Part I. Ecological Sites and Soil Survey

Part II. A Framework for Soil and Vegetation Dynamics

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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, CaCO3
- 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.

Constructional* and down-wearing

Down-wearing**

Slope percent and length affect these processes

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

Decades = management time scale
Decades to centuries = recovery time scale

Soil quality indicators are dynamic soil properties

Redrawn from Hibbard, 1995
Quantitative soil measures

Samples for

Organic carbon, POM, N, SAR, CaCO$_3$, CEC, etc
Dynamic soil properties through the transition from grass- to shrub-dominated systems

- Grass displaced by shrubs
- Soil surface organic matter decreases and size of bare spaces increases
- Aggregate stability and resistance to erosion decrease
- Topsoil and fertility lost, infiltration decreases and soil water decreases

Loamy Site
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

Black grama grassland: 42% canopy cover

Mesquite shrubland: 38% canopy cover
Calibration example (gap intercept method)

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

Threshold: 50-200 km/h @ 2m

Herrick, per comm.
Soil aggregate stability, field

Soil Stability Frequency Distribution for All Plots - Surface

Soil Stability Frequency Distribution for All Plots - Subsurface
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)
Bulk density

Organic carbon %

0-2 cm

2 cm to base of A

B to 25 cm

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

--- = Median  ----- = Mean

High and low values of reference state
Organic carbon (%)

0-2 cm

2 cm to base of A

B to 25 cm

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

--- = Median  --- = Mean

High and low values of reference state
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.