EFFECTS OF SOIL DISTURBANCE AND PACKED-BOX AMENDMENT STUDY ON SODIUM-AFFECTED SOILS RECLAIMED IN WAMSUTTER, WY

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School of Energy Resources

Wyoming Reclamation and Restoration Center

AGENDA

1. **Effects of disturbance** on naturally salty soils
2. **Packed-box study** on saline-sodic soil with amendments

http://billingsgazette.com/news/state-and-regional/wyoming/major-wyoming-natural-gas-project-brings-both-jobs-and-concerns/article_293419e3-cd89-5d44-9937-1a40936db940.html

INTRODUCTION: EFFECTS OF DISTURBANCE

- Wamsutter, WY holds one of the largest onshore tight natural gas fields in the nation
- Heading towards "reclamation phase" in many areas of the development after a boom in early 2000's
- Other land uses mainly wildlife habitat and grazing
- Goal in reclamation is to reestablish plant communities comparable to adjacent native plant communities

INTRODUCTION

- Well pad formation and reclamation entails:
  - Deep soil excavation to create a level platform (15-30+ cm)
  - Stockpiling soil, separating topsoil (suitable growth medium) from subsoil
  - After well production ceases (1-5 yrs for most modern wells), replacing stockpiled soil to a depth of at least 15 cm.
  - Tilling and seeding replaced soil with a native seed mix, usually in the Fall

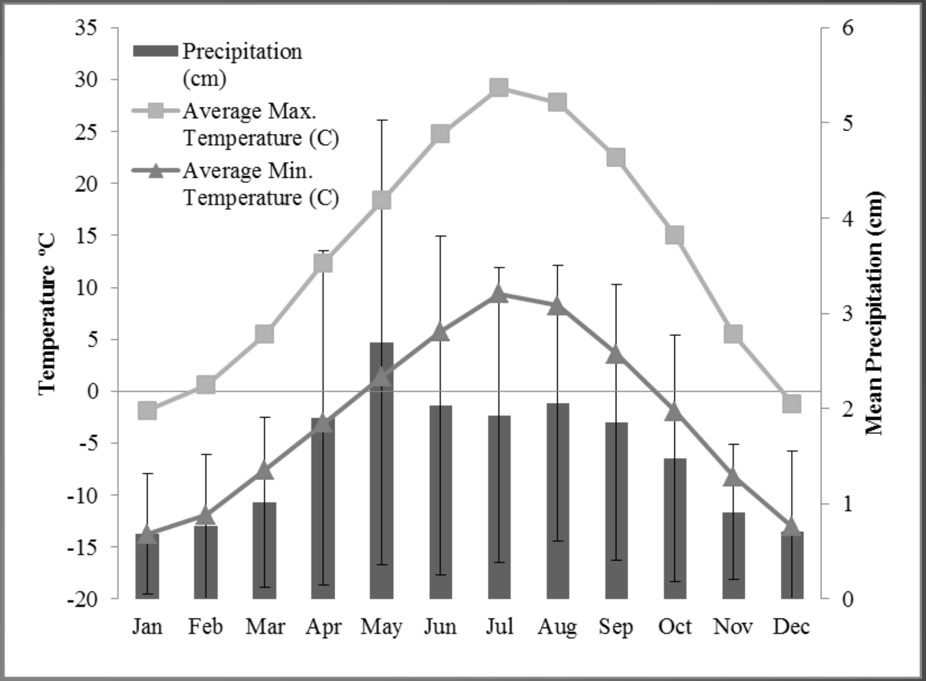
OBJECTIVES

To **quantify** and describe how the typical **disturbance** and reclamation of arid soils for natural gas extraction **affects soil salinity, sodicity, aggregate distributions**, and basic soil **organic matter** properties controlling reclamation success and **native plant reestablishment**.

SITE DESCRIPTION

The "Red Desert"

- Total average precipitation (rain & snow): 18cm and highly variable
- Average topsoil depth of 3cm
- Ancient lake bed and alluvial soils create red color and high clay content (smectitic)
- Soils are naturally salty due to cold-desert climate (high Ca and/or Na)
  - pH ranges from 8 to 9
- Many well pads exhibit saline conditions after reclamation, some sodic and saline-sodic conditions.
  - Saline soils are more common but sodic soils are more difficult to reclaim because of structural losses



SITE DESCRIPTION

- Native vegetation in the Red Desert area of the Wamsutter gas fields: mostly gardener's saltbush shrub-scrub community with grasses such as bottlebrush squirreltail and thickspike, and forbs such as evening primrose and desert parsley.
- Two well pads being reclaimed in 2012 in the Red Desert were chosen for the study based on Na-issues: one SALINE-SODIC, one SODIC

MATERIALS & METHODS

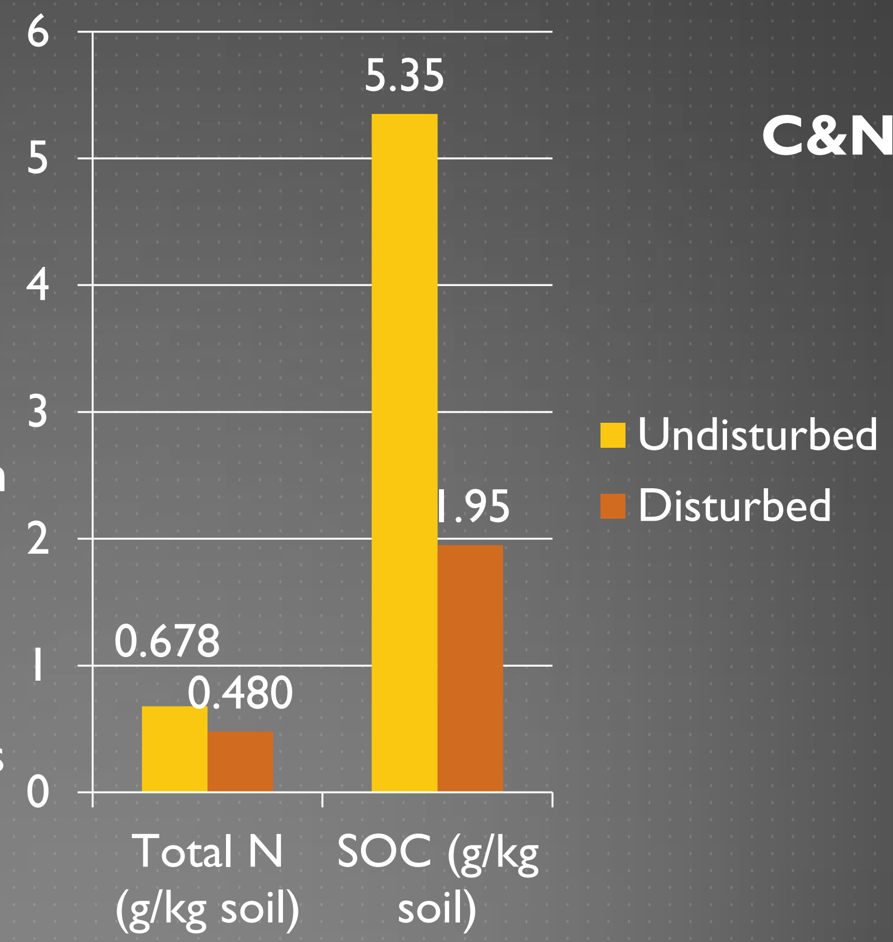
- Soil on both sites was sampled in 4 locations (each sample =3 composited soil cores) in both "disturbed" and "undisturbed"
  - n=4 for all analyses
- Analyzed at UW for:
  - Particle Size, Dry aggregate distribution, Water-stable aggregate distribution
  - %CaCO3, CEC, Exchangeable Sodium %, EC
  - SOC, Total N, DOC & DON
- 2-group t-test to compare "disturbed" to "undisturbed"
  - For variables with **no significant site effect**, data was averaged for overall disturbed and undisturbed values for both sites
  - For variables in which there was a **significant site effect**, data is reported separately for both sites

RESULTS

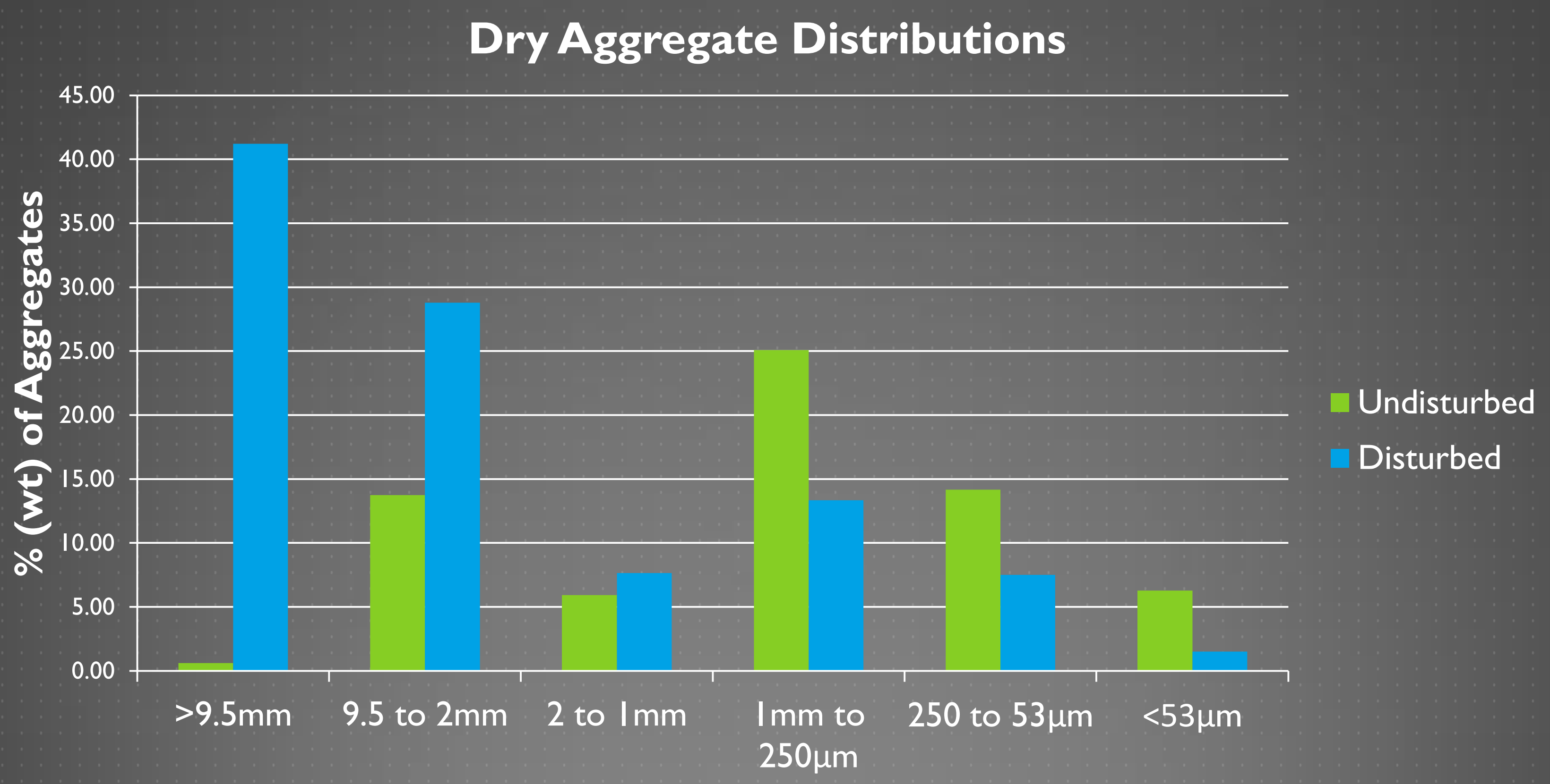
No Site Effect:

- Little differences in pH, bulk density, and porosity on both sites with disturbance
- Calcium behaved similarly with disturbance on both sites:
  - Increasing by about 27%
- Dry aggregate distributions behaved similarly on both sites (next slide)

C&N



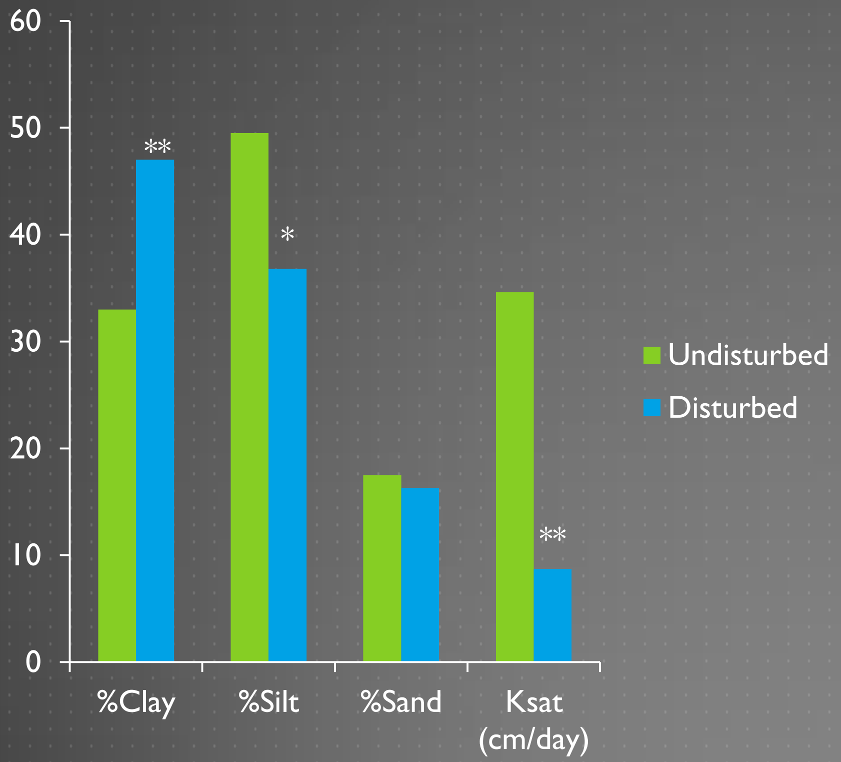
RESULTS



Dry Aggregate Distributions
% (wt) of Aggregates
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
>9.5mm
9.5 to 2mm
2 to 1mm
1mm to 250µm
250 to 53µm
<53µm
Undisturbed
Disturbed

RESULTS: SITE EFFECT

Saline-sodic

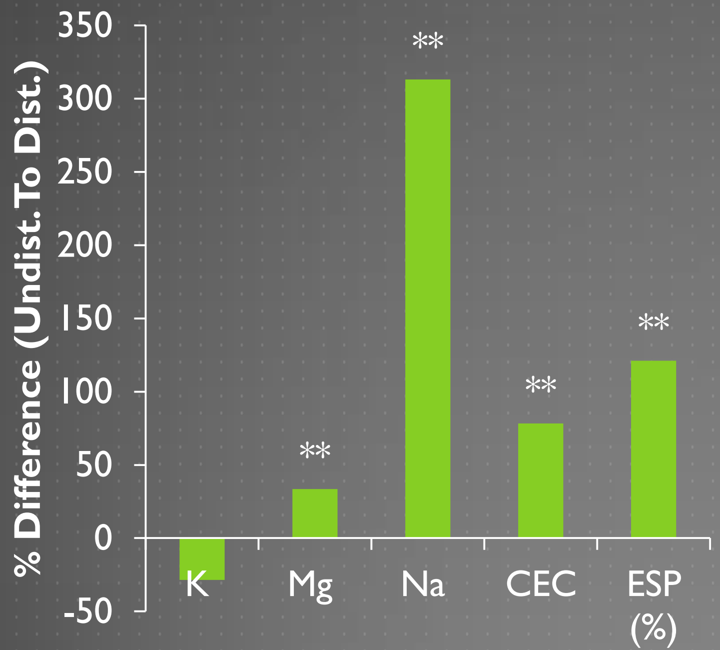


Sodic

RESULTS: SITE EFFECT

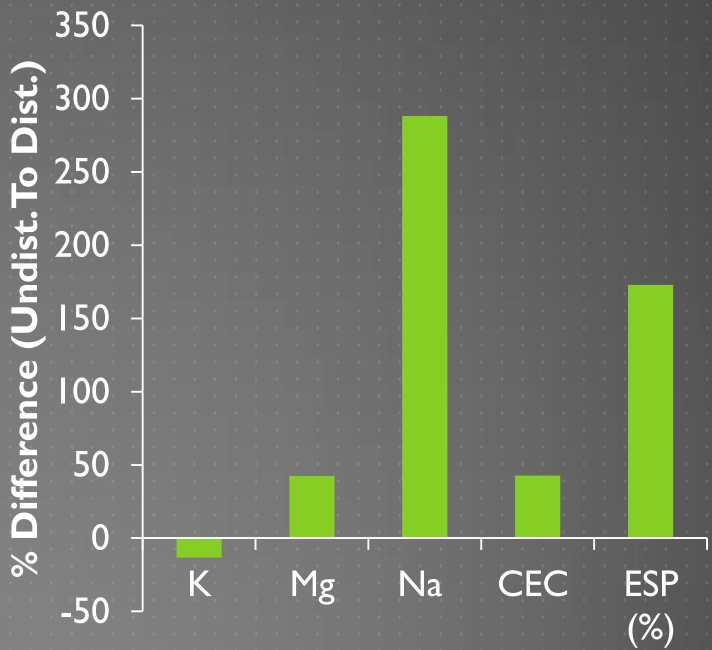
Saline-sodic

- EC increased from 0.61 to 8.51 dS/m



Sodic

- EC increased from 0.29 to 1.75 dS/m



***Concentrations in cmolc/kg

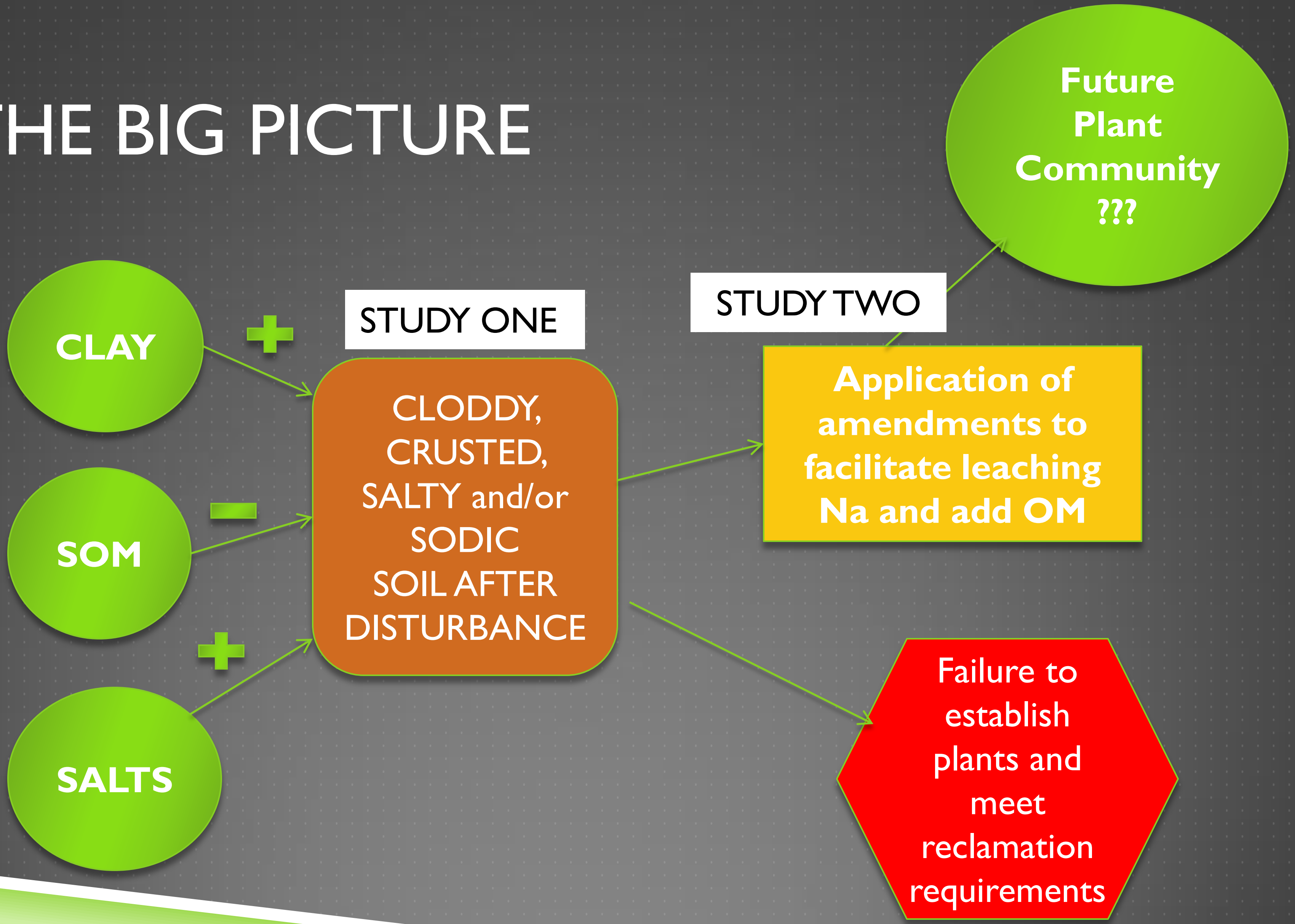
RESULTS: SITE EFFECT

- Both sites showed increases in dissolved organic C&N, though not always significant.
  - Mineralization of OM when stripped, stockpiled, replaced
  - Weed problems w/labile nutrients!
- Water-stable aggregate distribution results were variable…better trends with more samples (future studies)

DISCUSSION

- Introduction of clays and salts into the topsoil is evidence of soil stripping into unfavorable subsurface horizons
    - I.e. Bk horizons, Bt horizons etc.
- Loss of Total N and SOM can be a result of dilution in stockpile and rapid oxidation during excavation and soil mixing
- Dry aggregate distributions on both sites showed increases >9.5mm proportions due to Na and salts facilitating formation of "clods"
    - Mechanical disturbance + high clay + salts = "clay rocks" (not scientific)
    - Losses or dilution of SOM may also be a part of this change in aggregate distributions

THE BIG PICTURE



SODICITY

- Problems w/ excess Na: poor soil structure, losses in aggregation and hydraulic conductivity, increased bulk density (Makoi and Verplancke, 2010; Hanay et al., 2004).
- Additionally, dispersion causes formation of surface crusts, preventing exchange of air and water with soil pores, increasing runoff and erosion, and impeding plant germination and growth (Amezketa et al., 2005).

AMENDMENTS

- To leach Na, we apply chemical amendments with cations (Ca, Mg, Fe, K…) that can replace Na on the exchange, moving it into solution
- In reclamation settings:
  - One time amendment application/incorporation
  - No irrigation
  - Low natural rainfall
  - Logistical constraints w/industry safety measures

- ***Gypsum***: well-researched, cheap, widespread availability, but often criticized for low solubility
- ***Elemental sulfur:*** easier to apply than sulfuric acid, forms H2SO4, dissolves existing CaCO3 to displace Na
- ***Langbeinite:*** potash mineral ($K_2SO_4 \cdot 2MgSO_4$) that has solubility 200x gypsum (Artiola et al., 2000)
- ***MSW Compost***: reintroduces OM for microbial activity and nutrients. Organic acids help dissolve?

WHY PACKED-BOX?

- 2-year field study w/amendments to treat Na was set up in July 2012 in Wamsutter; however, it's very difficult to get to the field sites and sample for much of the year
- A packed-box, outdoor study in Laramie allowed us to use the same soil, same amendments, under environmental conditions, for one year, sampling every 3 months
- Laramie receives 10cm more precip on average a year

OBJECTIVES

Evaluate the use of gypsum, elemental sulfur, and langbeinite as chemical soil amendments to remediate a saline-sodic soil disturbed by arid region energy development;

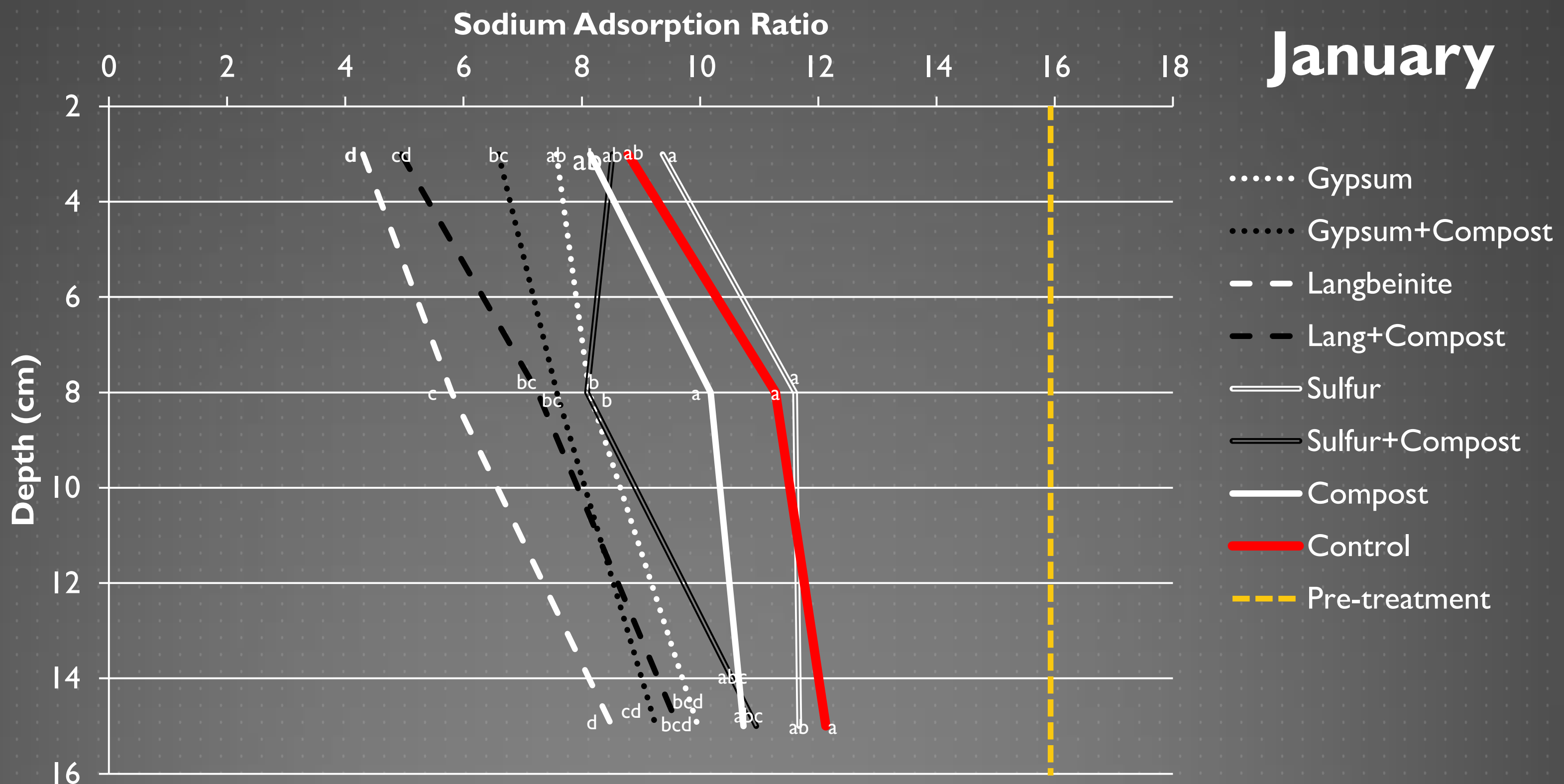
- under the conditions of low rainfall,
- no supplemental water,
- one-time application/incorporation,
- Logistical restraints associated with arid region reclamation.

METHODS

- Soil from saline-sodic site in previous study
  - Remember, Na content after disturbance was 18 cmolc/kg
  - Several tons hauled in a trailer to Laramie
- Soil packed into wooden frames, 24 boxes (3 reps/trt), 0.46 by 0.61 m in size
- Depth of 15cm with a mesh screen on the bottom to allow leaching
- 8 Treatments: G, GC, L, LC, S, SC, C, Control in an RCBD
- Buried level with soil surface in Oct 2012, uncovered for 1 year

- Sampled Jan, Apr, July, Oct 2013
- Depths 0-3, 3-8, 8-15cm
- pH 8.5 Nh4oAc extraction
  - Normandin et al., 1998
- ICP-OES for Na, Ca, Mg, K
- Statistics:
  - 3-factor factorial RCBD, depths as strips
  - Factors: depth, time, treatment
  - 3-factor interaction = 96x96 matrix!!!!

RESULTS: TREATMENTS



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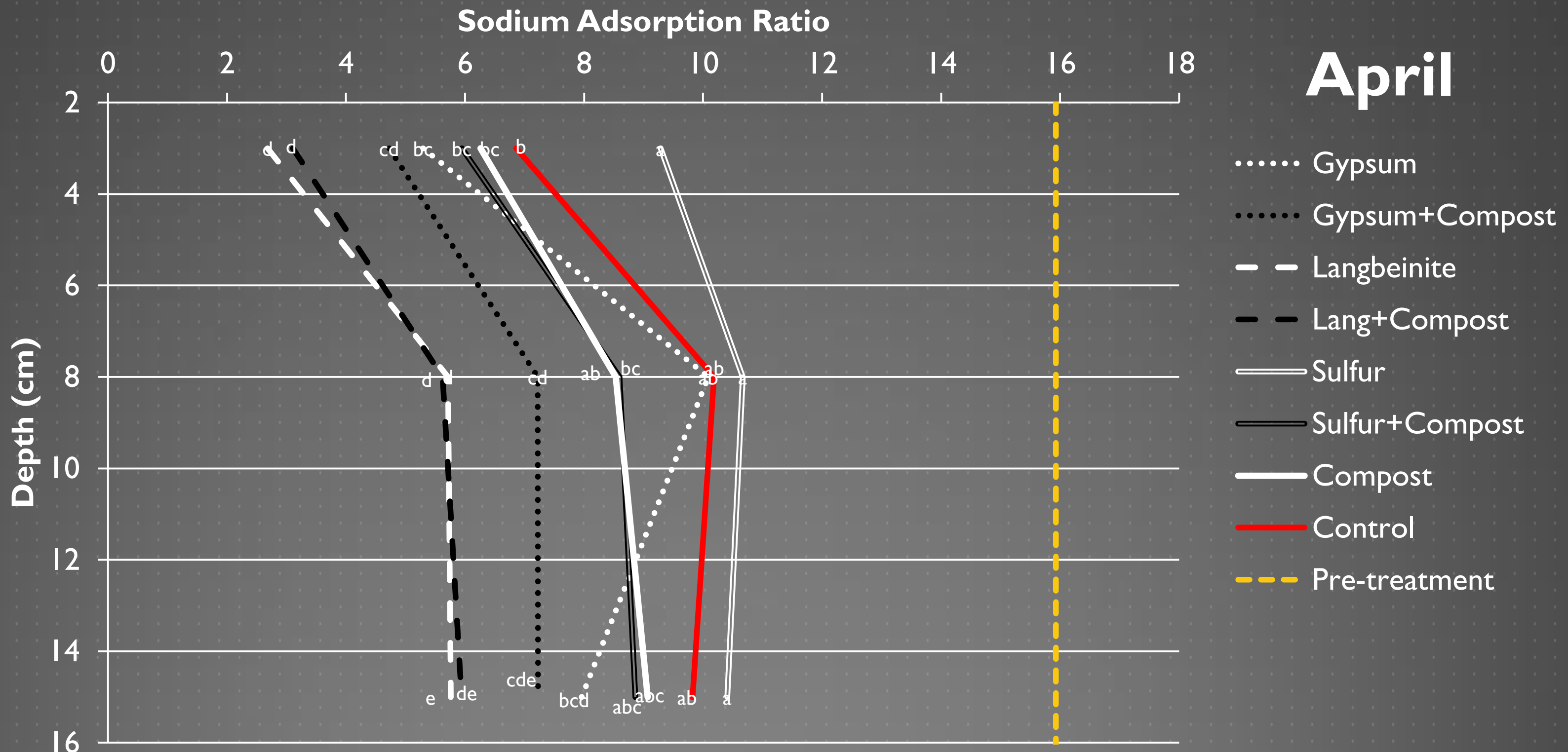

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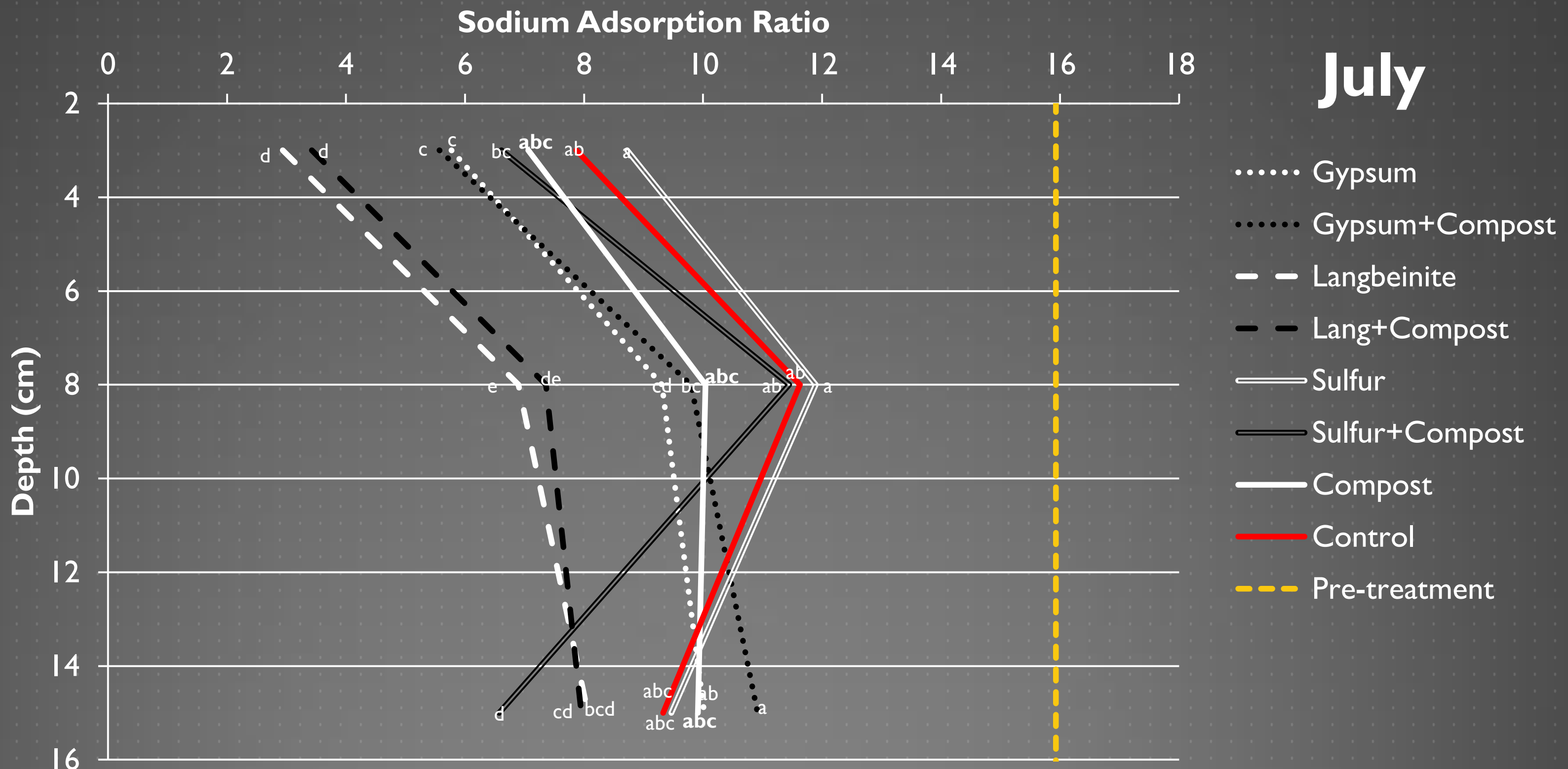

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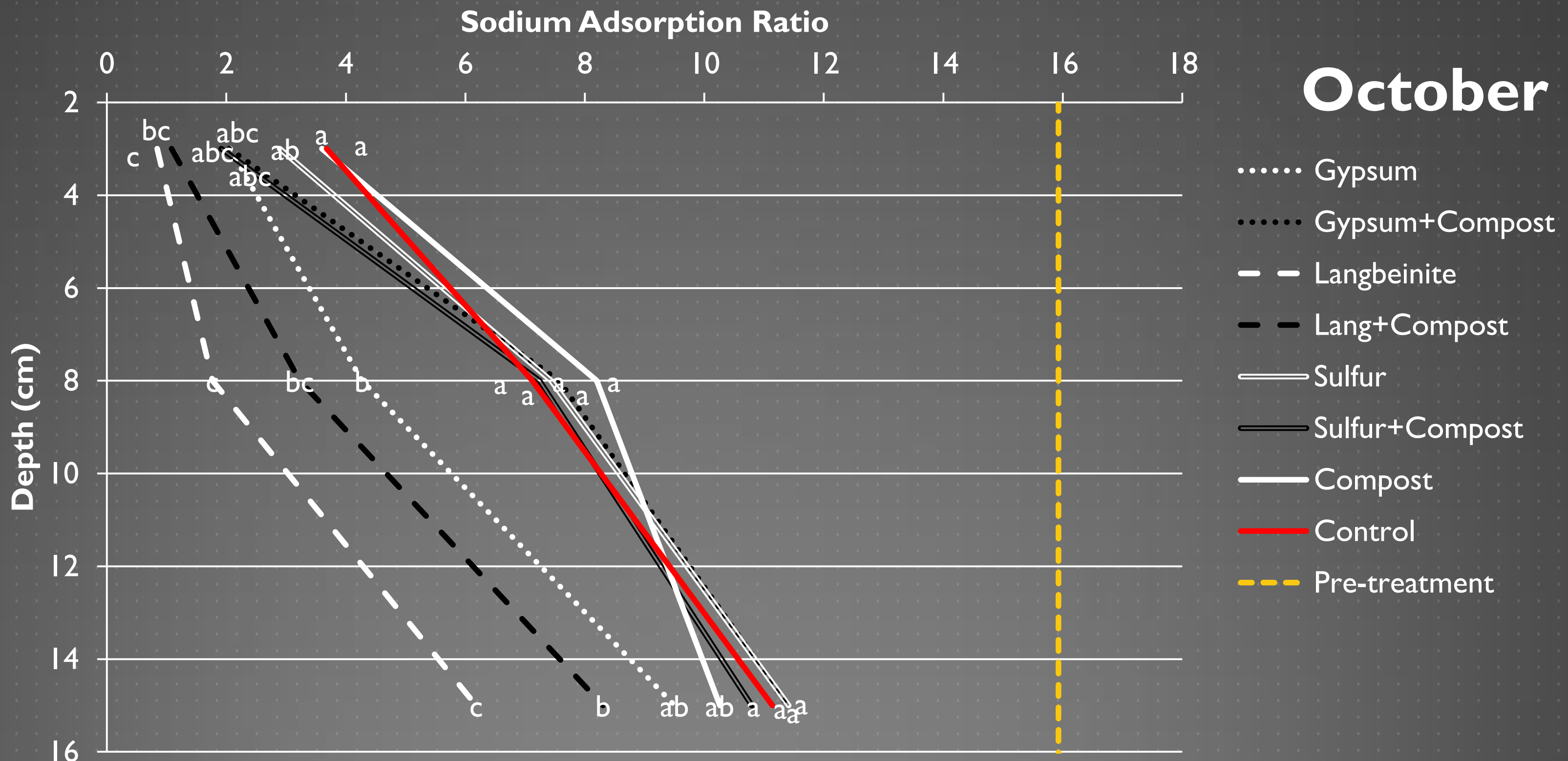
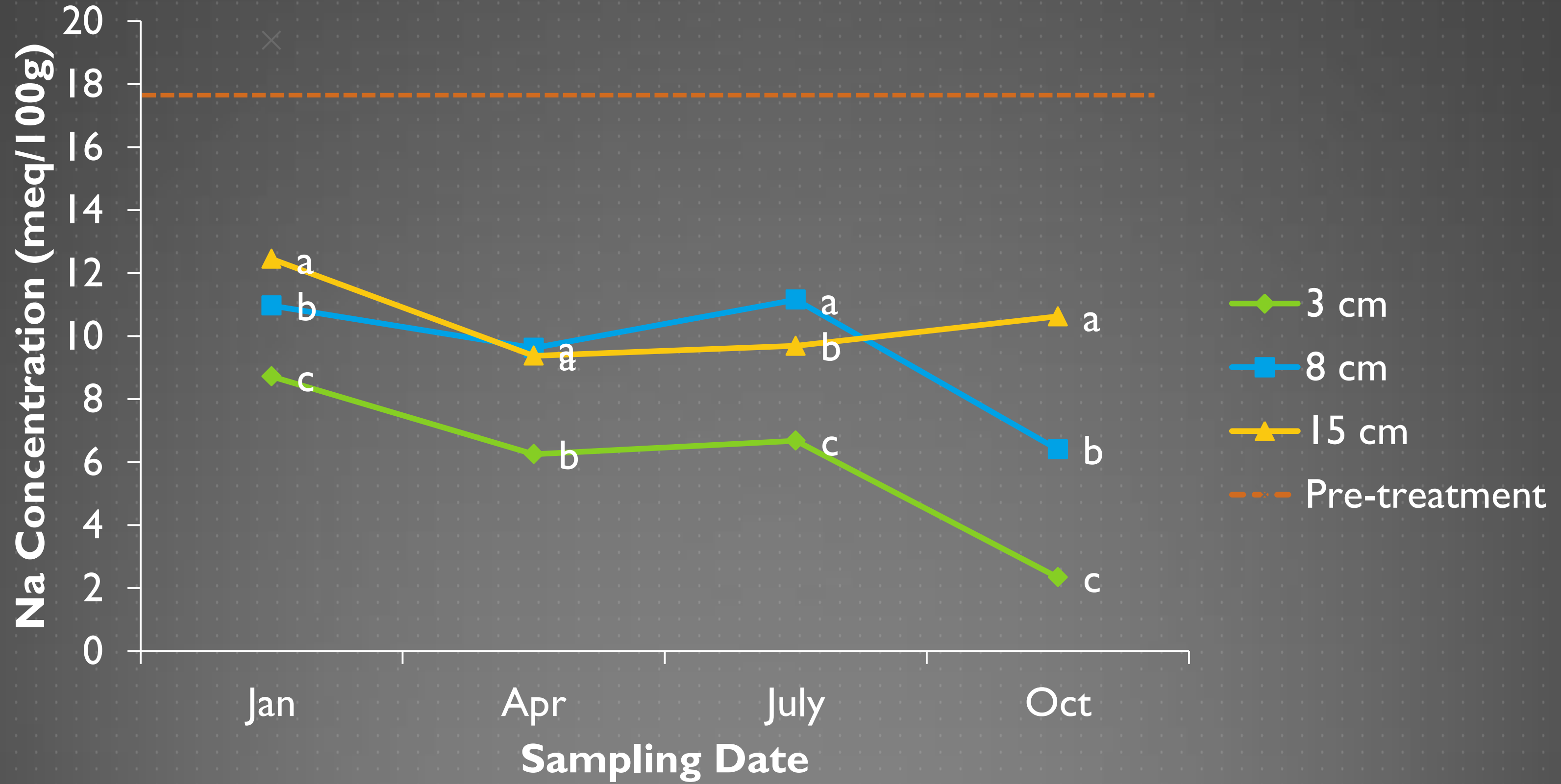
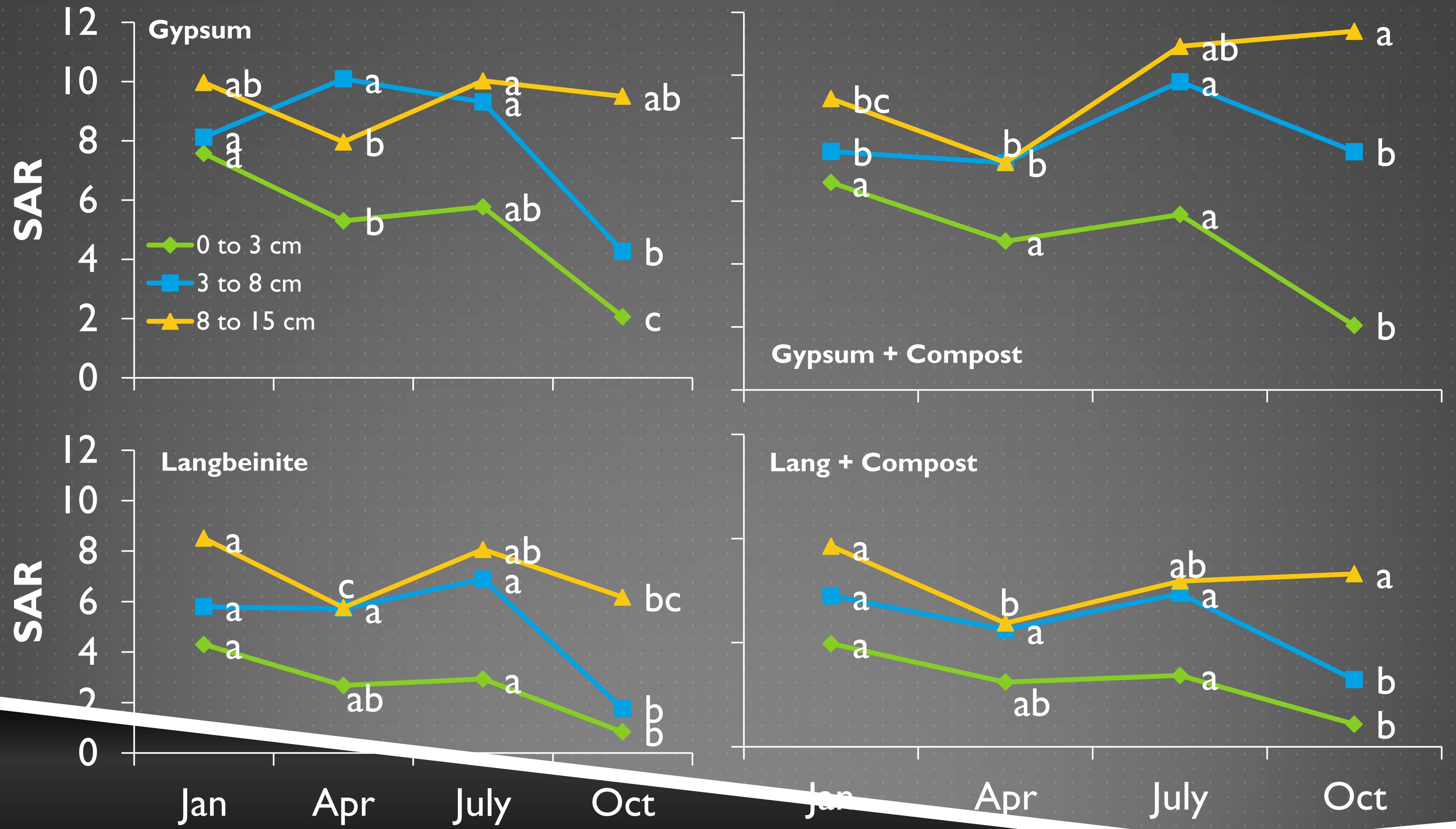


RESULTS: SODIUM, NO TRT EFFECT



RESULTS: 4 BEST TRTS



IN A NUTSHELL….

- Langbeinite > Gypsum > Sulfur treatments in leaching Na
- Compost didn't really effect dissolution or efficiency of chemical amendments
- Pattern of Na leaching dictated by precipitation; magnitude and/or timing of these changes by the treatments
- Sulfur might have done better with more time (microbially mediated oxidation to H2SO4). Maybe why SC trts did better than S alone.
- The 2 year field study using these amendments will tell us more about how these amendments affect other soil properties, and what an extra year can do

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THANK YOU!