What roles do biological soil crusts play in ecosystems?
Biological Crusts are not Physical Crusts

- Chemical and mechanical, not biological
- Formed by raindrop impact or hoof action
- Restrict plant growth and water infiltration
Mojave Desert
Sonoran Desert
Colorado Plateau
Great Basin
Aggregated Drylands of the U.S.
Alaska
Mongolia
Kenya
Regions where biological crusts are important

![Map showing regions with biological crusts](image)

Source: CRU/UEA, UNEP/GRID
Approximate equatorial scale 1:115 million
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.
<table>
<thead>
<tr>
<th>Crust types</th>
<th>Low elevation</th>
<th>Number of species</th>
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</thead>
<tbody>
<tr>
<td>MORE</td>
<td>Idaho</td>
<td>60</td>
</tr>
<tr>
<td>LESS</td>
<td>Oregon</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>So. Utah</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>So. Arizona</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>So. California</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>Death Valley</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Disturbed</td>
<td>10</td>
</tr>
</tbody>
</table>

Effective Rainfall

- Cyanobacteria
- Mosses
- Lichens
Soil Surface Roughness

**Four Types:**

- Flat 0-1 cm
- Rugose 1-3 cm
- Pinnacled 5-15 cm
- Rolling 3-5 cm

**Effective Rainfall**

- Less
- More

- Hyper-arid, Disturbed
- Mojave Sonoran
- Colorado Plateau
- Great Basin
Flat

Hyperarid or Disturbed
Rugose

Arid
Pinnacled

Cool Desert
Rolling Desert

Cool-cold Desert
Why are soil crusts important?
Because they influence soils.

- Soil stability
- Soil surface
- Roughness
- Soil moisture
- Soil fertility
- Soil temperature
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.
Soil Stability

Scattered Vegetation

In deserts, plants give little protection to desert soils
Soil Stability

Hill slopes

Soils held beyond angle of repose
Soil Stability Then and Now

Thin Soils:
- Easily lost
- Expands habitat
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?
Retention Time:

Path Connectivity/Surface Roughness

When soils are roughened, water is slowed = less water and soil loss
Surface Soil Permeability: Soils and plant litter can control!

Crust flora

Pore Space

bare > light cyano > dark cyano > patchy lichen > continuous lichen > moss
Natural vegetation patterns determine where you want infiltration.
Soil Moisture

Roughness, Permeability

Greater roughness
Bigger pores =
More water in
More organisms =
Less water in

Soils and vascular vegetation can control!

Capping, Soil Temperature

More capping =
Less water out
Darker surface =
More water out

Evaporation

Infiltration
Fertility Sources for Drylands

Crust

Dust
Dust Capture

Adapted from Verrecchia et al. 1995
Dust is critical!

<table>
<thead>
<tr>
<th></th>
<th>P</th>
<th>K</th>
<th>Mg</th>
<th>Na</th>
<th>Ca</th>
<th>Mn</th>
<th>Zn</th>
<th>Cu</th>
<th>Fe</th>
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<tbody>
<tr>
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<td>13.8</td>
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<tr>
<td><strong>Parent Material</strong></td>
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<td>1.27</td>
<td>0.08</td>
<td>0.04</td>
<td>2.1</td>
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<tr>
<td><strong>Enrichment (x)</strong></td>
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<td>1.2</td>
<td>4.6</td>
<td>4.3</td>
<td>1.3</td>
<td>2.1</td>
<td>2.7</td>
<td>1.4</td>
<td>1.6</td>
</tr>
</tbody>
</table>
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
Soil Food Webs:
More developed crusts $\Rightarrow$ abundance, $\Rightarrow$ richness
Soil Aggregates

- Site of microbial activity, nutrient transformation
- Increase water infiltration
- Enhance root environment
Native plant germination and establishment generally enhanced or not affected (except hyperarid deserts)
Vascular Plant Seedlings

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

= Faster growth
Plants in crusted soils have higher nitrogen content
*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

<table>
<thead>
<tr>
<th></th>
<th>Stability</th>
<th>N fixation</th>
<th>Water Capture</th>
<th>Biodiversity</th>
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</thead>
<tbody>
<tr>
<td>Sonoran</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Mojave</td>
<td>+++</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Colorado Plateau</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
</tr>
<tr>
<td>Great Basin</td>
<td>++</td>
<td>+++</td>
<td>+++</td>
<td>+++++</td>
</tr>
</tbody>
</table>

Other functionaries = Plants, roots, litter, rocks