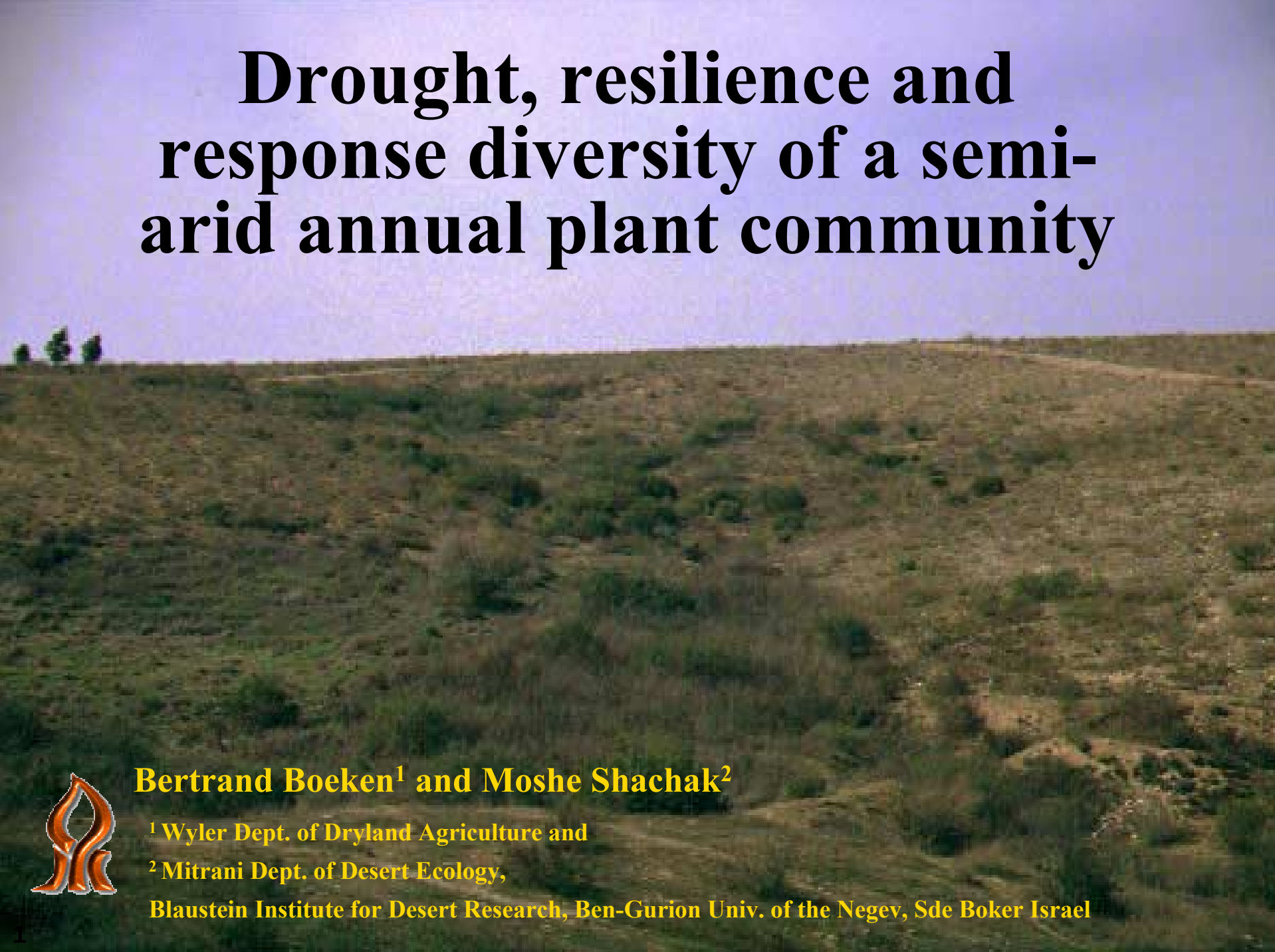
Drought, resilience and response diversity of a semi-arid annual plant community



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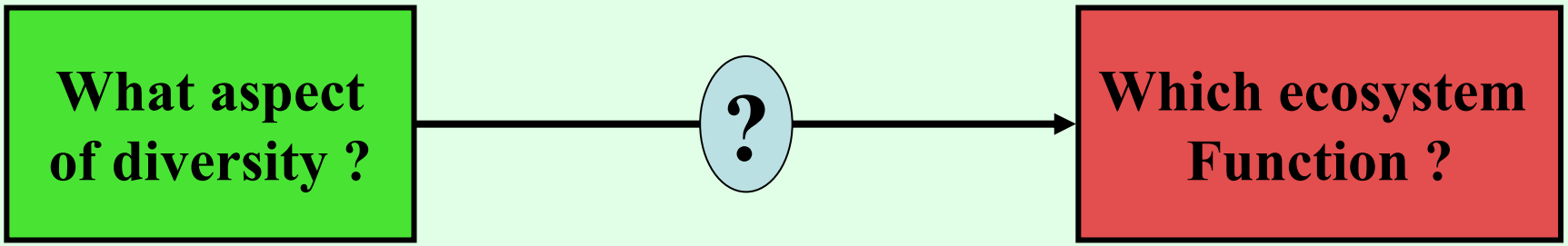
Drought, resilience and response diversity of a semi-arid annual plant community

- General question
- Hypothesis
- Research site
- Two-year drought
- Changes in annual plant density
- Response groups
- Specific mechanisms

Relationship between diversity and ecosystem function



- Species
- Functional groups
- Attributes

- Kinds of functions
  - production
  - decomposition
  - nutrient cycling
  - etc.
- Magnitude
- Stability, Resilience

Proposed hypothesis

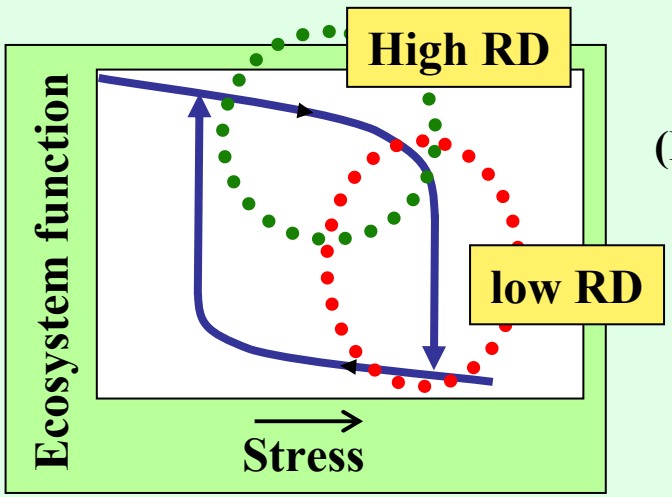
Stress

Species' response diversity → **Ensures** → **Ecosystem resilience**

- Species within a functional group
- with a variety of responses to the same stress

(Elmqvist et al. 2003)

- Self-organization
- Capacity to learn and adapt



- Recovery
- No state change

- the same controls on structure and function

(Holling 1973, Carpenter et al. 2001)

Testing the hypothesis

Required

1. Functional group with many species
2. Factor causing stress
3. A function with possible resilience
4. Variation in response diversity
5. Long-term data

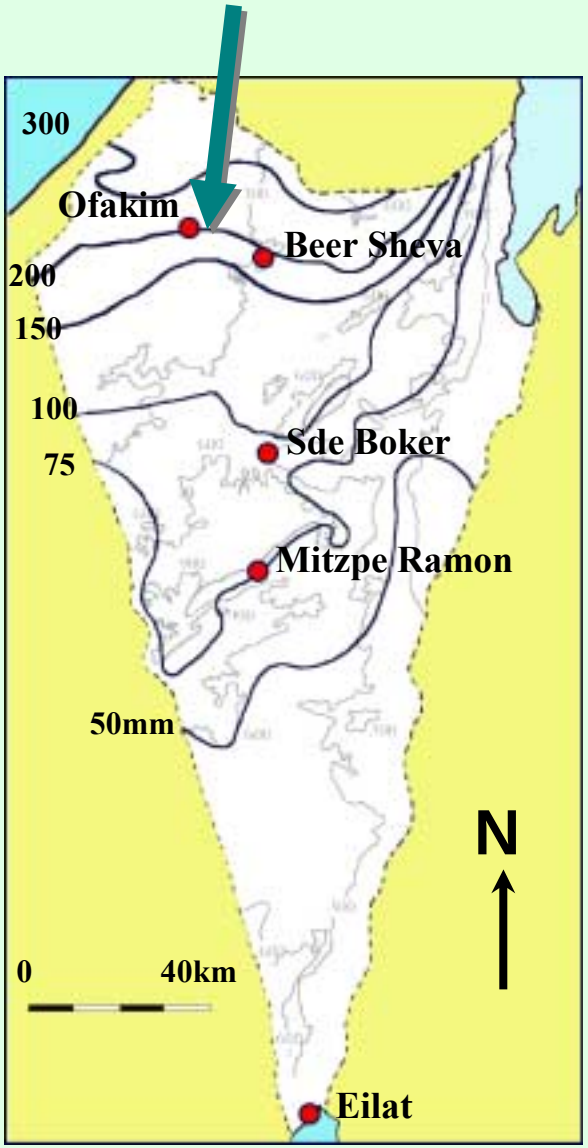
In semi-arid shrubland

1. Species-rich annual plant communities
2. Rare two-year drought event
3. Plant density and biomass production
4. Two patch types with different species
5. LTER site with annual measurements

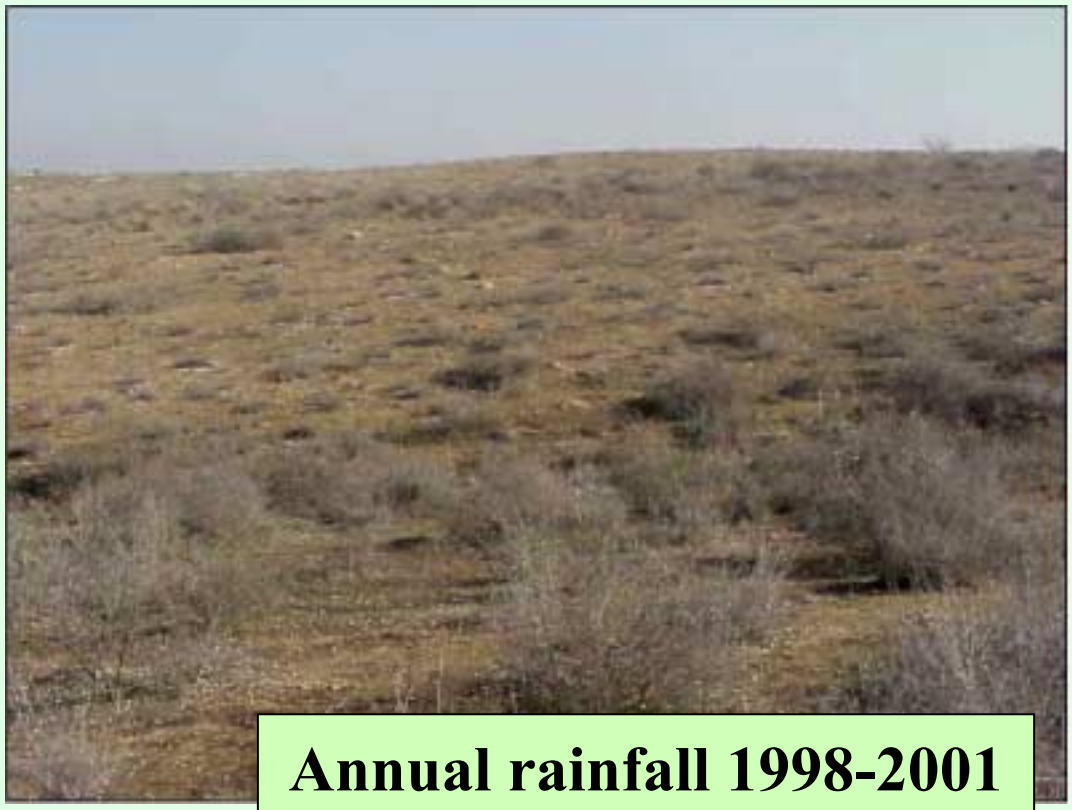
Sayeret Shaked Park ILTER

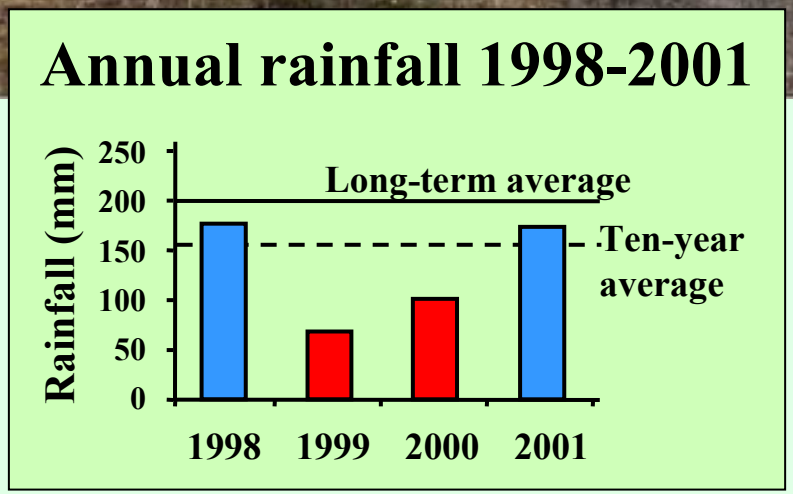
Northern Negev Desert, Israel

- Rainfall between November and March
- Long-term mean annual rainfall ca. 200 mm/yr
- Mean min. winter temp. 6°C
- Mean max. summer temp. 34°C



Two-year drought





Drought years

Annual rainfall < 50% of long-term average

Once in 8 yr

Two years in a row

Once in > 60 yr

Sampling design

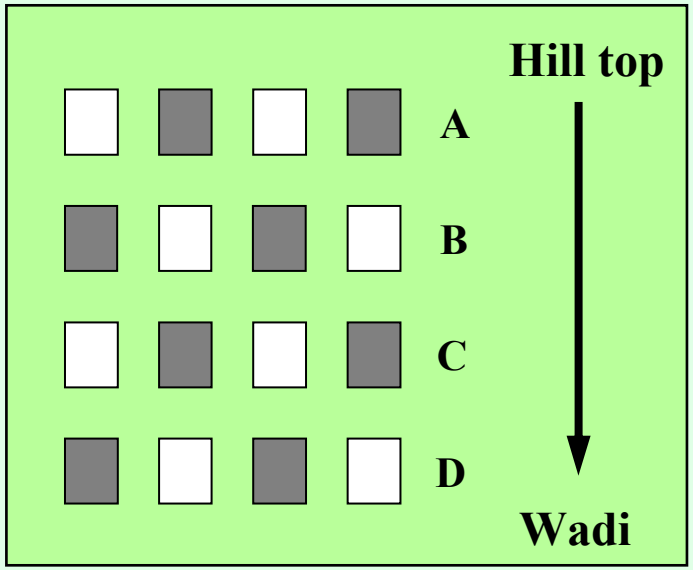
Field sampling

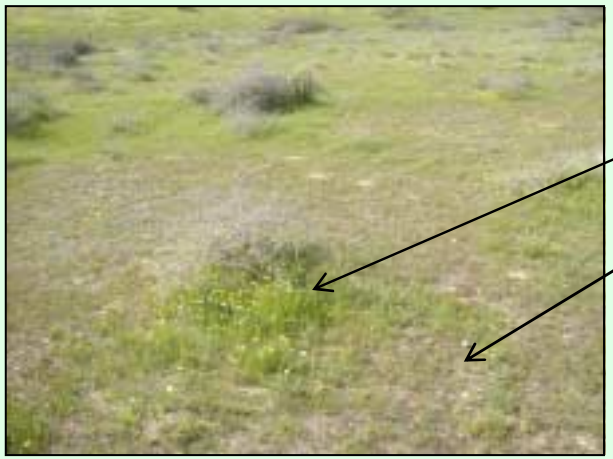
A north-facing slope (ca. 12%)

Four elevations, 16 plots (10 m x 8 m)

Herbaceous vegetation samples (10 cm x 30 cm, N ≈ 98)

In 3 shrub and 3 crust patches per plot.





Landscape patches

Scattered shrubs and

Crusted intershrub matrix

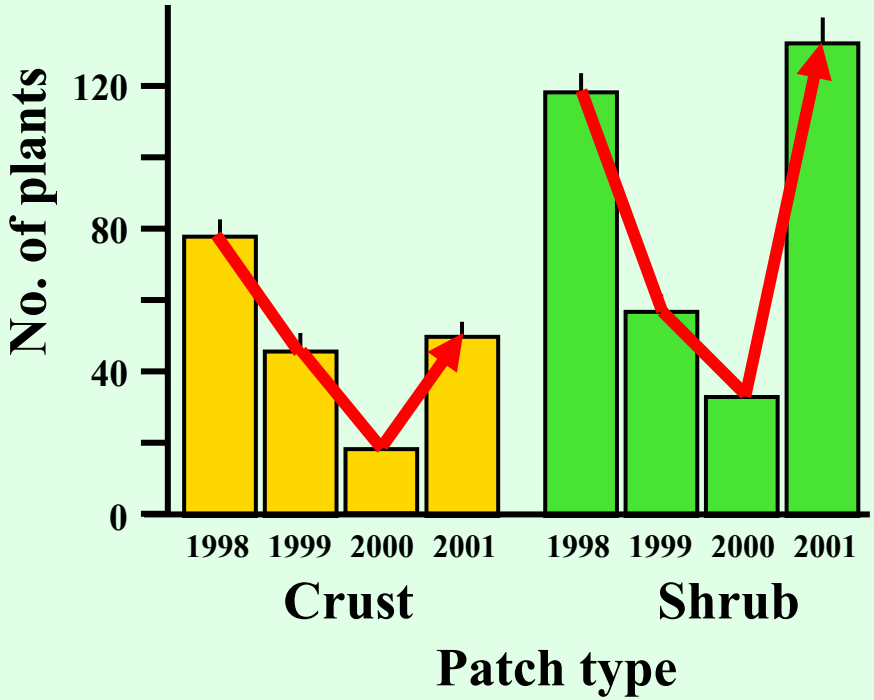
Measurements per sample

Counts of all individuals per species

Non-destructive sampling

Density as proxy variable for Biomass Production

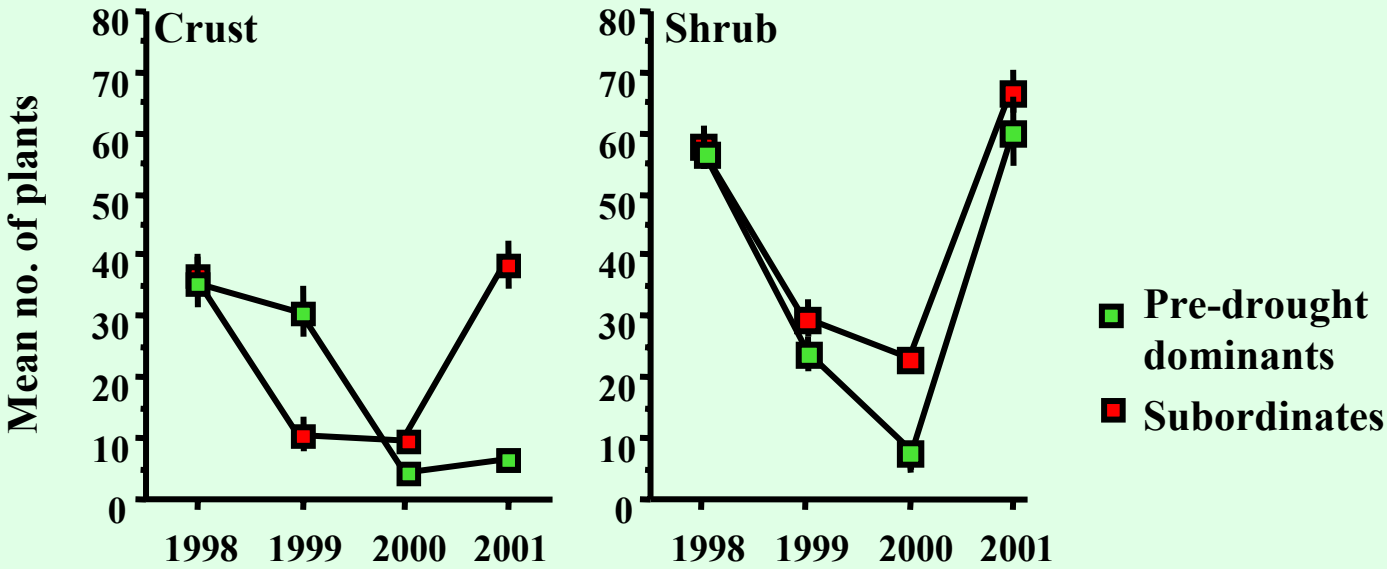
Annual plant density in semi-arid shrubland



Resilience

- **No state change - plant density and biomass maintained; and no changes in control - still by annuals.**
- **Differences between crust and shrub patches - crusts don't recover completely one year after the drought.**

Response groups



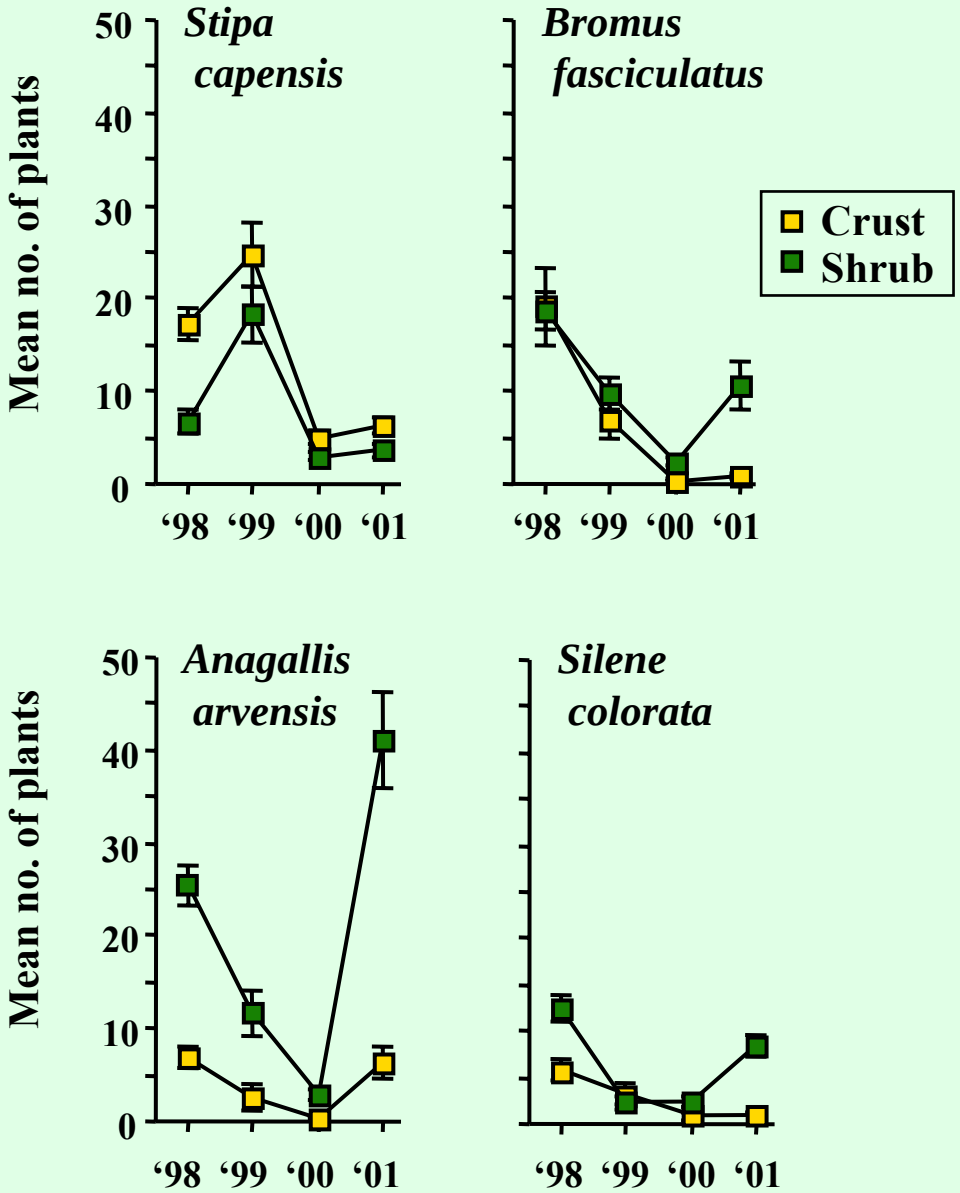
Decrease during drought

- Stronger in dominants
- On the crust delayed

Recovery after drought

- Subordinates increase
- In shrub patches also the dominants

Pre-drought dominants



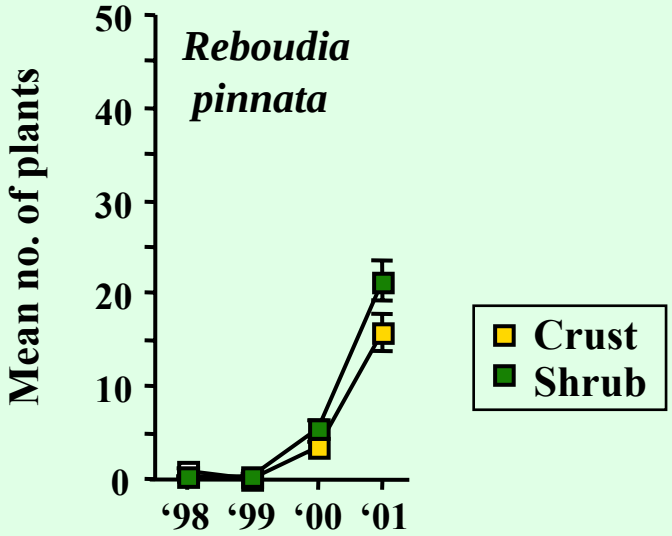
• Dominant grasses suffer during drought, and recover slowly.

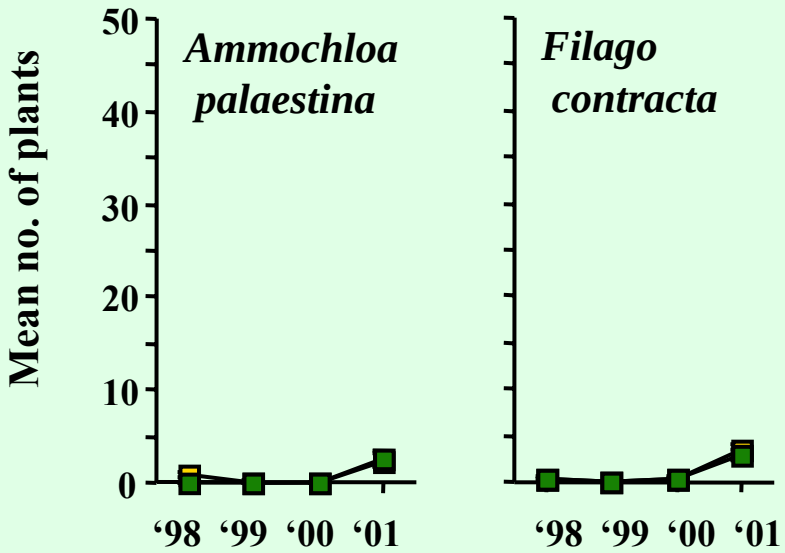
- Due to seed limitation?

• In shrub patches, dominant dicots suffer too, but recover faster.

- Due to site limitation?

Subordinate species





• Subordinate species suffer little, increase during and after the drought.

• Many subordinate species contribute to post-drought recovery in both patch types.

- Due to release of site or resource competition by dominants?

Response diversity

3 response groups

1. Dominant grasses *S. capensis* and *B. fasciculatus*

- **decrease during drought and**
- **recover slowly**

2. Dominant dicots *A. arvensis* and *S. colorata*

- **decrease during drought and**
- **recover faster**
- **only dominant in shrub patches**

3. Subordinates

- **increase during drought**
- **major contribution to recovery**
- **especially *R. pinnata***

Mechanisms

Dominants

***S. capensis* and *B. fasciculatus* in both patch types**

- ✓ Reduced seed production
- ✓ Seed-limited recruitment (Boeken and Shachak 1998)
- ✓ Have no seed dormancy (Boeken et al. 2004)

***A. arvensis* and *S. colorata* in shrub patches**

- • Limited germination sites
- • Recruitment from a dormant seed bank

Subordinates in both patch types

- • Dormant seed bank

R. pinnata:

- ✓ Better germination in light (Zaady et al. 1997) on exposed surface with less litter.

Conclusions

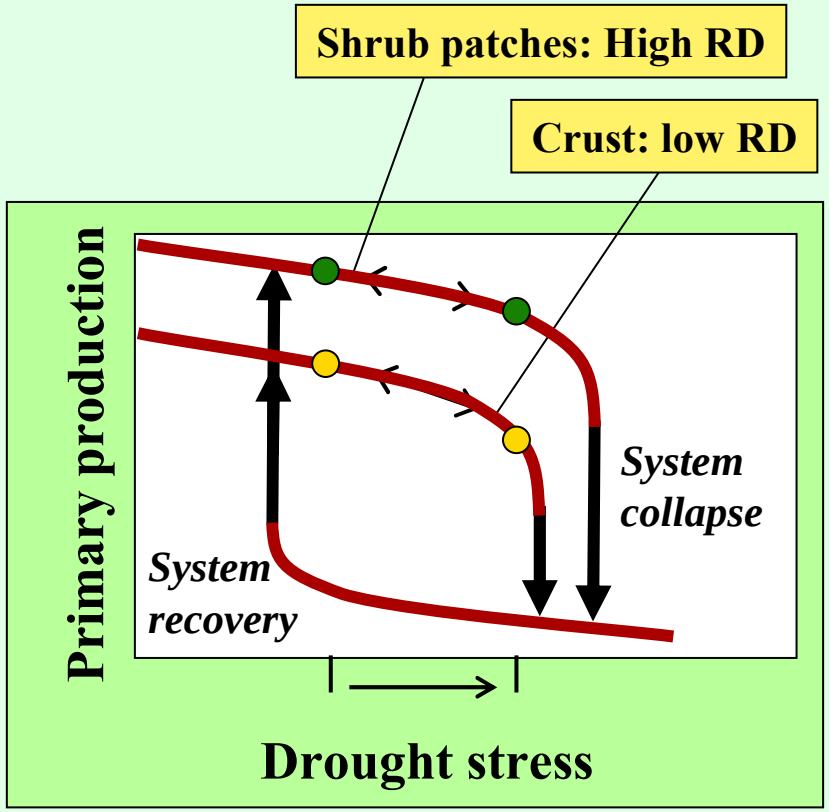
Resilience of ecosystem function

- No state shift

  (perhaps if drought more prolonged?)

- Re-organization of species ranks

- Shrub patches recover better than crusted intershrub matrix



Response diversity

- Shrub patches - 3 groups
  - Dominant grasses
  - Dominant dicots
  - Many subordinates
- Crusted matrix - 2 groups
  - Dominant grasses
  - No dominant dicots
  - Fewer subordinates

Thank you