Soil management during construction and reclamation on Wyoming rangelands

Jay Norton, Soil Fertility Specialist
University of Wyoming
jnorton4@uwyo.edu

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.

Final Soil Salvage Plan

Soil Depth Recommended For Salvage in Sections A, B, C and D. Depth Increment Evaluated = 0-18 inches
Soil Family: Coarse-loamy, mixed, superactive, frigid Ustic Haplargid

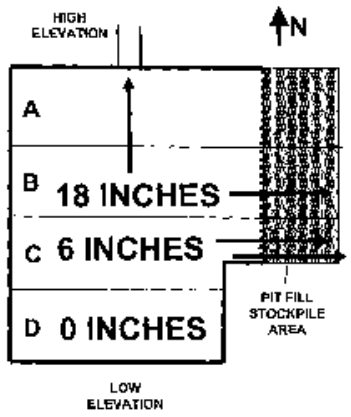
Estimated Excess Suitable Soil = 1285 yd³

Section A. Salinity (0.60-0.74 dS/m) and sodicity (SAR 0.41-0.43) were low. Soil pH was suitable (7.0-7.3). Soil textural classes and saturation % (24.6-30.0 %) were acceptable. The $CaCO_3$ content was suitable (0.9-1.5 %).

Section B. Salinity (0.45-0.67 dS/m) and sodicity (SAR 0.30-0.97) were low. Soil pH was suitable (7.0-7.4). Soil textural classes and saturation % (27.5-28.8 %) were acceptable. The $CaCO_3$ content was suitable (0.9-3.1 %).

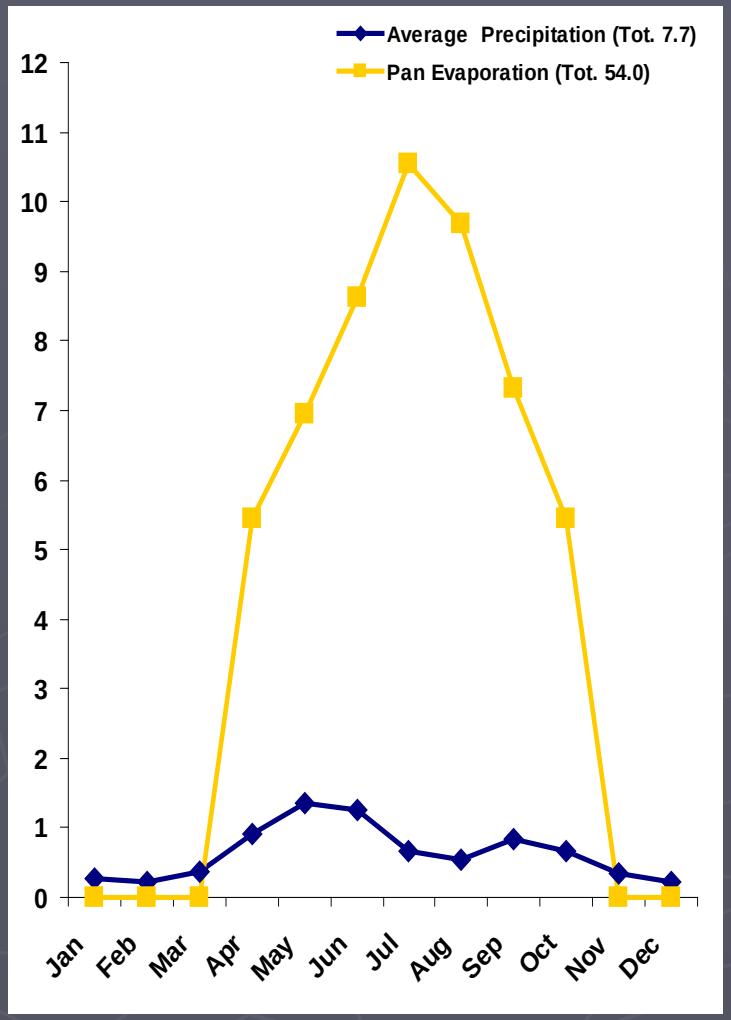
Section C. Salinity (0.50-0.98 dS/m) and sodicity (SAR 2.6-5.0) were low. Soil pH was suitable (7.4-7.8). Soil textural classes and saturation % (34.6-37.7 %) were suitable. The $CaCO_3$ content was low (2.6 %) in the 0-6 inch increment and elevated (5.3-10.4 %) in the 6-18 inch increment.

Section D. Salinity (0.45-0.92 dS/m) and sodicity (SAR 0.93-2.10) were low. Soil pH was suitable (7.6-7.0). Soil textural classes and saturation % (32.8-36.0 %) were suitable. The $CaCO_3$ content was high (10.0-13.6 %)



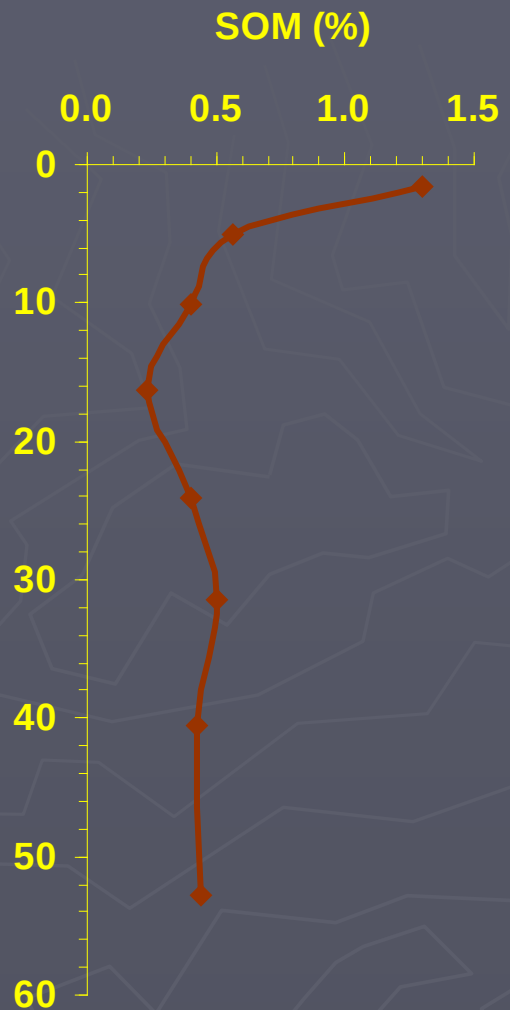
Wyoming soils: Bad dirt?

- 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 $CaCO_3$
  - Ties up P and some micronutrients;



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 $CaCO_3$
  - 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!



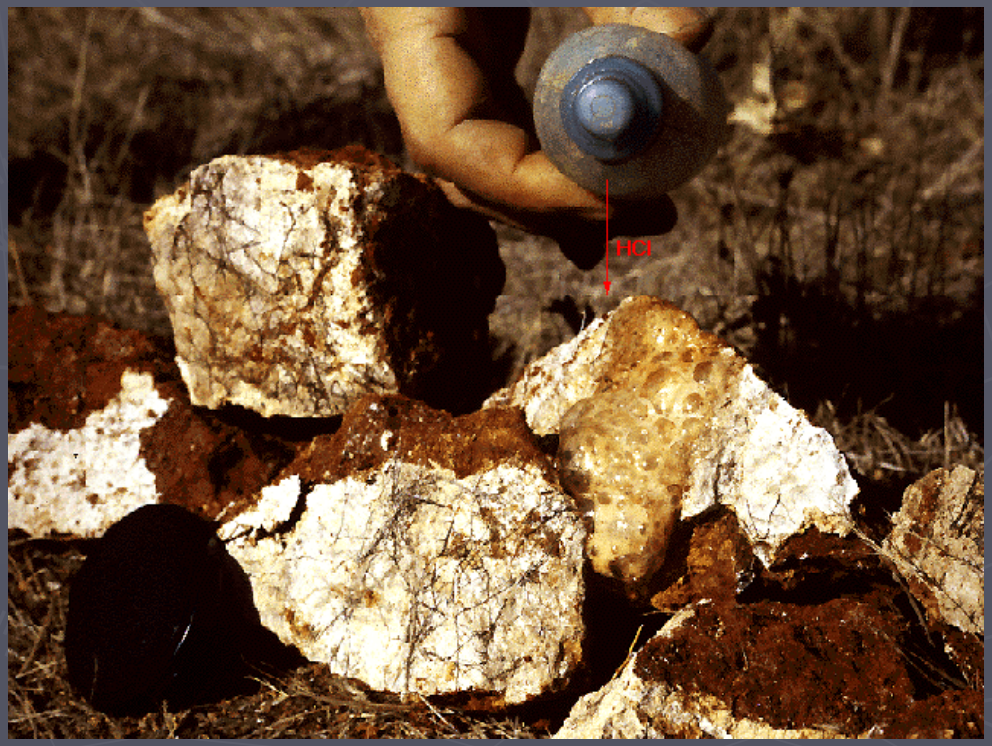
Protecting soil quality

- 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.


VALUE
CHROMA


HCl

- 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

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

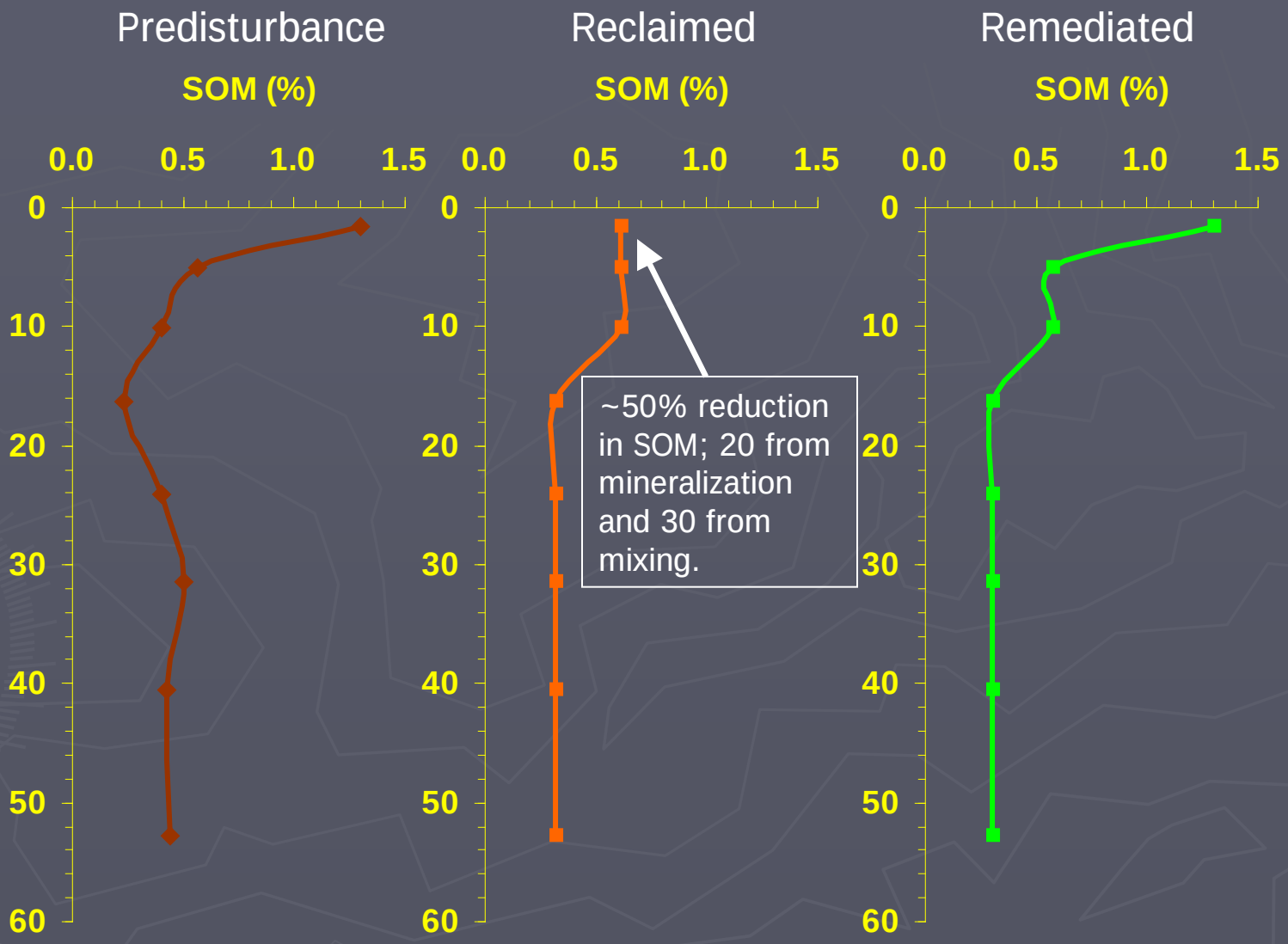
http://deq.state.wy.us/lqd/guidelns/guide1.pdf

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**.


Predisturbance
Reclaimed
Remediated
SOM (%)
SOM (%)
SOM (%)
0.0
0.5
1.0
1.5
0.0
0.5
1.0
1.5
0.0
0.5
1.0
1.5
0
10
20
30
40
50
60
0
10
20
30
40
50
60
0
10
20
30
40
50
60
~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;

Soil Sample Questionnaire – Field Crops

Date _____

Sample No. _____ Field Identification _____ Field Size _____ acres

A completed questionnaire must accompany each sample. Retain a duplicate copy for your records. Number the samples and questionnaires for your own identification. Directions for obtaining soil samples are on the next page.

Name _____ Address _____

City _____ Zip _____ Community _____

(If known) Range _____ Township _____ Section _____

Plant Life

1. Quality of recent plant life:

   Growth - uniform _____ uneven _____

   Color - deep green _____ light green _____ yellow _____ other _____

   Density - thick _____ medium _____ sparse _____

2. Field history and plans:

	Crop	Fertilizer used (available lbs./A.)				Tons/A Manure	Approximate yield/acre
		Nitrogen	Phosphorus	Potassium	Other		
Next year							
This year							
Last year							
2 yrs. ago							

3. If hay meadow or pasture: native ____ seeded grasses _____ legumes _____

   grass-legume mixture _____ If mixture, approximate grass _____% and legume ___%

Soil

4. Observable deposits: none _____ white specks _____ white, barren, crusty _____

5. Topsoil depth: _____ inches.

6. Subsoil: (if known) sand ____ gravel _____ clay _____ hardpan _____ lime _____ solid rock _____

7. Water penetration: rapid _____ moderate _____ slow _____ waterlogged _____

8. Field last heavy-leveled: never _____ date _____

Water

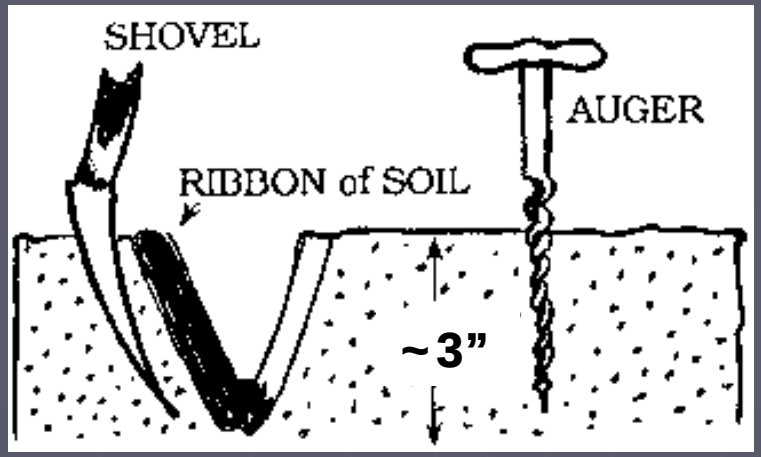
9. Method of irrigation: none _____ surface _____ sprinkler _____

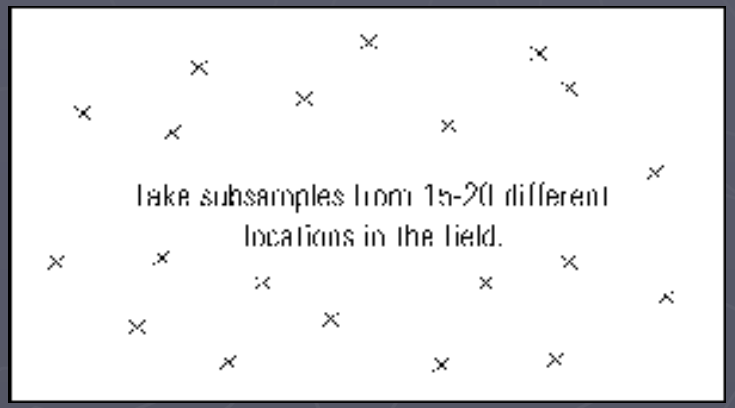
10. Water applications: number per season _____ hours per set _____ length of run _____ feet

11. Average duration of irrigation season: _____ days.

12. Water sources: well _____ reservoir _____ creek or river _____ canal project _____

    Name of creek, river, reservoir, or canal project _____





- 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

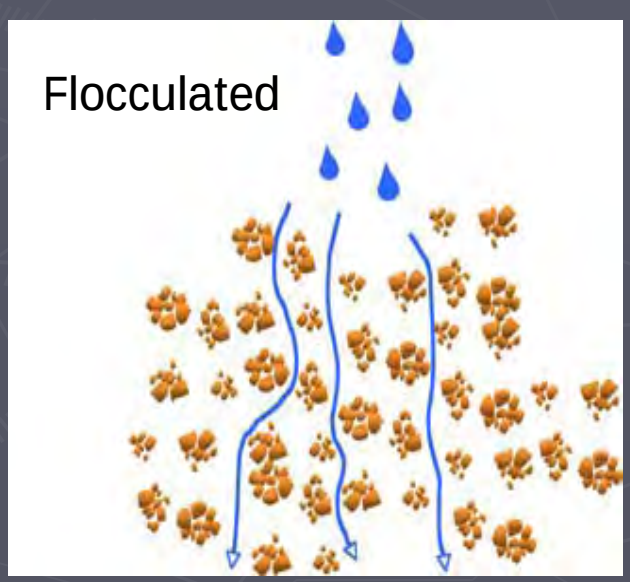
- Goal: promote germination and establishment;
- Amending to recover original surface soil properties should be best approach:
  - Compare to levels of SOM and salts in sample from undisturbed area;
  - Amend with organic materials to recover surface SOM content;
  - Amend with S or gypsum to remediate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

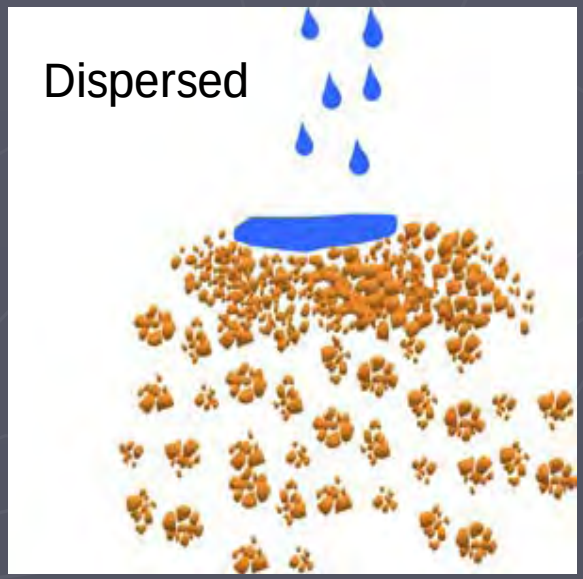
Organic materials

- 1% SOM = ~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.