

# **Soil Health, Soil Quality, Soil Indicators-How the Bureau of Land Management Uses Soil Information**

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Overview from BLM's development of our web-based soil training course emphasizing how soils form, their importance and value, how to use soils information.

Addressing soil properties and interpretations and the relation of dynamic soil properties with the soil survey

# Soils Training - Recognize

- Quality and health, and BLM's land health standards
- Choosing soil quality indicators
- Indicators relationships to the soil survey, ecological site descriptions and state transition models
- Life in the soils is much more diverse than above ground ecosystems and that living soil is critical to landscape health.
- Soil food web
- Differences among BLM's soil indicators versus data in the soil survey, (Web Soil Survey) and soil data (National Soil Information System).
- Soil properties are affected by management activities.
- Best management practices to minimize disturbance, improve surface cover and diversity of vegetation.
- Preventative measures are more prudent than expensive cleanup, restoration and corrections to soil damage.
- Linking Ecological Site Descriptions to Soil and Ecological Indicators for Land Health

# BLM's Planning Process

- Identifying impacts and preventing degradation from soil disturbance
- **Best management practices**, and
- **Mitigation measures** to restore damage that is unavoidable.
- A focus on activities altering the natural environment- removal of vegetation and surface soils—affecting infiltration and aggregate stability, leading to erosion from water and wind, impeding vegetative recovery.
- **Invasive** annual grasses and weeds can increase, with a loss of ecosystem services (soils, type of vegetative community, water routing and storage, wildlife habitats).
- **Soil stressors** – climate change (drought, flooding), fire, invasive species, population growth (increased disturbance)

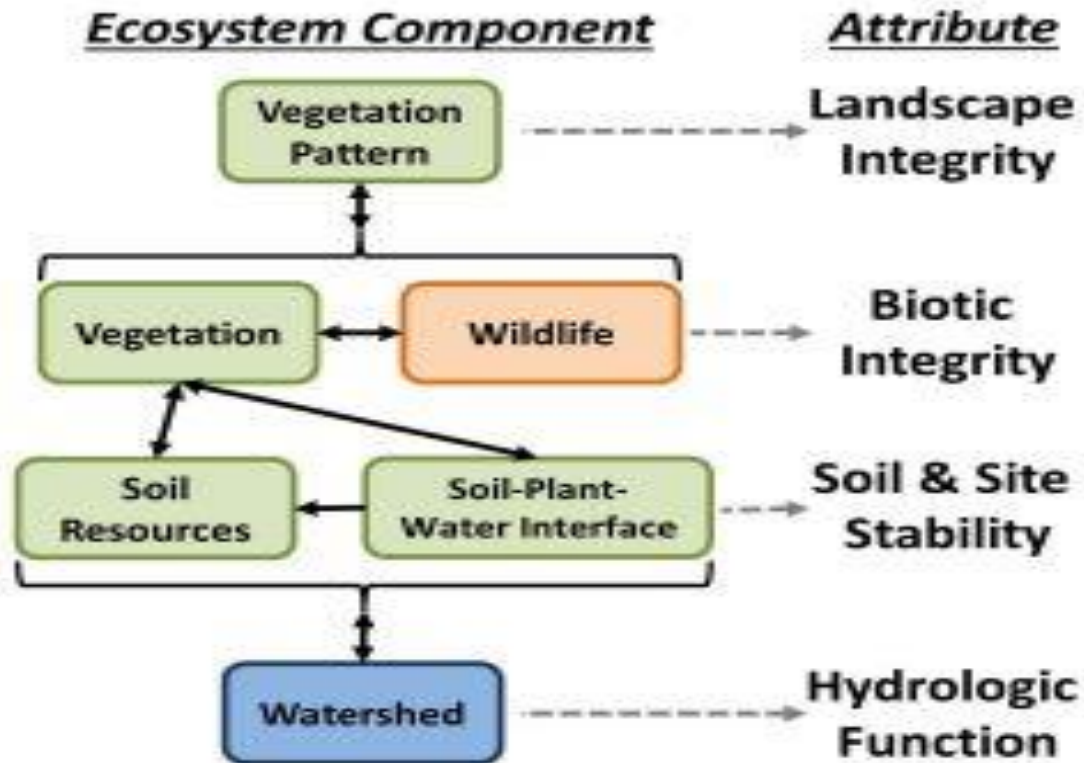
# Addressing Impacts to Soils

- Determining the **vulnerability** of soils to degradation through a look at pertinent **soil properties, soil indicators of land health** in relation to suitability and limitations
- Predicting how **vegetation and soil conditions may respond to disturbance** or change.
- Identifying both preventable and unavoidable impacts and **best management practices and mitigation.**
- **Application of a soil survey** for general planning narratives; with on-site project interpretations needing soil, vegetation, and other resource disciplines.

# Value of Soil

- Provides many soil functions including nutrient cycling, water infiltration and holding capacity, filtering, and ecosystem sustainability to support life -- including having proper tilth, providing for activities of soil organisms, root growth, soil surface cover, and vegetation

# Indicators address key attributes of ecosystem sustainability



**Table 1. Core and contingent indicators for the Assessment, Inventory, and Monitoring Strategy and their recommended collection methods.**

<b>Type</b>	<b>Indicator</b>	<b>Method</b>	<b>Where applied?</b>
Core	Amount of bare ground	Line-point intercept supplemented with plot-level species inventory	All vegetation monitoring
	Vegetation composition		
	Non-native invasive species		
	Plant species of management concern		
	Vegetation height	Height at selected LPI points	All vegetation monitoring
	Proportion of site in large, intercanopy gaps	Canopy gap intercept	All vegetation monitoring
Contingent	Soil aggregate stability	Soil stability test	When soils are potentially unstable (most rangelands)
	Significant accumulation of toxins	Sampling for toxins in soil	When toxins are believed present (e.g., chemical spills)

# Soil Function and Soil Quality

- Soil quality is the capacity of a soil to function.
- Healthy soils support plant/animal diversity and productivity, regulate and partition water and solute flow, filter and buffer pollutants, store and cycle nutrients, and support structures and protect archaeological treasures
- Soil quality is a result of soil management.
- Soil quality and indicators are used for BLM's management and activities, field guides and health score cards used with interdisciplinary teams assessing land health.



# Soil Quality and Resilience

Soil resilience is the capacity of a soil to recover soil functions after disturbance (i.e. fire, floods, compactive forces, etc.)

Soil quality indicators - for rangeland- forest health, used with management practices that manipulate vegetation, or after fire, disturbance, chemical / physical treatments, seeding, planting, etc.

# Soil Quality Indicators- Measures of Soil Functional State

- A soil quality indicator is a chemical, physical or biological property of soil that is sensitive to disturbance and represents performance of ecosystem function in the soil.
- Indicators are dynamic soil properties to evaluate how well soil functions since soil function often cannot be directly measured.
- Measuring soil quality involves identifying soil properties that respond to management, are correlated with environmental outcomes, and can be easily observed
- Soil quality indicators may be qualitative (e.g. drainage is fast) or quantitative (infiltration= 2.5 in/hr).

# Importance of Soil Quality Indicators?

1. Help the BLM's meet its mission of land sustainability
2. Help BLM meet its land management objectives
3. Help with soil assessment methods, tools
4. To specifically assess BLM's land health standards

# Soil Quality Indicators, Properties

- **Aggregate Stability**
- Available Water Capacity
- Bulk Density
- Compaction, penetration resistance
- **Infiltration**
- **Organic Matter, soil color**
- Respiration
- **Slaking**
- **Soil crusts**
- Soil enzymes
- Soil organisms
- Soil pH
- Soil Structure & Macropores
- **Texture**
- Total Organic Carbon
- Topsoil, soil depth

# Indicators Should:

- correlate with ecosystem processes
- integrate soil physical, chemical, and biological properties
- be accessible, observable to many users
- be sensitive to management & climate
- be components of existing databases
- be interpretable

# Physical soil quality indicator: Slaking and Aggregate Stability

**Slaking**: breakdown of large soil aggregates into smaller aggregates in water, when aggregates are too weak to withstand internal stresses during wetting (swelling of clay particles, air escaping, release of heat, etc.)

Compared to the raindrop splash, slaking plays the primary role in particle detachment and surface sealing of clay soils.

**Aggregate stability**: measures how well soil withstands external forces, such as the splashing impact of raindrops. Both poor aggregate stability and slaking result in detached soil particles that settle into pores, causing surface sealing, reduced infiltration and plant available water, and increased runoff and erosion.

# Soil Slaking

- Indicator-- stability of soil aggregates, resistance to erosion, upon soil wetting.
- Limited slaking -- clay and /or organic matter is present in soil to bind soil particles.
- Repeated disturbances, i.e. equipment use, wildfires, removal of surface cover reduces aggregate stability and organic matter by increasing soil slaking.
- Affected by wetting rate, soil water content, soil texture, clay, and organic matter.
- Slaking increases with fast wetting rates, when soil is initially dry.
- Moist aggregates slake less readily than dry aggregates because they have already completed some swelling and pores have some water.
- Pressure of entrapped air is main factor causing slaking of loamy soils, clay is associated with slaking caused by soil swelling.

# Field kits to measure slaking





# Soil Aggregates and Stability

- Protect soil organic matter and soil aeration.
- The loss of organic matter, soil aggregation, and nutrients for plants and microorganisms reduces vegetation growth.
- Protect organic matter and ground cover.
- Adding organic matter takes years, while disturbance that removes cover leads to rapid decline in soil organic matter, biological activity, and aggregate stability.
- Changes indicate recovery or degradation of soils. Large aggregates (>2-5mm) are more sensitive to management effects on organic matter. When the proportion of large to small aggregates (< 0.25 mm) increases, soil quality increases.
- Disturbance stimulates erosion, breaks up soil aggregates and promotes the loss of organic matter.

# Comparing aggregate stability

**Good aggregate stability – soil clods do not breakdown in water**



**Poor aggregate stability – soil clods breakdown in water**



# Soil Chemical Indicators - Organic Matter, Soil Carbon

- Soil carbon-- transcends all three indicator categories, the most influence on soil quality, tied to all soil functions.
- Affects other indicators, such as aggregate stability (physical), nutrient retention and availability (chemical), and nutrient cycling (biological); and is itself an indicator of soil quality.

# Another Soil Chemical Indicator - Electrical Conductivity, Salinity

- Electrical conductivity (EC), is the ability of soil to conduct current and to measure soil salinity and the potential for estimating variation in some soil physical properties.
- Soil salts when entering water sources can cause economic damages to infrastructure.

# Biological soil indicators

- Organisms that form the soil food web decompose organic matter and cycling nutrients.
- The numbers of organisms, i.e. bacteria, fungi, arthropods, etc., individuals and species, indicate a soil's ability to function or bounce back after disturbance (resistance and resilience).
- Organic Matter and Soil Respiration.
- Soil microbiotic crusts

# Soil Respiration

- Release of carbon dioxide from the soil surface
- A measure of biological activity and microbial decomposition, dissolution of carbonates, etc.
- As organic matter decomposes, organic phosphorus, nitrogen, and sulfur are converted to inorganic forms that are available for plant (mineralization). Soil respiration is also known as carbon mineralization.

# Respiration Rates

- Rates depends on organic matter amounts, temperature, soil moisture, and aeration. Soil organisms activity varies seasonally.
- Dry soils have reduced or less microbial activity, and in extremely wet soils, low oxygen levels results reduces organic matter decomposition— with lower respiration rates.
- With less respiration, nutrients not released to feed plants, roots, and soil organisms, hindering plant growth.

# Soil Biological Crust Ecosystems

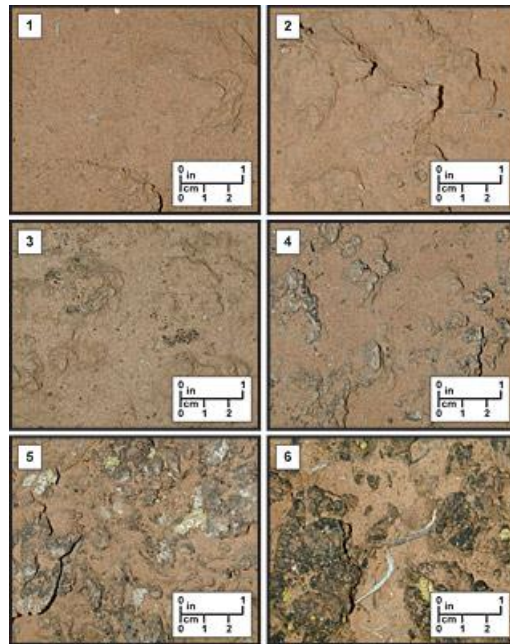
- Community of organisms at the surface of desert soils comprised of cyanobacteria, green algae, microfungi, mosses, liverworts and lichens.
- Enhance soil fertility and stability.
- Minimizing surface disturbance of soil crusts is vital to counter annual grass invasions prone to fire, and dust produced from disturbance.



# Microbiotic Soil Crusts



# Measuring soil crust cover



# **BLM scoring/ranking/measuring of eight commonly used soil quality indicators**

## **1. soil structure—cloddy**

powdery, massive, flaky to crumb, friable

**2 . free of compactive layers & abundant roots—**hardpans, roots turned, difficult-ease for wire flag penetration, good root distribution

**3. soil organisms --**absent to visible/full variety

**4. plant residue presence –**none or too much not decomposing to full decomposition

## **5. health of plants, roots:**

poor, stunted growth (discolored) to vigorous, uniform growth

**6. water infiltration, available —** water on surface for long time, to adequate drainage and lack of ponding

**7. bare ground---**considerable to expected cover of plants and residues of soil/site

**8. aggregate stability---**measured by the resistance of array of soil particle sizes and the ease to difficulty to hold together from rain, wind, disturbance

# What is the soil management history?

- Issues to address, problem solving

Erosion

Loss of Organic Matter

Soil Compaction, Traffic, Trampling

Salinization

Drainage

# What are some examples of BLM authorized management activities affecting soil resources?

- 1. Vegetative management
- 2. Oil and gas activity-development
- 3. Solid minerals management
- 4. Recreational activities
- 5. Fire management/Emergency Stabilization Rehabilitation
- 6. Renewable energy development
- 7. Landscape restoration projects

# Off Road Vehicles



# Renewable energy development



# Invasive species, red brome, prone to wild fire





# Increasing growth and urbanization



# Runoff and sediment

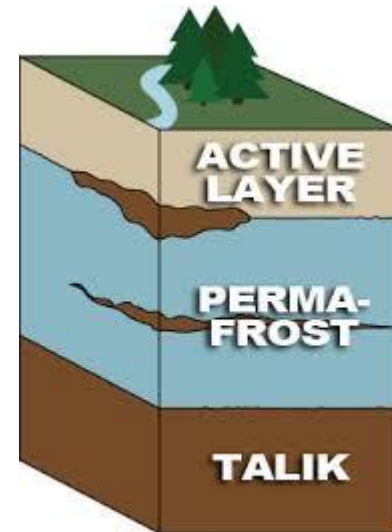
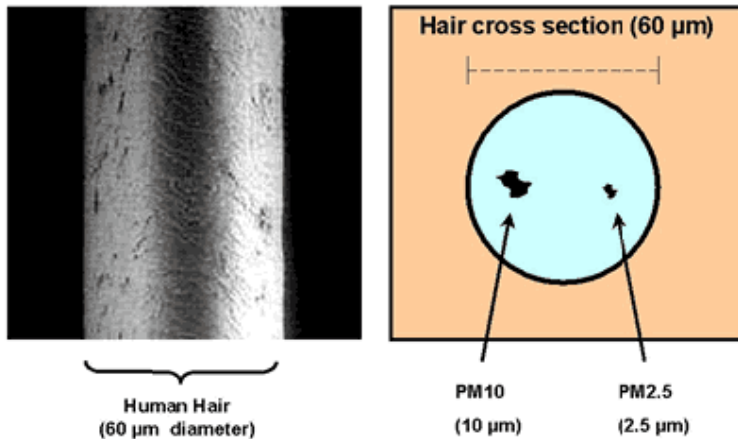


# Different Environments

Deserts, Dust

Arctic, permafrost

HOW SMALL IS PM?



# Importance of soil in public land management

- As demands and human values increase for using public lands, BLM must improve its understanding of soil science with regards to environmental regulations, sustainable management and productivity, biodiversity, health, and as a pathway for both nutrients and contaminants in the soil. Belowground soil processes determine the structure and function of above ground ecosystems and the soil is a key component of ecosystem services, providing major support to the human factors of health, well-being and economic values as well as protection from water and air pollution, fire and floods.