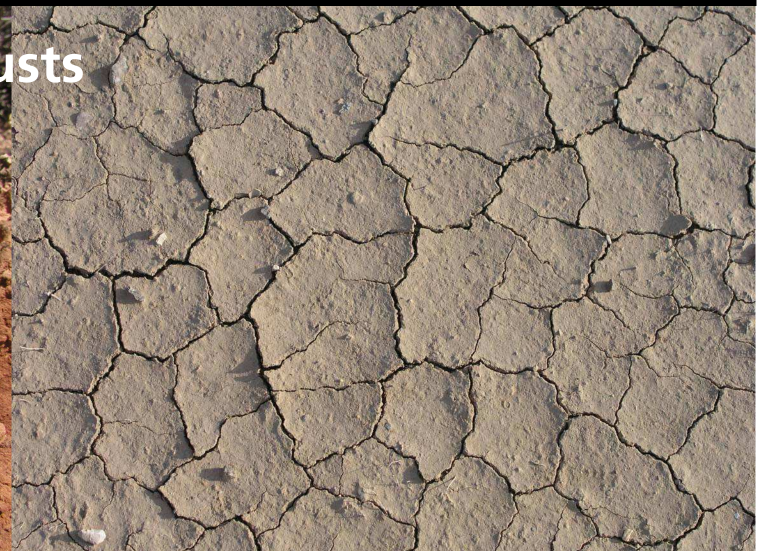
Rangeland Soil Quality

National Park Service
U.S. Department of the Interior

Natural Resources Program Center
Geologic Resources Division

Physical and Biological Soil Crusts



*A **physical crust** is a thin layer with reduced porosity and increased density at the surface of the soil. A **biological crust** is a living community of lichen, cyanobacteria, algae, and moss growing on the soil surface and binding it together. A **chemical crust** or precipitate is white or pale colored and forms in soils with a high content of salts. Both chemical and biological crusts can form on and extend into a physical crust. This information sheet deals only with physical and biological crusts.*

Why are soil crusts important?

Physical crusts generally indicate that the amount of organic matter in the soil has decreased and/or erosion has occurred. They have low aggregate stability, disperse readily when wet, and are easily reformed by raindrop impact or flowing water. They seal the soil surface, reduce the rate of water infiltration, and can increase runoff. Physical crusts generally have a very low content of organic matter and support little soil biological activity. The dense nature of the crusts can impede seedling emergence. Water that ponds in flat, crusted areas is likely to evaporate, reducing the amount of water available to plants. Physical crusts generally help to control wind erosion, but they do not protect the soil from water erosion.

Biological crusts stabilize the soil surface, protecting it from erosion. Depending on soil characteristics, biological crusts may increase or reduce the rate of water infiltration. By increasing surface roughness, they reduce runoff, thus increasing infiltration and the amount of water stored for plant use. Some organisms in biological crusts can increase the amount of nitrogen and other nutrients in the soil. In semiarid ecosystems biological crusts can provide a significant amount of nitrogen for plant growth. The germination of plants may be enhanced or inhibited, depending on the nature of the biological crust and the plant species. In general, the relative importance of biological crusts increases as annual precipitation and the potential plant cover decrease.

What determines crust formation?

Physical crusts form when organic matter is depleted from the surface layer, soil aggregates become weak, and raindrops disperse the soil into individual particles that clog soil pores, seal the surface, and form a layer that is dense when dry. A physical crust consisting of numerous thin bands can form when sediment from erosion is carried downslope and buries the soil surface. Physical crusts are more common on silty, clayey, and loamy soils and are relatively thin or weakly expressed, if present at all, on sandy soils. Soils with a high content of sodium disperse readily in water and are more susceptible to crust formation than other soils. To examine a crust, lift the soil surface with a knife tip and look for cohesive layers or thin bands parallel to the soil surface. These layers have no apparent binding by visible strands of organic material, such as cyanobacteria. Fragments of physical crusts disperse or "melt" when placed in water. A vesicular crust is a type of physical crust with many small, unconnected air pockets or spaces similar to those in a sponge. A biological crust occupies a large amount of the surface of calcareous and gypsiferous soils. Soil texture, moisture, temperature, season of precipitation, and history of disturbance largely determine the dominant organisms in the crust. For example, moss tends to be dominant in the Columbia Basin, whereas cyanobacteria and lichen are dominant in the Mojave, Sonoran, and Chihuahuan Deserts.

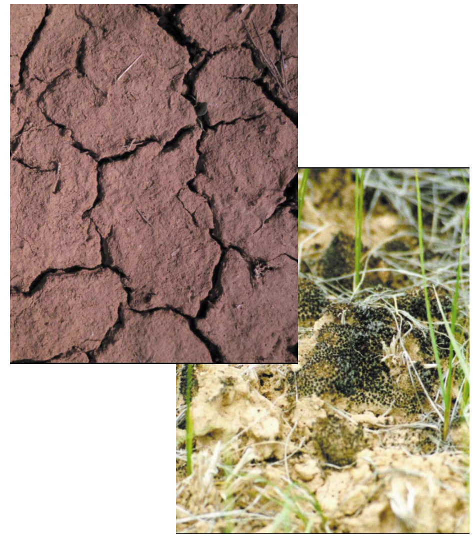
What affects crusts?

Organic matter and plants.—Organic matter in the soil inhibits physical crust formation by promoting the development of stable aggregates that resist rupture, dispersion, and water erosion. Plant cover, litter, and biological crusts inhibit the development of physical crusts by intercepting raindrops before they strike bare soil. Litter cushions biological crusts from trampling. Litter and plant cover moderate temperature and moisture extremes on the soil surface and thus aid in the development and diversity of biological crusts.

Soil features and erosion.—Soil features, such as fine texture, compaction, loss of organic matter, and soil structure, and an increase in the amount of bare ground decrease the rate of water infiltration and increase runoff. Increased runoff can erode the soil surface, removing biological crusts and leaving behind a layer that has a lower content of organic matter and is more susceptible to dispersion and physical crust formation. Burial by wind erosion and water erosion or a large amount of litter can damage biological crusts and kill some organisms. Burial of an unbroken physical crust does not overcome its water-restrictive features.

Fire.—Hot, frequent fires can damage some biological crusts. Increased runoff and erosion following hot catastrophic fires can promote the development of physical crusts and the loss of biological crusts.

Disturbances.—Both physical and biological crusts can be affected by physical disturbances caused by wheeled or tracked vehicles, livestock hooves, and hiking and cycling. The impact is determined by the severity, frequency, and timing of the disturbance and by the size of the disturbed area. Physical crusts tend to reform during the first rainstorm after a disturbance.



Management Strategies

The development of objectives relative to soil crusts is an important part of rangeland management. Biological crusts protect the soil from water erosion and wind erosion. Physical crusts can protect soils from wind erosion as effectively as biological crusts, except on very coarse textured soils. In the more humid areas, it generally is desirable to break up physical crusts and thus improve seedling emergence and plant establishment; however, desirable biological crusts can be destroyed when the physical crusts are broken. Adequate organic matter, seeds of desirable species, and a period of rest are needed for successful establishment of plants after crusts are broken. Recovery of biological crusts may take decades to hundreds of years. Therefore, preventing degradation by minimizing disturbance is important. Biological crusts that are in areas of low rainfall, are on coarse textured soils with low stability, and are in areas with a large amount of bare ground are most susceptible to frequent disturbances and have the longest recovery times. Biological crusts of all types are least susceptible to disturbance when the soil is frozen or is covered with snow. Biological crusts on sandy soils are less susceptible to disturbance when the soils are wet or moist, and the ones on clayey soils are less susceptible when the soils are dry. Trampling or grazing when the soil surface is very wet or ponded should be avoided because it can displace and bury the biological crust. The following management strategies apply to land used for grazing, wildlife habitat, or recreation:

- Maintain the optimum amount of live vegetation, litter, and biological crust relative to the site potential in order to maintain the content of organic matter and soil structure and control erosion.
- In humid areas improve soil structure and plant establishment by incorporating organic matter into the soil while breaking up a physical crust.
- Defer grazing and recreational use during periods when biological crusts are most susceptible to physical disturbances.
- Use prescribed burning according to the needs of each site to prevent fuel buildup that can produce hot fires followed by severe erosion.
- Control the establishment and spread of invasive annual plants that can carry fire.

For More Information

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More information can also be found on the Soils website at: www2.nature.nps.gov/geology/soils

The National Park Service, Soil Inventory and Monitoring Program is partnering with the USDA-Natural Resources Conservation Service, and the USDA Agricultural Research Service, Jornada Experimental Range, to develop a series of assessment and monitoring protocols to assist NPS Vital Signs Monitoring Networks in understanding and evaluating the important role soils play within ecosystems.