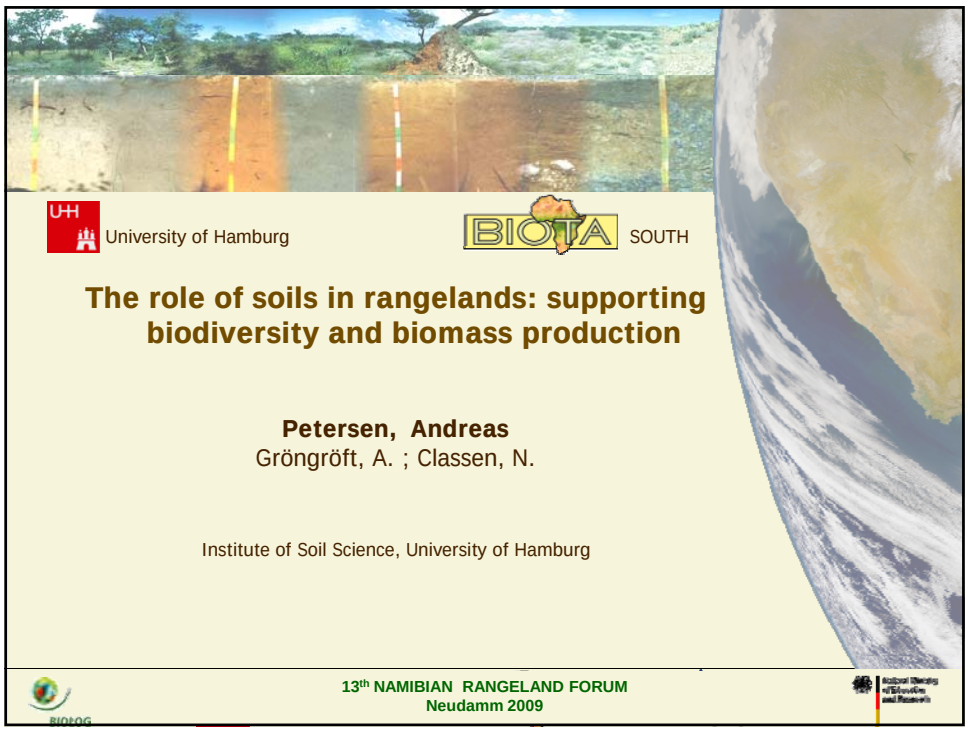


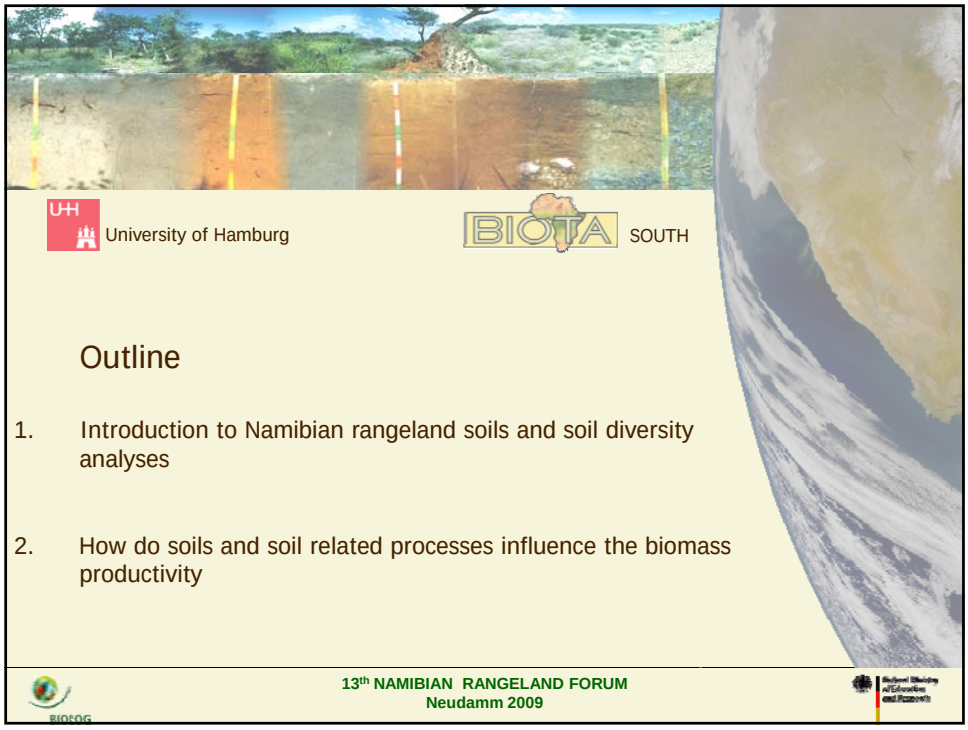
University of Hamburg

BIOTA SOUTH

The role of soils in rangelands: supporting biodiversity and biomass production

Petersen, Andreas
Gröngröft, A. ; Classen, N.

Institute of Soil Science, University of Hamburg



University of Hamburg

BIOTA SOUTH

Outline

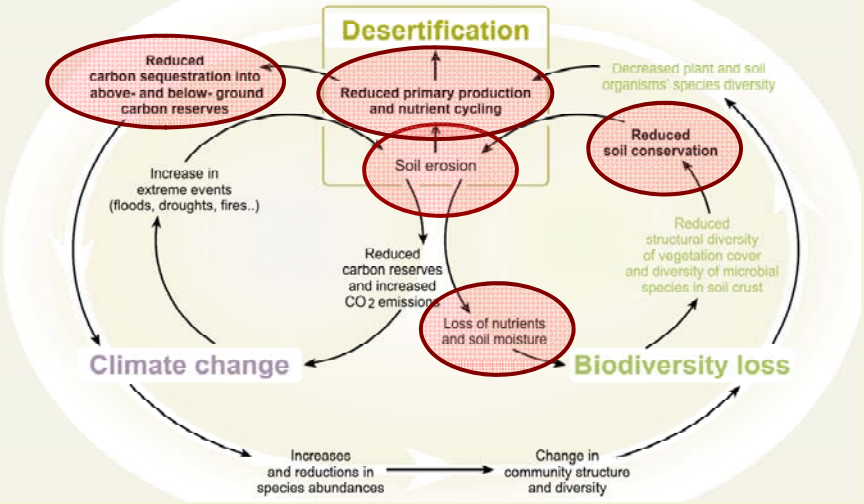
1. Introduction to Namibian rangeland soils and soil diversity analyses

2. How do soils and soil related processes influence the biomass productivity

13th NAMIBIAN RANGELAND FORUM
Neudamm 2009

Soil as a central part for (semi-) arid ecosystem functions

Role of soil in linkages in ecosystem components and services

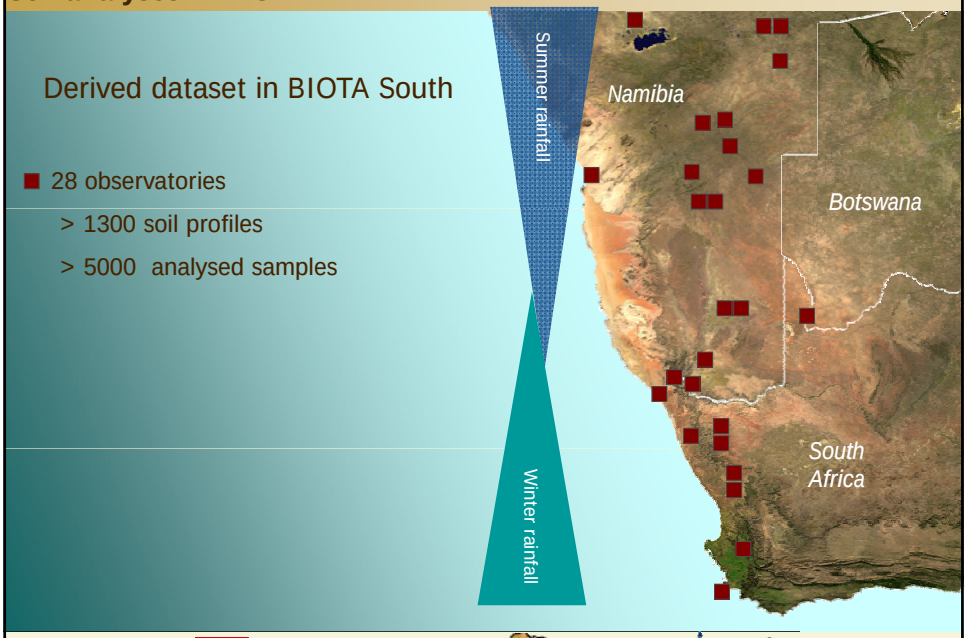


Source: Millenium ecosystem Assessment

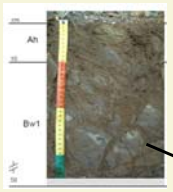
Soil analyses in BIOTA

Derived dataset in BIOTA South

- 28 observatories
  - > 1300 soil profiles
  - > 5000 analysed samples



Main soil units in Namibia

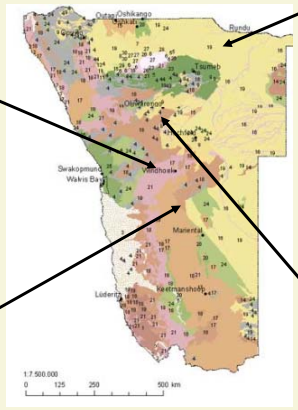


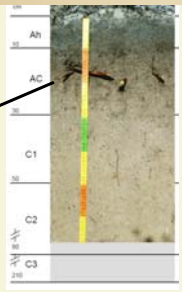
Leptosol

Shallow, many fragments

Soil map of Namibia

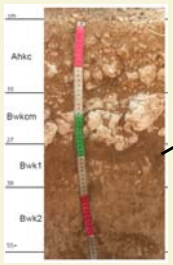
(Mendelsohn et al. 2002)





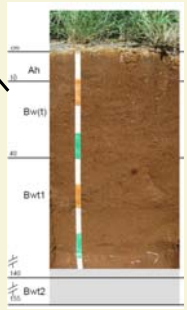
Arenosol

Deep sand



Calcisol

Shallow, many fragments

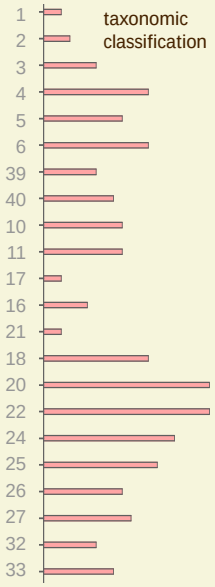


Cambisol

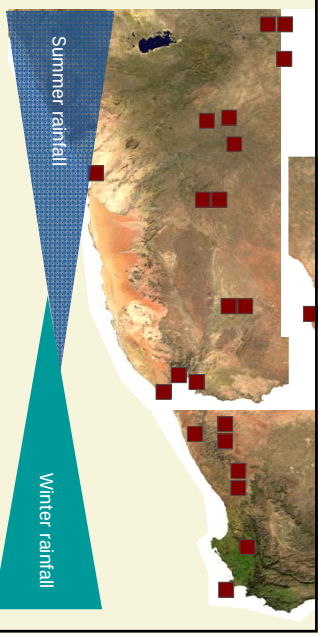
Deep loam

Results of soil diversity

Pedodiversity along the transect

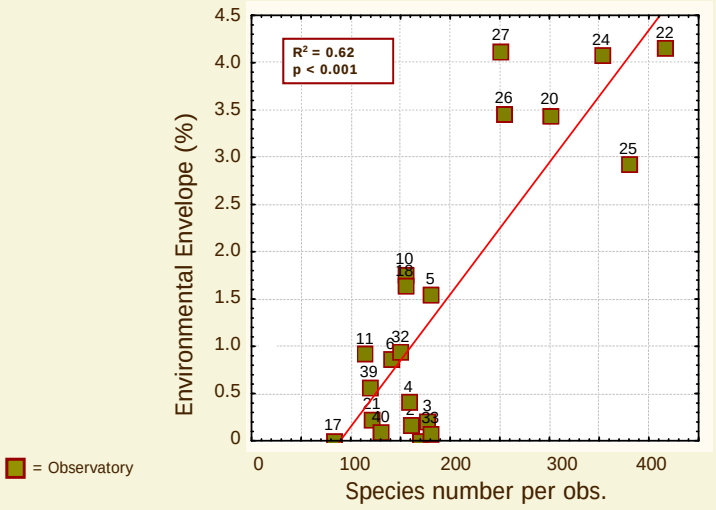


taxonomic classification

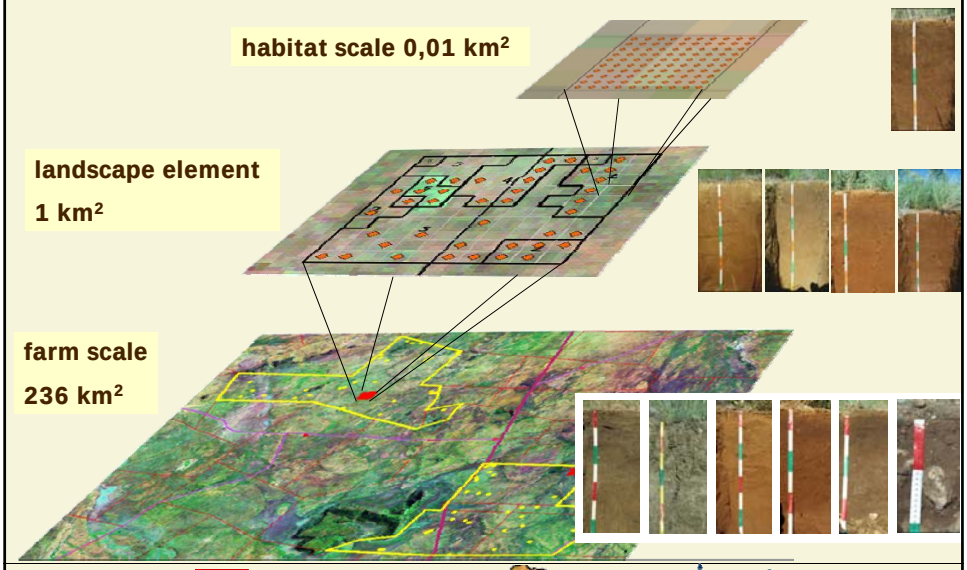


Results of soil diversity

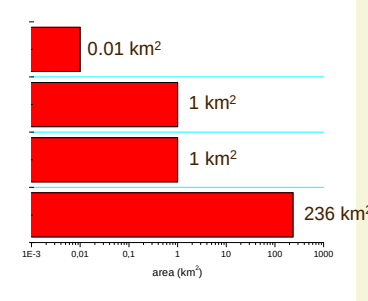
Correlation of pedo- and phytodiversity

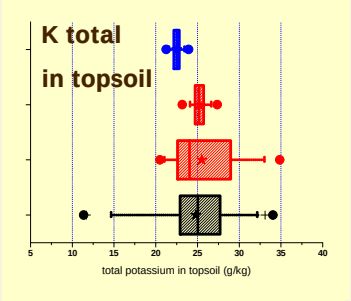


scale dependent soil variability



Scale dependent soil variability

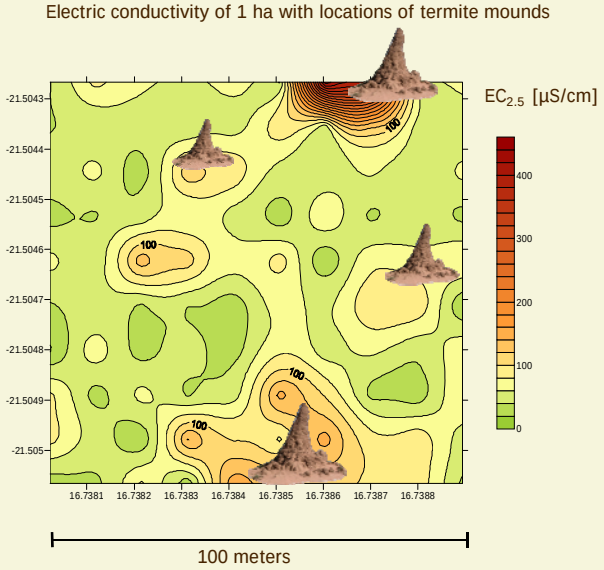




- for parameters that reflect the geogen situation the variability increases with the size of investigated area
- for parameters that reflect actual ecological processes the variability is even on a ha-scale large

Scale dependent soil variability

Electric conductivity of 1 ha with locations of termite mounds



Impact of termites on soil variability

Wide parts of the central savannah are influenced by the activity of the mound building, fungus growing termite

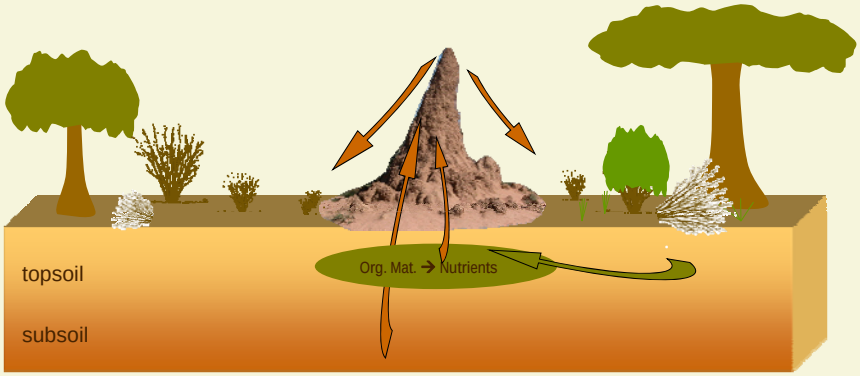
Macrotermes michaelseni (Sjöstedt).

Impact of termites on soil variability

Especially in arid and semiarid regions, termites are keystone species

- structure their habitats through soil turnover
- decompose plant material

→ influence nutrient cycles and patchiness in soil properties



Impact of termites on soil variability

Informations about the impact of soil turnover, soil properties and the nutrient cycling processes in semiarid regions are limited.

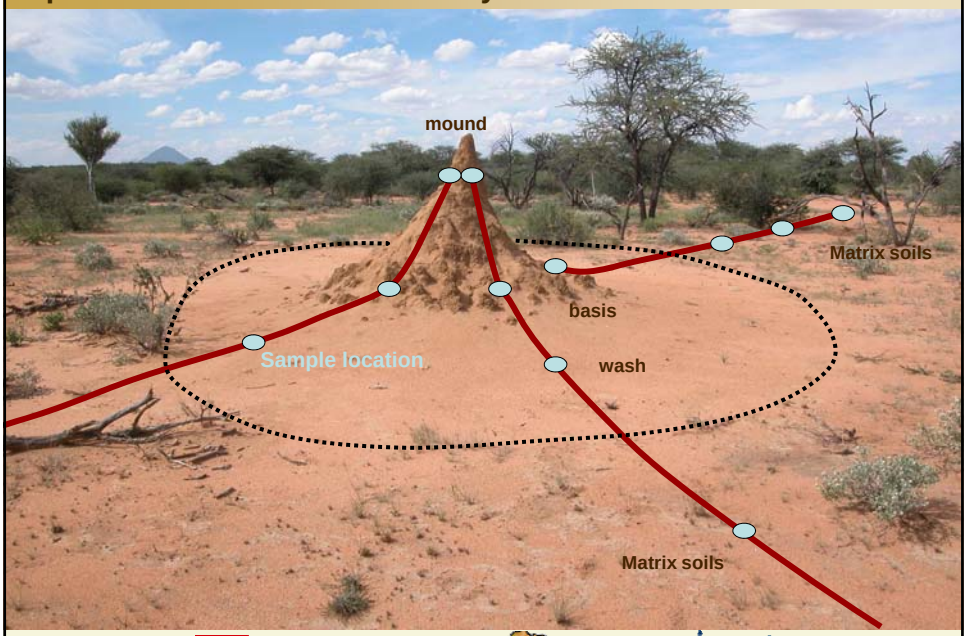
Active termite mound

Decay of termite mound

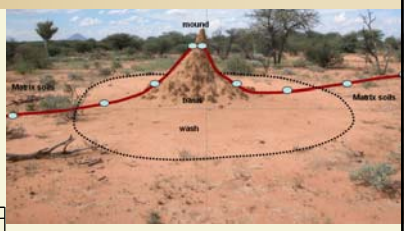
Remnant of termite mound

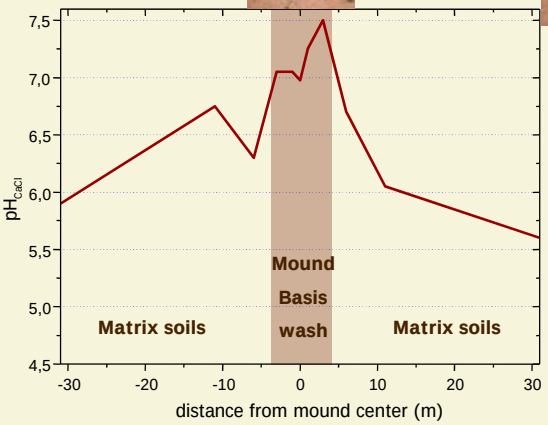
- Origin of the mound material
- Nutrient enrichment
- Re-distribution of mound material

Impact of termites on soil variability



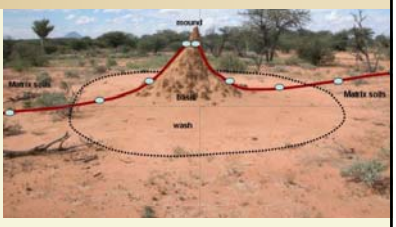
Impact of termites on soil variability

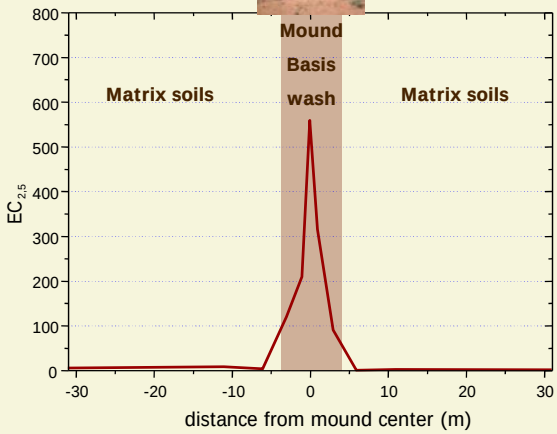




Increased pH in mound, basis and wash

Impact of termites on soil variability

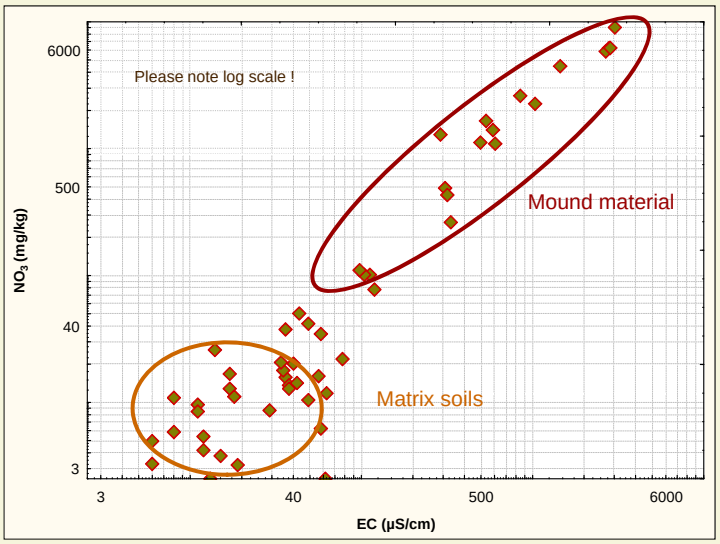




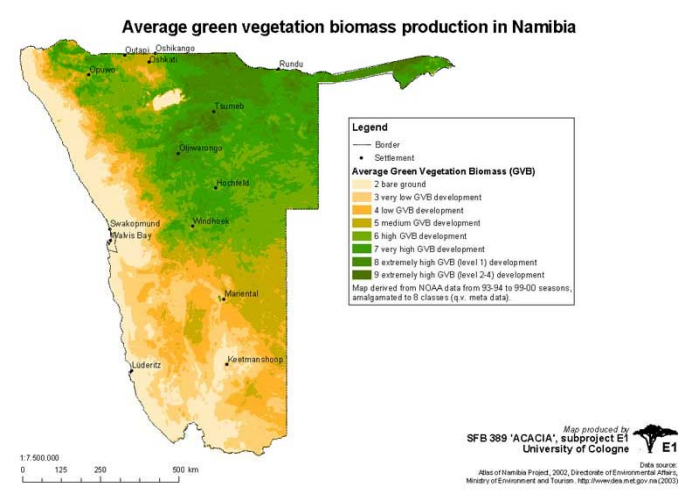
Increased EC in mound, basis and wash

Impact of termites on soil variability

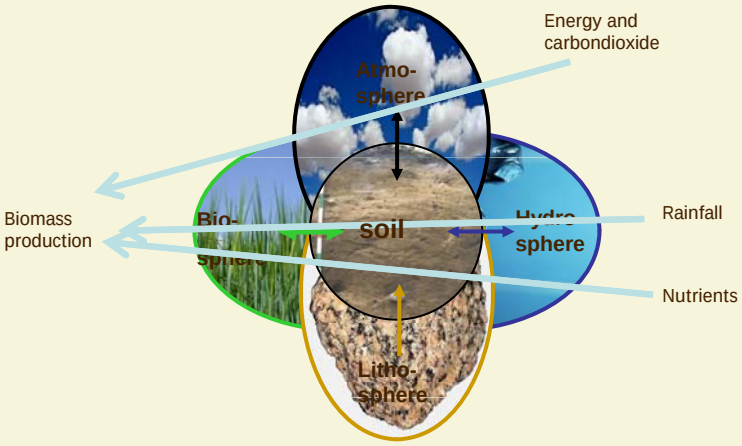
Results: Relationship between Electric Conductivity and Nitrate content



2. How do soils and soil related processes influence the biomass productivity



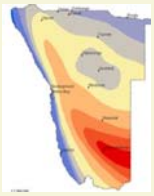
The role of soils for biomass production



- Soils provide the basis for biomass production (waterstorage, nutrients, rooting space)

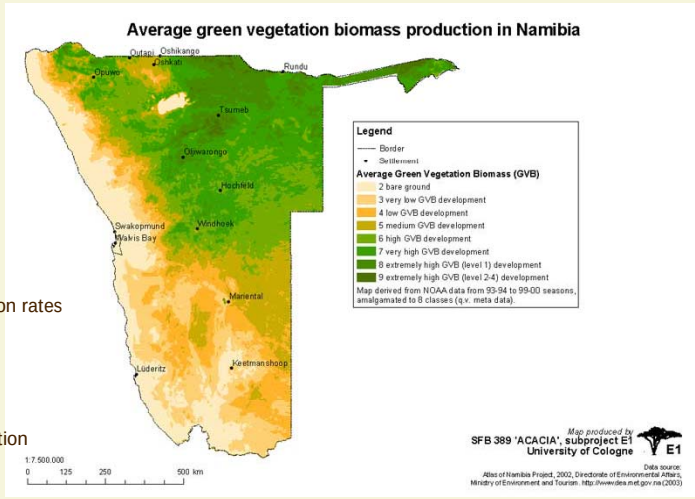
Major factors for biomass production

rainfall



evaporation rates

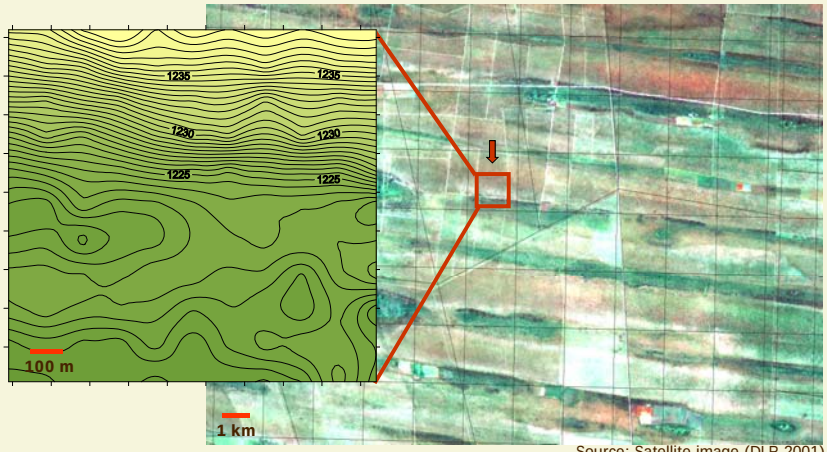
soil situation



Soil water dynamics - evaporation

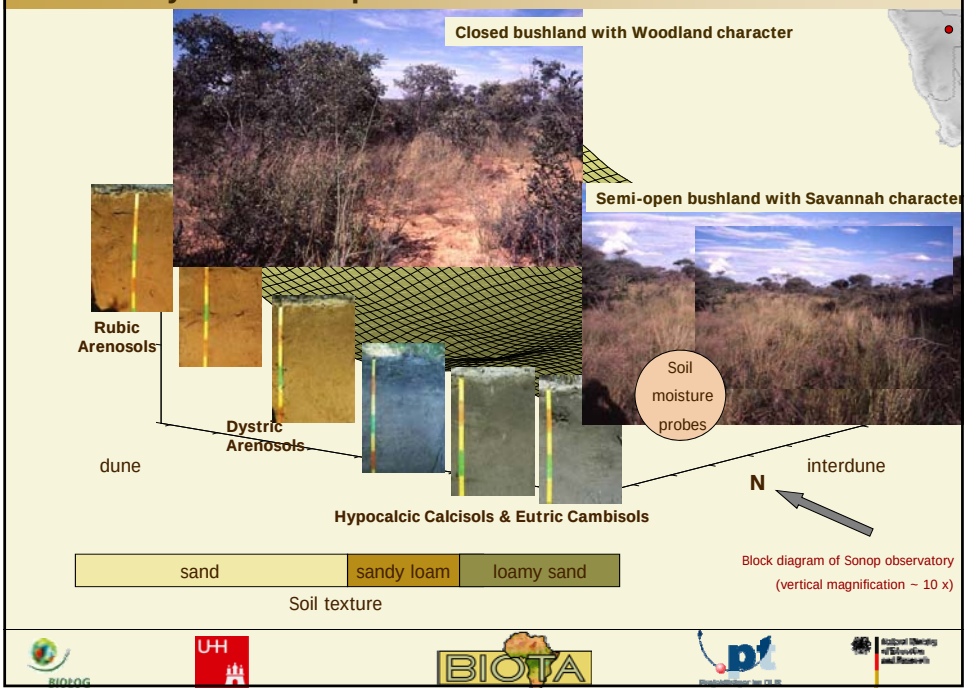
Site : Sonop Research Station, Kavango

Landforms: longitudinal dunes & interdunes

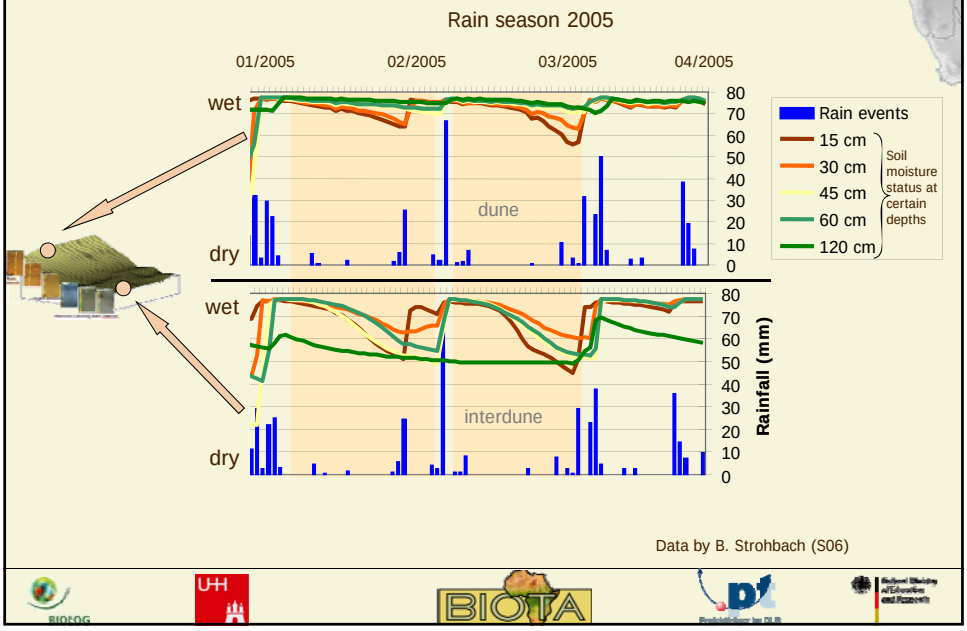


Source: Satellite image (DLR 2001)

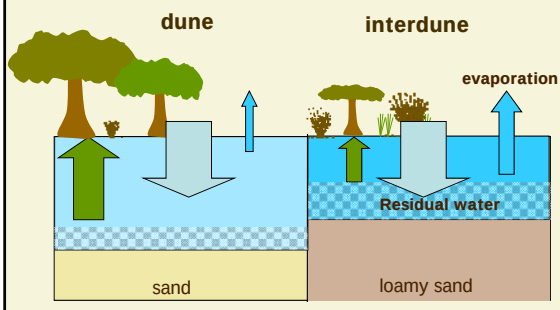
Soil water dynamics - evaporation



Soil water dynamics - evaporation



Soil water dynamics - evaporation



interdune

Higher water storage capacity

Higher content of non plant available water

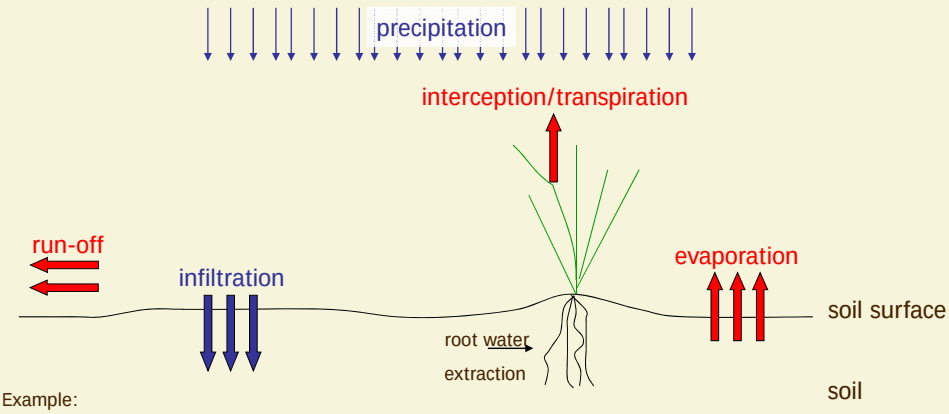
Higher evaporation rate

→ **Less plant available water**

Drier conditions in interdune due to the loamy soil texture

(inverse texture hypothesis)

Soil water dynamics - Soil water balance scheme



Example:

A 20 mm rain event infiltrates at a loamy sand theoretically

10 cm to the depth (20 Vol.% available water capacity). The potential evaporation in Namibia is at 5 to 6 mm per day and cause to a lost of the water to the atmosphere in 4 days. To drain water into 1 m 200 mm rain in a few days are necessary.

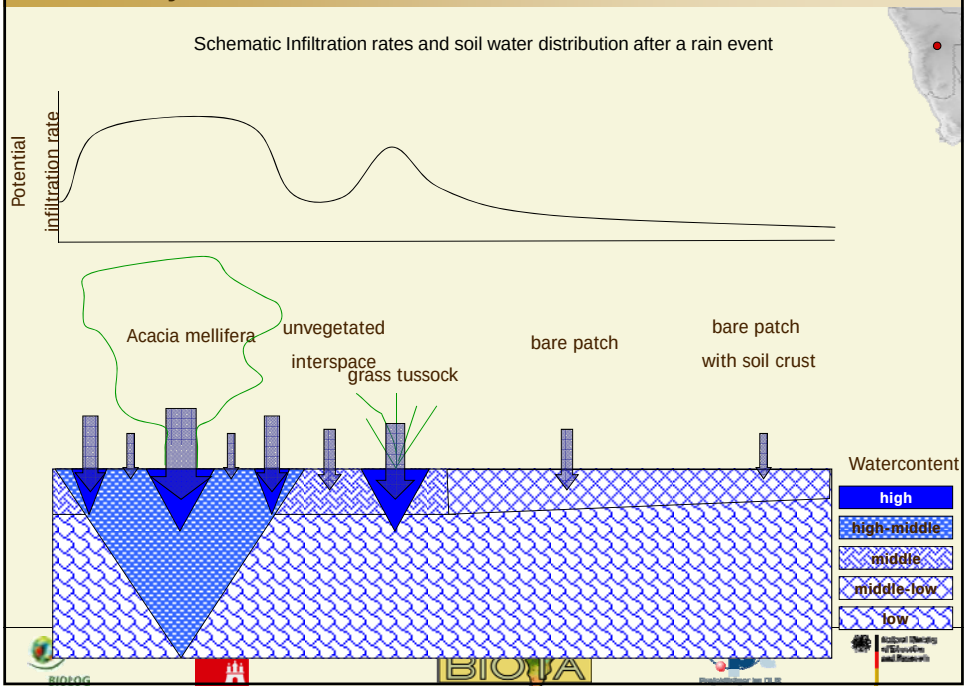
$$\sum E = \beta_1 * t_{dry}^{0,5}$$

β_1=soil specific parameter (cm $d^{-0,5}$)

t_{dry}= time (d) after a significant amount of rainfall

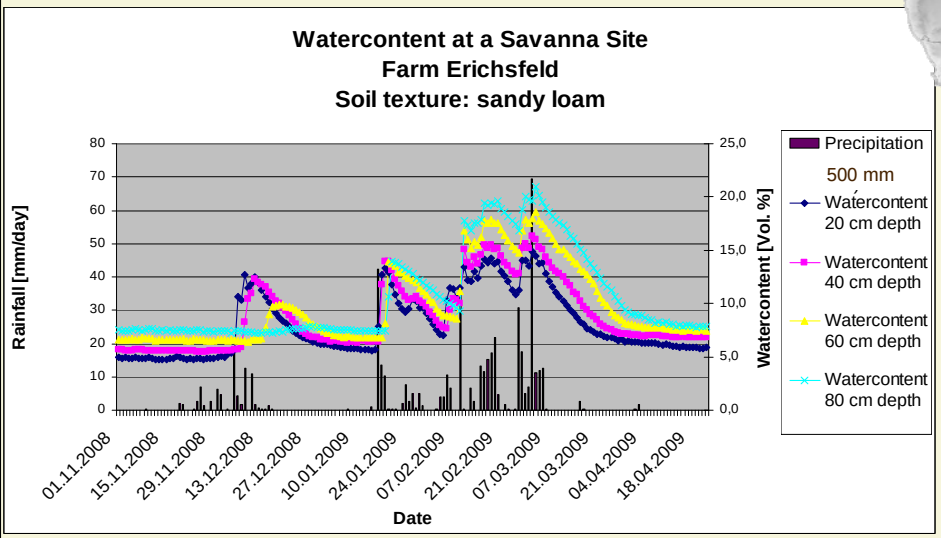
(BLACK et al. 1969)

Soil water dynamics - infiltration

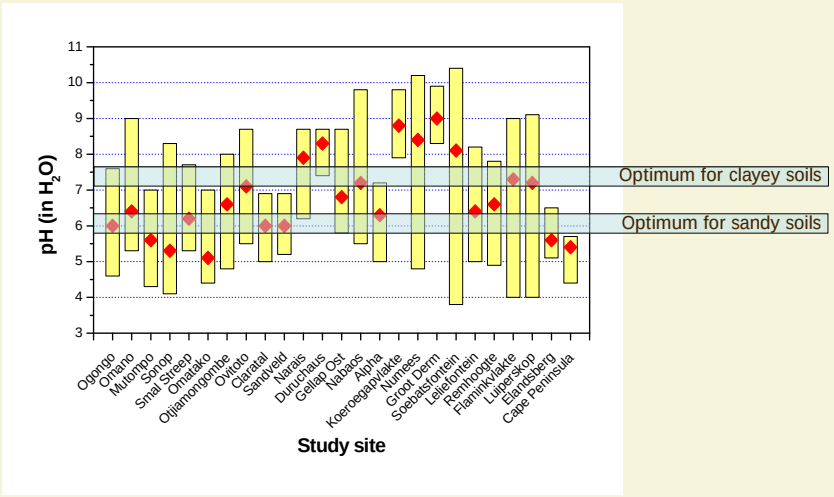


Soil water dynamics - infiltration

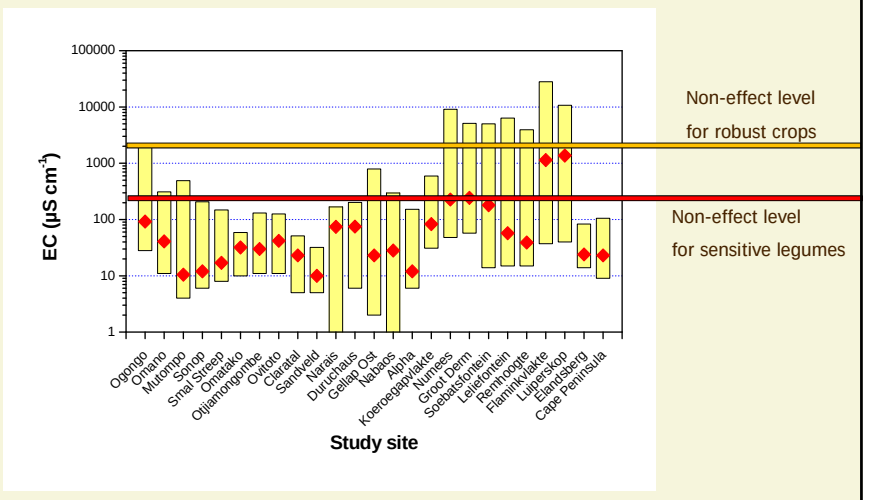
Soil water content during rain-season 2008/2009



Nutrients and soil chemical situation

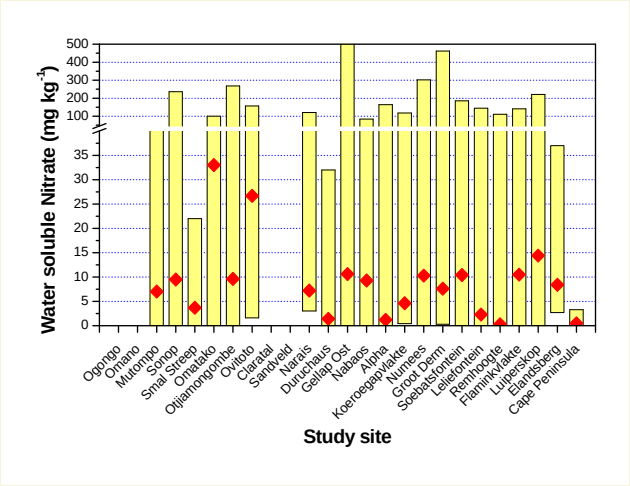


Nutrients and soil chemical situation



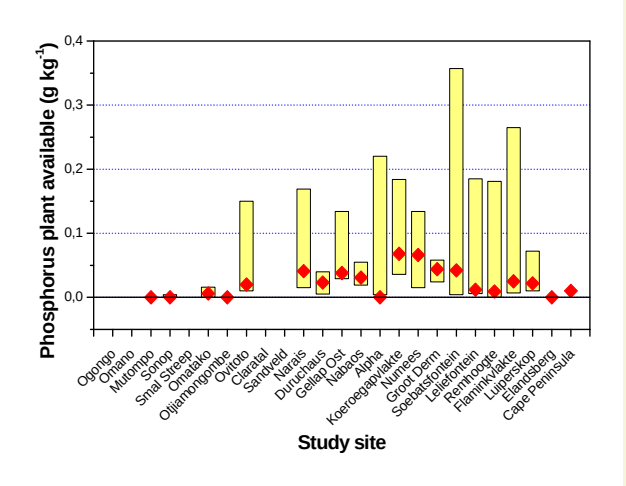
Nutrients and soil chemical situation

Nutrients: Nitrate

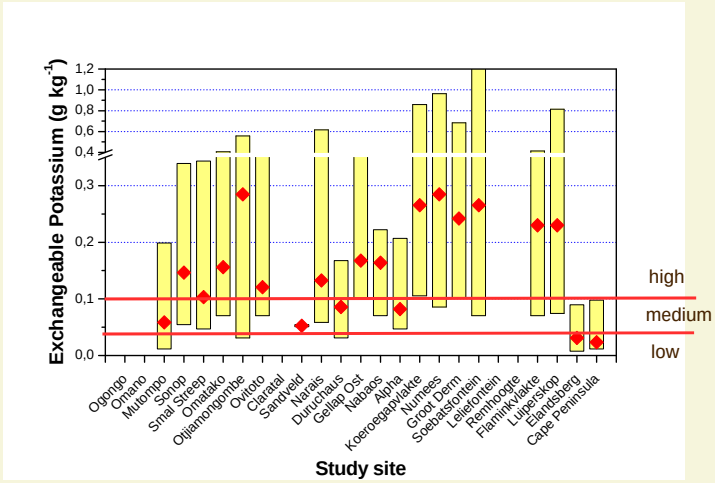


Nutrients and soil chemical situation

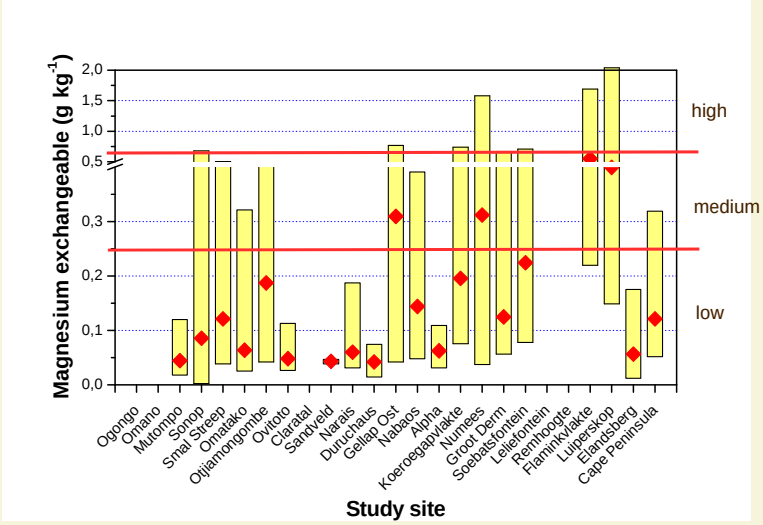
Nutrients: Plant available Phosphorus



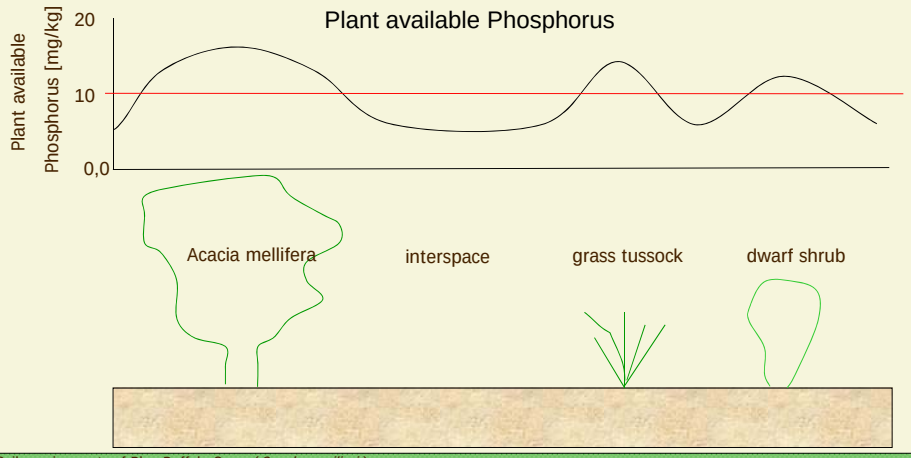
Nutrients and soil chemical situation



Nutrients and soil chemical situation



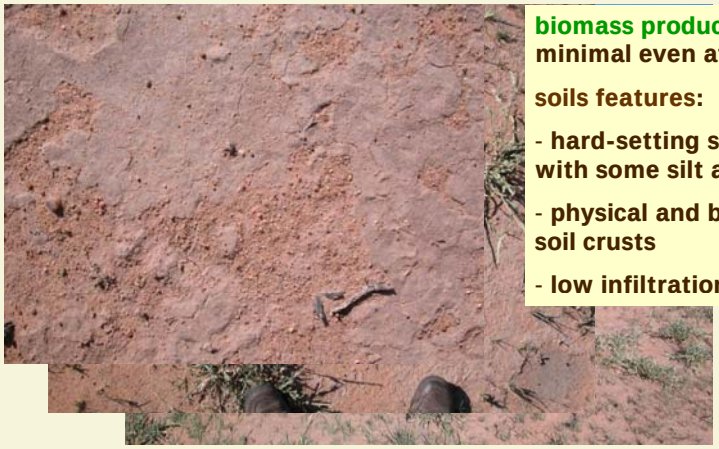
Nutrients and soil chemical situation



Soil requirements of Blue Buffalo Grass (*Cenchrus ciliaris*):	
well adapted to	sandy soils, sandy loam, loam, clay loam, (clay) and therefore the „red earth soils“
nutrients:	requires good fertility (N, P): P > 10 mg/kg, total N > 0,1%
pH growth optimum	at 7-8 but can grows on soils with a pH of 5.5

Soil related problems

Loss of productivity by vegetation degradation (‚bare patches‘)



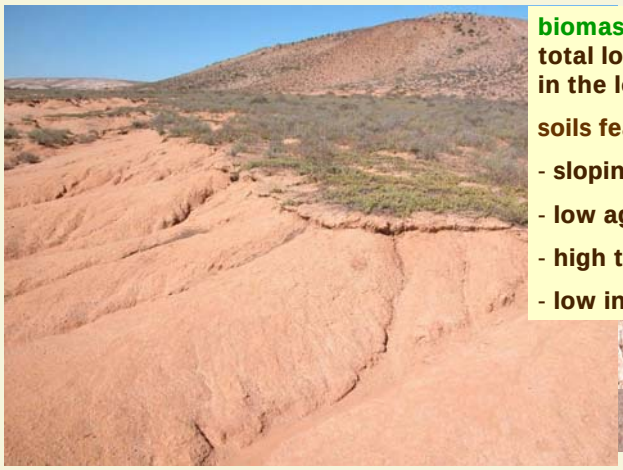
biomass production:
minimal even after rain

soils features:

- **hard-setting sands with some silt and clay**
- **physical and biological soil crusts**
- **low infiltration rate**

Soil related problems

Loss of productivity by soil erosion



biomass production:
total lost of productivity in the long run

soils features:

- **sloping areas**
- **low aggregat stability**
- **high tendency to crust**
- **low infiltration rate**

Conclusion

The role of soils in rangelands: supporting biodiversity and biomass production

- Soil diversity of southern African rangelands is strongly correlated with biodiversity of higher plants
- Biomass production is not only depending on the amount of rainfall but on the capacity of the soil to capture, storage and redistribute this water → soil water dynamics are the key element
- Overall nutrient level is low
- No accumulation of soluble salts (salinisation)
- Vegetation cover with perennial species increase infiltration, reduces splash effects, run-off, nutrient depletion and physical crusting which is problematic to restore

Outlook / Open questions

- Carbon & Nitrogen flux analyses → carbon sequestration is a key element for detection of changes by land use and climate change

  IPCC 4AR (2007) highlight the lack of dryland soil information regarding fluxes of Carbon and Nitrogen

- Ecohydrology → Analyses of soil water fluxes for further understanding of vegetation dynamics (e.g. bush encroachment) and water balance (groundwater recharge)

- Termites as a key species and ecosystem engineer for nutrient fluxes and diversity of savannah ecosystems