Road Map

• Grazingland characteristics
  – Rangeland vs. pastures

• What we know:
  – Environmental controls
  – Management
  – Genetics x Environment x Management (G x E x M)

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

- >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 on rangelands but large land area
- Ecosystem co-benefits
  - Greater soil water holding capacity
  - Improved soil structure
  - Enhanced nutrient cycling
  - Reduced soil erosion
  - Habitat improvements
Rangelands vs. Pastures

- **Rangelands**
  - Native species (mix of C3/C4)
  - Low inputs (if any)
  - Extensive rotational grazing management
  - High degree of spatiotemporal variability in soils, topography, climatic conditions/weather, plant communities, seasonal precipitation distribution

- **Pastures**
  - Improved species
  - Water, fertilizer and chemical inputs
  - Intensive grazing management
  - Capacity for increased soil C due to prior management and inputs
What We Know: Environmental Controls

- 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
## Summary of Different Grazinglands

<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
What We Know: Management Controls

- 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
- 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
What We Know: Genetics x Environment x Management

- Prediction of benefits of soil health difficult due to variability in soils, ecosystems, climate and management across large geographic areas
- 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 rangelands
What We Do Not 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?
Questions?