

Disturbance



Jayne Belnap

USGS - Southwest Biological Research Center



All have similar effects on soil crusts:

- **Soil surface disturbance**
- **Annual grass**
- **Altered fire**

- **Simplified community**
- **Reduced cover**

- **Less soil nitrogen, carbon, other nutrients**
- **Less stability**
- **Altered nutrient availability**

Soil Surface Disturbance

Indirect Effect: Burial



Direct Effects of Soil Surface Disturbance



- **Lose surface roughness**
 - **Greater water, wind velocity = greater erosion**
 - **Lose retention of dust, seeds, and organic matter**
- **Lose biodiversity**

Direct Effects of Soil Surface Disturbance



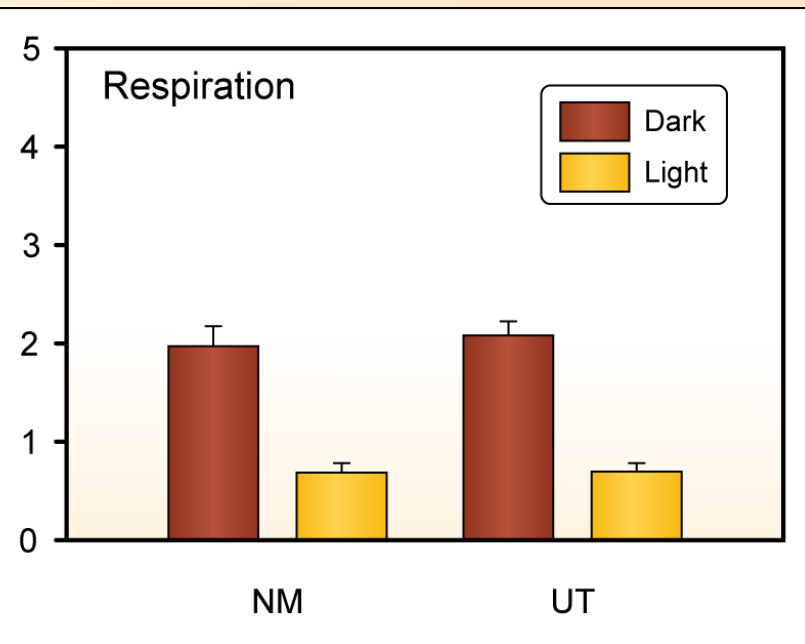
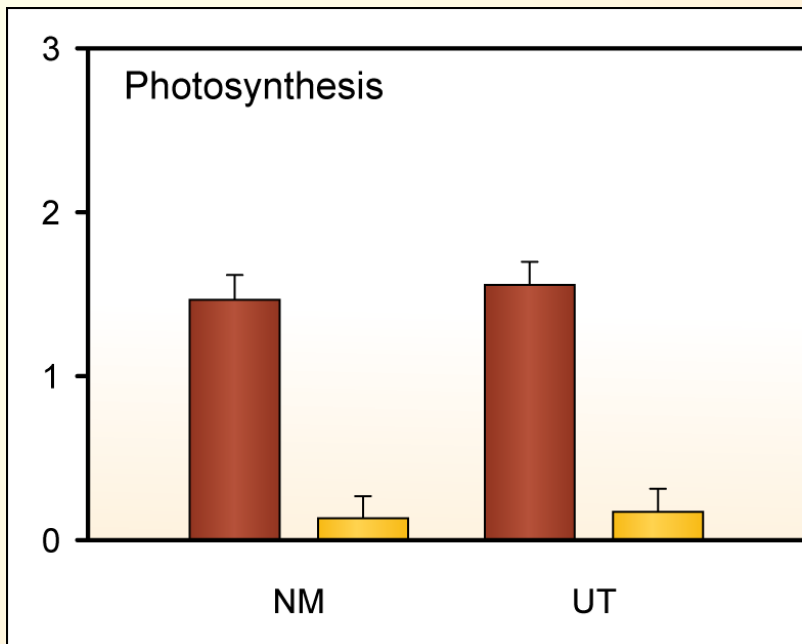
- **Nitrogen fixation stops**
 - **Soil aerated**
 - **Organisms buried**

With Disturbance:

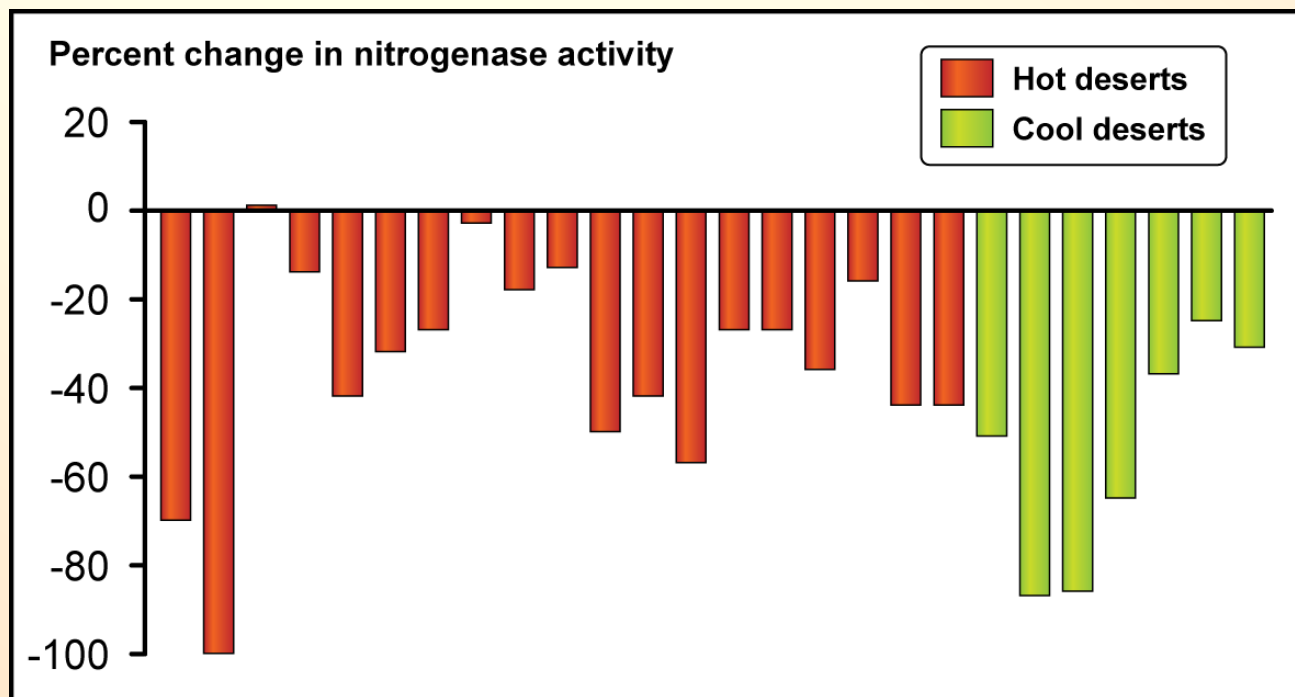
~~Inputs:
Biological N
fixation~~

- Water erosion
- Wind erosion

➤ Gas fluxes:
NO, N₂O, NH₃



**N and C
inputs to
interspace
soils are
lowered**



Direct Effects of Soil Surface Disturbance

Thirty years after disturbance

	Undisturbed		Disturbed	
	mean	std. error	mean	std. error
Organic matter (%)	2.6	± 0.2	1.7	± 0.2
Nitrogen content (mg N/g)	0.41	± 0.01	0.27	± 0.03
Mineralization potential ($\mu\text{gNH}_4\text{-N/g}$)	11.1	± 1.9	2.4	± 0.1
Soil δN (‰)	3.6	± 0.4	5.1	± 0.3
Plant δN (‰)	1.1	± 0.7	2.6	± 0.3



Direct Effects of Soil Surface Disturbance

Albedo increases/Soil temperature decreases



Direct Effects of Soil Surface Disturbance



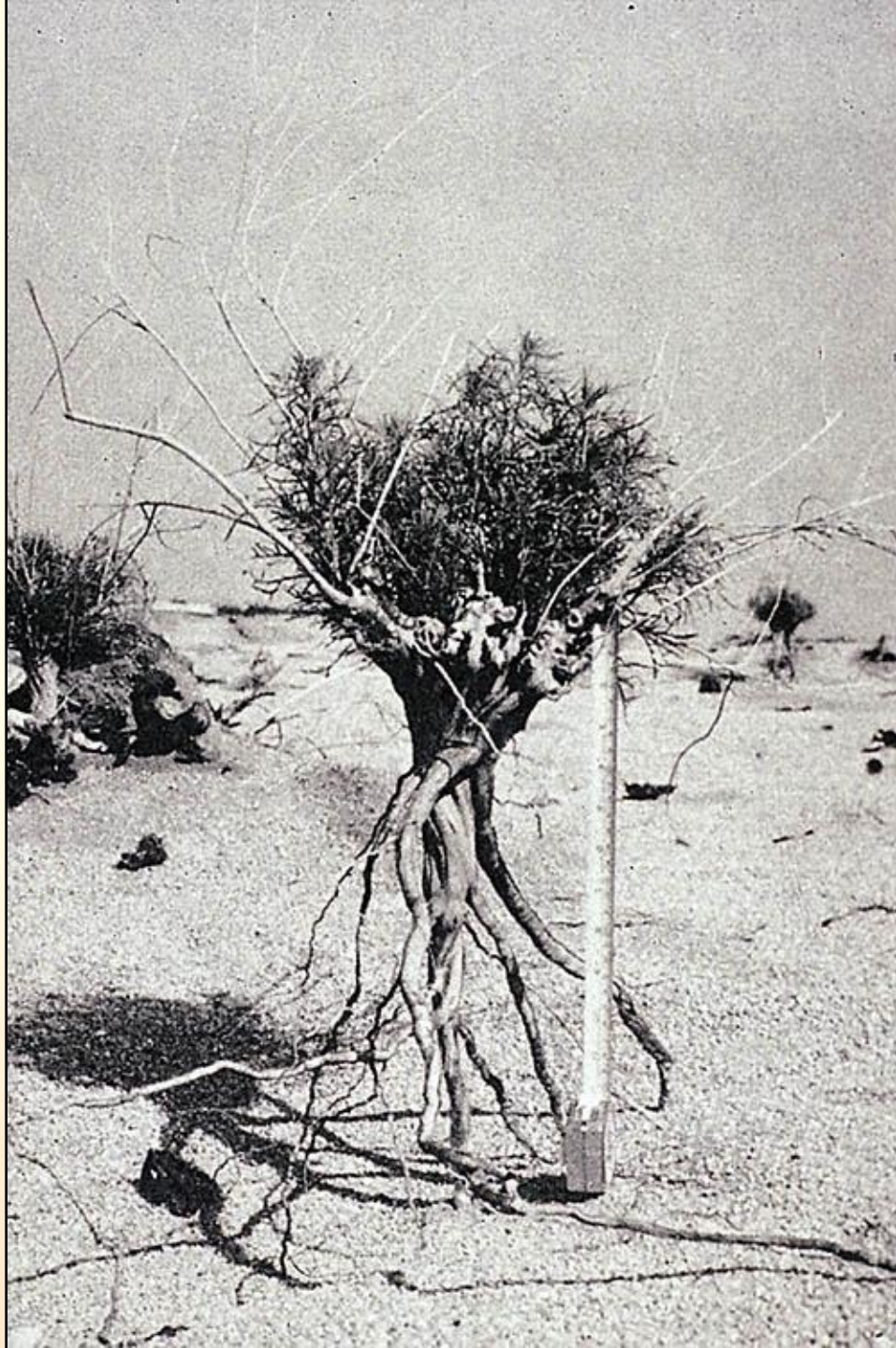
- **Lose soil stability**
 - **Filaments smashed**
 - **Organisms buried**
 - **Lichens, mosses lost**

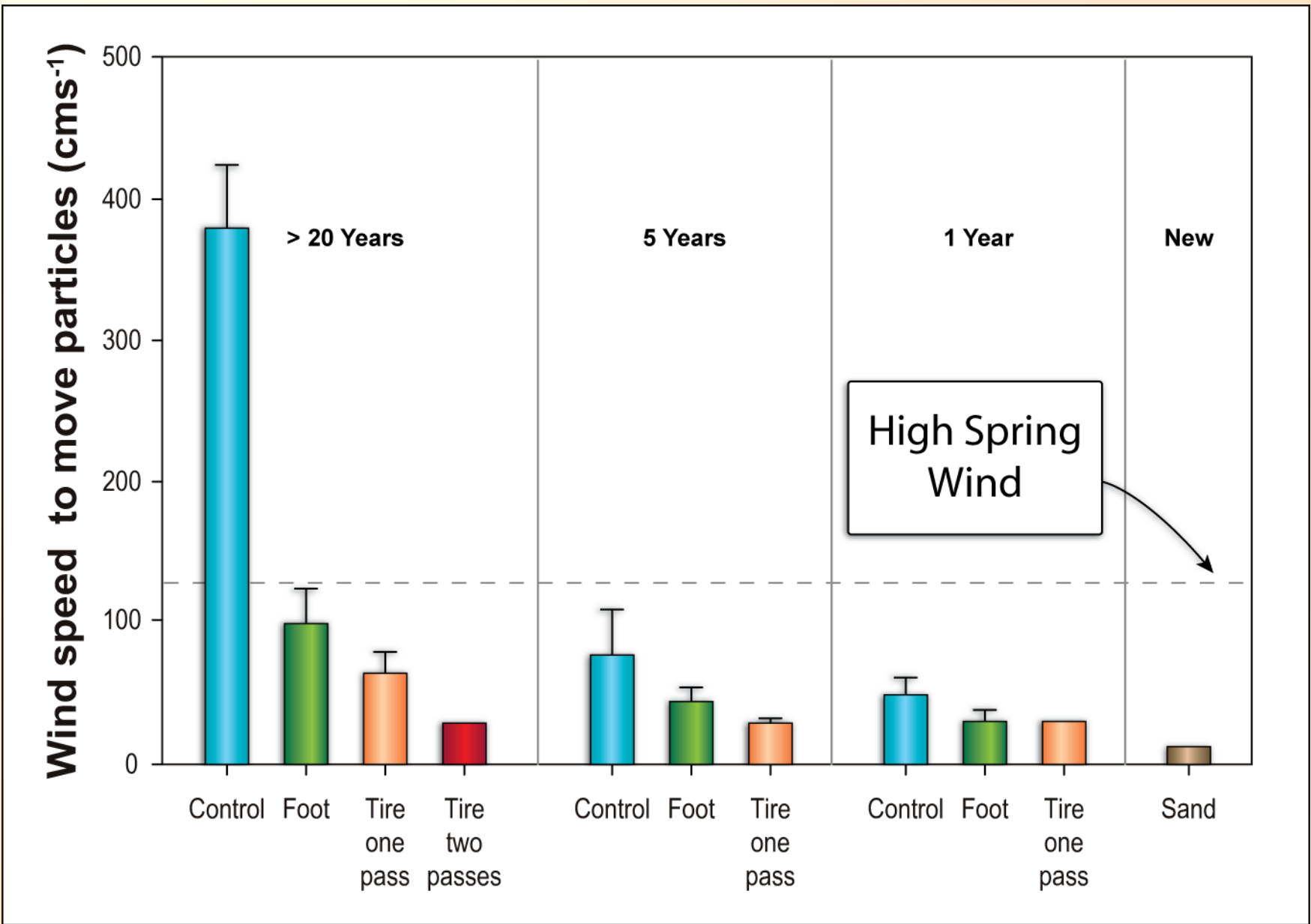


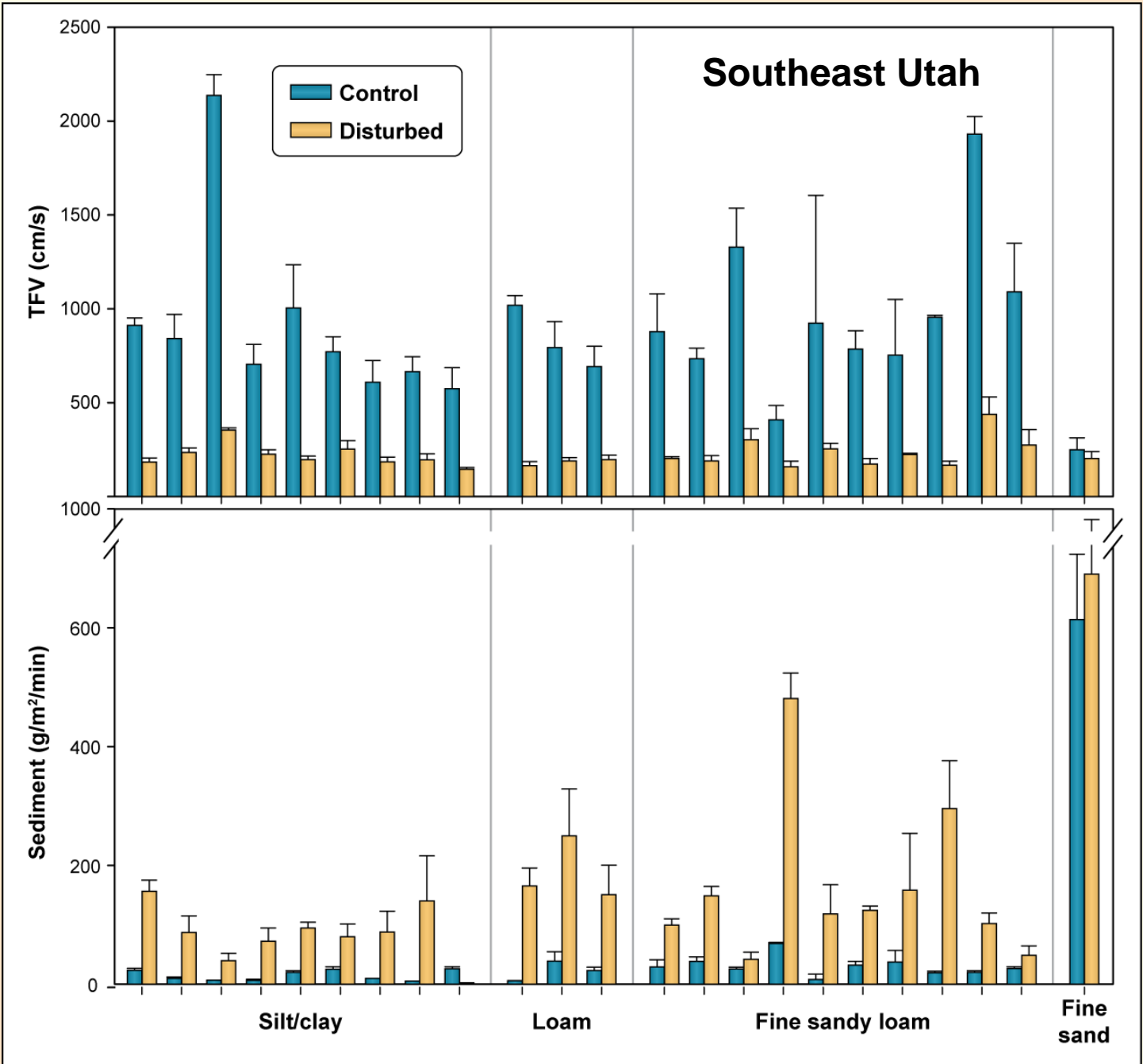
Dust Front Approaching Lubbock, Texas Ahead of Spring Convective Storm



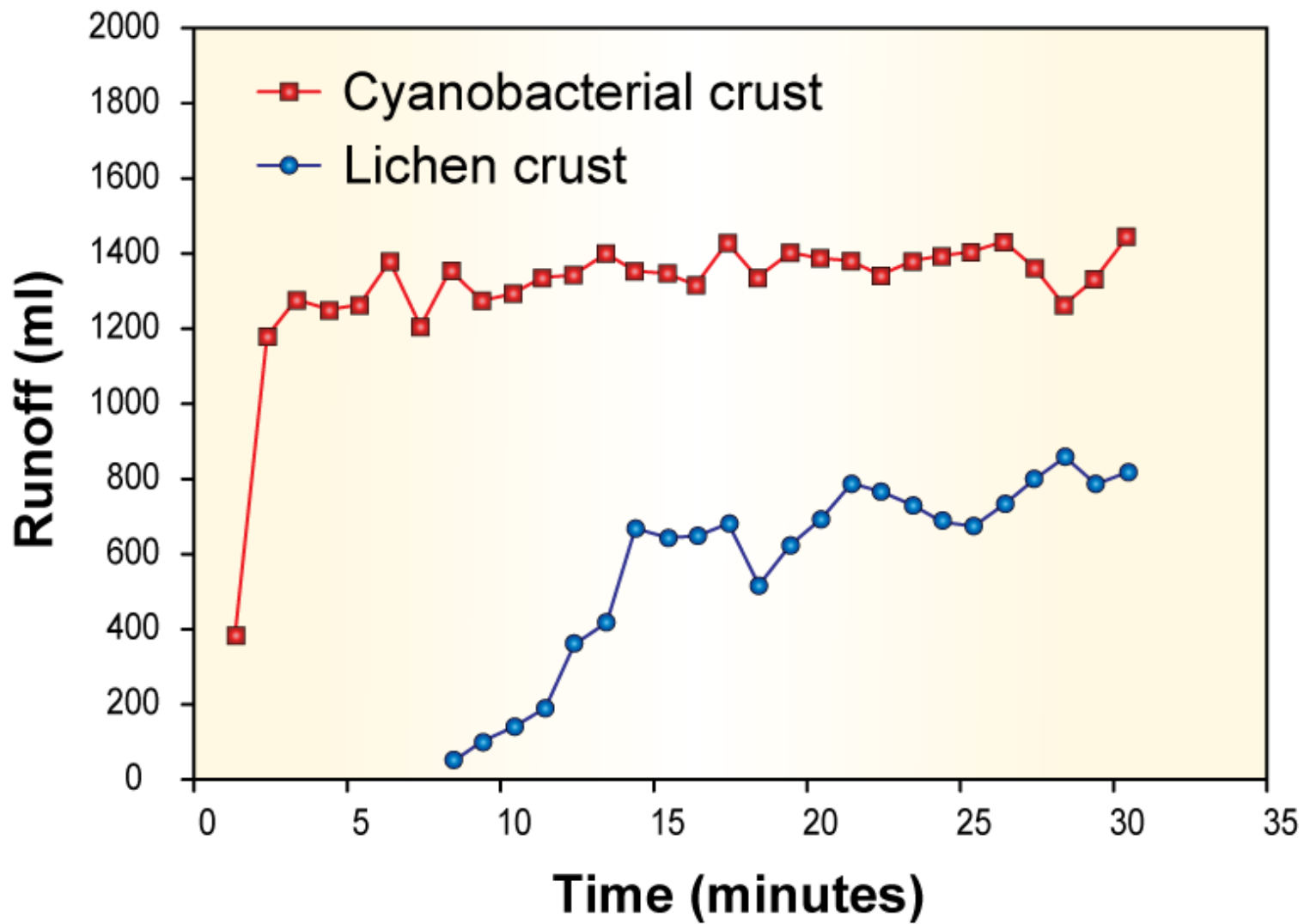


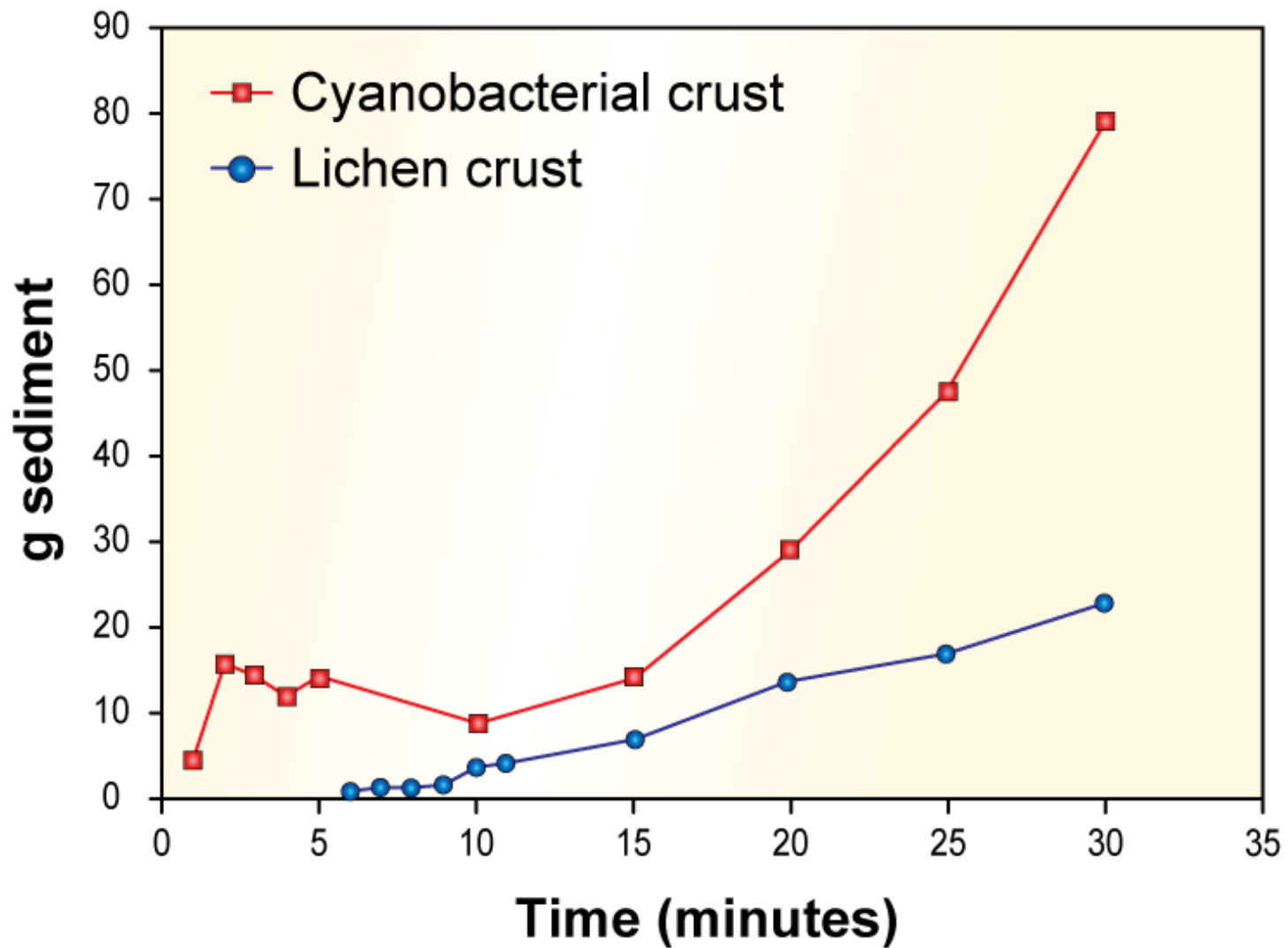


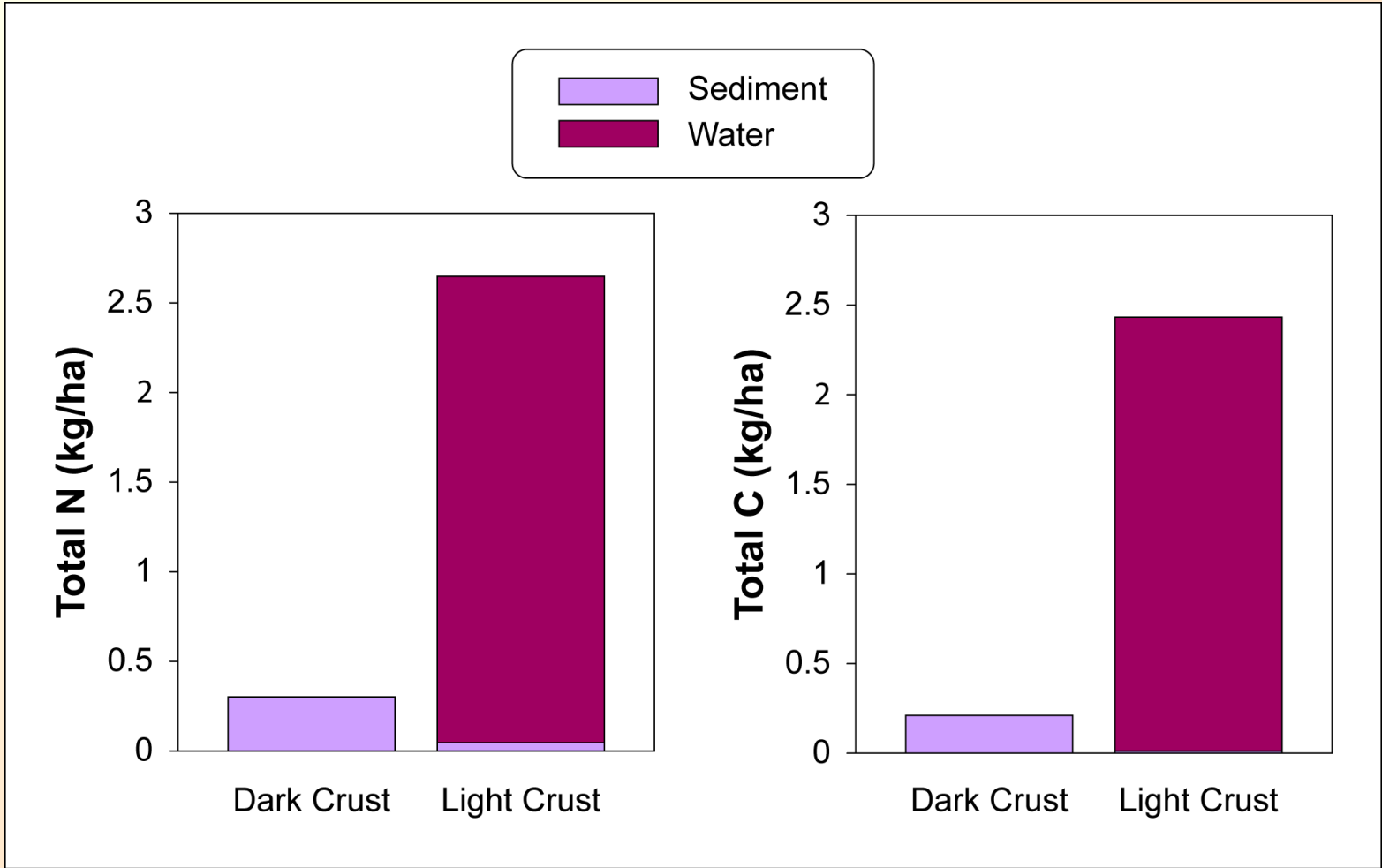




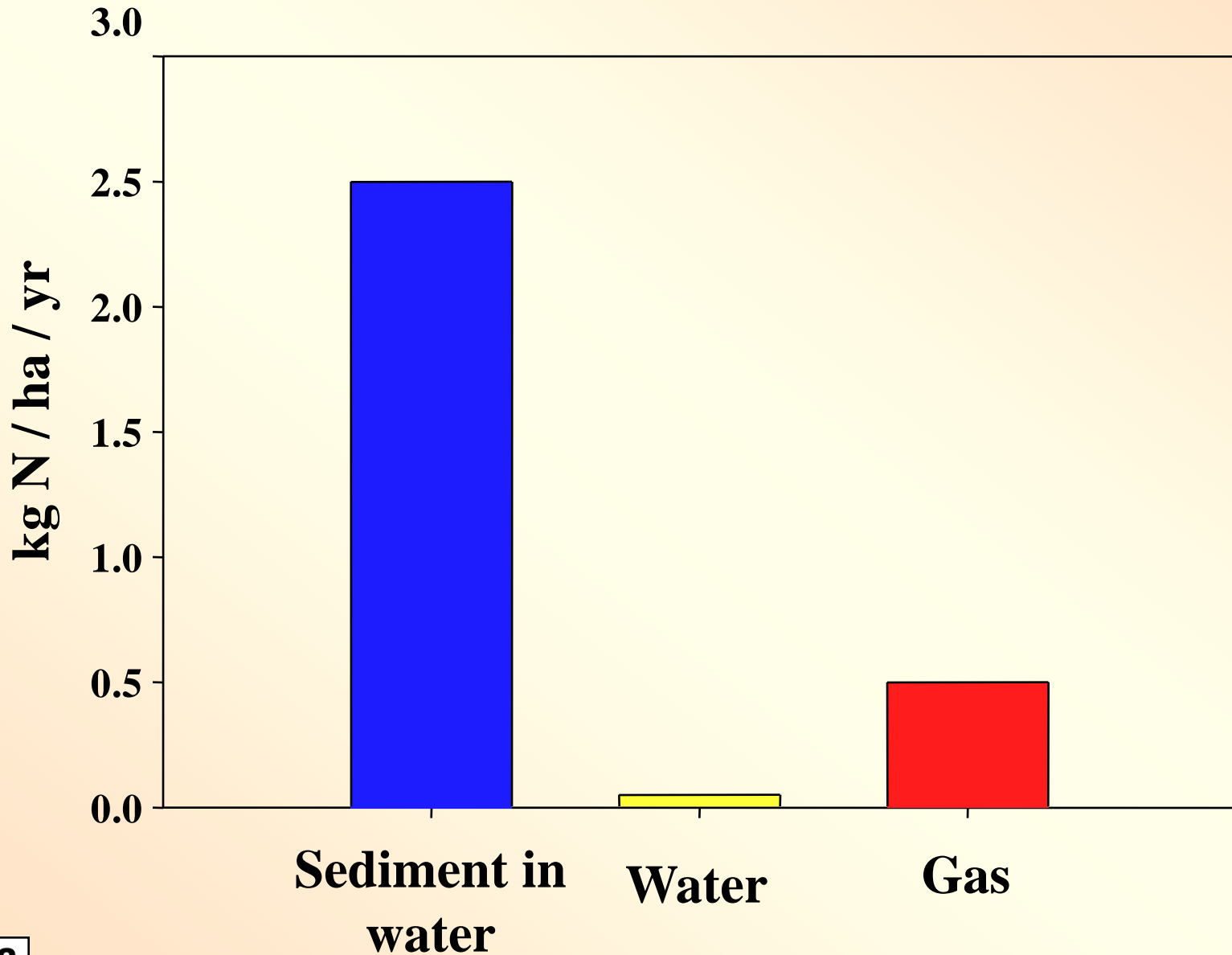








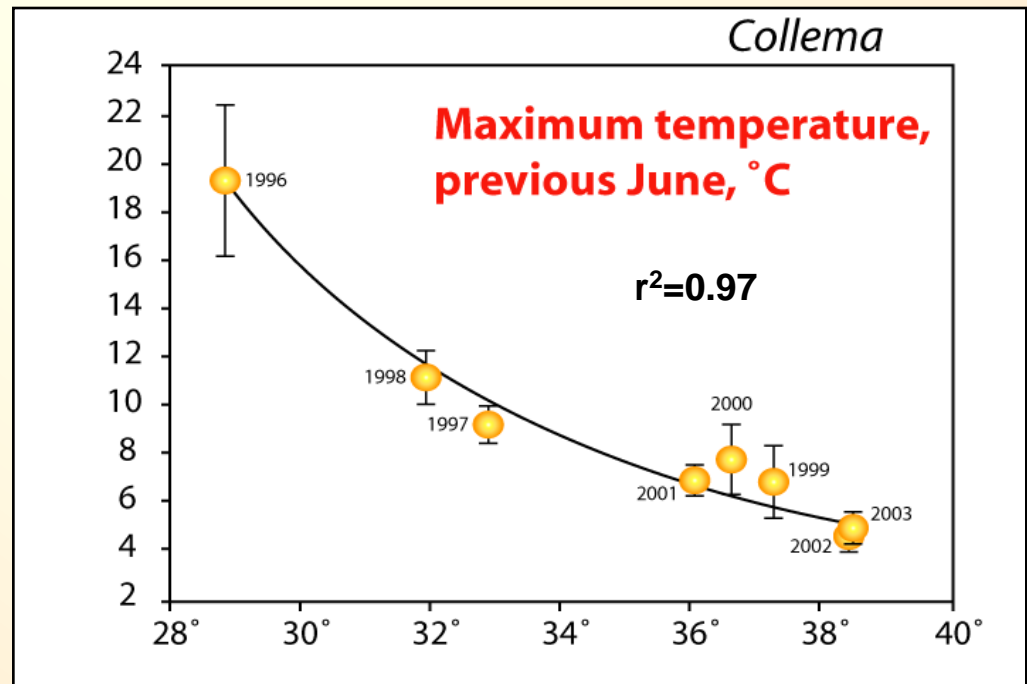
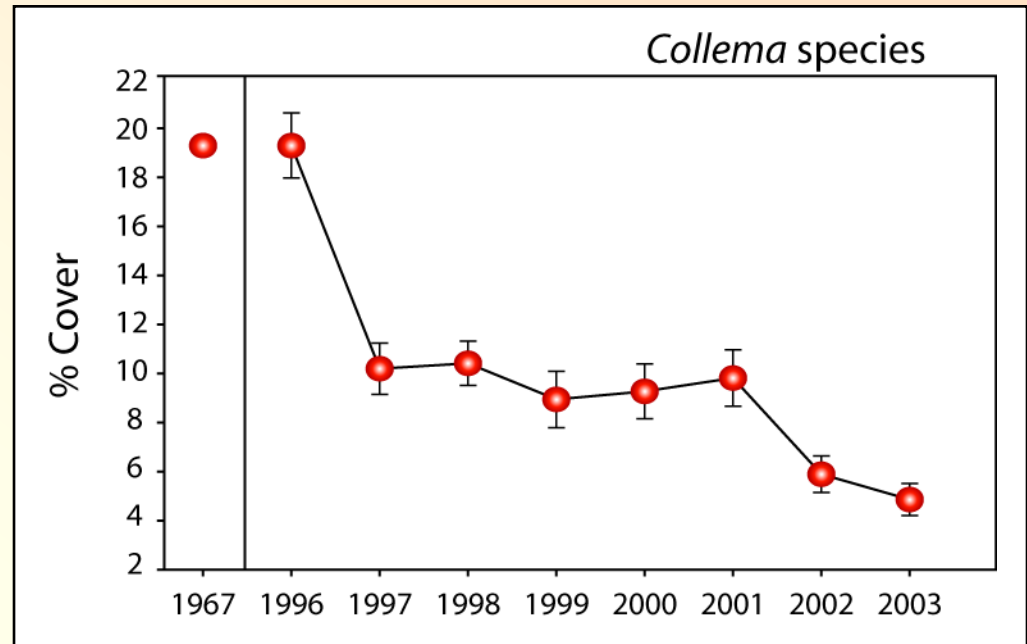
Nitrogen losses on the Colorado Plateau



Climate Change

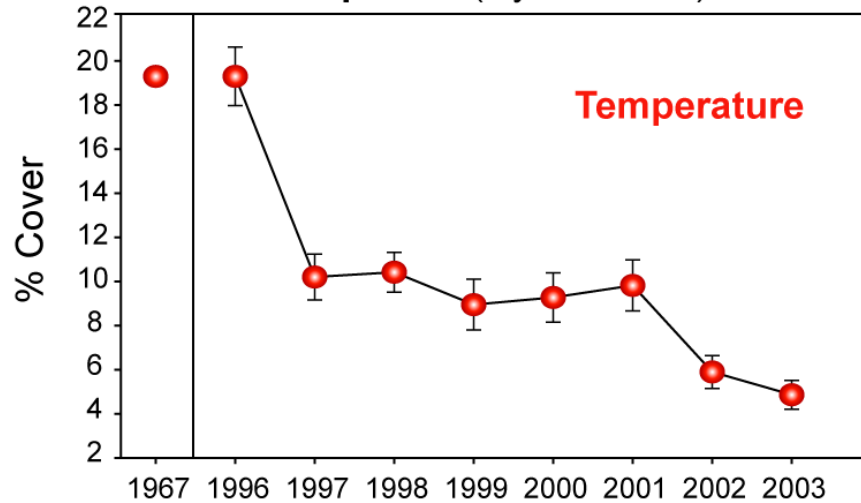
- **Altered temperature**
- **Altered precipitation timing, amounts**

Temperature

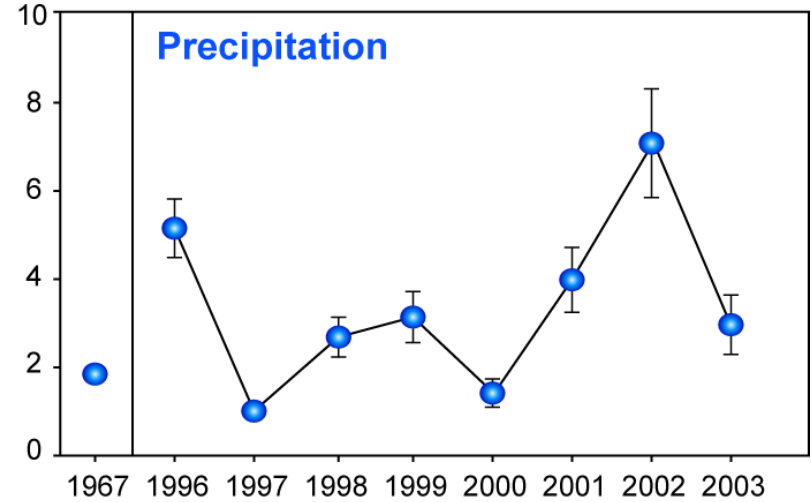


Climate

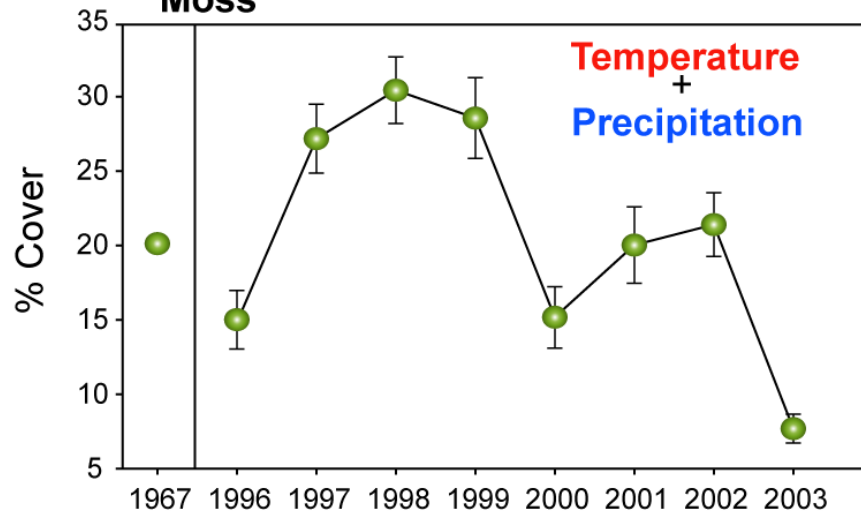
Collema species (Cyanolichen)



Chlorolichens



Moss



When precipitation frequency is increased

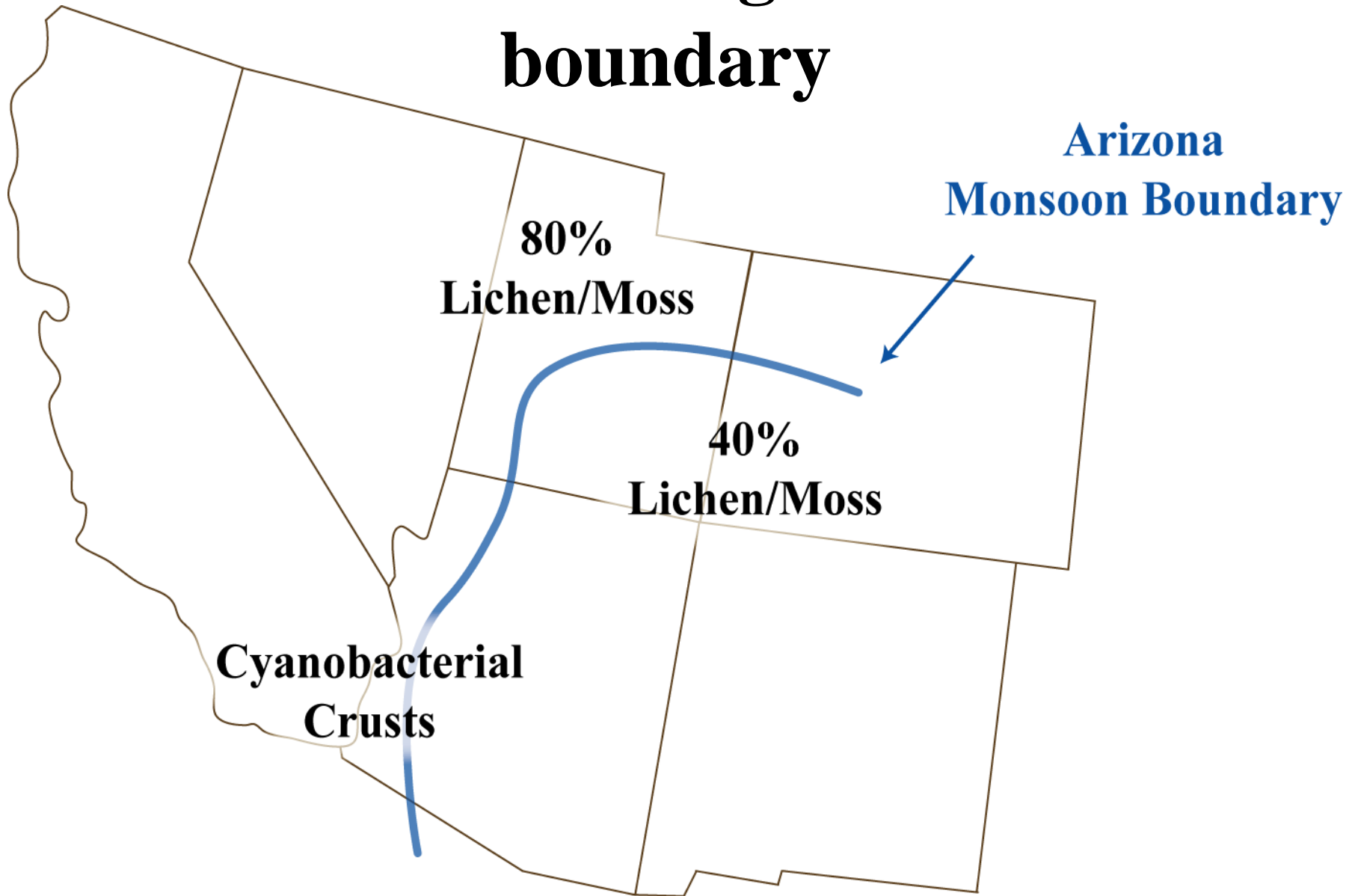
Carbon deficit results

< Chlorophyll *a*

< UV-protective pigments

> Mortality

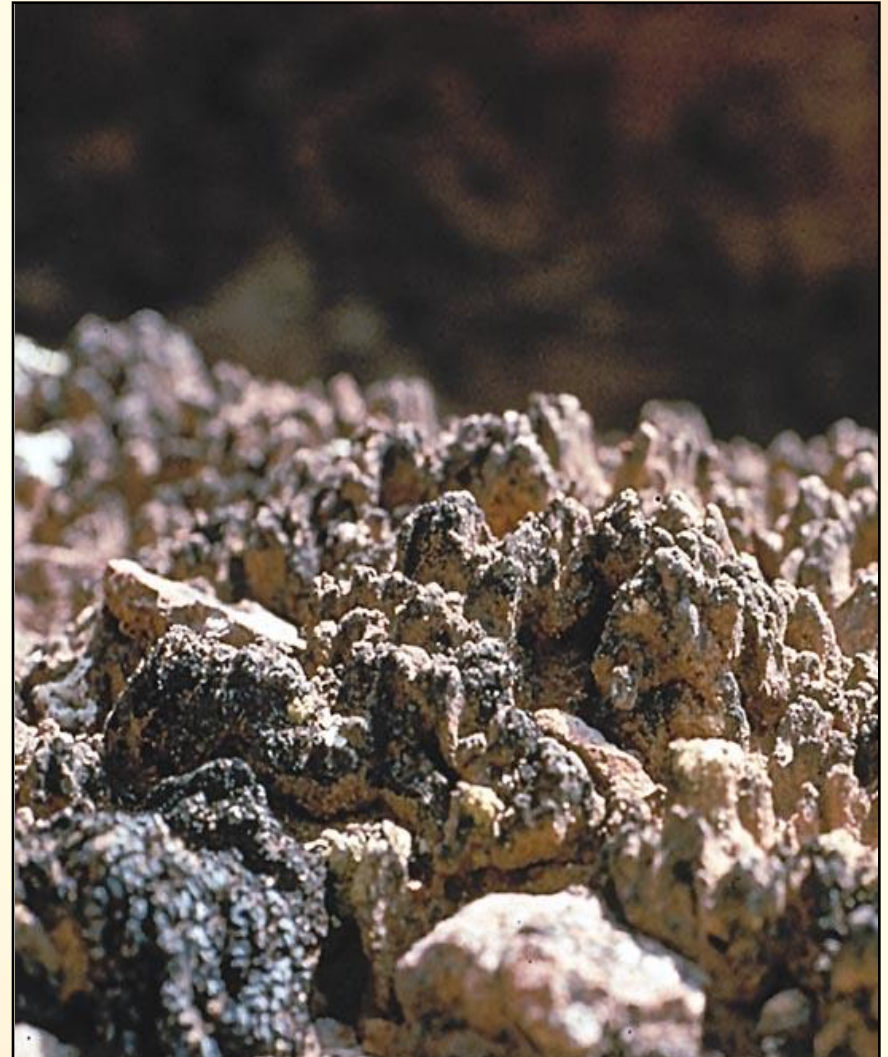
Seasonal timing will shift boundary



Rolling



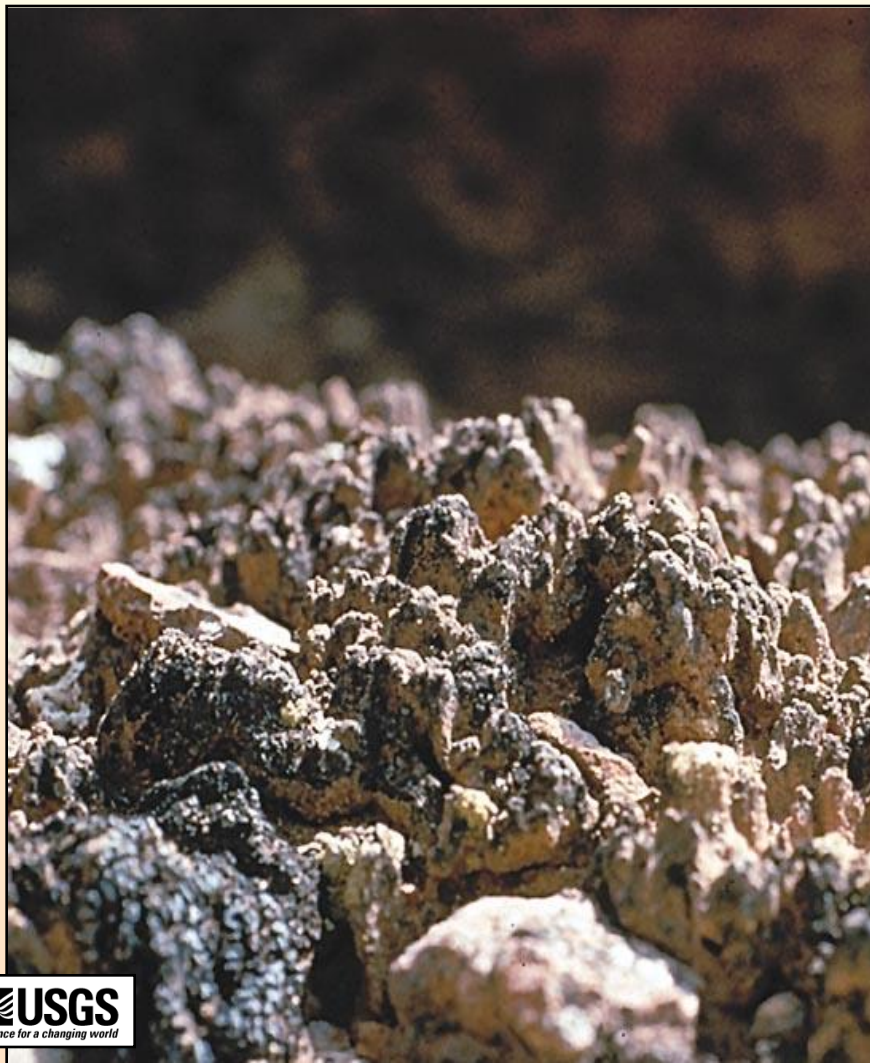
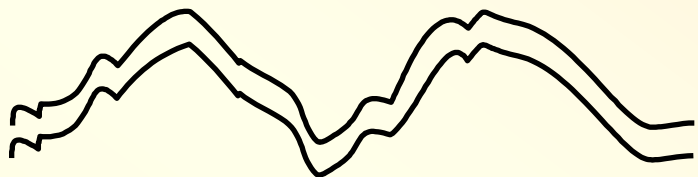
Pinnacled



Pinnacled



Rugose



Rugose



Flat



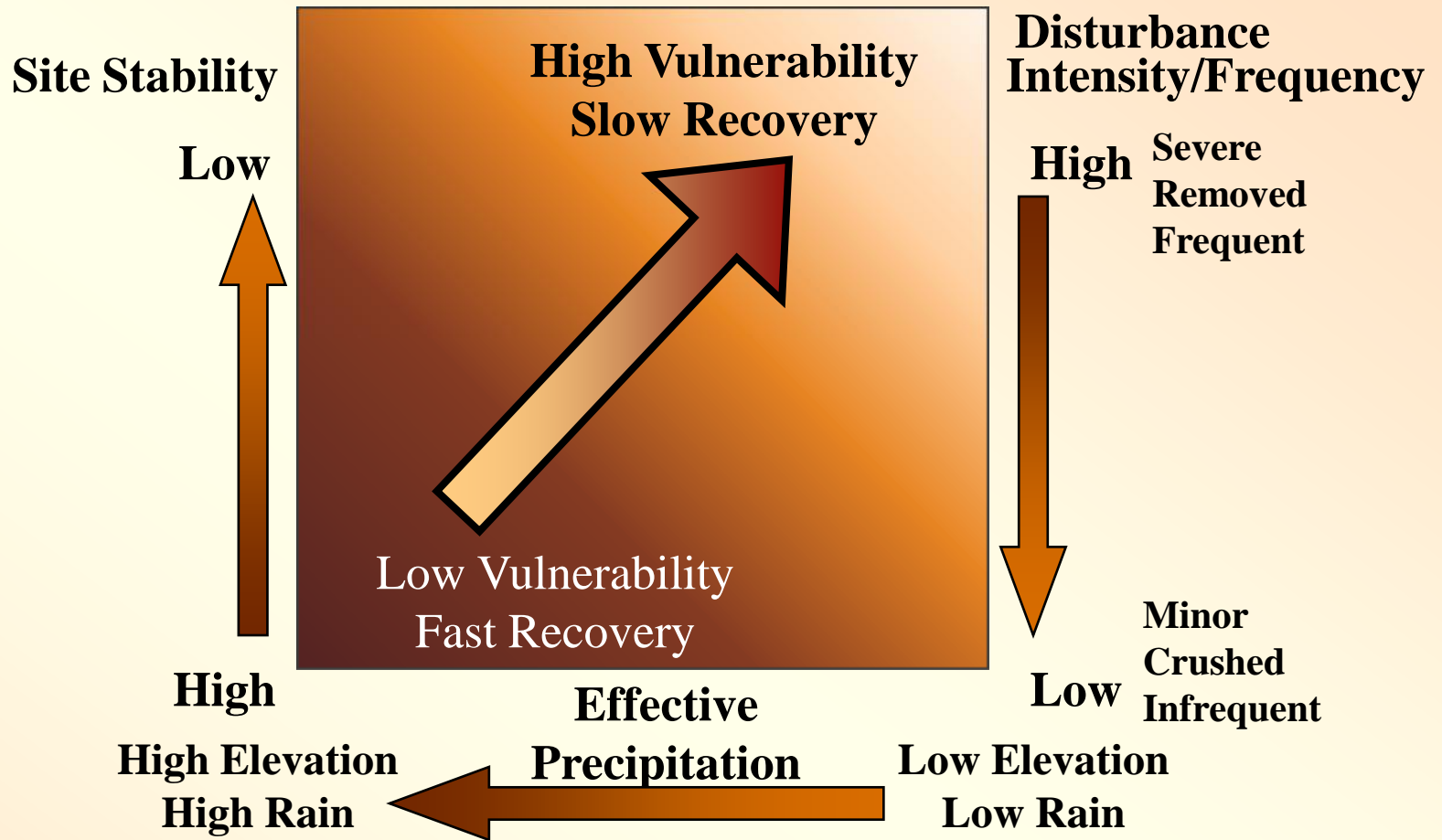
Land use and climate change reinforce each other

- Change in crust composition
 - Less soil N, C
- Less stability, increased dust
- Smoother surface
 - Less water
 - Less seeds
 - Less organic material





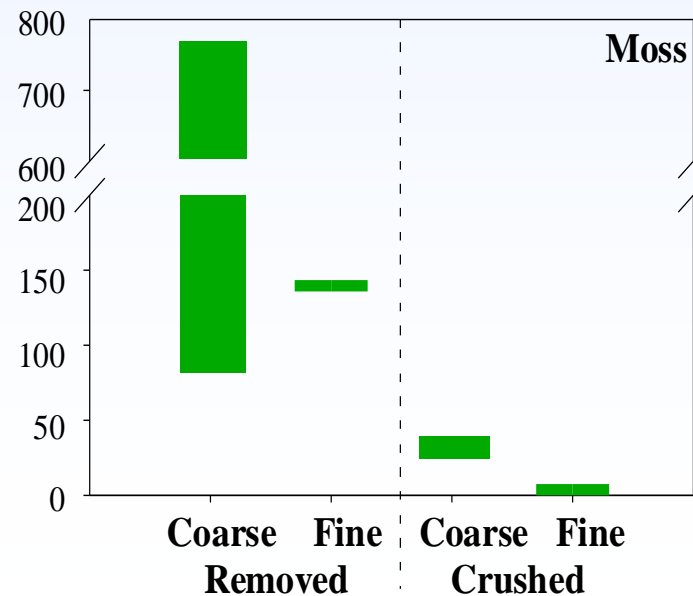
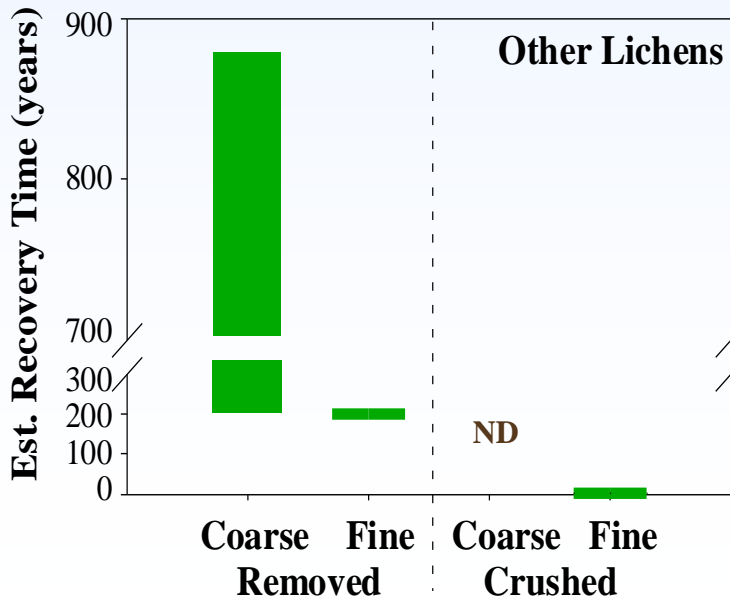
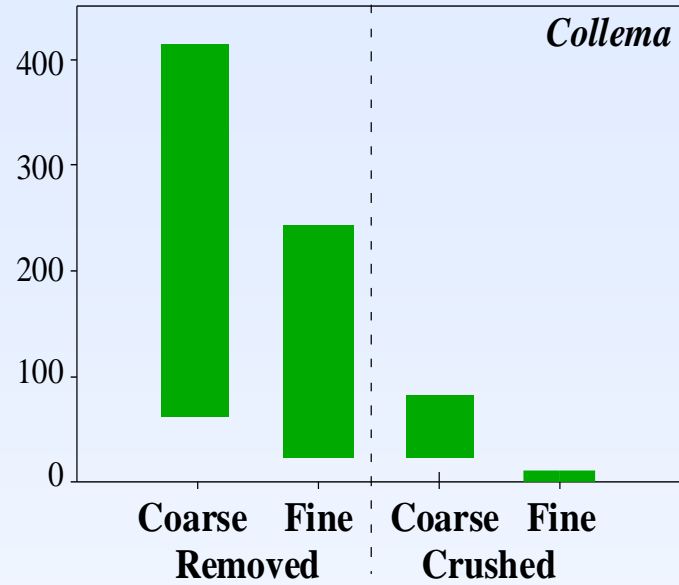
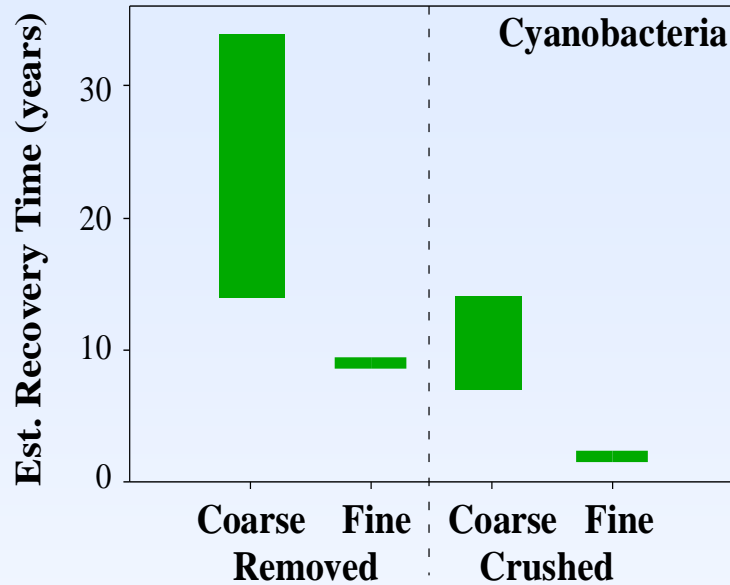
Recovery



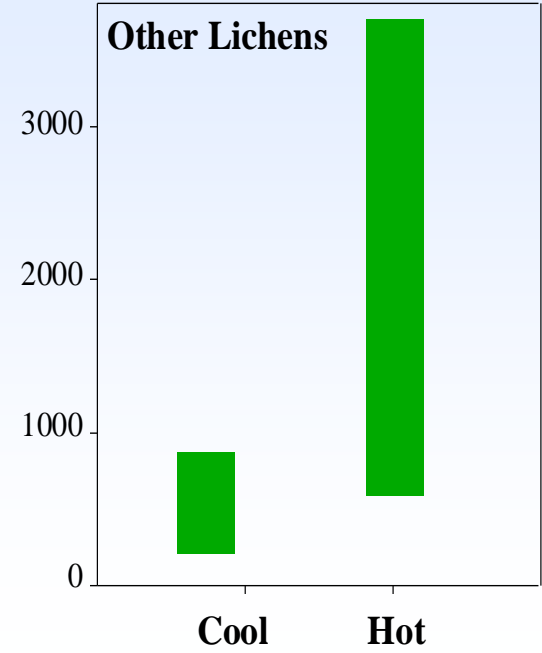
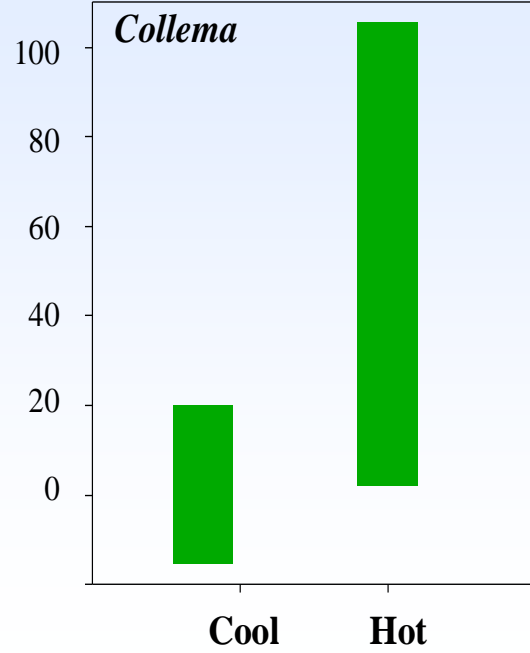
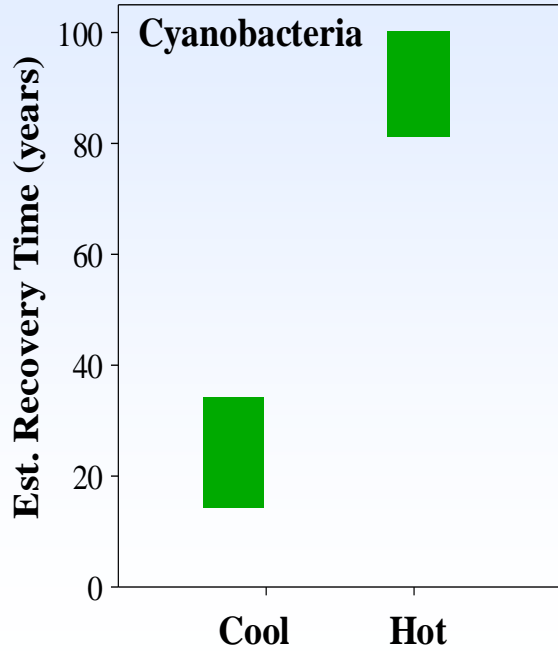
Factors Determining Site Stability

	Low Stability	High Stability
Soil Texture/Age	Coarse/Young	Fine/Old
Rock/Gravel Cover	Rolling	Embedded
Sand Deposition	High	Low
Plant Spacing	Sparse	Dense
Slope	Steep	Flat

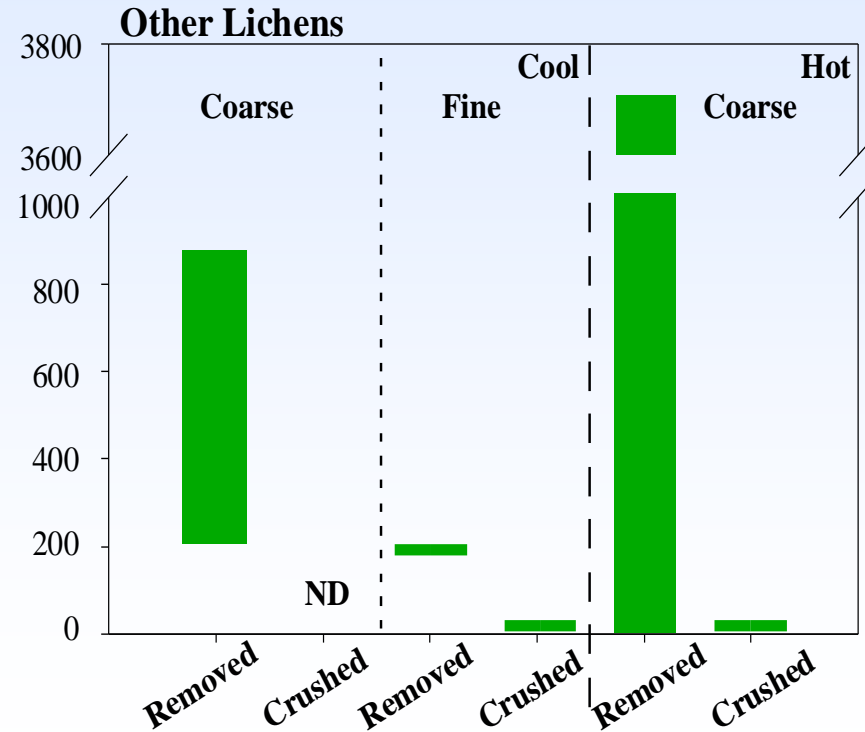
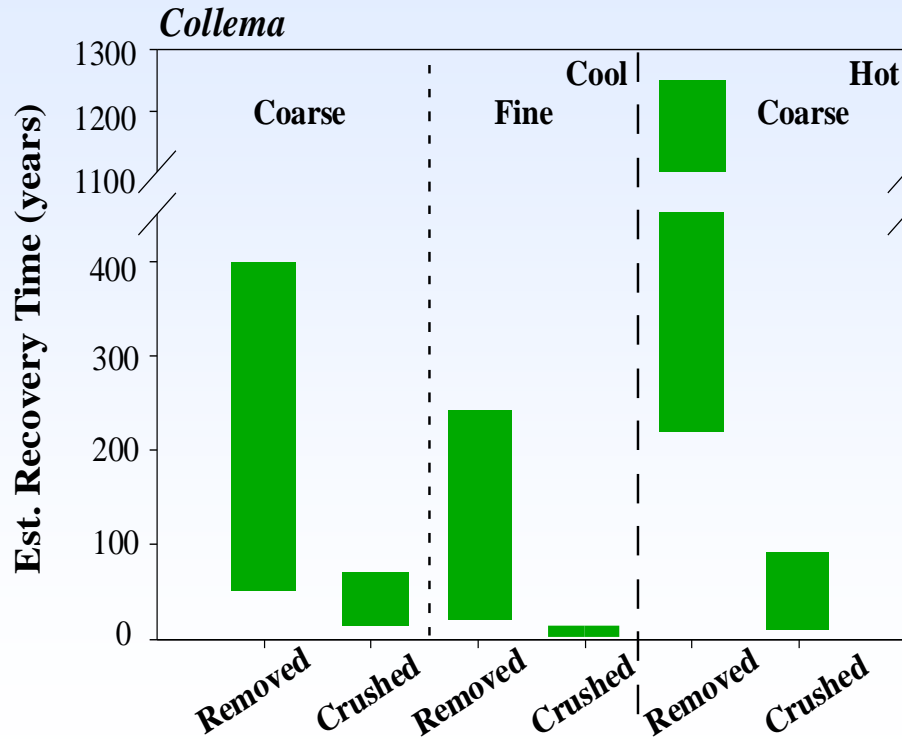
Soil Texture



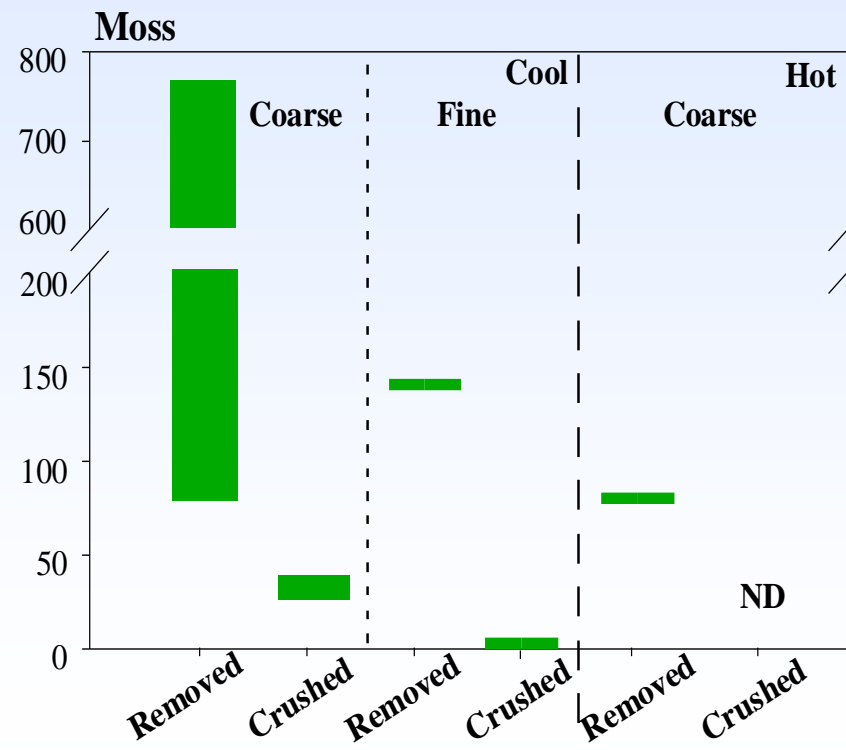
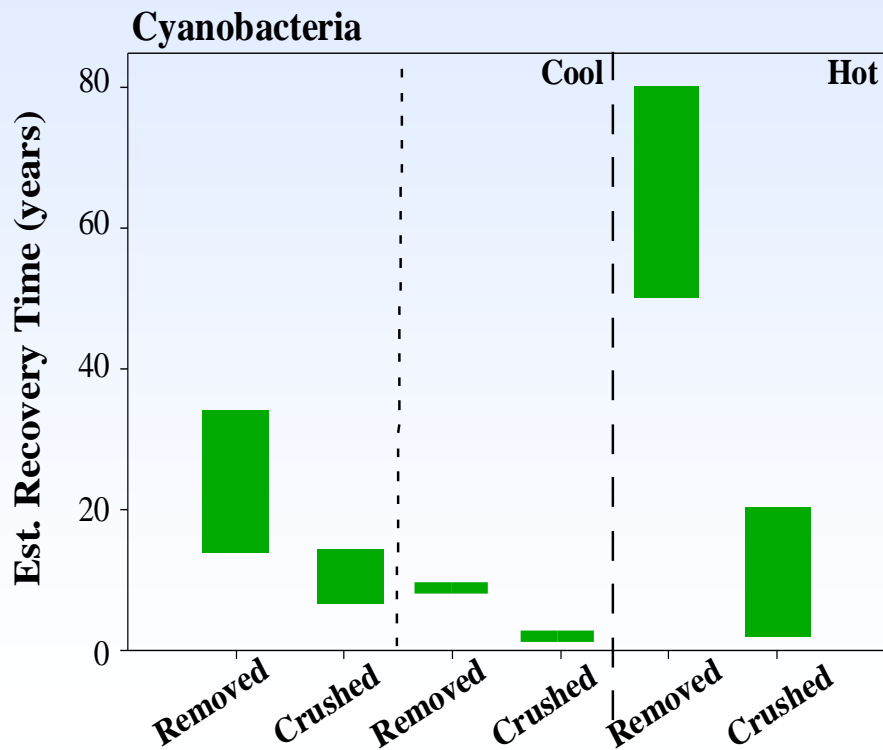
Effective Precipitation



Severity of Disturbance



Severity of Disturbance



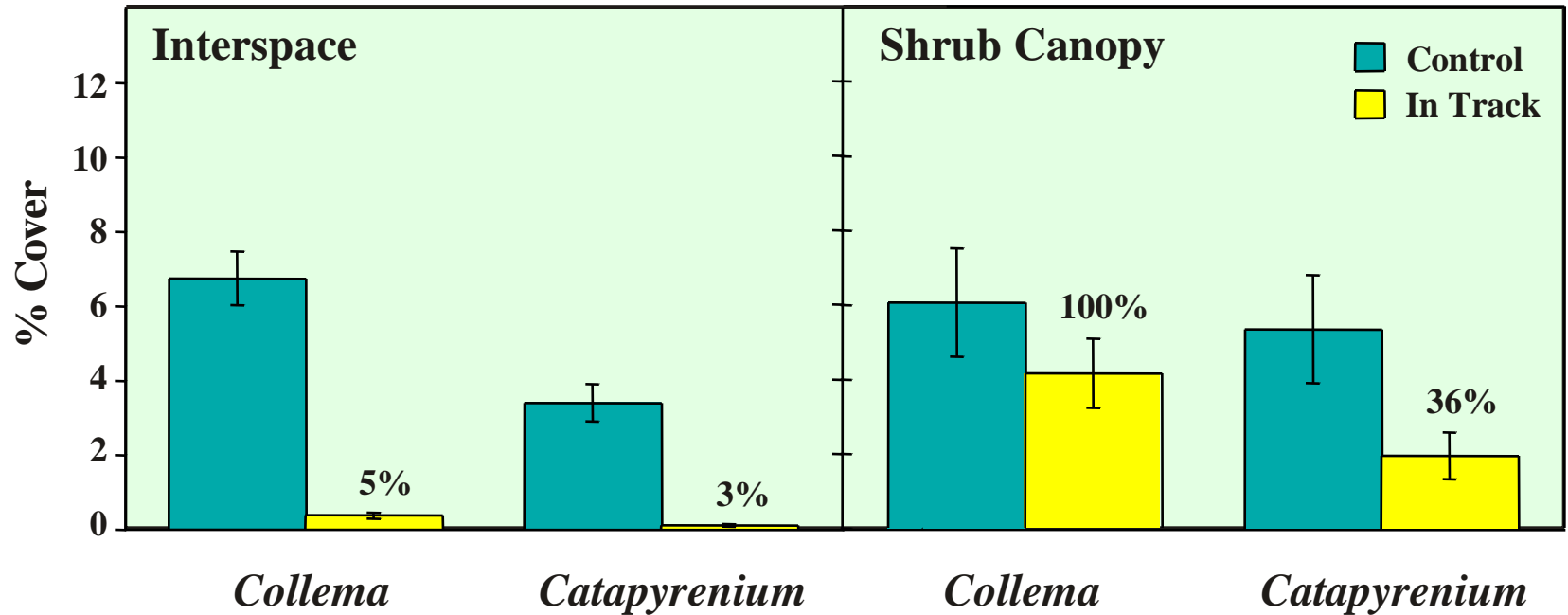
Disturbance Characteristics



- **Severity: crushed, removed/buried**
- **Frequency: redisturbance for recolonization**
- **Shape and shape: crusts recolonize from the edges**

Placement Matters

General Patton's Tank Tracks, after 55 years





Estimated Time to Full Recovery

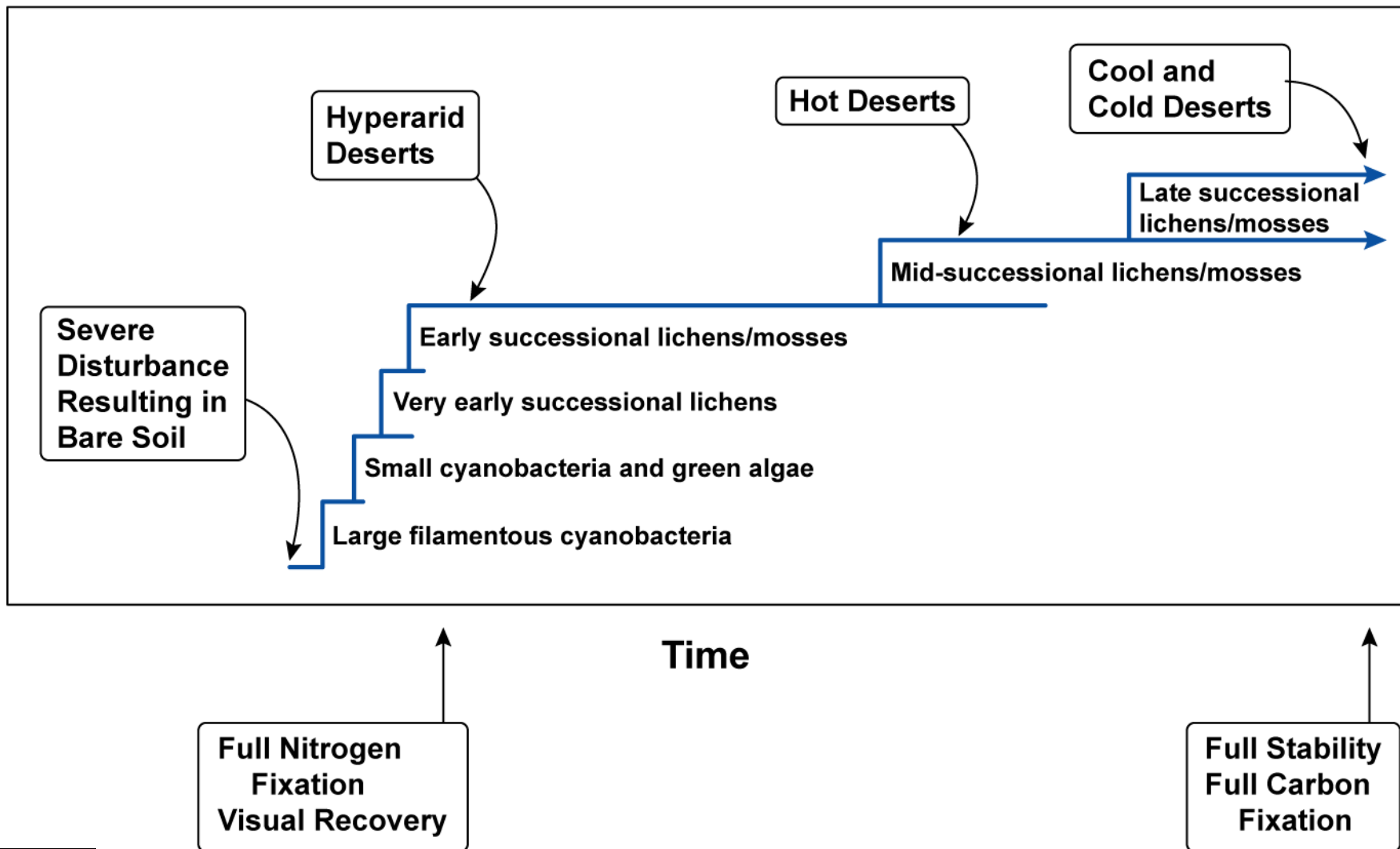
Interspaces		Under Shrub Canopy	
Cyanobacteria	85-120 years	NA	
<i>Collema</i>	~900 years	~85 years	
<i>Catapyrenium</i> :	~1900 years	~150 years	

Elevation matters

Skidoo Townsite, April 1998

	Control Sites	Streets and Alleys	% Difference	<i>P</i>	Years to Recovery
Cyanobacteria	12.78	15.22	19	0.07	
<i>Collema</i> sp.	18.19	6.79	-63	<0.0001	219
<i>Fulgensia</i> sp.	1.47	0.70	-53	0.01	172
<i>Psora decipiens</i>	2.03	0.34	-83	<0.0001	490
<i>Aspicilia reptans</i>	5.03	2.58	-49	<0.0001	160
<i>Toninia</i> sp.	1.09	0	-100	<0.0001	
<i>Heppia</i> sp.	0.31	0	-100	0.02	
<i>Catapyrenium squamulosum</i>	10.21	0.83	-92	<0.0001	1007
Moss	13.22	14.88	13	0.23	
Annual Plant	2.75	4.88	78	0.002	
Perennial Plant	14.25	15.11	6	0.80	
Litter	2.41	3.80	58	0.18	
Rock	16.25	34.87	115	<0.0001	

Recovery Sequence of Crust Species



Recovery Time

Desert	Cyanobacteria biomass	Early lichens	Mid-lichens and mosses	Late lichens and mosses
Mojave (hot, low elevation)	50 - 100	200 - 1200	600 - ?	?
Mojave (hot, high elevation) Colorado Plateau (cool, low elevation)	14-34	50 - 400	200- ?	?
No. Great Basin (very cool, low elevation)		20	60	125

Visual

Nitrogen
fixation

Carbon fixation
Soil Stability

Recovery: Is it linear?

	2-5 years	10-14 years
Cyanobacteria	45-110	14-34
Moss	400	42
Lichen	85	50

How can we enhance recovery?

(Nutrients? Water? Need to understand processes)

- ✓ Reduce disturbance
- ✓ Plant cover
- ✓ Inoculation
- ✓ Fertilization?



How to inoculate

- 1. Commercial inoculant**
- 2. Collect and spread**
- 3. Collect as chunks (alter shape)**
- 4. Storage**
- 5. Fertilize?**
- 6. Stabilize surfaces?**

Resistance Old Soils

Serengeti



Australia



Oman

