Regenerative Agriculture

Using Photosynthesis to create the Molecules of Life

Building Soil Health and Soil Organic Matter Quickly and Cost Effectively

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Mission:

To promote, facilitate and accelerate the global transition to regenerative food, farming and land management for the purpose of restoring climate stability, ending world hunger and rebuilding deteriorated social, ecological and economic systems.

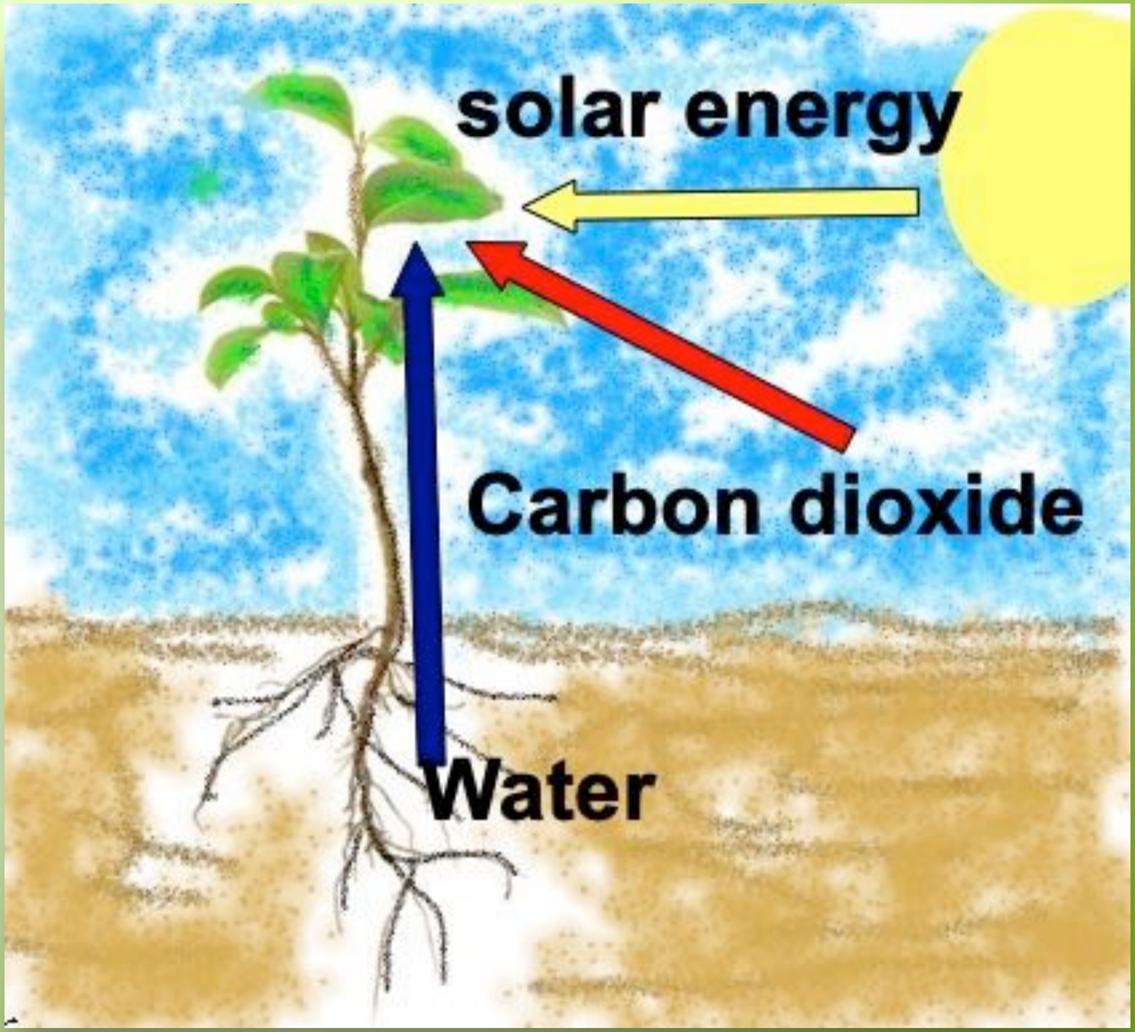
Regenerative Agriculture

Regenerative Agriculture is now being used as an **umbrella term** for the many farming systems that use techniques such as longer rotations, cover crops, green manures, legumes, compost, organic fertilizers

Includes: organic agriculture, agro forestry, agroecology, permaculture, holistic grazing, intensively time managed grazing systems and other **agricultural systems that can increase soil organic matter/carbon**.

Maximize Solar Energy

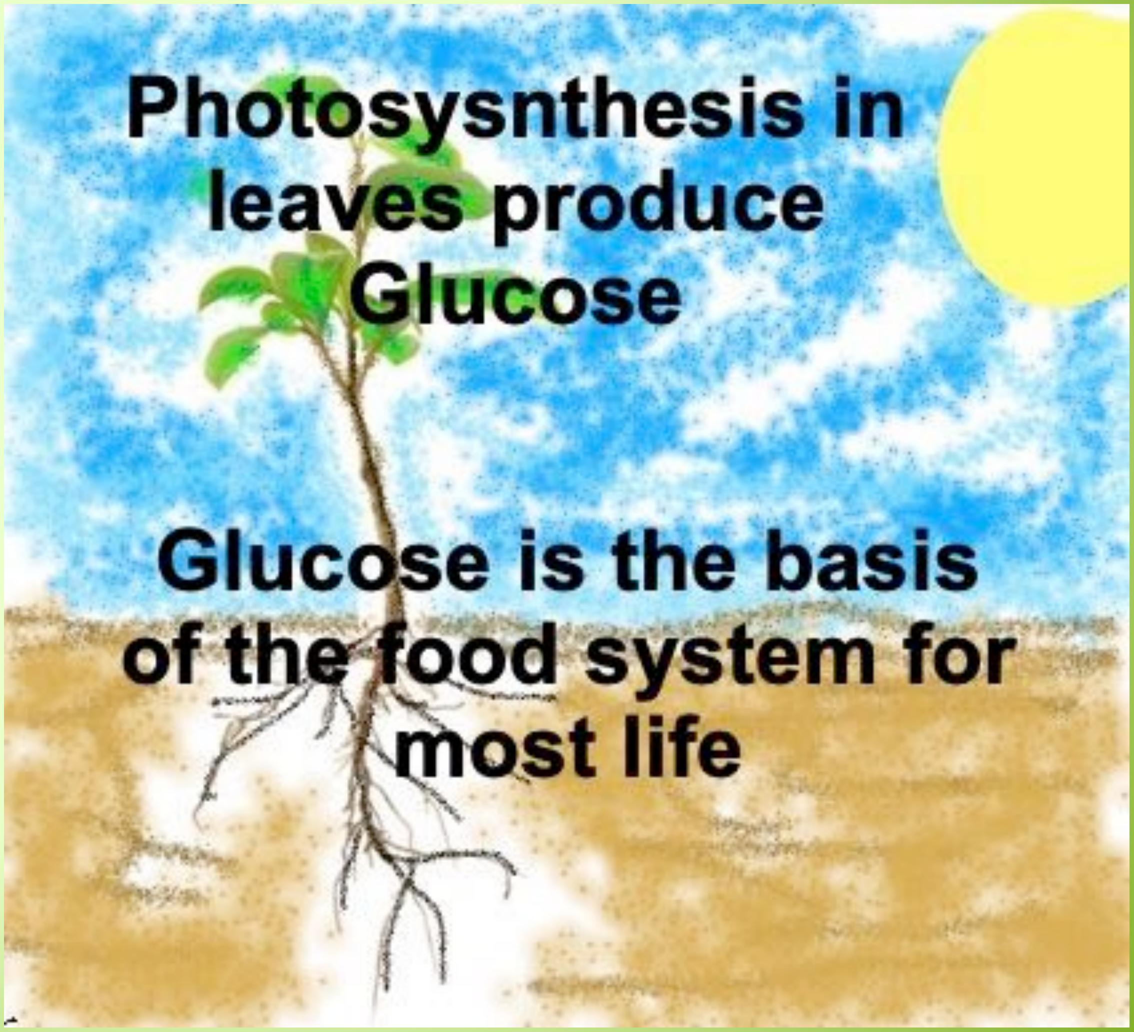
What is the most important thing we do when we farm?



Maximize Solar Energy

We use
solar energy
to power
photosynthesis
to create the

Molecules of Life



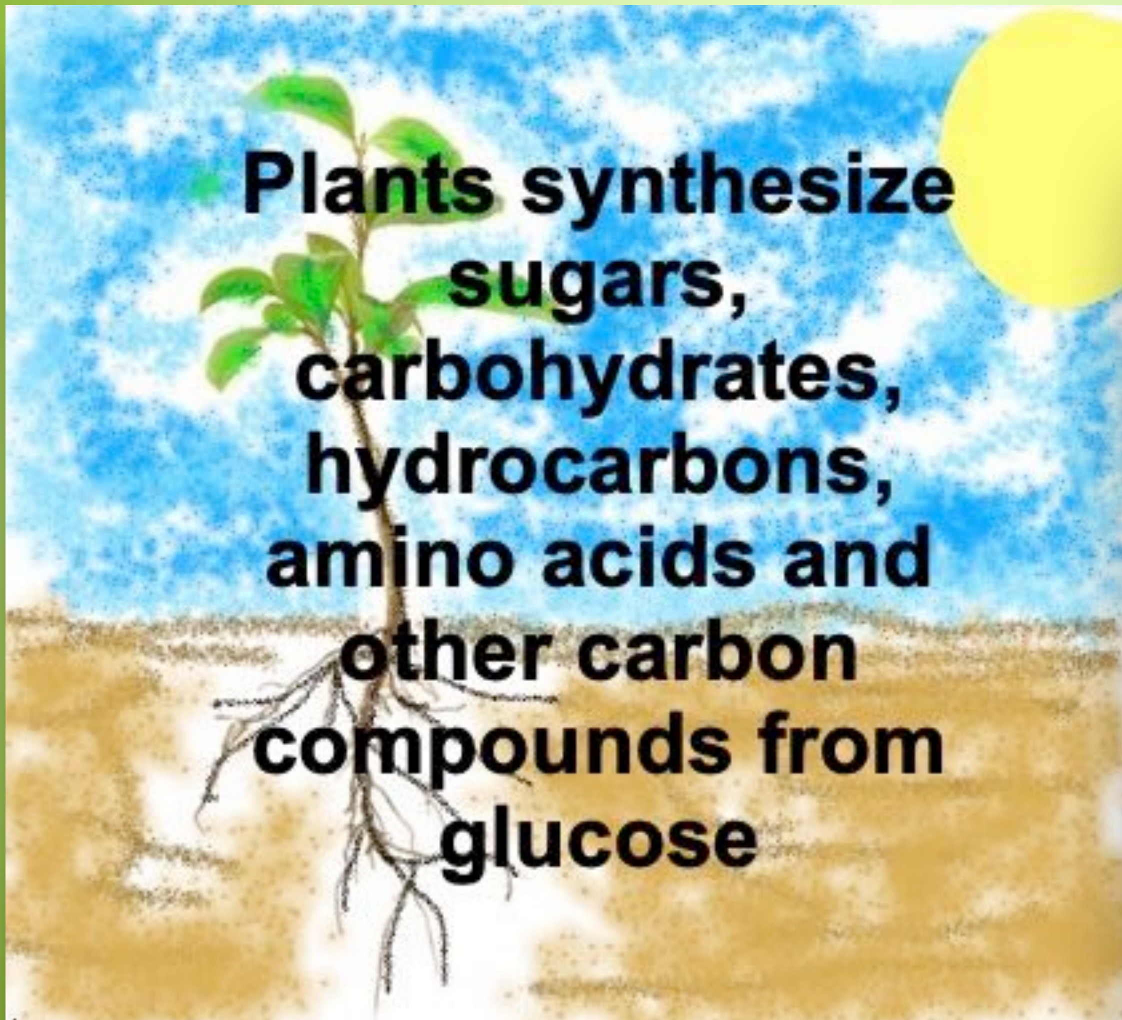
Maximize Solar Energy

Use Photosynthesis to make the key Molecule of Life

$6CO_2$	+	$6H_2O$	+	solar energy	=	$C_6H_{12}O_6$	+	$6O_2$
six molecules of carbon dioxide		six molecules of water				one molecule of glucose		six molecules of oxygen

- **Between 95% and 98% of a plant’s biomass come from water and carbon dioxide using the energy from photosynthesis to make glucose**

Maximize Solar Energy



Glucose is the key Molecule of Life

It is the basis of all the other **Molecules of Life**,

the compounds that all living entities need to grow, reproduce and to stay alive!

The Molecules of Life

Glucose is the key Molecule of Life

- It is a primary energy source of the cells of most living organisms, including plants and animals.

- Glucose molecules can be modified to build many other sugars such as fructose (fruit sugar), sucrose (cane sugar), lactose (milk sugar), maltose (malt sugar) etc.

- **Glucose molecules can be combined together in long chains to form cellulose. These are the basis of wood, leaves, stems and paper.**

- Glucose molecules can be also modified to form carbohydrates — starch which is the basis of flour, bread and staples such as rice, wheat, corn, potatoes, cassava, taro etc.

The Molecules of Life

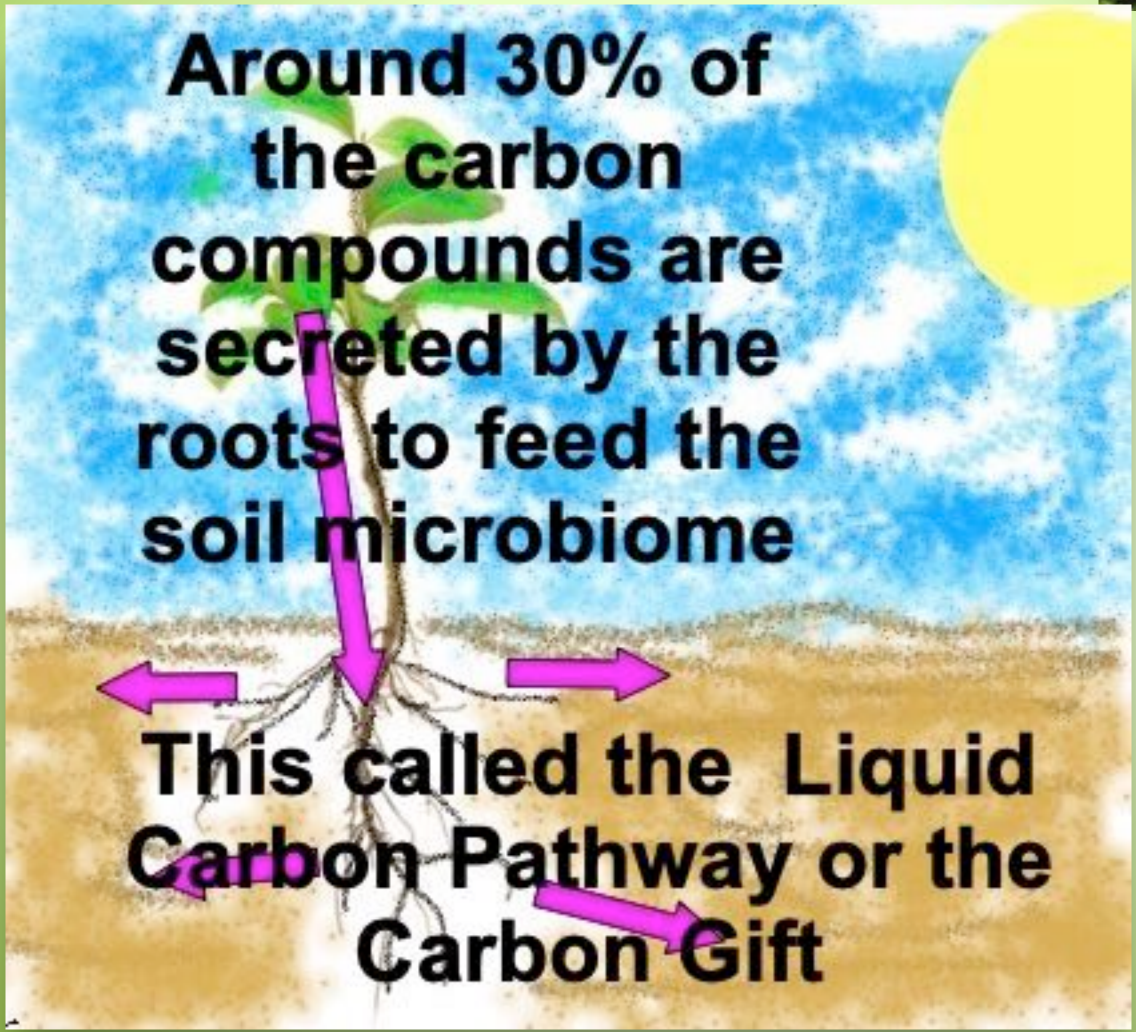
Glucose is the key molecule of life

- The carbohydrates can be modified to form hydrocarbons — oils and fats.

- Glucose molecules can be modified again with the addition of nitrogen and sometimes sulphur to form amino acids — the basis of proteins, DNA, hormones, etc.

- Nearly all life on earth is dependent on the products of photosynthesis either directly or indirectly
- We get our sugars, starches and oils from plants or from animals that have fed on plants.

Maximize Solar Energy



The Rhizosphere

Plant Roots and The Rhizosphere

- The majority of microbes live around plant roots
- This is called ‘The Rhizosphere’
- They feed off root exudates and have important roles in releasing nutrients and protecting plants from diseases
- ***Roots and microbes release enzymes, acids and other compounds that dissolve nutrients from rocks***
- Roots build soil structure
- Deep roots build deep soils

Maximize Solar Energy

The Liquid Carbon Pathway - the Carbon Gift

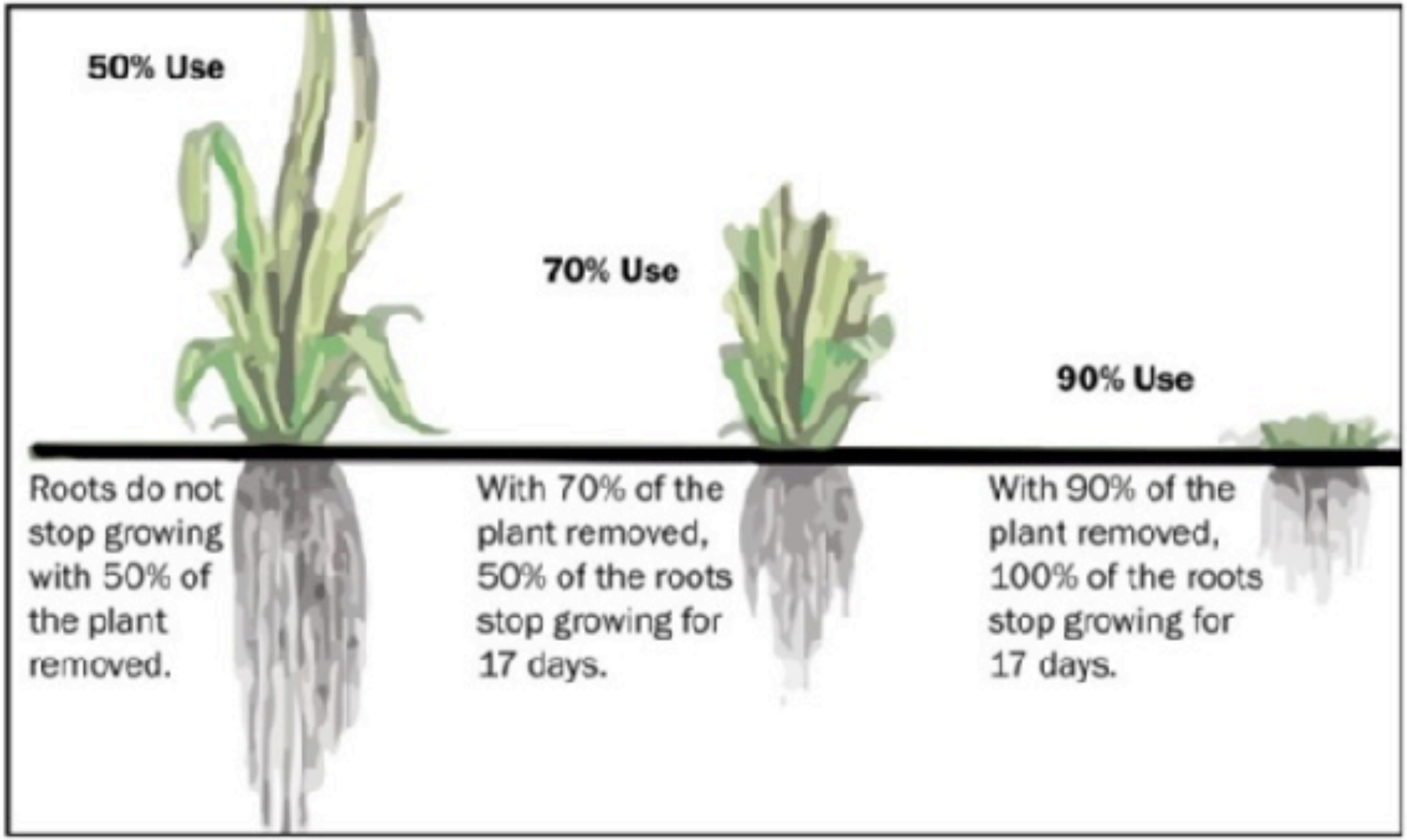
- Soils are created through the biological activity of the microbiome/soil food web/rhizosphere - mediated by roots
- Soil creation and resultant plant available nutrients are primarily due to biological processes rather than chemical or mechanical weathering processes
- **The greater the amount of food that can be provided to the microbiome/soil food web, the greater the soil and plant available nutrients can be produced.**
- Plants - **correctly managed** - increase soil nutrient levels rather than depleting them.

MANAGING GROUND COVERS

Rootmass activity stimulates nutrient availability in soil by:

- Root exudates that feed microbe communities
- Root enzymes and acids extract minerals from rocks
- Builds soil structure and deepens soils
- Generates soil carbon and nutrients for the crop through correct management

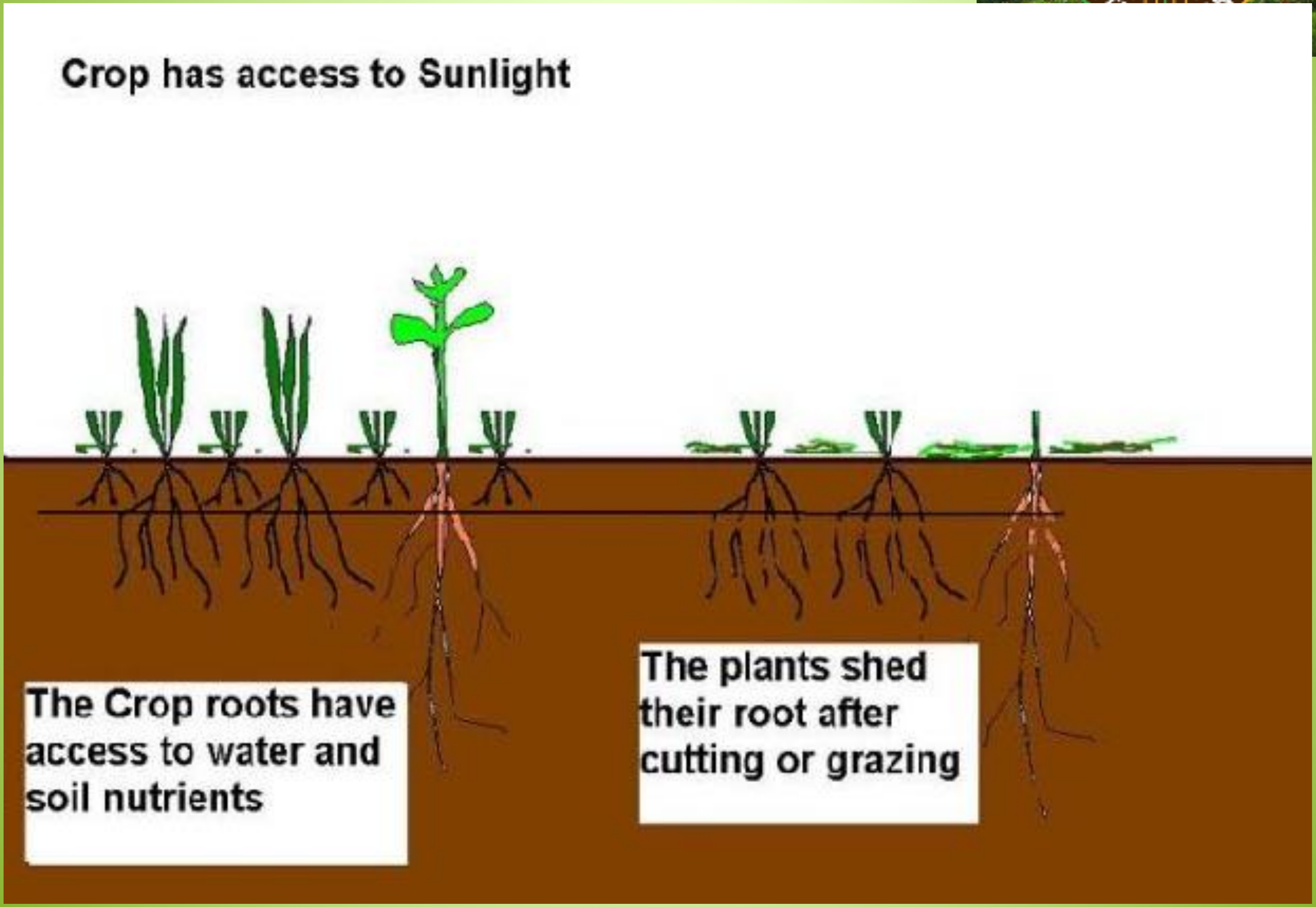
MANAGING GROUND COVERS



Growth of both tops and roots is significantly impaired if more than 50 percent of the green leaf is removed in a single grazing event (10).

This information can be used for management decisions

MANAGING GROUND COVERS



MANAGING GROUND COVERS

Building Topsoil

Soil organic matter increased from 1% to av. 6% in 11 years

- pH 4.5 to 6.5

The Total Exchange Capacity from 6.66 to 24.78.

- Available N from 46 kg/ha to 123 kg/ha.
- Calcium 534 ppm to 3696 ppm,
- Magnesium from 101 ppm to 391 ppm,
- Potassium from 45 ppm to 230 ppm,
- Phosphorous from 123 ppm to 1561 ppm.

Pasture Cropping

Sowing annuals into perennial pastures

Oats Sown into Pasture
Only a little bit of phosphate was added due to deficient soils

Gives the same yield as intensive plowing and fertilizers, at a fraction of the cost
Animals can go back on pasture after harvest- giving two crops and double income

Pictures: Colin Seis

Pasture Cropping

Dr Christine Jones has conducted research at Colin Sies's property in Australia

An average increase of 8 tons/ha of SOM per year

Increases in soil nutrients
Calcium 177%, Magnesium 38%, Potassium 46%, Sulphur 57%, Phosphorus 51%, Nitrogen 48%, Copper 102%, Zinc 86%, Cobalt 79%, Boron 56%, Molybdenum 51%, Selenium 17%

Soil Comparison between Winona and nearby property. Picture: Dr Christine Jones

SOIL CARBON

- **0 - 10cm 150%**
- **10 - 20cm 243%**
- **20 - 30cm 317%**
- **30 - 40cm 413%**
- **40 - 50cm 157%**

Pasture Regeneration

Soil Kee, Australia

- **Sowing annual cover and cash crops in perennial pastures**
- **5.6 metric tons of Soil Organic Matter/ha/yr. (11t CO_2 ha/yr)**
- **The Australian Clean Energy Regulator issued the first Australian carbon credits for this**

Organic Matter
Living Carbon

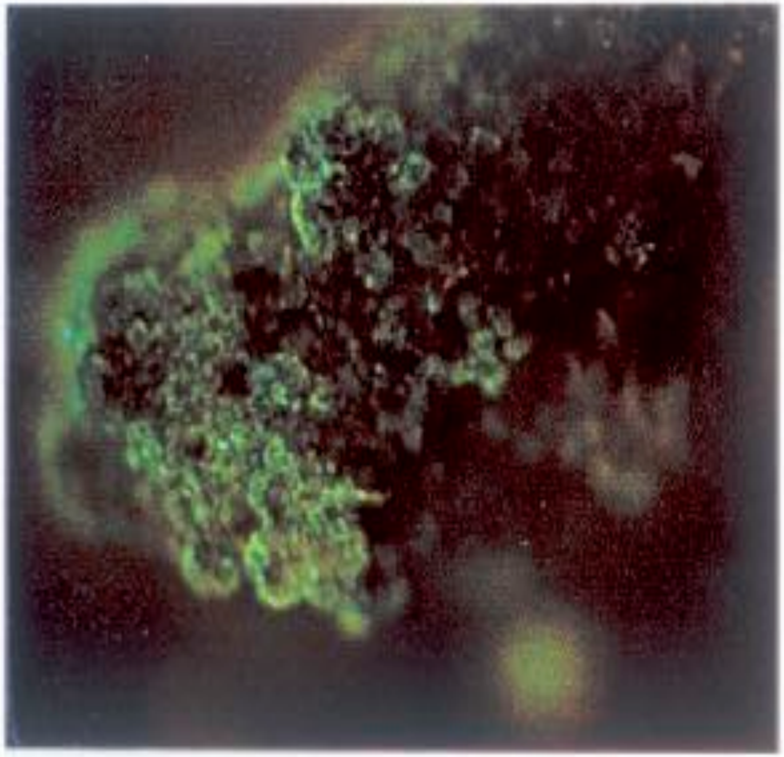
Organic matter management is the primary tool in regenerative farming

- Young plants are primarily composed of cellulose

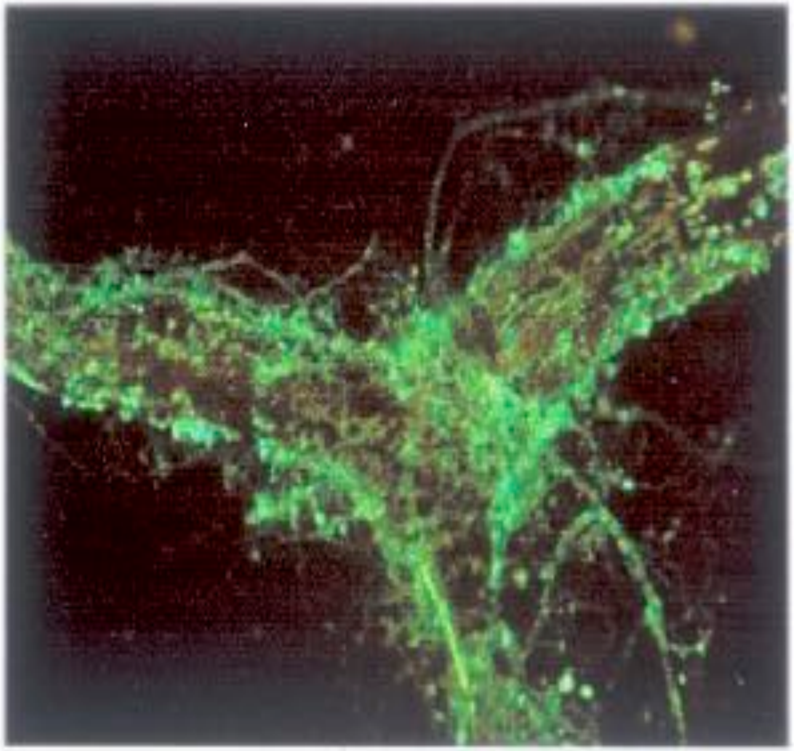
- They can rapidly biodegrade and release nutrients - especially glucose and minerals

These feed the soil microbiome - the soil food web
- To build soil healthy
- Make minerals available to plants
- Protect from pests and diseases

Soil Regeneration: A Biological Process



Glomalin is the green material on this soil aggregate.



An arbuscular mycorrhizal fungus colonizing a root. Hyphae are the thread-like filaments. The green coating on hyphae is glomalin.


Photo courtesy Aberdeen Mycorrhiza Research Group

Composition of Typical Soils

(for a plow layer $6\frac{2}{3}$ inches in depth, approximately 2,000,000 pounds)

COMPONENTS	SANDY LOAM (lbs/acre)	SILT LOAM (lbs/acre)	CLAY LOAM (lbs/acre)
Organic matter	20,000	54,000	96,000
Living portion, microbes earthworms, etc.	1,000	3,600	4,000
Nitrogen	1,340	3,618	6,432
Silicon dioxide	1,905,000	1,570,000	1,440,000
Aluminum oxide	22,600	190,000	240,000
Iron oxide	17,000	60,000	80,000
Calcium oxide	5,400	6,800	26,000
Magnesium oxide	4,000	10,400	17,000
Phosphate	400	5,200	10,000
Potash	2,600	35,000	40,000
Sulfur trioxide	600	8,500	6,000
Manganese	2,500	2,000	2,000
Zinc	100	220	320
Copper	120	60	60
Molybdenum	40	40	40
Boron	90	130	130
Chlorine	50	200	200

(Compiled by J.L. Halbeisen & W.R. Franklin.)

Organic Matter

Nutrient availability

- Organic acids (humic, fulvic, ulmic, acetic, citric etc) help make minerals available by dissolving locked up minerals
- Prevents mineral ions from being locked up
- Encourages a range of microbes that make locked up minerals available to plants.
- Helps to neutralise the pH
- Buffers the soil from strong changes in pH

Organic Matter

Directly assisting plants

- The spaces allow microorganisms to turn the nitrogen in the air into nitrate and ammonium (air is 78% N)
- Soil carbon dioxide contained in these air spaces increases plant growth
- Helps plant and microbial growth through growth stimulating compounds
- Helps root growth, by making it easy for roots to travel through the soil

Organic Matter
Living Carbon

Building Humus

- Older and coarse plants have higher levels of lignins
- Lignins are used by microbes to build Humus
- Humus is a very stable polymer that stores minerals and water for plants
- All Humus polymers have amino acids attached to them - an important source of organic nitrogen for plants
- It has numerous other important roles in building healthy nutrient rich soils

Organic Matter

Nutrient availability

- Stores anions - 90 to 95% of the nitrogen, 15 to 80% of phosphorus and 20 to 50% of sulphur in the soil
- Stores cations - calcium, magnesium, potassium etc and all trace elements
- Sand particles do not have charged sites to store ion nutrients, resulting in leaching
- Clays mostly have charged sites to store cations
- The charged sites in clays tend to repel anions such as nitrate, sulphur causing them to readily leach

Organic Matter

Nutrient availability

- Humus has many sites that hold mineral ions and consequently dramatically increases the soils' Total ion Exchange Capacity (TEC)
- This is the soil's nutrient 'fuel tanks'
- Humus is critical to preventing leaching and volatization, keeping nutrients in the soil to be available for the crop

Climate Resilience

Soil Organic Matter

Higher Yields in Climate Extremes

Regenerative/Organic Systems have higher yields than conventional farming systems in weather extremes such as heavy rains and droughts. (Drinkwater, Wagoner and Sarrantonio 1998; Welsh, 1999; Lotter 2004)

The Wisconsin Integrated Cropping Systems Trials found that organic yields were higher in drought years and the same as conventional in normal weather years. *(Posner et al. 2008)*

The Rodale FST showed that the organic systems produced 30 per cent more corn than the conventional system in drought years. *(Pimentel D 2005, La Salle and Hepperly 2008)*

Organic Matter Increases Infiltration and Soil Stability

Organic

Picture: FiBL DOK Trials

Conventional

Soil Organic Matter Mitigates and Adapts

- Increased soil stability
- Higher yields in drought years
- Increased soil C and N

- Higher water infiltration
- Higher water holding cap
- Higher microbial activity

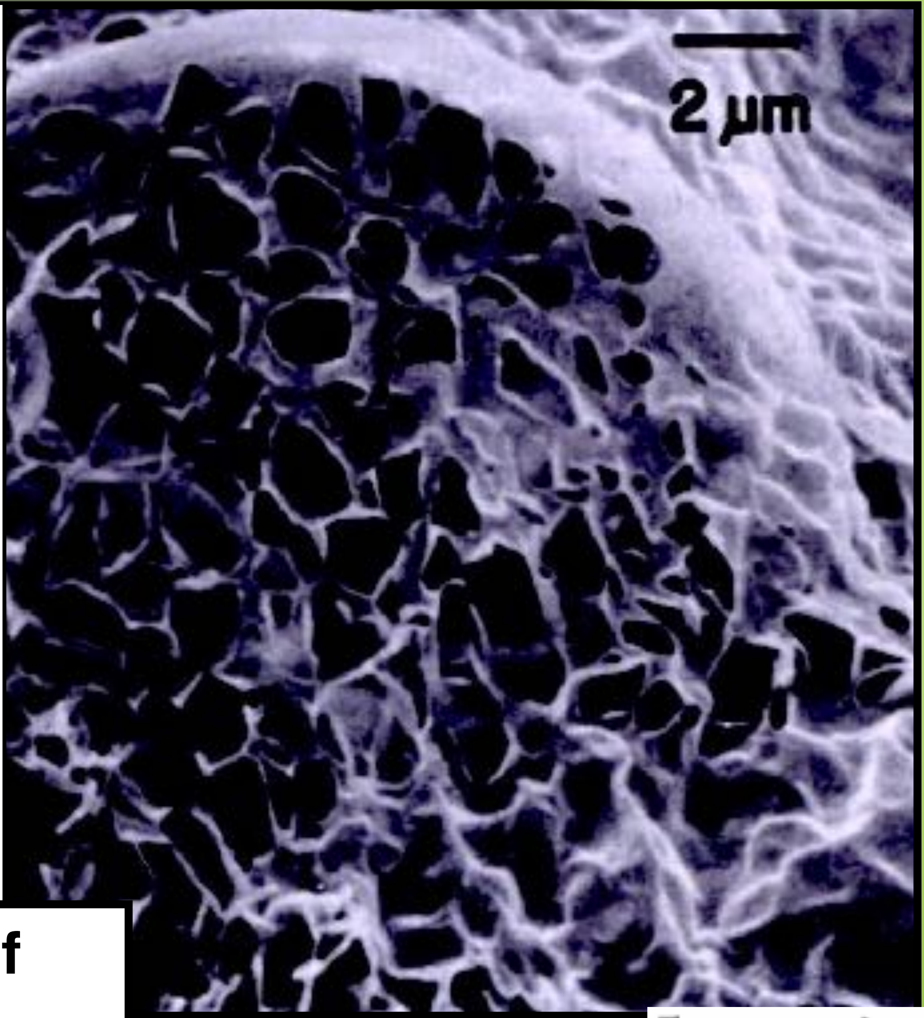
Humus and Soil Organic Matter

Holds up to 30X its weight in water

Cements soil particles and reduces soil erosion

Increases nutrient storage & availability

Humus can last 2000 years in the soil



Electron micrograph of soil humus

The Rodale Institute

Improved Efficiency of Water Use

Research Shows that Organic Systems use Water More Efficiently

Volume of Water Retained /ha (to 30 cm) in relation to soil organic matter (SOM)

0.5% SOM = 80,000 litres (common level Africa, Asia, Australia)

1 % SOM = 160,000 litres (common level Africa, Asia, Australia)

2 % SOM = 320,000 litres

3 % SOM = 480,000 litres

4 % SOM = 640,000 litres (levels pre farming)

5 % SOM = 800,000 litres (levels pre farming)

6 % SOM = 960,000 litres (levels pre farming)

Adapted from Morris, 2004.

Organic Corn - 1995 Drought

High Yield Regenerative Organic Agriculture

The average corn yields during the drought years were from 28% to 34% higher in the two organic systems.

The **yields were 6,938 and 7,235 kg per ha** in the organic animal and the organic legume systems, respectively, **compared with 5,333 kg per ha** in the conventional system (Pimentel et al. 2005)

Thank You

REGENERATION INTERNATIONAL