Soil Structure and Macropores As Indicators of Rangeland Soil Health

Outline

1. Land Use History
2. Soil Function:
   Determines Soil Health
3. Soil Properties & Thresholds:
   Compaction and Infiltration
4. Indicators:
   Soil Structure & Macropores
5. Monitoring:
   Field Form
6. Management:
   Response to Exceeded Thresholds

Land Use History

- Dryland Flax & Small Grains
- Tillage with heavy offset disk to maximum depth of 7" (18 cm)

Effects of Tillage on Soil

- Plow pan of massive soil structure immediately below maximum depth of tillage
- Degradation of soil structure and macropores
- Erosion of soil including formation of gullies
- Reduction in soil organic matter

Healthy Soils Perform These Functions

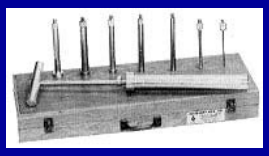
- Stable Habitat for Plants & Microbes
- Regulate Water
- Filter Pollutants
- Cycle Nutrients

Effect of Compaction & Infiltration on Soil Functions

	Soil Functions			
Soil Property	**Stable Habitat for Plants & Microbes**	**Regulate Water**	**Filter Pollutants**	**Cycle Nutrients**
Compaction	Restricts root penetration			
	May reduce plant health and production			
		Reduces infiltration and percolation to recharge ground water		
	May increase soil erosion by water running off steeper slopes	Increases runoff	Excessive runoff may transport pollutants to surface water	Excessive runoff may transport nutrients to surface water
		Reduces water storage capacity		
Infiltration		Reduces runoff so more water is stored in soil		
		Reduces soil erosion		
			Excessive percolation may leach pollutants to ground water	Excessive percolation may leach nutrients to ground water

Measurements of Soil Compaction		
Method	**Precision**	**Standard**
Bulk Density Core	**Quantitative**	**ASA 30-2**
Proctor Penetrometer	**Quantitative when calibrated for soil and moisture**	**ASA 37-3**
Pocket Penetrometer	**Quantitative when calibrated for soil and moisture**	**ASA 37-2**
Metal Rod	**Relative**	**SQTK**
Inspect Distribution of Roots in Soil Profile	**Visual**	**SQTK**

Measurements of Soil Compaction

Soil Compaction Thresholds *Effect of Bulk Density on Root Growth*			
	Ideal bulk densities	**Bulk densities that may affect root growth**	**Bulk densities that restrict root growth**
Soil Texture	**g/cm³**		
Sands, loamy sands	< 1.60	1.69	> 1.80
sandy loams, loams	< 1.40	1.63	> 1.80
sandy clay loams, loams, clay loams	< 1.40	1.3	> 1.75
silts, silt loams	< 1.30	1.6	> 1.75
silt loams, silty clay loams	< 1.40	1.55	> 1.65
sandy clays, silty clays, some clay loams (35-45% clay)	< 1.10	1.49	> 1.58
clays (>45% clay)	< 1.10	1.39	> 1.47
Source: USDA-NRCS Soil Quality Test Kit Guide, August 1999, p. 57.			

Measurement of Soil Infiltration (Ksat)		
Method	**Precision**	**Standard**
Double Ring Infiltrometer	**Quantitative**	**ASTM D3385**
Infiltration Test	**Relative**	**SQTK**
Inspect Soil Structure and Macropores in Soil Profile	**Visual**	**SQTK**

Measurements of Infiltration



Soil Infiltration Thresholds *Typical Soil Permeability (Ksat) Related to Soil Texture*				
		Permeability (Ksat)		
Soil Texture	**% Clay**	**Class**	**Inches/ Hour**	**um/sec**
Coarse Sand	<= 8	**Very Rapid**	20 - 60	141 - 423
Coarse Sand	> 8	**Rapid**	6 - < 20	42 - 141
Sand, Fine Sand, Very Fine Sand				
Loamy Coarse Sand, Loamy Sand, Loamy Fine Sand	<= 8			
Loamy Coarse Sand, Loamy Sand, Loamy Fine Sand	> 8	**Moderately Rapid**	2 - < 6	14 - 42
Loamy Very Fine Sand				
Coarse Sandy Loam, Sandy Loam, Fine Sandy Loam	<= 12			
Coarse Sandy Loam, Sandy Loam, Fine Sandy Loam	> 12	**Moderate**	.6 - < 2	4 - 14
Very Fine Sandy Loam				
Loam, Silt Loam, Silt				
Sandy Clay Loam	<= 30			
Sandy Clay Loam	> 30	**Moderately Slow**	0.2 - < 0.6	1.4 - 4
Clay Loam, Silty Clay Loam	<= 35			
Sandy Clay	<= 40			
Clay Loam, Silty Clay Loam	> 35	**Slow**	.06 - < .2	0.4 - 1.4
Sandy Clay	> 40			
Silty Clay				
Clay	< 60			

Soil Structure & Macropores as Indicators of Soil Health

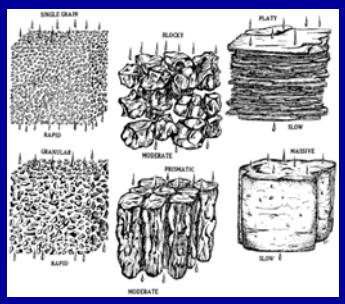
Emphasizes

1. Stability Against Erosion
2. Compaction
3. Infiltration & Permeability

Thresholds for Soil Structure

- Type
- Grade
- Size

Soil Structure: Type



Soil Structure: Grade

- Weak: barely observable in place or in hand
- Moderate: evident in place or in hand
- Strong: distinct in place, separates cleanly in hand

Thresholds for Macropores

- Abundance
- Continuity

Macropores

- Preferential Flow Paths between Aggregates

Limitations of these Indicators

- Soil structure and macropores may be difficult to observe in soils that swell at higher moisture content. These features may be more evident in the fall.
- Some soils have inherent structure that limits its performance and may not be improved by management. Monitoring should not penalize these soils.

Rangeland Soil Health Indicator (Field Form)

Ranch: *Winding Brook Ranch*	Location: *Northeast pasture, 100' south of windmill*
Observer: *Ken Oster*	Date: *1/10/2008*

Soil Layer	Depth	Structure			Macropores (Space between Aggregates)		Rating
		Type of Aggregate	Grade	Size	Abundance	Continuity	
Surface	0-10 cm	*Granular*	*Strong*	*1 to 5 mm*	*> 5/dm²*	*5 to 15 cm*	*Satisfactory*
Subsoil	10-20 cm	*Angular Blocky*	*Moderate*	*> 5 mm*	*2 to 5/dm²*	*5 to 15 cm*	*Satisfactory*
Choices		Angular Blocky Granular Subangular Blocky	Strong	> 5 mm	> 5/dm²	> 15 cm	Superior
		Columnar Prismatic Single Grain, Sand Wedge	Moderate	1 to 5 mm	2 to 5/dm²	5 to 15 cm	Satisfactory
		Massive Platy Single Grain, Not Sand Surface Crust	Weak	< 1 mm	> 5/dm²	< 5 cm	Unsatisfactory

Protocol for Rangeland Soil Health Indicator

Step	Procedure
1	Select sites representative of soil and management.
2	Dig a small pit about 20 cm deep to expose a vertical cut in the soil.
3	Examine the soil structure both in place and in hand.
	For the surface layer (0-10 cm) and the subsoil (10-20 cm) do the following steps:
4	Record the soil type, grade and size.
	Type Angular Blocky: imperfect cubes with sharp angles Columnar: vertically elongated units with rounded, often bleached, tops Granular: imperfect spheres, usually sand sized Massive: cohesive mass Platy: horizontally flattened or compressed Prismatic: vertically elongated units with flat tops Single Grain: unconsolidated mass such as loose sand Subangular Blocky: imperfect cubes with rounded edges Surface Crust: surface covered with thin cohesive layer sealing out water Wedges: interlocking lenses that terminate in acute angles
	Grade Weak: barely observable in place or in hand Moderate: evident in place or in hand Strong: distinct in place, separates cleanly in hand
	Size See dimensions in table.
5	Record the abundance and continuity of macropores (spaces between aggregates). Consider macropores visible to the naked eye. See dimensions in table.
6	Assign the most limiting rating.

Response to Exceeded Thresholds

Management of Livestock & Vehicle Traffic

- Fence seasonally wet areas
- Delay use when soil is wet and vulnerable
- Use trails

Management of Vegetation

- Favor plants with tap roots
- Favor deep rooted perennials

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