What roles do biological soil crusts play in ecosystems?

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Biological Crusts are not Physical Crusts

- Chemical and mechanical, not biological
- Formed by raindrop impact or hoof action
- Restrict plant growth and water infiltration

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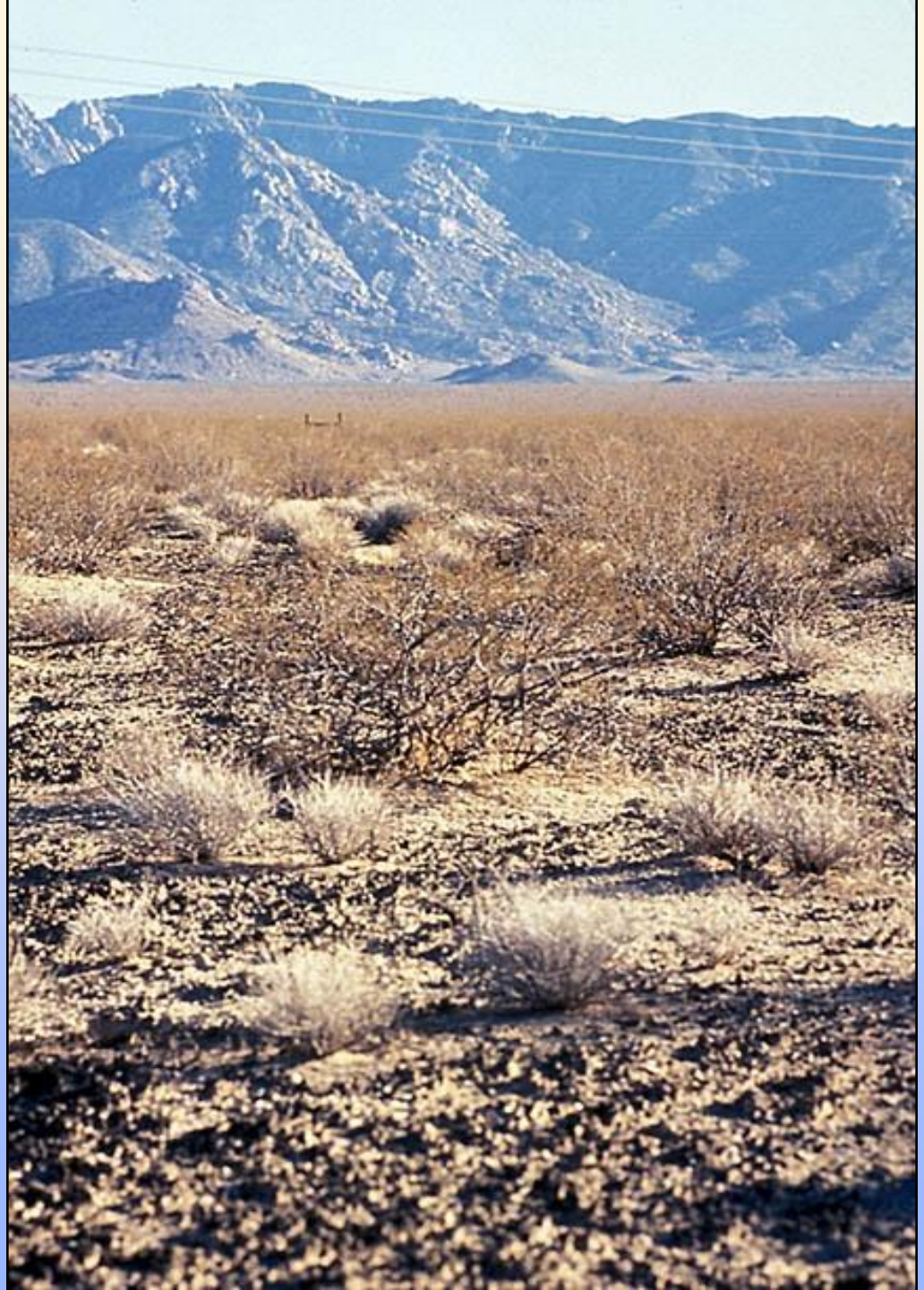
Mojave Desert



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Sonoran Desert

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Colorado Plateau

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Great Basin

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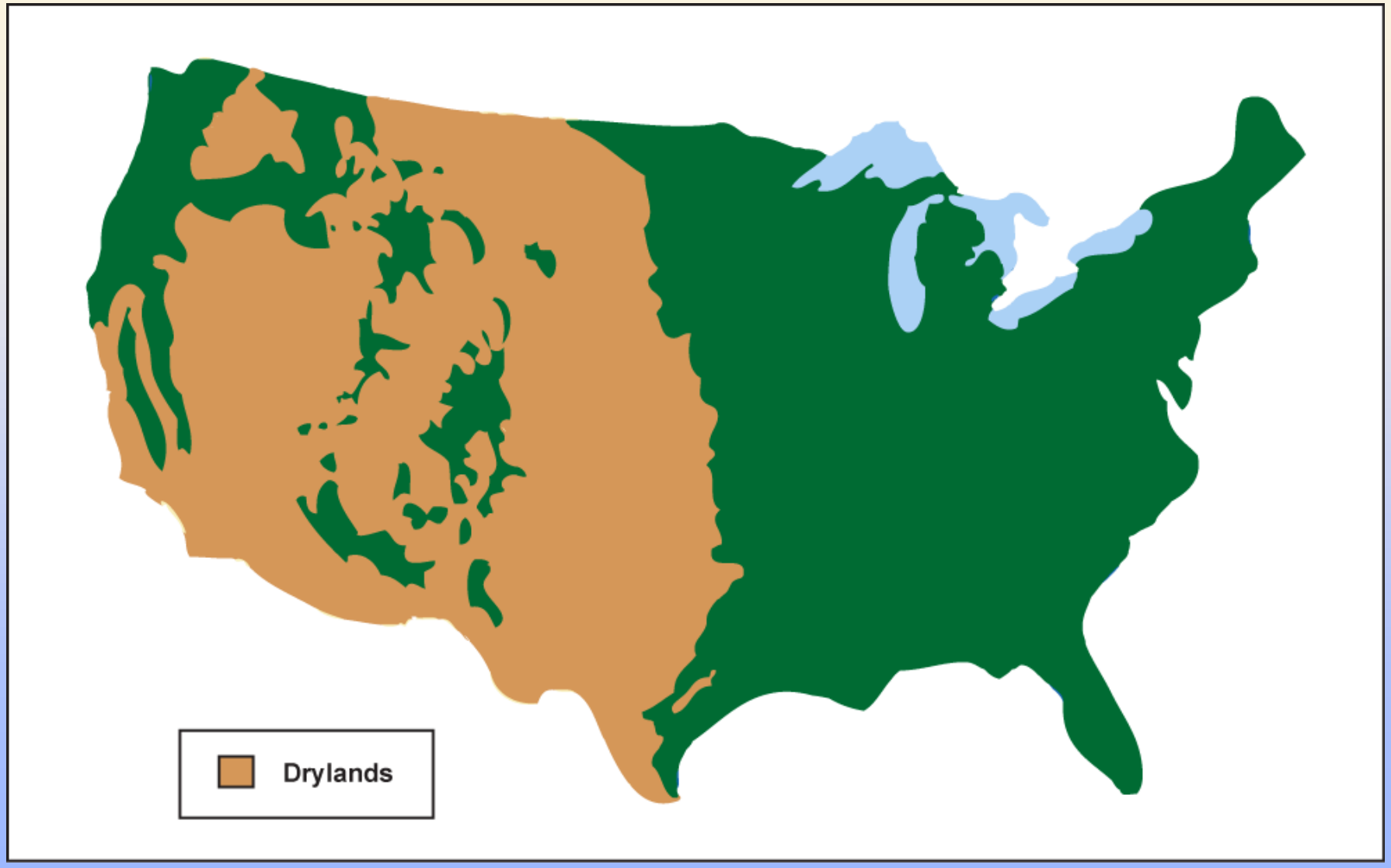
Aggregated Drylands of the U.S.



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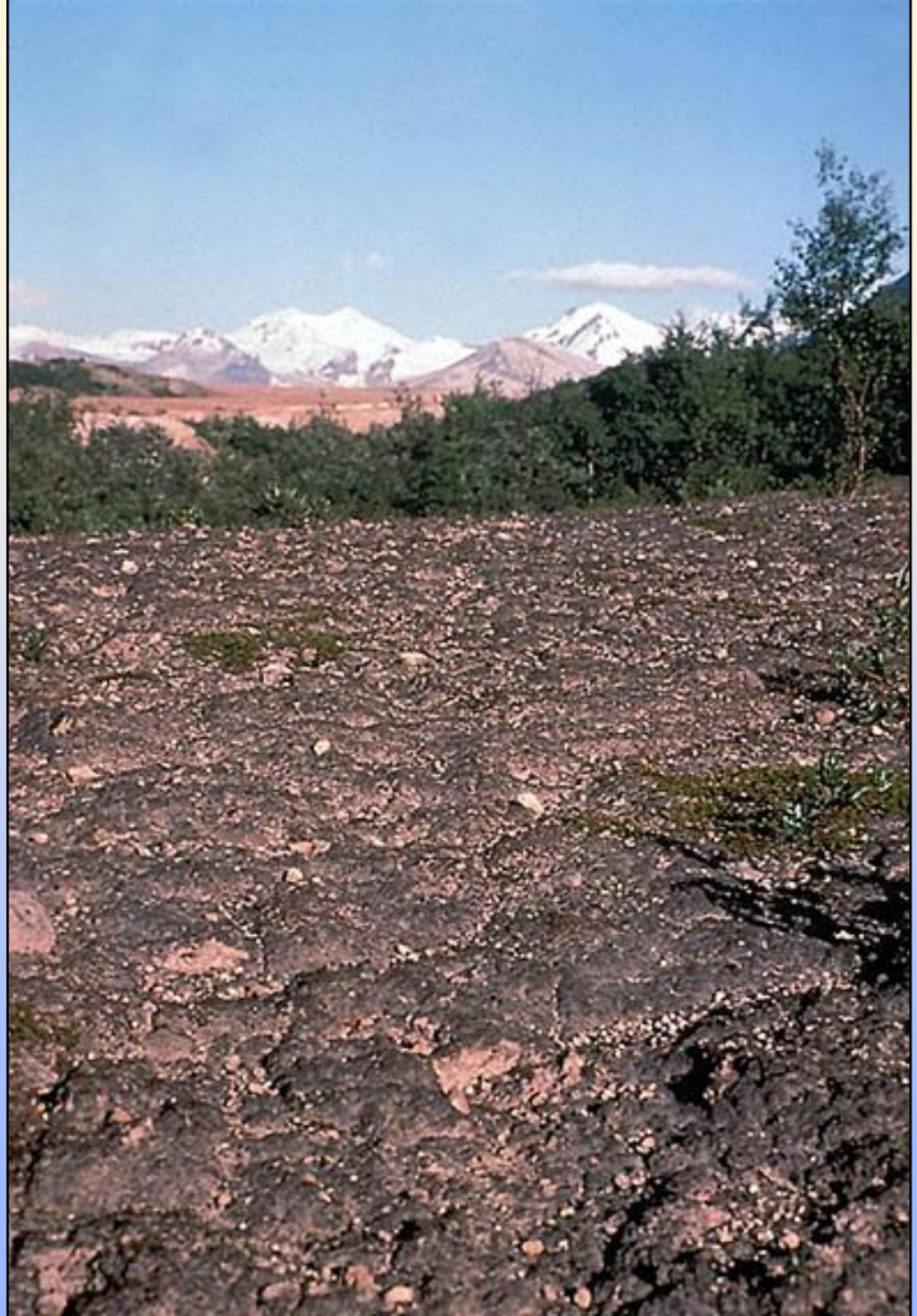
Alaska



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Mongolia

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Kenya

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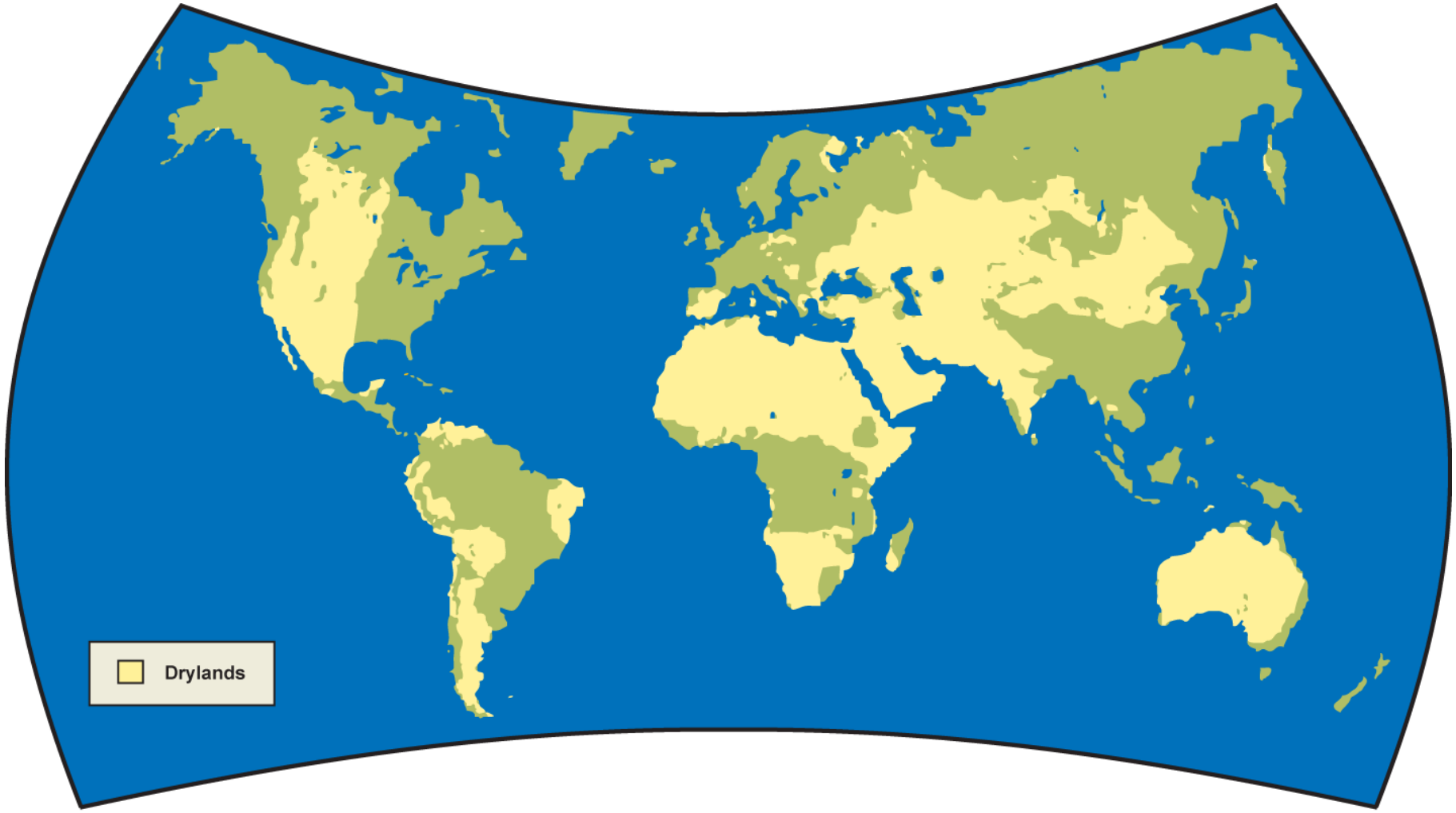
Regions where biological crusts are important



Source: CRU/UEA, UNEP/GRID
Approximate equatorial scale 1:115 million

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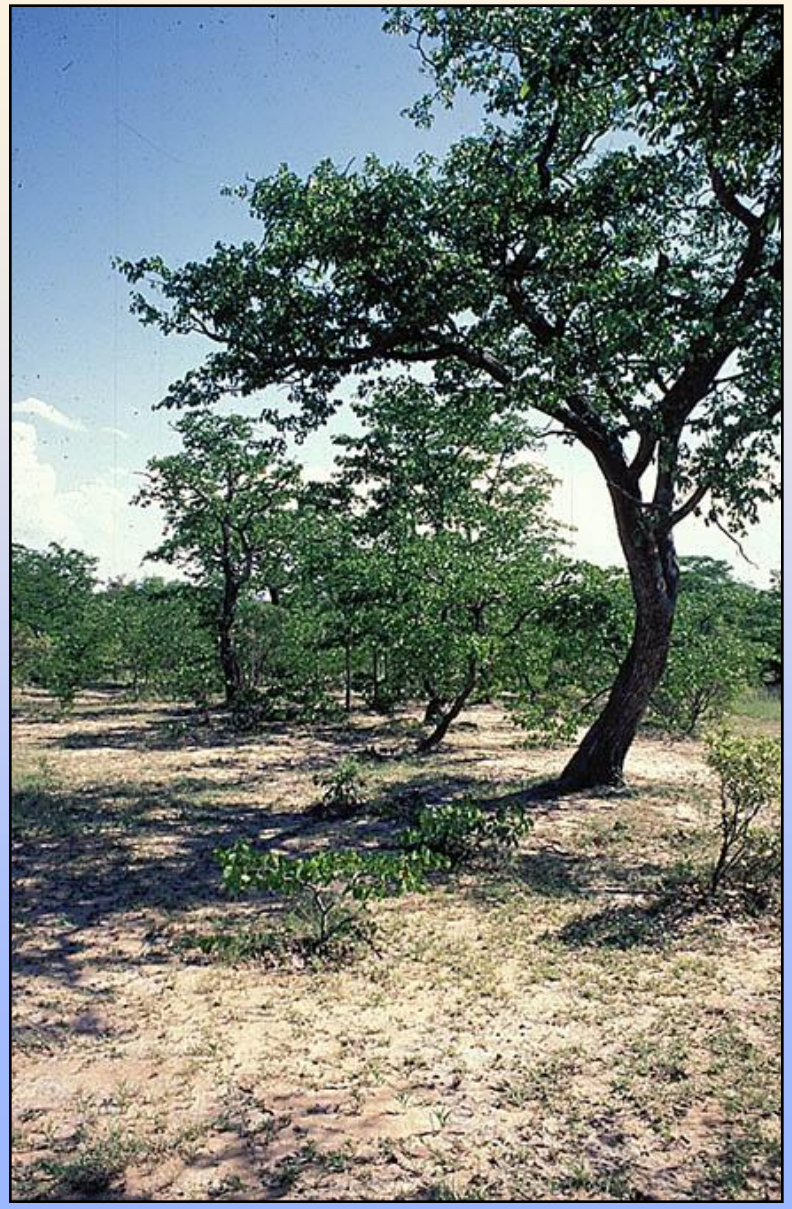
Crusts are in a variety of habitats



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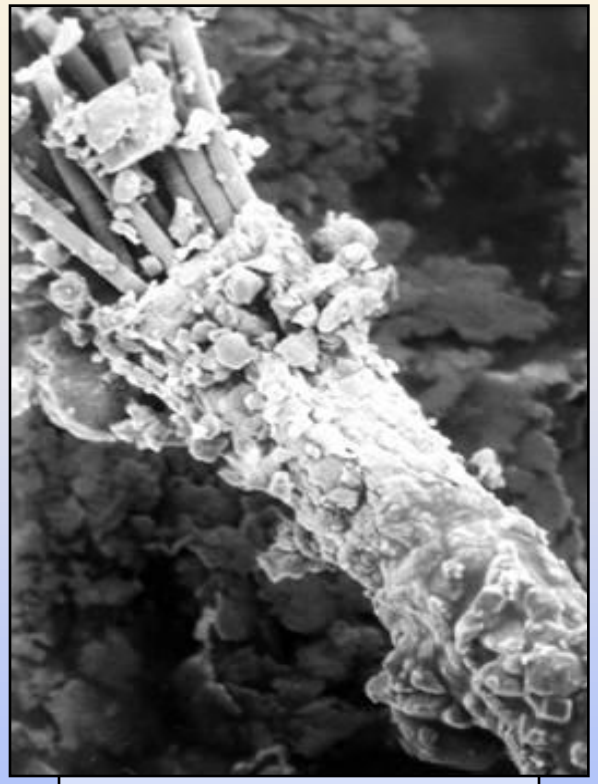
Biological Soil Crusts are a community of:



Cyanobacteria

Lichens

Mosses

Each plays a different role, so each crust type does too

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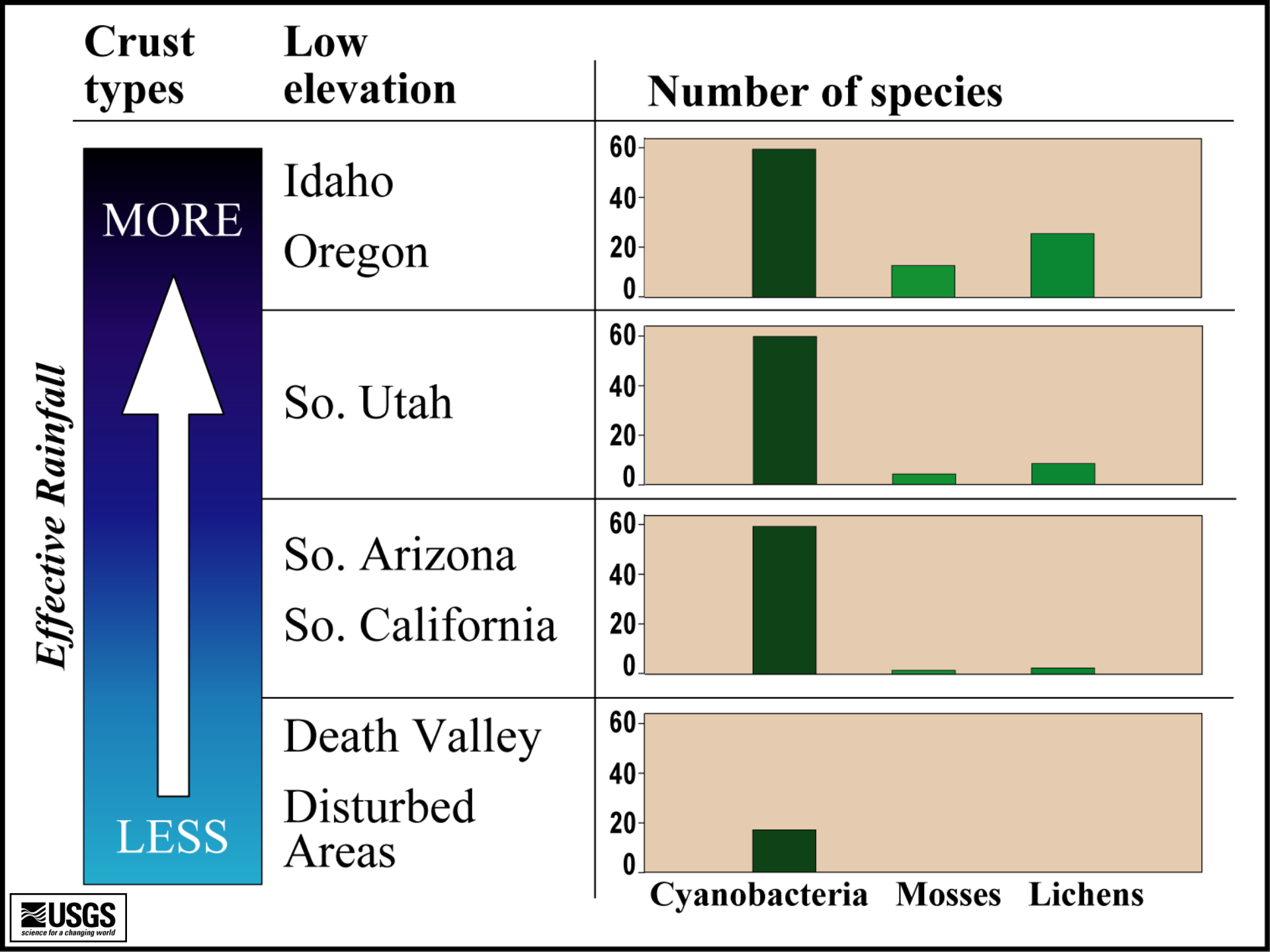
Crust types
Low elevation
Number of species
MORE
LESS
Effective Rainfall
Idaho
Oregon
So. Utah
So. Arizona
So. California
Death Valley
Disturbed Areas
60
40
20
0
Cyanobacteria
Mosses
Lichens
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Soil Surface Roughness

Four Types:

Flat
0-1 cm

Rugose
1-3 cm

Pinnacled
5-15 cm

Rolling
3-5 cm

Less

Effective Rainfall

More

Hyper-arid,
Disturbed

Mojave
Sonoran

Colorado
Plateau

Great
Basin

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Flat

Hyperarid or Disturbed

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Rugose

Arid

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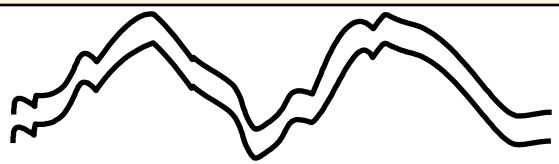
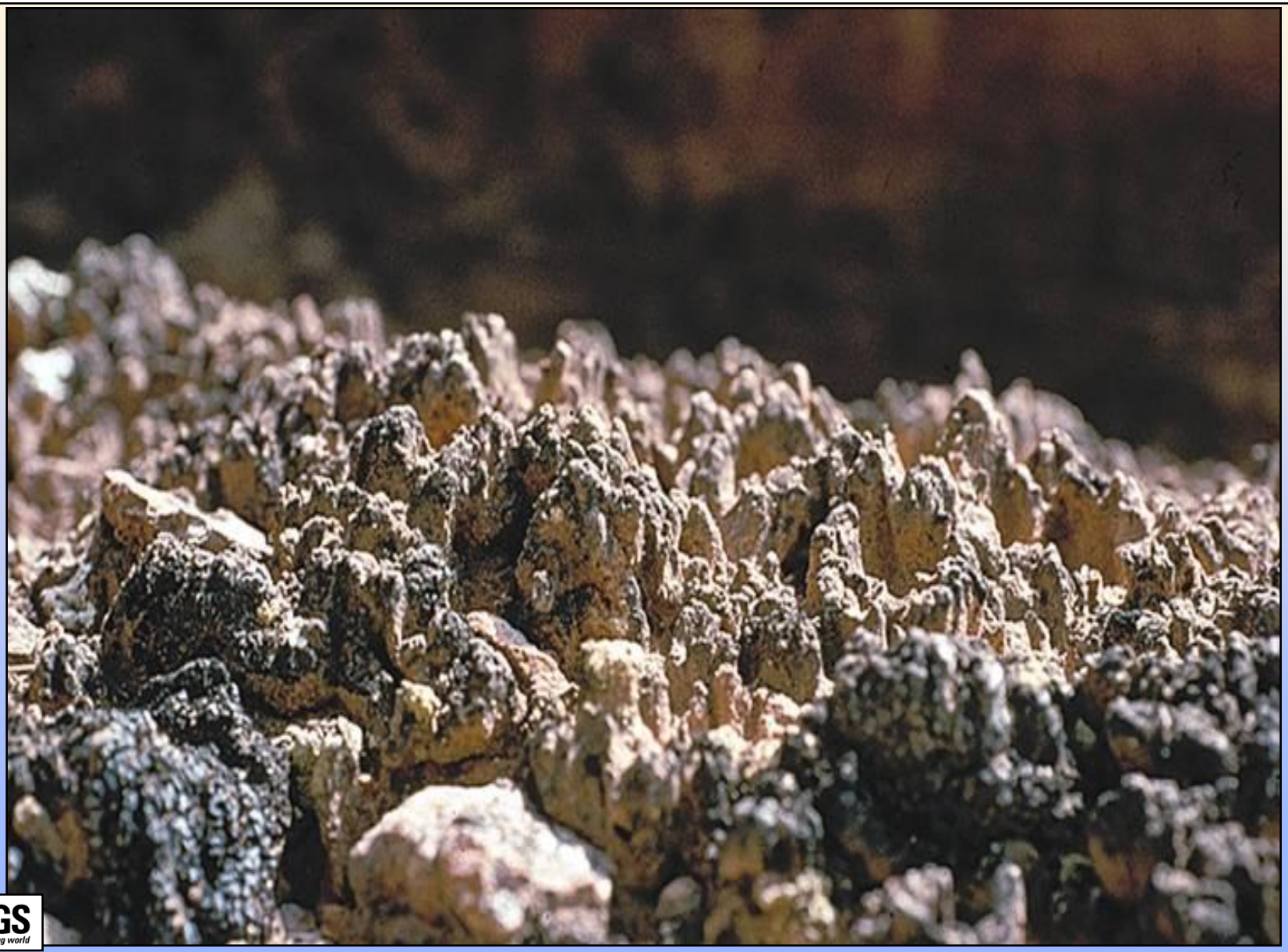
Pinnacled



Cool Desert



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Rolling

Cool-cold Desert

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Why are soil crusts important?

Because they influence soils.

- Soil stability
- Soil surface
- roughness
- Soil moisture
- Soil fertility
- Soil temperature

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Soils:

- Basis for terrestrial life
- Determine plant communities species and form
- Take 5,000-10,000 years to form
- Require protection from wind, water erosion: plants, rocks, soil crusts. Without protection, soils are easily lost.

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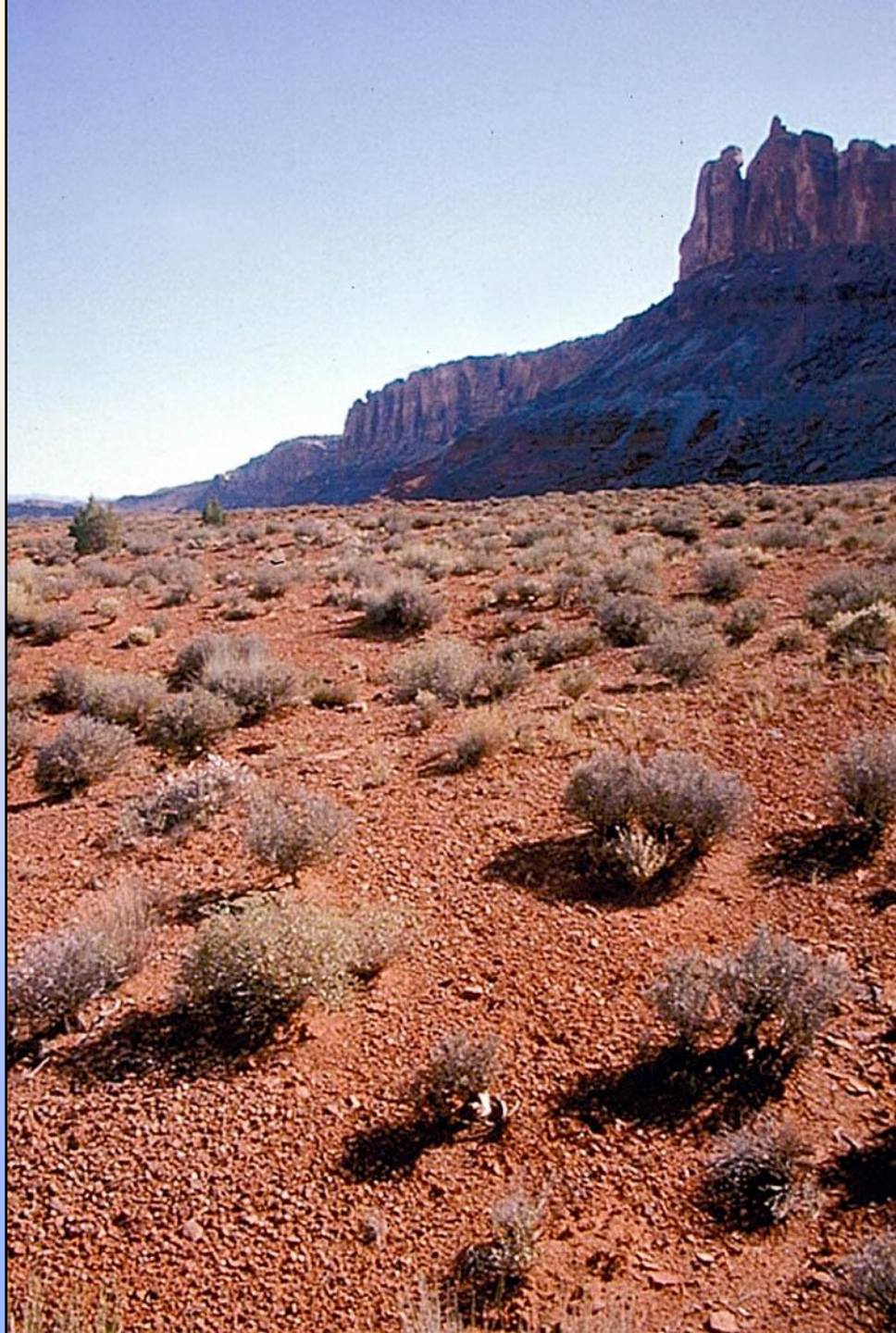
Soil Stability

Scattered Vegetation

In deserts, plants give little protection to desert soils



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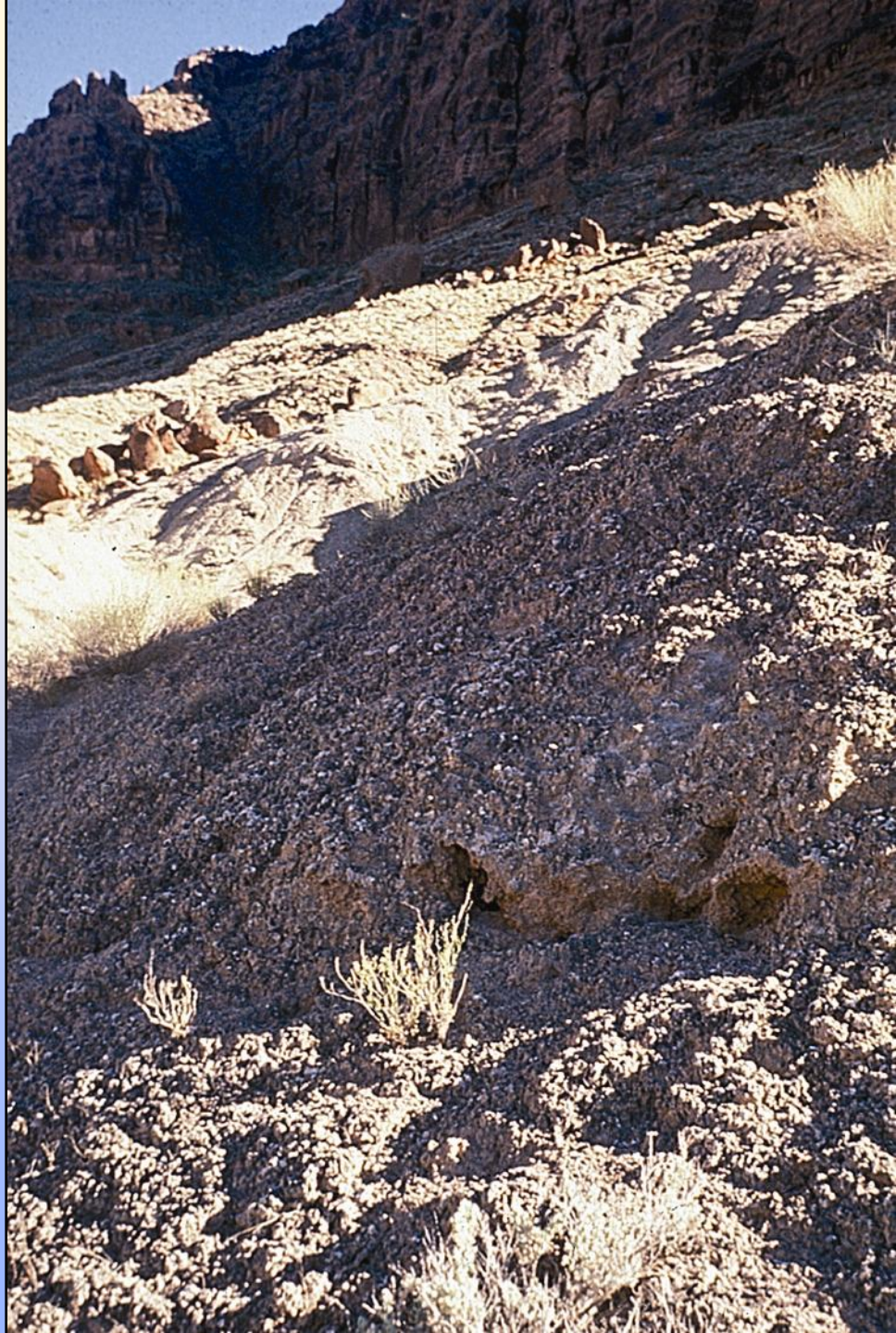
Soil Stability

Hill slopes

Soils held beyond angle of repose



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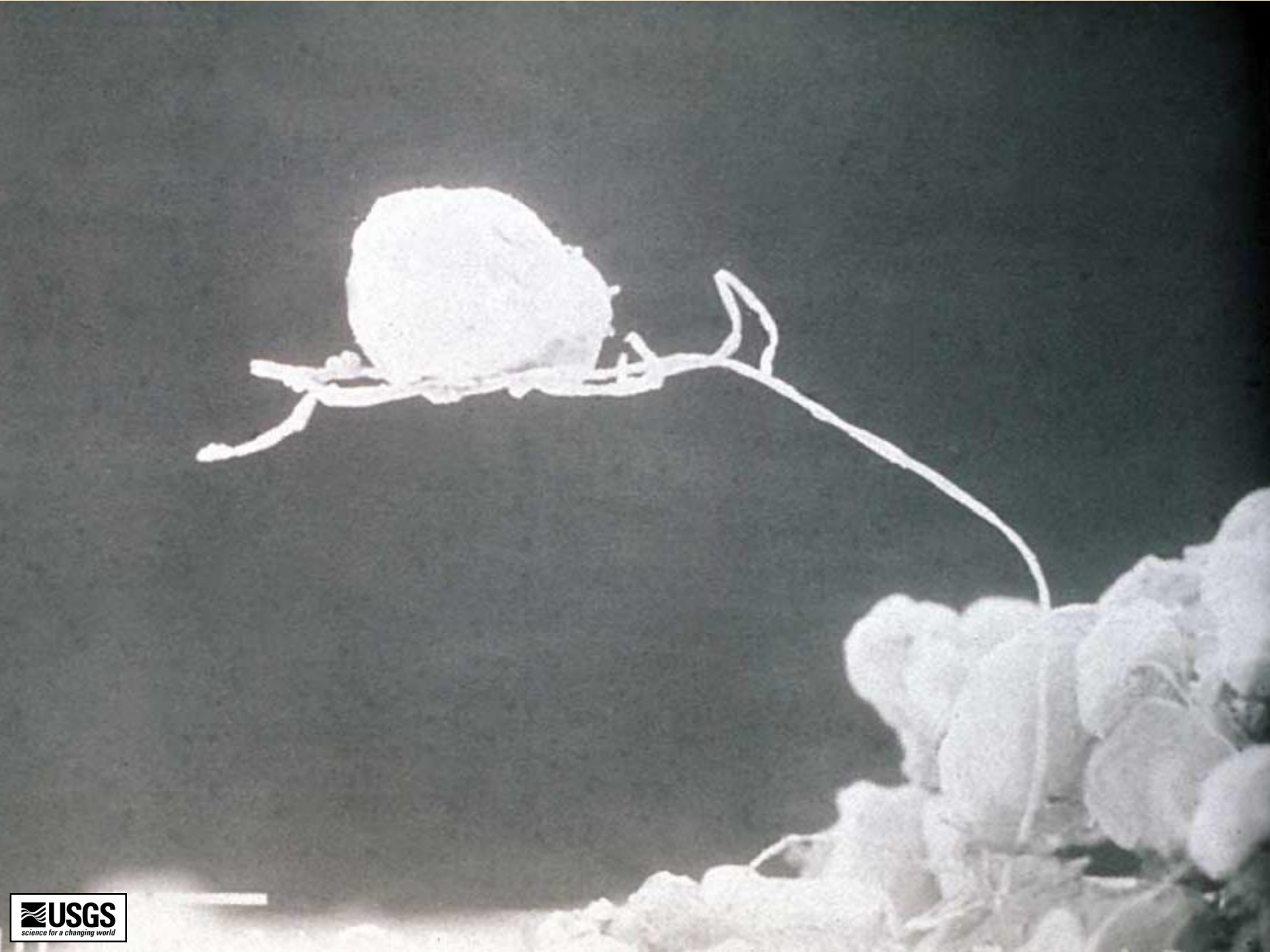
90x



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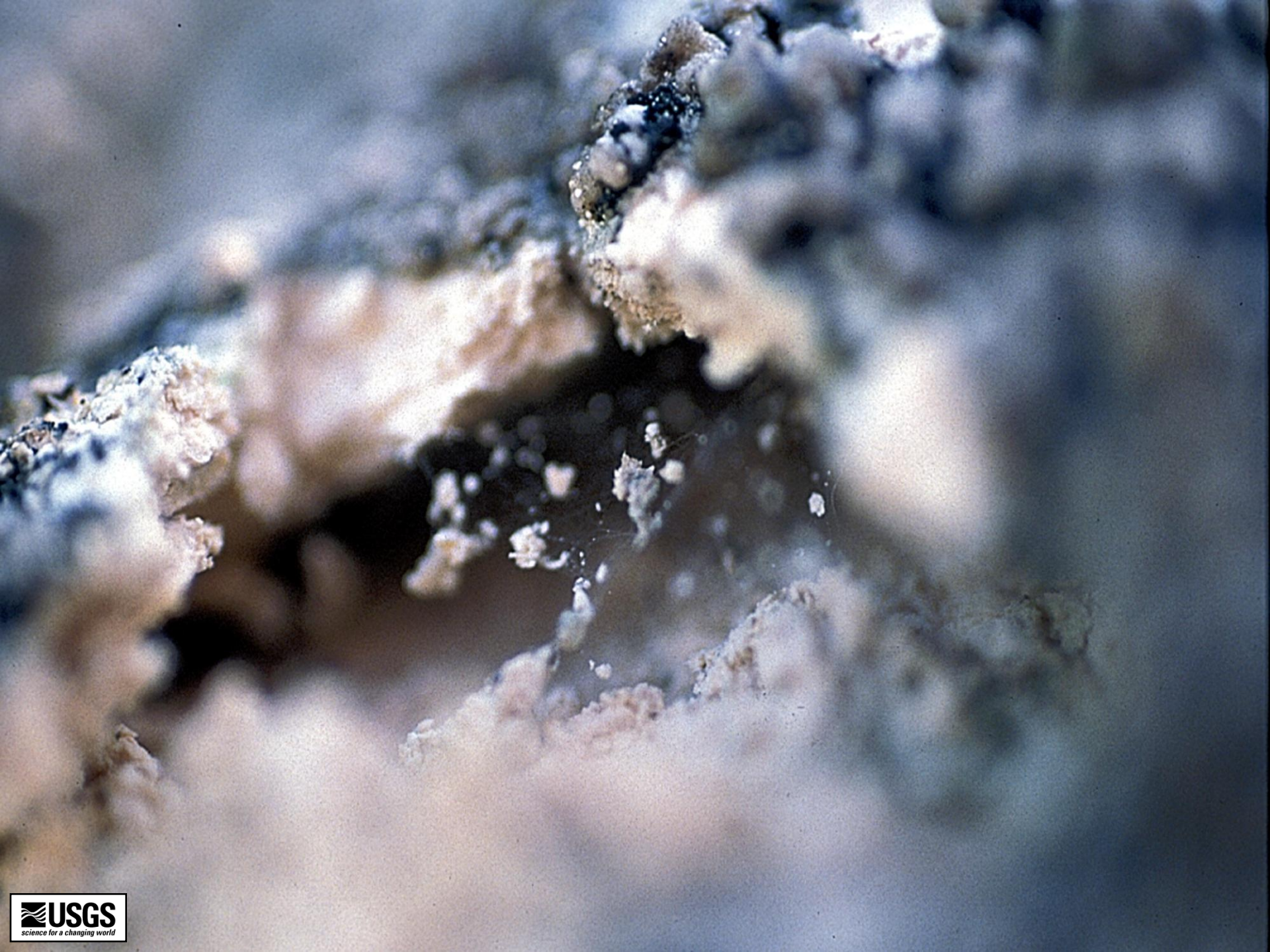
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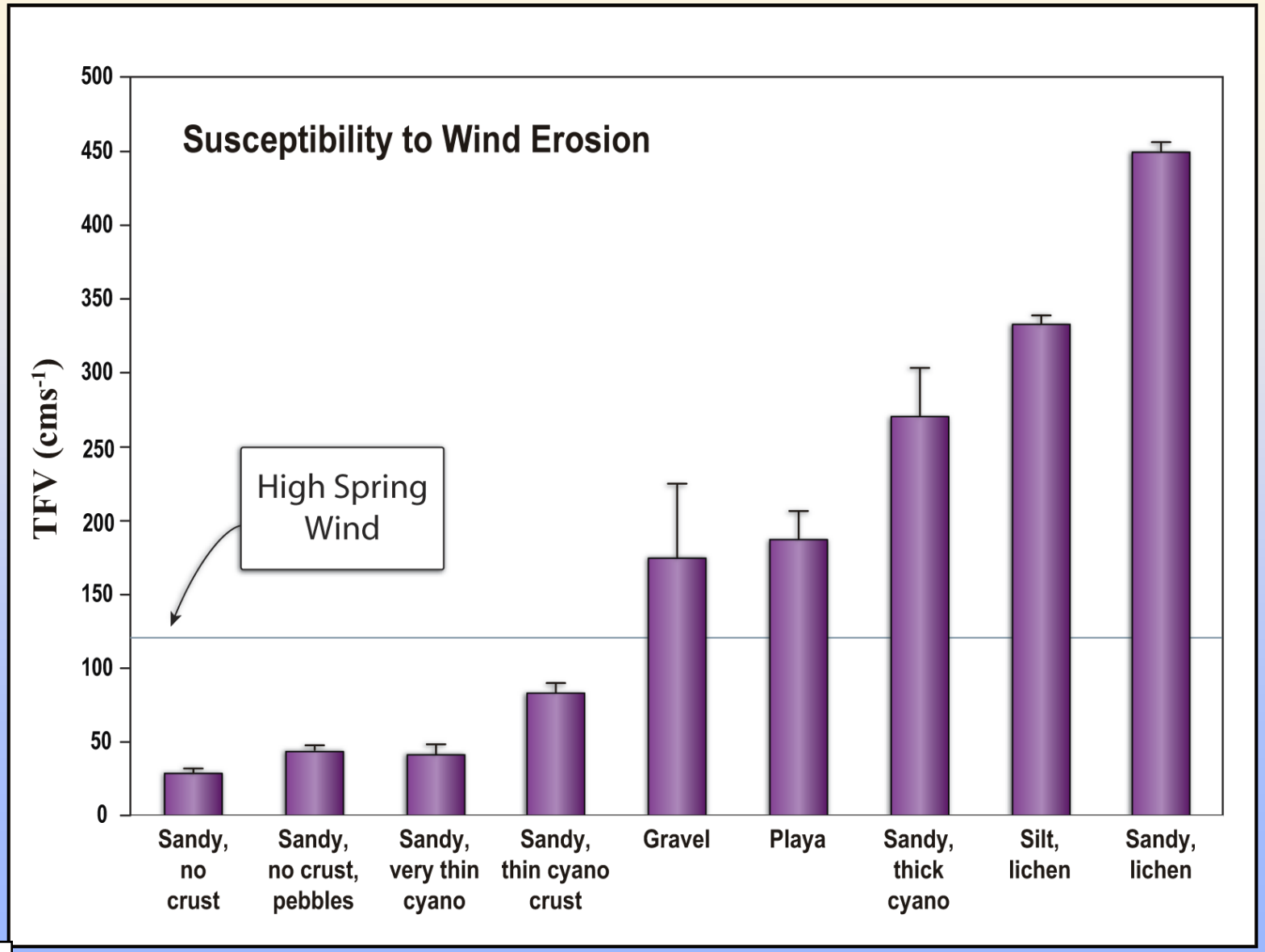
Soil Stability Then and Now

Wind Erosion



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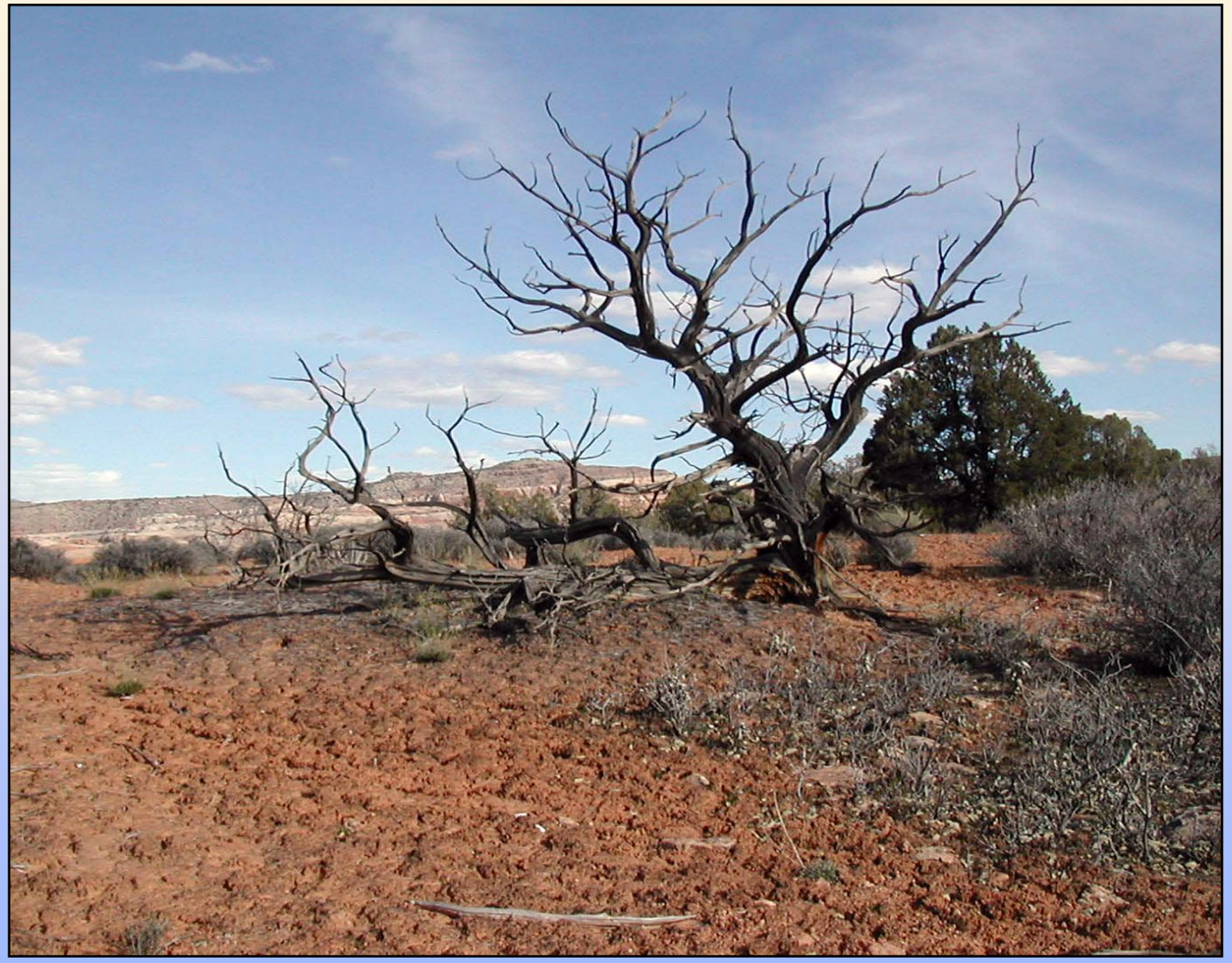
Effect of soil crusts on local hydrology



Very site-specific (strong soils, high vegetation cover will control)

Factors affecting infiltration/runoff/sediment transfer in plant interspaces

Retention time

- How much for how long?

Soil Permeability

- How much, how deep?

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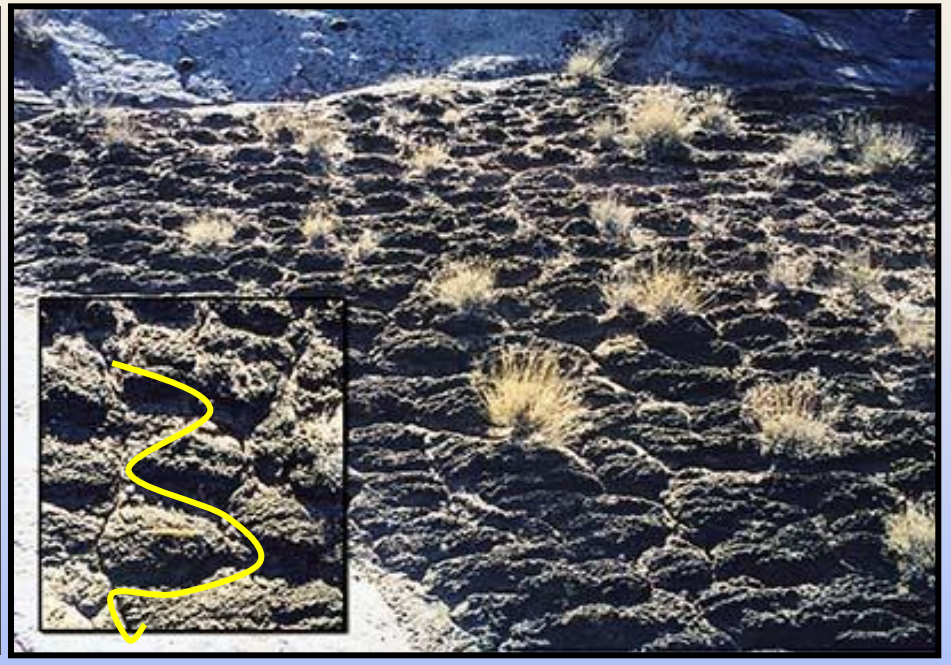
Retention Time:

Path Connectivity/Surface Roughness



When soils are roughened, water is slowed = less water and soil loss

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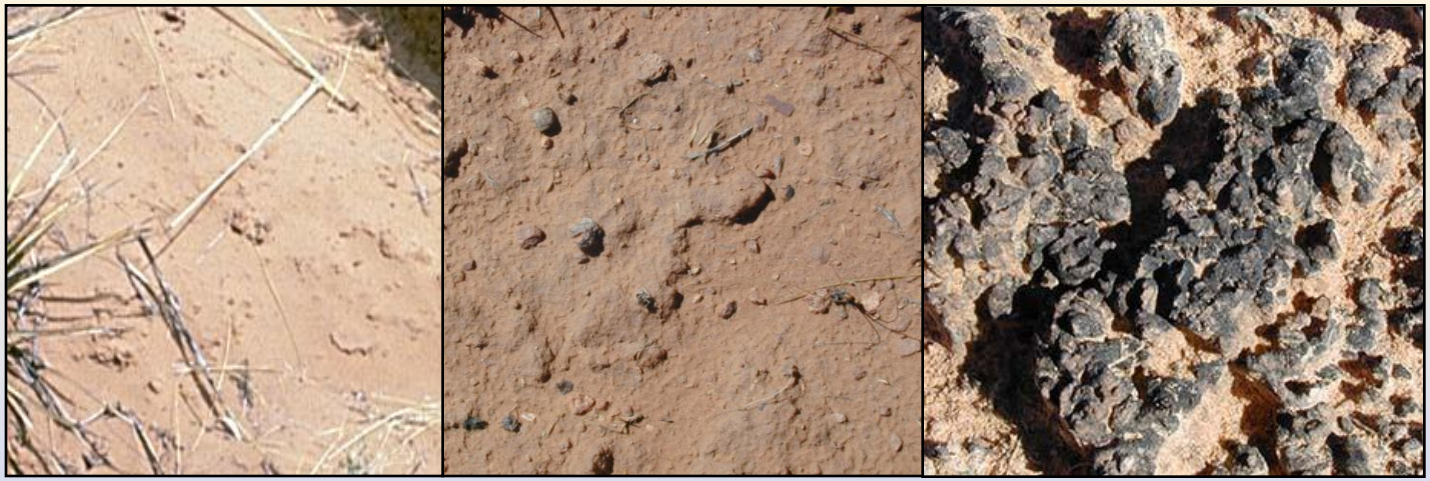
Crust flora

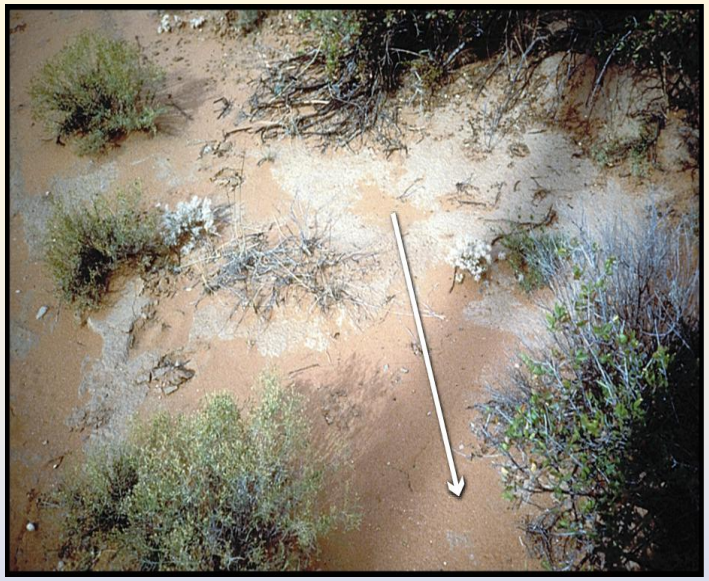
Surface Soil Permeability: Soils and plant litter can control!

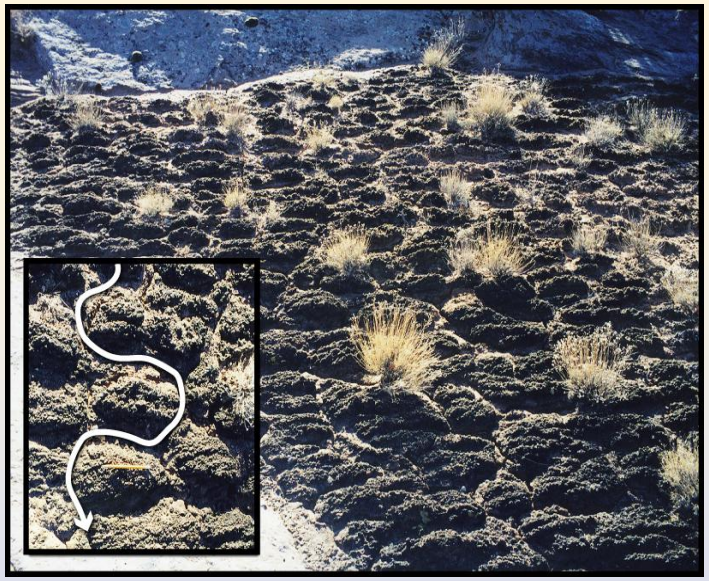
Pore Space

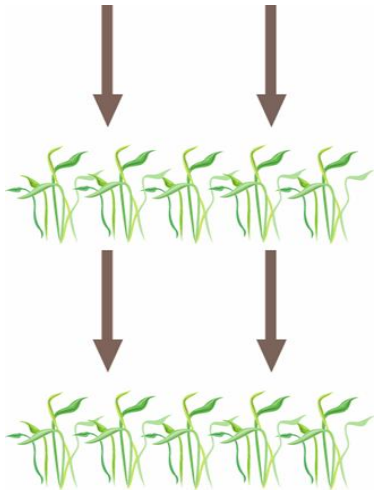


bare > light cyano > dark cyano >

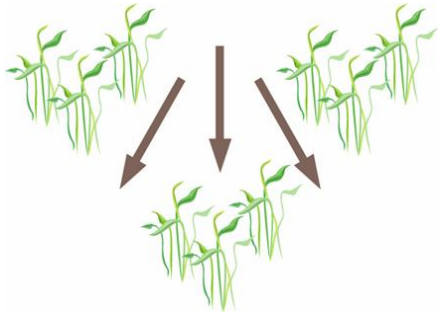
patchy lichen > continuous lichen > moss



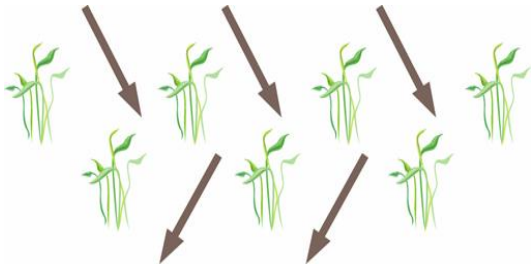




Banded

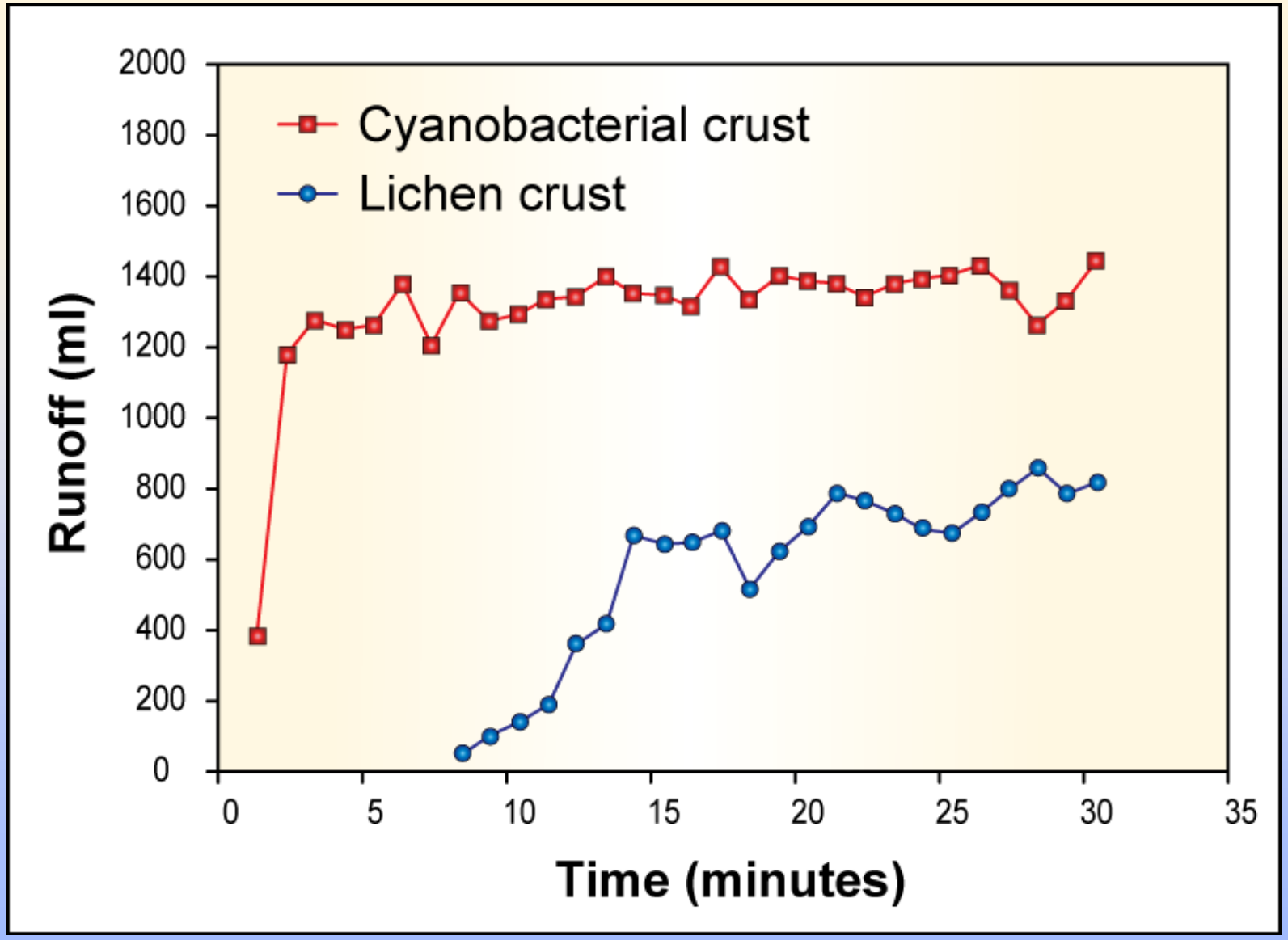


Clumped



Homogenous

Natural vegetation patterns determine where you <u>want</u> infiltration



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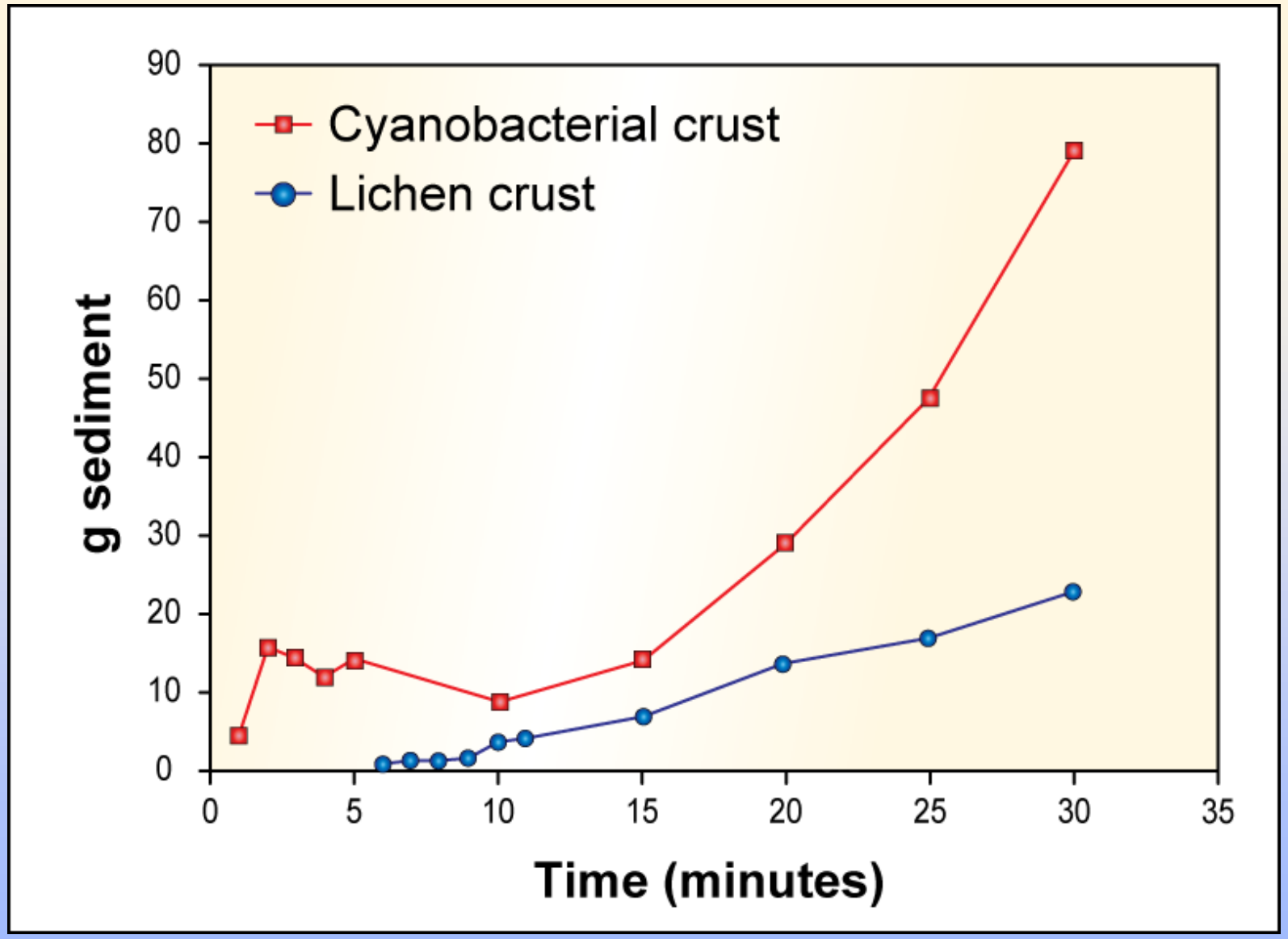

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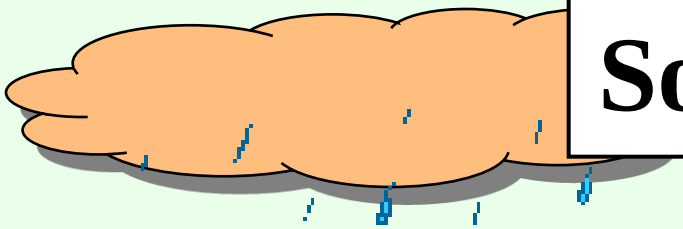
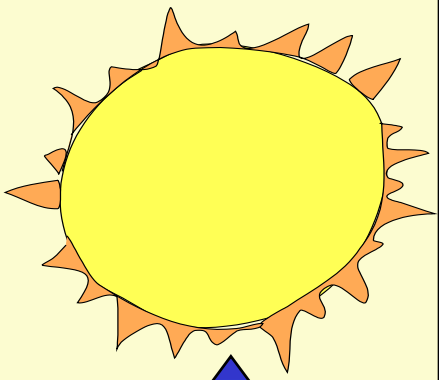
Soil Moisture





Infiltration

Roughness,
Permeability

Capping,
Soil
Temperature

Evaporation

Greater roughness
Bigger pores =
More water in

More organisms =
Less water in

Soils and vascular vegetation can control!

More capping =
Less water out

Darker surface =
More water out

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Fertility Sources for Drylands

Crust

Dust

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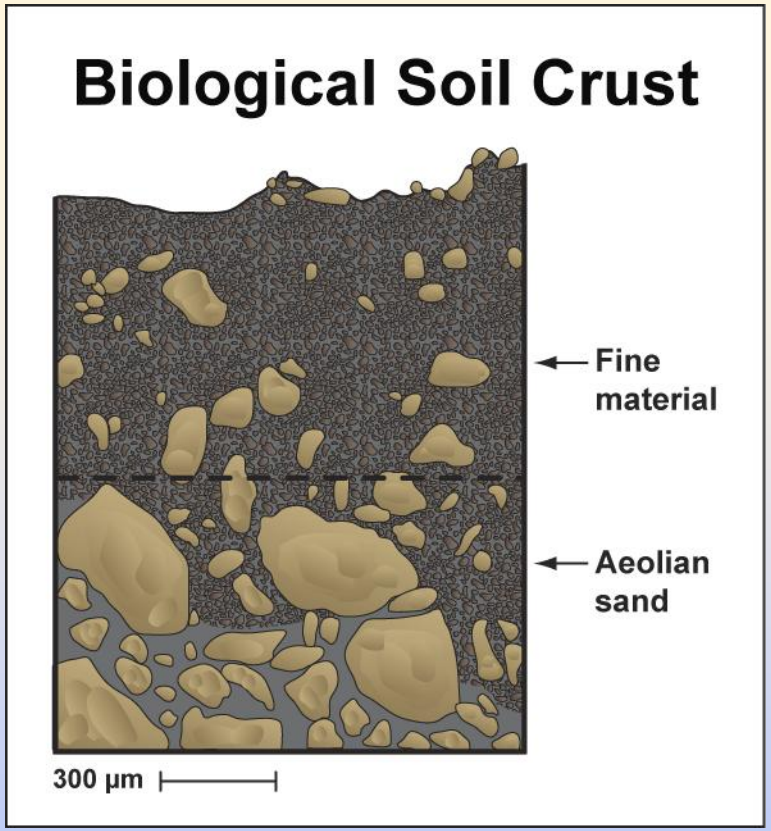
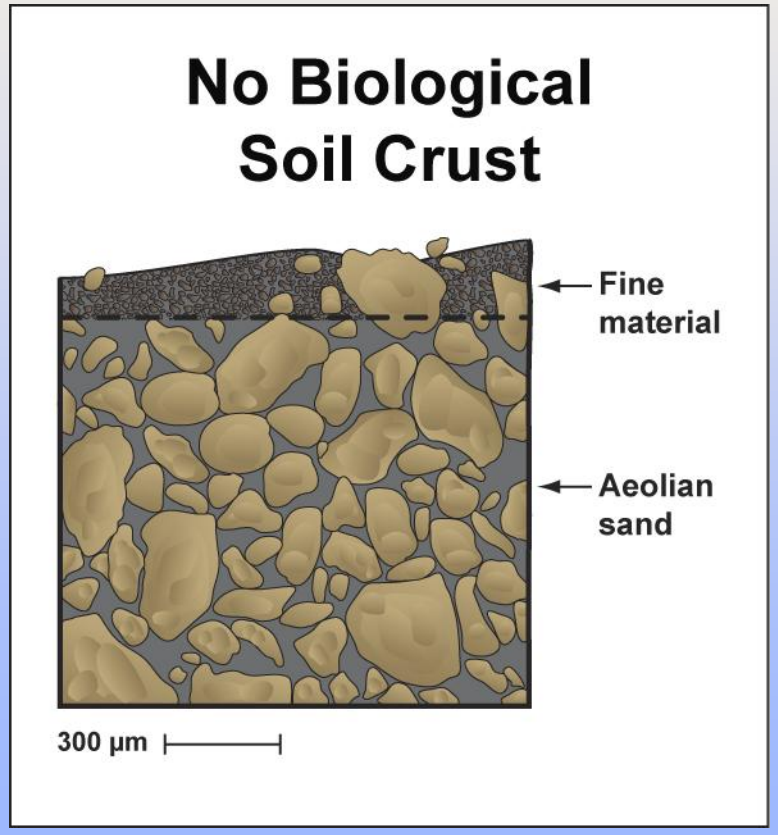
Dust Capture





Adapted from
Verrecchia et al. 1995

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Dust is critical!

Colorado Plateau, Sandy Soils									
	P	K	Mg	Na	Ca	Mn	Zn	Cu	Fe
Soil	271	1.49	0.37	0.17	2.7	196	21.4	13.8	1.04
Parent Material	104	1.27	0.08	0.04	2.1	94	7.8	10.2	0.66
Enrichment (x)	2.6	1.2	4.6	4.3	1.3	2.1	2.7	1.4	1.6

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Soil crusts also capture:

- Seeds
- Organic Matter

Also Secrete Growth Factors

Soil Fertility

- Crusts convert atmospheric N and C into bio-available forms
- N is a basic building block of all proteins
- C is needed for other soil biota
- Many desert soils are very low in N and C, especially in plant interspaces

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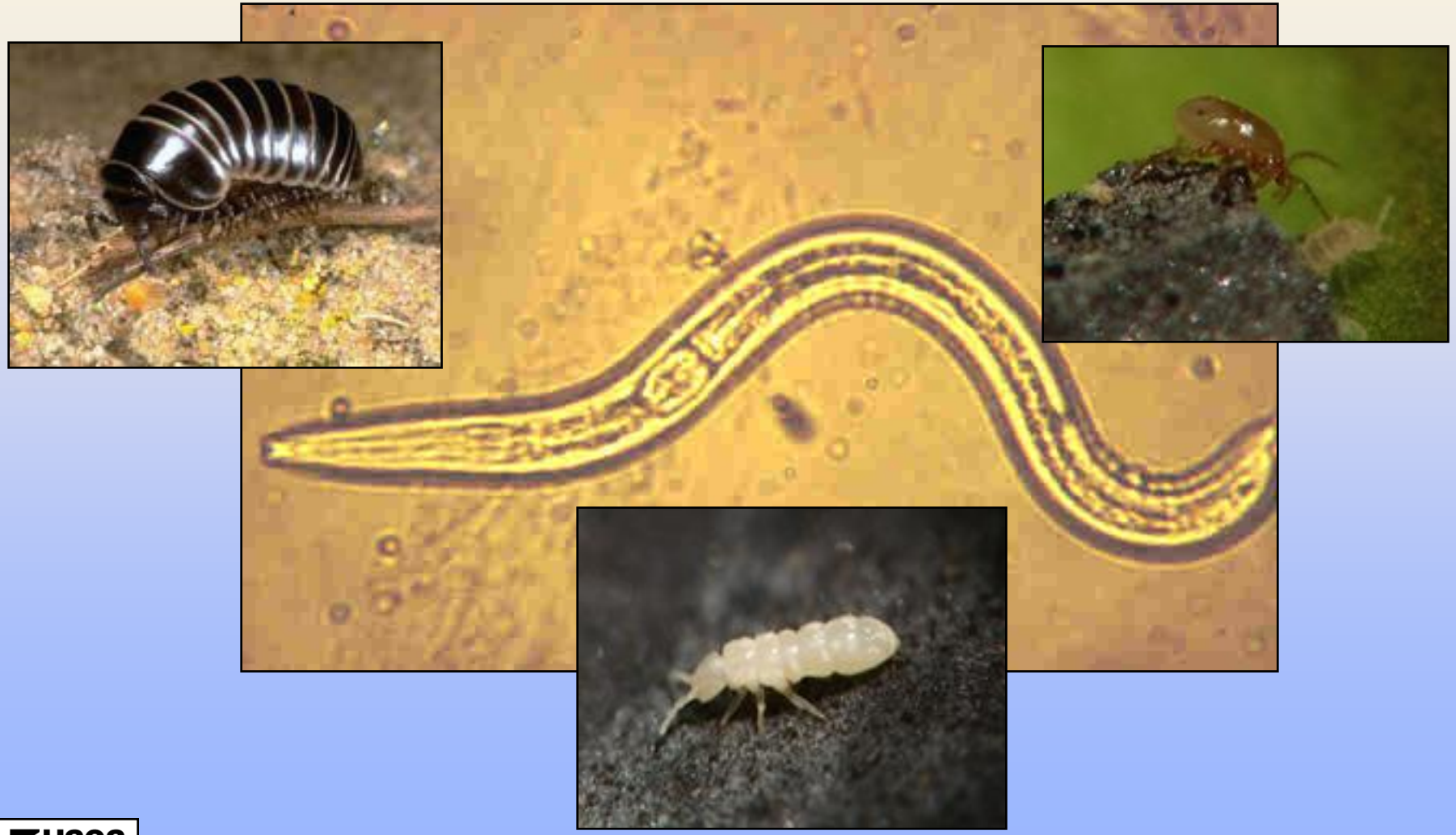
Soil Food Webs:

More developed crusts = > abundance, > richness



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Soil Aggregates

- Site of microbial activity, nutrient transformation
- Increase water infiltration
- Enhance root environment

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Native plant germination and establishment

generally enhanced or not affected (except hyperarid deserts)

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Vascular Plant Seedlings

- Crusts increase soil temperature
- Increased moisture retention
- Added nutrients

= Faster growth

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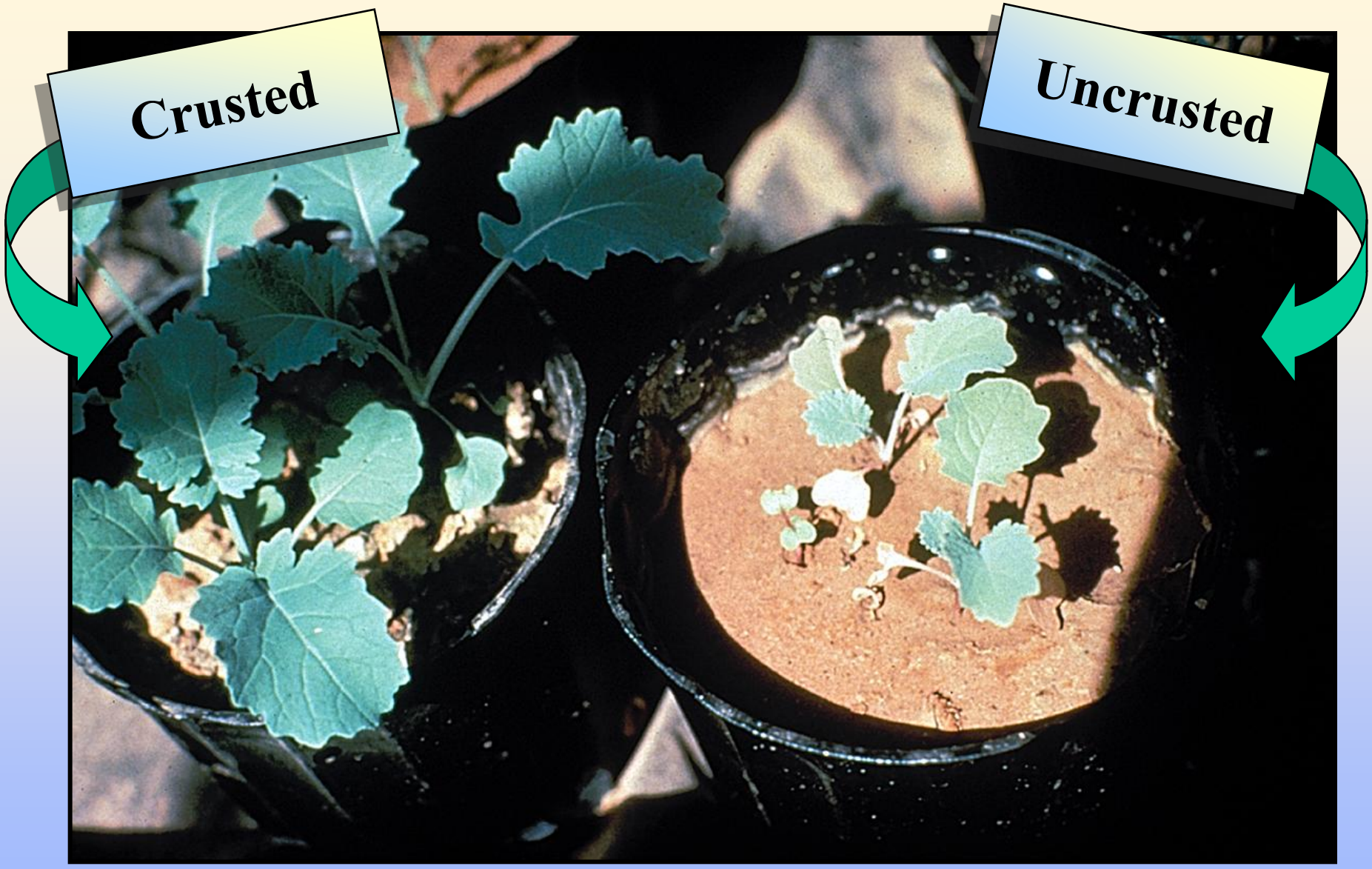

Plants in crusted soils have higher nitrogen content

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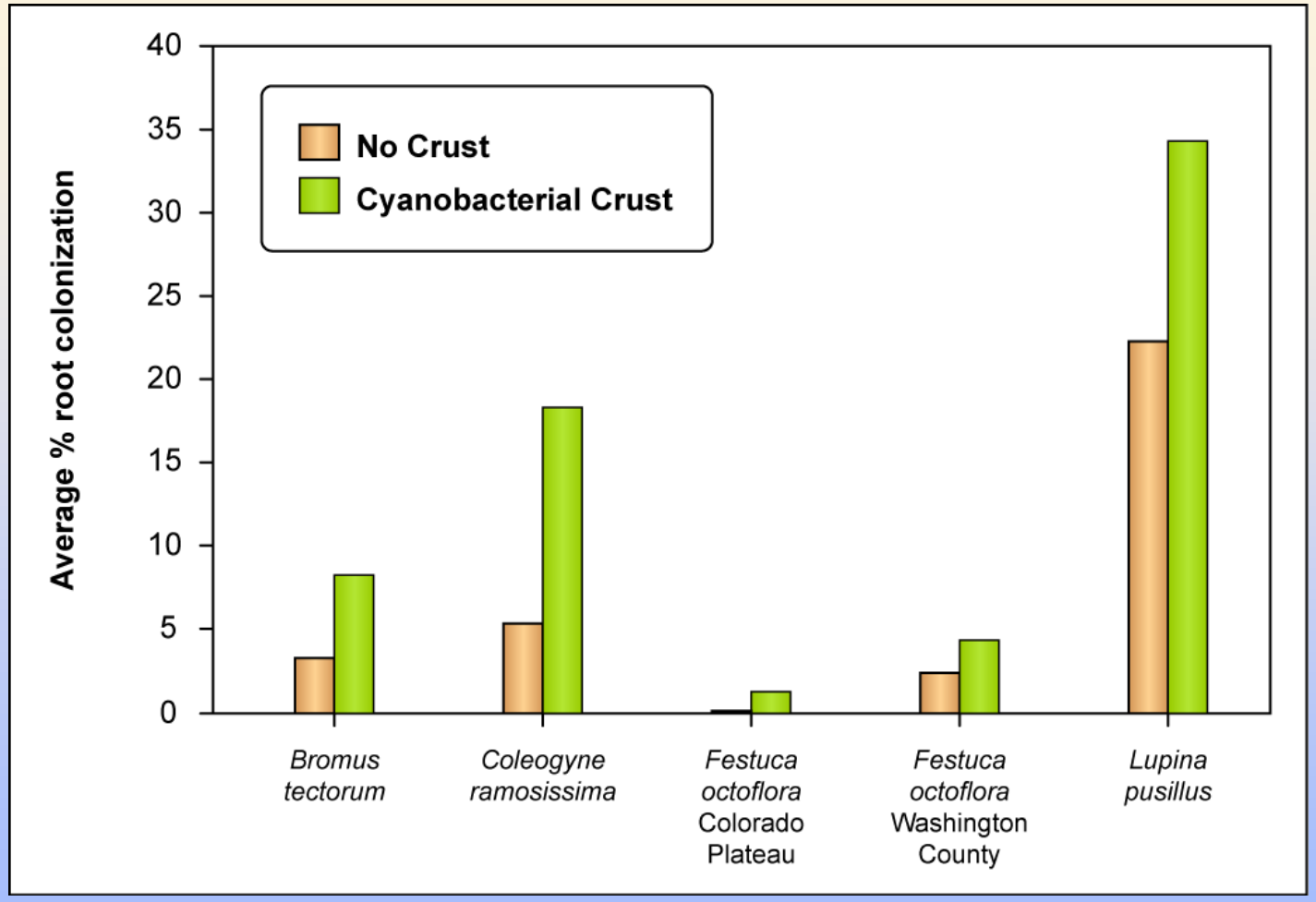
VAM colonization



***Roots of *Cryptantha petrocarya, Cryptantha crassisepala, Mentzelia albicaulis,* and *Streptanthella longirostris* were studied, but no mycorrhizae were observed. All of these species are annuals.**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Ecosystems where crusts are the primary providers of these functions

	Stability	N fixation	Water Capture	Biodiversity
Sonoran	+	+	+	+
Mojave	+++	+	+	+
Colorado Plateau	+++	+++	+++	+++
Great Basin	++	+++	+++	++++

Other functionaries = Plants, roots, litter, rocks

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