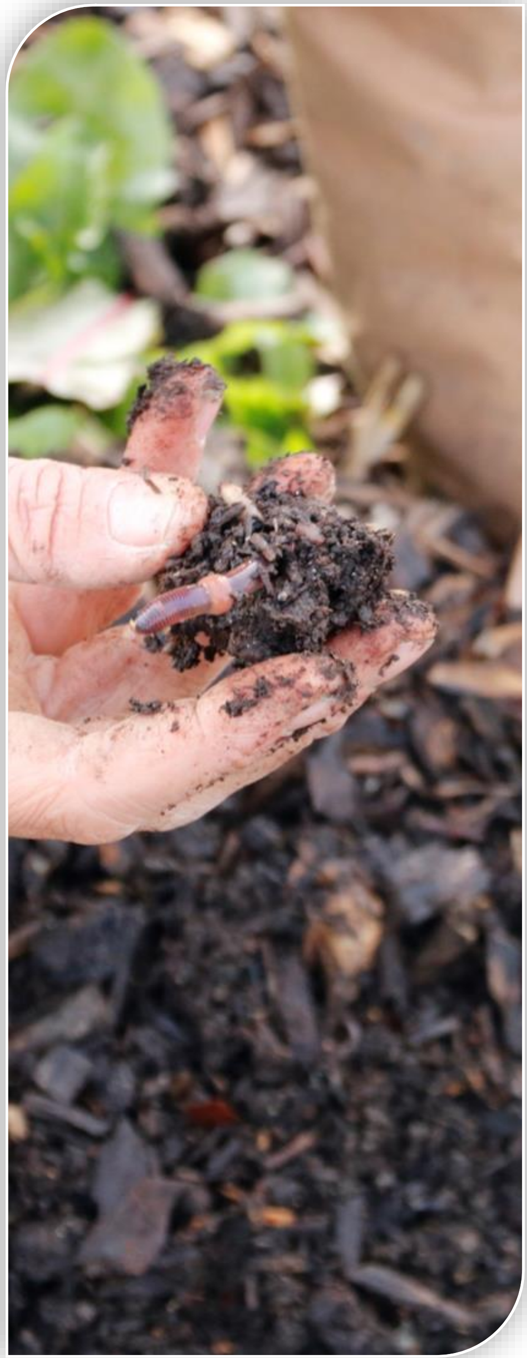
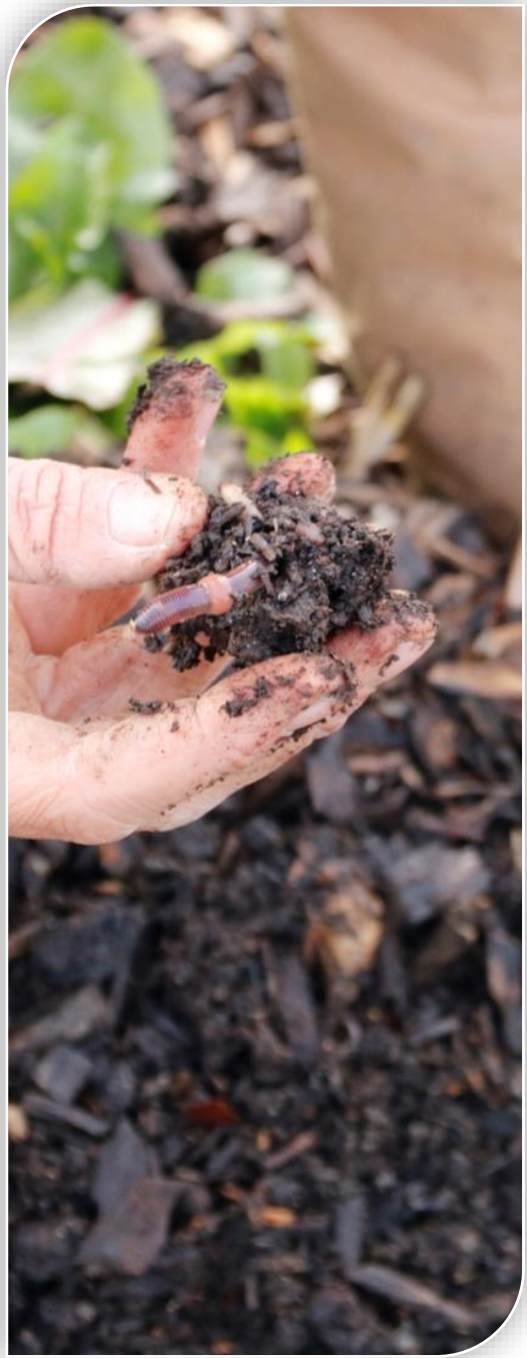


5 december 2022
Soil Health Conference

Mechanisms of soil health restoration in regenerative agriculture

Dr. Kris Nichols

MyLand Company LLC - Research Director

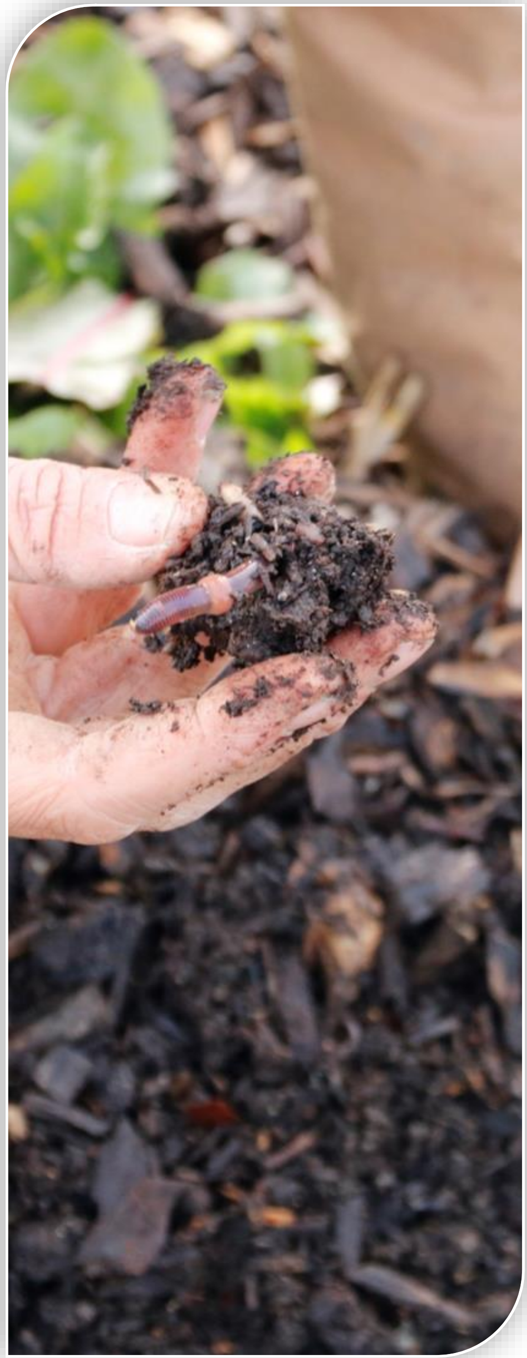


REGENERATIVE AGRICULTURE:

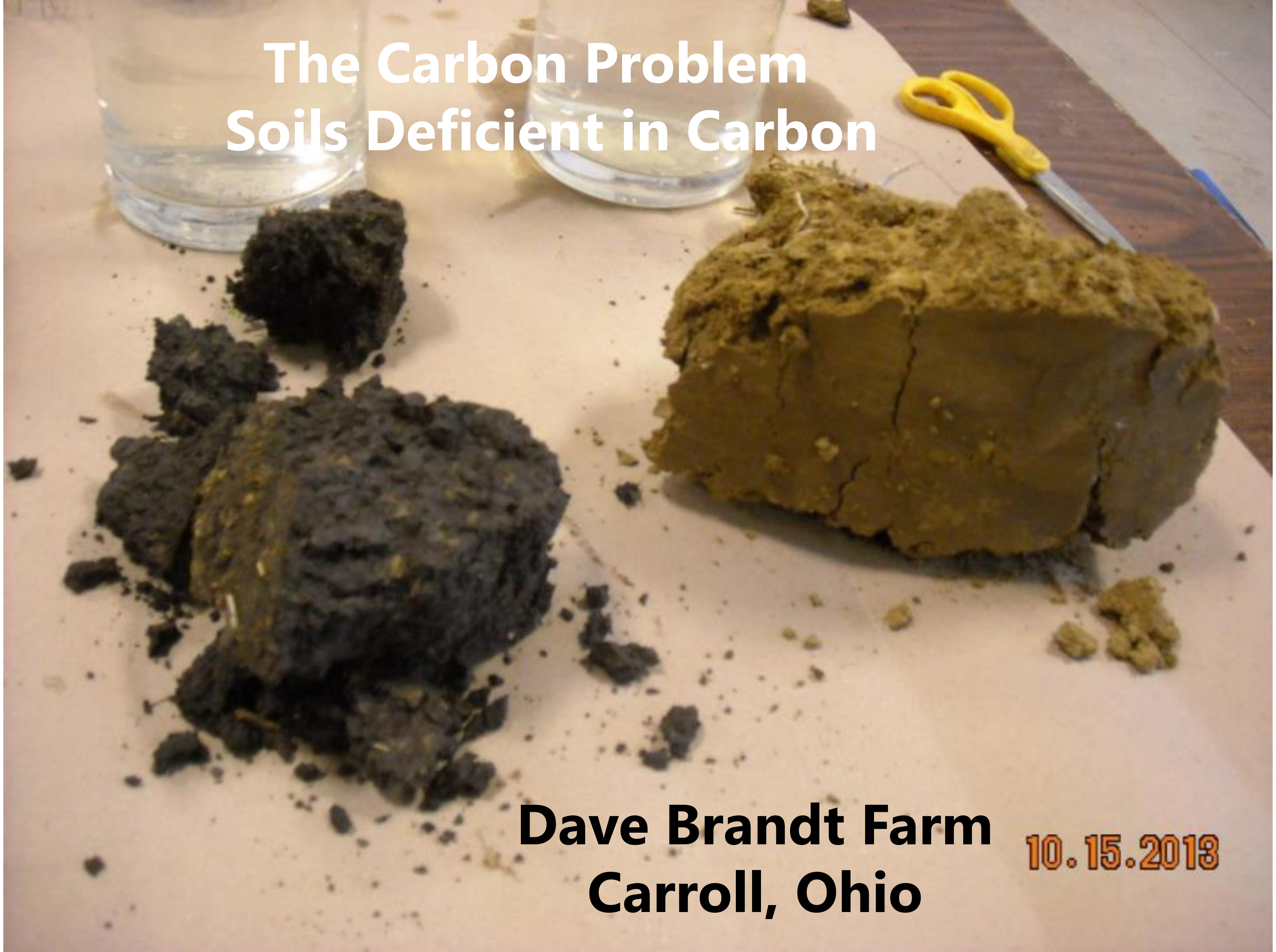
- **Systems Approach**
- **Dynamic, Innovative, Integrated, Intensive**
- **Photosynthesis – Carbon Flow/Costs**

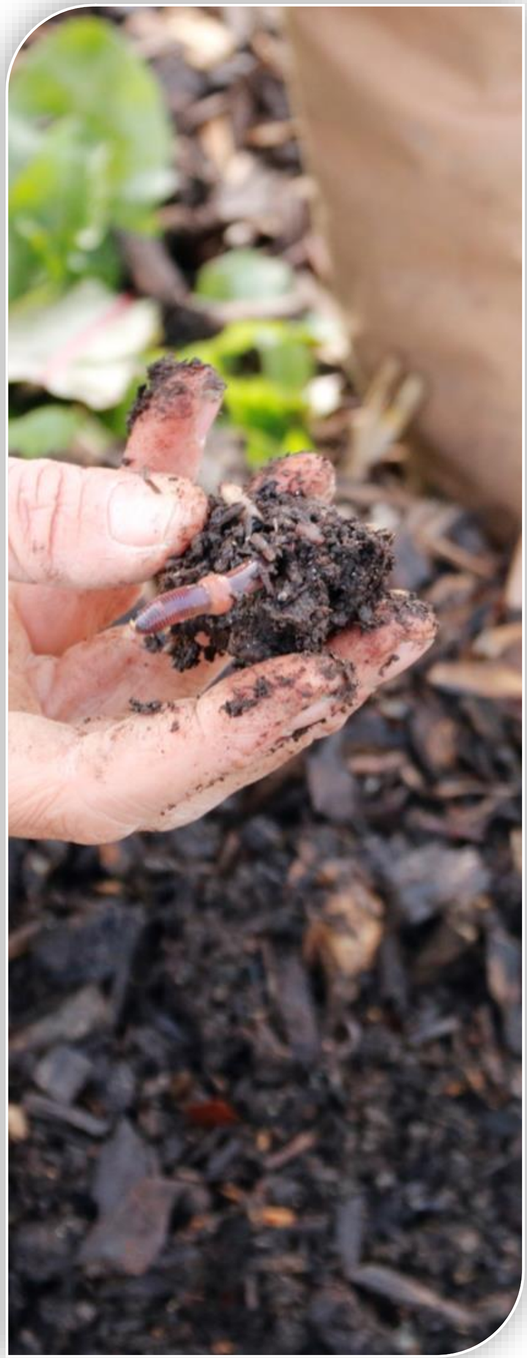
Photosynthesis – most efficient form of solar energy conversion to chemical energy in the bonds between carbon atoms or carbon atoms and other atoms.

Regenerating soils



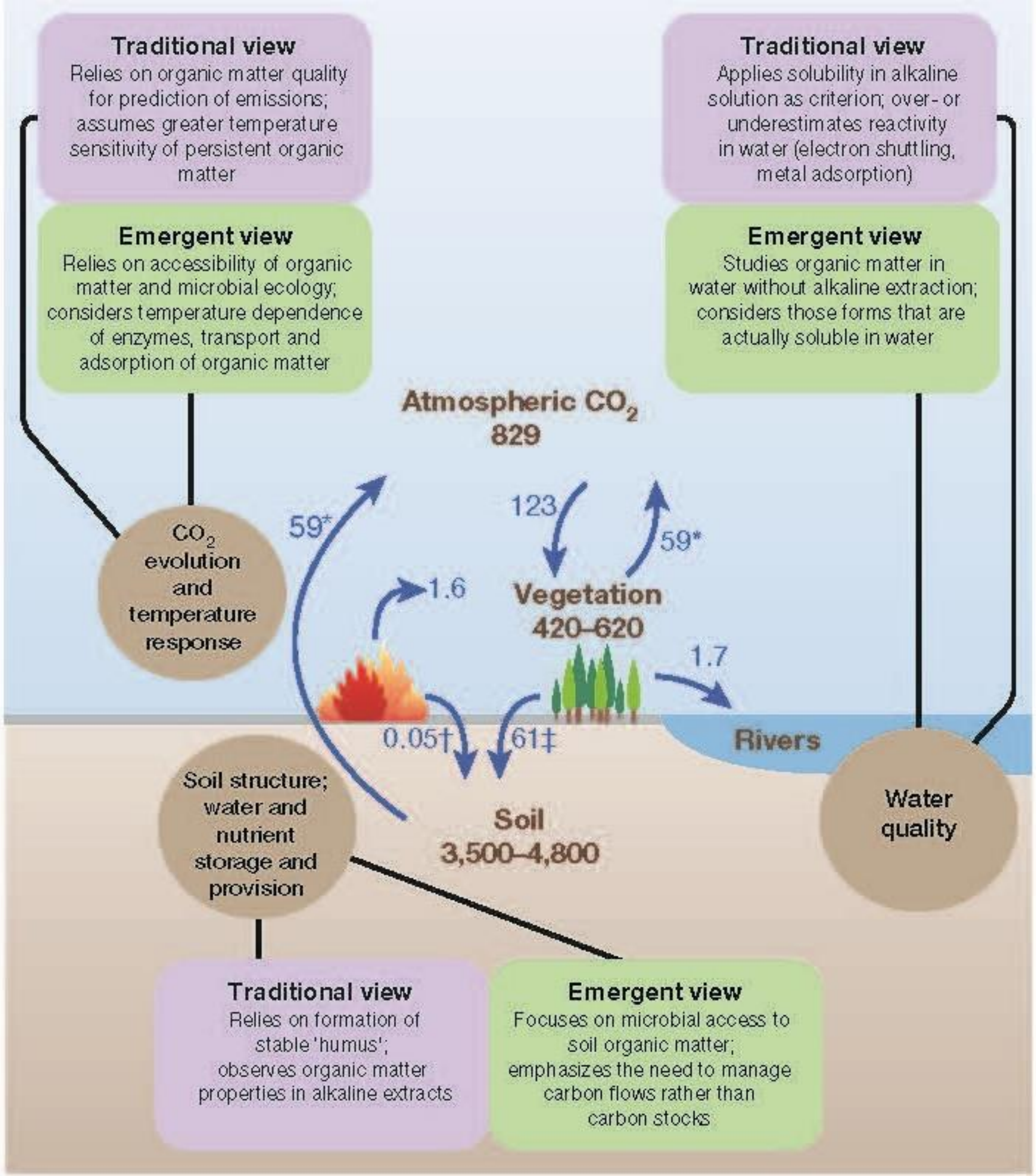
- Soil – Carbon, Hydrogen and Oxygen (Organic Matter) + Sand, Silt and Clay


The Carbon Problem
Soils Deficient in Carbon
Dave Brandt Farm
Carroll, Ohio
10.15.2013

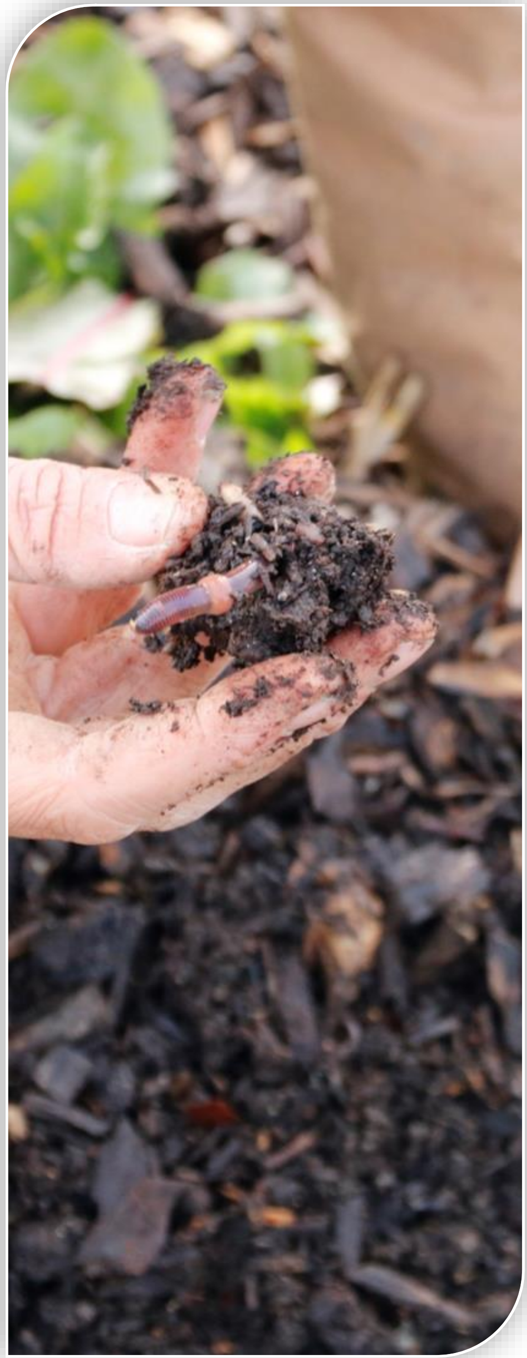


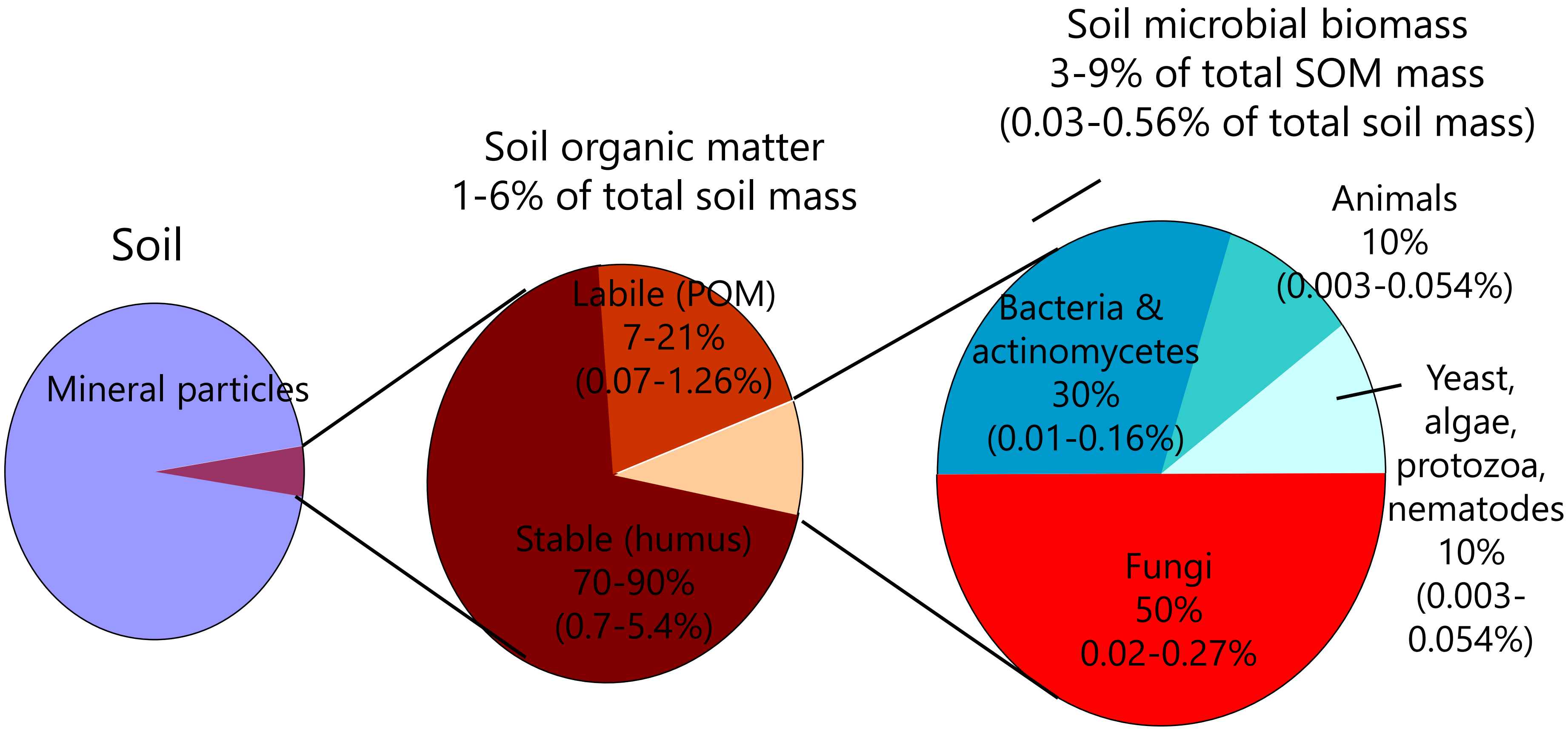
Emerging view of SOM supports Regenerative Ag – We can build SOM in our lifetime!

Lehmann and Kebbler, 2015

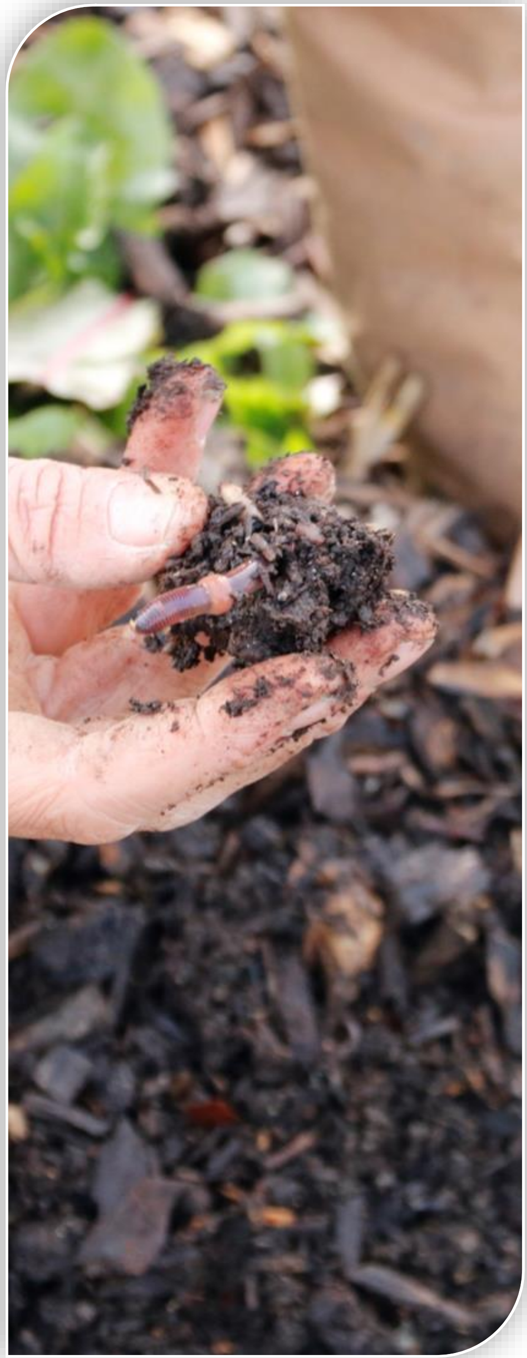


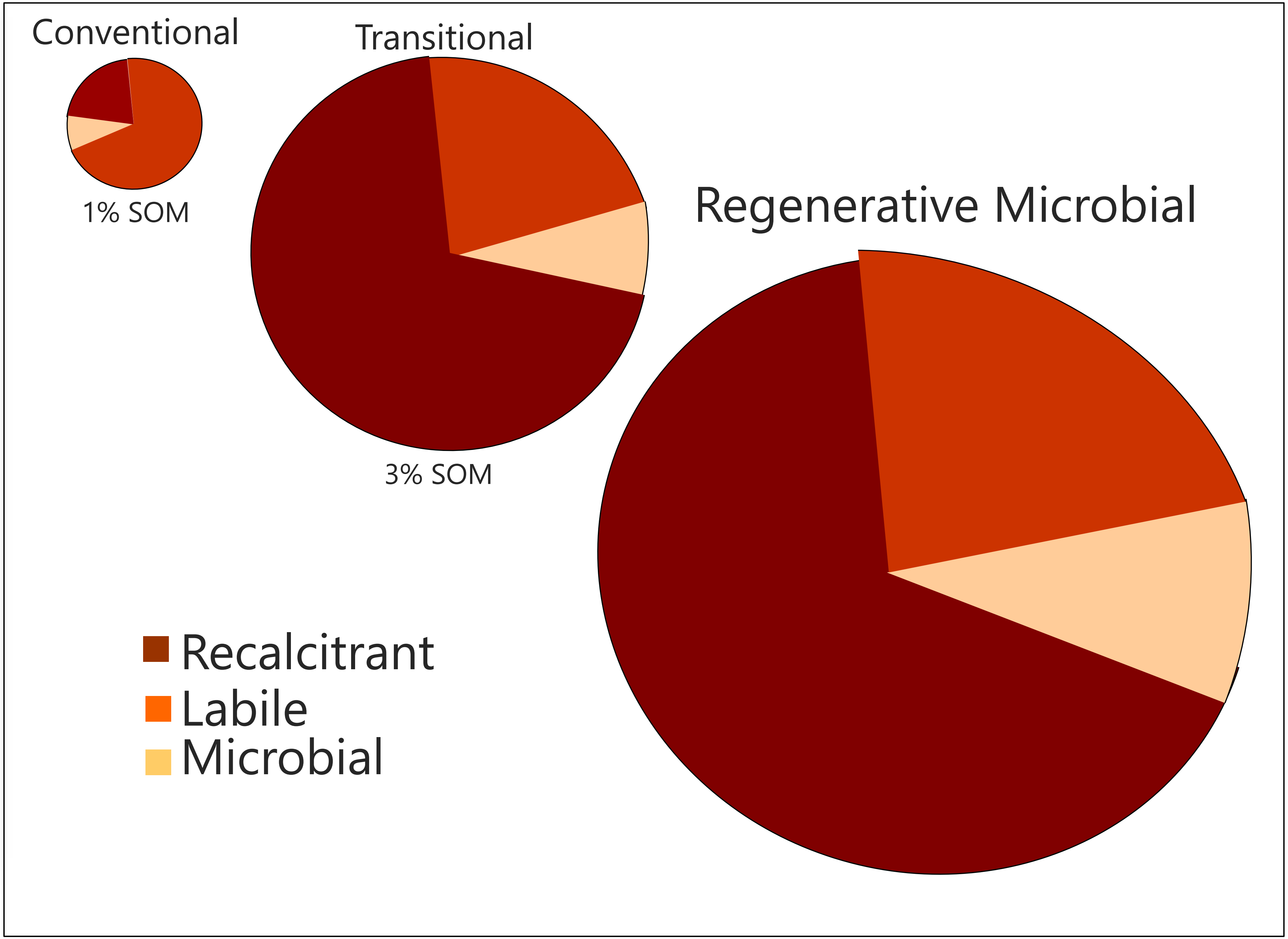
Soil Organic Matter Composition

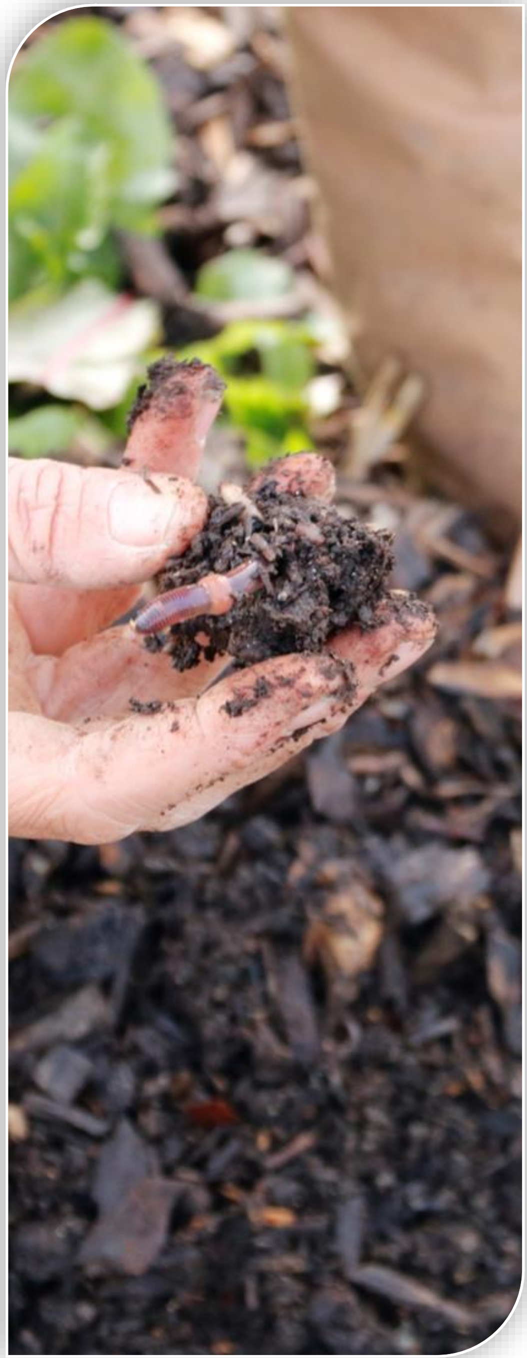


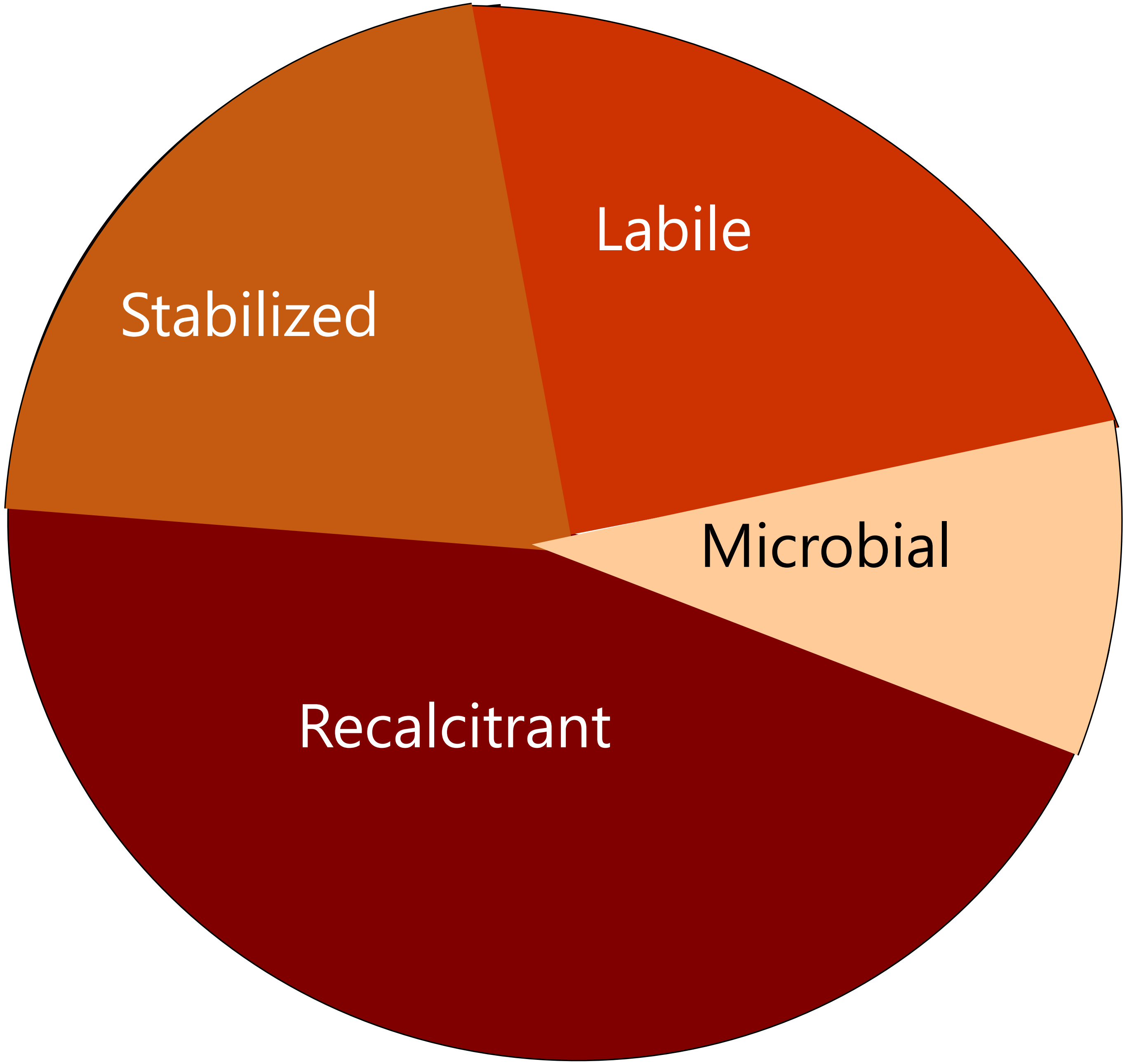


- Modified from Building Soils for Better Crops, Magdoff and van Es, 2000

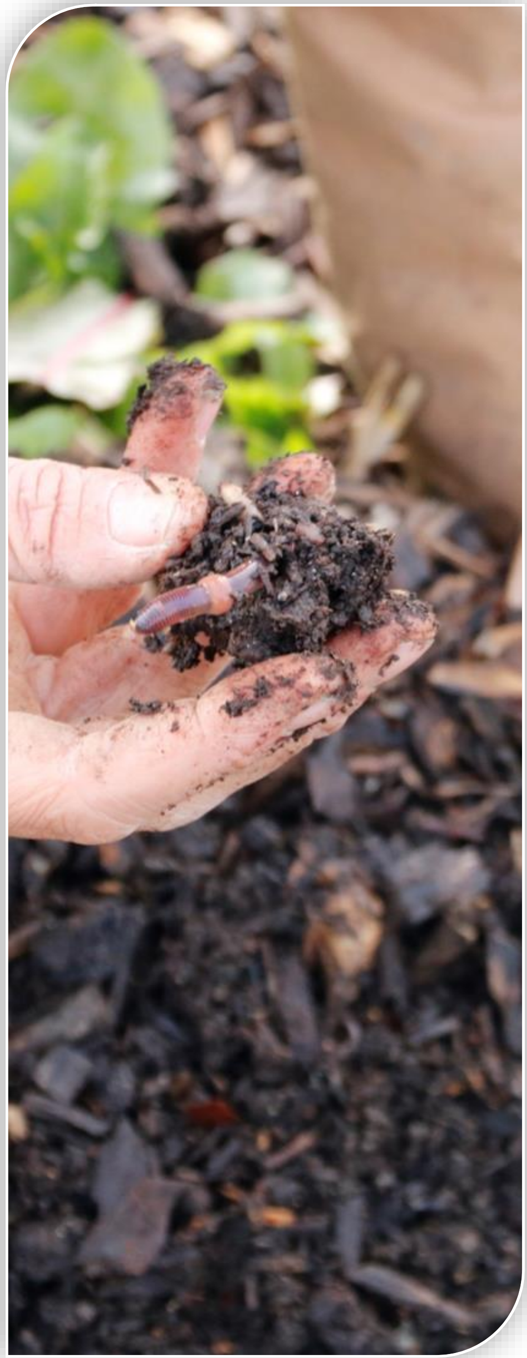



Conventional
1% SOM
Transitional
3% SOM
Regenerative Microbial
Recalcitrant
Labile
Microbial





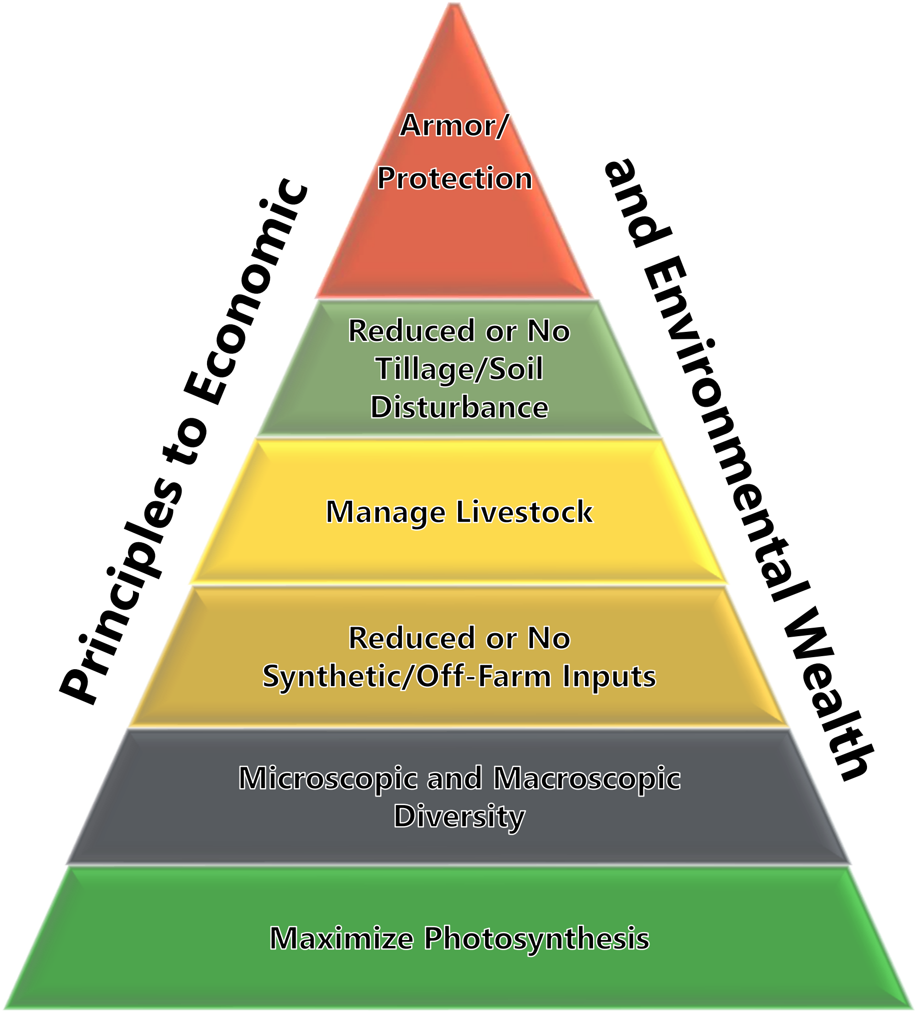
Labile
Stabilized
Microbial
Recalcitrant

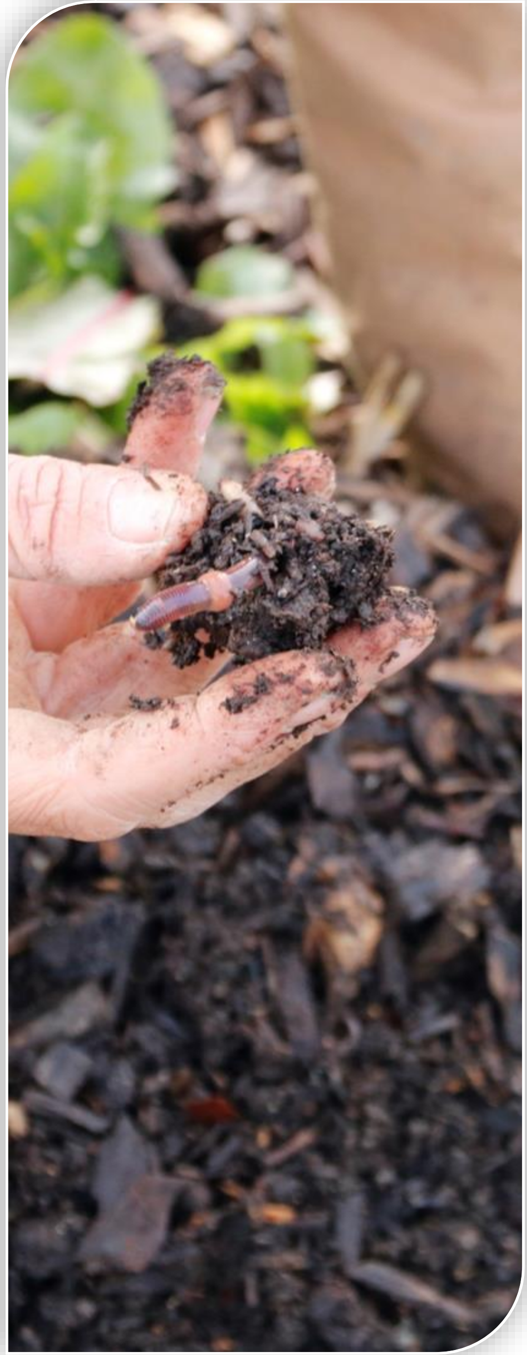


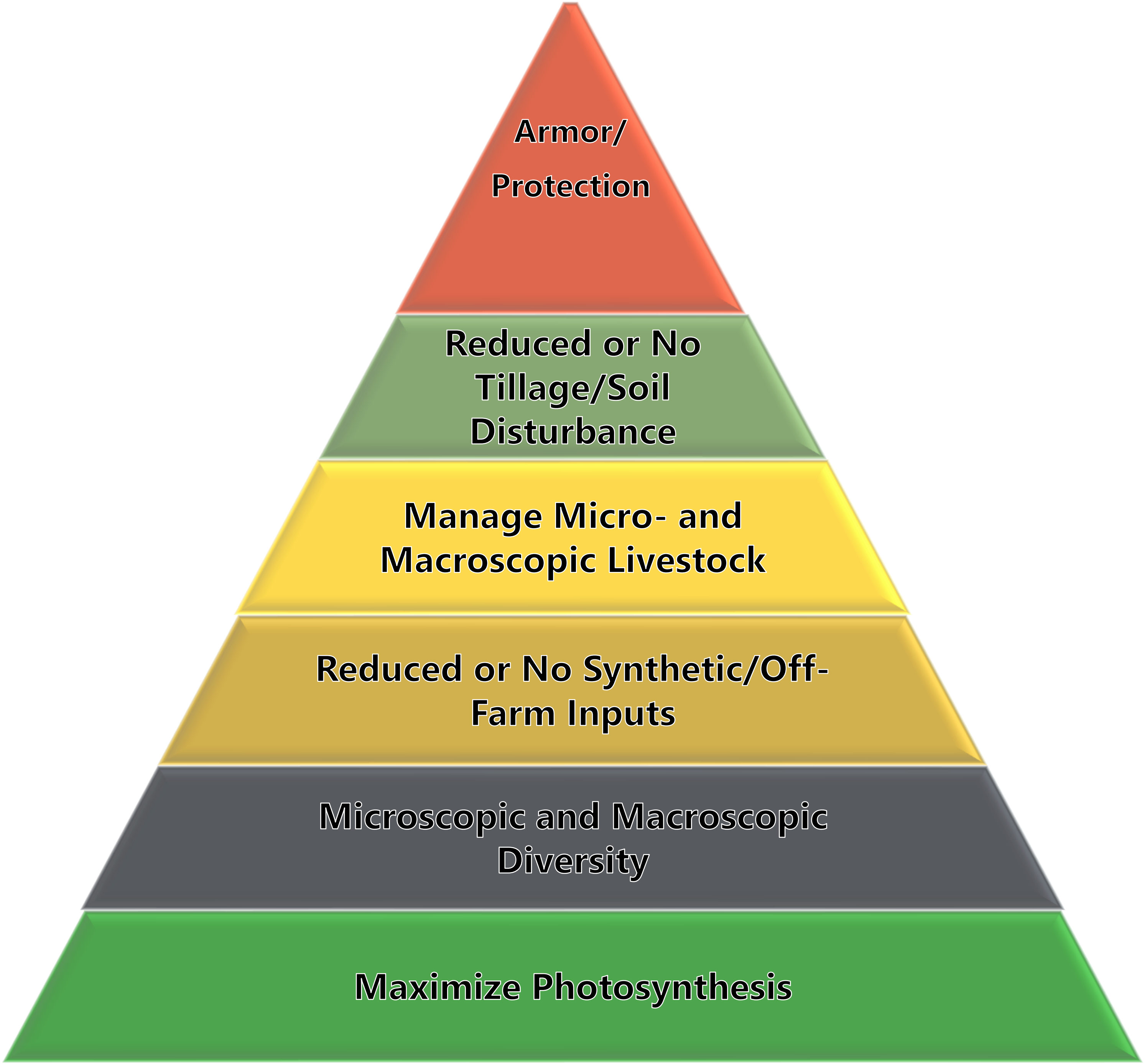
BROWN REVOLUTION

Eco-Functional Intensification

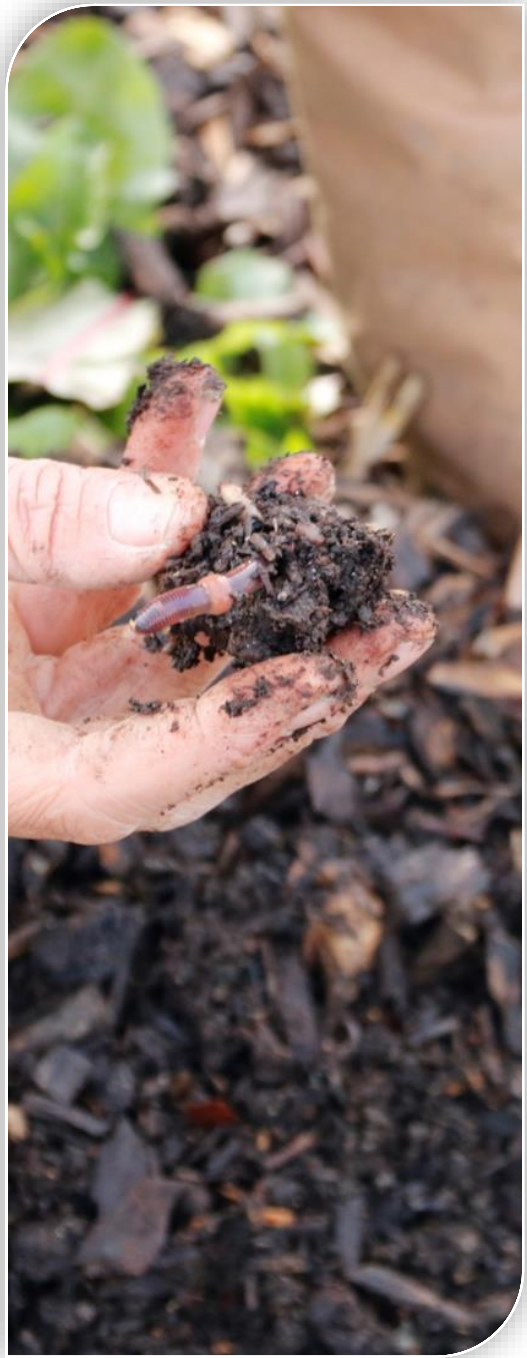
- Optimize landscape use
- Maximize efficiencies
- Not more but less
- Multiple enterprises
- Everything costs
- Redistribute risk
- Nutrient density







Armor/
Protection
Reduced or No Tillage/Soil Disturbance
Manage Micro- and Macroscopic Livestock
Reduced or No Synthetic/Off-Farm Inputs
Microscopic and Macroscopic Diversity
Maximize Photosynthesis



F I S T

System Not Tools and Practices

Nutrients

Tillage

Grazing

F – Frequency

I – Intensity

S – Scale

T – Timing

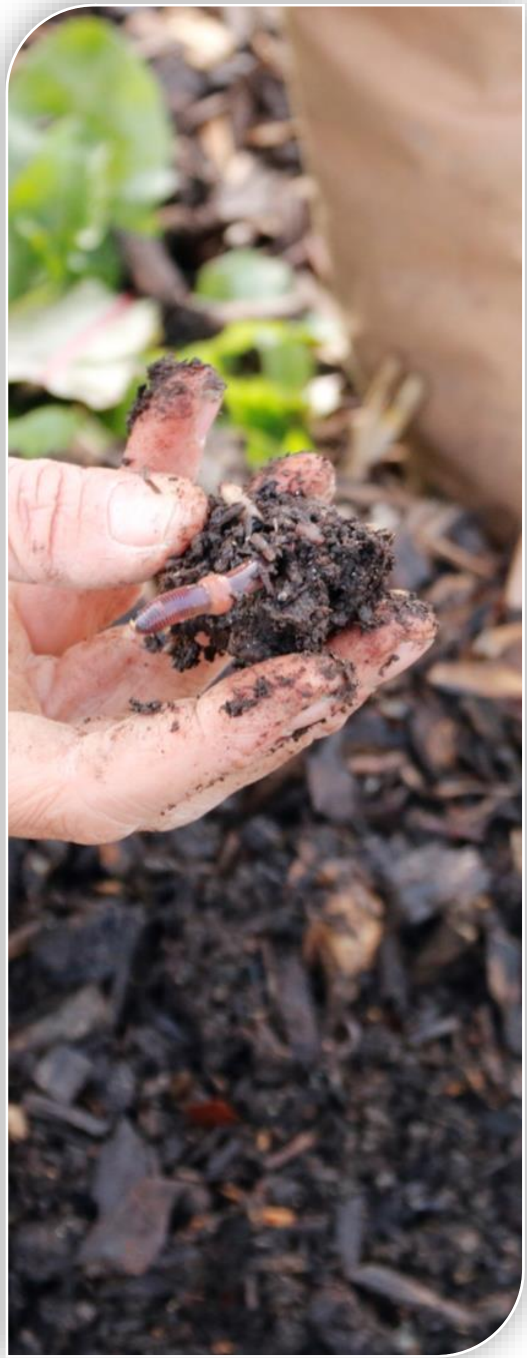
Nitrogen

Diversity

Phosphorus

Pesticides

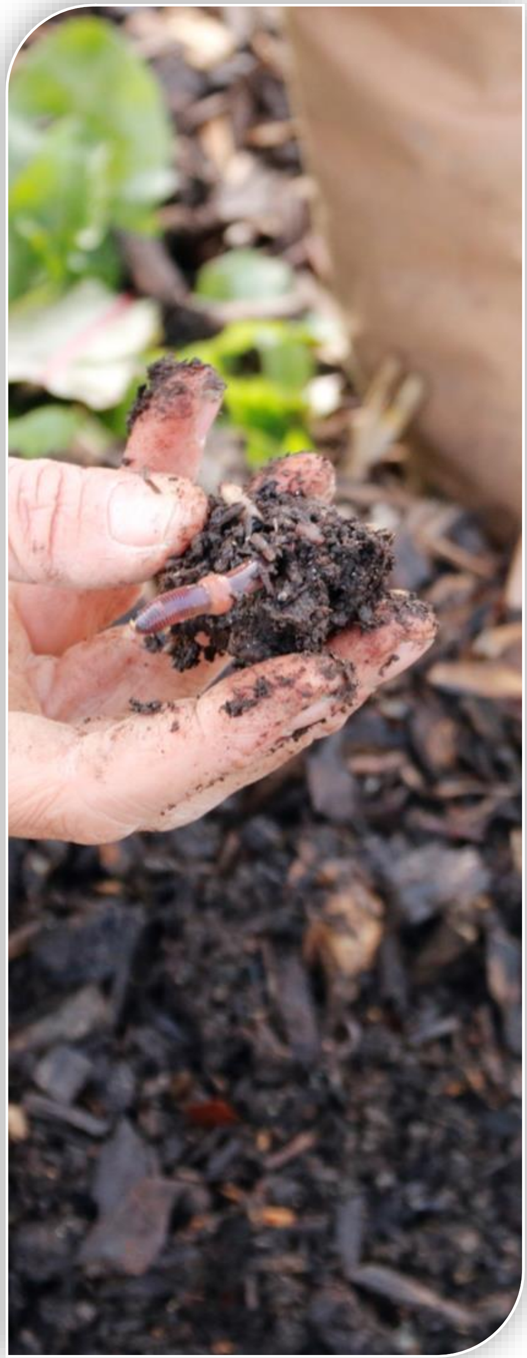
Crops



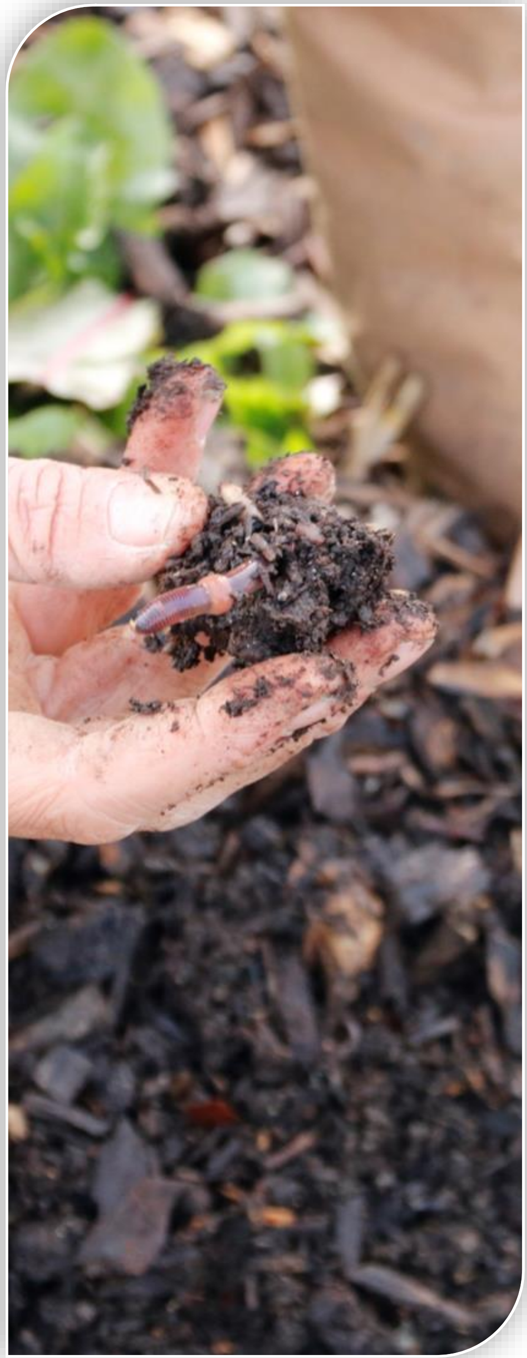
F I S T Matrix

Five Whys

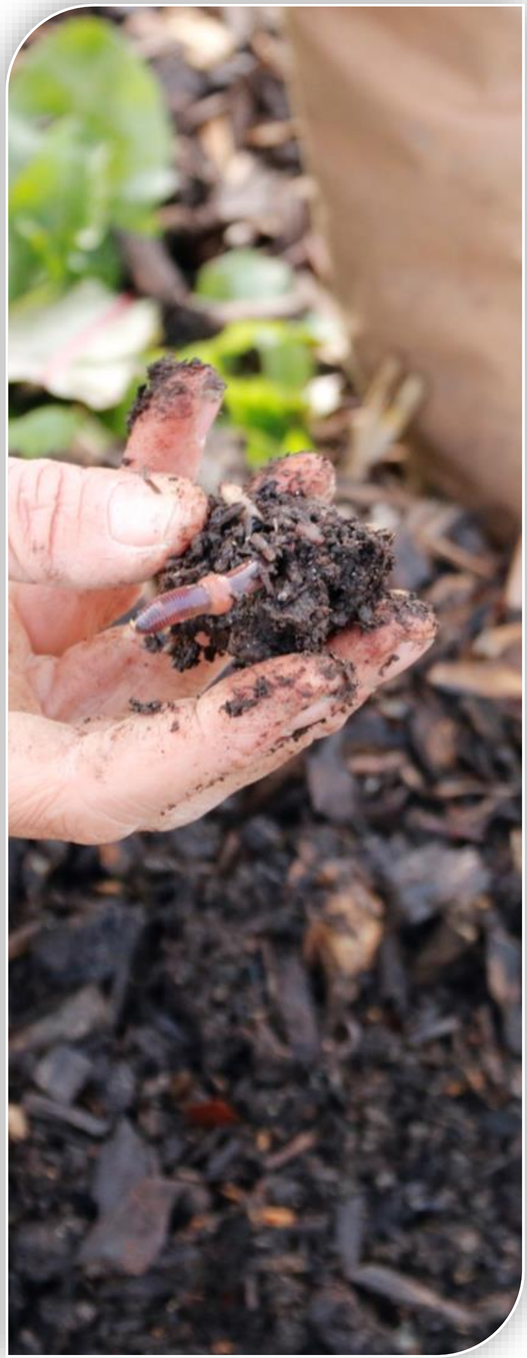
Issue	**Perennial Weeds**			
Tool Choice	**Deep Tillage**			
Trade-Offs/ Carbonomics	Frequency (number of times tool is used in a season)	Intensity (amount of force to be effective)	Scale (total volume of soil impacted)	Timing (when is most effective)
Positives				
Negatives				



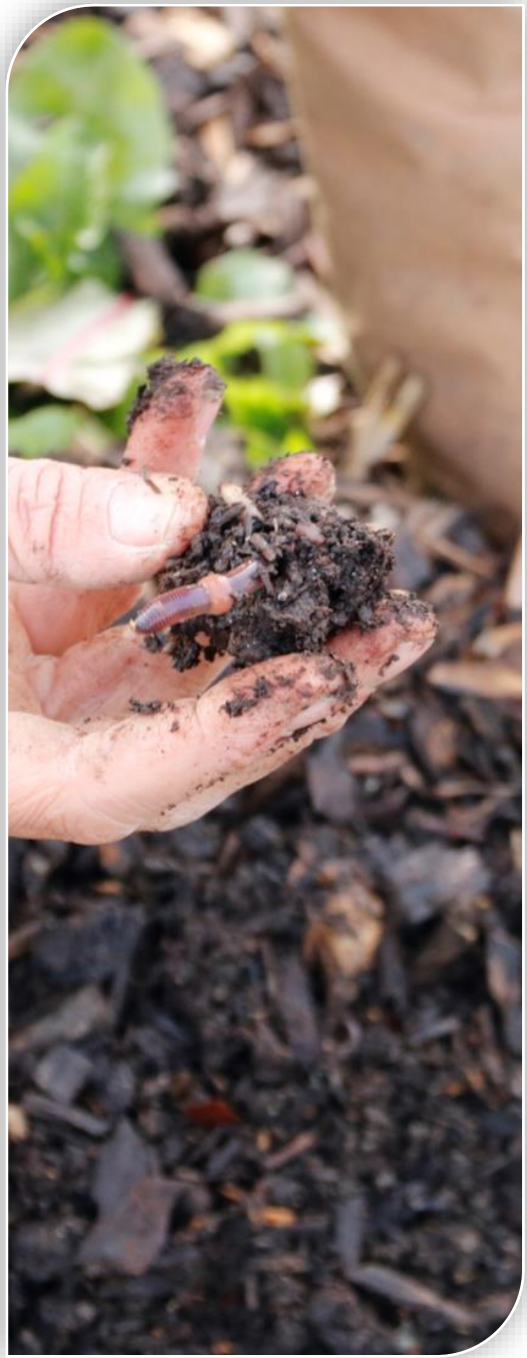
Issue	**Perennial Weeds**			
Tool Choice	**Deep Tillage**			
Trade-Offs/ Carbonomics	**Frequency**	**Intensity**	**Scale**	**Timing**
Positives	Prevents several in-season tillage passes; Prevents herbicide use; Fiscal costs are limited to equipment, fuel, and labor	Choosing an implement and tractor speed to be effective and not very destructive	Effective weed termination with deep tillage	Perennial weeds most impacted at weakest growth times; Labor needs at a low stress time
Negatives	Tillage may destroy aggregates and rip apart fungal hyphae; Multiple passes needed to be effective	Implement or speed needed for weed termination may be destructive to soil physical structure and biology	Deep tillage may more destructive; Although the implement being used goes deep into the soil is the volume of soil impacted more or less than a surface shredding such as rototilling	Impacts microbes if done at high growth periods



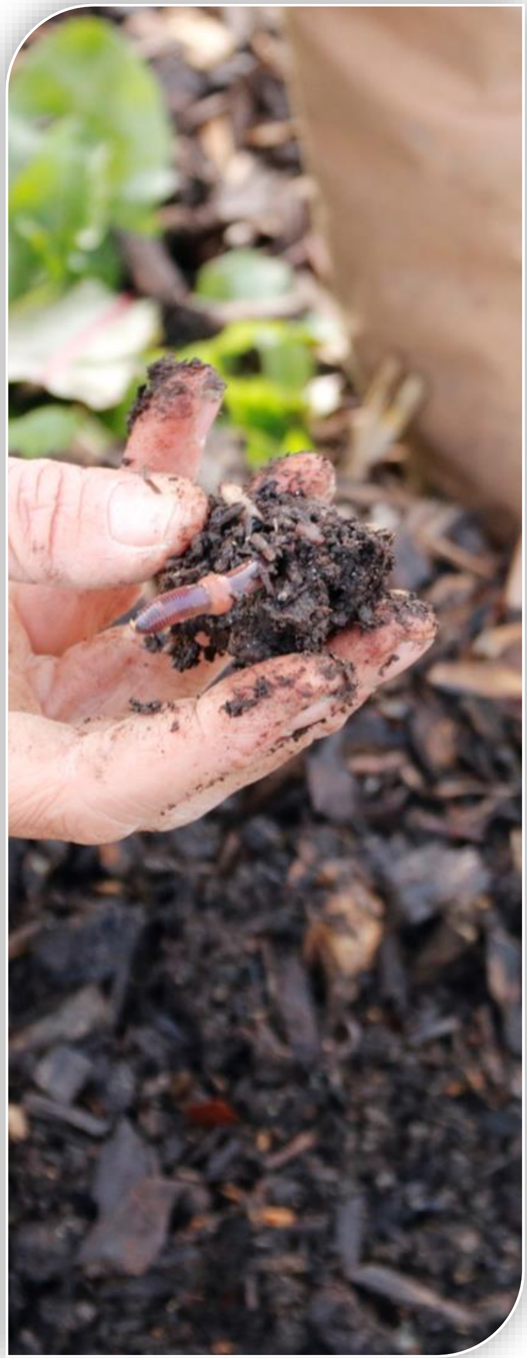
Issue	Perennial Weeds			
Tool Choice	**Herbicide(s)**			
Trade-Offs/ Carbonomics	**Frequency**	**Intensity**	**Scale**	**Timing**
Positives	Prevents the use of tillage and/or herbicides		New application tools, chemistry, and genetics may reduce the amount needed	When most effective
Negatives	Fiscal costs compared to other tools; Efficacy may be limited and require increased frequency of use or additional tools	May negatively impact soil biology and physical structure	New chemicals or chemical combinations may be needed	Impacts on cash crops, labor, expenses, and soil biology and physical structure



Issue	**Perennial Weeds**			
Tool Choice	**Poly-, Inter-, Companion, or Cover Cropping**			
Trade-Offs/ Carbonomics	**Frequency**	**Intensity**	**Scale**	**Timing**
Positives	Prevents the use of tillage and/or herbicides	Crop choice may provide benefits - enhance nutrient cycling and soil physical, chemical, and biological activity for cash crop	Rooting depth and architecture may be positive; Leaf size and architecture needs to be a part of plant selection	When most effective
Negatives	Fiscal costs include seeds and field operations – planting; Efficacy may be limited and require increased frequency of use	Crop choice may have negative impacts on nutrient cycling soil and/or cash crop – too much nitrogen in the system, compaction, water use, etc.	Rooting depth and architecture may negatively impact water use and chemistry; Leaf shading is a concern	Impacts on cash crops, labor, and expenses



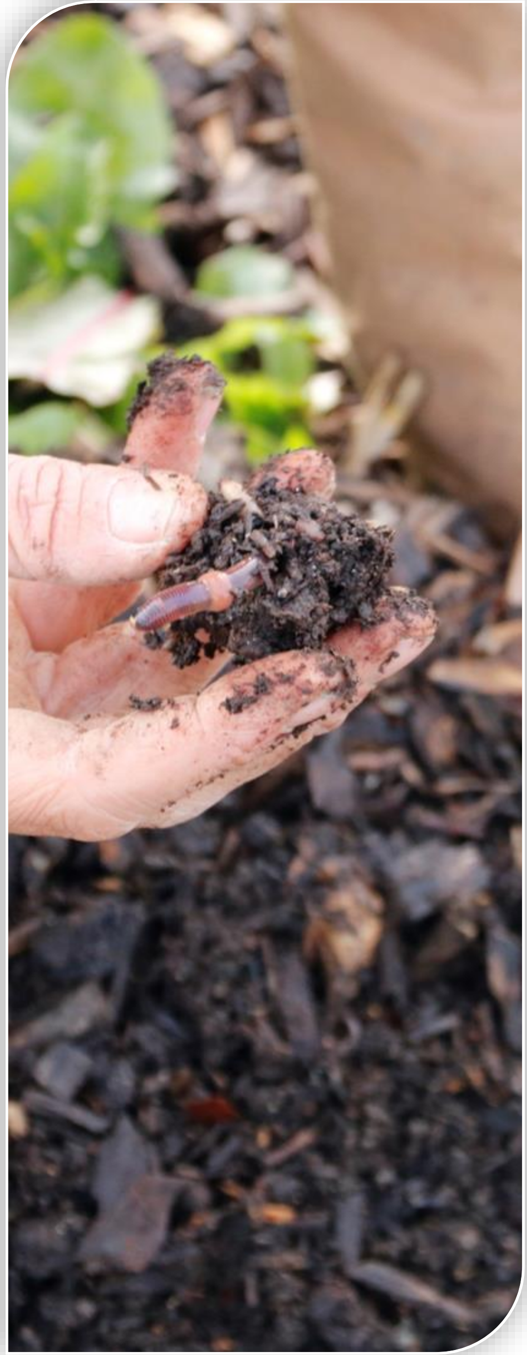
Issue	**Perennial Weeds**			
Tool Choice	**Grazing/ Haying/ Mowing – Plant Biomass Removal**			
Trade-Offs/ Carbonomics	**Frequency**	**Intensity**	**Scale**	**Timing**
Positives	Prevents the use of tillage and/or herbicides; Provides another potential income source; May add nutrients	Potential nutrient source; Add carbon; May alter soil temperatures	Potential nutrient source; May increase rooting depth; Add carbon; May improve soil compaction	Flexible timing may help with nutrients and water use
Negatives	May export some carbon and nutrients; Efficacy may be limited	Animal choice, animal units, and/or grazing days may be destructive; Mowing implements impact carbon flows	May cause surface compaction	Impacts on labor, expenses – animals, fencing, water, and labor; and soil biology and physical structure



F I S T

Recovery Plan/ Recarbonization

Issue	**Perennial Weeds**			
Tool Choice	**Herbicide(s)**			
Trade-Offs/ Carbonomics	**Tillage**	**Herbicides**	**Cropping**	**Grazing**
Recovery Plan/ Recarbonization/ Chaos	Offset soil carbon and soil structure losses and negative impacts on microbial community via cropping and/or grazing	Offset soil carbon and soil structure losses and negative impacts on microbial community via cropping and/or grazing	Assess plant species impacts on nutrient cycling and water use, including crop stressors and new weed pressures and respond with grazing or enhancing plant diversity	Overgrazing as a termination tool needs to offset soil carbon losses via cropping and/or additional grazing; If grazing is used continuously then you need to insert chaos into grazing plan; Choose plants to address any compaction issues caused by grazing



Compounding Principle of Consortia

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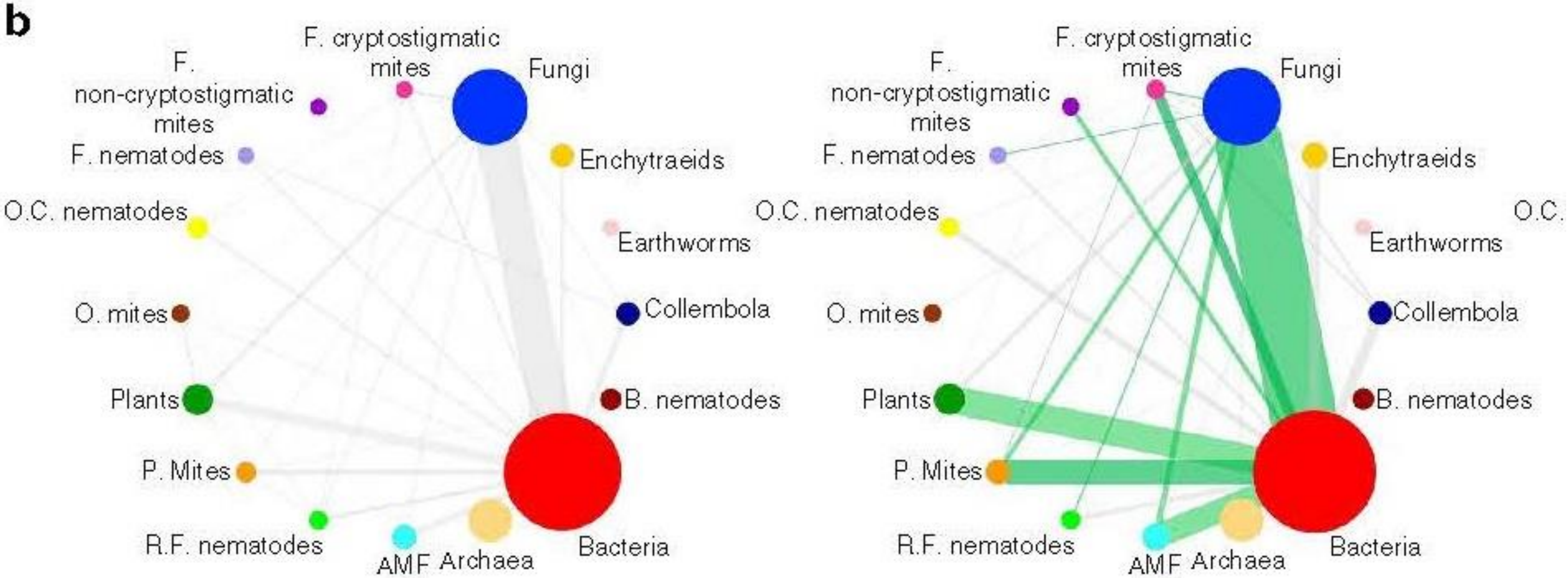
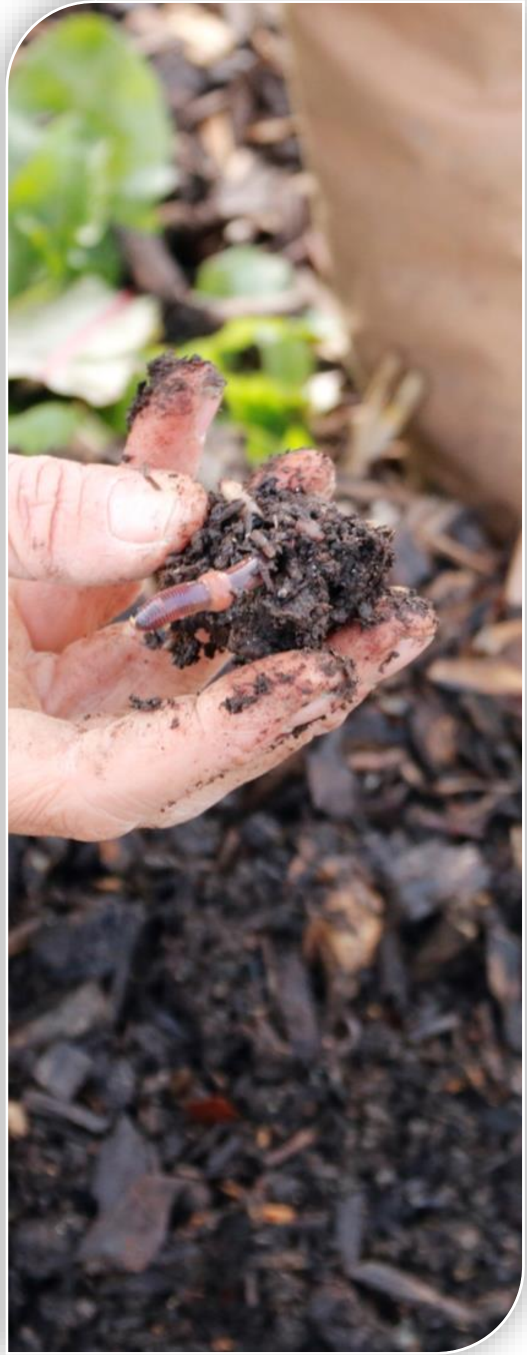
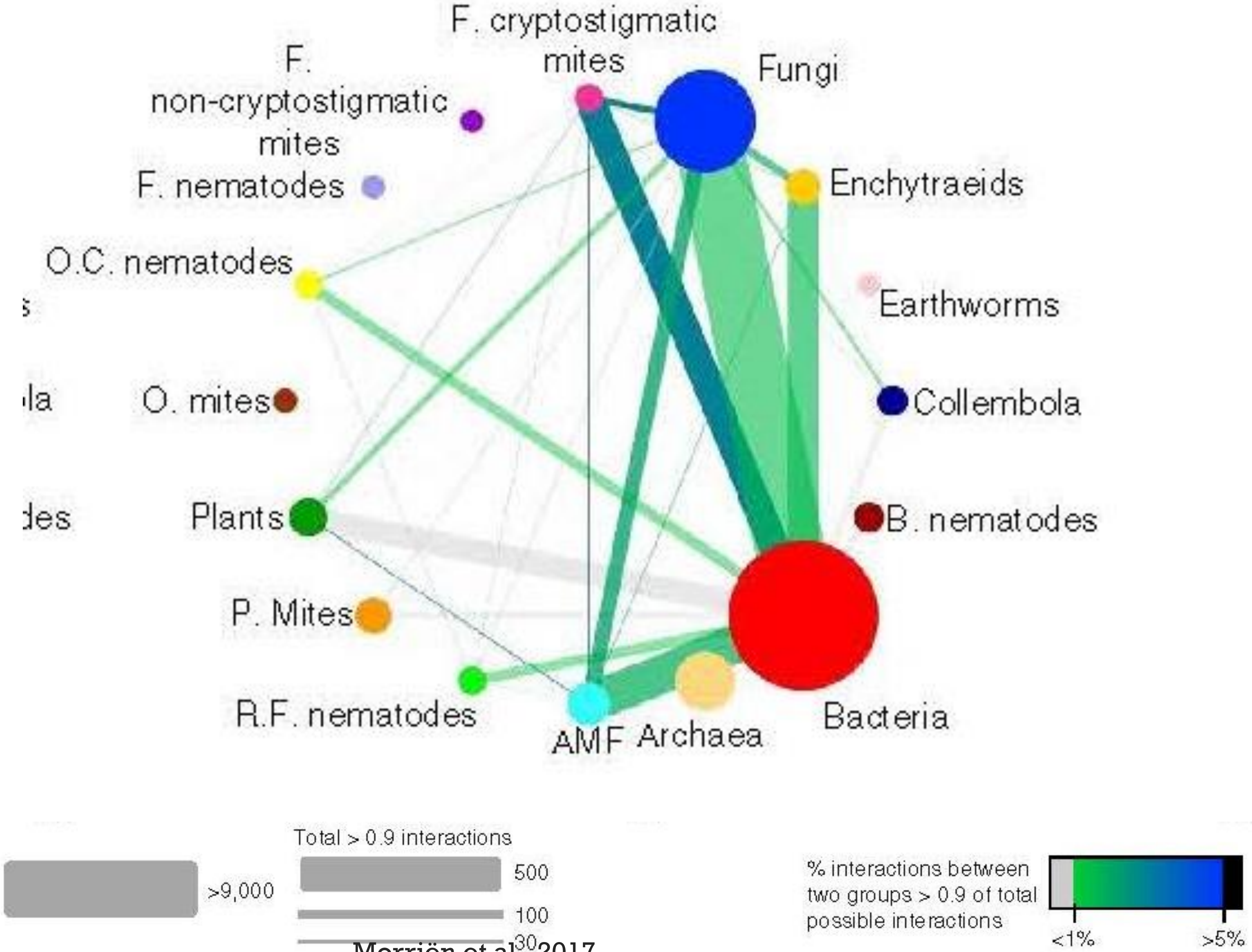
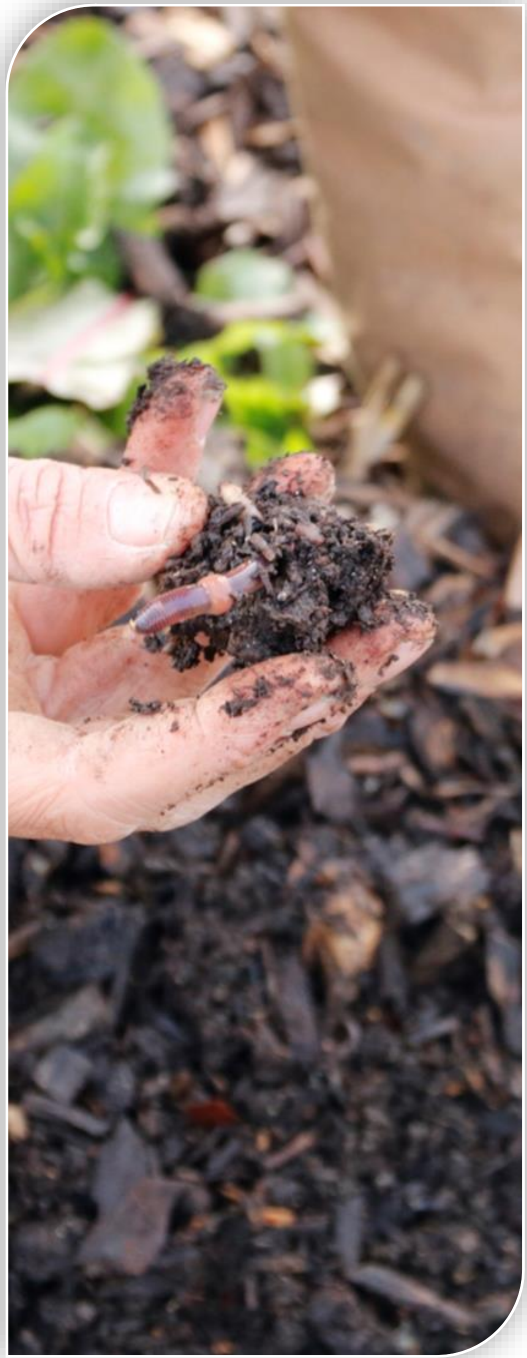


Morriën et al., 2017

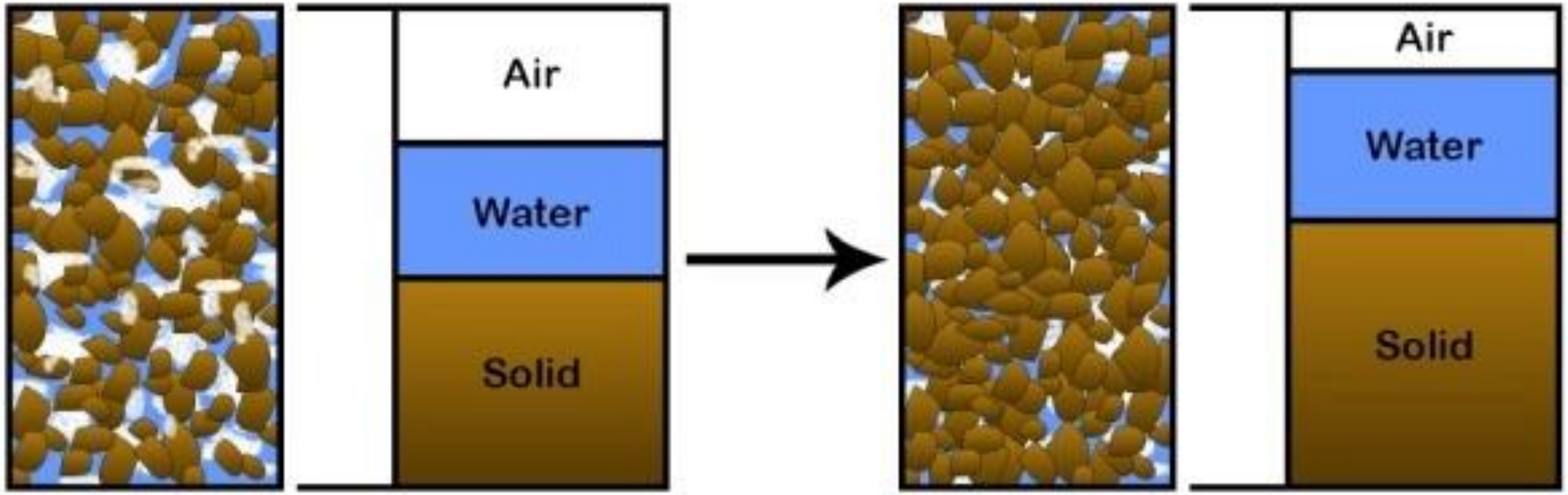




Morriën et al., 2017



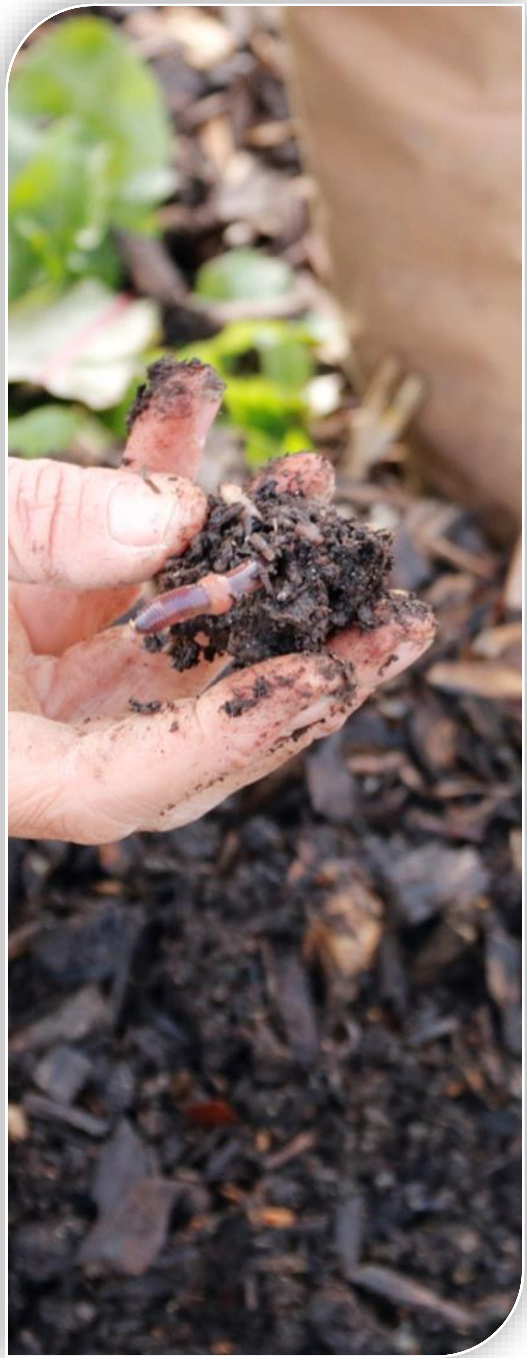
Soil Porosity



Healthy Soil

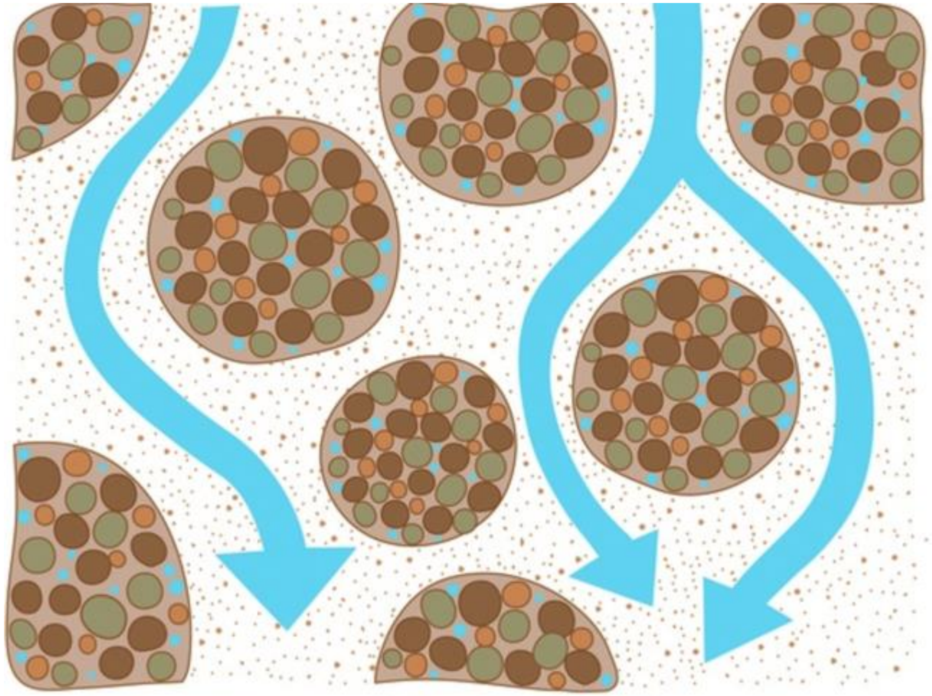
Unhealthy Soil

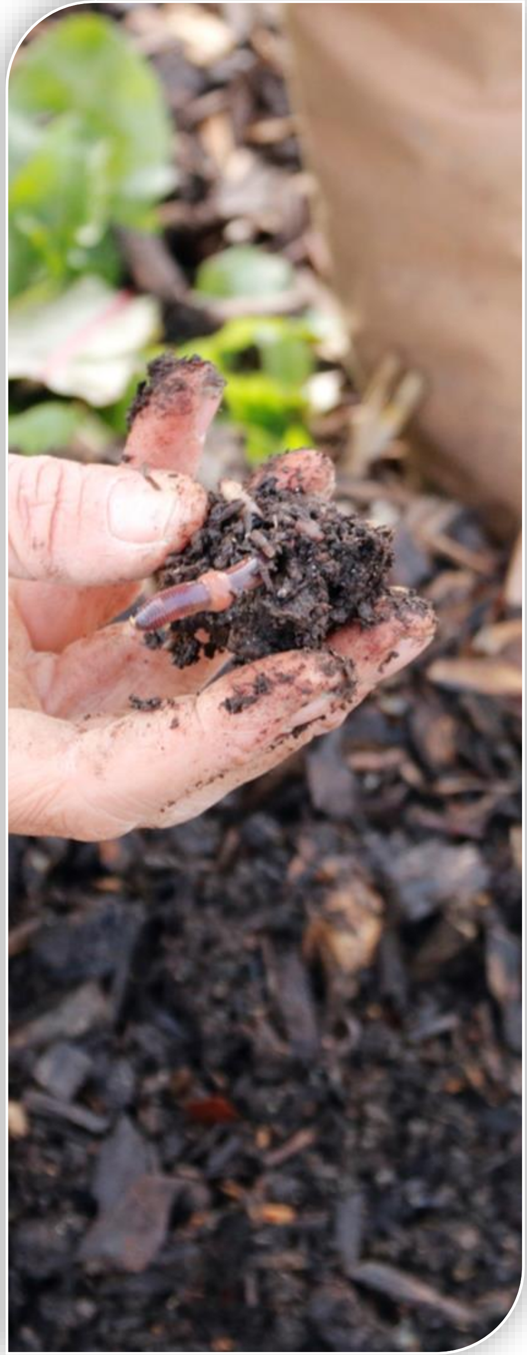
- 45% greater porosity increases infiltration by 167% for the first inch and 650% for the second inch - Karlen et al., 1998



Soil Aggregation and Porosity

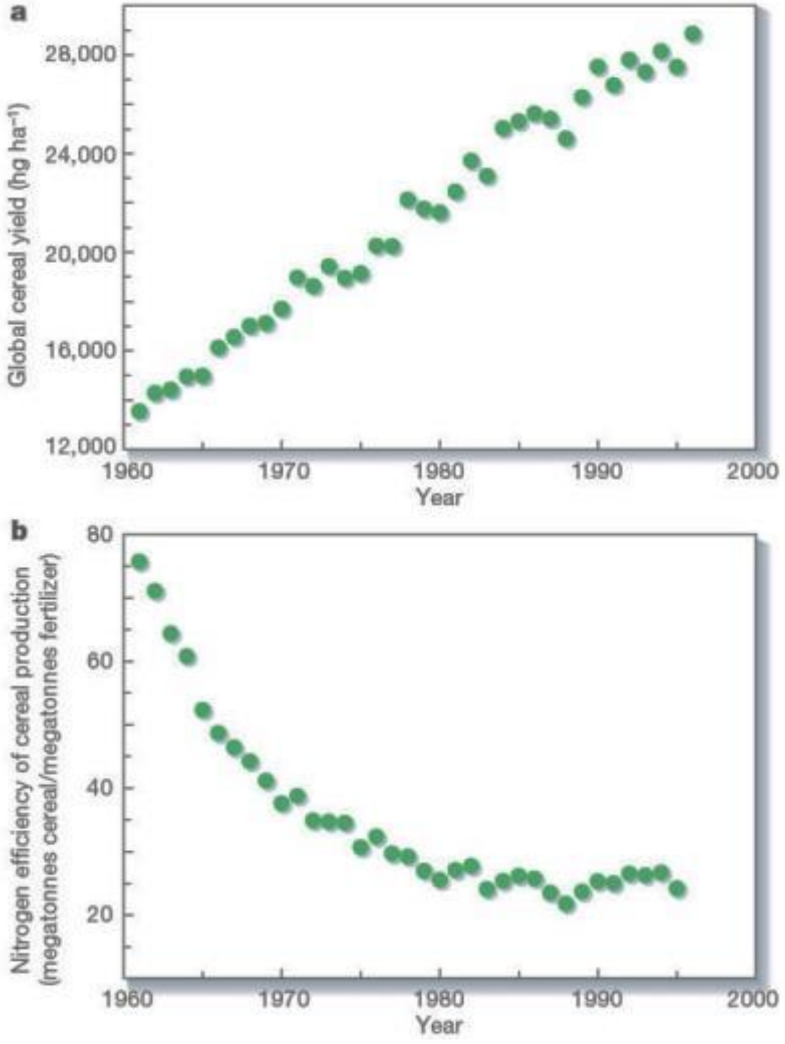
1-2 mm
Aggregates

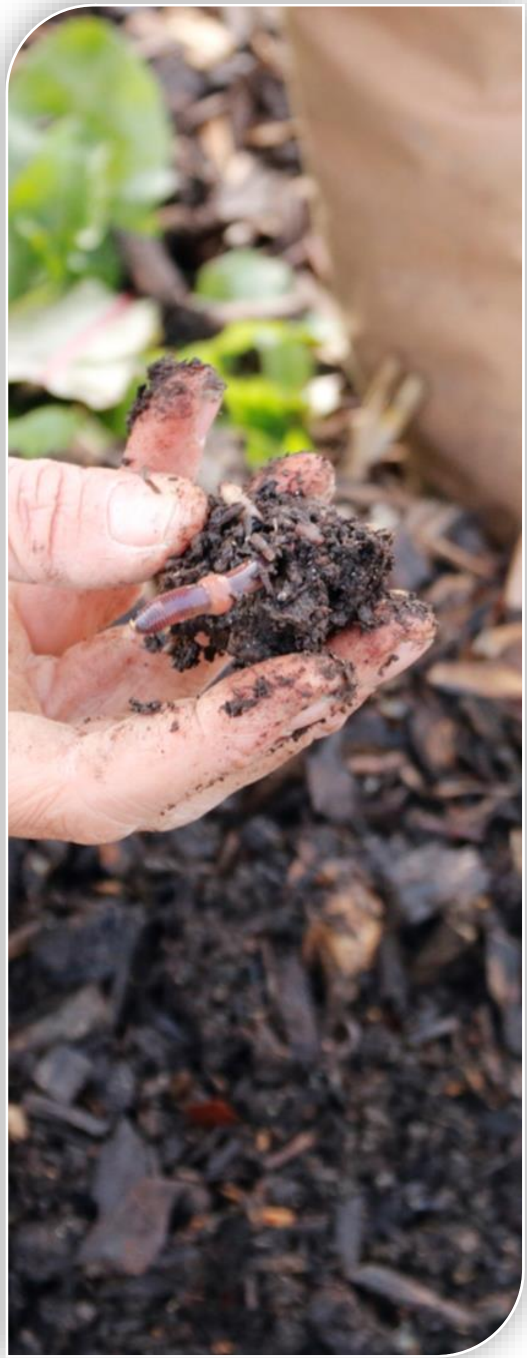




Nutrient Use Efficiency

- Plant available – synthetic vs. biologic
- 30-50% of nitrogen fertilizer is used by the plant (Hirel et al 2011)
- 30% of phosphorus is used by the plant
- Availability, timing, water, and pH





Fertility Management

- Too little fertility
  - Plant available – synthetic vs. soil biology
  - Fertility and water
- Too much fertility
  - Availability, timing, water, and pH

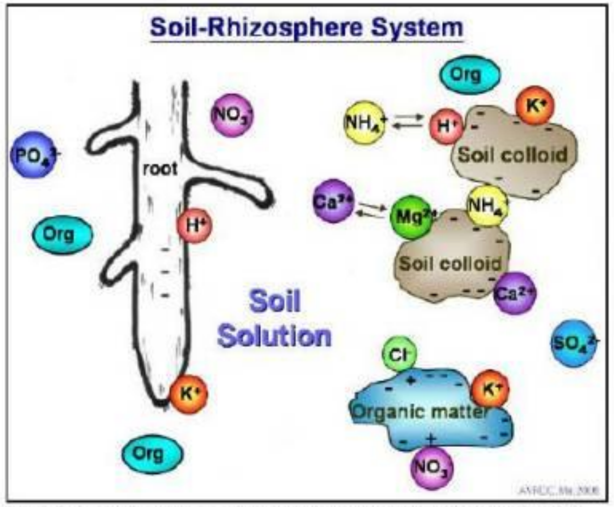
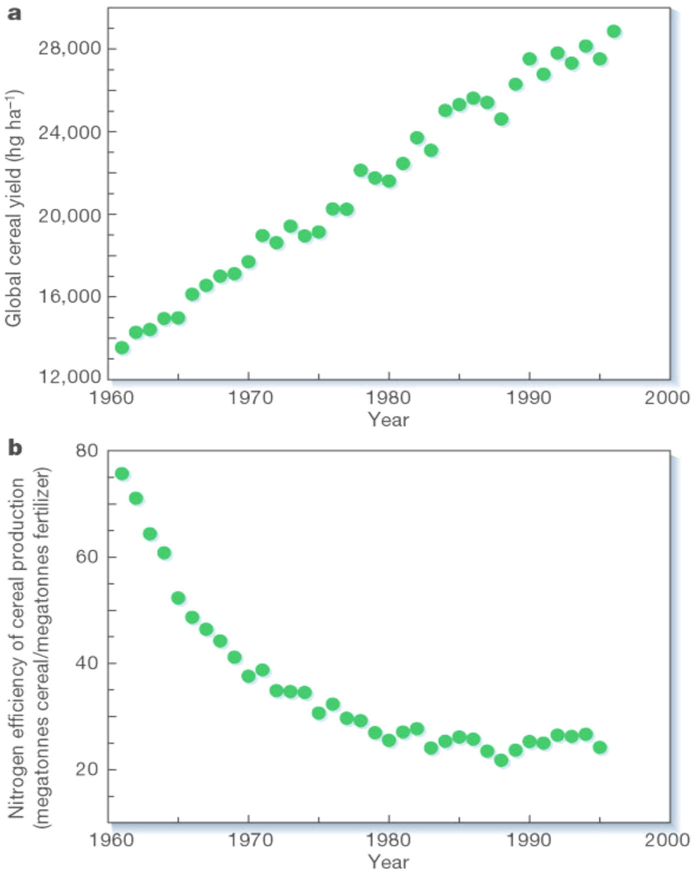
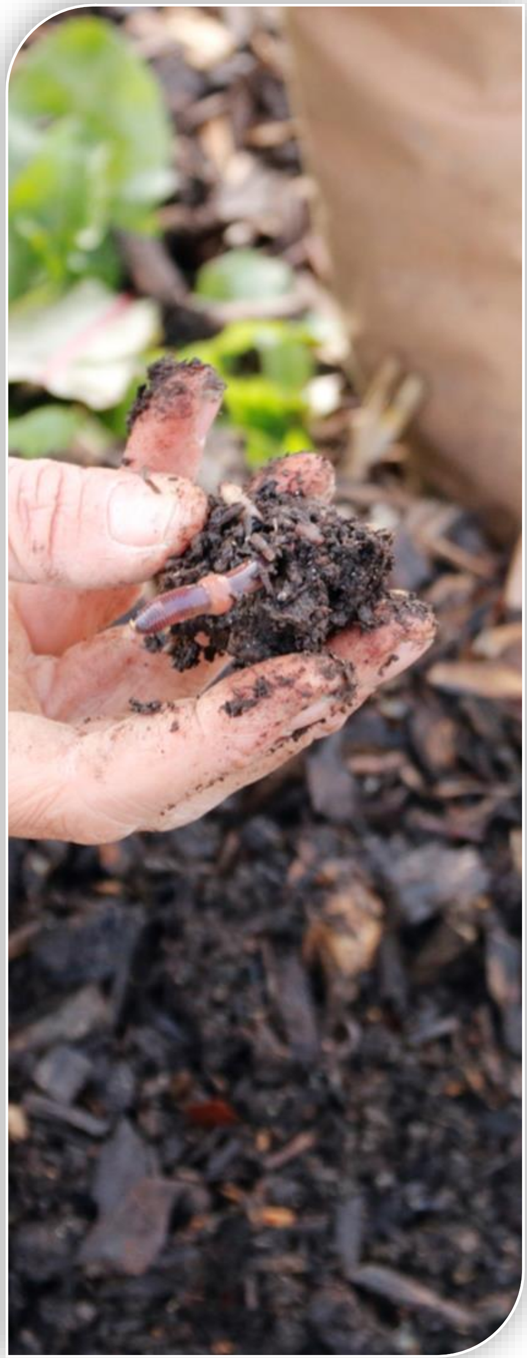


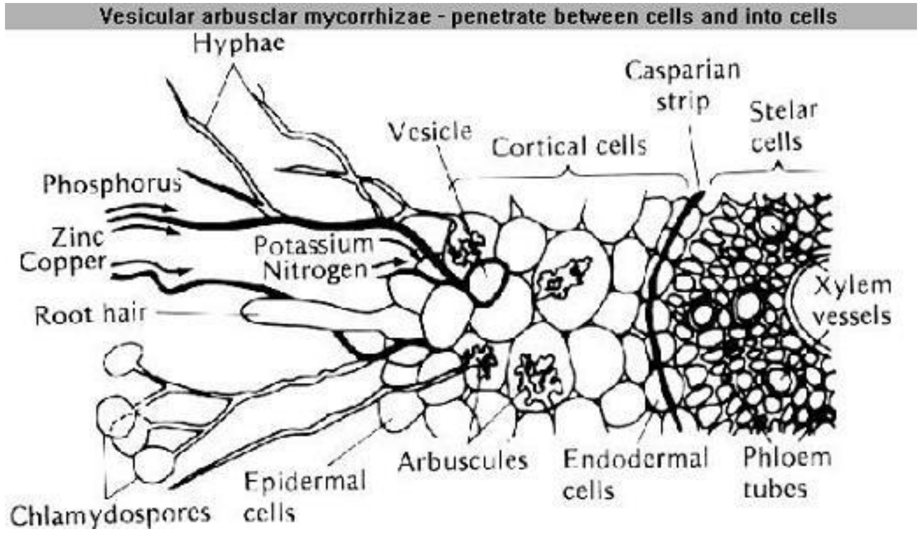
Figure 2. Components that relate to nutrient availability in the soil-rhizosphere system

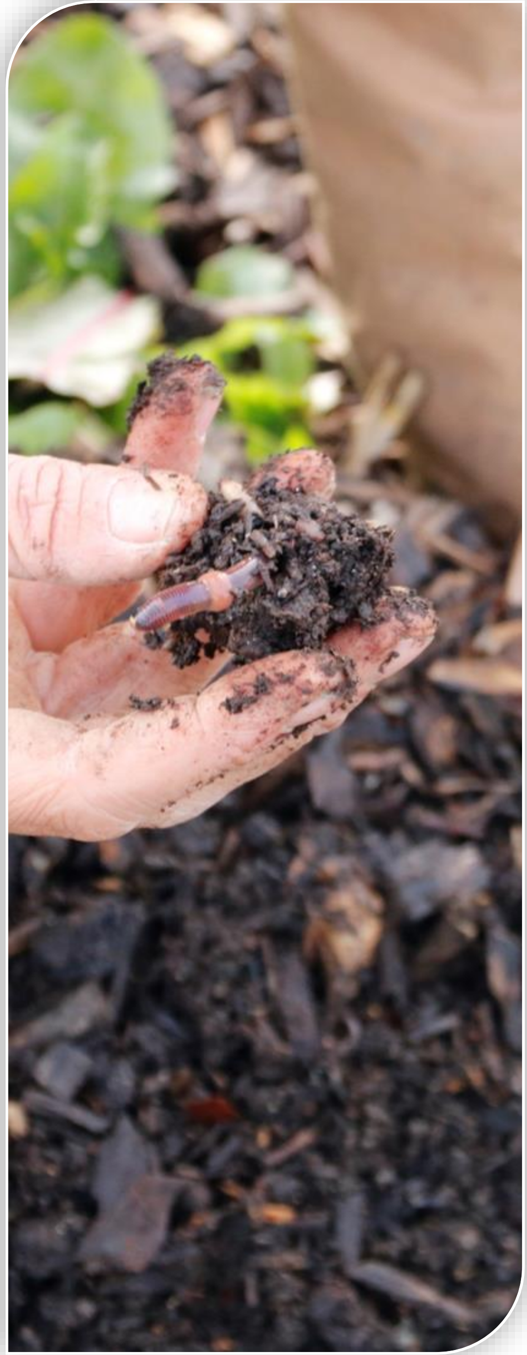


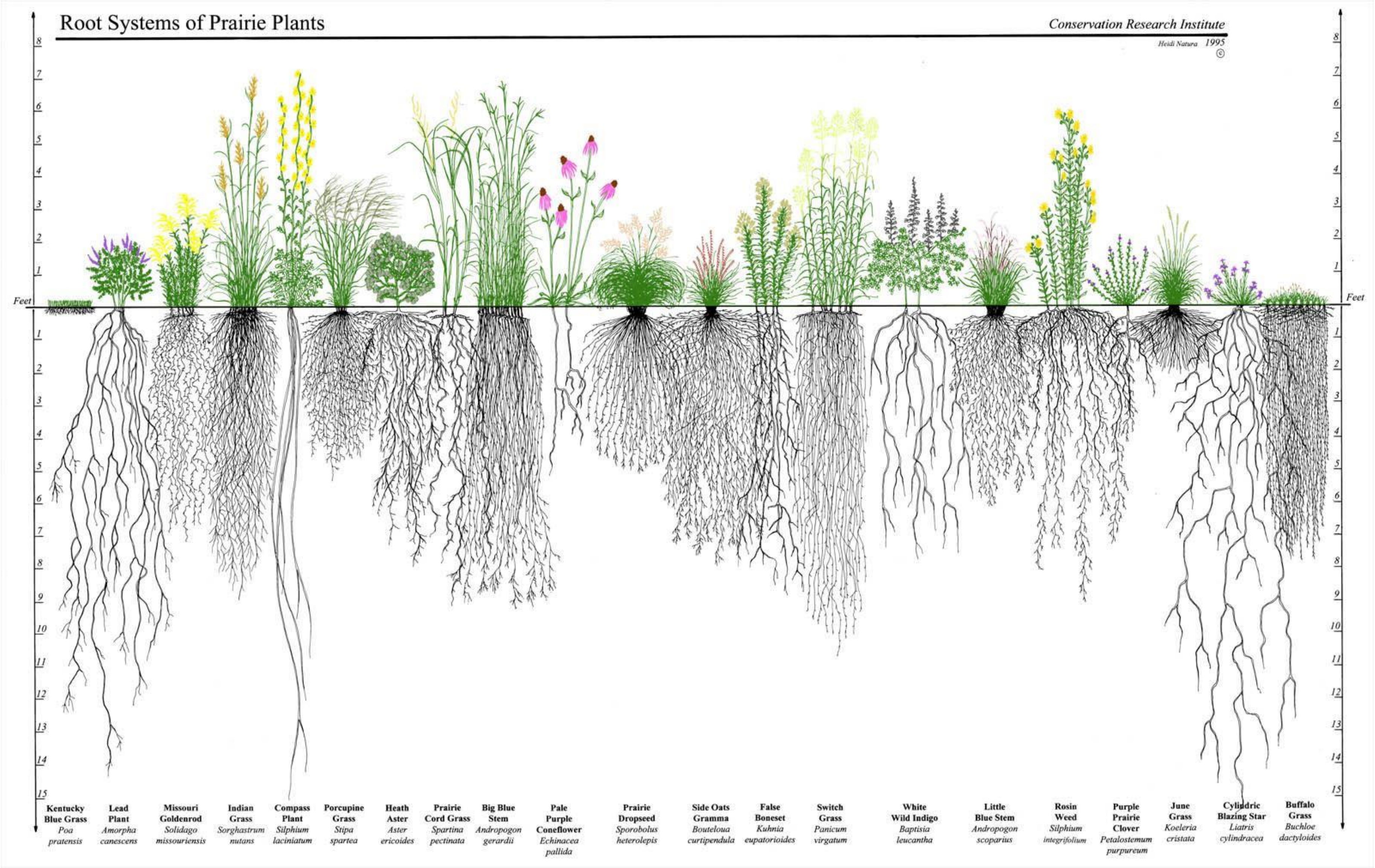


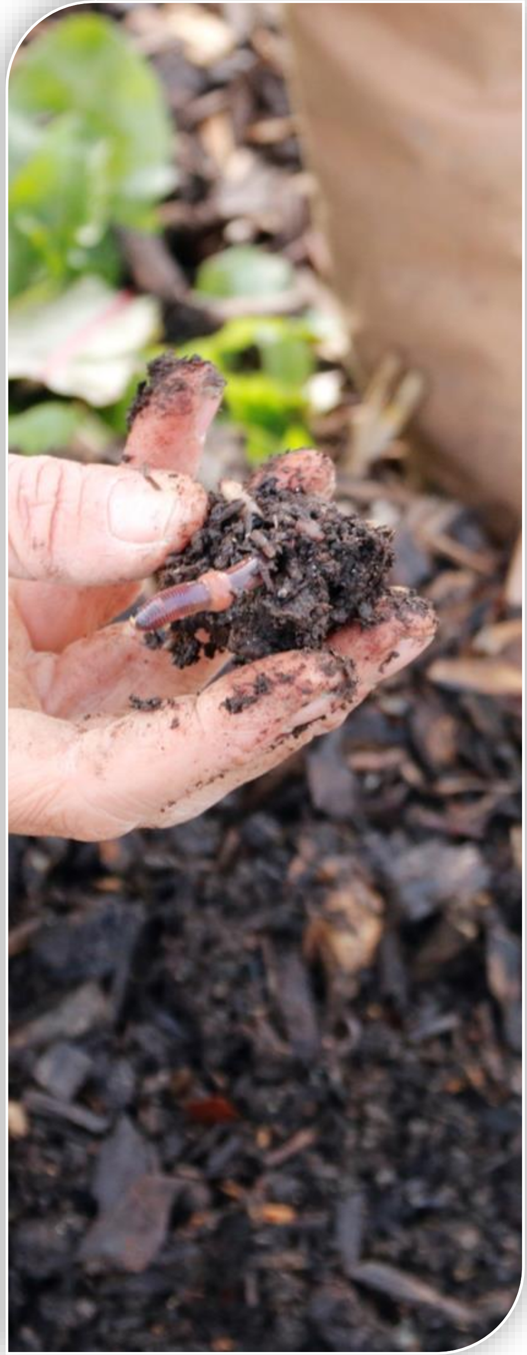
Arbuscular Mycorrhizal Fungi

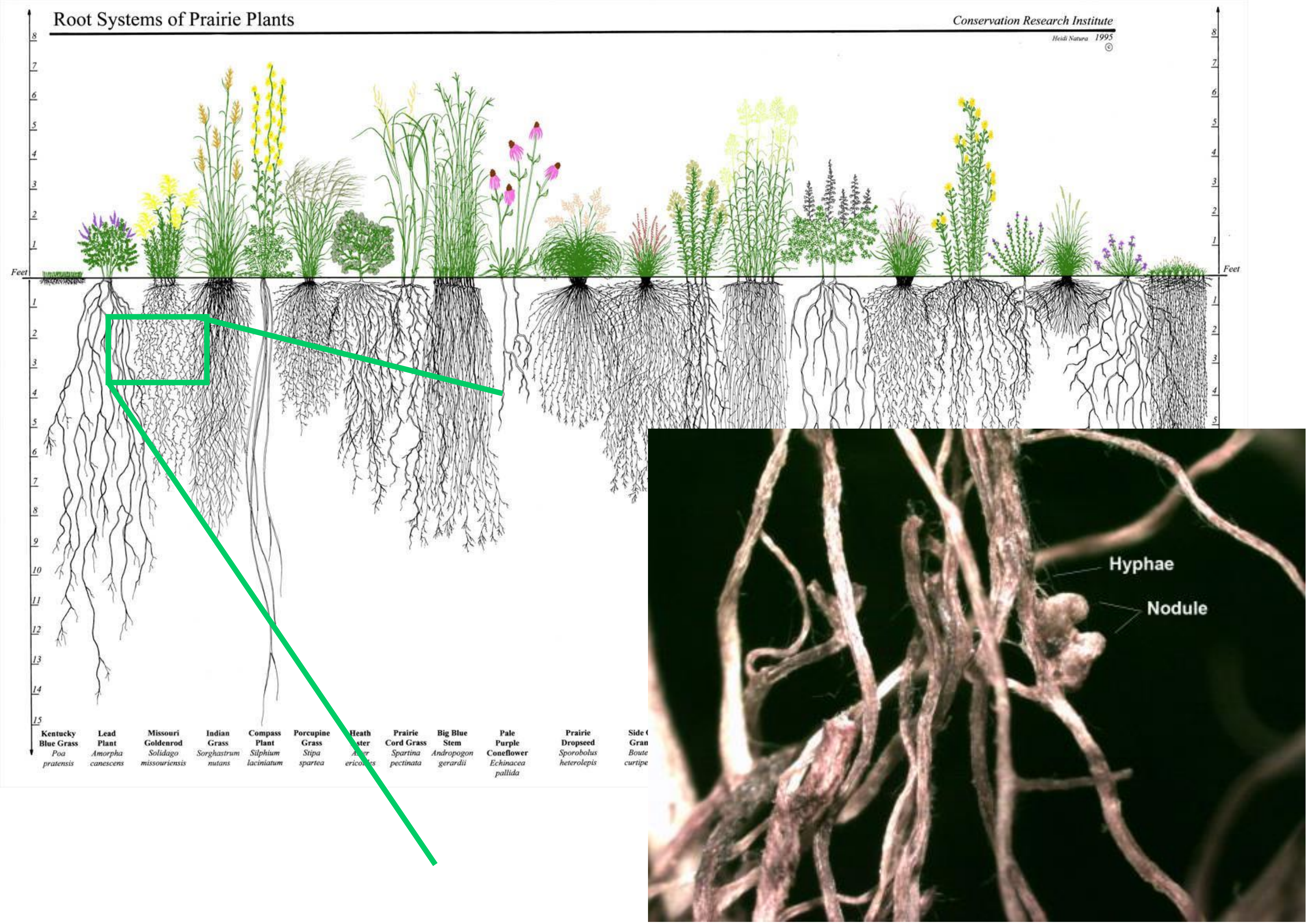
- Obtain nutrients (up to 90% of N and P) – Smith and Read, 2008
    - Phosphate-solubilizing bacteria – Toro and Barea, 1996
    - Mixed cultures more efficient, but this was also AMF species dependent – Walder et al 2012
    - Non-legume trades P for N via AMF and rhizobia activity – Chalk et al, 2014
- Transfer water
- Induce antioxidants (Garcia-Sanchez et al., 2014)






Root Systems of Prairie Plants
Conservation Research Institute
Heidi Natura 1995 ©
Feet
Kentucky Blue Grass *Poa pratensis*
Lead Plant *Amorpha canescens*
Missouri Goldenrod *Solidago missouriensis*
Indian Grass *Sorghastrum nutans*
Compass Plant *Silphium laciniatum*
Porcupine Grass *Stipa spartea*
Heath Aster *Aster ericoides*
Prairie Cord Grass *Spartina pectinata*
Big Blue Stem *Andropogon gerardii*
Pale Purple Coneflower *Echinacea pallida*
Prairie Dropseed *Sporobolus heterolepis*
Side Oats Gramma *Bouteloua curtipendula*
False Boneset *Kuhnia eupatorioides*
Switch Grass *Panicum virgatum*
White Wild Indigo *Baptisia leucantha*
Little Blue Stem *Andropogon scoparius*
Rosin Weed *Silphium integrifolium*
Purple Prairie Clover *Petalostemum purpureum*
June Grass *Koeleria cristata*
Cylindric Blazing Star *Liatris cylindracea*
Buffalo Grass *Buchloe dactyloides*




Root Systems of Prairie Plants
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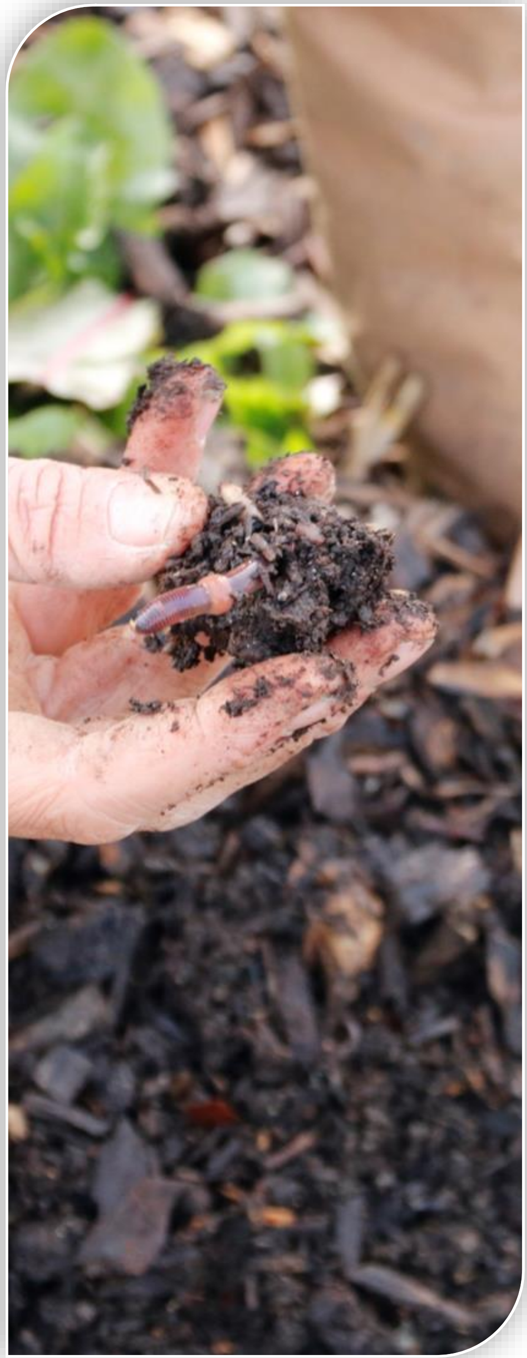
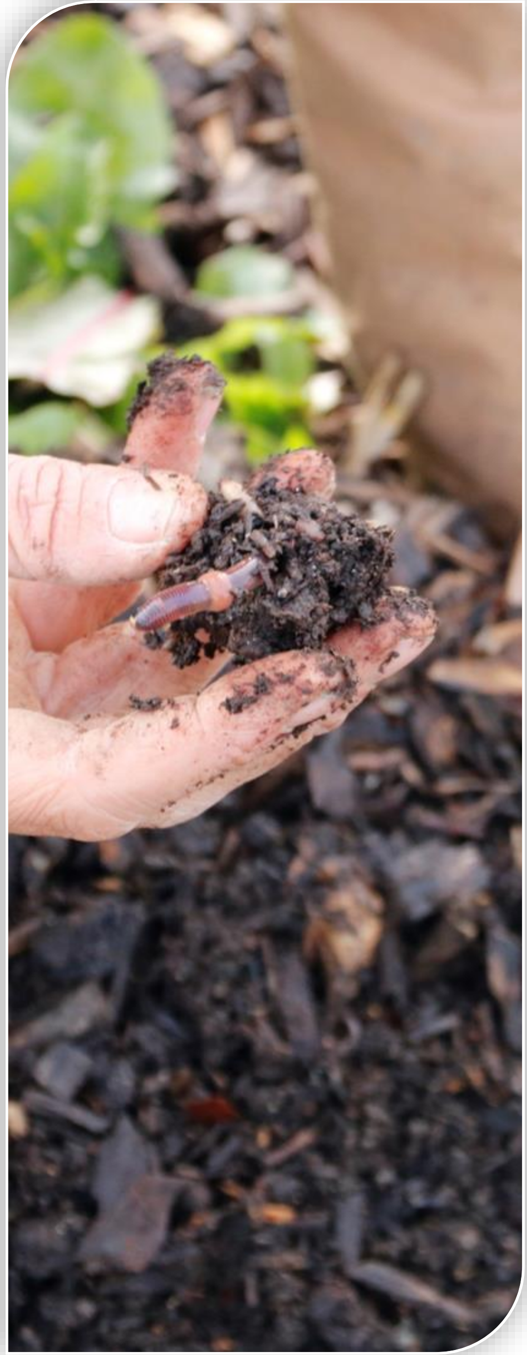
Silphium laciniatum
Porcupine Grass
Stipa spartea
Prairie Cord Grass
Spartina pectinata
Big Blue Stem
Andropogon gerardii
Pale Purple Coneflower
Echinacea pallida
Prairie Dropseed
Sporobolus heterolepis
Hyphae
Nodule



Water Use Efficiency

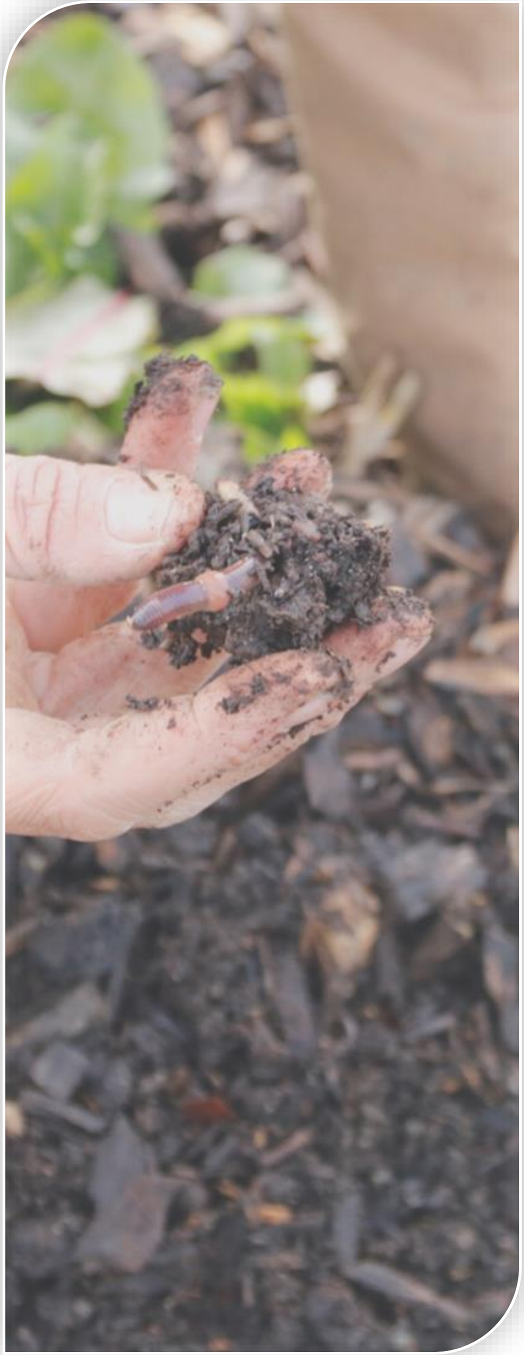
- The Drought Myth - a case of plant hunger rather than thirst - unfertilized corn required 26,000 gallons of water per bushel yielded 4X less than a fertilized field receiving only 5,600 gallons of water per bushel. – W.A. Albrecht, 2000
- Seven-way cover crop mix yield almost 3 times higher than of single crop on 7 in of soil moisture. Field with manure and no commercial fertilizer yielded the same as a fertilized field and plant tissues tested sufficient or high for N, P, K, and S – North Dakota, 2006
- 45% greater porosity increases infiltration rate by 167% for the first inch and 650% for the second inch - Karlen et al., 1998
- Loose soil has a slower rate of drying compared to packed soil, because the water films are discontinuous and moisture is not readily conducted to the surface.



Treat Soil Like you're supposed to treat yourself

- Eat small meals throughout the day (be a grazer).
- Eat a diverse diet.
- Exercise but don't over exercise – FIST (Frequency, Intensity, Scale, Timing).
- Protect your body from injury, radiation, temperature extremes, etc. (armor).

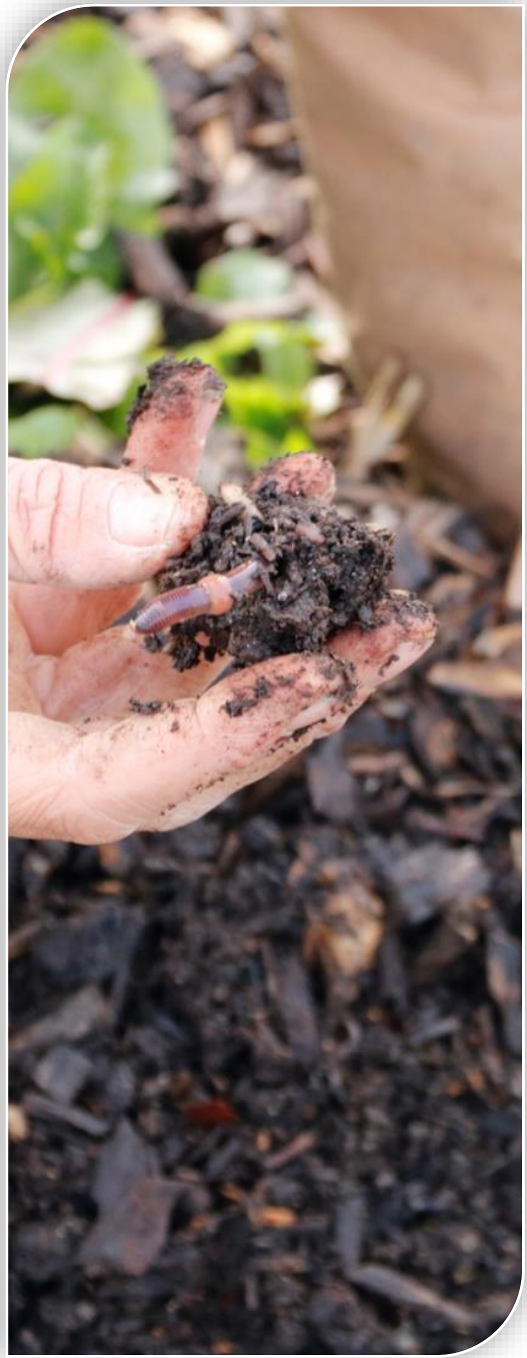
KRIS Systems
Education & Consultation
Knowledge for Regeneration & Innovation in Soil



It really boils down to this: that all life is interrelated. We are all caught in an inescapable network of mutuality, tied into a single garment of destiny. Whatever affects one destiny, affects all indirectly.

Martin Luther King Jr., Christmas Eve Serman, 1967

Dr. Kris Nichols
Food Water Wellness Foundation
MyLand Company LLC, www.MyLand.ag
Kris@KRIS-Systems.com
glomalin1972@gmail.com



Questions?