

Dr. Sara Via, UMD svia@umd.edu,
Please don't use slides without permission

June 17, 2020

**Healthy Soil,
Healthy Plants,
Healthy Planet**

Dr. Sara Via
Professor & Climate
Extension Specialist
svia@umd.edu

Source: Modern Farmer

6

North American Soils Before Europeans

- Native soils in forests & prairies -- peak soil health
- High organic matter, deep roots, good soil structure
- Great water infiltration & water quality, flooding & erosion rare
- Very high biodiversity in the soil
- Soil ecosystem in balance

Then came the Europeans....

7

Deep roots of prairie plants built rich topsoil of Midwest

- deep, dense roots hold the soil & prevent erosion
- prairie topsoil was > 4' deep, now 6-8"
- more than half the organic matter of North American soil is gone after 150 years of agriculture

Dr. Jerry Glover w/
Compass plant,
Big Bluestem,
Indiangrass

National Geographic 2015

8

The Dust Bowl (1930s)
A major wake-up call about unsustainable behavior

- Agriculture w/o understanding of how soil & water interact
- Continuous tillage & winter fallow left soil unprotected from erosion
- Some modifications made under the New Deal (1940s), but...

9

Modern agriculture continued to damage soil
Tillage, winter fallow, synthetic N fertilizer, heavy equipment

→ **erosion, compaction, loss of organic matter**

Eroded soil has crust, reduced infiltration and ability to purify water
Increases runoff & flood risk, reduces water quality

10

Strategies to rebuild the soil now spreading

- No-till:** less erosion, soil structure maintained, crop residue adds organic matter, soil drains better & holds more water, water filtered & cleaned
- Cover crops:** reduce erosion, living roots feed soil microbes
- Crop rotation:** increases diversity of plants & soil microbes

We can apply the same ideas to gardening & landscaping

11


Soil is Earth's second largest ecosystem

Healthy soil performs crucial ecosystem functions:

- **Physical support of plants**
- **Water storage, filtration & cycling:** Stable soil aggregates resist erosion, drain & hold water
- **Nutrient cycling:** Soil organisms decompose dead things to make nutrients available to plants
- **Provides habitat for biodiversity:** Healthy soil is diverse, & diversity stabilizes ecosystems

90% of ecosystem functions are driven by soil organisms!

Which organisms are the most abundant?



12

Microbes!




Friendly bacteria & fungi battle the unfriendly ones.




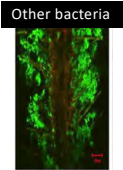
Microbes are

- crucial for healthy body
- AND healthy soil

13

The secret life of soil




- 1t soil contains >1 BILLION microbes
- **Plants give** up to 40% of the sugar they make from photosynthesis to soil bacteria & fungi
- **Plants get** nitrogen, water, nutrients, protection from diseases, predators & abiotic stress

14

Nitrogen-fixing Bacteria

- Some bacteria can take N_2 from air, make ammonia (NH_3)
- In legumes, make root nodules
- First N-fixing bacteria evolved about 2 billion years ago


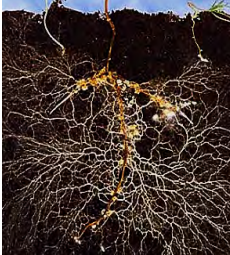
15

Mycorrhizae: Fungi that colonize plant roots

Aid plants in water, nutrient uptake - evolved at the same time as land plants (450 MY ago)

Mycorrhizae also

- Fight disease
- Combat plant stress
- Act as predators!
- Link plants, even different species

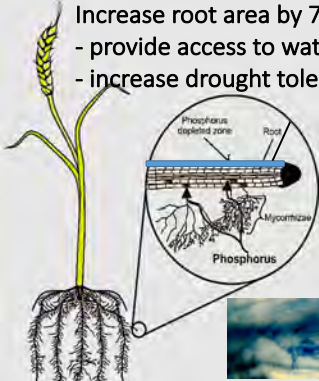

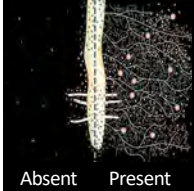



16

Up to 90% of all plants have mycorrhizae

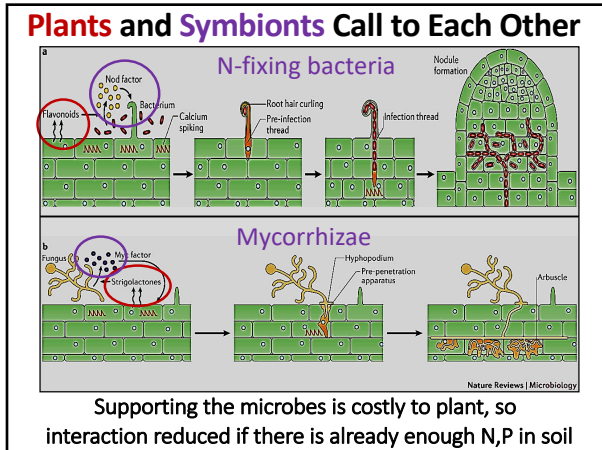
Increase root area by 700x

- provide access to water & nutrients,
- increase drought tolerance

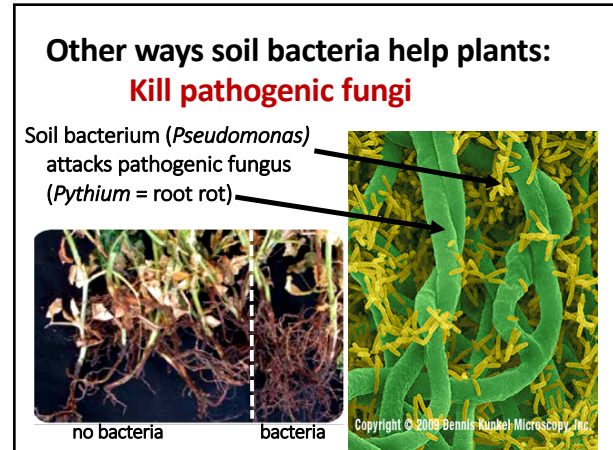




Absent Present

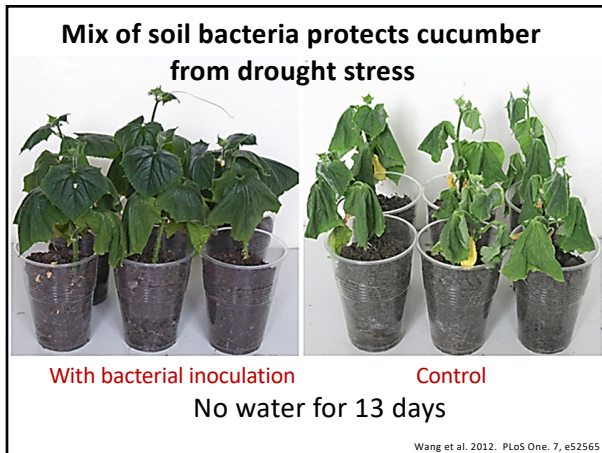
17



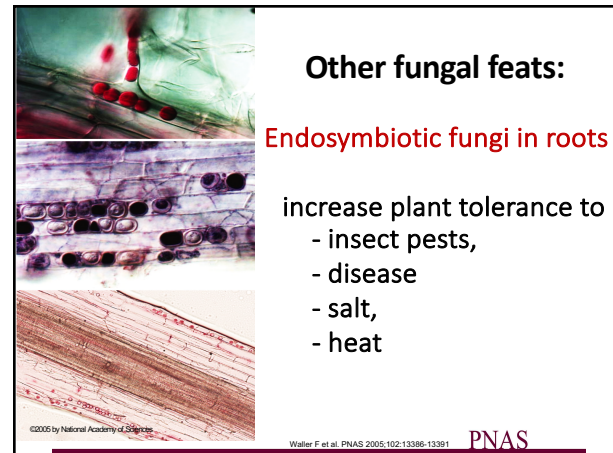
18



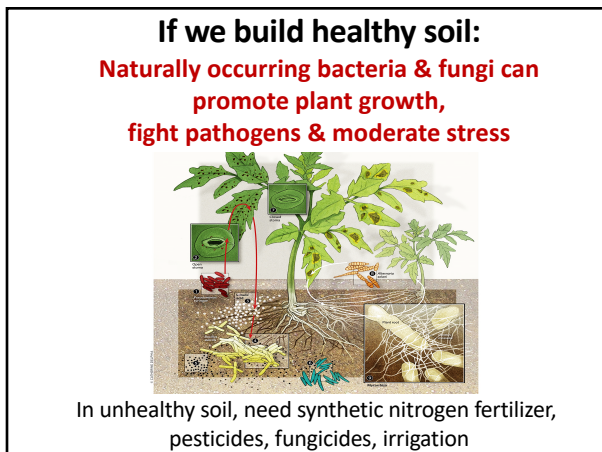
19



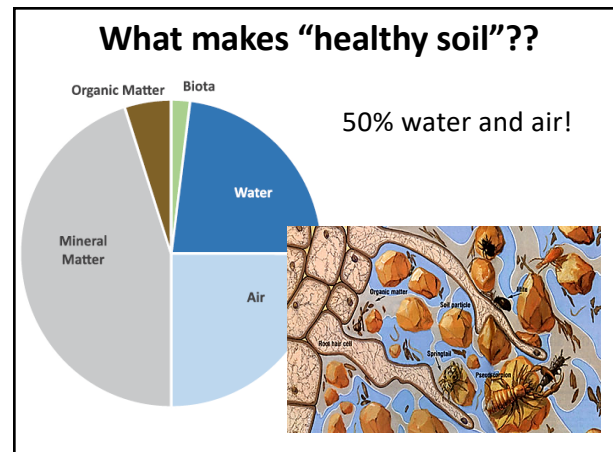
20



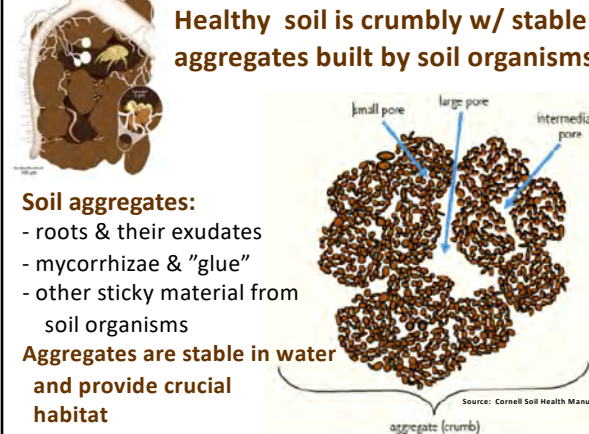
21



22



23



Healthy soil is crumbly w/ stable aggregates built by soil organisms

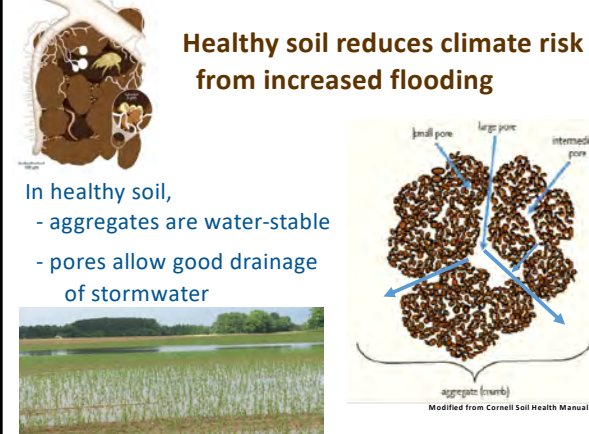
Soil aggregates:

- roots & their exudates
- mycorrhizae & "glue"
- other sticky material from soil organisms

Aggregates are stable in water and provide crucial habitat

Source: Cornell Soil Health Manual

24



Healthy soil reduces climate risk from increased flooding

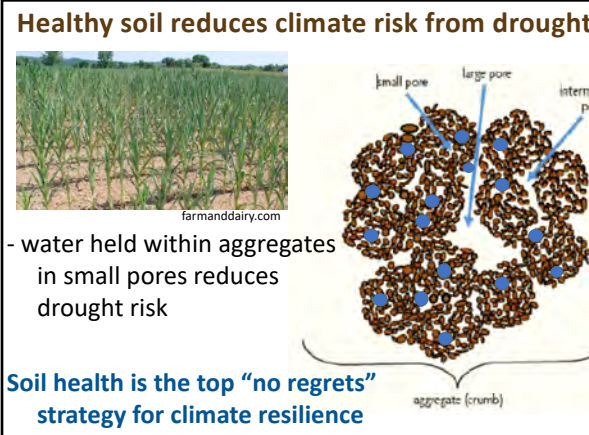
In healthy soil,

- aggregates are water-stable
- pores allow good drainage of stormwater

Modified from Cornell Soil Health Manual

Jim Lewis

25



Healthy soil reduces climate risk from drought




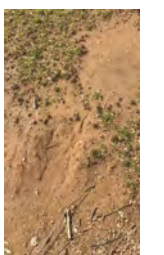
- water held within aggregates in small pores reduces drought risk

Soil health is the top "no regrets" strategy for climate resilience

farmanddairy.com

26

See the difference

Healthy	Unhealthy
	
	
Healthy soil co-benefit	overgrazed & eroded = continuous till
- protects water quality	
- helps control stormwater	

40-year meadow mowed 2-3 times/yr

27

What can we do to restore soil?



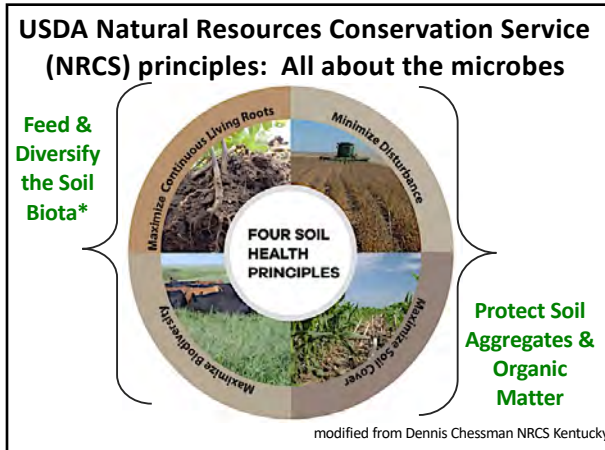
Mimic Nature!

28

Soil organisms know how to build soil— let them work!

1. Limit disturbance & inputs
2. Keep the soil covered
3. Increase diversity, rotate crops
4. Maintain live roots all year

29



30

1. Limit disturbance: Tilling

- breaks soil aggregates, destroys habitat
- increases runoff, water & nutrients lost
- increases water & wind erosion
- exposes protected organic matter to microbial decomposition (aerobic erosion)

31

Limit physical disturbance through compaction

Soil compaction from machinery or foot traffic reduces aeration and infiltration & crushes soil habitat

Lairland Farms u-pick strawberries: Tillage radishes planted between rows in fall to reduce compaction from foot traffic

Ray Weil

32

Use fertilizer & chemicals judiciously to protect microbes and the environment

Fertilizer can limit microbial action

- too much P: inhibits mycorrhizae
- too much N: inhibits N-fixers
- Excess N leads to N_2O emissions
- Synthetic fertilizer production very energy intensive

Chemicals & other additives

- impacts on microbes still uncertain
- even additives approved for organic can have an impact
- limit runoff into waterways

33

2. Keep soil covered to prevent erosion from rain and wind

~20 mph

<http://erieconserves.org/your-farm/crops/>

Can use plant residue or cover crops

34

3. Increase plant diversity with crop rotation and cover crop mixtures

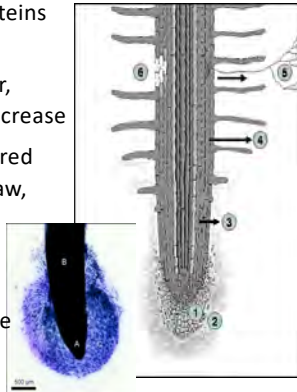
Helps manage nutrients, pests & diseases

More plant diversity, more microbial diversity

35

4. Maintain live roots to feed microbes

- Roots exude sugars & proteins that feed microbes
- If no live roots over winter, microbial populations decrease
- Winter cover crops preferred over crop residue (or straw, leaves)
- More diverse & healthier microbes means more healthier plants and more carbon sequestered



36

Is your soil healthy??

DIY quick check: Maryland soil health card

Indicator	Table		
	Poor	Medium	Good
Earthworms	0-1 worms in shovelful of top foot of soil. No casts or holes.	2-10 in shovelful. Few casts, holes, or worms.	10+ in top foot of soil. Lots of casts and holes in tilled clods. Birds behind tillage.
Organic Matter Color	Topsoil color similar to subsoil color.	Surface color closer to subsoil color.	Topsoil clearly defined, darker than subsoil.
Organic Matter Roots/Residue	No visible residue or roots	Some residue	Noticeable roots and residue
Subsurface Compaction	Wire breaks or bends when inserting flag.	Have to push hard, need fist to push flag in.	Flag goes in easily with fingers to twice the depth of plow layer.
Soil Tilt Mellowness Friability	Looks dead. Like brick or concrete, cloddy. Either blows apart or hard to pull drill through.	Somewhat cloddy, balls up, rough pulling seedbed.	Soil crumbles well, can slice through, like cutting butter. Spongy when you walk on it.
Erosion	Large gullies over 2 inches deep joined to others, thin or no topsoil, rapid run-off the color of soil.	Few rills or gullies, gullies up to two inches deep. Some swift runoff, colored water.	No gullies or rills, clear or no runoff.
Water Holding Capacity	Plant stress two days after a good rain.	Water runs out after a week or so.	Holds water for a long period of time without puddling.
Drainage, Infiltration	Water lays for a long time, evaporates more than drains, always very wet ground.	Water lays for short period of time, eventually drains.	No ponding, no runoff, water moves through soil steadily. Soil not too wet, not too dry.

July 15: What about suburban landscapes? Source: NRCS

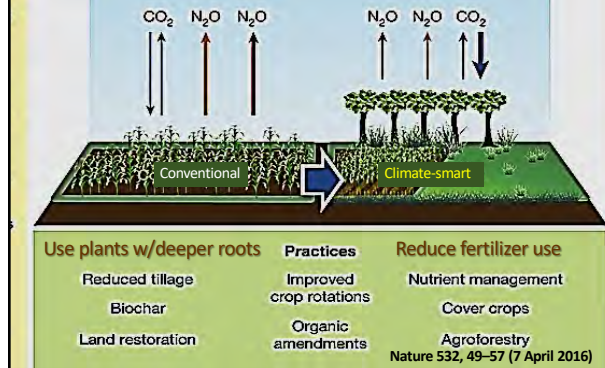
37

Multiple agricultural & ecosystem co-benefits from soil health practices



38

Healthy soils fight climate change by storing carbon



39



Contact me anytime with questions or comments!

Dr. Sara Via
Professor & Climate Extension Specialist
University of Maryland
svia@umd.edu

July 1: Regenerative Gardening!

40