessment of the impact caused by domestic stock, under the following premises:

- Damage to and use of vegetation and thus to the monitored trees in the survey area is caused, for the most part, by domestic stock. Game like gemsbok, springbok, mountain zebra,

steenbok etc. could be observed on very few occasions only, and observations have always been restricted to some individuals. Therefore the impact of game can be neglected, compared to hundreds of goats, for example.

- A distinct and/or clear ("shaved") browseline reflects a higher impact than an indistinct one.

- *Salvadora* develops (under normal conditions, not under extreme drought conditions) so-called "runners", which may reach a length of more than 5 metres. Non-occurrence of runners has been considered a possible consequence of mechanical impact, i.e. destruction by the hoofs of stock.

- "Umbrella" phenomenon means a special growth-form of *Salvadora*, which is most likely to be caused by extreme overgrazing. Only a thin stem or a string of stems, which can also be wrapped around the trunk of another tree, is left below browseline level. The resulting appearance is sometimes reminiscent of an umbrella (cf photo 15).

- Pods of *Acacia albida* are the main food source of goats in the Kuiseb (Seely et al. 1981), and therefore the presence or absence of pods was considered a clear indication of goat presence or absence (cf photo 1,2 and 5).

The data were compiled along the riverbed, at survey points about 1 km apart (cf appendix, map). The latter ones were determined with an ordinary odometer; a GPS (Global Positioning System) "GARMIN 50" was used to locate the exact position (cf appendix).
At each of these points, the situation of a stretch measuring about 50 to 150 metres up and downriver from that point was taken into account on both sides of the river. The situation in the floodplain more than about 20 metres beyond the edge of the riverbed was not monitored for the following reasons: Partially severe drought symptoms, a less uniform composition of the vegetation, and irregular visits by stock in the actual floodplain.
While collecting field data, an attempt was made to estimate the different conditions as objectively as possible. Hereby a tape measure was the only instrument applied (browselines).
To record the browseline-height and general condition of *Tamarix usneoides*, *Euclea pseudebenus* and *Acacia albida*, an attempt was made to apply an average for the respective survey points, whereas the situation of *Salvadora* was estimated in terms of the maximum impact visible. This can be justified by the fact that *Salvadora* showed a wide variety of different conditions at some survey points and thus the average would have furnished an erroneous idea of the actual situation.
Browseline-heights, especially of *Acacia albida* were only measured on large, old trees, as younger specimens often do not have a clear browseline (cf chapter 5.3.).
To avoid recording only a momentary situation, the average amount of *Acacia albida* pods on the ground was estimated by repeated visits to the same points.

4.2. Data preparation

To allow a synthesis of all the data compiled, "Impact Indication Points" (IIP's) were assigned to the variables or a combination of variables. The idea was to represent the respective situation of a tree species at a certain survey point by a single value. (The amount of *Acacia albida* pods on the ground was valued separately, as this cannot be considered a direct impact

on *Acacia albida*.) The scale comprises points from 0 to 100. In general, few points were allocated for little visible impact, and in turn, many points for high impact at the respective survey point (cf appendix, questionnaire for exact points system):

0 points: no visible impact
50 points: clear beginning of visible impact
100 points: maximum impact on the tree species

The height of browselines could not be evaluated in the same way for all tree species, as the different species were found to have widely varying browselines. It is important to note that the number of points allocated does not signify an estimation of percentages of damage.

5. Results and discussion, including additional observations

5.1. Overview of the survey area

Comparing the calculated average Impact Indication Points of the survey points to each other permitted quantification of the impact in the survey.
Figure 1 shows clear differences in the extent of impact along different stretches of the river: Two distinct peaks, one around Natab (80.4 IIP's), and another one around Oswater/Homeb (100/93 IIP's) are evident, while a clear decrease of impact can be seen between Natab and Oswater, as well as east of Homeb. Furthermore, the graph indicates a direct relationship between increasing distance from villages and decrease of impact.
While Oswater and Homeb show the highest impact determined in the area, the influence around Natab is also rather high. The situation there, however, is somewhat less extreme. The lower extent of impact at Natab may be due to one or both of the following circumstances: The more recent recolonization of Natab (Seely, pers. comm.) or the proximity of Oswater and Homeb to each other, and thus higher numbers of stock. Probably both of the facts mentioned have a role to play.

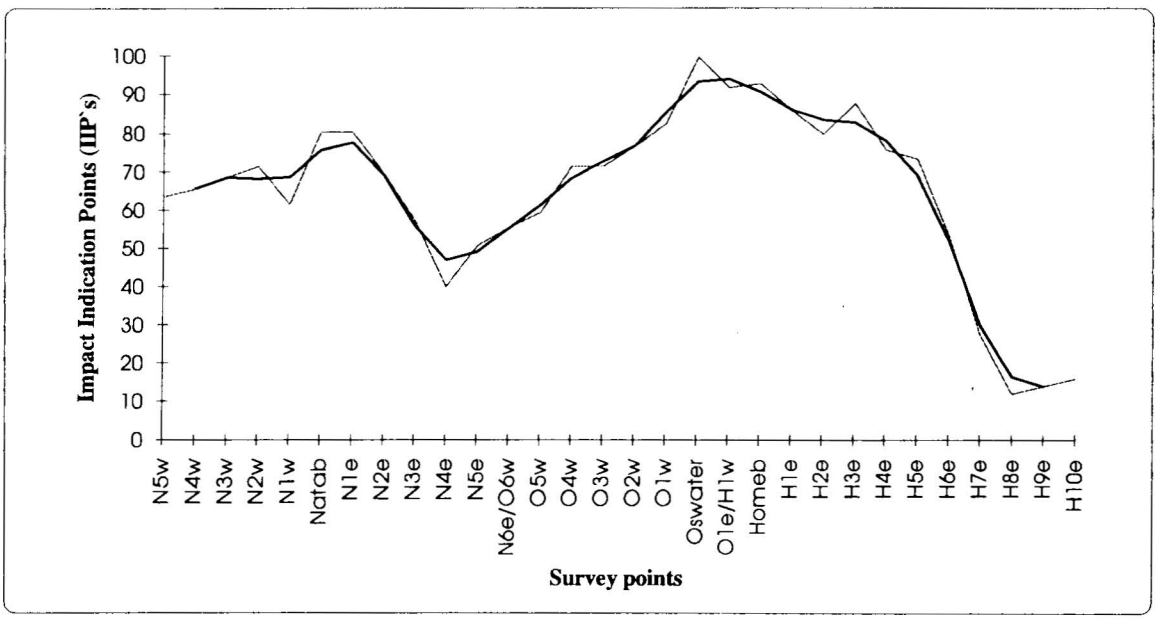

Figure 1. Average extent of impact in the survey area, original and modified graph.

The influence of stock between Natab and Oswater decreases continuously towards a point located about 4 km east of Natab (N4e), and about 8 km west of Oswater, where the impact has been calculated at 40 points. This signifies that impact of domestic stock according to the points system applied, is not yet clearly visible. Indeed, the area around this survey point furnished quite a natural impression, showing a high degree of covered soil, similar to areas of the Kuiseb where domestic stock never penetrates (cf photo 1).
Because this point is not equidistant from both villages, a stronger impact can be assumed to originate from Oswater/Homeb. About 4 km east of Homeb there is a distinct decrease of impact, which is no longer clearly visible, in terms of the points system, around 7 km east of Homeb. It might be of interest to note that immediately after leaving this point, game like gemsbok or springbok was encountered on numerous occasions, whereas west of this point observations of game remained the exception while conducting the survey.

5.2. Situation of the four tree species used as indicators

5.2.1. General conditions (cf figure 2)

The impact on the four tree species shows the following links and differences in the survey area: In general, all species turn out to be most affected around the villages of Oswater and Homeb (at Oswater all five indicators have 100 IIP's!), while a second, but lower peak of impact occurs around Natab. Furthermore they correspond in terms of a decrease of impact between Natab and Oswater, while the location of lowest impact differs slightly for the respective species. However, the deviation from the point of lowest impact at N4e (cf chapter 5.1.), is limited to a maximum of 2 km.
The average extent of impact provides a different picture as regards the respective species: While the average impact on *Tamarix* and *Salvadora* is nearly the same (*Tamarix*: 47.8 IIP's, *Salvadora*: 51.66 IIP's) along the surveyed stretch of the Kuiseb, it is definitely higher as regards *Euclea* (71.85 IIP's) and *Acacia albida* (71.5 IIP's). Further differences in this context are the wider ranges as regards *Tamarix* (0 to 100 IIP's) and *Salvadora* (10 to 100 IIP's), while *Acacia albida* and *Euclea* show a minor range of only 50 to 100 IIP's, at least in the area where impact definitely exists (cf chapter 5.1.). This means that there is visible impact on *Acacia albida* and *Euclea* in all locations with stock penetration, while in turn, the influence on *Tamarix* and *Salvadora* may not be evident in areas which are not located in the direct vicinity of villages.
Finally, it may be interesting to note that east of H7e, impact on both *Tamarix* and *Euclea* was not detected at all. In contrast to the tree-indicators, the amount of *Acacia albida* pods on the ground produces a very clear, but simple picture; the diagram is self explanatory.

5.2.2. Browselines (cf figure 3)

The browselines, which already represent an important aspect for the points system, deserve closer examination themselves, as they show some interesting differences as regards the heights measured.
First of all, quite distinct deviations from the generally reported 1.50 metres - browseline are evident. In the case of *Euclea* and *Acacia albida* these deviations can only be seen around the Oswater/Homeb area, whereas they are extreme as regards *Tamarix* and *Salvadora* throughout the survey area.

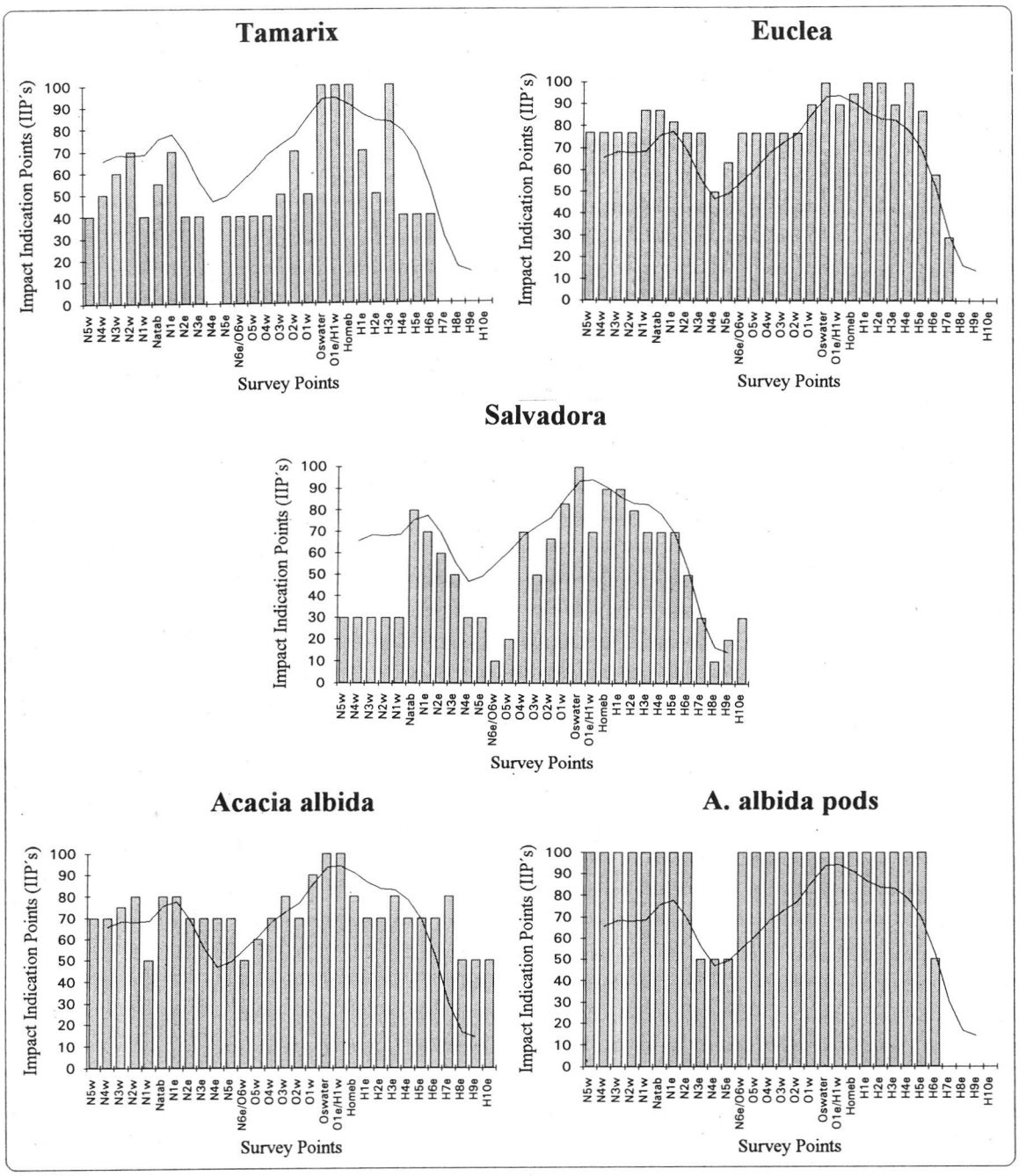

Figure 2. General condition of *Tamarix usneoides*, *Euclea pseudebenus*, *Salvadora persica* and *Acacia albida*, in conjunction with the modified graph "Average extent of impact in the survey area".

In general the highest browselines or damagelines for all the tree species occured in the Oswater/Homeb area (cf photo 7). Although it was not the actual aim of this survey to monitor the reason for this, it is worth some reflection:

While conducting the survey, donkeys and billy goats were mainly encountered in the Oswater/Homeb area. Obviously these animals usually do not stray more than 3 km away from the villages. As their numbers are definitely lower than those of nanny goats (and sheep) and as they can still reach places in the trees which nanny goats and sheep cannot reach, they probably do not have to wander around so far in the river region, as there is still enough food

available around the villages.
Apart from the Oswater/Homeb area, a more or less uniform browseline level of about 1.5 m was established as regards *Acacia albida* and *Euclea*, whereas the wide range of browseline levels as regards *Tamarix* and *Salvadora* is worth further consideration:
Basically, a browseline represents the maximum height reached by (in this case) stock on a plant which they use as food. Its existence must be understood as a consequence of a food shortage below this level in a certain area and/or period of time (Seely et al. 1981, van Wyk et al. 1985). This also means that a certain species of animal can only produce a single, typical browseline at a more or less uniform level, indicating the maximum level attainable by this species. In the author's opinion, slight variations of this level as a result of sexual differences within an animal species, as well as specific regional or temporary conditions, where the animals "try even harder", are likely.
Furthermore, certain plant species may exert a stronger attraction than others, thus producing slightly different browseline levels on different plant species. However, there is no evidence to justify the possibility of several well-developed browseline levels being caused by a single animal species. In particular it is not possible to imagine a browseline at a lower level than the height of the animal responsible for its occurence. This means in turn that the occurence of different browseline levels in a certain area must either be caused by different animal species, or the "browseline" is not a real browseline, in the sense of the plant being used for food.
This seems to be the case for *Tamarix* and *Salvadora*. The lowest "browseline" measured, from now on called "damageline", is situated at 1.1 m on *Tamarix*, and at only 0.5 m on *Salvadora*. None of these heights is likely to represent the maximum height attainable by any of the Topnaar stock animals, and thus cannot be considered as browselines. Furthermore, as the levels on *Salvadora* fluctuate by as much as 1.1 m, this makes it impossible to interpret these heights as browselines. At present no explanation of this phenomenon can be given for *Salvadora*.
On the other hand, the author has made some observations concerning the situation of *Tamarix*, allowing some conclusions: A pretty distinct damageline could be established on *Tamarix* in the survey area on several occasions, while on the other hand, stands of *Tamarix* a close distance away (some metres to some tens of metres away) did not have any damagelines. It turned out that those stands with a clear damageline only occured where tracks frequently used by goats were apparent in or around such stands of *Tamarix*. In turn, no distinct tracks were evident in the surroundings of virtually unaffected stands of *Tamarix* in the immediate vicinity. The height of the damageline in such areas is determined at around 1.20 m, which practically coincides with the average size of a goat or a sheep. Therefore repeated and continuous chafing at *Tamarix* twigs and leaves as an inevitable consequence of frequently passing herds of goats/sheep is considered to be the most likely reason for the development of the damageline in this particular case (cf photo 3).
This assumption is also backed up by the high sensitivity of *Tamarix* leaves. Furthermore no observation of goats or sheep feeding on *Tamarix* could be made within the scope of the survey, so *Tamarix* at least does not represent a preferred fodder plant. Another observation supporting the assumption that goats and/or sheep do not usually feed on *Tamarix* has been made in the vicinity of the survey point H1e: A *Euclea* tree showing a browseline at 1.5 m was found next to a stand of *Tamarix* showing a damageline at 1.1 m (cf photo 13).

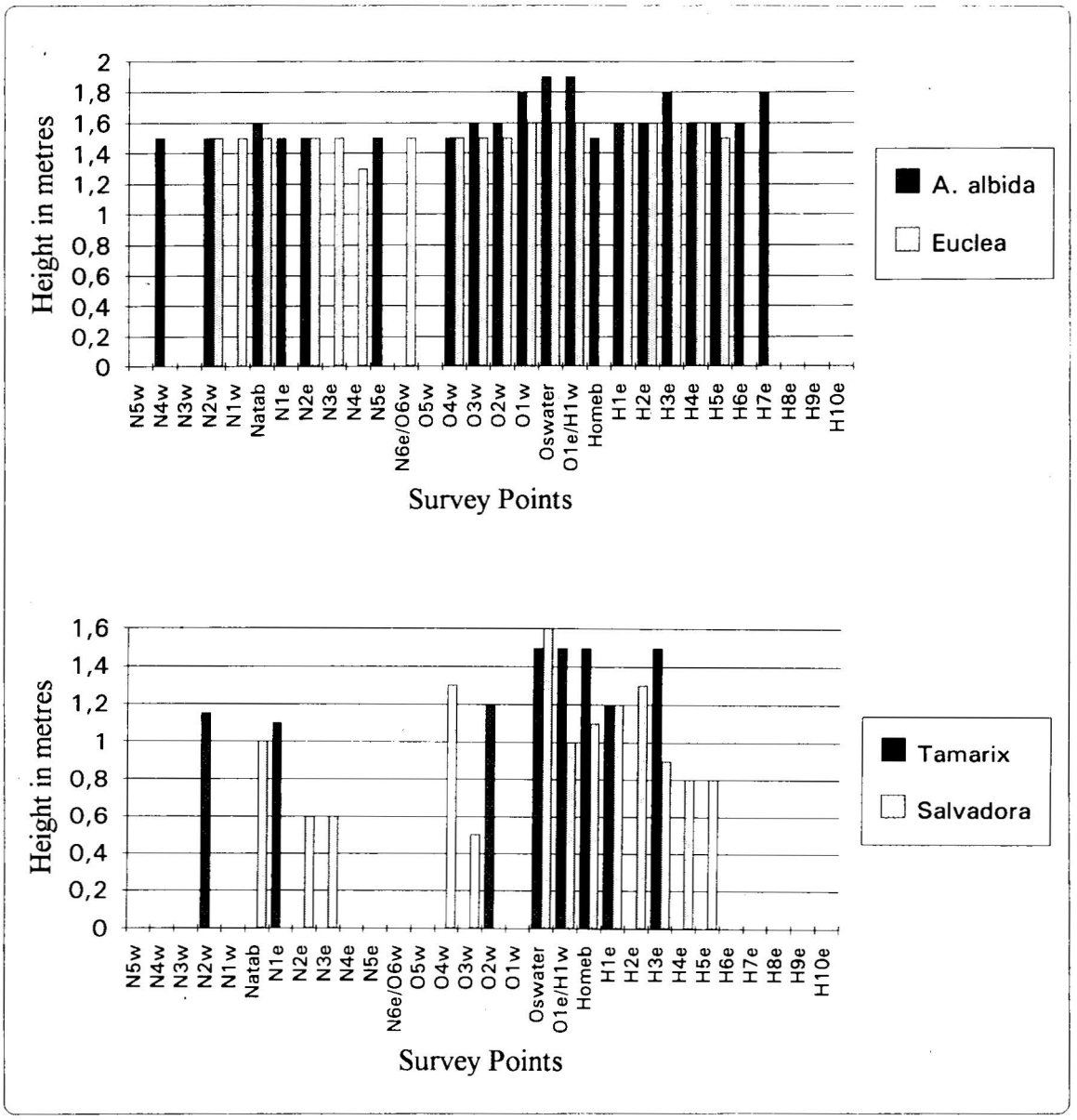

Figure 3. Browseline-heights of *Tamarix usneoides* (= damageline), *Salvadora persica*, *Acacia albida* and *Euclea pseudebenus* in the survey area.

5.3. Further observations

Finally some observations concerning *Acacia erioloba* and *Acacia albida* are also of interest. Impact on *Acacia erioloba* could also be established. But this was restricted to the close vicinity of the villages, at least as far as older trees are concerned. Similar to *Acacia albida*, impact on this species was reflected in a browseline, but generally to a lower extent. The reason for this is probably better protection granted by stronger thorns in *Acacia erioloba*. The different situation is reflected by up to 50 cm long fresh *Acacia erioloba* shoots while at the same place fresh *Acacia albida* shoots showed a maximum length of only 15 cm (cf photo 11). In contrast, damage in the form of peeled bark could be observed on some occasions as regards young *Acacia erioloba* (cf photo 12), but never on *Acacia albida*.

Surprisingly, there is obviously less impact on the natural regeneration of both *Acacia* species than assumed. This is indicated by numerous young trees growing below browseline level, even in close vicinity of the villages. Usually they are even less affected than the old trees in the same area. The reason therefore is not clear, but the fact that there are still young trees in the area, is, however, positive.

6. Statement on methodology

With regard to the extent of impact exerted by Topnaar stock, the method applied within this survey proved to be suitable for a straightforward, quantitative evaluation of a certain stretch of the Kuiseb. In principle, implementation of the method presented seems feasible in different stretches of the Kuiseb as well. Neverthelesss it should not be considered fully mature, but should be viewed as a first attempt which still has some weaknesses in theory and practice.

As far as objectivity is concerned, it must be said that a certain degree of subjectivity cannot be denied, as this is unavoidable within data collection as conducted in the framework of this survey. Estimating browseline conditions, for example, is virtually based on subjectivity, whereas recording browseline heights can be considered objectively within a tolerance of less than 10 cm.

As points allocation is concerned, full objectivity cannot be guaranteed for each indicator, simply because in the field, these indicators presented varying possibilities for assessment. (For *Tamarix* there were 7 possibilities of points allocation, whereas for *Salvadora* there were 10, for example (cf appendix, questionnaire)).

However, the overall relationship between increasing distance from villages and decreasing extent of impact, would not have changed significantly, if different values had been assigned in one or even several cases. Nonetheless, for the moment, a single indicator should not be used for an approximation of the impact in a certain area, but an average from all the indicators.

In the field, several problems were encountered, such as the complete absence of one or several tree species at a survey point, or problems concerning the estimation of a tree condition. The latter was the case in some areas because of drought symptoms due to the extremely bad water supply. Therefore some values had to be interpolated for the general estimation of the whole survey area.

7. Conclusions and final remarks

The results obtained from this investigation show that the impact caused by stock varies along different stretches of the Kuiseb.

The question now concerns the actual influence on the Kuiseb-ecosystem. This includes single aspects like damage to the indicators/tree species themselves, as well as a possible effect on more complicated ecological interdependences. On the one hand, it is a question of determining the extent of the damage, and, on the other hand, to assess whether the extent of the damage is reflected in the picture provided by the points system pertaining to the survey in question.

Further work in this direction, as well as dealing with the other questions arising from the

survey, will be the subject of further investigation, with the aim of improving the method applied.
The main objective of the whole topic, however, must be to determine the capacity of the Kuiseb, aiming towards an optimal solution as regards both the unique Kuiseb ecosystem and the needs of the Topnaar people.

8. Acknowledgements

First of all I would like to thank Dr. Mary Seely for enabling me to work at Gobabeb, for providing facilities, and for the inspiring discussions. Furthermore I would like to thank Nature Conservation for the permit to work in the Namib Naukluft Park.
Last not least I owe special thanks to all "Gobabebians" and to my friend Rolf Walter in particular, for making my stay at Gobabeb a very pleasant one.

9. References

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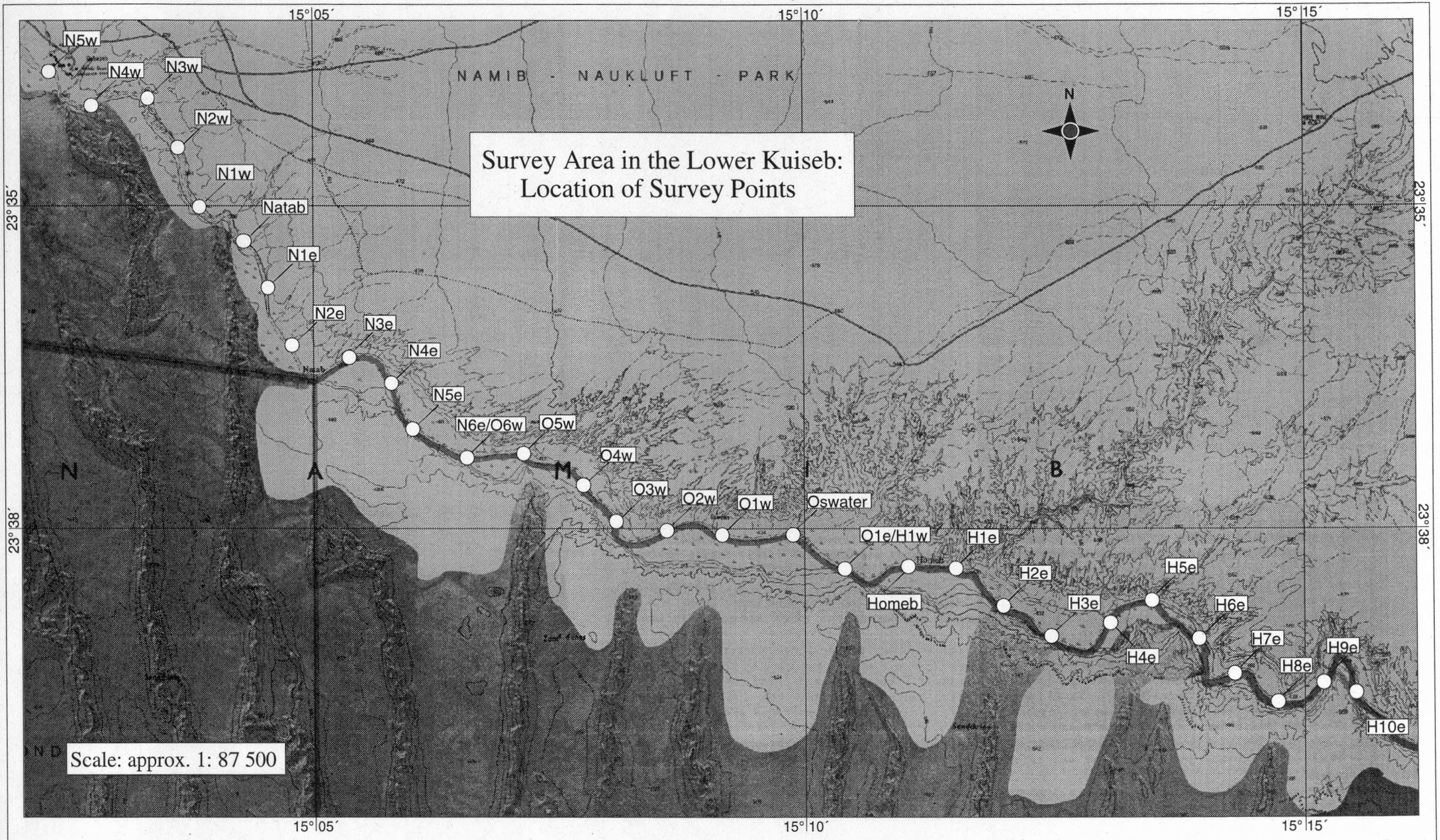
Author: Cand. geogr. Martin Gabriel, Department for Geography, University of Regensburg, Bavaria, Germany. Address: Erlenweg 6, 93053 Regensburg, Germany. Tel.: 0941-703389

Appendix



Map based on: SOUTH WEST AFRICA 1: 50 000 Sheet 2315 CA GOBABEB/2315 CB GOROB,
Second Edition, Surveyor General, Windhoek

Computer graphics: M. Gabriel 1993

Exact position of survey points:
(Global Positioning System "GARMIN 50")

Survey Point	S	E
N5w	23 33.76	15 02.39
N4w	23 33.98	15 02.85
N3w	23 34.05	15 03.34
N2w	23 34.41	15 03.66
N1w	23 34.95	15 03.80
Natab	23 35.31	15 04.24
N1e	23 35.82	15 04.55
N2e	23 36.32	15 04.78
N3e	23 36.46	15 05.23
N4e	23 36.51	15 05.74
N5e	23 37.01	15 05.99
N6e/O6w	23 37.30	15 06.57
O5w	23 37.30	15 07.04
O4w	23 37.42	15 07.66
O3w	23 37.96	15 08.07
O2w	23 38.07	15 08.45
O1w	23 38.03	15 09.10
Oswater	23 38.05	15 09.72
O1e/H1w	23 38.33	15 10.28
Homeb	23 38.32	15 10.89
H1e	23 38.38	15 11.58
H2e	23 38.72	15 11.97
H3e	23 39.02	15 12.51
H4e	23 38.89	15 13.00
H5e	23 38.64	15 13.48
H6e	23 38.97	15 13.94
H7e	23 39.32	15 14.29
H8e	23 39.56	15 14.69
H9e	23 39.35	15 15.20
H10e	23 39.51	15 15.49

Questionnaire		Impact Indication Points (IIP's)
Tamarix:		
Browseline visible?		
Yes: - distinct, height ca. .....m	O	- 1.2m: 70 - 1.3m: 80 - 1.4m: 90 - 1.5m: 100
- indistinct	O	50
No: - but some damage evident	O	40
- no damage visible at all	O	0
Euclea:		
Damage to bark visible? Yes	O	+10
No	O	both - 0
Browseline visible? No	O	
Yes: - height ca. .....m	O	- 1.3m: 50 - 1.4m: 63 - 1.5m: 77 - 1.6m: 90
Salvadora:		
Condition (max. damage):		
- covered with leaves in all parts and runners at least 5m long	O	0
- covered with leaves in all parts and runners 2 - 5m long	O	10
- covered with leaves in all parts, but runners max. 2m long	O	20
- covered with leaves down to the ground, but no runners	O	30
- covered with leaves in the upper parts only, no leaves up to a height of .....m		- 0.7m: 50 - 1.0m: 60 - 1.3m: 70 - 1.6m: 80
↳ extent of "umbrella"-phenomenon, if developed: - distinct	O	+10
- extreme	O	+20
A. albida:		
Browseline visible? No	O	0
Yes: - browseline indistinct, but visible	O	50
- browseline distinct, but does not appear "shaved"	O	+10
- browseline distinct, appears "shaved"	O	+20
height ca. .....m		- 1.6m: 60 - 1.8m: 70 - 2.0m: 80
A. albida pods:		
- covering the ground	O	0
- ground covered to a certain extent, but obviously eaten from time to time	O	50
- generally no pods left on the ground all eaten by domestic stock	O	100

Questionnaire for data collection in the field, combined with points system for analysis. (+10/20 = additional points for special phenomena)