

Sun to Snow Soil Solutions

Health:

- 1. a: the condition of being sound in body, mind, or spirit; especially: freedom from physical disease or pain;
- b: the general condition of the body <in poor health> <enjoys good health>
- 2. a: flourishing condition : <u>well-being</u> <defending the health of the beloved oceans — Peter Wilkinson>
- b: general condition or state <poor economic health>
- 3. : a toast to someone's health or prosperity – (Merriam Webster)

Origin: Old English hælth, of Germanic origin; related to whole. (Oxford dictionary, with a nod to Wendell Berry and Dr. Guy Jodarski)

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HEALTHY SOIL



Soil Physical Characteristics

- Texture (% sand, silt, clay)
- Structure (aggregation and aggregate stability)
- Porosity
- Color (humus, drainage)
- Organic matter content (macro and decomposing)
- Infiltration/ aeration
- Compaction/bulk density
- Water holding capacity
- Bearing strength

The importance of structure

- Structure = aggregation: grouping soil particles
- Protects soil minerals, organic matter, nutrients, and water
- Good aggregation = high porosity
- High porosity = good water and air movement, root development, and biological diversity



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Forming and stabilizing soil aggregates

 Plant roots and soil fauna start the aggregation process. Calcium helps to aggregate clay (smallest particles), followed by macro-aggregates being glued together by mycorrhizal exudates (glomalin) and bacterial secretions, fungal hyphae, and root hair bonding.





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Aggregation is a biological process

- · Luxuriant plant growth and turnover
- Healthy and abundant supporting biology:
 - Earthworms, arthropods, bacteria, fungi, nematodes, actinomycetes, protozoa, etc.
 - Almost all other organisms in the soil depend on either living plants or fresh organic matter produced by plants.
 - Living plants or recently dead
 - Must be replaced continuously!

Practices that harm structure

- Tillage—any sort.
- Too little fresh OM going into the soil.
- Bare ground (no mulch or crop on top of soil).
- No living crops (no roots in the soil).
- Soluble fertilizers without concurrent addition of carbon rich vegetation, mulches, or composts.



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- Beneficial plant nutrients (selenium, sodium, silicon, ???)
- Other nutrients needed by organisms other than plants—too many to mention. For:
 - Microbes
 - Earthworms, arthropods
 - Livestock
 - -People!





Some biological tools and concepts

- Fostering interactions between the physical, chemical, and biological realms of the soil
- Increasing species abundance and diversity
- Enhancing biological nitrogen fixation – Legume-associated and free living
- Enhancing rooting density/ depth/ pattern
- Promoting and protecting mycorrhizae
- Managing soil fertility and plant nutrition

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Soil biology and organic matter

- Three main categories of soil organic matter:
 - living
 - recently dead
 - long dead
- Living and recently dead: Fuel for the soil foodweb
- Long dead: humus (water and nutrient holding)
- It's all good, but for different reasons—get as much as you can.
 - (your soil type will automatically limit this, but very few agricultural soils are at their practical upper end)

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The biological health of the soil affects:

- Structure (aggregation and aggregate stability)
- Porosity
- Color (humus, drainage)
- Organic matter content (macro and decomposing)
- Infiltration/ aeration
- Compaction/bulk density
- Nutrient dynamics: acquisition, absorption, cycling
- Plant health
- Feed/ food quality





A Quantitative Study



Table 1. Roots

Root Categories	Number of roots per unit*	Total number of roots by categories	Average length (inches)	Total root length by categories (feet)	Total root surface, by categories (sq. feet)
Main	1.0	143	18.0	214.50	1.53
Secondary	249.0	35,607	6.0	17,803.50	45.06
Tertiary	16,060.5	2,296,651	3.0	574,162.75	758.60
Quaternary	80,302.6	11,483,271	1.5	1,452,075.60	1,748.90
TOTALS	97,613.1	13,815,672		2,044,256.50	2,554.09

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Nutrient availability and cycling

- "Decomposition" of organic residues:
 - Mineralizes nutrients
 - Creates humus
- Biological nitrogen fixation
 - Symbiotic
 - Autotrophic (free living)
- Mycorrhizal associations
 - Phosphorus, micronutrients
 - Nitrogen transfer
 - Plant communication
 - Pre-assembled complex organic molecules within plants





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One goal for improving soil health: Develop a Disease-suppressive soil

 Suppressive soil: Pathogen fails to persist or cause infection despite presence of susceptible host and favorable environment

- 1st documented in late 1880's
- * Since been observed in multiple pathosystems worldwide



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Mechanisms of suppression:

- Competition:
 - Beneficial microbes occupy niches on plant root surfaces to fight pathogens and help acquire nutrients
- Antibiosis:
 - Production of antimicrobial metabolites that are detrimental to pathogens and that trigger defensive capacity in plants
- Predation & Parasitism
- Induced systemic resistance (pathogens and insect herbivores)
- Improved resource acquisition (example: mycorrhizae)
 (Source: Dr. Lori Hoagland, Purdue University)

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