Soil management during construction and reclamation on Wyoming rangelands

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Reclamation 101 Workshop
Reclamation

► Restoration of key ecological functions;
► Plus stability and resistance to degradation;
► **Ecological functions**: wildlife habitat, water quality & quantity, forage production, others;
► Note that soil quality is not a function!
► But it is the foundation of ecological productivity and resiliency.
Overview

► What is soil? Topsoil?
► Wyoming soils: special issues for reclamation;
► How to protect soil quality:
  ▪ Shield the soil from damage, i.e., oak mats (a great option for level sites, but not covered here);
  ▪ ID, strip, stockpile, and respread topsoil;
► How to mitigate impacts of “protecting” the soil:
  ▪ Soil testing;
  ▪ Seedbed preparation (not covered here);
  ▪ Soil amendments for rangeland reclamation;
What is soil?

The intersection of geology, biology, and climate.
What is topsoil: Depends who’s asking

► Soil scientist: It’s the A horizon marked by:
  - low salt and clay contents relative to subsoils due to eluviation/illuviation;
  - Relatively dark colors and good fertility due to accumulation of soil organic matter.
Reclamationist:
Suitable growth medium:

- Includes surface and upper subsurface;
- Nontoxic with respect to salts & sodium;
- Suitable texture for water infiltration and holding capacity.

Nothing about fertility or organic matter content.
Wyoming soils: Bad dirt?

- Evaporation far exceeds precipitation:
  - Elements released through weathering of soil parent materials accumulate as salts;
  - Soluble components move UP, not down;
- Alkaline pH (>7.0) from abundance of base cations, including CaCO₃
  - Ties up P and some micronutrients;
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  - Ties up P and some micronutrients;
- Low soil organic matter content
  - concentrated very near the surface;
  - Low water and nutrient holding capacity;
- BUT the wetter the site the more forgiving it is!
Protecting soil quality

► Construction footprint is temporary;

► Ideal to avoid disturbance through directional drilling or shielding soil with mats;

► 2nd best: Remove topsoil, store it, and put it back;

► This has major impacts soil quality;

► Proper stripping, stockpiling, and respreading speeds recovery and minimizes negative impacts.
Stripping: ID the topsoil

- Nutrient and moisture properties best for plant germination and growth:
  - Best for the site (not necessarily good);
  - Soil organic matter (by soil test or color): Higher (darker moist colors) than below;
  - Calcium carbonate: lower (less fizz) than below;
  - pH and EC (acidity and salt content): lower than below;
  - Texture: less clay or less sand than below.
Ideal topsoil stripping in Wyoming would usually be two to three inches;

Very difficult: six inches is typically the minimum for the equipment used;

Results in dilution of organic matter and increased salts, pH, and clay (or sometimes sand): inevitable loss of soil quality;

Research suggests 30 percent loss of SOM due to mixing is typical.
## WY DEQ Suitable Topsoil Guidelines

<table>
<thead>
<tr>
<th>Parameter and method</th>
<th>Suitable</th>
<th>Marginal</th>
<th>Unsuitable</th>
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<tbody>
<tr>
<td>pH (acidity or alkalinity)</td>
<td>5.5-8.5</td>
<td>5.0-5.5</td>
<td>&lt;5.0</td>
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<tr>
<td></td>
<td>8.5-9.0</td>
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<td>&gt; 9.0</td>
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<td>EC (mmhos/cm)</td>
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<td>8-12</td>
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<td>Lab value:</td>
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<td>Field meter value:</td>
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<td>1.6-2.0</td>
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<td>Texture by feel</td>
<td>Loams</td>
<td>clay, silty clay, sand</td>
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<tr>
<td></td>
<td>&lt; 40% clay,</td>
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<td></td>
<td>&gt; 90% sand or silt</td>
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<td>Gravel (&gt;2mm)(% vol)</td>
<td>&lt;25%</td>
<td>25-35%</td>
<td>&gt;35%</td>
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<td>Sodium ion activity (Sodium Adsorption Ratio)(Lab analysis)</td>
<td>0-10</td>
<td>10-12, clay soils</td>
<td>&gt;12</td>
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<tr>
<td></td>
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<td>10-15, other soils</td>
<td>&gt;15</td>
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</tbody>
</table>

**Stockpiling**

- **Organic matter losses:**
  - Undisturbed Wyoming rangeland soils have ~1% organic matter
    - plant inputs;
    - regulated decomposition in soil peds;
  - Handling breaks down structure and stimulates decomposition;
  - Elimination of plants eliminates surface and root inputs;
  - Common sense: low, vegetated piles;
  - **Reality:** increasing the footprint defeats the purpose.
  - Current recommendation: Pile < 15 feet and plant fast-growing native cover (e.g., slender wheatgrass, bee plant).
  - Ongoing research may modify these recommendations.
Stockpiling

- Time: likely some degradation with age, but no consistent effect has been reported;
- In one study, direct haul lost more SOM than topsoil stockpiled for 20 years;
- Suggests that time effects are difficult to study and are probably overshadowed by disturbance and mixing effects;
- Research on disturbance suggests at least 20 percent loss due to decomposition.
~50% reduction in SOM; 20 from mineralization and 30 from mixing.
Soil amendments

► Goal is to recover site structure, functions, and values following development activities;

► Goal is not to *change* site potential but restore it;
   - Remediation: restoring soil attributes lost during stripping, stockpiling, spreading, and cultivating;
   - Enhancement: facilitating germination and establishment of native plants.

► Benefits diminish with increasing moisture: weeds become major issue;

► More research is needed
Soil amendments: Determining needs

- **Soil sampling**: take ~ 20 samples from depth of undisturbed A horizon (usually 2-3 inches):
  - All around the pad after topsoil is respread and soon before seedbed prep;
  - From a matched undisturbed area;

- Mix samples from each area in bucket and place a subsample in a carefully labeled 1-gallon ziplock bag;

- Soil labs usually require at least a month;
► Routine test: $20
  ▪ Includes N, P, SOM, salts, pH, lime, texture;
► K, Fe, Zn: $4.00 each
► Actual data is more important than fertilizer recommendation;
► For accurate recommendation must provide yield from clipping or ESD.
Determining needs

- Goal: promote germination and establishment;

- Amending to recover original surface soil properties should be best approach:
  - Compare to levels of SOM and salts in sample from undisturbed area;
  - Amend with organic materials to recover surface SOM content;
  - Amend with S or gypsum to remediate increased surface sodium contents;
  - Fertilizers and other amendments should not be necessary and will promote weeds.
Organic materials

1% SOM = \( \sim 5 \) tons per acre, top 3 inches;

- About 2.5 tons needed if 50% lost;

Manure: one 4-yard spreader full per acre;

Composted is better because of lower salt, weed seed, and nutrient content:

- Make sure C:N ratio is about 20 or less;
- Fresh saw dust or wood chips have C:N ratio > 200 and may reduce seeding success;
- Know the source to avoid weeds.
Saline-sodic soils

- Plants on saline sites are adapted, but disturbance can increase surface concentrations to toxic levels.
Remediating high salt content

► Reducing salts and sodium is very difficult - careful stripping is critical;

► Goal is to match original content:
  ▪ Agronomic perspective is detrimental and will promote weeds;

► For high salts, addition of low-salt organic materials is the only way to reduce;

► For high exchangeable sodium:
  ▪ About 50 lbs elemental S per acre-inch of soil to reduce 1 meq Na/100 g soil;
  ▪ Gypsum not as effective on calcareous soil common in Wyoming;
  ▪ Units: talk with soil testing lab, or see salt-affected soil pub on my website: http://uwyo.edu/soilFert
Fertilizer recommendation approach

► Many soil labs return results with a fertilizer recommendation: use with care!

► Must know accurate “yield goal” or site production:
   - From ecological site descriptions;

► University of Wyoming Soil testing lab recommends 40 lbs N per ton of grass, minus residual N in soil and from SOM (20 lbs per 1%).

► Organic material is still best source of nutrients for reclamation:
   - Time release instead of excess nutrient
   - Beef manure: about 12 lbs N per ton with 25% available 1st year;
   - Compost: about half that.
Conclusions

► Low rainfall causes low SOM concentrated very near surface, plus high salt content;

► Strip to depth of topsoil: highest OM, lowest pH, EC, and (usually) clay – less than 6 inches;

► Stockpile less than 15 feet and vegetate;

► Remediate inevitable SOM losses and pH/EC increases, but only to recover site potential, not improve it;

► Concentrate on top 3 inches: 1 spreader load per acre typically replaces 50 percent loss of SOM.