Usable Science: Soil Health

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On the Ground

- Healthy soils are fundamental to sustainable rangelands, but soils function in obscurity. This is reflected in the belowground black-box mentality often attributed to soils.
- Transformational changes get the attention of land managers and the publicfor example, soil erosion associated with the Dust Bowl of the 1930s. This provides benchmarks for the context of importance in maintaining healthy soils for the productive capacity of rangelands.
- Benefits of soil health include enhanced soil water-holding capacity and appropriate nutrient cycling, which increases rangelands resilience to weather variability and predicted climate change.
- Future directions of usable science for soil health include: 1) characterization of soil health indicators for sensitivity levels that affect transitions/thresholds of state-and-transition models, 2) influences of management practices, predicted climate change, and extreme events, and 3) impact of prescribed fire and wildfires on soil health.

Keywords: infiltration, nutrient cycling, organic matter, productive capacity, resiliency, soil structure.

Rangelands 1–2

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Soil functions in obscurity and is often underappreciated and taken for granted. That is, soil receives little press until it garners public attention when it is lost from lands due to wind and water erosion, or when mismanagement leads to degradation in productive capacity through loss of topsoil, organic matter, and/or changes in structural/chemical/biological attributes. Benchmark events such as the 1930s Dust Bowl remain entrenched in the memories of land managers for how drought can lead to widespread wind erosion (Fig. 1). Loss of soil due to water erosion (Fig. 2) can also be problematic on rangelands through reducing productivity and negatively impacting water quality. Soil erosion is expected to increase with predicted greater frequency of extreme rainfall events.[1]

Obscurity of Soils

The obscurity of soils was reflected in the prioritization of 142 issues identified from the workshop on Future Directions for Usable Science for Rangeland Sustainability held in Ardmore, OK, 2 June to 5 June 2014 (***see*** Maczko et al. ***this issue***). For the five topic groups discussed (water, animals, vegetation, socio-economics, and soils), only one soils issue was in the top 20%: in 28th place—the last of the top 20%—was the connection of soil health with state-and-transition model states in ecological site descriptions. A cluster of soils issues occupied rankings 50–52: 50) relevance of soil surveys to ecological site descriptions, 51) prescribed fire vs. wildfire effects on soils, and 52) targeting conservation programs/practices for soil resources on the post fire landscape. Of note, two soils issues were the lowest prioritized, with soil microbial designer communities ranking 141st, and dust and particulate matter ranking 142nd.

Why Soil Health is Important to Rangeland Sustainability?

There is a tremendous interest, both from producers and the US Department of Agriculture (USDA), in augmenting the physical, chemical, and biological components of soil health with applicable conservation practices to increase production capacity and ecosystem services through enhanced soil water holding capacity, appropriate nutrient cycling, and greater resilience to weather variability and predicted climate changes. This interest, primarily driven by demonstrations of increased organic matter and soil structure in croplands through reduced tillage, no-till, and cover crops in mesic environments, has resulted in land managers expressing similar enthusiasm for soil health recovery on rangelands.

Primary relevant differences between soil health for croplands and rangelands include 1) intensive (e.g., maximizing inputs of capital and energy to maximize yields) management for crops vs. extensive (e.g., optimizing inputs of capital and energy to maintain and sustain yields) management for rangelands; 2) annual plants for crops vs. perennial plants in rangelands; and 3) croplands are mostly found in more mesic environments (along with improved pastures) with intrinsically higher soil quality, whereas rangelands are largely in more semiarid and arid environments that can restrict crop production. Even within the

Figure 1. Wind erosion of soils from 1930s Dust Bowl (photo NRCSDC0100, courtesy of NRCS).

broad category of rangelands, these ecosystems are markedly different in terms of their soils and climate (exemplified by the mollisols of the Great Plains vs. the aridisols of the Great Basin), vegetation physiognomy (grasslands, shrublands, prairies, savannas), and evolutionary history (Great Plains with large migratory herbivore herds vs. Great Basin with small browsers). Together, these factors—classically defined as organisms (plants, animals, microbes), climate (growing season and precipitation), parent materials (geological substrates), and topography (slope and aspect)—establish a vast matrix of soil regions and individual sites that produce a variety of plant communities having a diversity of production potentials for ecosystem goods and services.

Identification of Issues for Soil Health

Three issues of usable science for soil health were identified during the Future Directions for Usable Science for Rangeland Sustainability Workshop:

1) characterization of soil health indicators for sensitivity levels that affect transitions/thresholds of state-and-transition models
2) influences of management practices, predicted climate change, and extreme events
3) the impact of prescribed fire and wildfires on soil health

We use these identified issues to frame the following sections of this article by addressing a key question for each of these issues.

Question: How to Characterize Indicators of Soil Health for Sensitivity to Transitions/Thresholds of State-and-Transition Models?

Differential responses to grazing, defined as ecological state changes, for rangelands are illustrated by the conversion of sagebrush shrublands in Nevada to monocultures of invasive annual grasses and the conversion of desert grasslands in New Mexico to sparse shrublands with high amounts of bare ground

Figure 2. Water erosion of soils from California rangelands in 1952 (photo NRCSCA52085, courtesy of NRCS).