UNIVERSITY OF WYOMING
COLLEGE OF AGRICULTURE AND NATURAL RESOURCES

SOILS OF SAGE-GROUSE HABITAT: DEGRADATION AND RESTORATION

Jay Norton
Extension Soil Scientist, Dept. of Ecosystem Science & Management

OVERVIEW

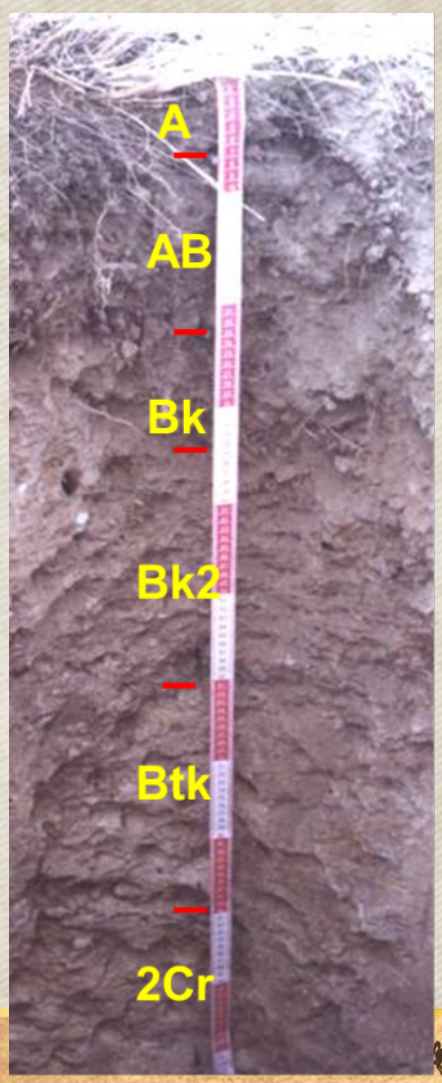
- Soils of quality sage-grouse habitat;
- Effects of chronic disturbance and restoration considerations;
- Effects of drastic disturbance and restoration considerations;
- No especially effective solutions; info to put in your thinking caps when you're figuring out how to solve particular problems.

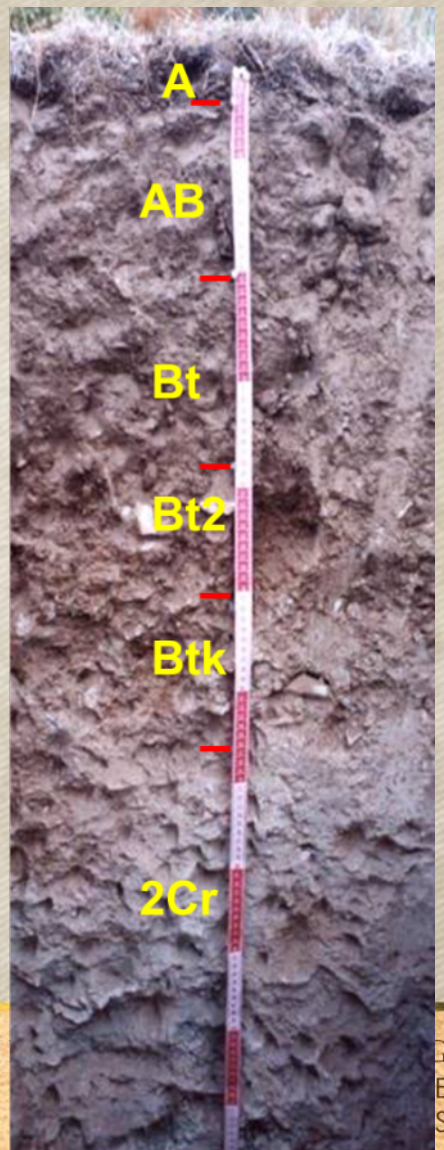
SOILS OF QUALITY SAGE-GROUSE HABITAT

- Quality habitat: mosaic of shrub, herbaceous, bare ground cover of different species, heights, and densities;
- Lightening fires of limited extent and variable rates of recovery of different species on different soil types creates rich natural variation and diversity;
- Variation is both caused by and reflected in soil properties;
- Many human activities have a homogenizing effect that degrades habitat.

SOILS OF QUALITY SAGE-GROUSE HABITAT

- Occurs on a wide variety of soils mostly formed on alluvial valley and basin deposits;
- Mollisols in higher precip areas with mountain big sage: more forgiving;
- Alfisols and Aridisols in dry and highly seasonal moisture: more fragile and difficult to restore;

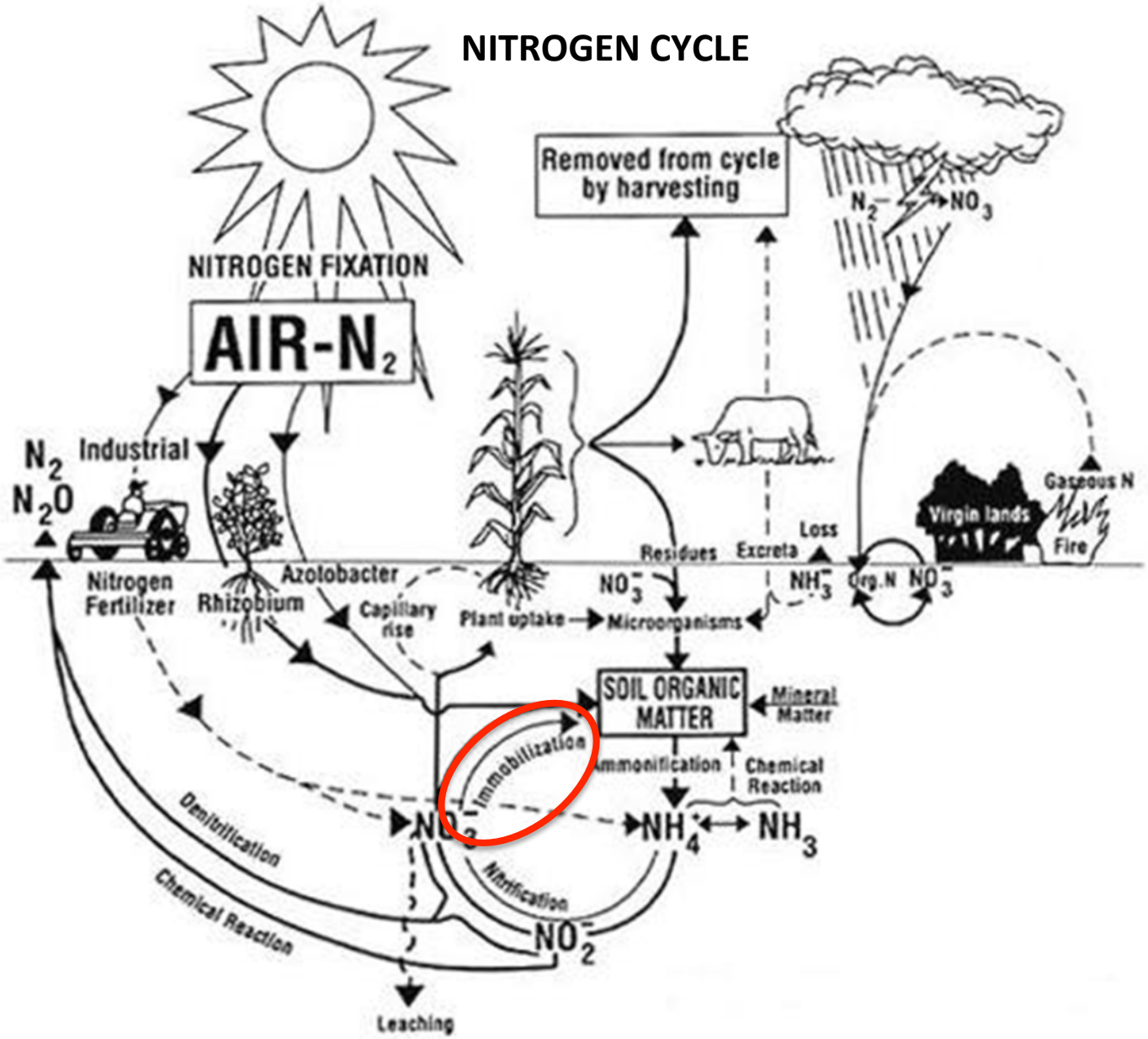




SOILS OF QUALITY SAGE-GROUSE HABITAT

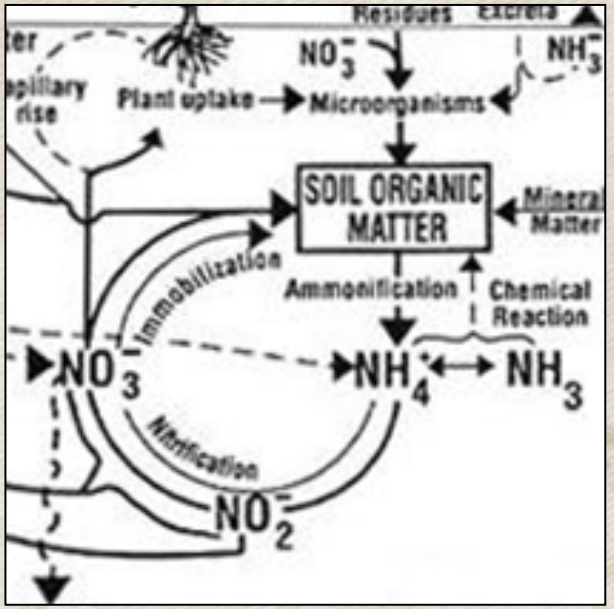
- Important features that support habitat:
- Low frequency of major disturbances:
  - Fire: 27-40 years and limited extent due to discontinuous fuels;
  - Intense rainfall is not common;
- High frequency of minor disturbances:
  - Freeze-thaw;
  - Wetting-drying;
- Nitrogen-limited, "closed, conservative, tight" nutrient cycling;
- Spatial heterogeneity: horizontal & vertical:
  - Mosaic scale: fire and soil;
  - Shrub scale: Islands of fertility.

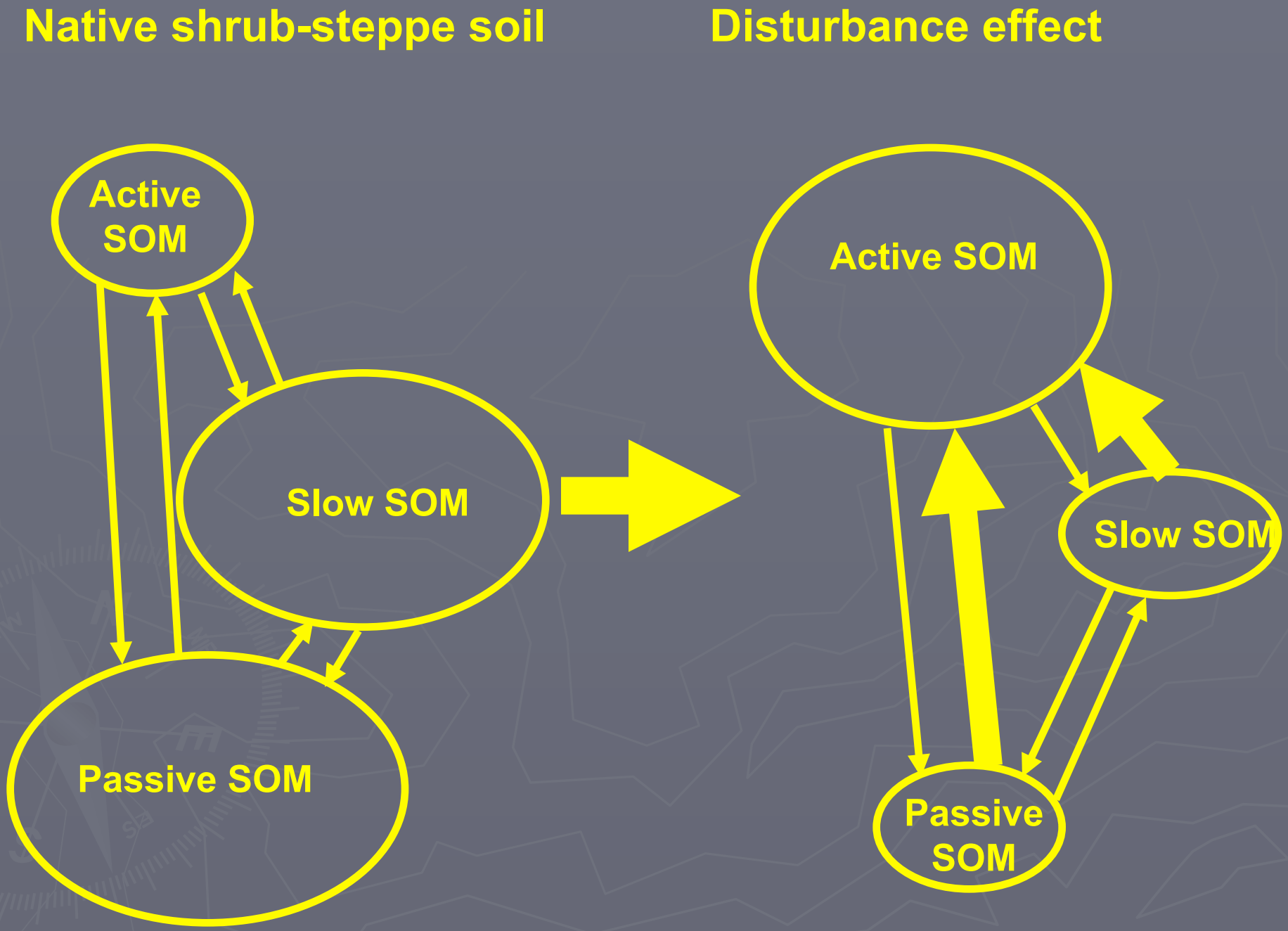
NITROGEN CYCLE



N-LIMITED TIGHT INTERNAL CYCLING

- Abundant and variety of C compounds




Native shrub-steppe soil
Disturbance effect
Active SOM
Slow SOM
Passive SOM
Active SOM
Slow SOM
Passive SOM

CHRONIC DISTURBANCE

- Overgrazing: effects persist from historic practices
  - Homogenization: Loss of herbaceous cover, increase in shrub cover;
  - Less OM input and less diverse materials;
  - OM tied up in woody material;
  - Loss of OM and interspace soils via wind and water erosion;

CHRONIC DISTURBANCE

- Transition to C-limited, open or leaky N cycle;
  - The candy store is open! Microbial uptake is limited by C;
  - System is vulnerable to weed establishment;
  - Eventually continuous fuels feed larger fires.

FIXING EFFECTS OF CHRONIC DISTURBANCE

- Soils perspective: move toward N-limited environment;
  - Foster diversity of herbaceous vegetation:
    - Open shrub canopy;
    - Interseeding mixed early and late seral grasses & forbs.
  - Create a mosaic (think multi-scale);
- Include cereal cover crop to speed transition toward N-limited environment???

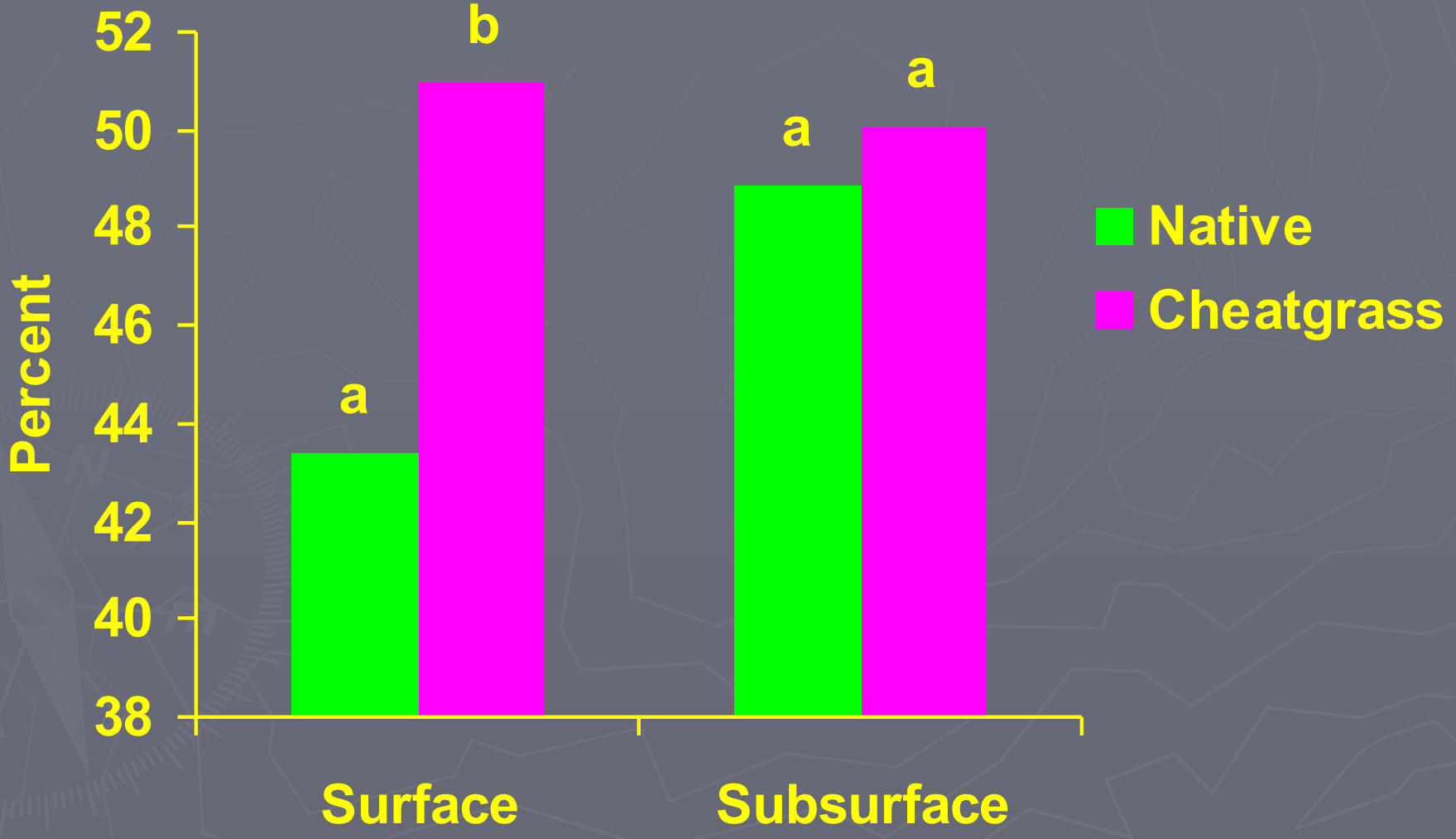
BLM photo

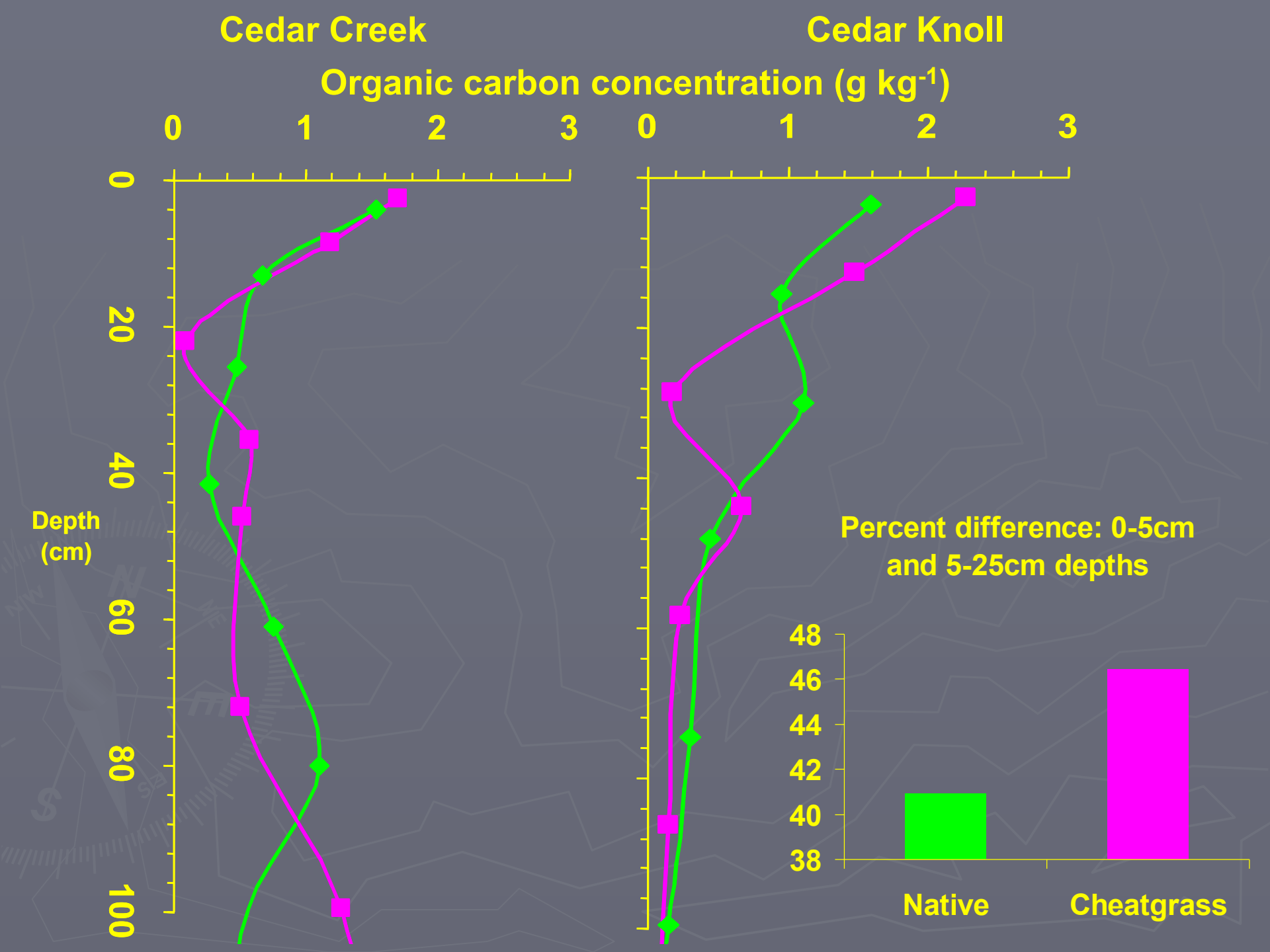
Closed canopy with weedy understory can cause sudden conversion: major homogenization.

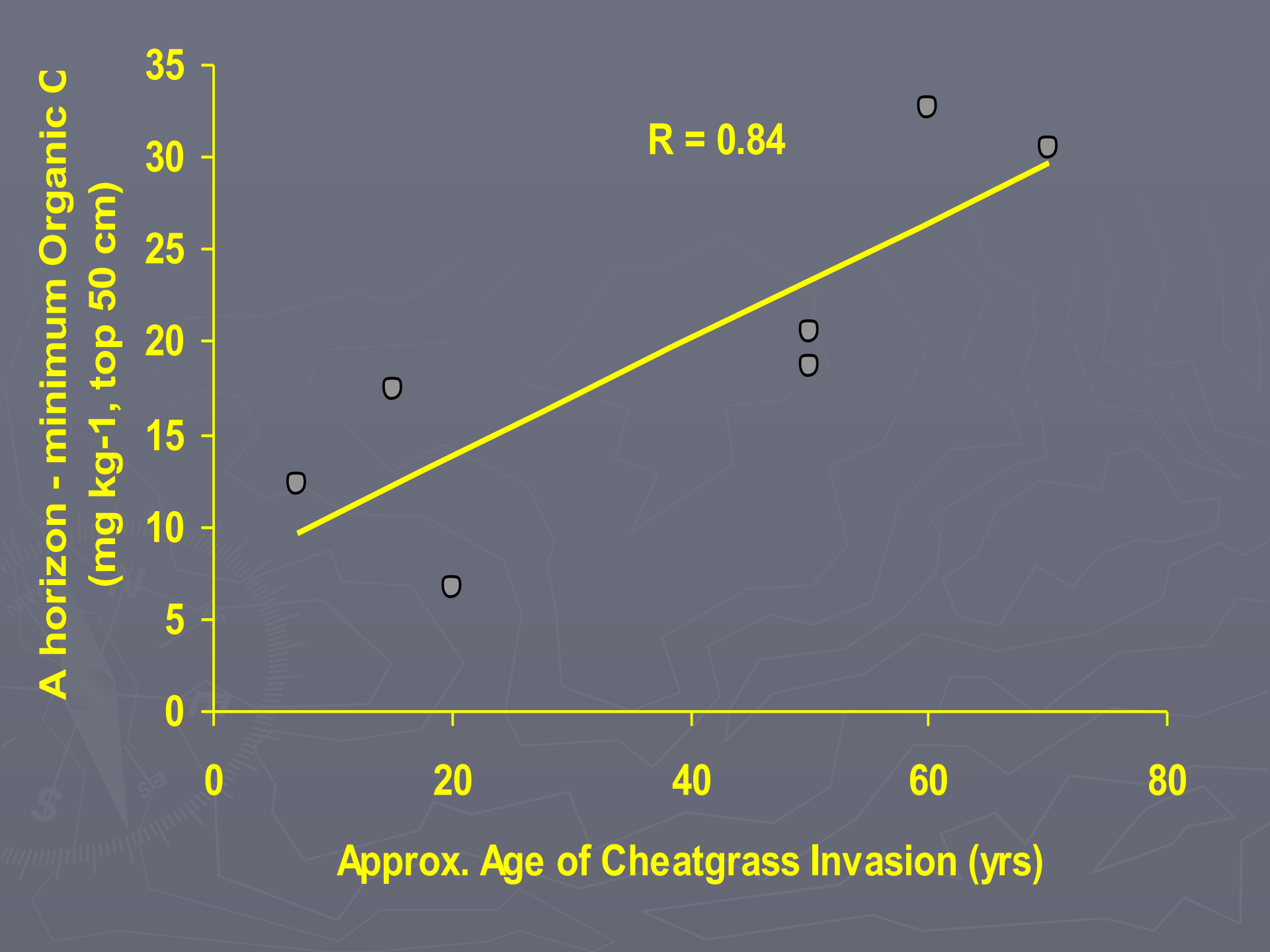
CONVERTED: SHRUBS ARE GONE

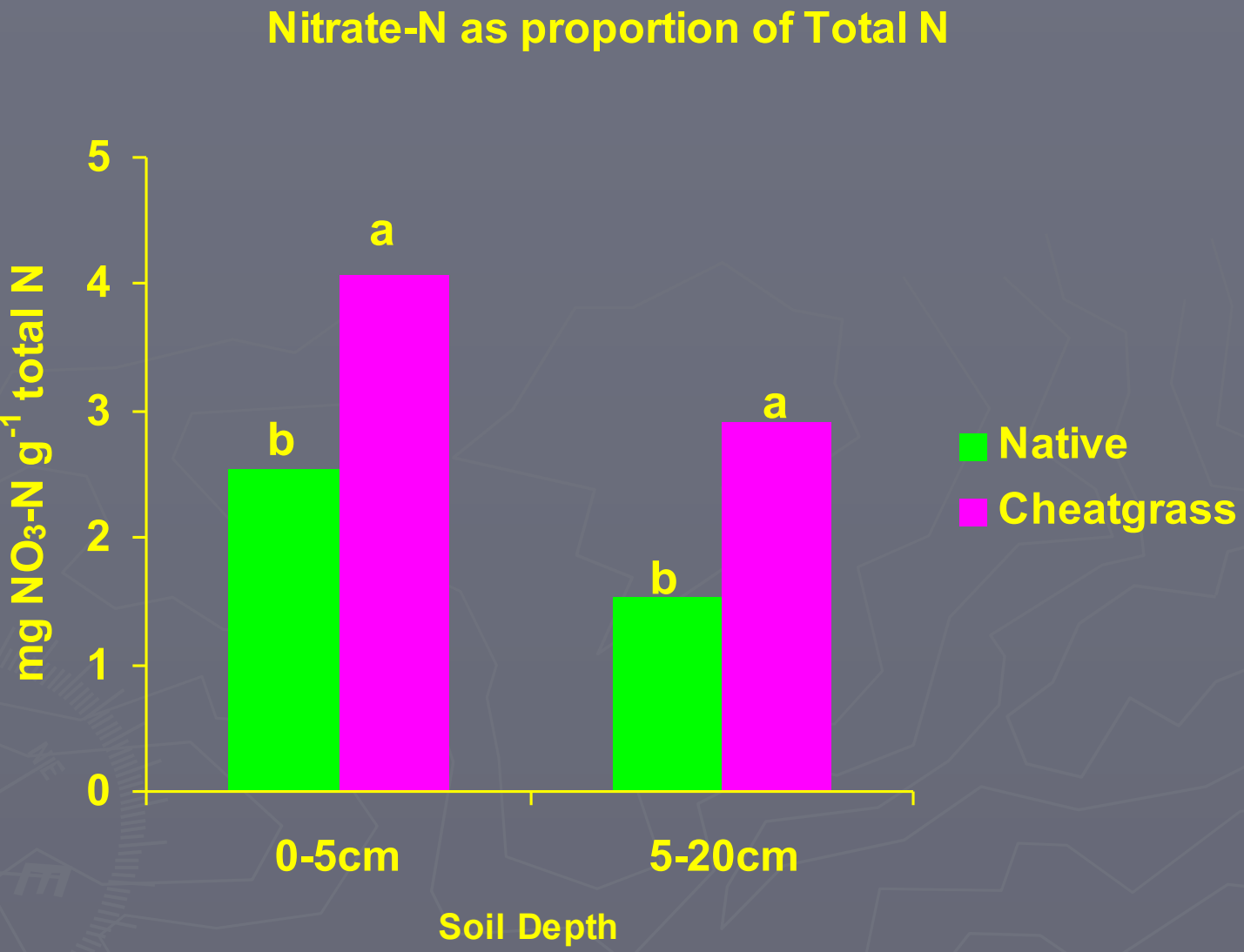
- Cheatgrass monocultures cover most previous sagebrush steppe in the Great Basin;
  - Parts of Wyoming are vulnerable;
- Shallow, prolific, very fine roots that die in early summer:
  - Increased aeration

Porosity


52
50
48
46
44
42
40
38
Percent
a
b
a
a
Native
Cheatgrass
Surface
Subsurface

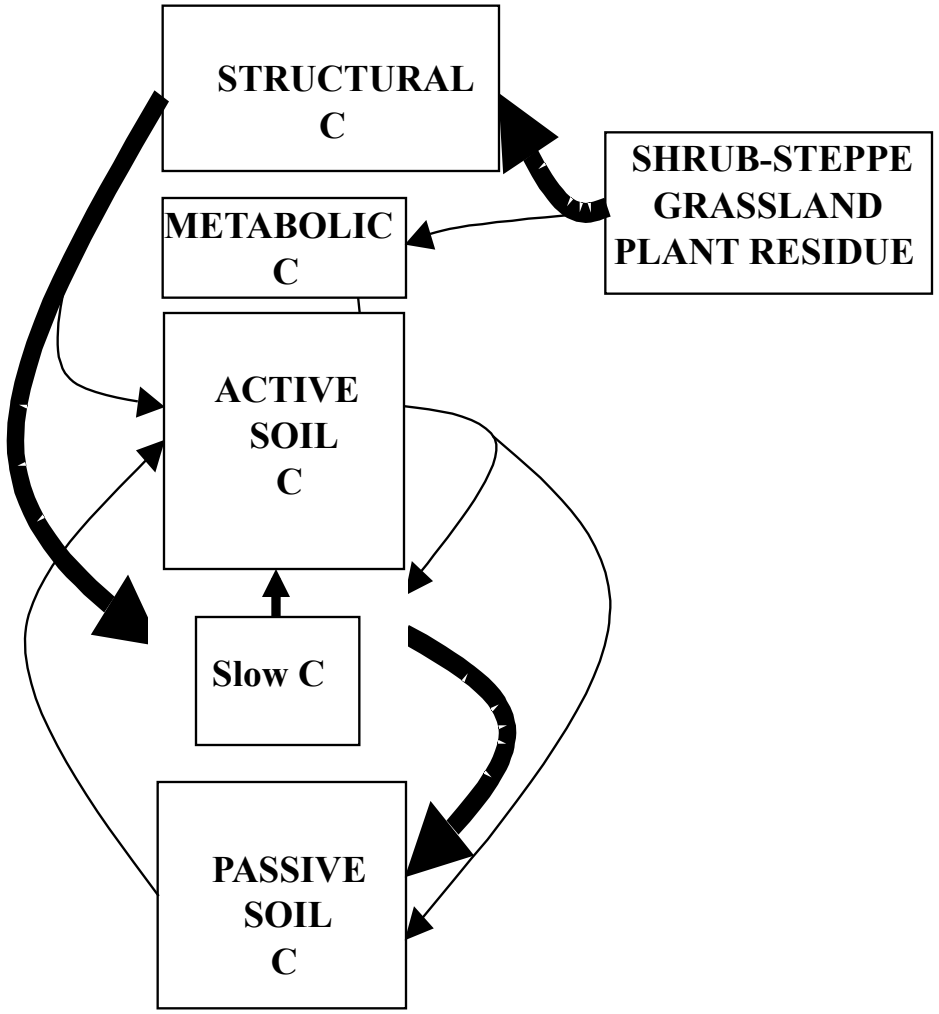

Cedar Creek
Cedar Knoll
Organic carbon concentration (g kg-1)
0
1
2
3
0
20
40
60
80
100
Depth (cm)
Percent difference: 0-5cm and 5-25cm depths
48
46
44
42
40
38
Native
Cheatgrass


A horizon - minimum Organic C
(mg kg-1, top 50 cm)
35
30
25
20
15
10
5
0
R = 0.84
0
20
40
60
80
Approx. Age of Cheatgrass Invasion (yrs)



- C-limited, leaky N cycle due to short life span of annual grass.

Soil Carbon Pools



Active, or labile, SOM:

Annual turnover

Mineral C & N

Mineralizable C& N

dissolved organic C & N;

Microbial C & N;

light fraction C & N.

Slow, or protected, SOM:

Decades;

Same as labile, but protected from mineralization within soil structure.

Passive, or stabile, SOM:

Centuries to millenia;

Humus;

Mineral-associated C & N;

- More mineral N and sharper drops between surface and subsurface horizons suggest long-term mining of stored SOM under cheatgrass.
- Large-scale environmental change in cycling of water, carbon, nitrogen, and other ecosystem components.
- Legacy of soil heterogeneity diminishes rapidly under increased turnover and frequent fires.

RESTORING CHEATGRASS-INVADED SHRUBLANDS

- Multi-step process;
- Soils perspective: Need to close nutrient cycles; transition to N-limited environment;
  - Stimulation of immobilization by adding labile C, including tons of sugar, has been tried;
- Recapture, or "reperennialize" with competitive native or introduced grasses:
  - Adds more diversity and mass to C additions;
  - May allow multiple attempts at chemical cheatgrass control;
- Establish "permanent" introduced perennial firebreaks to limit fire size/frequency;
- Reduce stand to facilitate shrub & forb establishment.

CONVERTED TO INTRODUCED OR NATIVE GRASSES

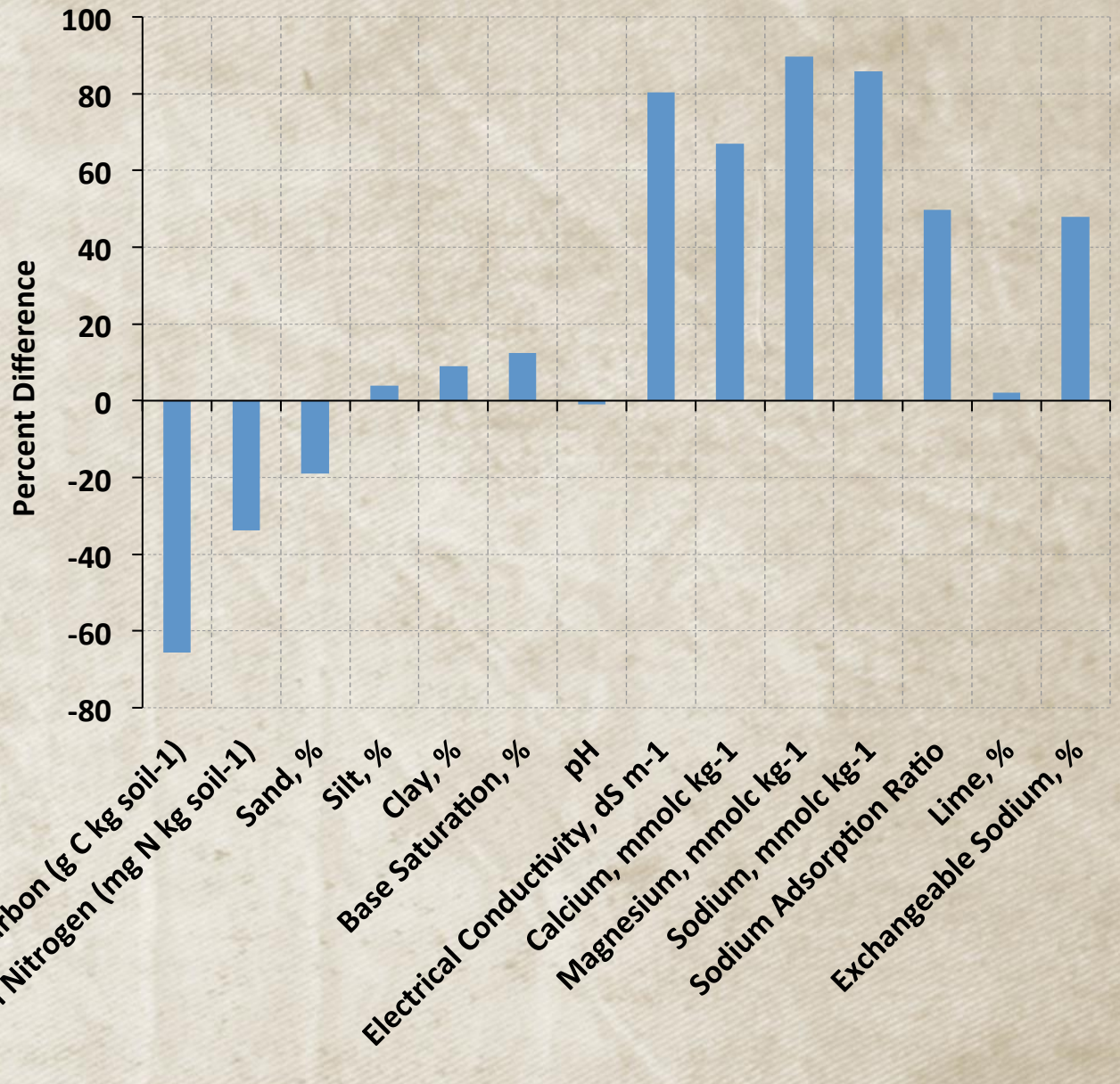
- Shrub removal occurred and competitive grasses prevent natural recovery;
- Crested wheatgrass & Russian wildrye are very competitive and can persist as near-monocultures for decades;
- Valuable forage and resistant to cheatgrass and fire, but little value to sage grouse;
- Must open stand to establish shrubs and forbs.
- Can fail in presence of cheatgrass.

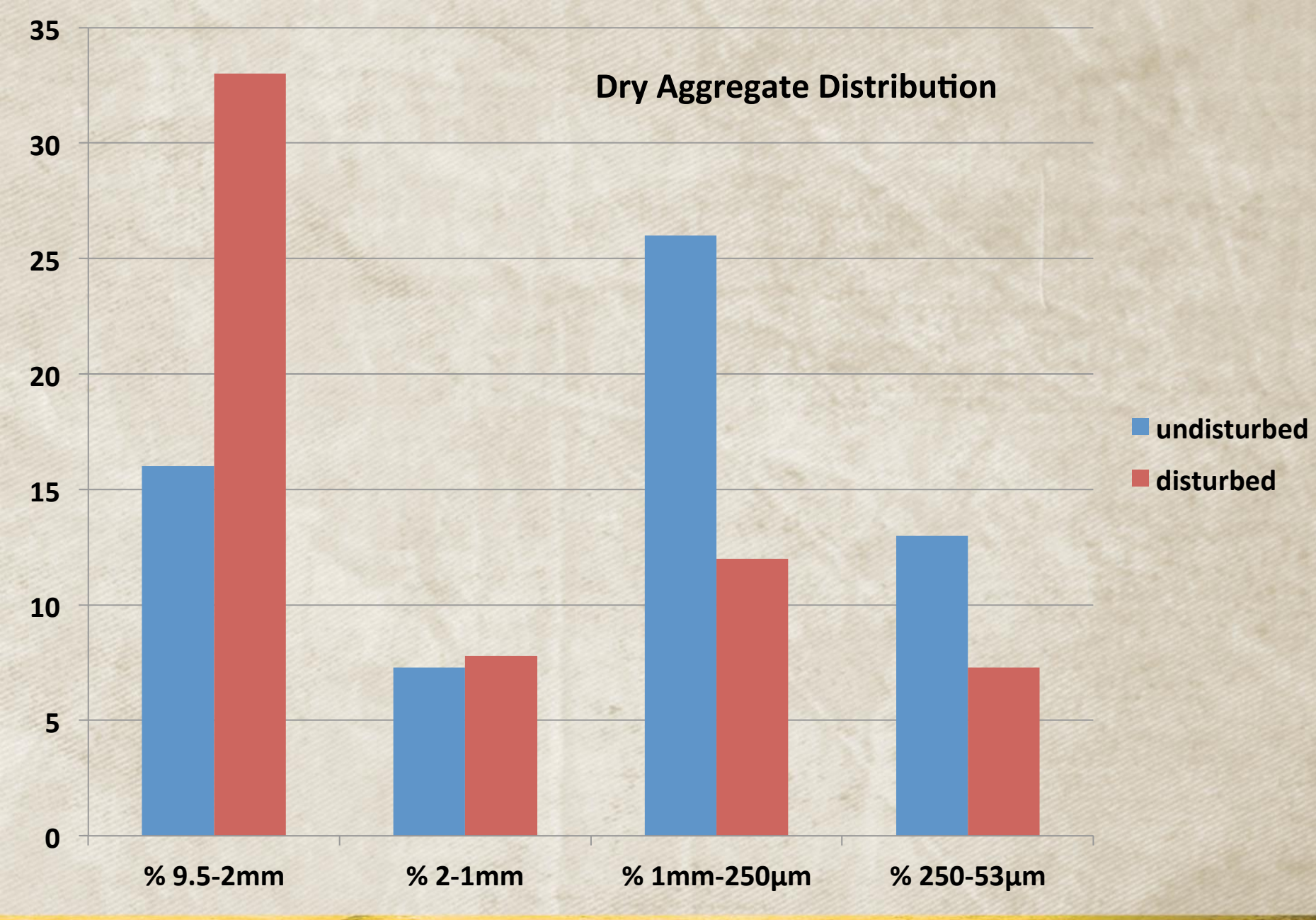
DRASTIC TEMPORARY DISTURBANCE

- Stripping, stockpiling, and respreading topsoil affects soils in three ways:
  - Pulverizes soil aggregates;
  - Stimulates decomposition, loss of SOM and shifts toward C-limited environment, with leaky N cycle;
  - Increases salinity/sodicity.
- Stockpile size and age are not as important as other factors, especially in dry environments.

AND NATURAL RESOURCES

Soil Property	U	D
SOC (g C kg soil-1)	5.8	2.0
TN (mg N kg soil-1)	0.68	0.45
Sand, %	29.8	25.0
Silt, %	37.0	38.5
Clay, %	25.0	36.5
Base Saturation, %	44.9	51.3
pH	7.71	7.64
EC, dS m-1	1.14	5.79
Ca, mmolc kg-1	6.65	20.1
Mg, mmolc kg-1	1.68	16.1
Na, mmolc kg-1	3.94	27.9
SAR	3.95	7.85
Lime, %	4.16	4.25
Exchangeable Na, %	4.96	9.51



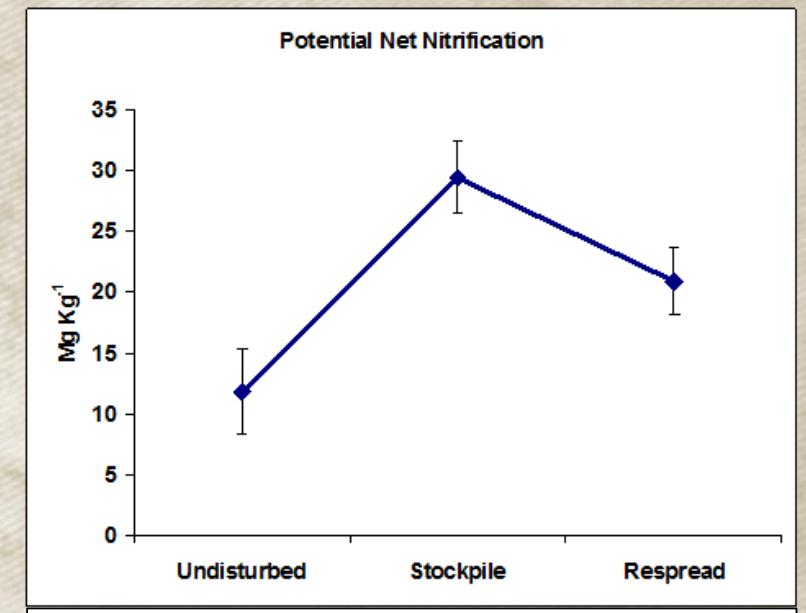

Dry Aggregate Distribution
35
30
25
20
15
10
5
0
% 9.5-2mm
% 2-1mm
% 1mm-250µm
% 250-53µm
undisturbed
disturbed

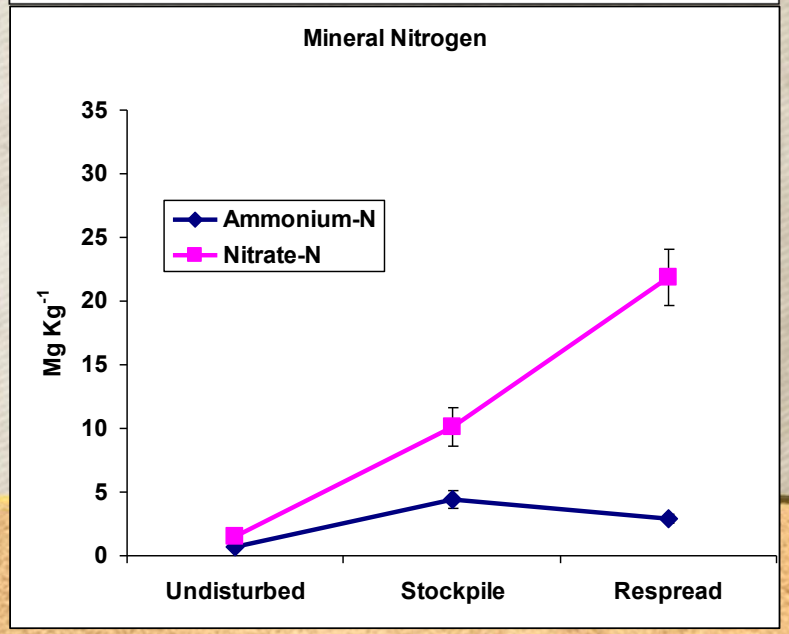
PULVERIZING SOIL STRUCTURE

- Conserving structure would improve soil water properties and conserve SOM;
- Alternative salvage techniques?
  - Dozer piles?
  - Sod cutting?

MAINTAINING N-LIMITED ENVIRONMENT

- Increase in labile SOM with stripping;
- Burst of mineralization at respreading: IDEAS
- Preemptive:
  - Plant high seeding rate of fast-growing cereal **BEFORE** stripping;
  - With adequate moisture "plow effect" might create high biomass;
  - Might increase C:N with labile C to capture bursts of mineral N;
  - OR spread straw prior to stripping, to be mixed in stockpile?
- Amendments
  - Incorporated straw reduces mineral N and weeds;
- Reseeding
  - "cover crop": high rate of native annual grasses and forbs in reclamation seeding mix;
  - May compete with weeds and add diverse OM to soils.





SALINITY/SODICITY

- Soil test is necessary to detect Na; field meter for EC;
- Careful inventory and variable-depth salvage to avoid Bk horizon;
- Compost to offset negative effects on soil structure: no other option for high EC soils;
  - Enough OM to replace that lost in surface 3 to 6 inches;
  - If 1 % is lost, it may take 12-15 tons of compost per acre to replace, depending on SOM content of compost
- Amendments:
  - adding Ca and Mg to sodic soils can moderate negative effects of Na on soil structure, even if Ca and Mg levels are already high.
    - Gypsum, langbeinite, lime;

SUMMARY

- Multi-scale diversity of plant spp, shrub size, shrub density is key attribute of quality habitat: N-limited, closed soil nutrient cycles;
- Dense shrub cover, low herbaceous cover from historic overgrazing:
  - C-limited due to reduced input and loss of SOM: vulnerable to weed invasion;
  - Reduce shrubs, plant grasses & forbs;
  - Treat to create mosaic of shrub size & density;
- Cheatgrass dominated: disturbed due to inputs of fine labile SOM that creates C-limited environment;
  - Multi-step process: fire breaks, perennial grasses, shrubs & forbs;
- Converted shrub free introduced or native grass stands:
  - Break in to plant shrubs & forbs;
- Temporary drastic disturbance:
  - Manage C:N ratio; add labile C to maintain N-limited environment;
  - Careful soil salvage to avoid saline/sodic subsoils;
  - Compost and amendments to remediate.