Report from the Quivira Conference, Nov 11, 2015

Fundamentals of Soil by Dr Christine Jones

KEY TAKE AWAYS and important key facts

Tilling is VERY damaging to soil biology (especially M. fungi)

3 years seems to be a kind of "magic time point" for re-starting the biology. You will see positive changes over first 3 years, but after that, the changes and benefits really kick off. Not sure why.

Adding mulch to soil doesn't help NEARLY as much as improving photosynthesis and microbial activity (but is does help protect soil biology, hold water, feed microbes as it decomposes, and releases CO_2 as it decomposes that can feed plants if they are there)

Soil organic matter over 30% doesn't really help plant growth (more like peat) because it is plant material that isn't decomposing (meaning a LACK of microbial activity)

Biochar – not so helpful – better to focus on creating photosynthesis

Photosynthesis takes energy IN to plant.   So, you can tell the amount of photosynthesis going on by the TEMPERATURE of the plant.   The cooler it feels, the higher the Brix level, the higher the rate of photosynthesis.

Taste is a key indicator too. The sweeter the grass, the higher the photosynthesis rate

Humus is very difficult to study – take it out of the soil and it's all different.
If you can measure only 1 thing – measure carbon in soil (not static point, but how much is it increasing)

This presentation is really about Food.
Agriculture is mostly about Food production, and soil is the foundation of Agriculture

<u>Fundamental Problems with Agriculture & Food</u>

1.Nutrition in food very degraded:

Mineral depletion in vegetables 1940 - 1991
Average of 27 kinds of vegetables …
•Copper declined by 76%
•Calcium declined by 46%
•Iron declined by 27%
•Magnesium declined by 24%
•Potassium declined by 16%

Mineral depletion in meat 1940 - 1991
Average of 10 kinds of meat …
•Copper declined by 24%
•Calcium declined by 41%
•Iron declined by 54%
•Magnesium declined by 10%
•Potassium declined by 16%

Ref: David Thomas 'A study on the mineral depletion of the foods available to us as a nation over the period 1940 to 1991'. Nutrition and Health 2003; 17: 85-115

2. Why? 'Dilution Effect' (higher yield spreads out minerals available) is FALSE
There are PLENTY of minerals in soils (soil tests don't tell you what is really available to plants)
The reason there is less nutrition in food is because conventional practices have killed soil biology.

3. Chemical residues in food are 'double whammy' for health (toxins added to lack of nutrition) to soil, plants, and animals and humans
(70% of rainwater samples contain glyphosate)

What is Soil?

1.Weathered rock materials (sand/silt/clay) in contact with plant **roots**
If no green plants in soil, soil is dying (bare ground, soil is dying)
2.Green plants capture sunlight and CO_2 to make soil
photosynthesis + microbial re-synthesis = fertile topsoil
Photosynthesis = making life from light
Microbes create the enzymes, Enzymes break chemical bonds to "let loose" minerals
3. Without Microbes in soil, plants die
85-90% of plant nutrients is made available by MICROBES in soil
Can test plant with refractometer (15-20+ brix) to see how well it is photosynthesizing
High brix plants are sweeter to taste as well
This info is not new -- 1890s – first research into mycorrhizal fungi
1938 "No life without soil and no soil without life"
4. So, plants feed the microbes, with liquid carbon (sugars produced by photosynthesis)
In healthy system, ONE HALF of sugars produced by plant are exuded to feed microbes
One big problem with feeding chemical fertilizers, it stops plant from feeding microbes

Important Principles for Soil Health

1. LIVING Groundcover Matters

A. Build photosynthesis capacity
B. Enhance photosynthesis rate:
To measure: Brix (refractometer)
Temperature (cooler the plant leaf, higher photosynthesis rate
Taste – sweeter means higher photosynthesis rate
C. building topsoil is a BIOLOGICAL process
soil nutrient levels WITHIN root systems of plant are 2x – 4x higher than outside roots
(tests done ON SAND-VERY poor land)

-If you can only measure one thing – measure carbon/SOM (Soil Organic Matter)
- for nutrition of plant->animal->people
- for soil moisture holding capacity (soil moisture is often the limiting factor)

Example: Ian and Dianne Haggerty in Western Australia
Increased soil carbon 41.5%
Increased soil nitrogen 27.7% (equals 800 lbs/acre)
Increased soil water holding capacity 13%
Even more increase in carbon deeper

This was all done by:

- Keeping green plants in soil all year
- Stop adding chemical Nitrogen and Phosphorus
- Use earthworm leachate and compost extract to enhance soil biology
- Use grazing animals

Example: Colin Seis - Central West New South Wales
Land was awful – ground water so saline it killed trees… left only bare ground.
Planted salt resistant oats. Now has 70-80 perennial grasses, grazes with sheep (wool & meat)
Soil carbon increased 413% at 30-40 cm depth
Increase nitrogen 2,200 lbs/acre
Increase soil water holding capacity18,000 gallons/acre (2 buckets per square yard)
Increase in calcium – 177%
Increase in magnesium 38%
Increase trace elements: copper 102%, boron 56%, selenium 17%
Increase brix of wheat from 2or3 up to low 20s
Has fungal ratio 15x that of bacteria!
This was done by:

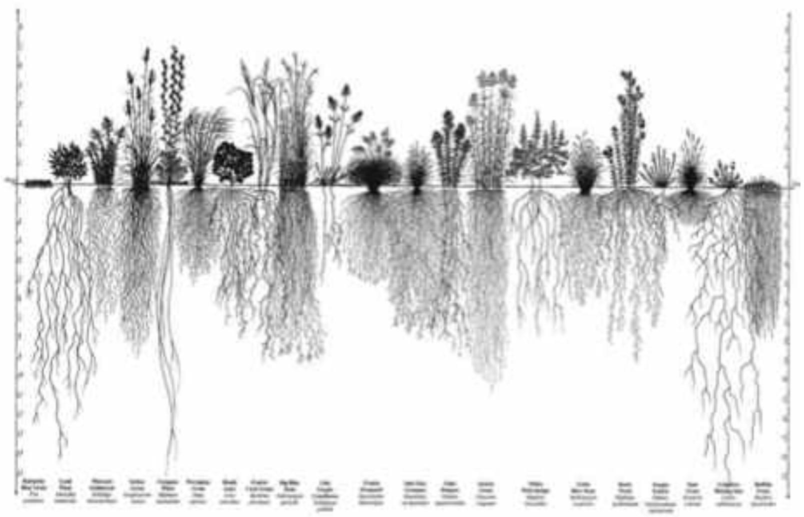
- No fertilizer - Planned grazing, using animals to apply biology and fertilizer
- Green plants all year
- Reducing chemical fertilizers and eliminating fungicides and insecticides (cides kill biology)

2. Grazing Management Matters

Leaf area removed related to root die off (as above, so below)
Too severe grazing or re-grazing before full plant root recovery = kills roots AND kills microbes
Properly managed grazing INCREASES soil biology and builds topsoil
Methane not an issue in properly grazed lands (soil microbes 'eat' methane, methantropes) net methane sink (forests and wetlands and elephants produce a lot of methane too)
CANNOT GET OPTIMAL SOIL HEALTH WITHOUT SOME KIND OF ANIMAL IMPACT

3. Diversity Matters

A. Different plant have different root structure



Gabe Brown's 'chaos garden'

B. Diversity of plants & roots creates diversity of soil microbes

If there's enough diversity, ALL of the plant's nutritional requirements are met by soil microbes

C3 plants (clovers, cool season, rye grass)

C4 plants (warm season grasses – more water efficient, exude more carbon into soil than C3

Example: Gabe Brown

17 species cover crops (no Nitrogen applied, but still higher yield)

If not higher yield, then higher quality grain crop (more money per bushel)

4. <u>Microbes Matter</u>

Importance of mycorrhizal fungi: Fungi are the highway and internet of soil

Fungi grow INTO plant roots; extend reach of plant roots

Incredibly amazing system of communication between microbes and plant roots

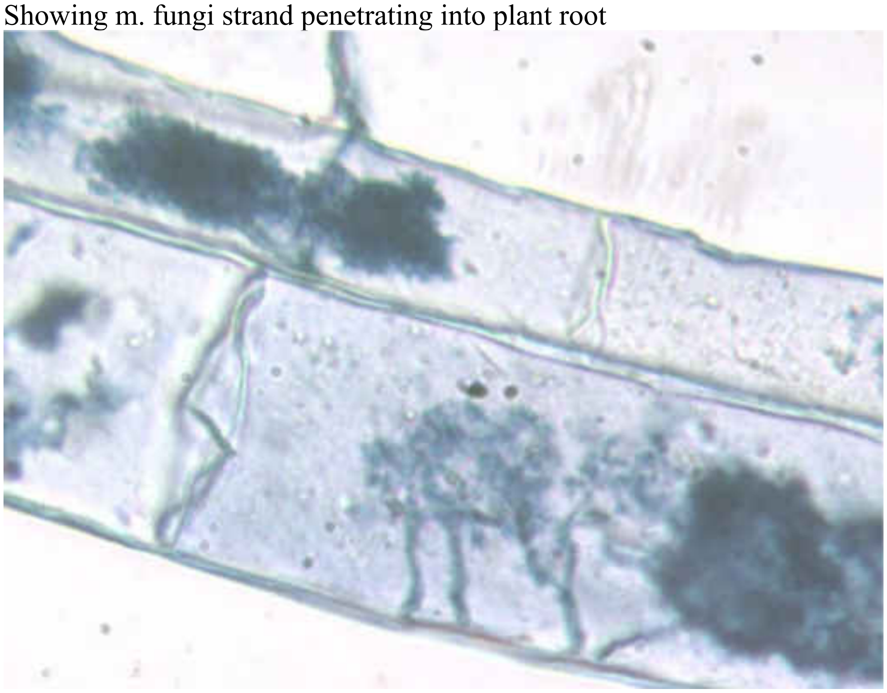
Some plants don't use M. fungi (cultivars – WE have created these plants by creating cultivars in dead soil using chemical inputs – creating chemical dependent plants)

Weeds are plants that don't need fungi – release acids to dissolve minerals

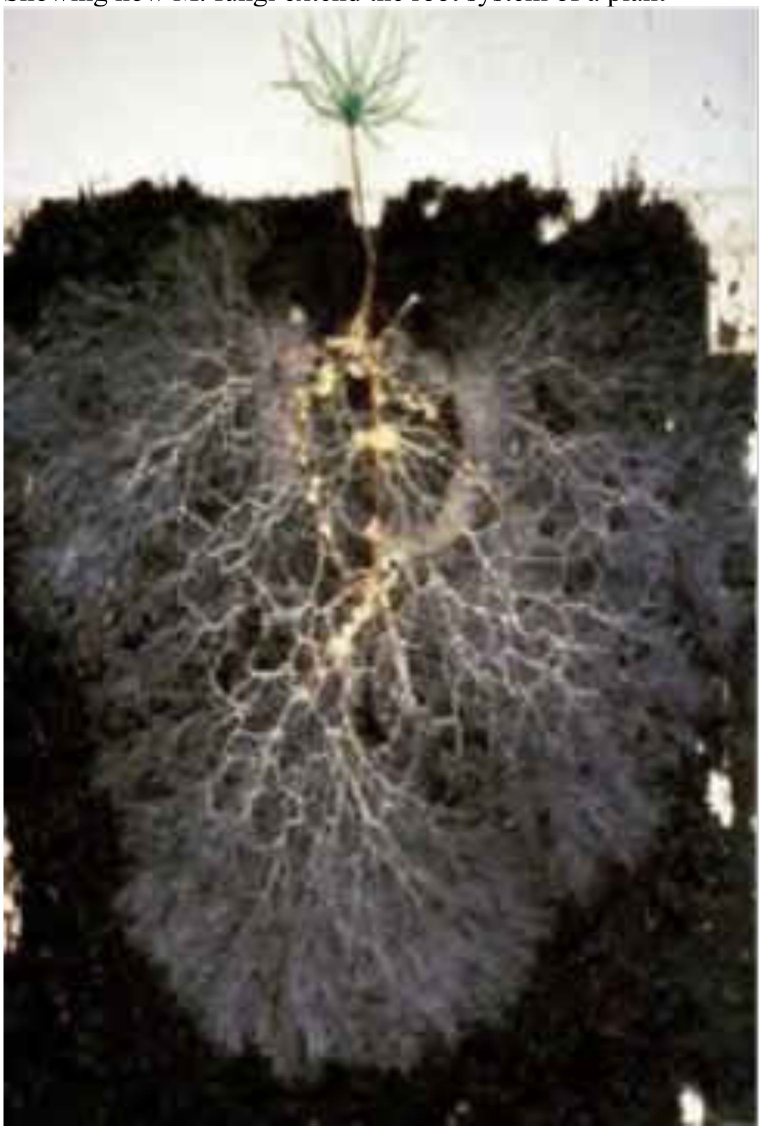
Microbes create “rhizo sheath’ which fixes nitrogen for plant, and is communication pathway for plants
Bacterial colonies out at the end of M. fungi network provide energy to entire web.

Picture of roots with rhizo-sheaths’ covered in macroaggregates

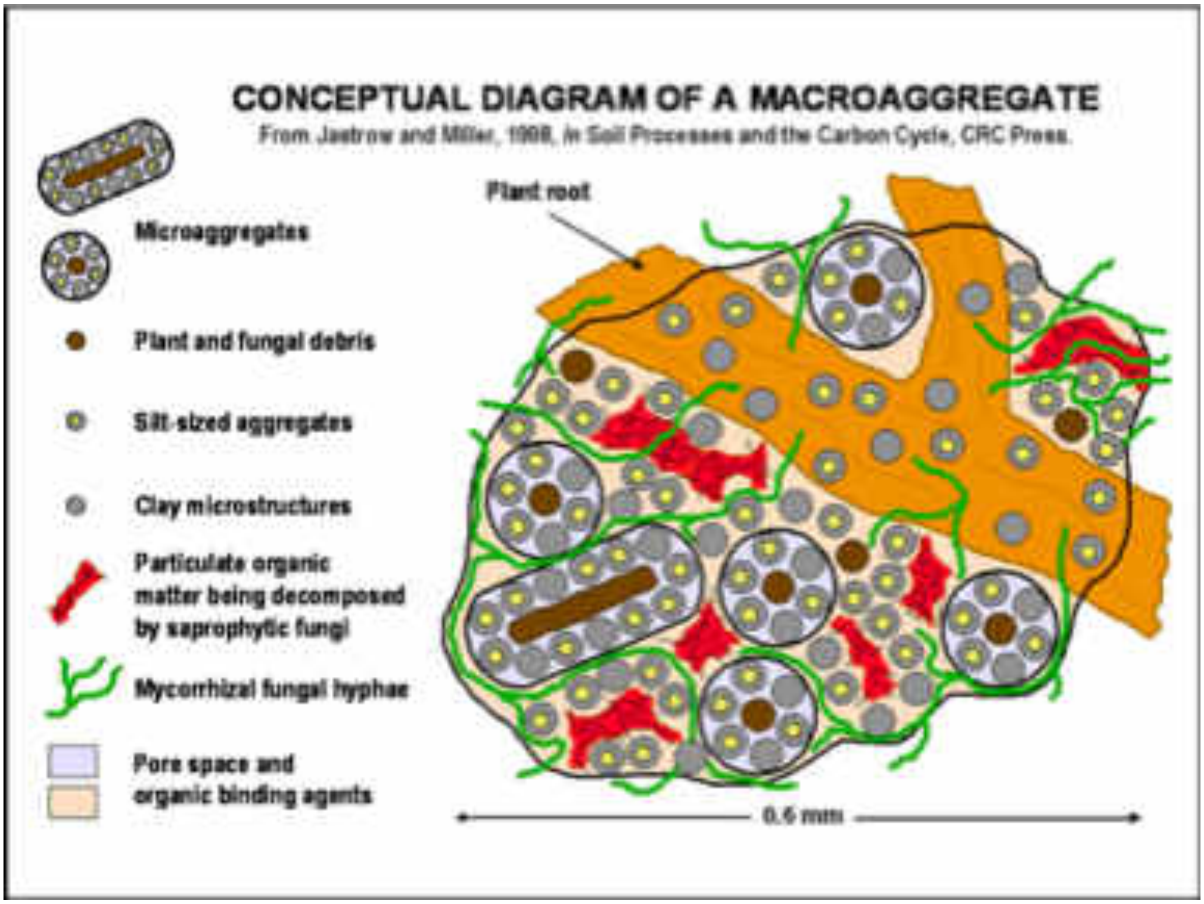
Showing m. fungi strand penetrating into plant root



Showing how M. fungi extend the root system of a plant



Showing how microbes create nutrient rich community for plant roots



Problems with applying chemical Nitrogen and Phosphorus

Web of Death (chemical) versus Web of Life (microbially mediated)

NITROGEN

AIR = 78% Nitrogen + 21% Oxygen = 99%
All other gases only 1% -- Only 0.04% carbon dioxide

All green plants are Nitrogen fixers – sugars created by photosynthesis feed microbes that transform Nitrogen in the air to plant available N

In most farms, Nitrogen is limiting factor because these practices (listed below) have killed biology, so no microbes left to fix nitrogen (pull from air and use enzymes to release bonds, converting nitrogen to plant soluble ammonia
Bare fallowing of land, applying N fertilizers, fungicides, pesticides, poor grazing management

60-90% of applied Nitrogen is lost to leaching, runoff, etc
Inorganic Nitrogen limits plant uptake of minerals and trace elements
Increases plant pests and disease
Then requiring insecticides and pesticides
Thereby reducing profits and adding unnecessary chemicals to the food chain
Reduced plant minerals and trace elements has big effect on animal health
Inorganic Nitrogen

makes “funny proteins” in plants which makes animals sick
stimulates weeds
pollutes water

Wean off N fertilizer over 3 years– to allow biology to take over for chemical feeding

Optimizing photosynthesis, optimizes N fixation and nutrition in plants

PHOSPHORUS

In a biologically active soil, mycorrhizal fungi makes phosphorus available to plant roots as well as important micro nutrients like copper, zinc and selenium

Application of synthetic phosphorus makes plants quit “feeding” the mycorrhizal fungi, so it dies and the plants become dependent on the application of phosphorus fertilizers