Modeling self organizing shrub mound formation and their stability on semi-arid slopes

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Introduction

- Shrubs become enriched
- Crusted areas are depleted

→ self promoting process
Introduction

- Shrubs often grow on mounds
- Dust and OM deposition
- Water erosion
- Splash erosion and sedimentation
- Root growth and bioturbation
Aim of the study

- Shed light on shrub mounds
  - Process of mound formation
  - Circumstances under which mounds form
  - How stable mounds are

- Studying shrub mounds in the field and with thin sections in Sayeret Shaked

- Model simulations for single events and 100 years events based on Sayeret Shaked
Results field studies
Results field studies

2.03 cm

2.85 cm

5 mm
Discussion field study

→ Sedimentation ±2.03 cm, erosion ±2.85 cm
→ Mounds are formed by erosion and sedimentation
# Material & methods model simulations

- Single precipitation events → effect shrub size and cover on water and soil redistribution and surface circumstances for mound formation
- 100 years precipitation events at 3 precipitation scenarios (100, 200 & 400 mm / year) → reconstruct mounds and climate range for mound formation
- Using test slope of 20x20 m based on study site
- Surface only covered by shrub and crust
- Using landscape evolution model LAPSUS-DE
LAPSUS-DE

- Landscape Processes modeling at multi dimensions and scales in Deserts
- Spatially explicit
- Water redistribution
- Erosion and sedimentation
- Dust deposition
- Daily precipitation events
- Borland C++

Based on:
E. Buis & A. Veldkamp (in press)
Results single event simulation

→ Shrub cover has strongest effect
Discussion single event simulation

- Shrub mound formation occurs only if both erosion and sedimentation are active.
- Individual shrubs receive most resources on slopes with low shrub cover and large shrub size.
- Mound formation is strongest on these highly erosive slopes.
Results 100 years simulation – normal scenario

200 mm per year

- Shrub mounds are formed: sedimentation 1.32 cm, erosion 2.77 cm
Discussion 100 years simulation

- At the current annual precipitation shrub mounds are formed, though simulation not totally correct

  - Erosion is well simulated
  - Sedimentation too low:

    1) no splash erosion in model,
    2) additional dust collection surface not modeled,
    3) bioturbation and increased porosity not modeled
Results 100 years simulation – dry scenario

100 mm per year

- Shrub mounds are barely formed: sedimentation max. 0.9 cm, almost no erosion
Results 100 years simulation – wet scenario

400 mm per year

- Deep gullies are formed: almost no sedimentation, erosion very severe (max. 64 cm)
Discussion 100 years simulation

- At dryer climate no shrubs are formed, as barely erosion takes place and no sediments are available
  → Slopes are very stable: no shrub – crust landscape

- At wetter climate erosion is too strong for mound formation
  → Slopes are unstable. BUT in natural situation vegetation cover is complete: no shrub – crust landscape
Conclusions

- In the study site shrub mounds are formed by combined process of erosion and sedimentation.
- Mound formation strongest on slopes with low shrub cover and large shrub size.
- Shrubs do best in a degrading environment and form a highly resistant shrub – crust landscape.
- In both dryer and wetter climate no mound formation will occur → mound formation is limited to a small precipitation range.