

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

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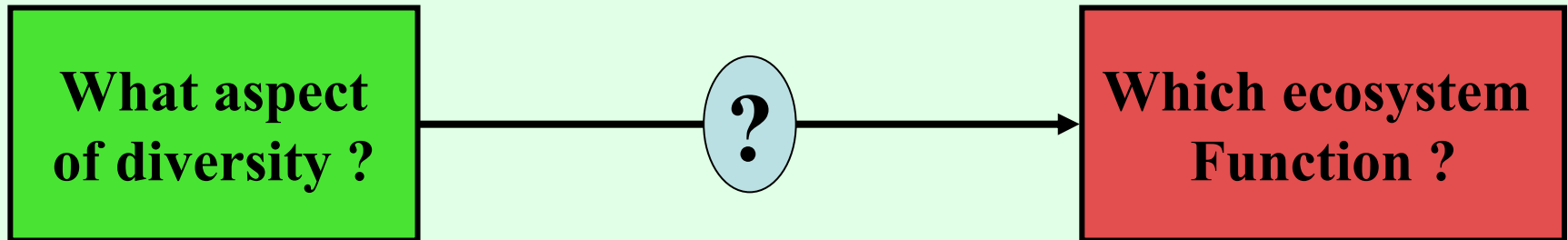
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# **Drought, resilience and response diversity of a semi-arid annual plant community**

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

# Relationship between diversity and ecosystem function

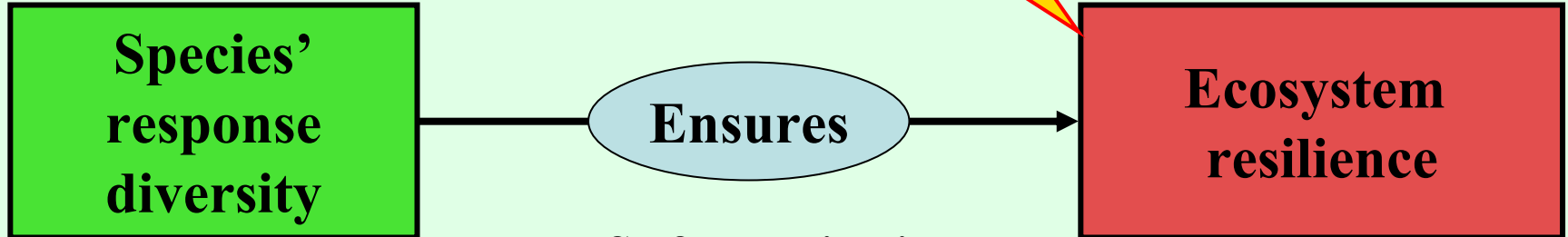


- **Species**
- **Functional groups**
- **Attributes**

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

# Proposed hypothesis

Stress



• Self-organization

• Capacity to learn and adapt

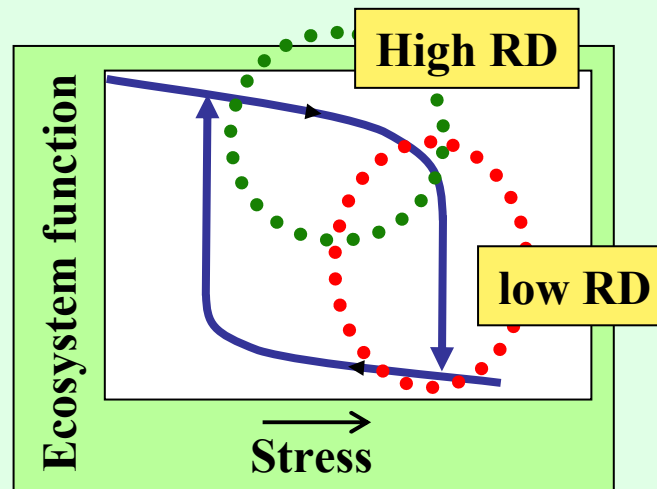
• Recovery

• No state change

- the same controls on structure and function

(Holling 1973, Carpenter et al. 2001)

- Species within a functional group
- with a variety of responses to the same stress  
(Elmqvist et al. 2003)



# 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**

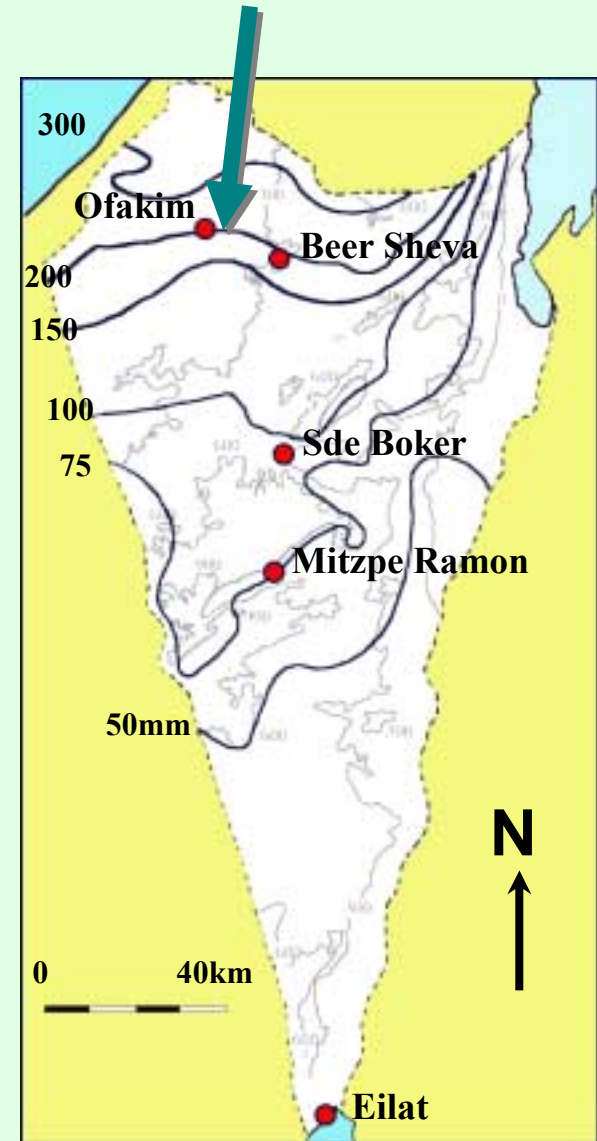
## In semi-arid shrubland

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. **LTERR site with annual measurements**

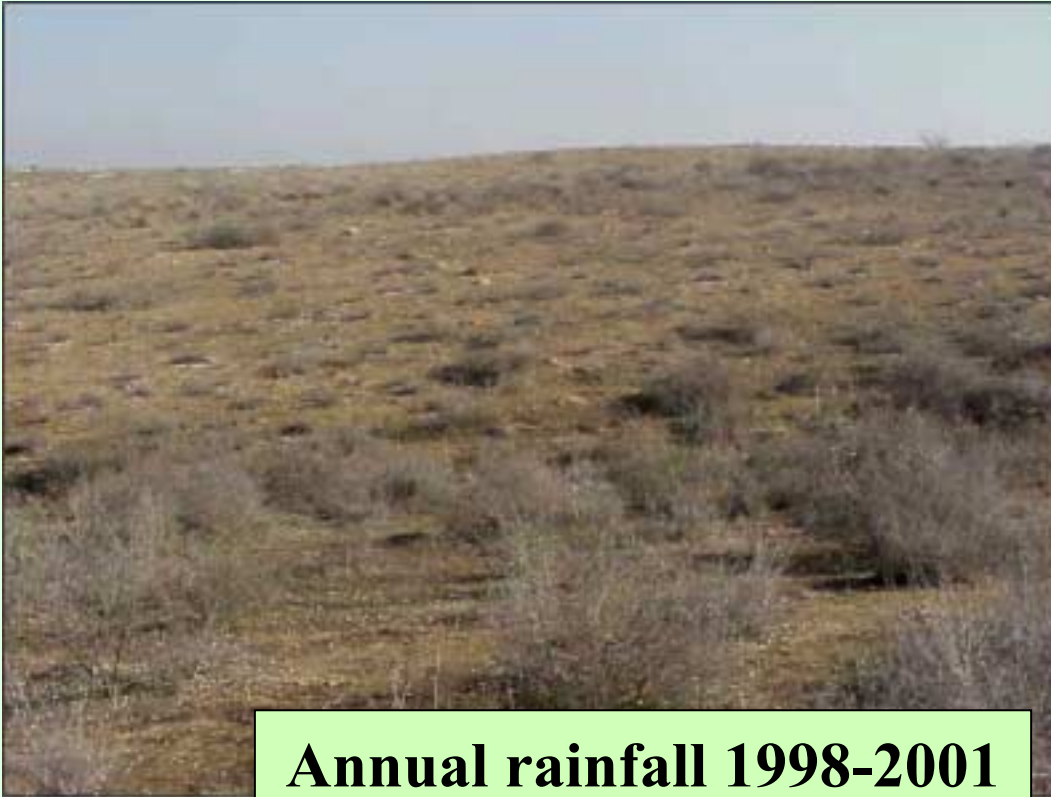
# Sayeret Shaked Park ILTER

## 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



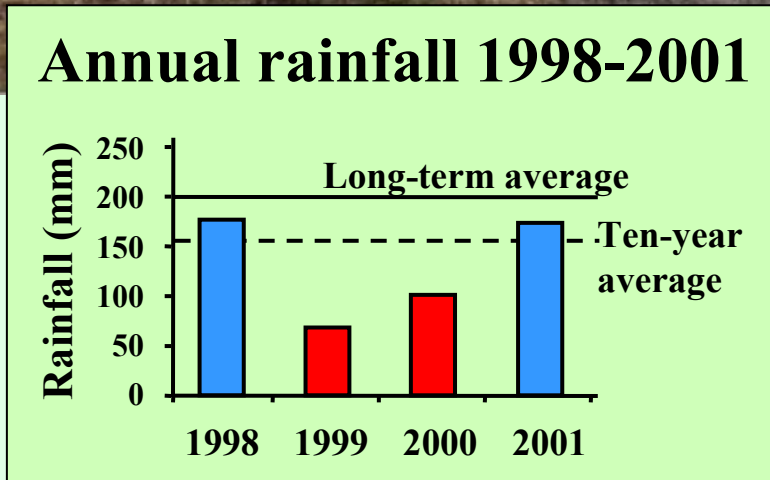
**Drought years**

**Annual rainfall < 50%  
of long-term average**

**Once in 8 yr**

**Two years in a row**

**Once in > 60 yr**



# Sampling design

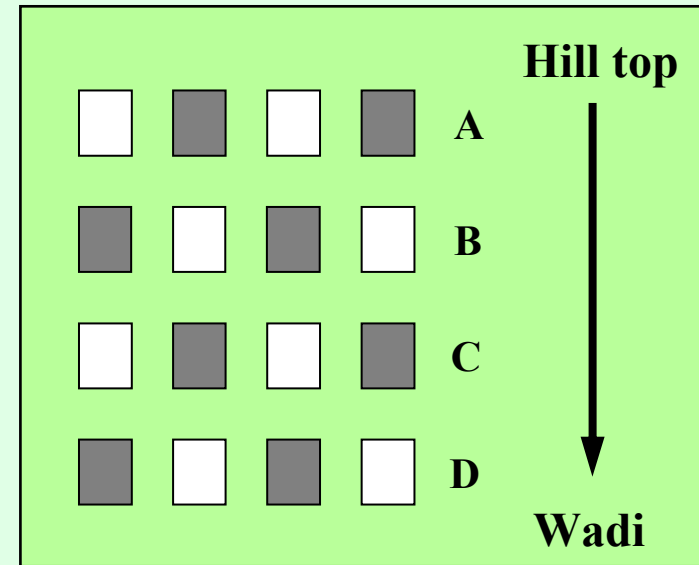
## Field sampling

**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**

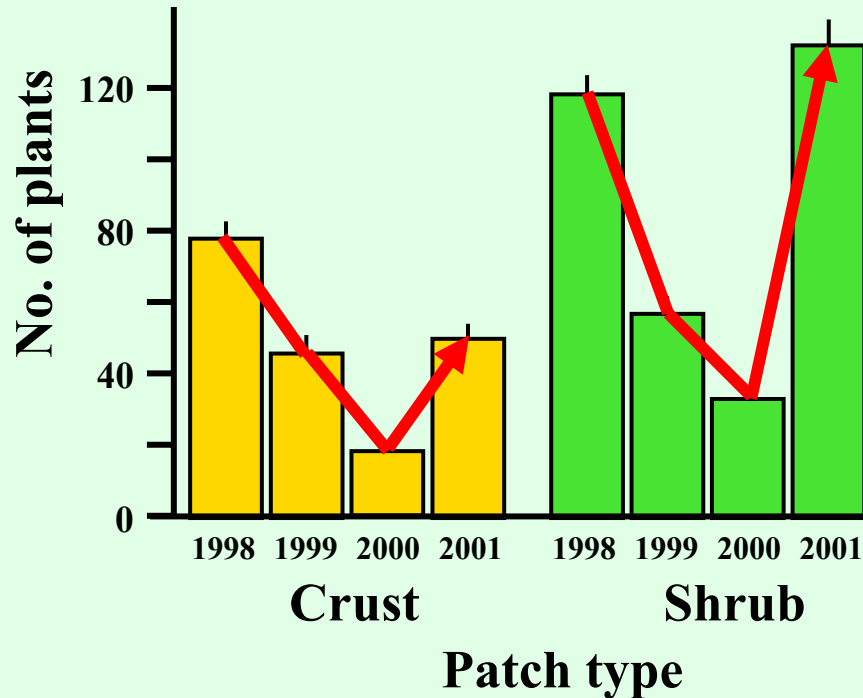
## Measurements per sample

**Counts of all individuals per species**

**Non-destructive sampling**

**Density as proxy variable for Biomass Production**

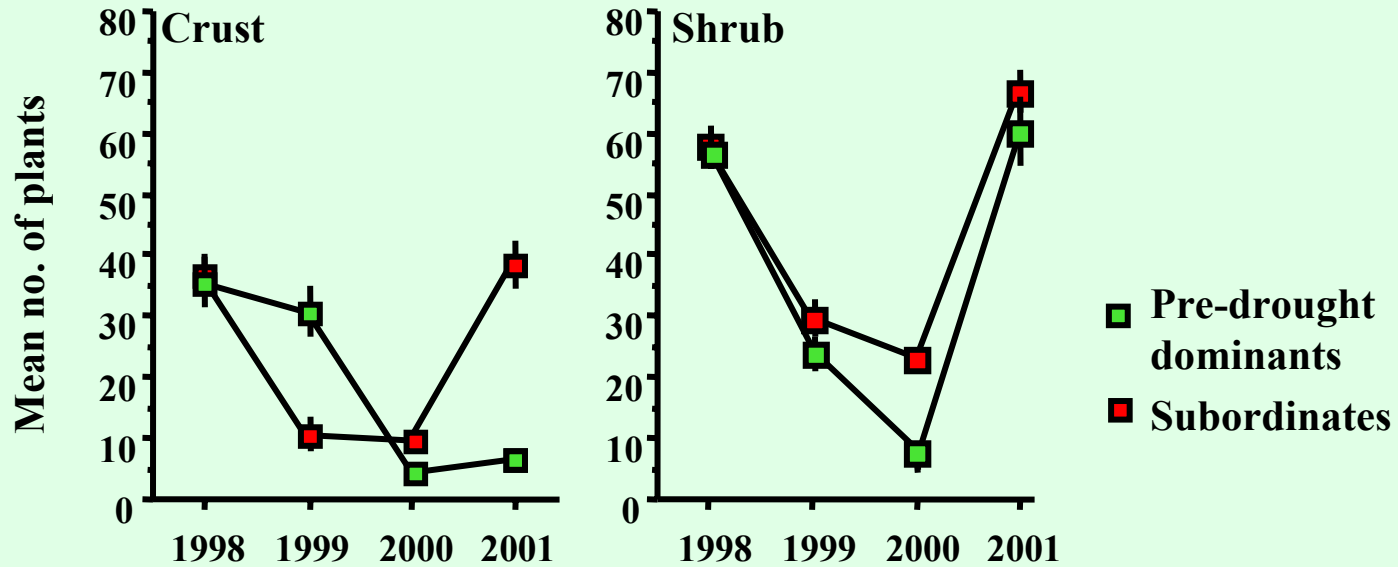
# Annual plant density in semi-arid shrubland



## 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



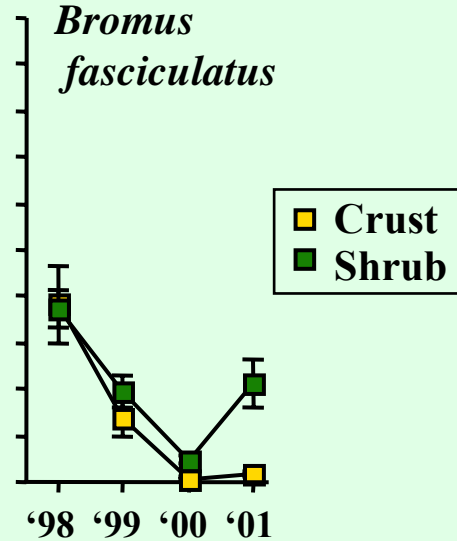
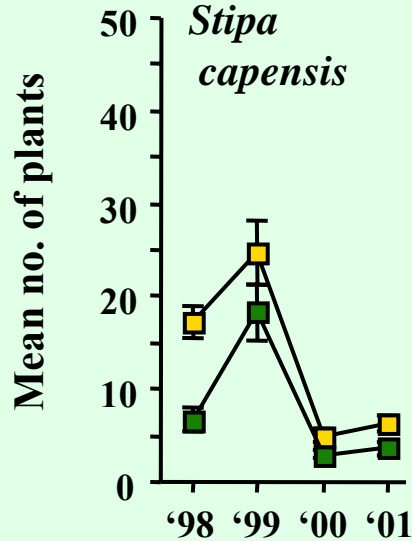
## Decrease during drought

- Stronger in dominants
- On the crust delayed

## Recovery after drought

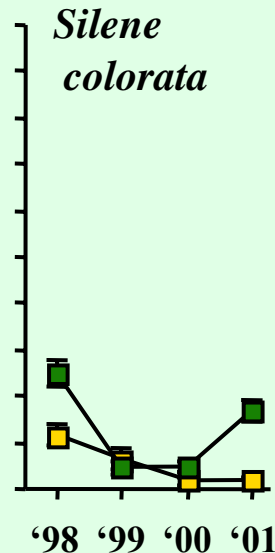
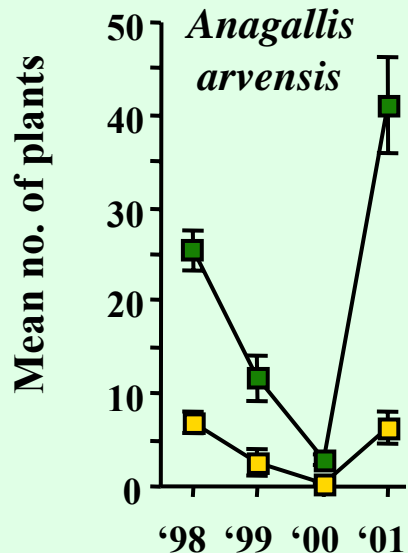
- Subordinates increase
- In shrub patches also the dominants

# Pre-drought dominants



- **Dominant grasses suffer during drought, and recover slowly.**

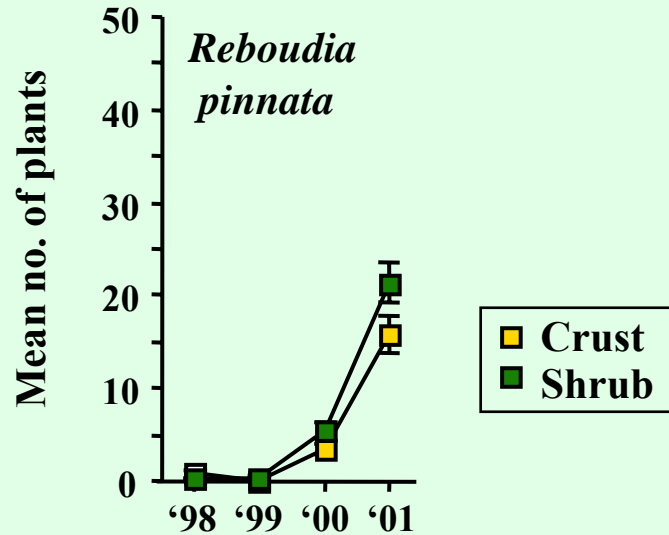
- Due to seed limitation?



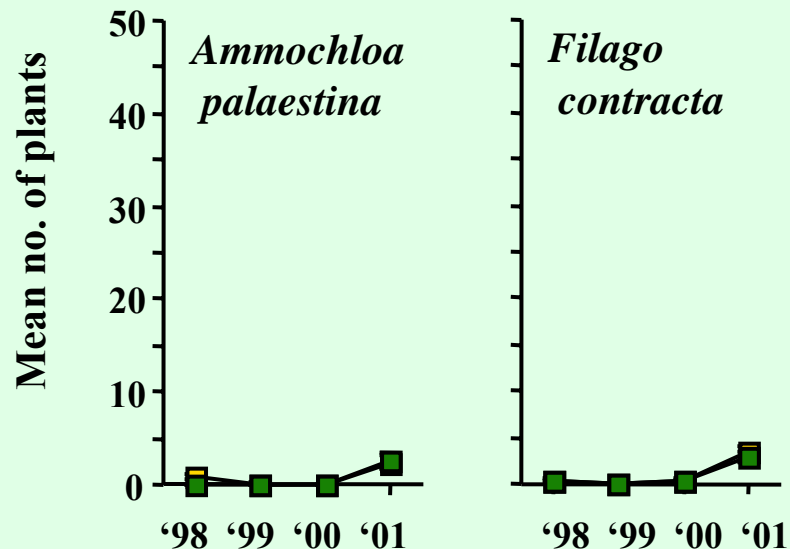
- **In shrub patches, dominant dicots suffer too, but recover faster.**

- 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

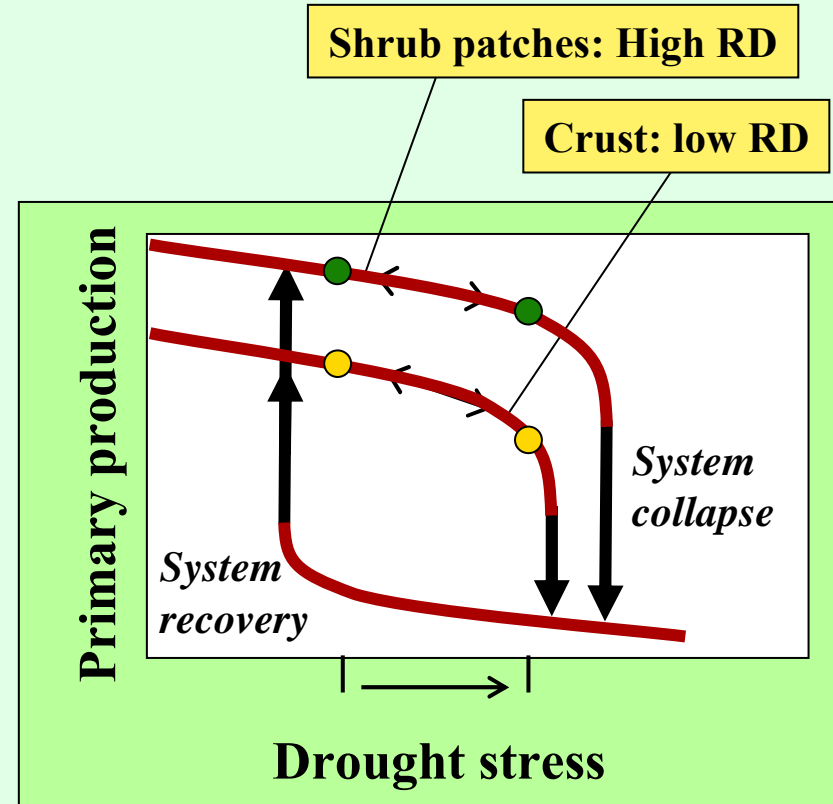
*R. pinnata*:

- ✓ 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

