Recovery of soil function after drastic disturbance: **Building an “A” horizon**

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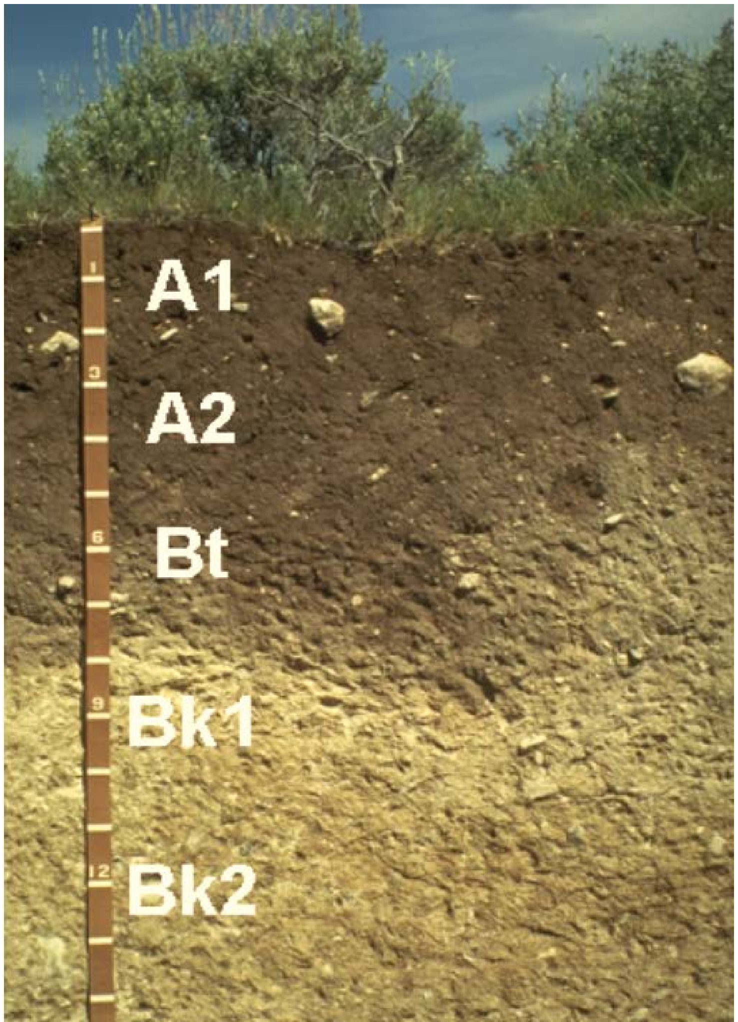
Soil survey resources

- Web soil survey
- Soilweb
  - Smartphone app
  - Google layer
  - Internet:

  - http://casoilresource.lawr.ucdavis.edu/soilweb-apps

Earth's living skin

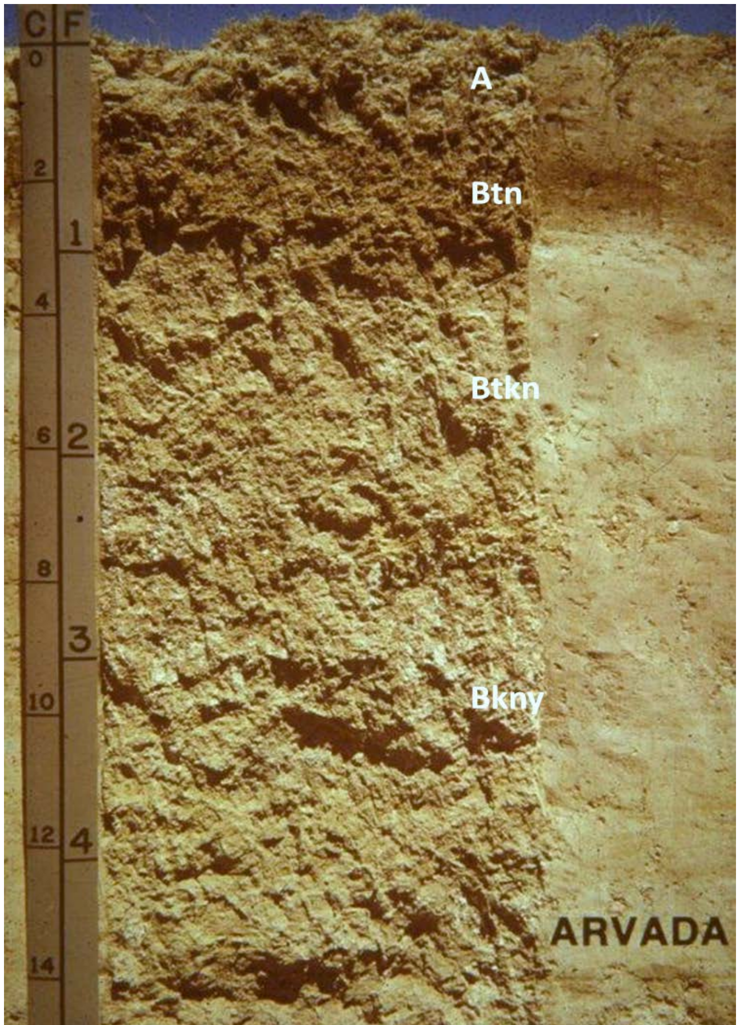


Performs functions crucial to life

- **Nutrient Cycling** - Soil stores, moderates the release of, and cycles nutrients and other elements. During these biogeochemical processes, analogous to the water cycle, nutrients can be transformed into plant available forms, held in the soil, or even lost to air or water.
- **Water Relations** - Soil regulates the drainage, flow and storage of water and solutes, which includes nitrogen, phosphorus, pesticides, and other nutrients and compounds dissolved in the water. With proper functioning, soil partitions water for groundwater recharge and for use by plants and soil animals.
- **Biodiversity and Habitat** - Soil supports the growth of a variety of plants, animals, and soil microorganisms, usually by providing a diverse physical, chemical, and biological habitat.
- **Filtering and Buffering** - Soil acts as a filter to protect the quality of water, air, and other resources. Toxic compounds or excess nutrients can be degraded or otherwise made unavailable to plants and animals.
- **Physical Stability and Support** - Soil has the ability to maintain its porous **structure** to allow passage of air and water, withstand erosive forces, and provide a medium for plant roots. Soils also provide anchoring support for human structures and protect archeological treasures.

See: http://soilquality.org/functions.html NRCS and others

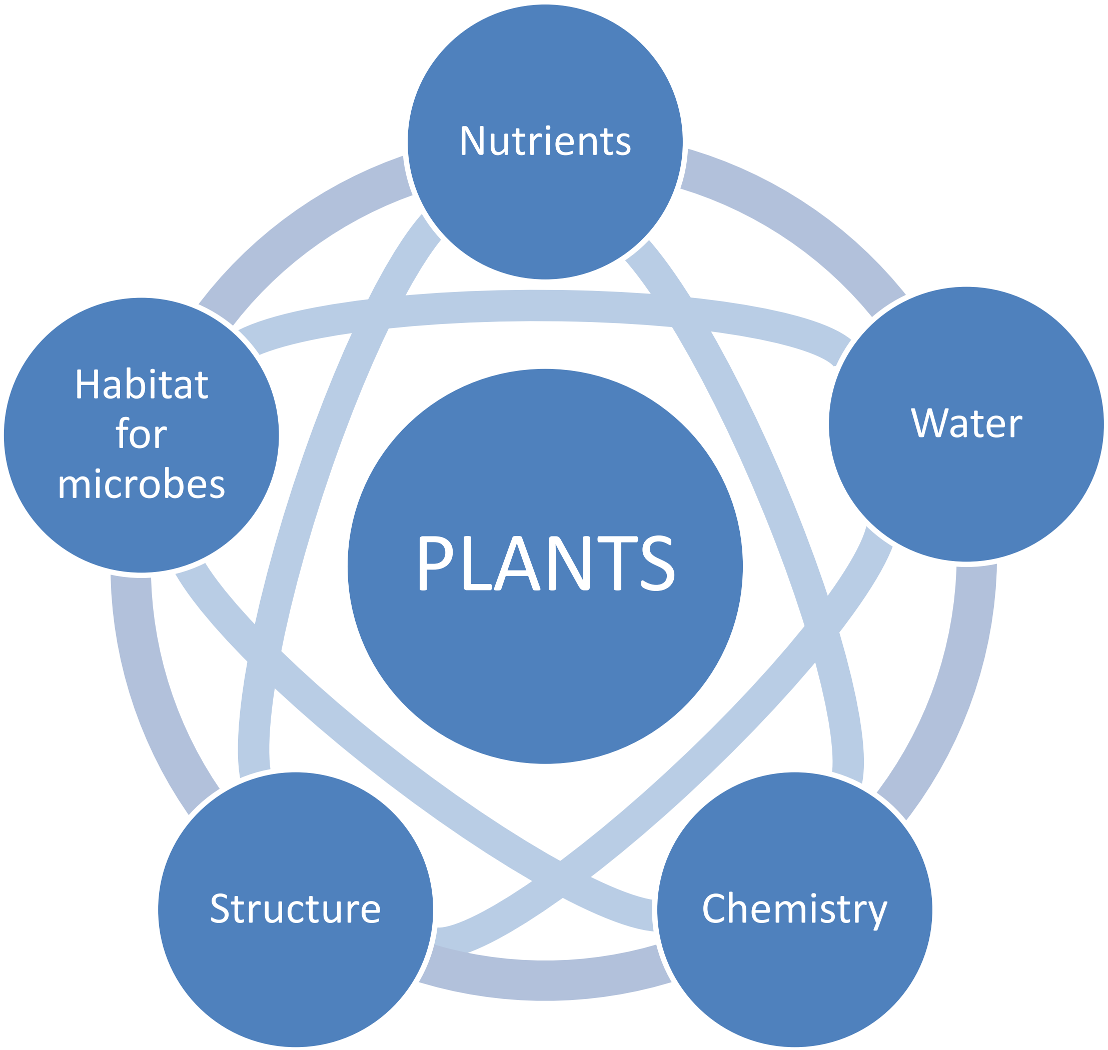
Wyoming is thin-skinned



Thin surface soils support self-sustaining native plant communities

- **Nutrients**: microbe-mediated cycling;
- **Water**: must absorb & hold for adequate length of time;
- **Habitat** for microbes: facilitate nutrient cycling;
- **Chemistry**: salinity, sodicity, & pH supportive of seedlings and microbial activity;
- **Structure**: prevents crusting, provides habitat, holds moisture.

Interconnected



Soil formation

CL O R P T H

CLIMATE

Temperature speeds up or slows down chemical reactions that break down, or weather, rocks and minerals. In areas of high rainfall, more water drains downward, leaching minerals through soil layers.

ORGANISMS

Burrowing animals, growing plant roots, and enzyme-secreting bacteria and fungi chemically alter and physically mix soils.

RELIEF

Topography—the slope and the direction a landscape faces—influences sunlight hours, temperature, water runoff, erosion, and organic matter build-up.

PARENT MATERIAL

The chemical composition of original unweathered rock influences the mineral content of soil. Parent materials can be the underlying bedrock, but most are sediments-sand, silt, or clay carried in from elsewhere by wind or water.

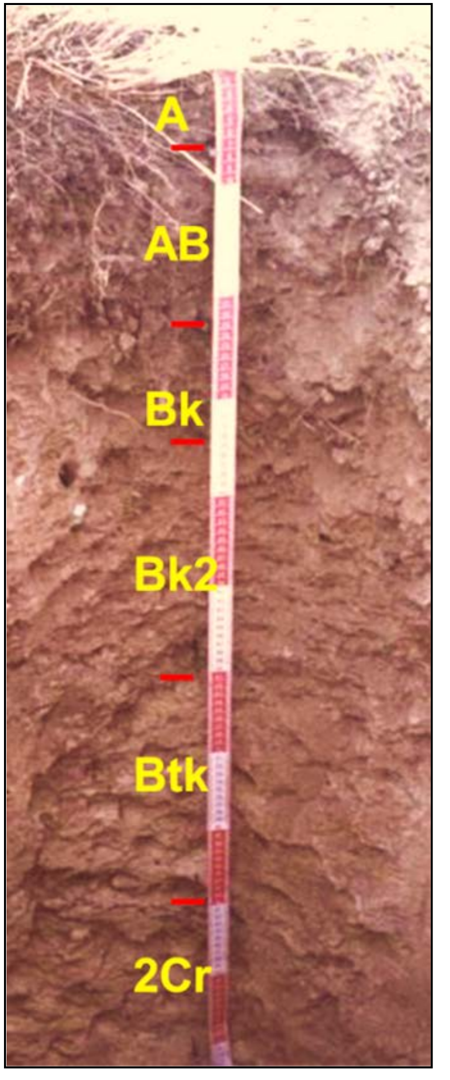
TIME

Weathering partly depends on age: older soils are more weathered than younger ones. Soils in the tropics tend to be old because they have not been affected by the remixing effects of glaciation.

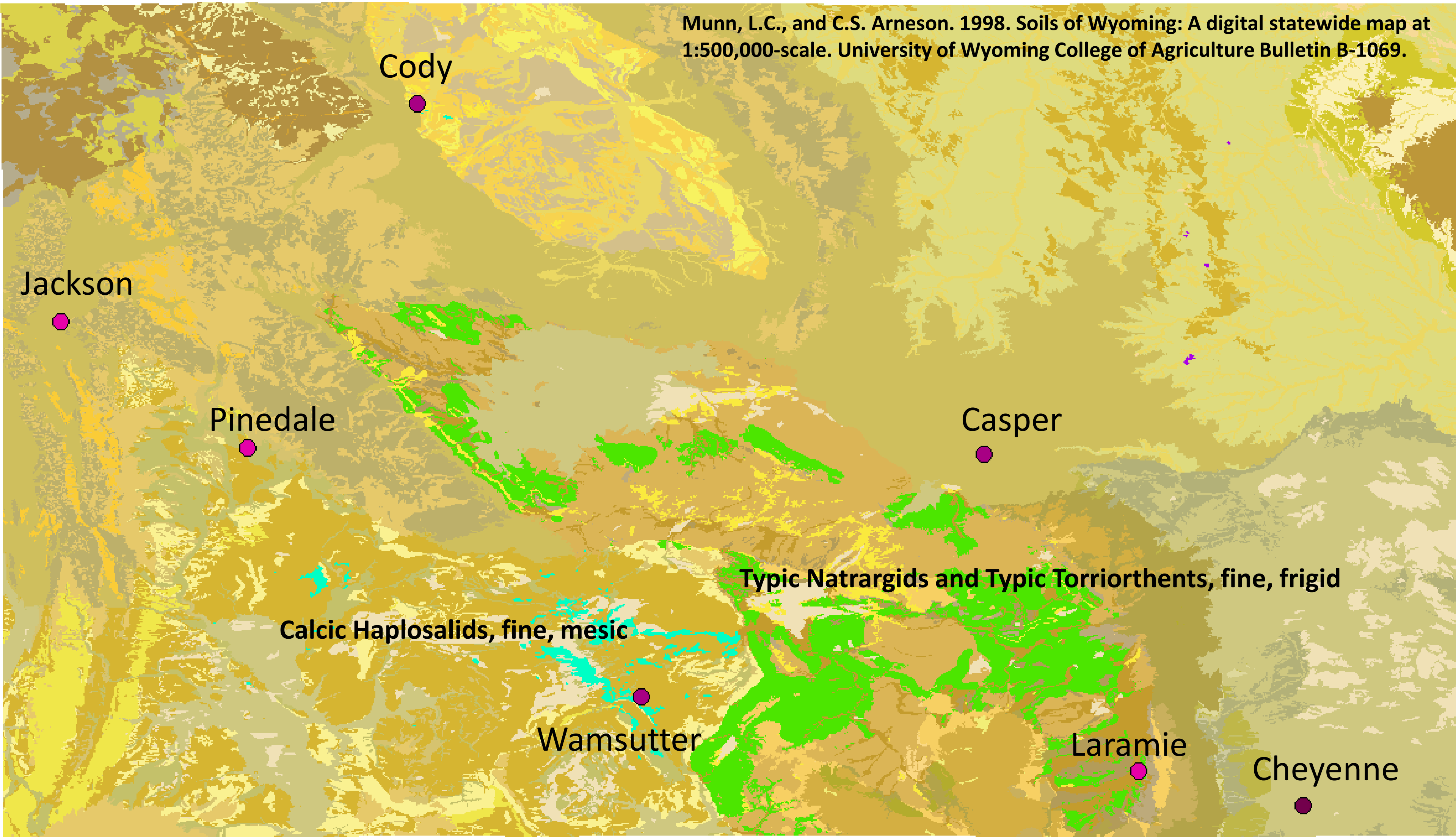
- Expression of LONG-term equilibrium with the environment;
- Resulting SOIL has horizons that support functions;
- Reclamation erases the influence of TIME

How do horizons/morphology perform functions?

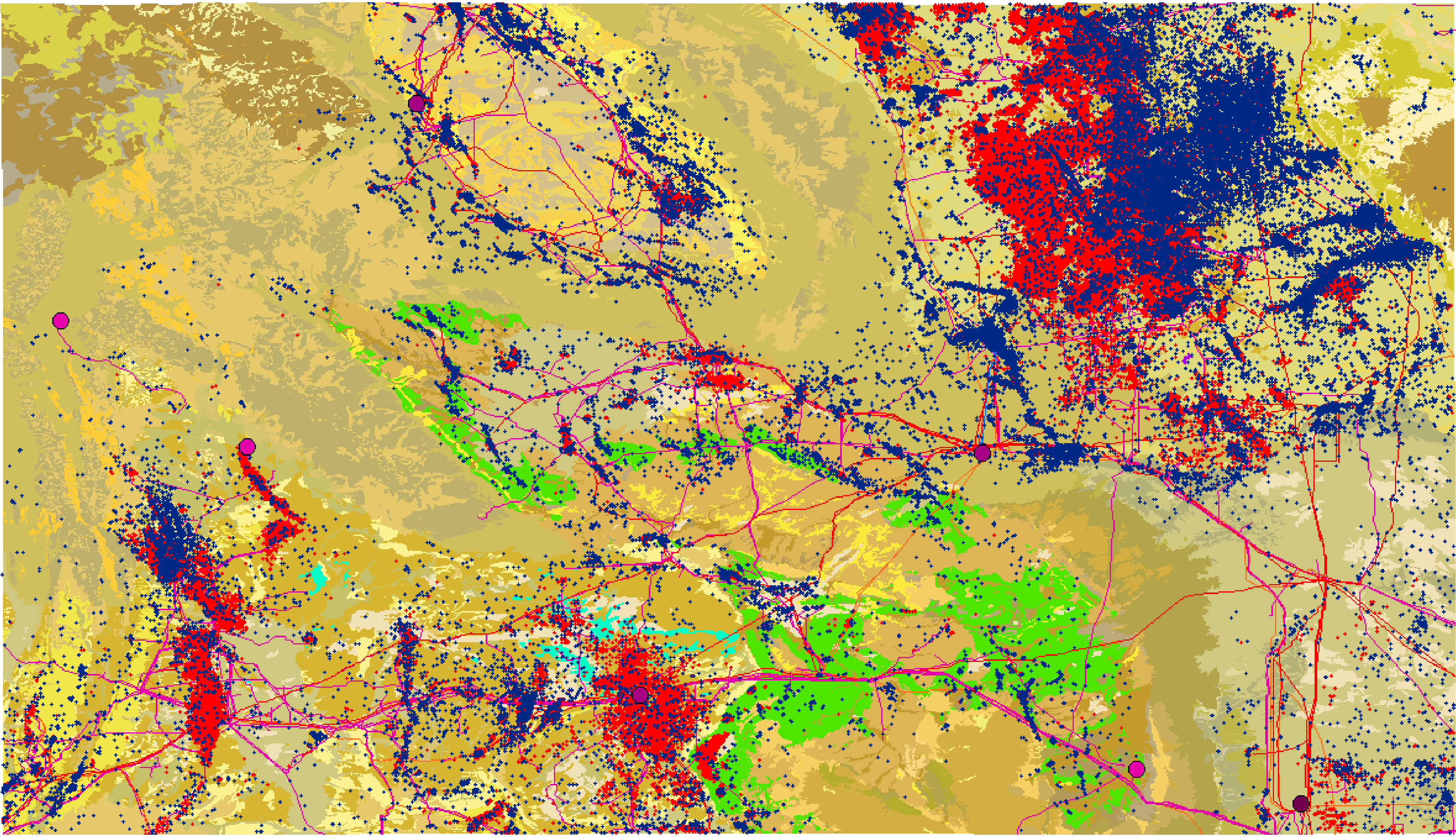
- A horizon: interface with atmosphere:
  - OM accumulation and ELUVIATION;
  - loss of clays, solutes;
  - More OM, coarser texture, lower EC & pH than other horizons;
  - Water infiltration & holding; nutrient cycling (microbes)
  - **Germination/establishment**;
- B horizon: zone of accumulation of clays and solutes: ILLUVIATION
  - Less OM, coarser texture, higher EC & pH
  - Water holding in finer texture



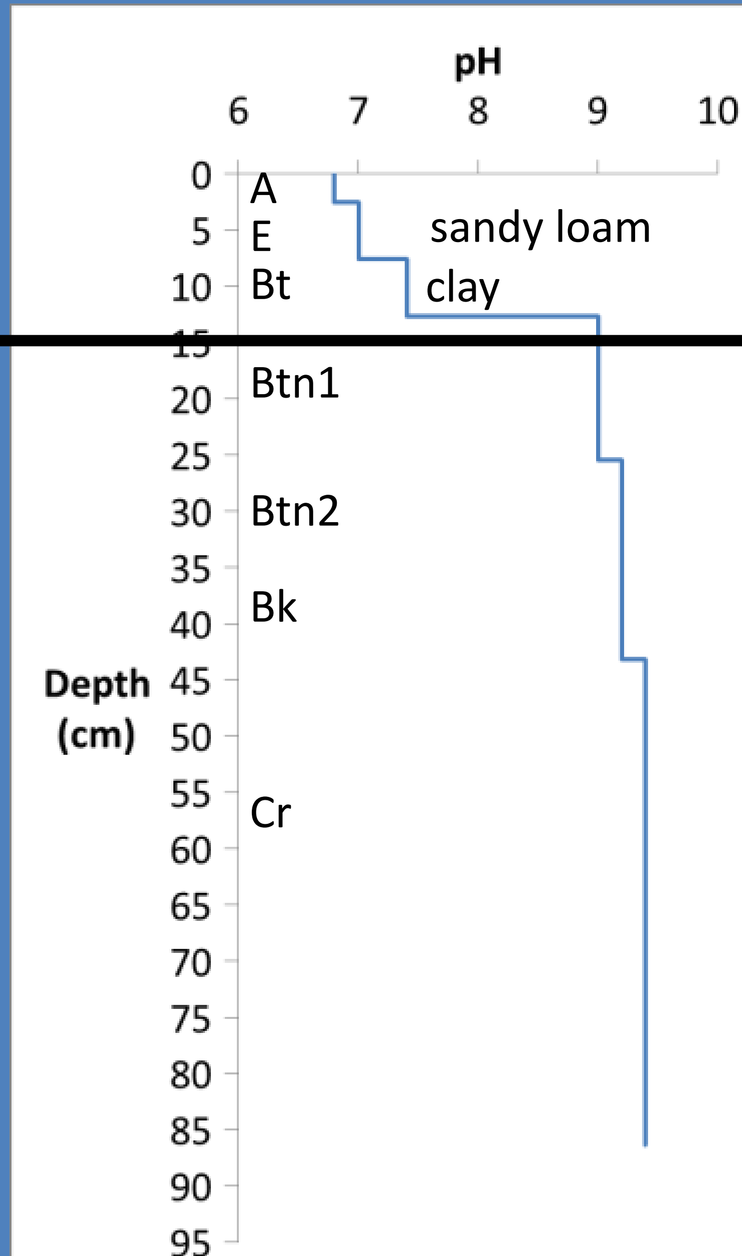
Wyoming Soils

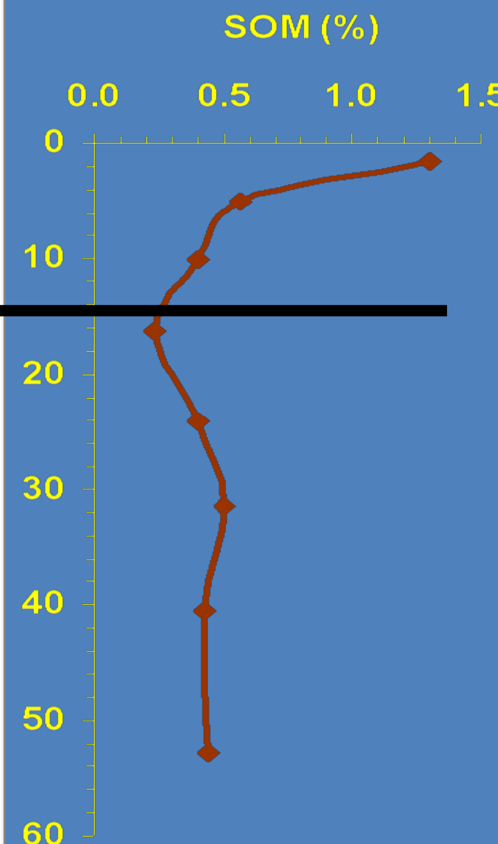


Pipelines + P&A + Active wells

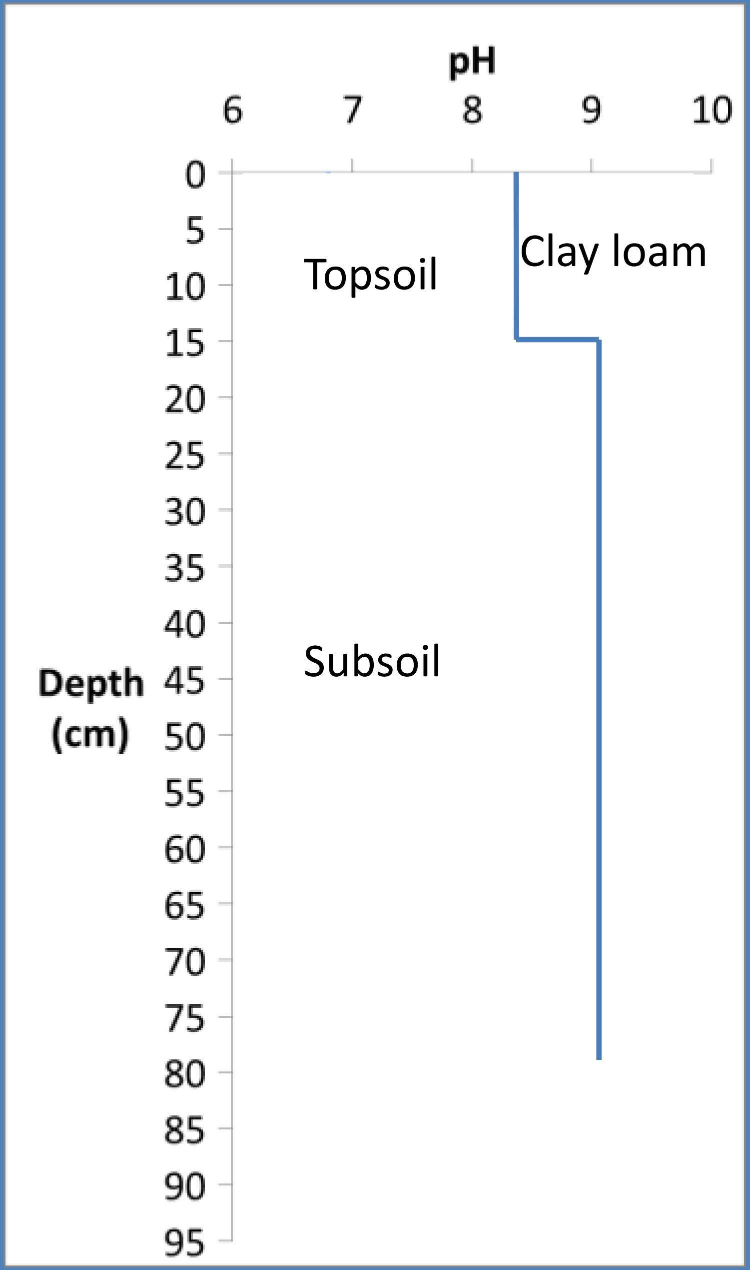


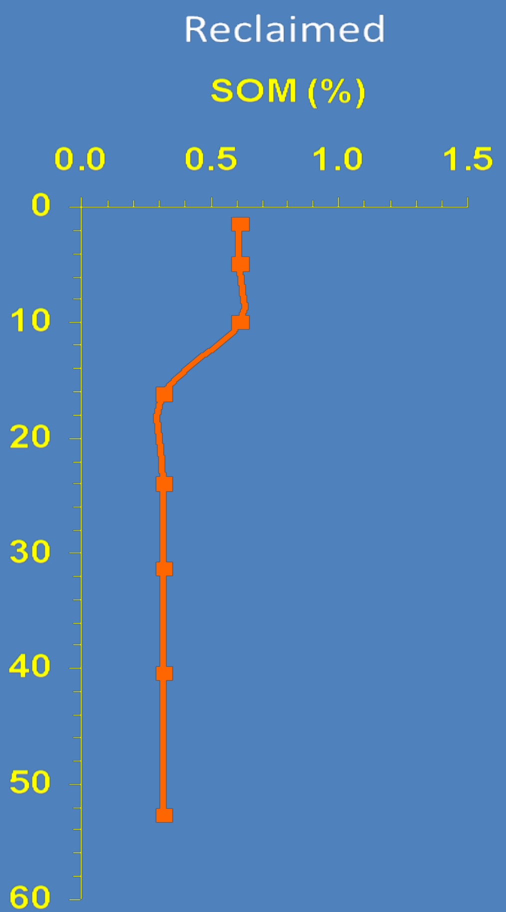
ABSTON FINE, SMECTITIC, FRIGID USTIC NATRARGIDS





ENTISOL


pH
6
7
8
9
10
Depth (cm)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
Topsoil
Clay loam
Subsoil


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

Loss of A horizon reduces already slim chances for germination & establishment

- Lifeless: little SOM to support microbial activity and nutrient cycling;
- Finer: inhibits water infiltration and facilitates evaporation;
- Drier: less OM and fine texture decrease plant-available water;
- Saline: EC > 4; osmotic potential and ion toxicity slow germination;
- Sodic: ESP > 15 disperses aggregates, exacerbating the above.

Rebuilding an A horizon: SOM

- Compost:
  - ~50% SOM;
  - 3 inches of soil = ~1,000,000 pounds;
  - To increase SOM by 1% = 10,000 pounds of SOM;
  - 10,000 lbs SOM ~ 20,000 pounds, or 10 tons of compost;
  - **3 1/3 tons per inch of soil per 1 % SOM increase**

Texture: Soil moisture

- Clayey soils have small pores that accept water very slowly;
- Sodium disperses clay, destroying aggregates and further reducing pore size;
- Small pores facilitate **capillary rise** that carries moisture and solutes (salts) to the surface:
  - Moisture evaporates and soluble salts are deposited;
  - Height of rise is inversely proportional to pore size;
  - improving soil structure

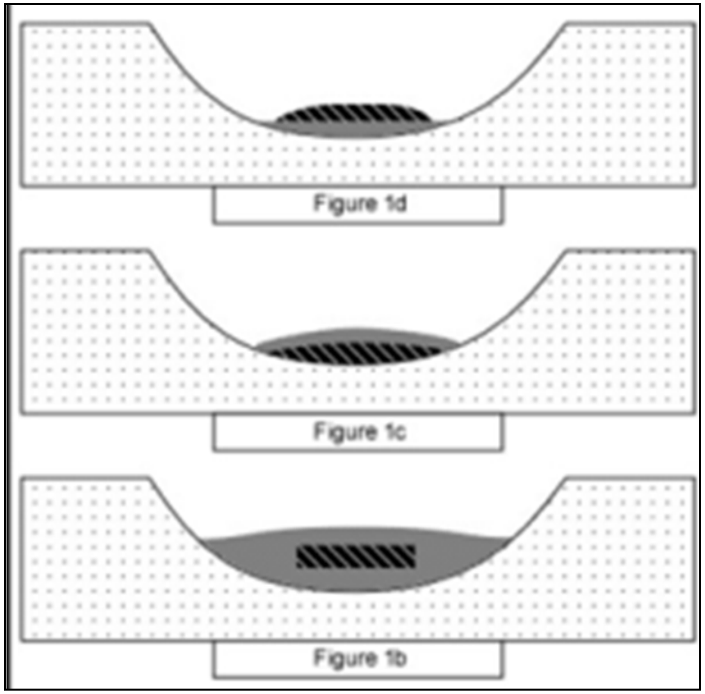
Salinity & sodicity

- Germination even of halophytes is slowed, but:
  - Germination is high when EC is reduced during moist periods.

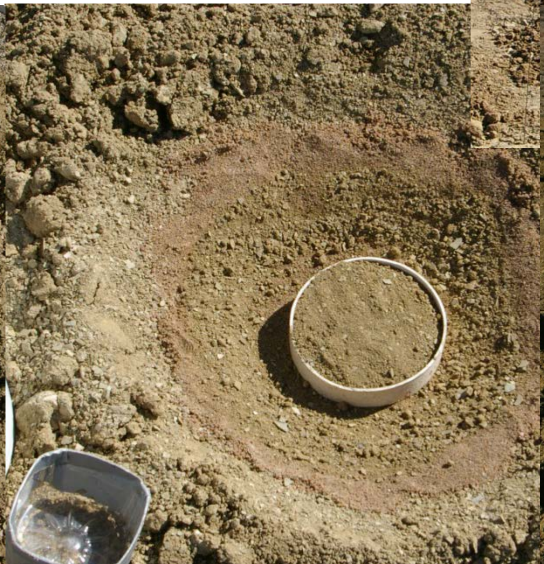
Physical approaches

- Adding SOM can:
  - "dilute" salinity;
  - Improve water infiltration to move salts downward.
- Mulches reduce evaporation and capillary pull toward surface;
- Sand mulch may be most permanent capillary barrier.
- Capilliary barrier below the seedbed prevents salts from moving to surface.

- Evaluation of sand mulch and caplillary barrier (Seth Cude)



Creating Reclamation Pies

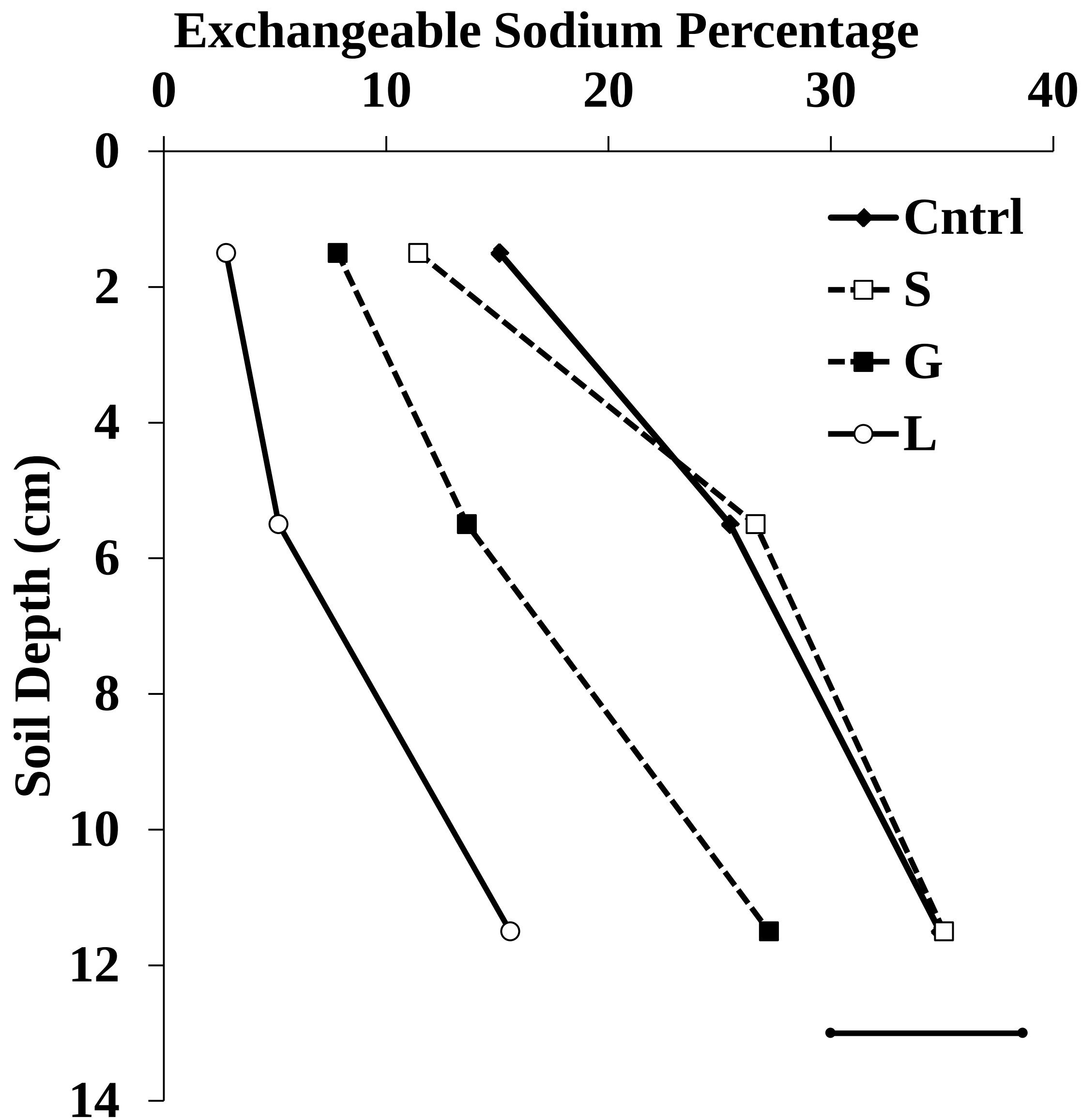


Sand mulch with and without capillary barrier drastically improved germination.

Salinity & sodicity

- Chemical approaches:
  - Displace sodium with Ca, Mg, K to flocculate soil particles
  - In experiment at Wamsutter, Langbeinite (Mg, K – SO_4) and gypsum (CaSO4) mobilized sodium and improved soil structure (Samantha Day);
  - Langbeinite was more effective: more soluble than gypsum under low moisture conditions;
  - BUT salinity and osmotic potential increased greatly;
  - Possible that improved structure/infiltration will facilitate lower salinity during moist periods.
  - Also tested elemental S but no effect so far.

- One year after amendment application;
- Initial ESP was 38.6;
- All trts moved sodium;
- L and G most effective:
- 2013: high rainfall year.



S = sulfur; G = gypsum; L = langbeinite

Salinity & sodicity

- Leaching with irrigation water :
  - Salinity (EC > 4)

$$\text{Leaching Requirement} = \frac{ECiw}{5(ECse) - ECiw}$$

Gives % water needed over saturation

ECiw = EC of irrigation water

ECse = target EC (e.g., 4)

- It generally takes ~ ½” of water to saturate one inch of soil;

Example:

If EC of water = 1.5 and EC 4 is the target for the top 2 inches:

$$\frac{1.5}{5(4) - 1.5} = 1.5/18.5 = 0.08$$, or 8% more than saturation

To leach top 2 inches of soil:

- 1 inch of water needed to saturate;
- 1.1” needed to leach salts to 2 inches.

One acre inch = 27,154 gallons

- BUT if we have also lost SOM, destroyed the structure, and created a clayey surface, then salts will rapidly wick back to the surface;
- May be most effective in combination with amendment of compost and langbeinite.

Conclusion

The A horizon is very thin on many Wyoming soils but long-term weathering, leaching, and organic matter accumulation make it crucial to self-sustaining desert plant communities.

Since salvaging soil at 2 to 5 cm depths is not feasible, remediation of the thin A horizon is needed to facilitate germination & establishment.