What roles do biological soil crusts play in ecosystems?

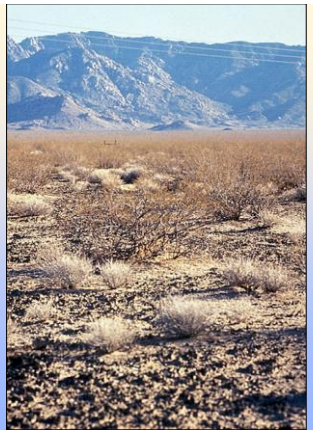
USGS

Biological Crusts are not Physical Crusts

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

USGS

Mojave Desert

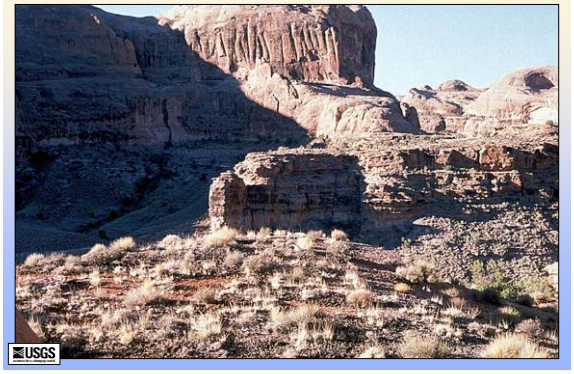


USGS

Sonoran Desert

USGS

Colorado Plateau

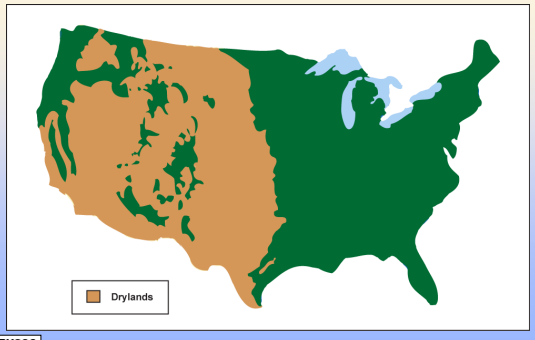


USGS

Great Basin

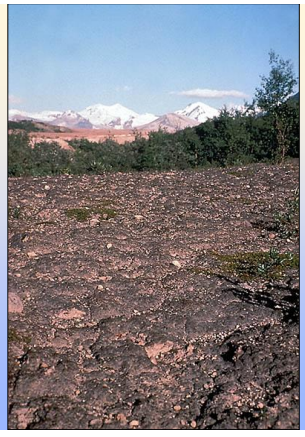
USGS

Aggregated Drylands of the U.S.



USGS

Alaska



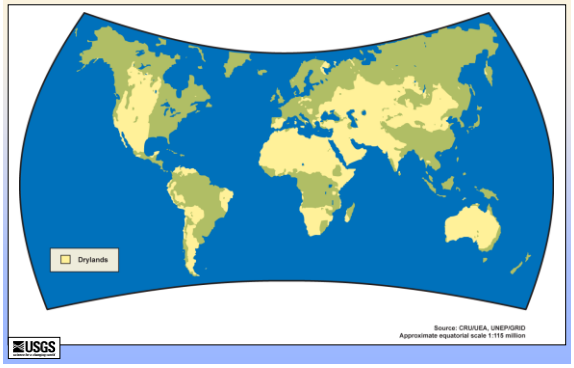
USGS

Mongolia

USGS

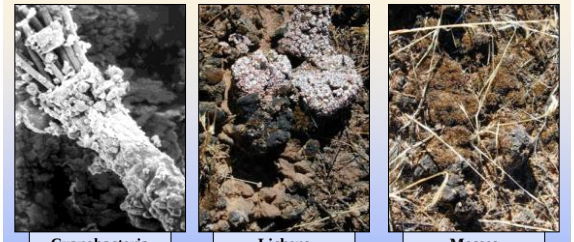
Kenya

Regions where biological crusts are important



Crusts are in a variety of habitats

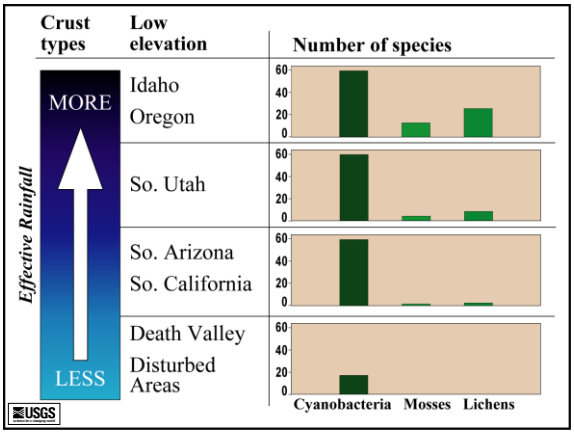
Biological Soil Crusts are a community of:



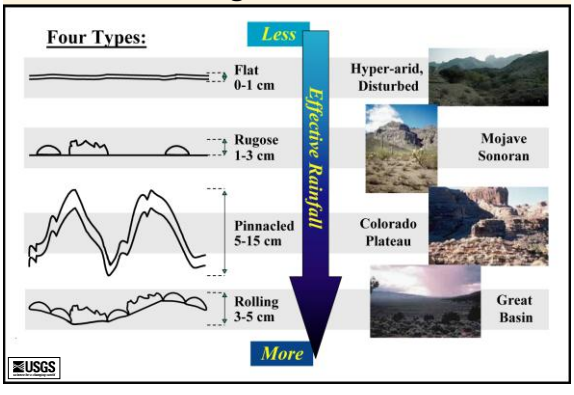
Cyanobacteria | Lichens | Mosses

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

USGS



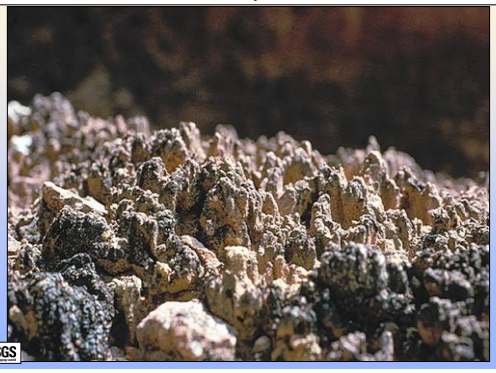
Soil Surface Roughness



Flat — **Hyperarid or Disturbed**

Rugose — **Arid**

Pinnacled Cool Desert



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Rolling Cool-cold Desert

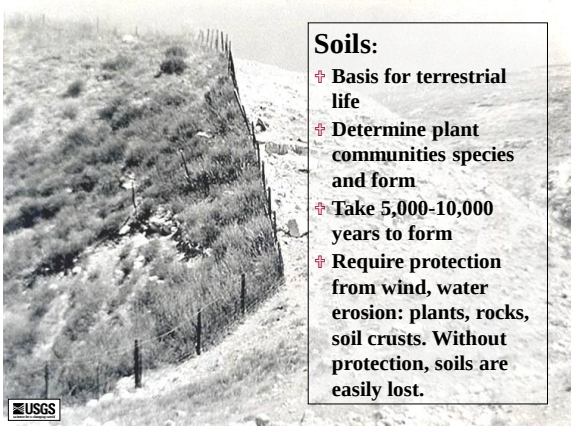
USGS

Why are soil crusts important?

Because they influence soils.

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

USGS



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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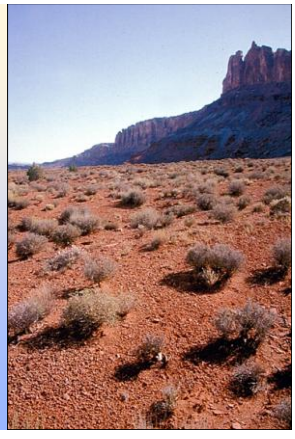
Soil Stability

Scattered Vegetation

In deserts, plants give little protection to desert soils



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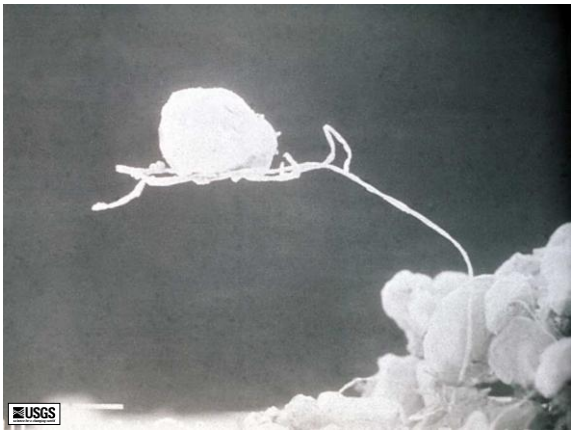
Soil Stability

Hill slopes

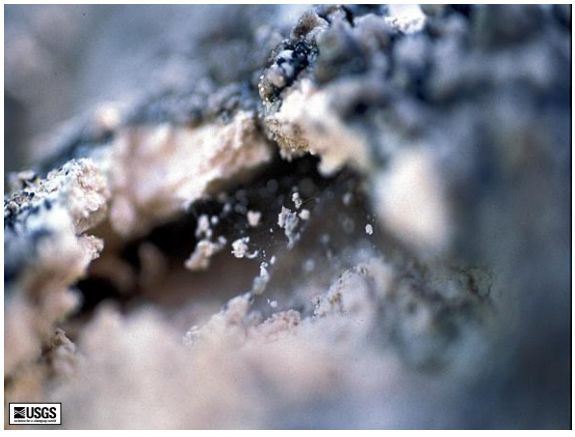
Soils held beyond angle of repose

USGS


USGS
90x

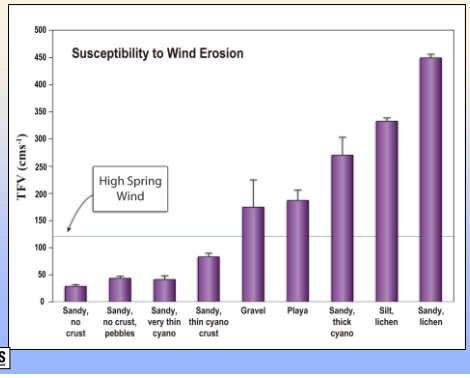

USGS


USGS



Soil Stability Then and Now

Wind Erosion



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?

USGS

Retention Time:

Path Connectivity/Surface Roughness

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

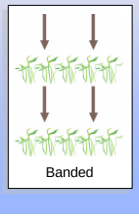
USGS

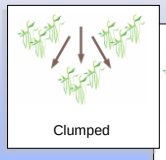
Crust flora

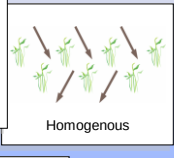
Surface Soil Permeability: Soils and plant litter can control!

Pore Space

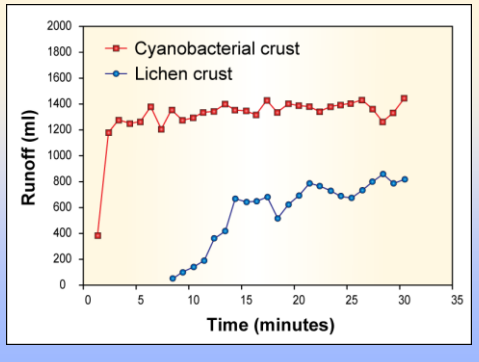
bare > light cyano > dark cyano > patchy lichen > continuous lichen > moss







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



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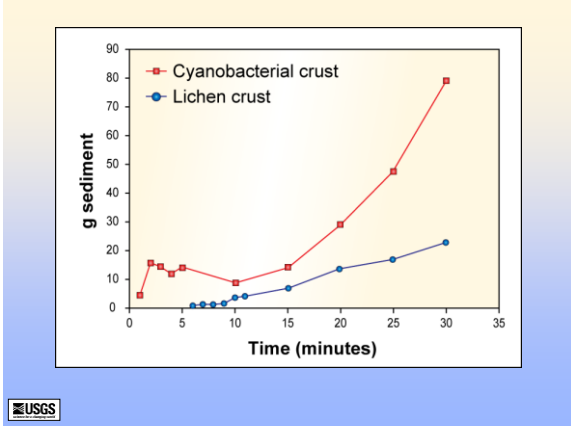
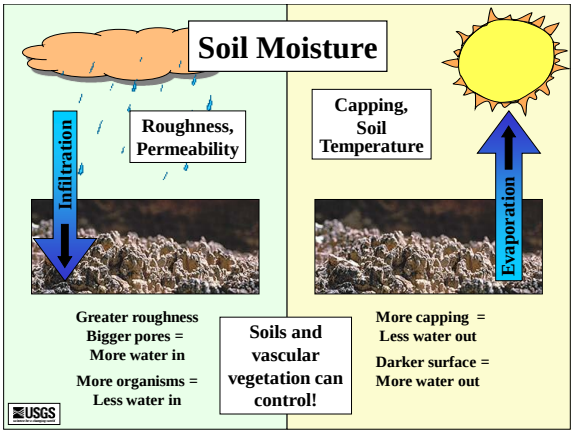
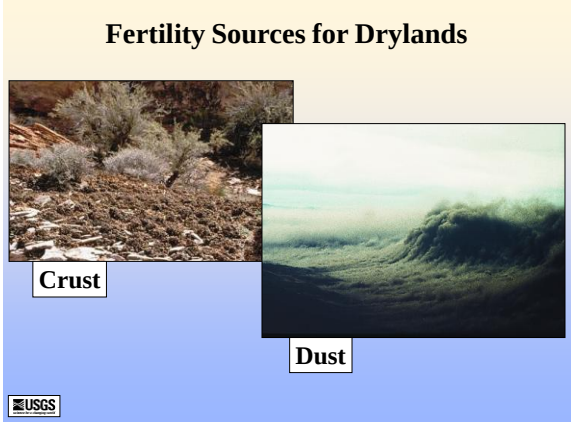
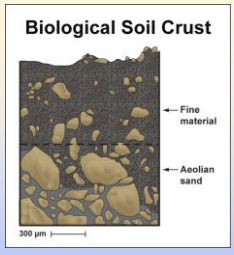
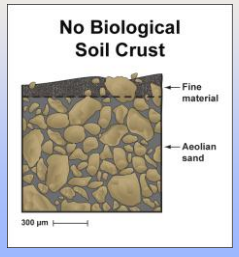

Cyanobacterial crust
Lichen crust
g sediment
Time (minutes)
0
10
20
30
40
50
60
70
80
90
0
5
10
15
20
25
30
35
USGS


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
USGS


Fertility Sources for Drylands
Crust
Dust
USGS



Dust Capture



Adapted from
Verrecchia et al. 1995

USGS

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

USGS

USGS

Soil crusts also capture:

- **Seeds**
- **Organic Matter**

Also Secrete Growth Factors

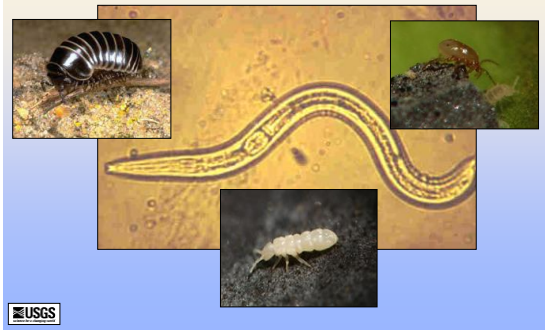
Soil Fertility

- 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

USGS

Soil Food Webs:

More developed crusts = > abundance, > richness



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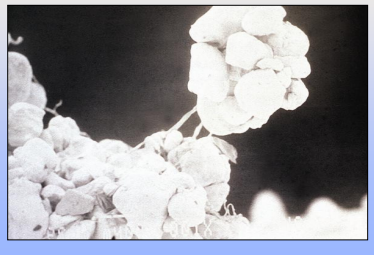
Soil Aggregates

- 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

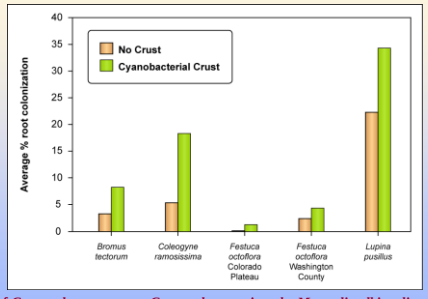
= Faster growth

USGS

Plants in crusted soils have higher nitrogen content

USGS

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.

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

USGS