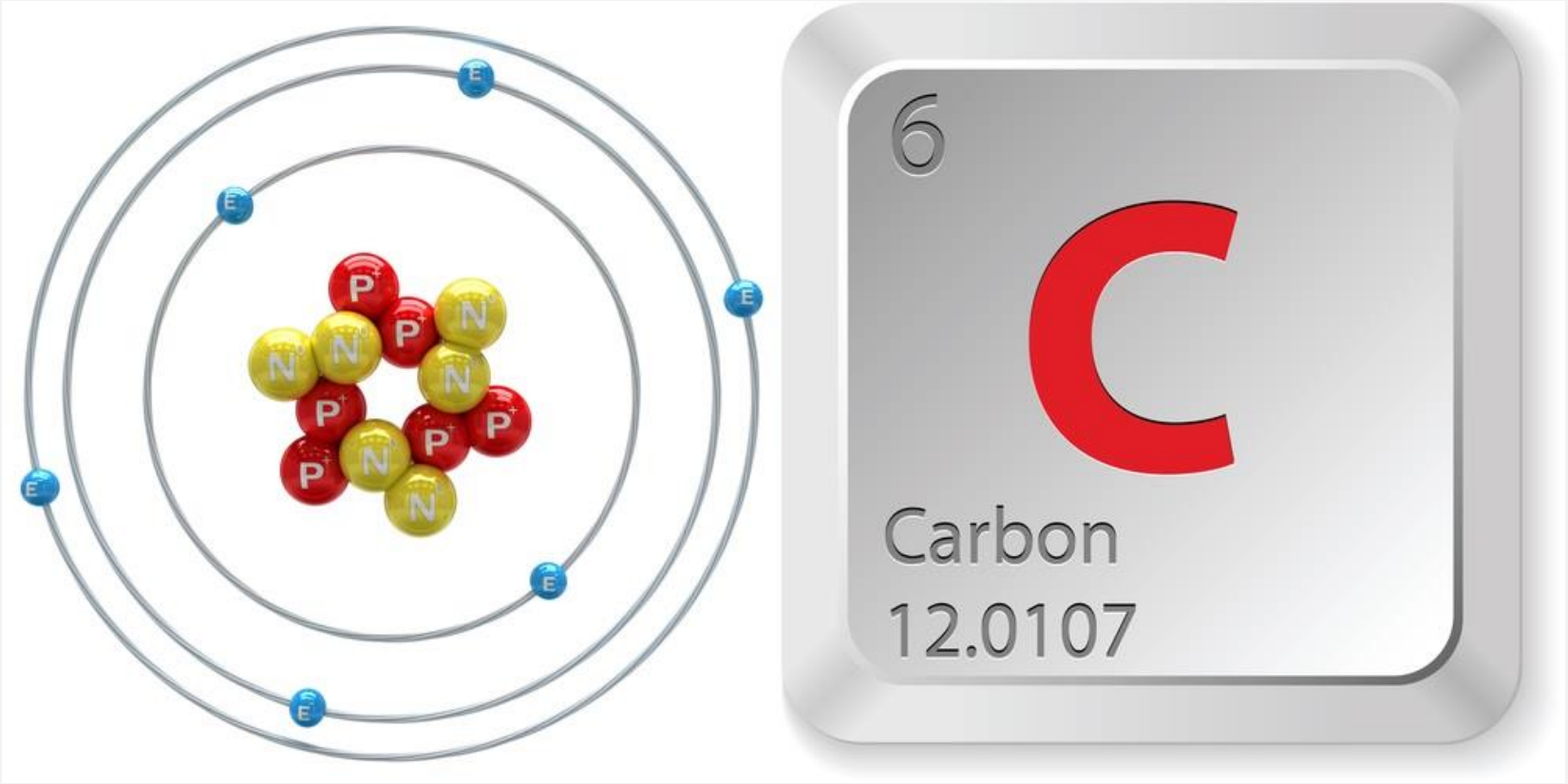
CLIMATE CHANGE, SOIL HEALTH, AND COMPOST

Growing Our Opportunities

Innovation is the ability to see change as an opportunity – not a threat.

- Steve Jobs

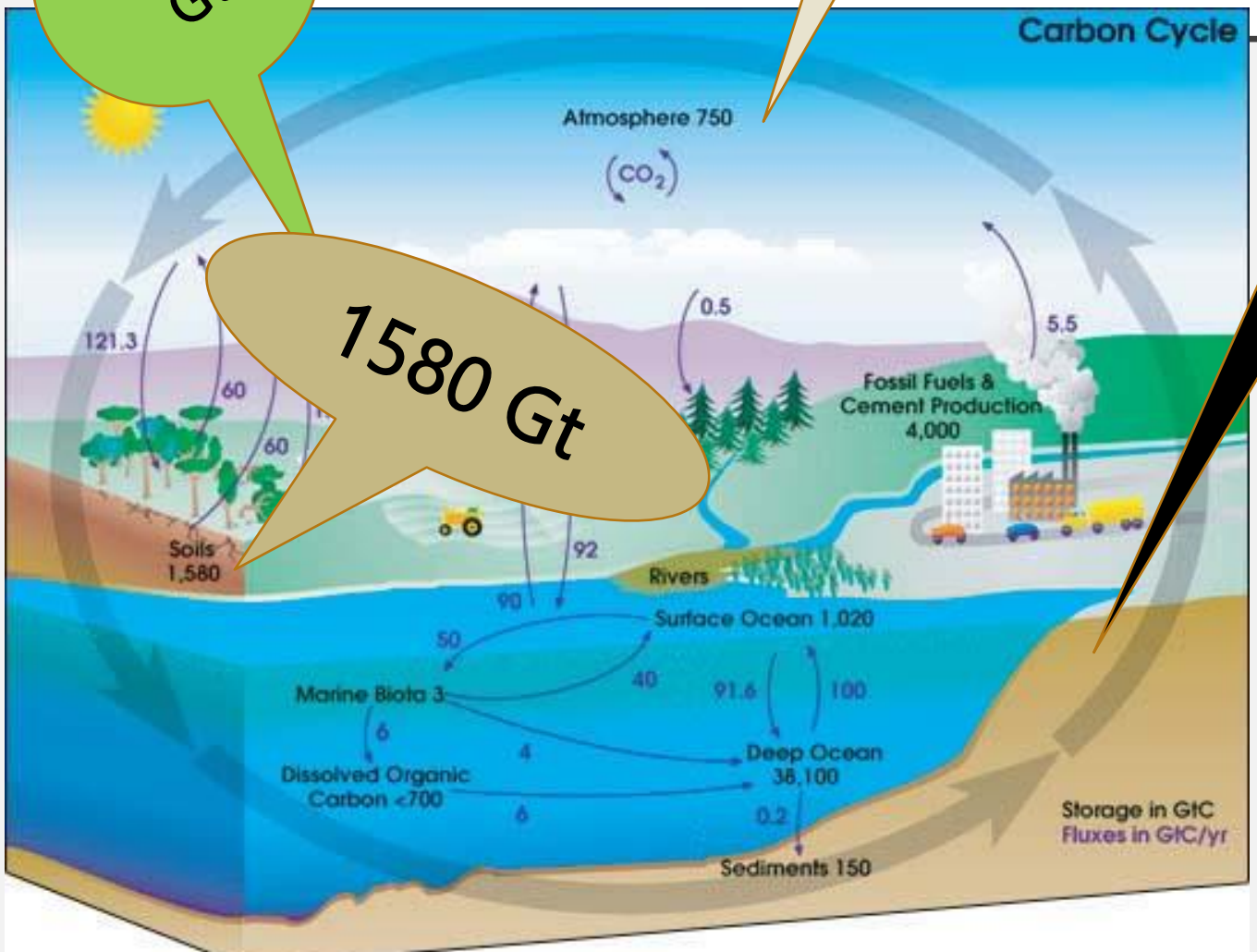
CARBON – THE ENERGY CURRENCY OF LIFE



SOME FACTS ABOUT CARBON

- 4th most abundant element in the universe
- Formed in the heart of stars (NOT in the Big Bang!)
- Extremely versatile (diamonds, charcoal, graphite, etc.)
- The basis for life on earth (organic chemistry)
- About 58% of all soil organic matter (SOM)

THE CARBON CYCLE



750 Gt

610 Gt

1580 Gt

2,795 GT of known fossil fuel reserves

COMPOSITION OF THE EARTH'S ATMOSPHERE

Gas	Per cent of atmosphere
Nitrogen (N_2)	78
Oxygen (O_2)	21
Argon	.93
Carbon dioxide (CO_2)	.04

THE CARBON [redacted] OPPORTUNITY

- **Too much C in the atmosphere**
  - CO2 levels have gone from 315 ppm in the 1950s to more than 400 ppm recently
  - 350 is the level many scientists feel we should achieve & maintain
- **Too little C in our soils**
  - Organic matter in agricultural soils has dropped by an average of more than 50 per cent since the introduction of the plough
  - This drop in organic matter represents an addition to atmospheric carbon as well as a loss in soil fertility
- This is an opportunity!

Too little carbon in a living soil ecosystem?

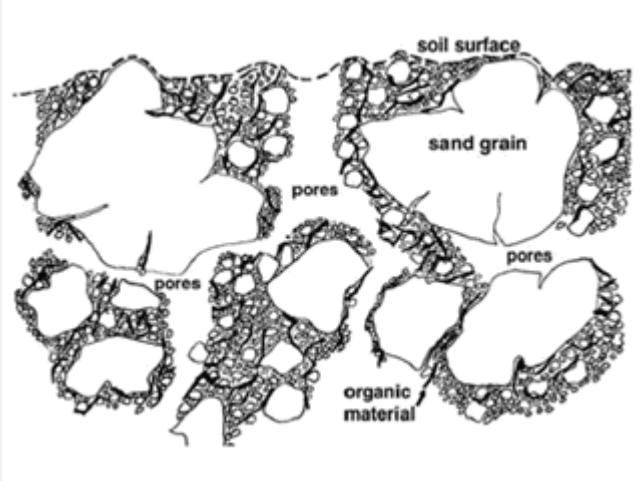
Sounds like the right opportunity for carbon managers!

THE SOIL FOOD WEB IS A COMMUNITY

Like our own communities, it **organizes itself** to optimize conditions for its members

To do this, it uses the **energy** that comes from the above-ground ecosystem

For example, the community organizes a **soil structure** similar to our community infrastructure



GOOD SOIL STRUCTURE – CRUMBLY, WELL AGGREGATED

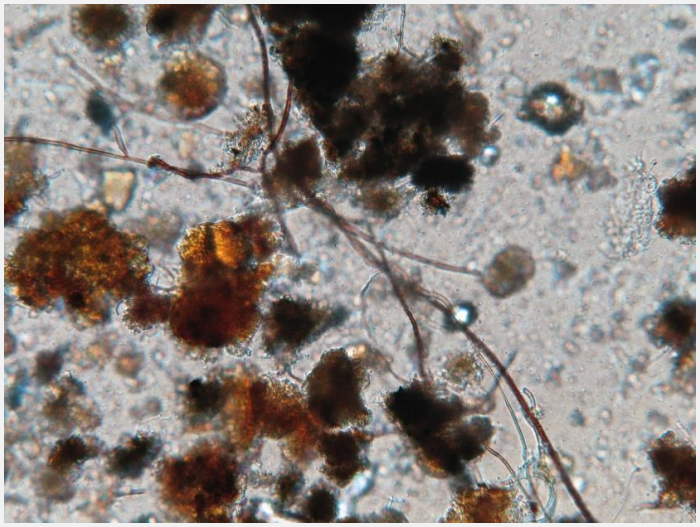
Field: Adam Ireland, Teeswater (same field, cover cropped vs not). Photo: Ontario Soil Network (Mel Luymes)

UNDERGROUND CARBON TRADING

Two basic systems:

1 - **Plant root exudates:** Up to 44% of photosynthate exuded into rhizosphere

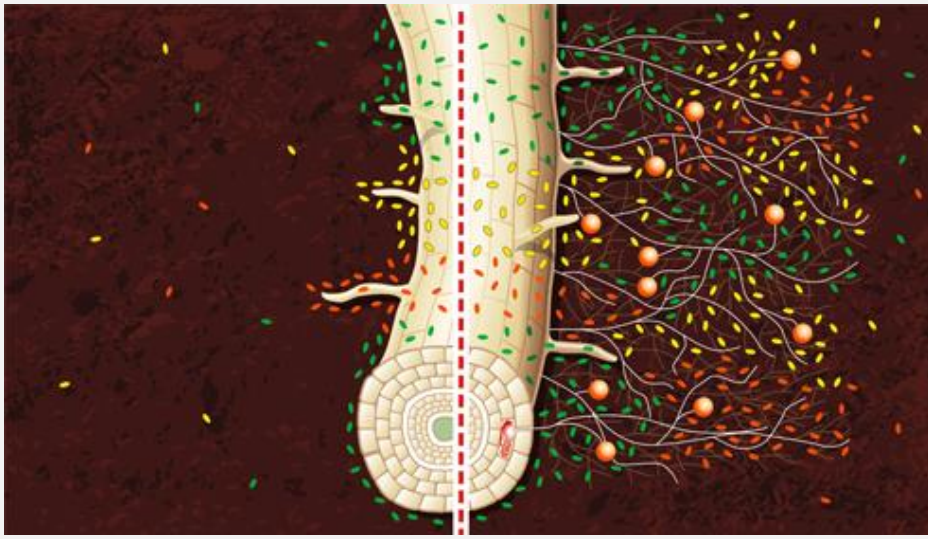
2 - **Mycorrhizal fungi:** Two-way delivery system – nutrients traded for C compounds



Source: Soil and Water Conservation Society

PLANT ROOT EXUDATES AND FERTILITY

- However --- most of the exudates become food for the microbes in the root zone, or "rhizosphere"
- This is known as the **"rhizosphere effect"** – much greater populations of microbes near roots because of these rich energy sources



PLANT ROOT EXUDATES AND FERTILITY – CONT'D

This "give-away" benefits the plant in many ways:

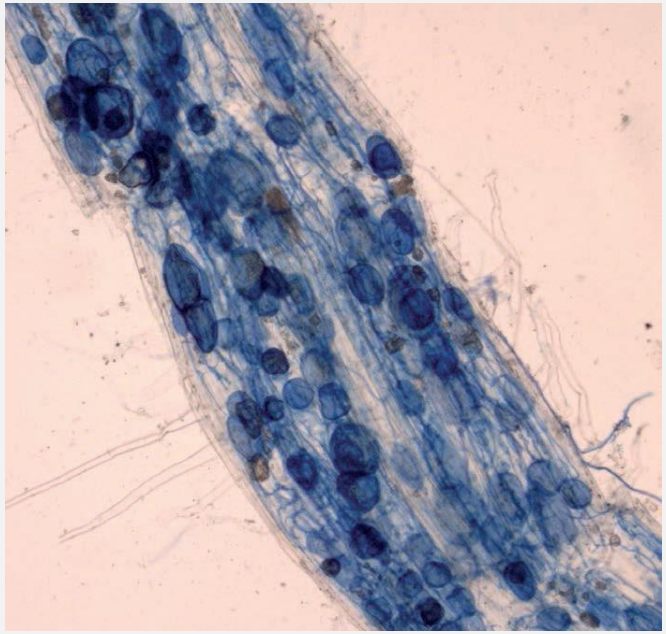
- **Nutrients:** predators are attracted to root zone because of the high density of prey (bacteria and fungi)
- The predators consume the prey and release plant-available nutrients as wastes, right where the plant needs them

THREE TYPES OF SOIL FUNGI

- Pathogenic – disease-causing
- Saprophytic -- decomposing
- Mycorrhizal -- symbiotes

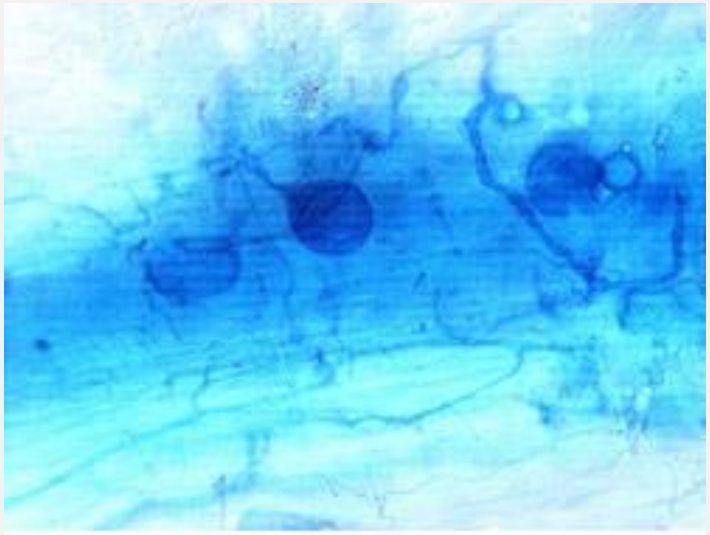
AMF: ARBUSCULAR MYCORRHIZAL FUNGI

- Most common mycorrhizae in farm fields and turf
- Many different species
- Confer many benefits, including: water and nutrients, disease suppression, soil structure, increased C levels
- Suppressed by high levels of fertility, especially P
- Damaged by tillage, inappropriate chemical use

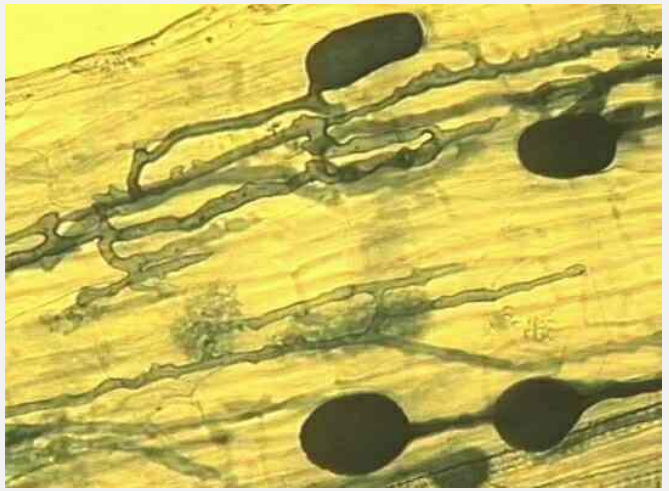


Source: Soil and Water Conservation Society

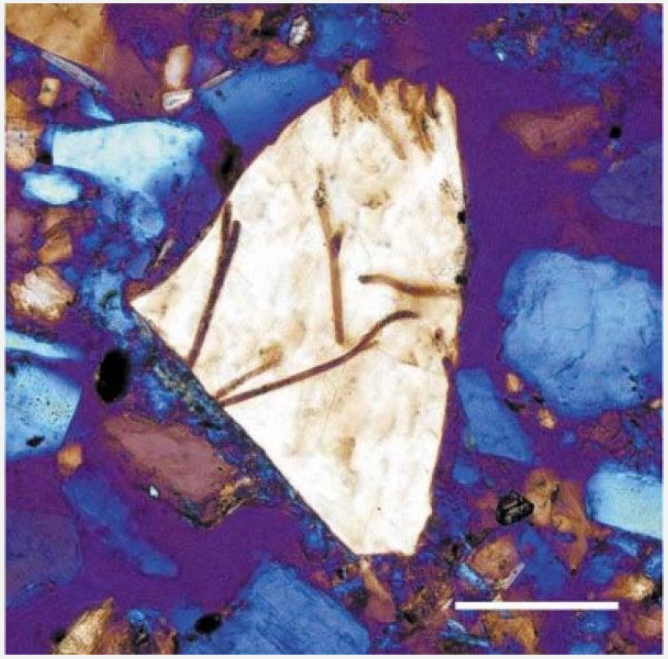
MYCORRHIZAL CONNECTIONS TO ROOTS



Symbiotic association of Mycorrhizal fungi and the plant root (200x magnification)



MYCORRHIZAL FUNGI AT WORK



Credit: Box 4 I(c) from Landeweert et al. 2001.

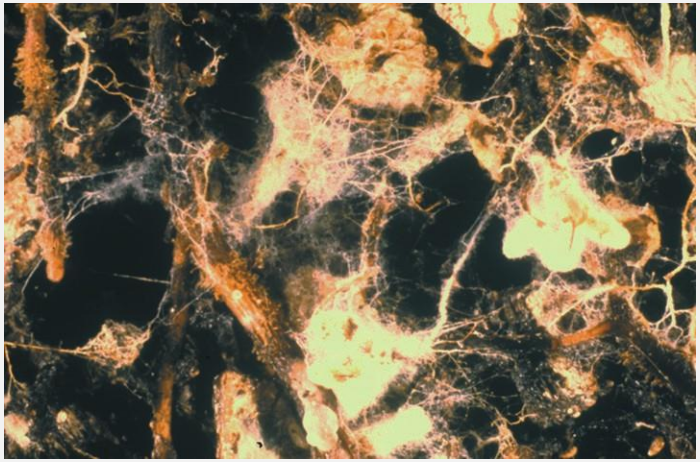
A piece of feldspar with tunnels created by mining fungi

THE BIOLOGY OF SOIL CARBON

…and its connection to climate and resilience

HOW DO SOILS SEQUESTER CARBON? (CLIMATE REGULATION)

- Used to be thought that soil carbon came solely from organic residues
- Therefore, to sequester carbon in soils -- leave residues, add manure, compost



Source: Soil and Water Conservation Society

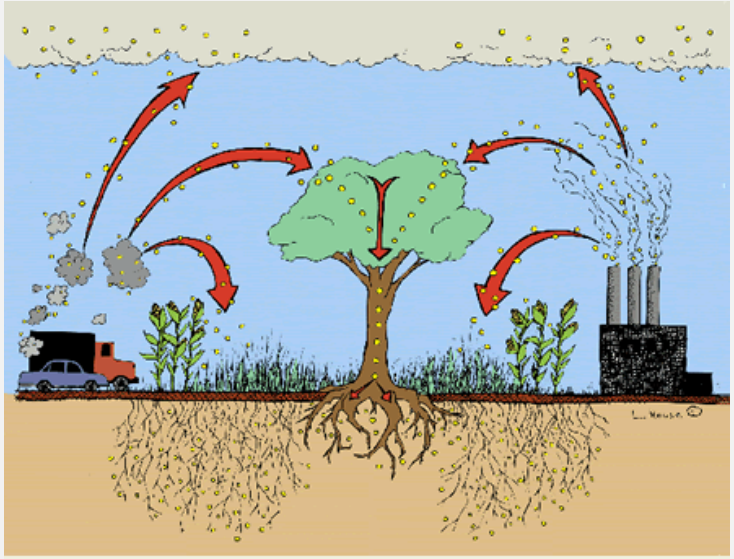
Now understood that the C coming through plant roots (**carbon trading system)** is a key to higher sequestration

CLIMATE REGULATION (2)

How Fast Can Soils Sequester Carbon?

- IPCC estimates: 1.1 to 1.8 tonnes of CO_{2e} per ha per year
- 2007 study for central Canada: 0.36 to 1.1 tCO_{2e}/ha/yr
- ECO report – Ontario farmer: 4.75 tCO_{2e}/ha/yr
- Similar (or higher) figures in anecdotal literature
- Recent study in southeastern US: 29 tCO_{2e}/ha/yr (degraded grazing land)

Why the difference?



Source: ERS/USDA

US EPA has stated that the average car generates 4.7 tCO_{2e}/yr. Even at lowest IPCC estimate, a 500 ha farm would offsetting the GHG emissions of 117 cars annually. The 4.75 rate would offset the GHGs of 505 cars annually.

THE SHIFTING UNDERSTANDING OF WHAT CONSTITUTES SOIL HUMUS

- What exactly IS soil humus?
  - OM too tough for the bugs?
  - Huge organic molecules synthesized by either chemical or biological means?

THE SHIFTING UNDERSTANDING OF WHAT CONSTITUTES SOIL HUMUS

- New understanding emerging:
  - **Persistence of SOM as an ecosystem property**
  - Does "soil humus" really exist in the way we have always thought? – Lehmann and Kleber – **"Contentious Nature of SOM"**
- Relevance to compost, composting, and climate change
  - Kallenbach 2016 – **"Direct Evidence for Microbially Derived SOM formation and its ecophysiological controls"**

Soils, Compost and Climate Change

THE SOIL STORY

https://www.youtube.com/watch?v=08TI1RKj54g

MARIN CARBON PROJECT: NPP AND CARBON SEQUESTRATION

UC Berkeley – Marin Carbon Project

- 4000 cu yds of food-waste compost on 100 acres of rangeland
- 50 per cent increase in forage production
- Increase of one tonne of C (3.7 t CO_{2e}) per ha per year for three years after single application

American Carbon Registry –

Developed offset protocol for application of compost to rangelands

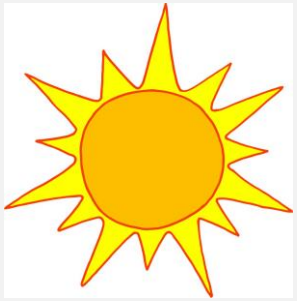
NOTE: Soil C not from compost – it comes from the increased root biomass production and the root exudates!

CREATING HEALTHY SOIL ECOSYSTEMS

--- concepts, principles, practices

THREE IMPORTANT REQUIREMENTS OF A LIVING SOIL ECOSYSTEM

Sufficient food/energy



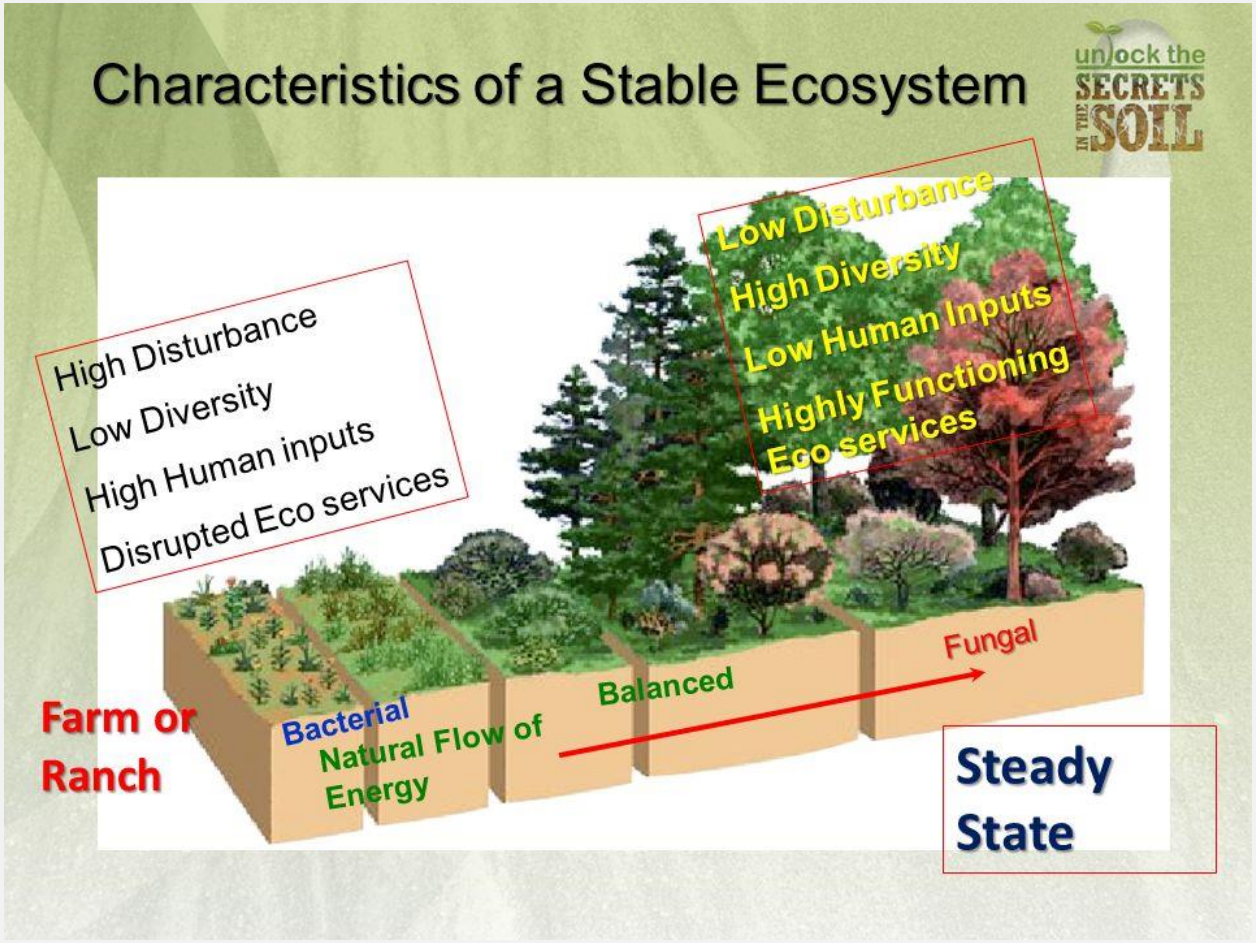
A safe home (habitat)

Diversity

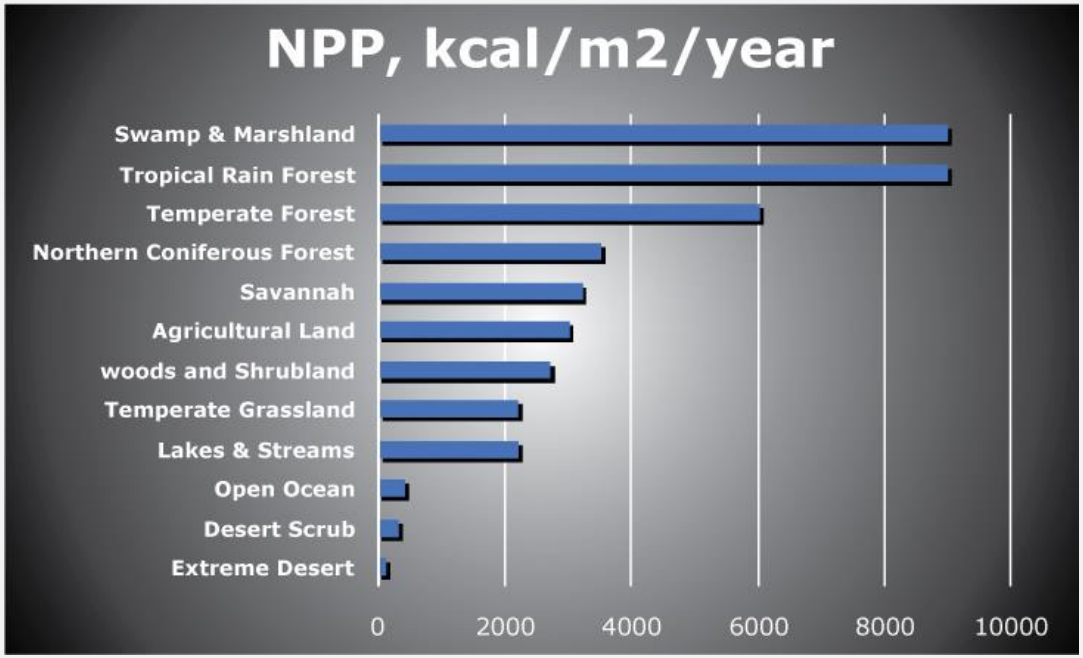
GIVING AND GETTING

What Healthy Soil Gives Us:	What Soil Needs From Us to be Healthy:
Water management	Energy/Food management
Nutrient management	Habitat protection
Disease & pest suppression	Diversity management

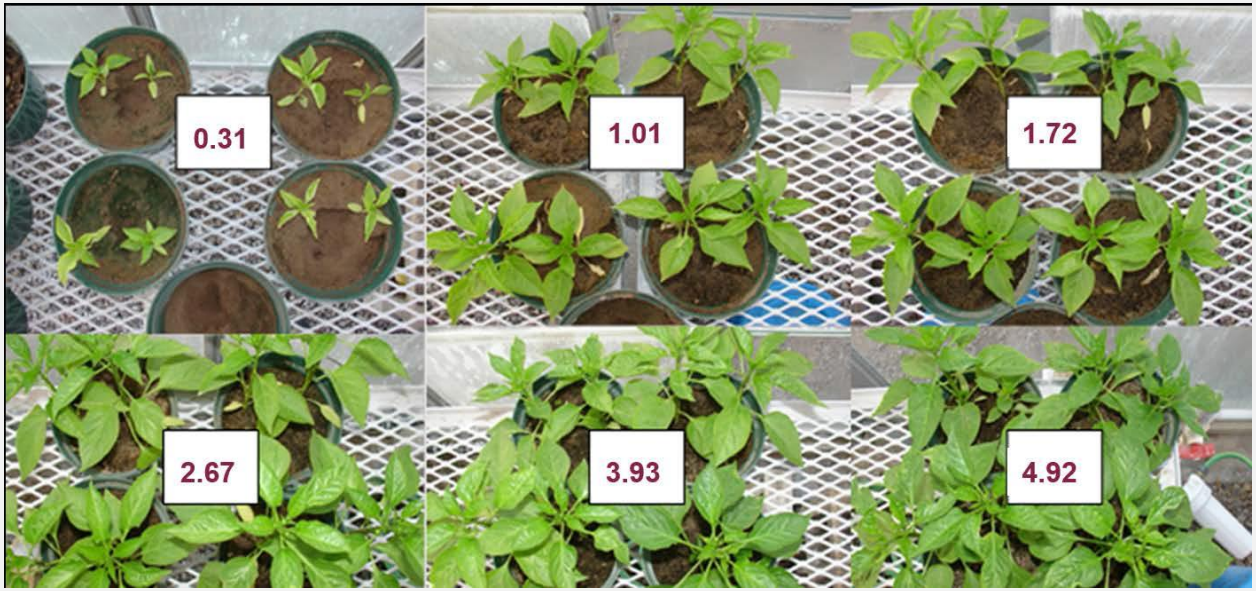
ECOLOGICAL SUCCESSION IN SOILS (AND COMPOST)



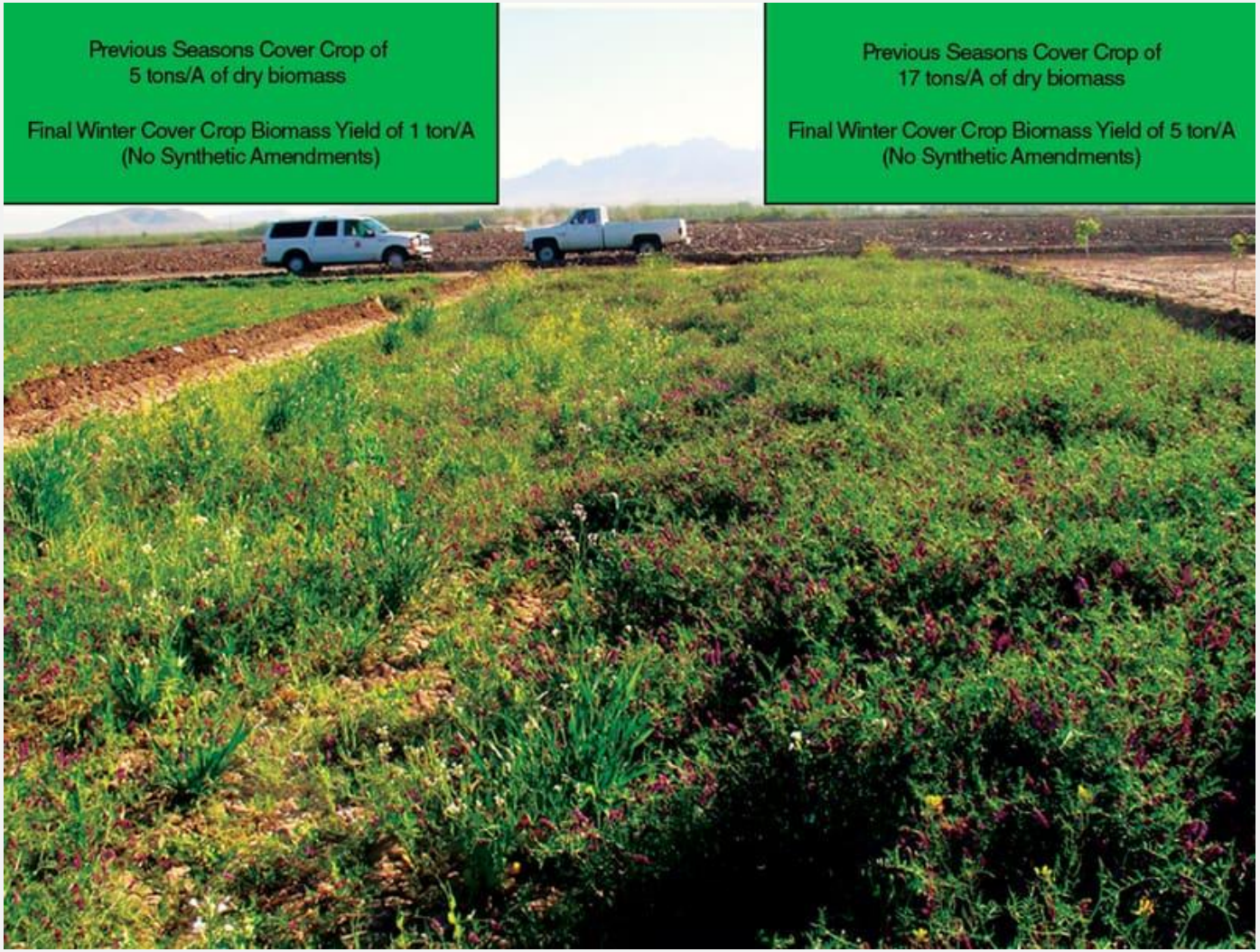
PRODUCTIVITY IN DIFFERENT STAGES OF SUCCESSION



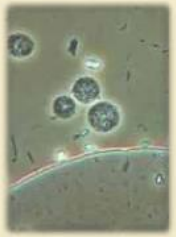
COMPOST AND SOIL HEALTH: DR DAVID JOHNSON



EFFECTS OF BEAM COMPOST INOCULATION ON COVER CROPS



BE A SOIL BUILDER



Cover the soil

Keep roots in the ground

Add organic amendments

Support plant & soil diversity

Minimize soil disturbance

Conseil canadien du COMPOST Council of Canada www.compost.org ALLIANCE DE LA QUALITÉ COMPOST QUALITY ALLIANCE

This project was funded in part through *Growing Forward 2 (GF2)*, a federal-provincial-territorial initiative.
The Agricultural Adaptation Council assists in the delivery of *GF2* in Ontario.

Growing Forward 2 AAC agricultural adaptation council Ontario Canada


ALLIANCE DE LA QUALITÉ
COMPOST
QUALITY ALLIANCE

Compost Quality Parameters for the CQA

USE	pH	C/N ratio	Moisture	Particle size	Soluble salts	%Na
Remediation	5.8-8.5	10-40	NA	<2 inch	<20	<3%
Soil Amendment	5.8-8.5	10-30	NA	<1/2 inch	<6	<2%
Landscaping	5.8-8.5	12-22	<50%	<1/2 inch	<5	<2%
Planting Media	5.5-7.8	12-22	<50%	<1/2 inch	<4	<2%
Turf Topdressing & establishment	5.8-7.8	12-22	<50%	<3/8 inch	<3	<1%
Potting Soil	5.5-7.2	12-22	<50%	<1/4 inch	<2	<1%

Be A Soil Builder

We sometimes call it dirt, forgeting how much we depend on the quality of soil for our food, water and environment.

We have to stop taking soil for granted.

An easy first step to create healthy soil is based on a simple equation.

What you take out, you must put back in.

Adding compost restores soil's vitality, providing the texture, structure and nutrients needed for healthy soil and plant growth.

Feed Our Soil

COMPOST!

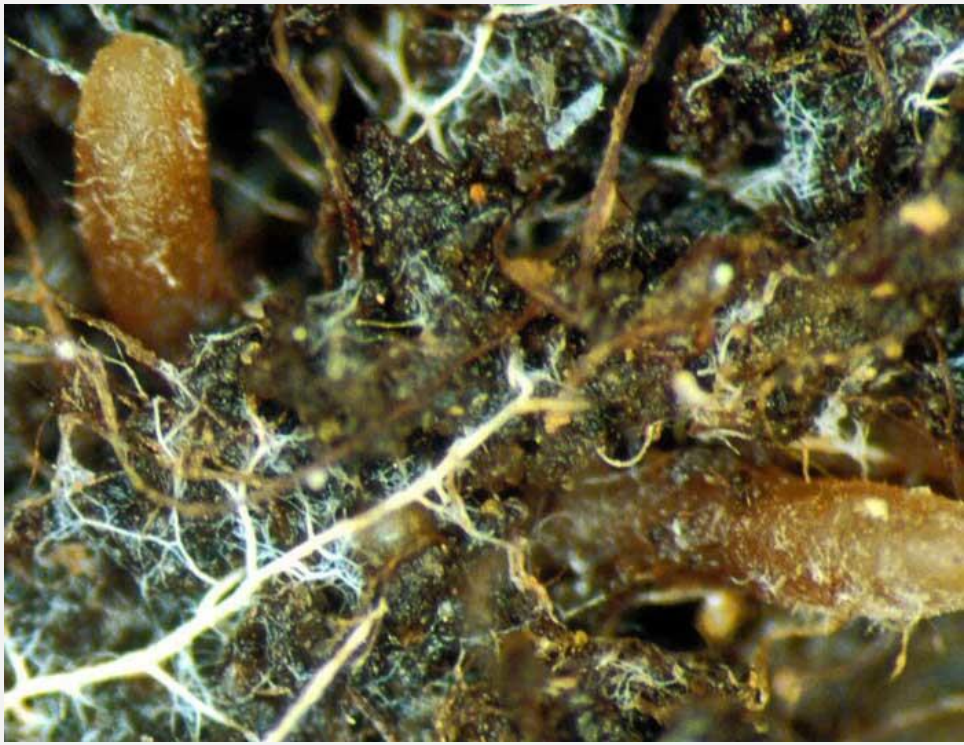
Conseil canadien du COMPOST Council of Canada

www.compost.org.

ALLIANCE DE LA QUALITÉ COMPOST QUALITY ALLIANCE

WE CAN BE HEROES

Thank you!



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