Part I. Ecological Sites and Soil Survey

Part II. A Framework for Soil and Vegetation Dynamics

Arlene Tugel, Soil Scientist Liaison to ARS, USDA-NRCS
Las Cruces, NM
and the
Soils-ESD Advisory Group

Part II. Ecological sites and state and transition models: A framework for soil and vegetation dynamics and management

The soil survey is the foundation of the ecological site inventory process.

- Ecological sites are comprised of soils with similar inherent soil and landscape features.
- These features determine or moderate the unique soil behavior and ecological processes of the site.
- These features help differentiate sites.

Inherent soil-landscape properties are the foundation of an ecological site.

Soil behavior (and processes) are estimated from inherent soil properties

- Surface texture
- Rock fragments (surface and horizon)
- Soil depth
- Kind of depth restriction
- Abrupt textural change
- Salinity, alkalinity, $CaCO_3$
- Available water capacity
- Water table depth
- Run-off, run-in
- Parent material
- Other regional features
- Landform
- Slope

The effects of geomorphic position on vegetation dynamics:
Different processes of erosion and deposition could be used to differentiate sites.

→

Active alluvial fan (gravelly ecological site)

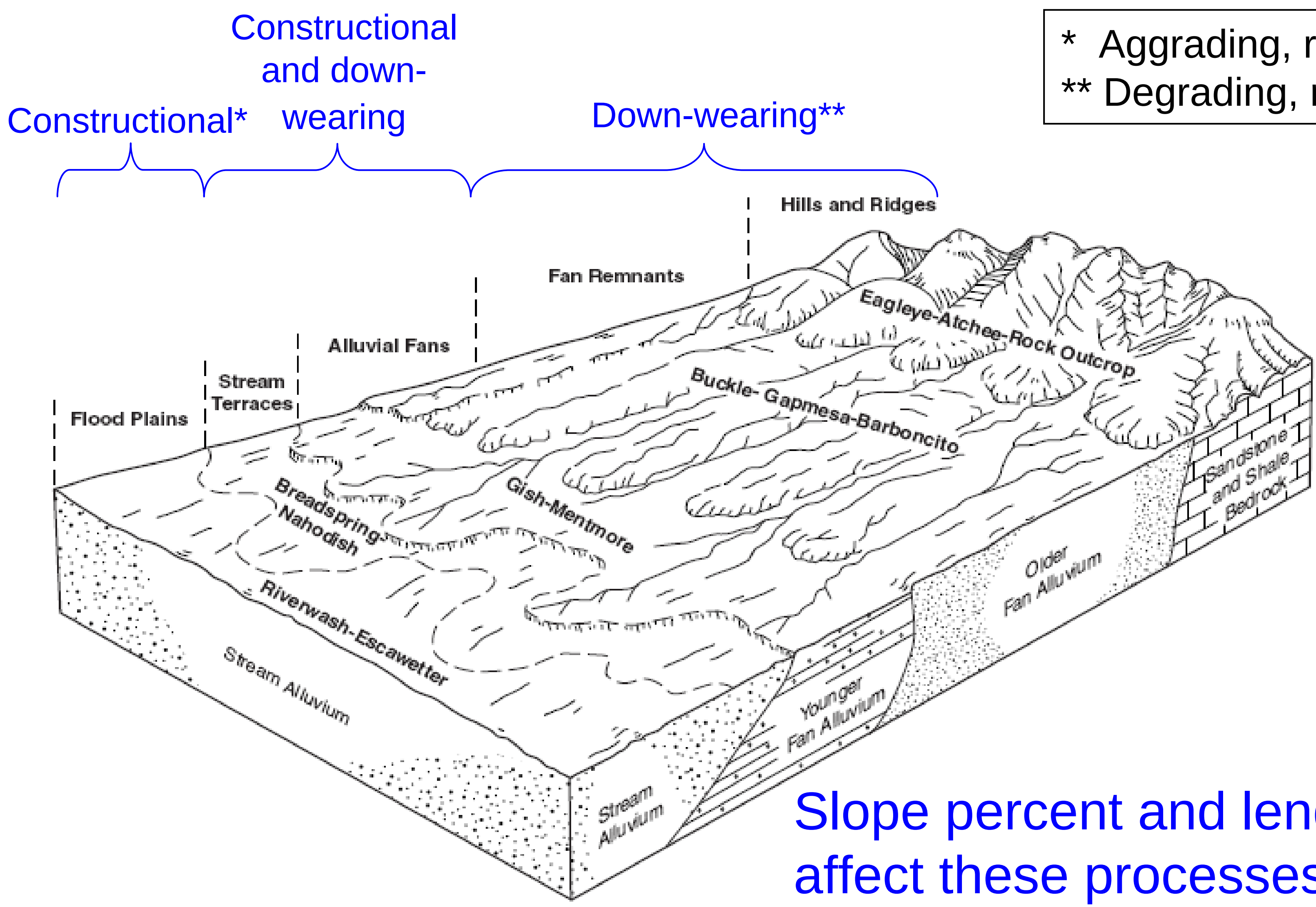
→

Relict, dissected alluvial fan (currently in gravelly ecological site)

Photos from Gile and Bestelmeyer

Inherent dynamics: Soil-landscape units have characteristic stability and hydrologic features.

* Aggrading, run-in
** Degrading, run-off



Slope percent and length affect these processes

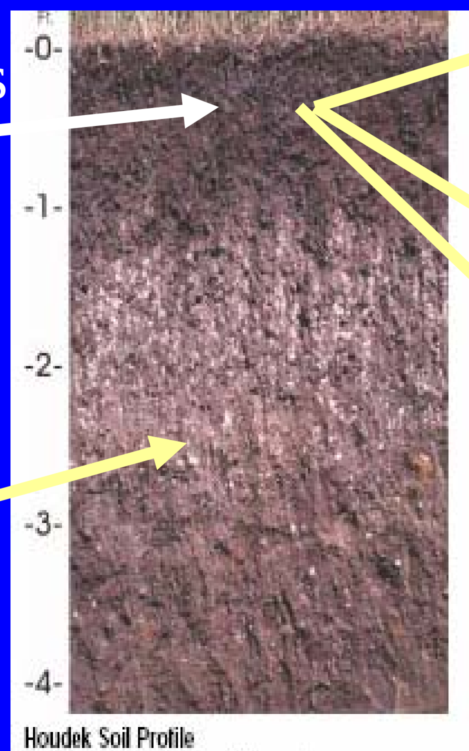
Organizing framework for dynamics

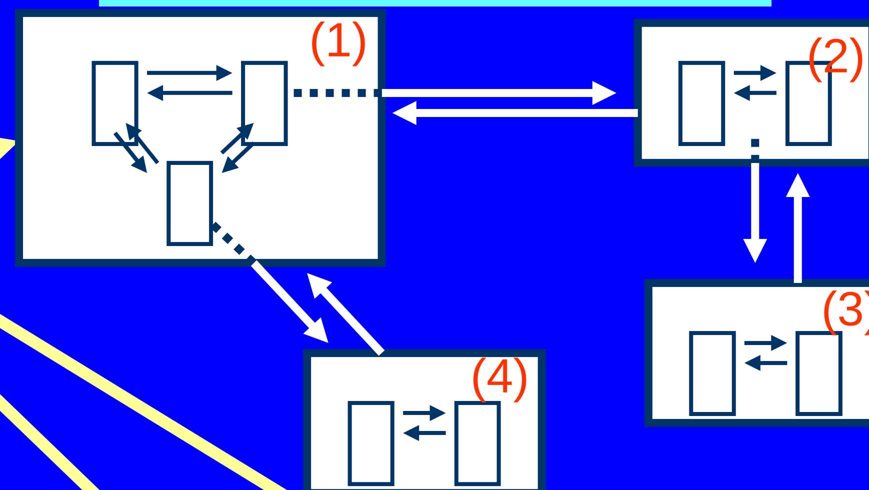
Soil survey today: Only one set of values exists for all land uses

Need multiple values based on management (states)

Dynamic Properties
(Use-dependent)

Static Properties





(6) No-till Cropland

(5) Tilled Cropland

State and transition models, by definition, include soil

- A state is made up of the plant community and its soil foundation.
- Transitions include processes of change and management practices.
  - Many processes are soil-based.
- Some dynamic soil properties of a state change through a transition.

Transitions:
Soil-based processes after disturbance

Erosion/sedimentation
- •Nutrient loss/gain

Organic matter loss
- Structural degradation
- Crusting, sealing
- Decreased porosity

Compaction
- Decreased infiltration, Ksat
- Decreased AWC

Altered hydrology
- Salinization
- Water-logging/drained

Transitions:
Soil-based processes after disturbance

Fire-induced water repellency
- Increased infiltration
- Increased run-off

Increased bare spaces
- Increased soil temperature

Change in soil surface cover
- Loss/gain in biological crust cover, surface rocks
- Loss/gain in litter

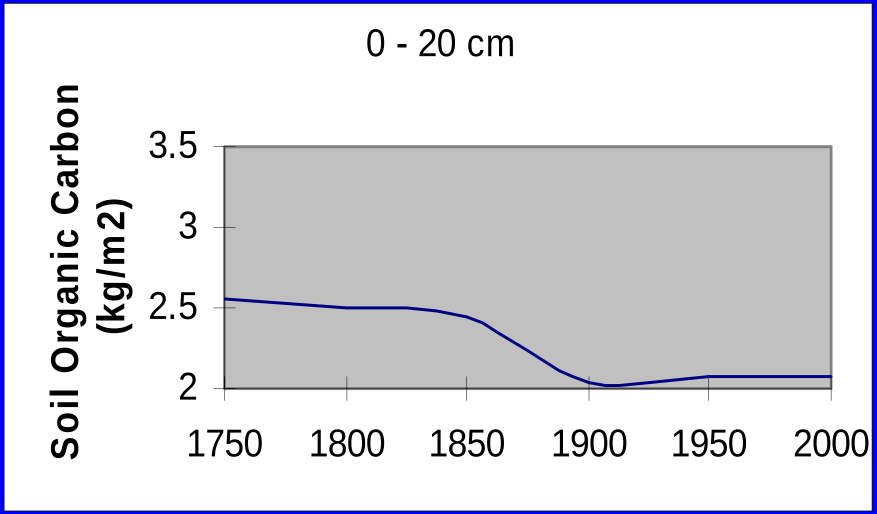
Dynamic soil properties

= soil properties that change over the human time scale.

Soil quality indicators are dynamic soil properties

Decades = management time scale

Decades to centuries = recovery time scale



Redrawn from Hibbard, 1995

Quantitative soil measures

Infiltration, Ksat

Soil stability

Aggregate stability

Penetrometer

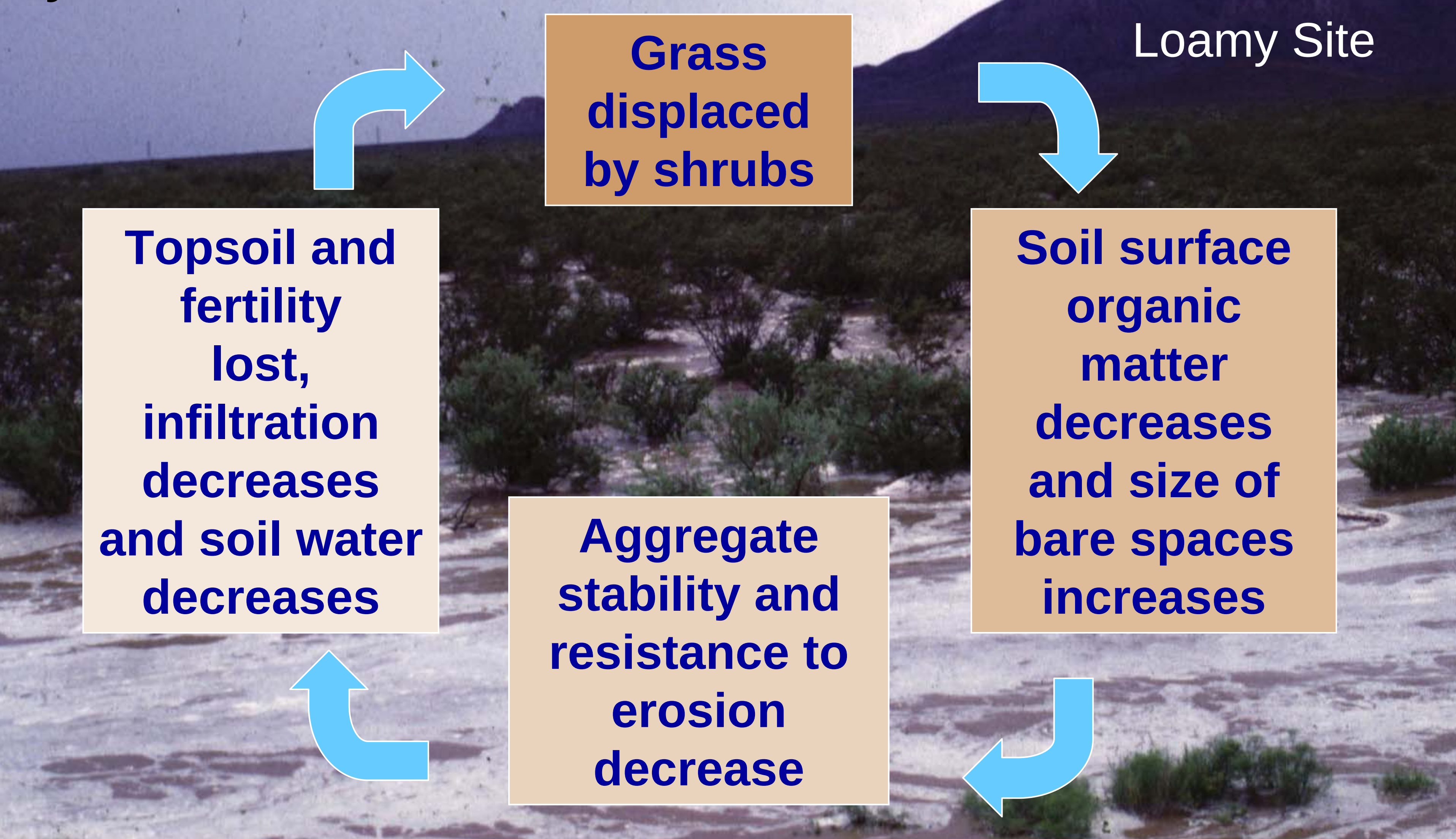
Bulk density

pH, EC

Samples for

Organic carbon, POM, N, SAR, $CaCO_3$, CEC, etc

Dynamic soil properties through the transition from grass- to shrub-dominated systems



Effect of grass and shrubs on percent of precipitation that runs off

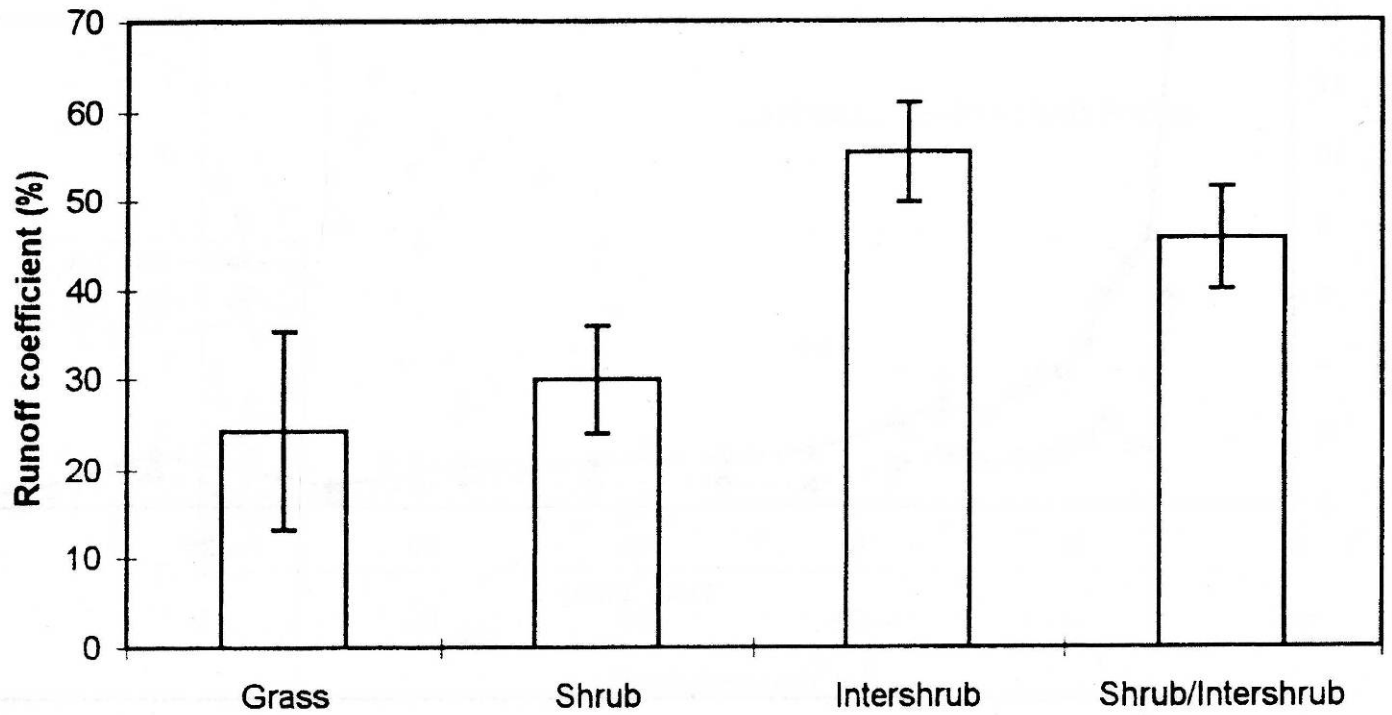
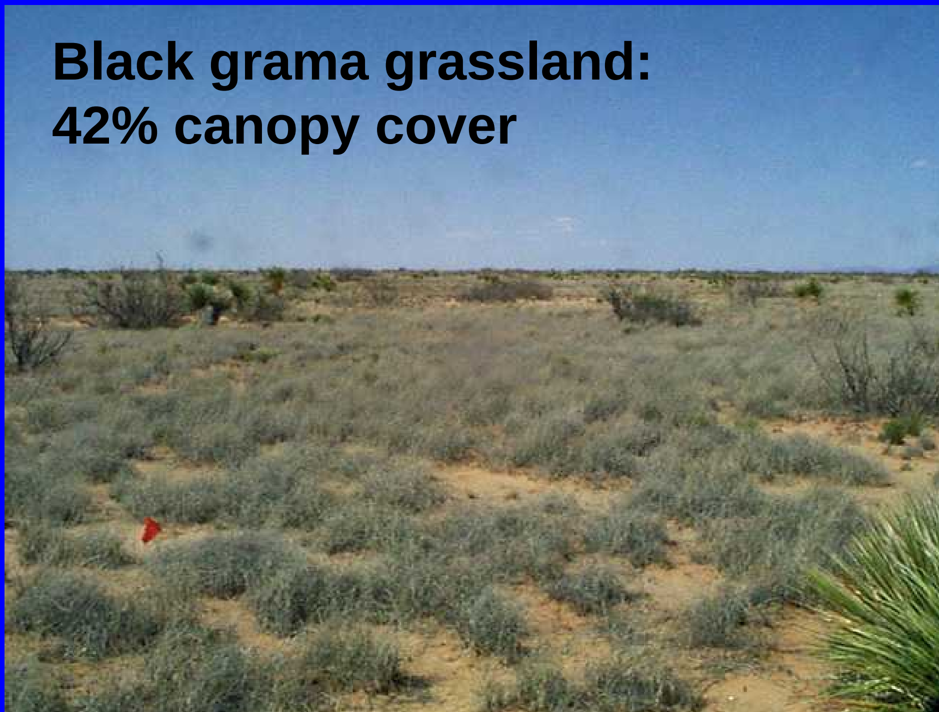
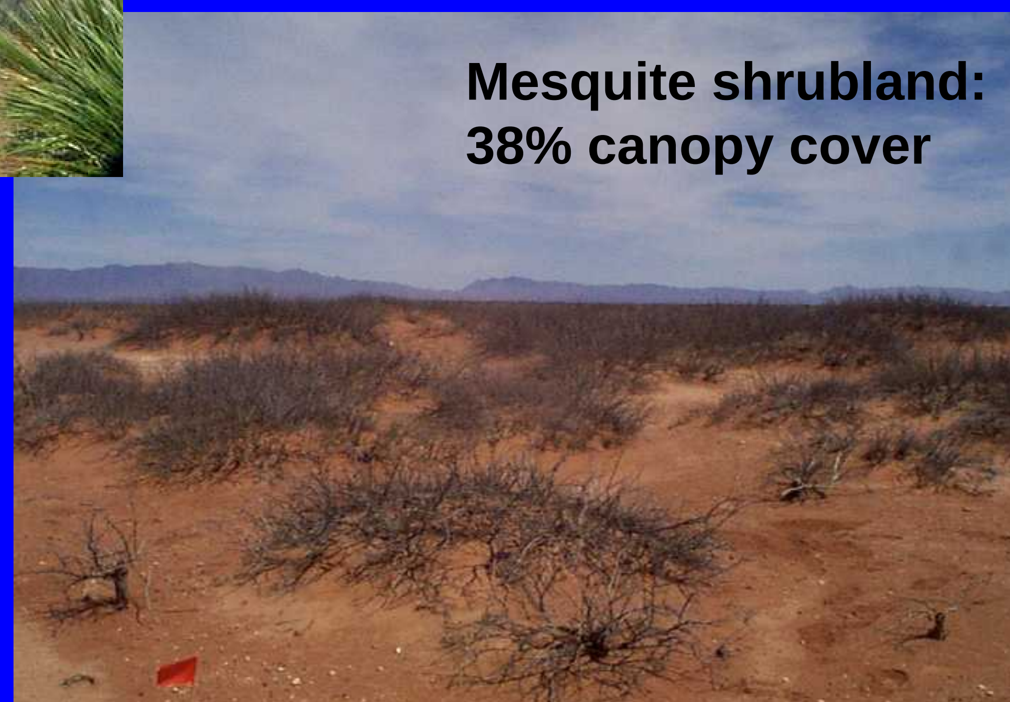


Figure 2. Runoff coefficient (Discharge/precipitation × 100% ± S.D.) for field plots used for rainfall simulation experiments. Shrub/intershrub is the estimated discharge from shrublands, obtained by weighting the relative shrub (38%) and intershrub (62%) cover on the landscape.

Schlesinger et al., 1999

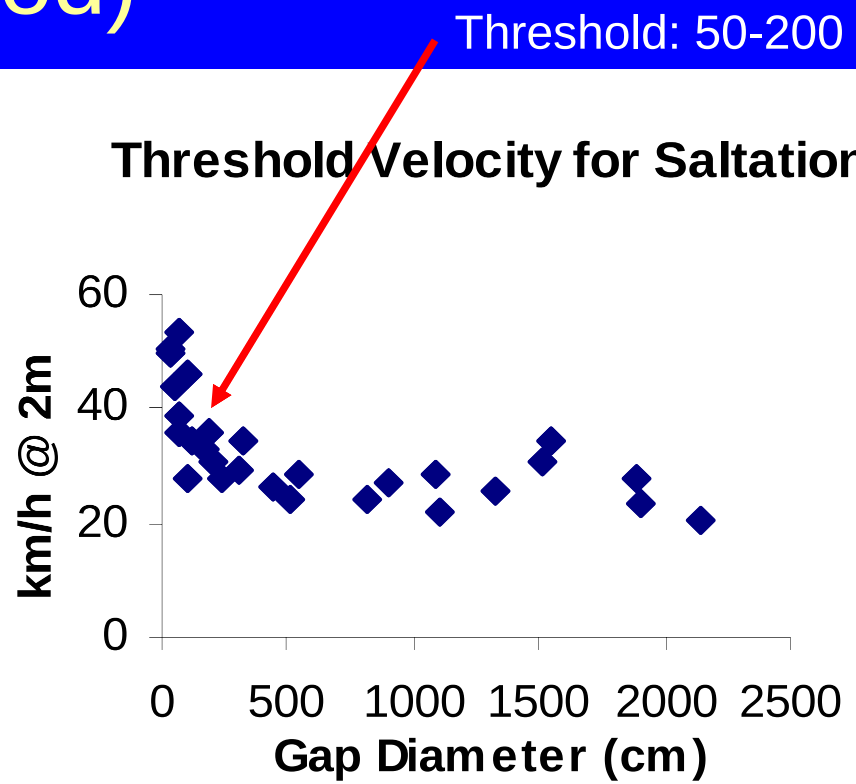
Sandy Site: bare ground and gap size affect erosion

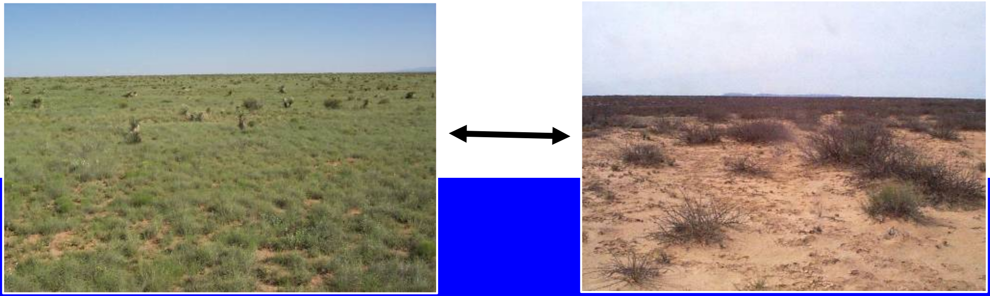




Calibration example (gap intercept method)

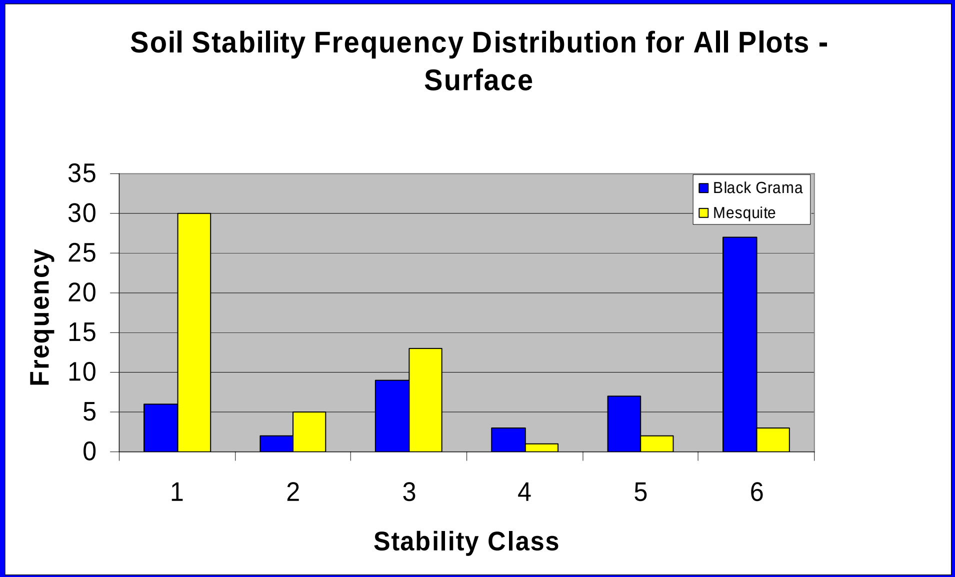
Wind erosion thresholds are often crossed during shrub invasion as gap sizes increase

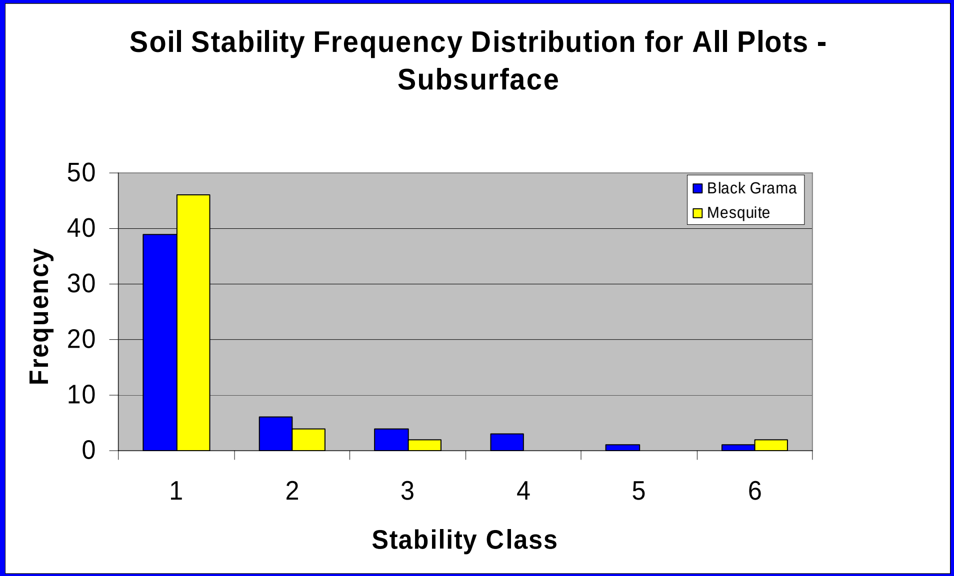


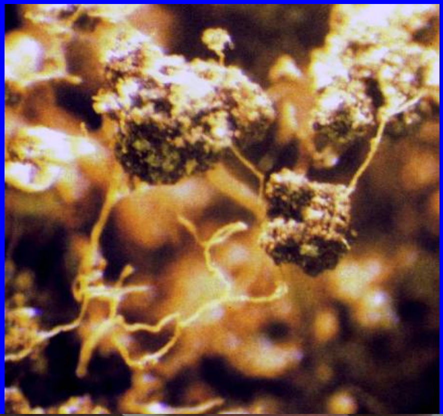


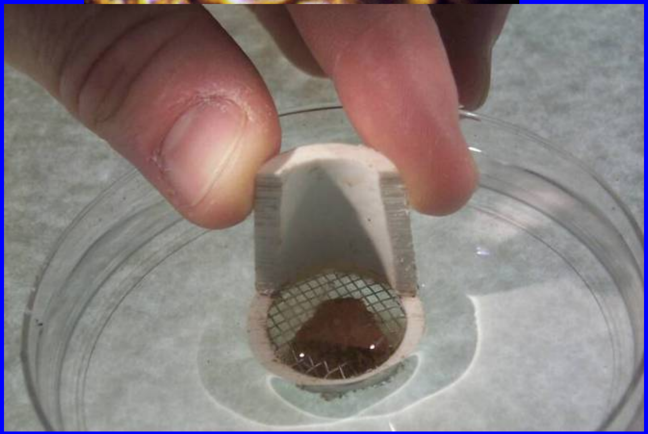
Herrick, per comm.

Soil aggregate stability, field





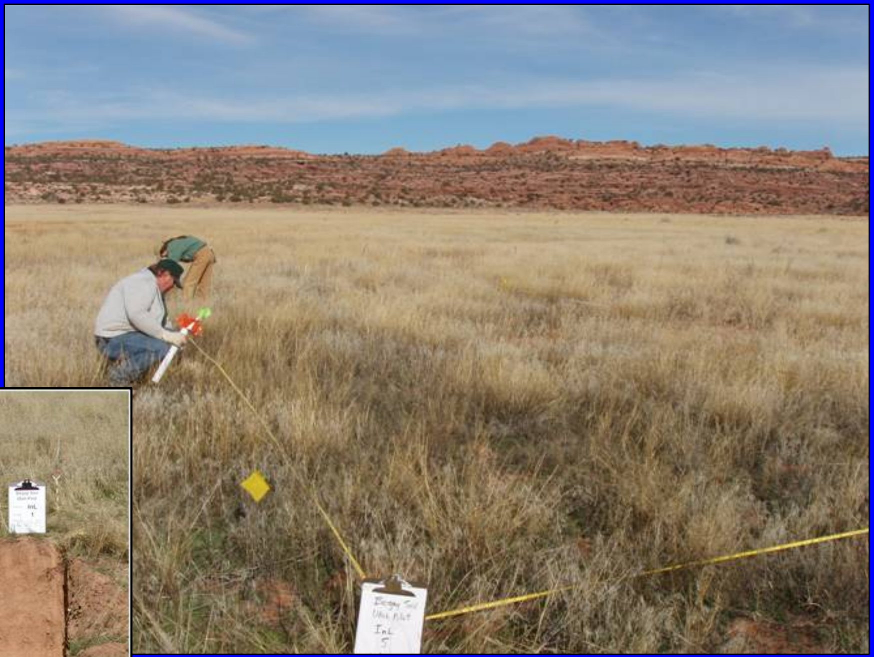




Semi-desert sandy loam (Fourwing Saltbush), MLRA 35 Utah, Arches National Park

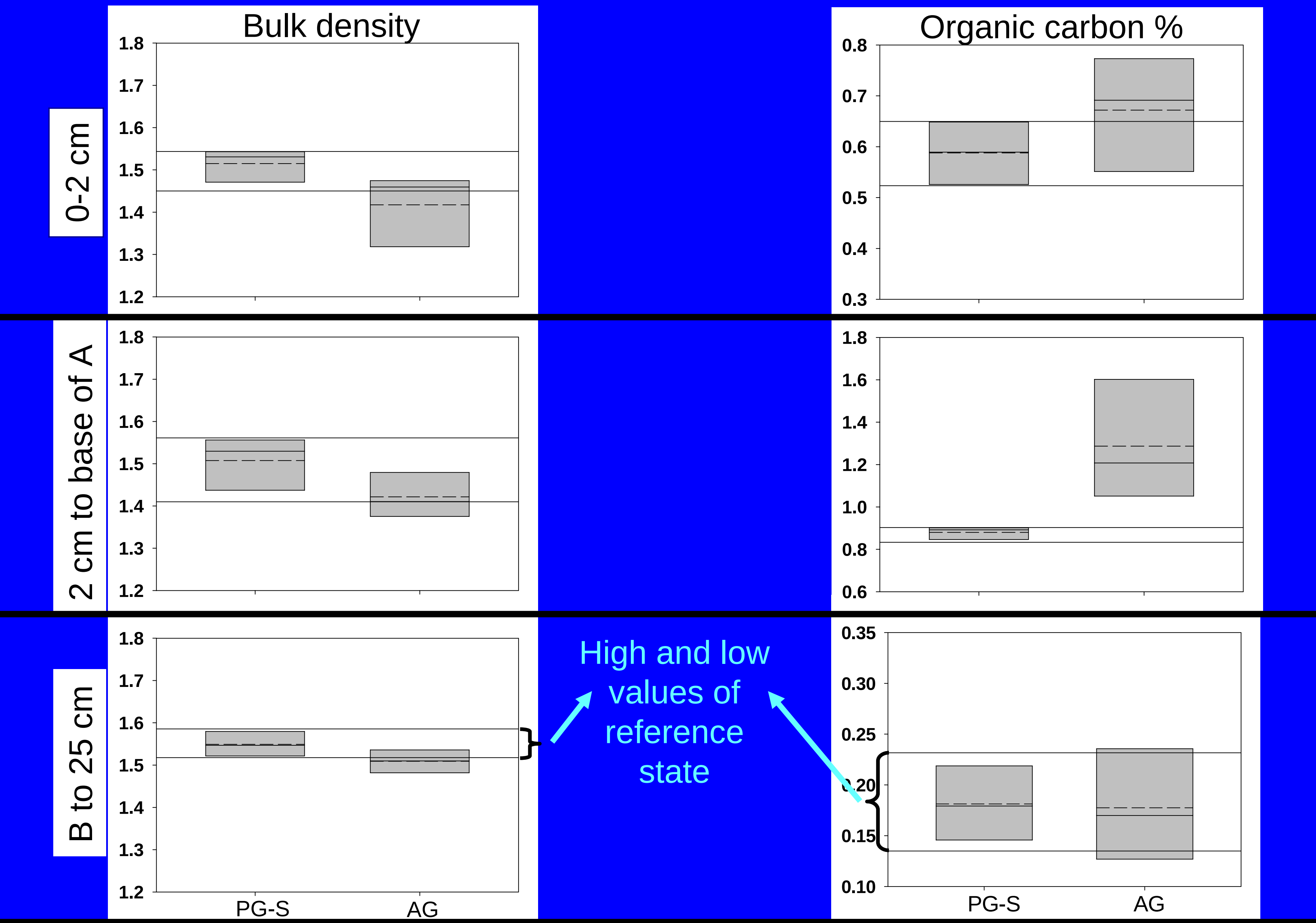
Annual grass invasion

Mixed perennial grass/shrub community



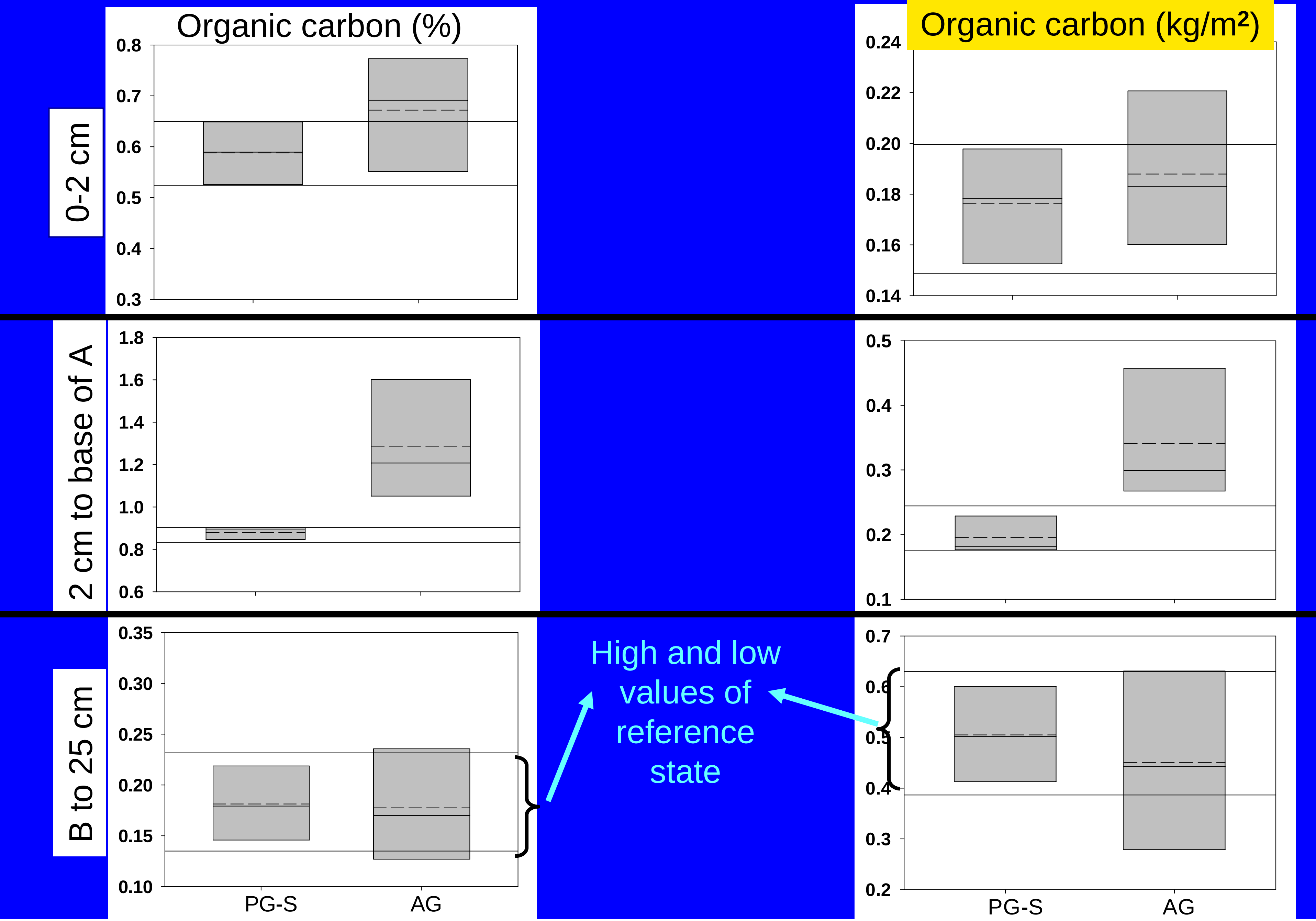
Annual grass invaded (cheatgrass) community

•Begay fsl, 1-6% slopes (Coarse-loamy, mixed, superactive, mesic Ustic Haplocambid)



PG-S = perennial grass-shrub sub-state; AG = Annual grass (cheat grass) sub-state; n=4

——— = Median – – – – – = Mean



PG-S = perennial grass-shrub sub-state; AG = Annual grass (cheat grass) sub-state; n=4

——— = Median – – – – – = Mean

Summary

1. Inherent soil and landscape features help differentiate sites and reflect differences in soil behavior important for management.

2. Sites with different soil properties can respond differently to the same disturbance (wind erosion on sandy vs loamy).

3. Grass fragmentation and displacement of shrubs affects surface hydrology, soil-water relations, susceptibility to erosion, and erosion (run-off, AWC, soil stability, etc.

4. Invasive grasses can alter the soil rooting environment (bulk density, SOM, etc)

Conclusions

1. We need to move forward cautiously with dynamic soil properties until critical requirements are addressed:
   a. Clearly defined plant communities within states.
   b. Soil property spatial variability and sampling techniques at plot and landscape scales.
   c. Scale of disturbance.
   d. Reliability—How confident do we need to be? 95%? 80%?

2. Because of the shear magnitude of the workload, we need a new paradigm: data collection for benchmark soils* within benchmark ESD's.

*A benchmark soil is extensive and/or important.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