Rangelands and Soils: What we know and don’t know

Justin D. Derner
Justin.Derner@ars.usda.gov

United States Department of Agriculture
Road map

• Importance and characteristics of rangeland

• Rangeland vs. pastures

• What we know:
  – Environmental controls
  – Management
  – Management x environment

• What we don’t know:
  – Where does the thermometer go?
Importance of rangeland

- >50% of earth’s land area
- Contains 10-30% of global soil organic carbon (SOC)
  - Improper management can release this back to atmosphere
  - Carbon sequestration rates are low (0.07 to 0.30 Mg C ha/yr), but large land area available
- Ecosystem co-benefits
  - Greater soil water holding capacity
  - Improved soil structure and
  - Enhanced nutrient cycling
Characteristics of rangelands

- Inherent high degree of spatial and temporal variability
  - Soils
  - Topography
  - Plant communities
  - Seasonal distribution and total precipitation
  - Climate
- Ecosystem C storage >90% in soil organic matter (SOM)
- Slow vegetation change
Rangelands vs. Pastures

• **Rangelands**
  – Native species (mix of C3/C4)
  – Low inputs (if any)
  – Often extensive rotational grazing management

• **Pastures**
  – Improved species (often C3 grasses and legumes)
  – Inputs of water, fertilizer and chemical control
  – Intensive grazing management
    • Keep plants in vegetative state
  – Capacity for increased soil C due to prior management and inputs
What we know: environmental controls

- Spring (AMJ) precipitation drives aboveground biomass production
- Soil C sequestration characterized by short periods (2-3 months) of high C uptake and long periods of C balance or small losses
- Lag effect following drought where flush of accumulated soil N is incorporated into biomass
- Clay and loamy soils have more soil C capacity than sandy soils
- Need for increased resilience
  - Healthy soils are important
    - Intra- and inter-seasonal precipitation variability
  - Adaptive management emphasis
## Summary of different rangelands

<table>
<thead>
<tr>
<th>Location</th>
<th>Vegetation</th>
<th>Mean (and range) annual net ecosystem exchange (g C/m²/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Las Cruces, NM</td>
<td>Desert grassland</td>
<td>-160 (-254 to 94)</td>
</tr>
<tr>
<td>Lucky Hills, AZ</td>
<td>Desert shrub</td>
<td>-93 (-162 to 55)</td>
</tr>
<tr>
<td>Burns, OR</td>
<td>Sagebrush steppe</td>
<td>73 (-61 to 229)</td>
</tr>
<tr>
<td>Dubois, ID</td>
<td>Sagebrush steppe</td>
<td>83 (-47 to 260)</td>
</tr>
<tr>
<td>Mandan, ND</td>
<td>Northern mixed prairie</td>
<td>53 (-27 to 119)</td>
</tr>
<tr>
<td>Nunn, CO</td>
<td>Shortgrass steppe</td>
<td>107 (4 to 227)</td>
</tr>
</tbody>
</table>

Svejcar et al. 2008
Livestock grazing: Adaptive management

Outcome-based decision making incorporating monitoring feedback

- Management-science partnerships
- Spatial and temporal movement flexibility of livestock
  - Within and across years
- Adaptation to weather variability
What we know: management controls

- Moderate grazing for livestock production
- Vegetation heterogeneity needed, however
  - Patch burning
  - Adaptive management
  - Grassbanking
- Soil bulk density increases with stocking rate
- Grazing increases soil C compared to non-grazing
- Light to moderate grazing enhances soil C
- Heavy grazing: C gains in wet years and large losses in dry years/seasons
- Improper management could release C stocks
- Adding legumes has large potential for soil health
Management to increase soil C

- **Stimulate C cycling**
  - Aboveground plant litter to soil
- **Stimulate aboveground production**
  - Alter vegetation composition
  - Adding legumes for N
- **Alter above:below ground C allocation**
  - Shift allocation more belowground
Adding a legume

\[ y = 2.668 + 0.396 \text{ (years)} \]
\[ P = 0.0181 \]
\[ r^2 = 0.99 \]

Mortenson et al. 2004
Derner and Schuman 2007
What we know: management x environment

- Soil C dynamics related to precipitation trends
- Soil C dynamics greatest with heavy grazing
- Short-term soil respiration is a good indicator of soil biological activity and nitrogen cycling
- Little known about adaptive management and soil C for application to ranches
- Difficulty with rangeland health in Great Plains, especially grazing resistant systems
  - Protocols developed for arid systems of Intermountain West and desert Southwest (shrub-dominated systems)
What we don’t know

- Soil health research lacking for rangelands
  - Lots of efforts on croplands, but not directly applicable
- Where does the thermometer go?
  - What do we “measure” for soil health?
  - Do we focus on structural, chemical or biological components of soil health?
  - What are the key “tests” for soil health?
- With prior proper management, is there capacity for improving soil health?
- How to correct misinformation that is available
Questions?