Common Ground: Engaging Basic Soil Science for Ecosystem Restoration

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Soil Knowledge
Aggregation>

degradation
formation
texture
structure
aggregates
macro/micropores
moisture
organic matter
healing
Barriers to Soil Recovery

Transition threshold controlled by biotic interactions

Recovery requires vegetation manipulation

Recovery only requires improved management of plant removal or damage

Transition threshold controlled by abiotic limitations

Recovery requires modification of the physical environment

Primary processes are fully functional

Primary processes are nonfunctional

Water capture efficiency

Energy capture efficiency

Nutrient retention efficiency

Resource flows captured by organic materials

Relative value of landform features in resource capture

Relative value of microtopographic features in resource capture
Soil Degradation Spiral

Prolonged loss of vegetative cover resulting in a crusted soil surface

- Increased erosion (decreased nutrient & water-holding capacity)
- Deteriorated soil structure
- Decreased biotic activity in soil
- Reduced fertility & soil organic matter
- Greater soil temperature extremes

- Decreased infiltration & increased runoff
- Reduced soil-water for plant growth
- Decreased plant production
- Decreased organic inputs to soil
ecosystem degradation

chronic suppression of native vegetation
climate change

Exposed soils erode
Invasives establish

Continued loss of native vegetation
Wider scale soil loss

Simplification of soil ecosystem
invasive dominance

Decreasing structural & functional complexity
Losing functional redundancy
Decreasing resilience & resistance

= disturbance

= ecosystem

= resilience
regenerating

stable

historical

continued disturbance

or

healing collaboration

projected

stable

degrading
Increasing resilience & resistance

- Install native vegetation
- Soil treatments
- Maintenance
- Supplemental planting
- Thinning

Gaining functional redundancy

Newly regenerated ecosystems have low resilience & resistance

Increasing structural & functional complexity
The Pedosphere
Soil Formation > Physical Weathering

Soil Formation > Chemical Weathering
Soil Forming Factors > CLORPT!

- Climate
- Organisms
- Relief (topography)
- Parent material (bedrock)
- Time
Soil Particles > Sand/Silt/Clay
Particle Size & Surface Area

\[ \text{SA (surface area)} = \# \text{ blocks} \times \text{SA of each block} \]
Clay is chemically active which makes it sticky. It tends to dominate soil texture even in small amounts. As little as 20% clay imparts a clay texture to a soil.
Structure – Aggregates/Peds

Macroaggregate
- Roots
- Hyphae

Microaggregate
- Root hairs
- Hyphae
- Polysaccharides

Submicroaggregate
- Mineral grains encrusted with plant and microbial debris
- Plant debris coated with clay

Primary particles
- of silt, clay and humus
- Clay and clay-humus domains

Fungal hyphae
- Root
- Spore

Silt encrusted with microbial debris
- Plant and microbial debris encrusted with clay

Clay-humus domains
- Microbial debris
- Iron oxides
- Water retention pores

AKA Ped
Structure – Aggregates/Peds

Soil Structure

Granular ➔ Blocky

Platy ➔ Massive ➔ Single grain

COMPACtion ➔ AGGREGATION

STRUCTURE IS CHANGEABLE!
Macropores > bulk movement of resources & organisms, root paths, habitat
Micropores > storage of resources, microbial habitat
Cation Exchange Capacity

Soil particle surrounded by film of water

Water available to plant

Air space

CLAY or HUMUS

Soil particle

K⁺

Cu²⁺

K⁺

Mg²⁺

Ca²⁺

H⁺

H₂O + CO₂ → H₂CO₃ → HCO₃⁻ + H⁺
Soil Water

**PWP**
Permanent Wilting Point

- **Hygroscopic water**
  - Remaining water adheres to soil particles and is unavailable to plants

**FC**
Field Capacity

- **Capillary water**
  - Water held in micropores
  - Available water-plant roots can absorb this

**SWC**
Saturated Wet Conditions

- **Gravitational water**
  - Drains out of the root zone

Available water for plant growth

Field capacity

Wilting point
Soil Water Movement: Gravitational & Capillary
Soil Matric Forces

matric forces!
capillary
osmotic
hygroscopic
Plant Guts!
AKA
The Rhizosphere
Inhale Death, Exhale Life
Soil Food Web > Constellation of Collaboration
Stone Soup > Soil Ecosystem Evolution
O Horizon

Cold, wet forest ecosystem

Warm, wet grassland ecosystem
Functions of Humus

- Improves plant growth.
- Brownish/black colour absorbs heat.
- Binds tiny soil particles. Improves soil structure. **AGGREGATION!**
- Has high water holding ability.
- Good at storing nutrients.
- Useful for micro-organisms.
Humus

active/labile humus > ‘soft & simple’ cellular tissues, starches, sugars, short polysaccharides
stable/resistant humus > ‘tough & complex’ structural tissues, lignin, cellulose, waxes, resins
<table>
<thead>
<tr>
<th>CROP RESIDUES</th>
<th>PARTICULATE ORGANIC CARBON</th>
<th>HUMUS CARBON</th>
<th>RECALCITRANT ORGANIC CARBON</th>
</tr>
</thead>
<tbody>
<tr>
<td>labile</td>
<td>labile</td>
<td>resistant</td>
<td>inert</td>
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**Organic material becomes more decomposed**
- weeks to years
- years to decades
- decades to centuries
- centuries to millennia

**C:N:P ratio decreases and material becomes more nutrient rich**

**Active/labile humus** > readily available carbohydrates & nutrients

**Stable/resistant humus** > aggregates, water retention, CEC, carbohydrate/nutrient reserves

**States of Humus**
Key Soil Healing Goals >

- stop disturbance & stabilize
- manage a/biotic barriers
- provide & place OM like ecosystems do
- establish & nurture primary producers & decomposers
- promote aggregation for complex macro/micropore structure
- collaborate with the soil ecosystem to build resilience & repair functions

_become a soil organism!_