

Developing Fertile Biological Systems



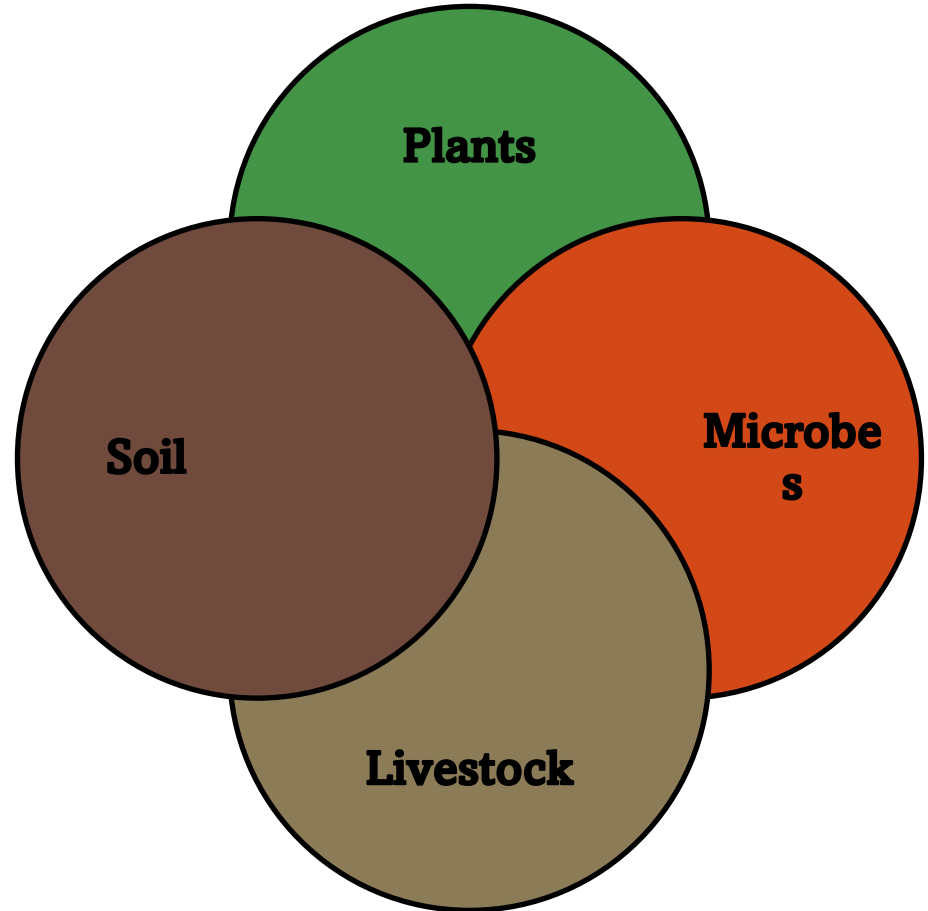
AS PRIMARY PRODUCERS,
WE ARE IN THE BUSINESS OF
GROWING LIVING THINGS
!!!

The Basics of Life

- Every cell in every living thing, from the smallest bacteria to the largest tree, requires the **energy** and **materials** needed to grow, function and reproduce
- The **energy** and **materials** needed by and for life must be acquired from the environment
- There are a range of mechanisms that different groups of organisms employ, to acquire **energy** and/or **materials** and make them biologically available
- Within living communities, the combined function of a diversity of species drives the generation of a collective **energy** and **matter** supply

The Chicken and the Egg

What came first:
healthy plants,
active microbes,
good soil or
happy animals ?



We all know that good soils grow healthy plants, but without plants and their microbial and animal associates, soil would be little more than weathered rock particles





It All Starts With Photosynthesis

- Plants are able to convert water, carbon dioxide and sunlight into simple sugar carbohydrates, releasing oxygen in the process

Carbon Dioxide + Water + Sunlight = Carbohydrates + Oxygen

- The energy captured from sunlight and held in carbohydrates is the predominant source of energy used for living.
- Carbohydrates are molecules of Carbon, Hydrogen and Oxygen from which, along with other elements, organic materials are built.

Recommended viewing: How to Grow a Planet – Life from Light

Plant Matter

- Living Plants are made up of 80-90% water
- 97.5% of dried plant tissue is still made up of the atmospheric elements C, O, H and N
- The remaining 2.5% is made up of minerals that come from the soil

PLANT DRY MATTER WEIGHT

ELEMENT	% DRY MATTER WEIGHT	COMPOUND IT COMES IN
^{12}C	45%	CO_2
^{16}O	45%	CO_2 , H_2O , NO_3
^1H	6%	H_2O , NH_4
^{14}N	1.5%	NO_3 , NH_4 (Rhizobia $\text{N}_2 \rightarrow \text{NH}_4$)
4 elements/gases	97.5%	
Mg	0.2%	9 elements = 99.5%
K	1%	
Ca	0.5%	
P	0.2%	
S	0.1%	
5 elements	2%	

MINERAL PERCENT OF DRY WEIGHT PLANT MATTER – COFACTOR ENZYME ACTIVATORS

Micro Elements	Symbol	Atomic Number	Period	Plant Dry Weight %
Boron	B	5	2	0.002
Chlorine	Cl	17	3	0.01
Manganese	Mn	25	4	0.005
Iron	Fe	26	4	0.01
Copper	Cu	29	4	0.006
Zinc	Zn	30	4	0.002
Molybdenum	Mo	42	5	0.00001
All Other Elements				0.46499
				TOTAL: 0.50%

The Carbon Economy

Carbohydrates are utilised by living organisms throughout the community food chain. In exchange, these organisms perform a range of services that promote plant growth as it is in their best interest to further the production of carbohydrates

- nitrogen fixation
- mineral acquisition
- deliver nutrition
- retain and cycle nutrient elements
- produce humus
- structure soil
- modify soil conditions
- assemble useful compounds
- induce immunity
- provide protection
- distribute products and resources

life.org

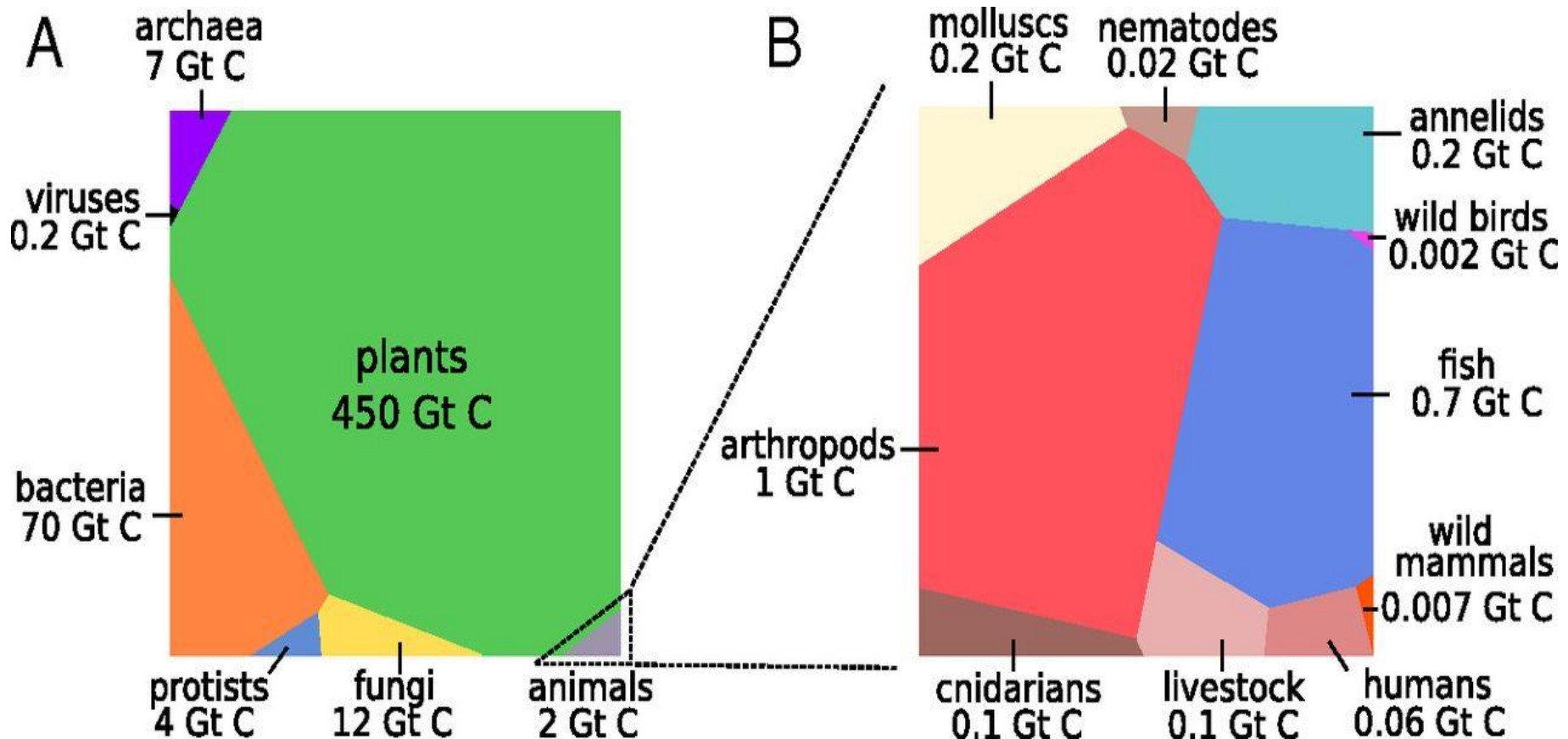
The capacity of living systems is determined by the efficiency
with which they:

organise **matter** for the harvesting of **energy**, from sunlight,
to fuel living activity

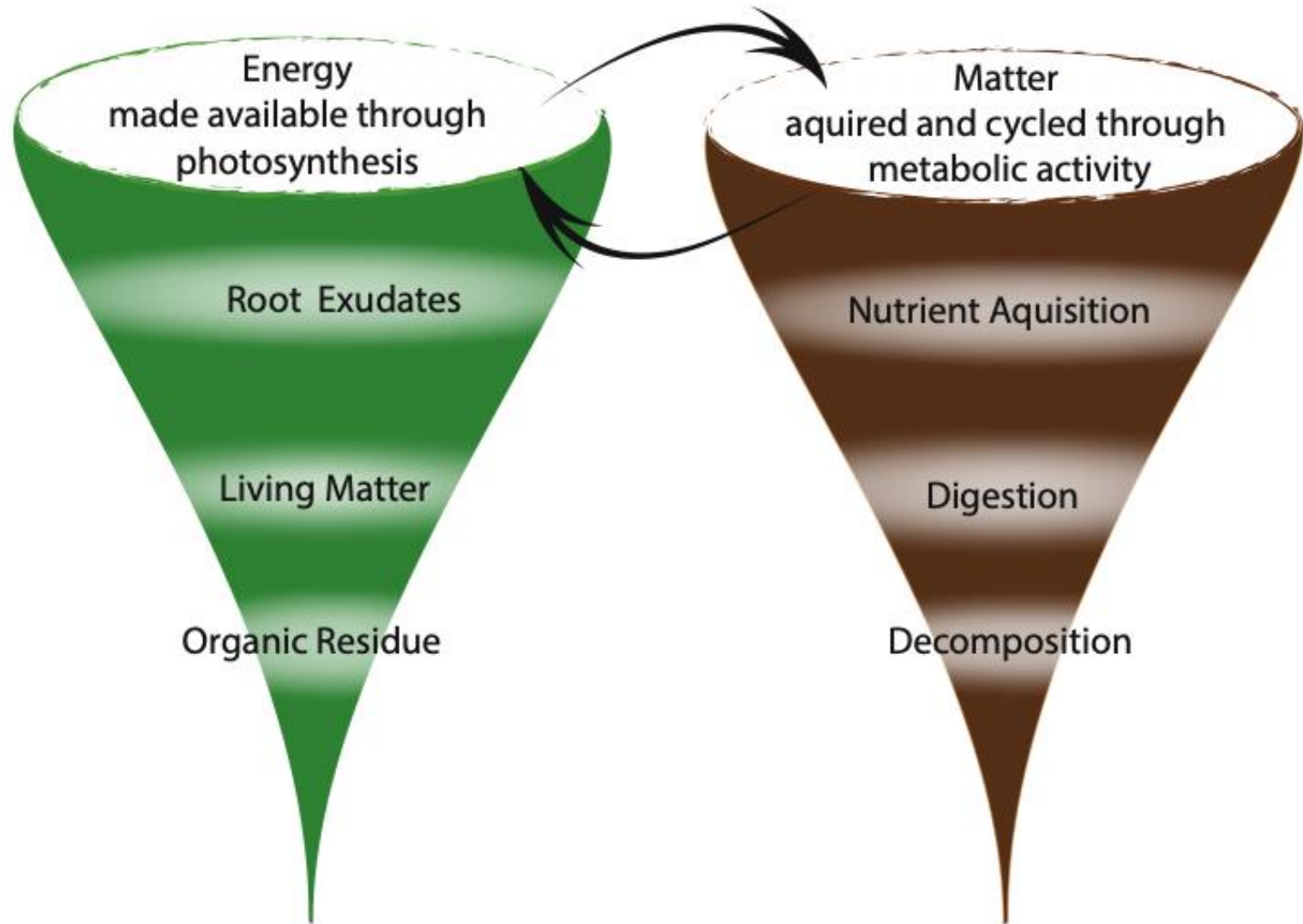


use available **energy** to acquire **material** elements, from the
environment, and build living biomass

Composition of Global Biomass



Biological Production Economy



It's All
Happening in
the
Rhizosphere



It is evident that plants actively cultivate microbes internally, on surfaces and in soils to acquire nutrients, modulate development and improve health



Residue	Weight (μg)	mole% ¹
Arabinose	113.7	13.7
Fucose	377.0	41.8
Xylose	27.1	3.3
Glucuronic acid	28.6	2.7
Galacturonic acid	0.0	0.0
Mannose	27.1	2.7
Galactose	354.3	35.8
Sum	927.8	100
¹ Values are expressed as mole % of total carbohydrate		

Diazotrophs

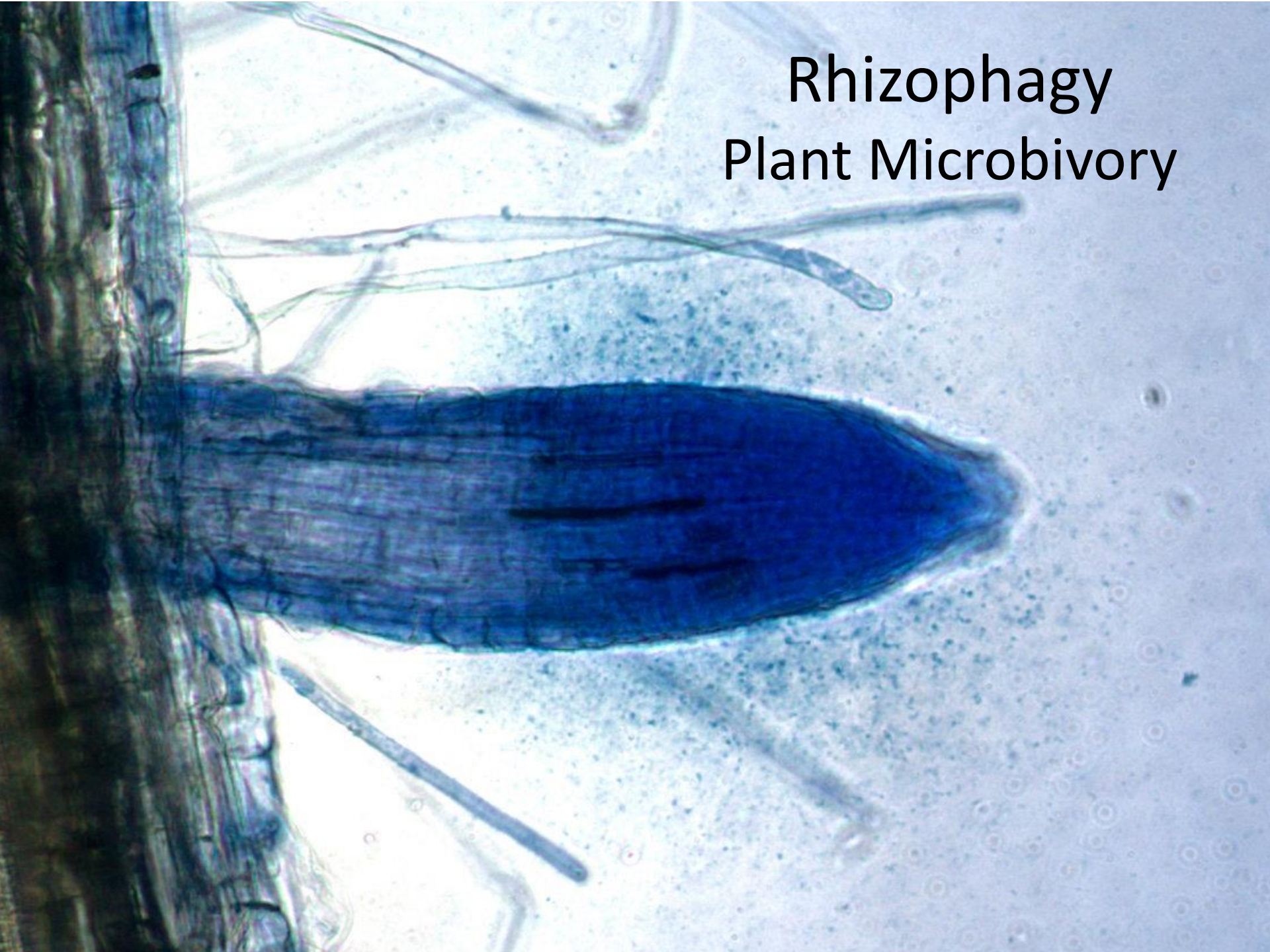
Nitrogen Fixation



Mycorrhizal Fungi Root Networks



Rhizophagy Plant Microbivory



Animals

- Consume species that aren't performing well, making resources available for higher production
- Regulate vegetative growth
- Rapidly turnover organic materials
- Incorporate organic materials
- Structure soil
- Deposit fertility through the landscape
- Keep weed and pest populations in check
- Pollinate plants





Pest Patrol



Parasitism



Decomposition

- Decomposers including saprophytic fungi, small invertebrates, worms, protozoa, bacteria, yeasts etc... break down residual materials.
- In the process, they liberate inherent nutrients, making them available once again for plant uptake.
- Other by-products of the decomposition process include humus and bio-chemicals (auto-inducers) that are known to stimulate soil microbial activity, promote growth and trigger root exudation.





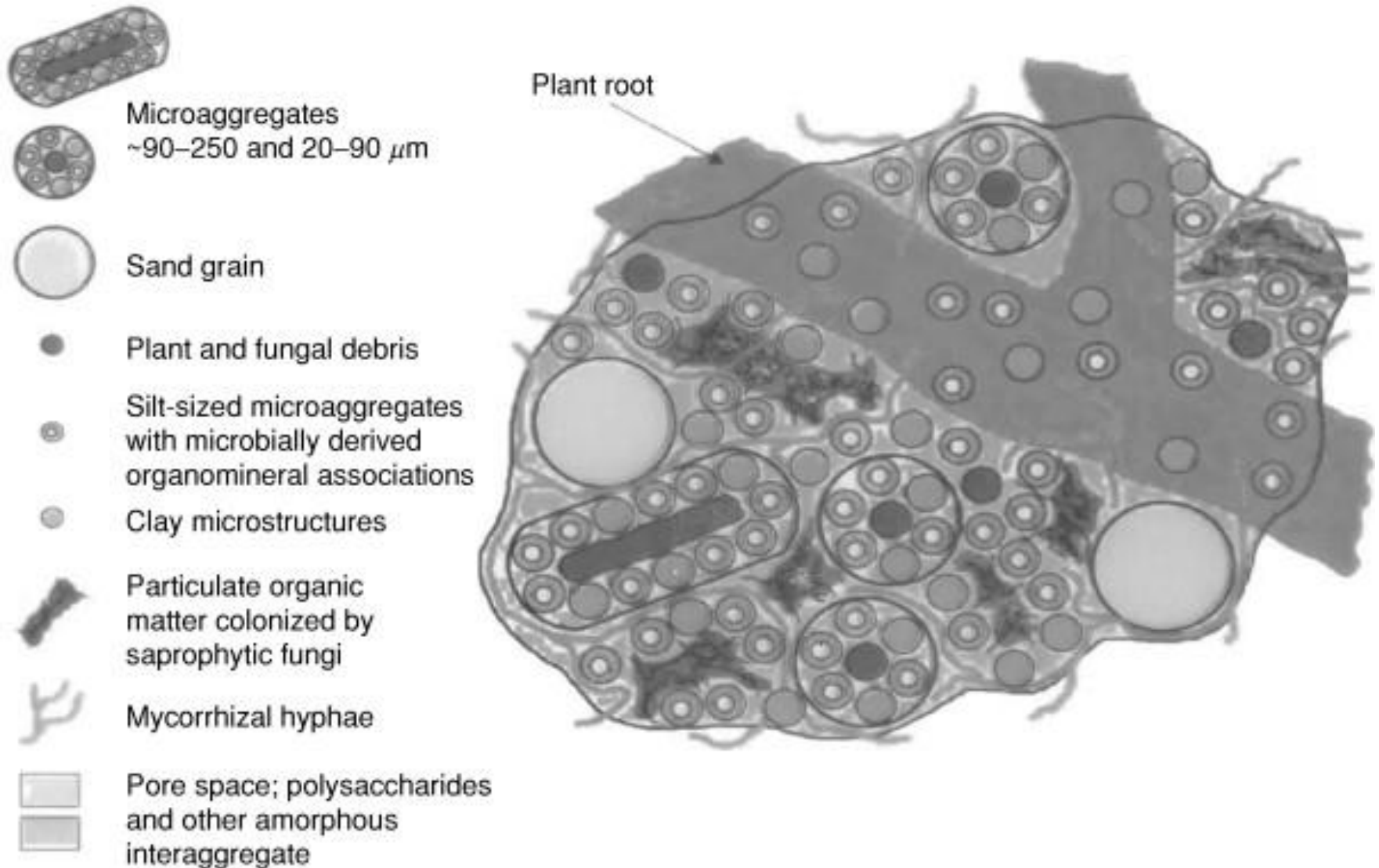
A Sense of Humus

- Humus is minute fractions of organic matter that are resistant to further decomposition
- It is predominantly made up of microbial necro mass
- It adheres to the surface of mineral particles, forming stable organo-mineral complexes that persist in the soil for long periods of time
- Humus colloids have a much higher holding capacity than soil particles
- Has fractions that hold onto anions as well as cations
- In the soil, humus coats and bind clusters of fine soil particles together, forming micro aggregates

Soil Structure

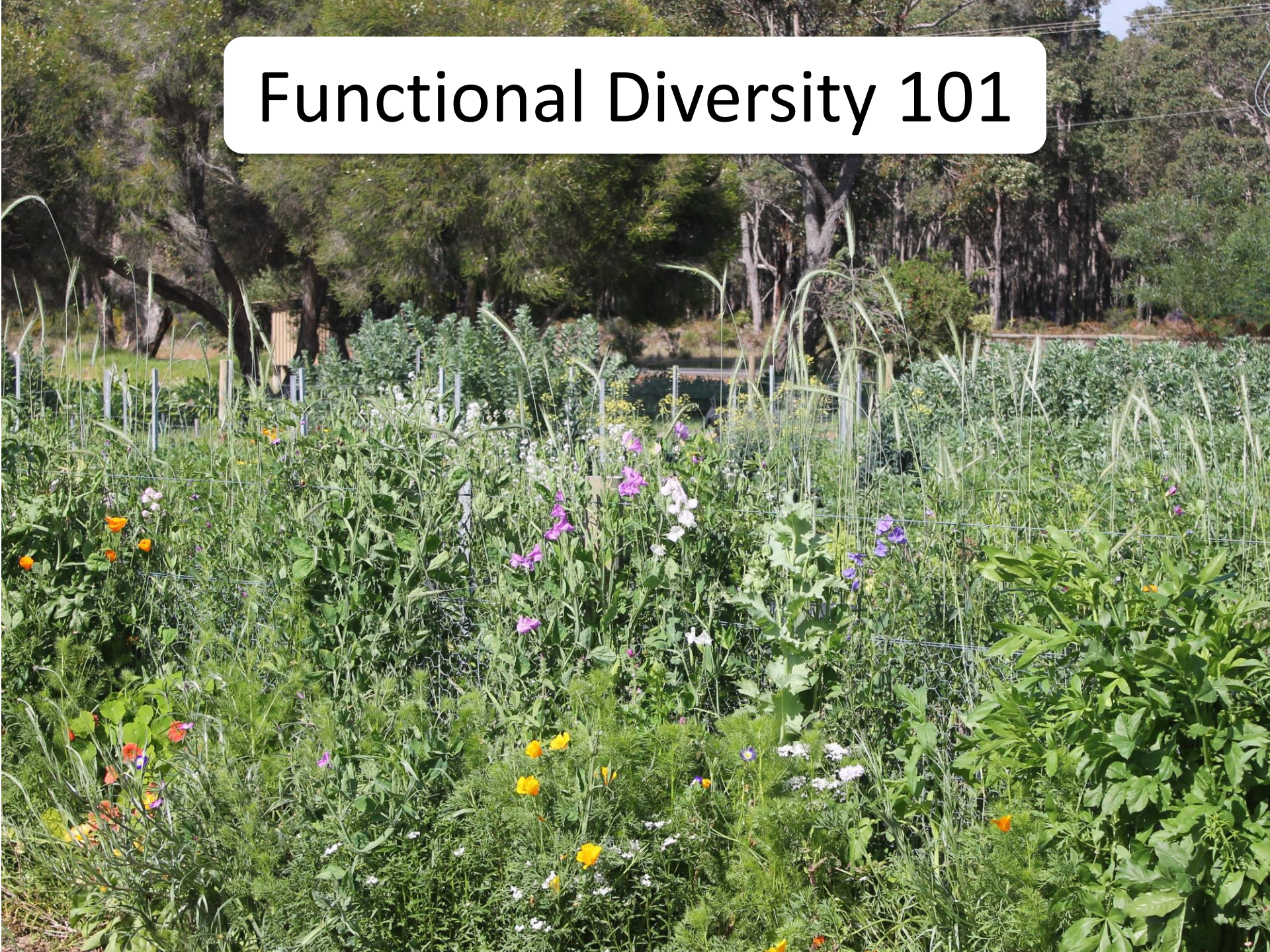
- Micro aggregates, along with larger soil particles and organic materials, are bound together by mycorrhizal fungi, plant roots and soil organisms like earthworms, into macro aggregates
- Moisture levels and the state of nutrients remain more stable within the contained environment of soil aggregates, through seasonal fluctuations
- The gaps between aggregates enable water and air, to move down into the soil, and carbon dioxide released through decomposition to escape up and out
- Decaying plant roots and larger soil microbes and animals create channels for air and water as they move up through the soil
- Unlike dirt, there is structure in living soils, making materials far less prone to being washed or blown away

Aggregation , Aggregation, Aggregation !!!





Functional Diversity 101



Variety is the Spice of Life

It is well established that plant diversity is an important characteristic of robust and resilient living systems

- Different plant types host and associate with unique microbial and animal populations
- Plant diversity promotes microbial and animal diversity, above and below ground
- Diversity entails better access to and production of resources and a greater range of services
- Diverse living networks enable efficient and widespread exchange of goods and services
- Communities as a whole, benefit from the inherent traits various species bring to the table

Multi Species Cover Crops



Putting it to the Test



Peas in Mix



Peas Alone



No Fert ?



Fert ?



Annual Multispecies Green Manure Seed Mix

Amount (kg/Ha)	Species	Price \$/kg	Price \$/Ha
20	Williams Oats	0.60	12.00
20	Peas	1.90	28.50
12.5	Vetch	2.40	30.00
5	Ryecorn	2.20	11.00
5	Linseed	3.30	16.50
2.5	Buckwheat	5.80	14.50
2.5	Sunflowers	6.00	15.00
2.5	Serradella	5.50	13.75
1	Tillage Radish	8.60	8.60
66kg	6 Families, 9 Species		\$149.85



Planting Multi Species Cover Crops

- In our Mediterranean climate It's easier to sow cover crops in early autumn when there is reliable rainfall on the way
- After the dry summer, there isn't an active stand of existing pasture plants and weeds to deal with
- Weed management at establishment is just as important as it is when you sow other crops
- Weed management strategies include dry seeding before autumn weeds germinate (with the season rain break) or carrying out some sort of weed control once weeds have germinated i.e. shallow cultivation, herbicide application...
- Planting and growing conditions are better earlier in the season, before it gets too cold and wet

Setting the Scene for Pasture Diversity

- It must be understood that there may initially be some production trade offs during the establishment of multispecies pastures.
- The successful implementation of a multispecies pasture program may take a number of seasons and can only be maintained with appropriate management



Annual Pasture Species

Grasses

- Ryegrass
- Forage Barley/Oats

Legume

- Balansa, Persian, Sub Clovers
- Medics
- Seradella

Broadleaves

- Forage Brassicas
- Beets

Establishing Perennials

- For the establishment of perennial species, the soil needs to be in a healthy enough state to foster strong growth over the wet season and hold onto enough moisture in the dry season for them to survive their first summer
- Perennials, especially perennial grasses, are notoriously slow to get going and don't fare well with competition so measures must be taken to manage faster growing annual weeds and pasture species
- We can use annual cover crops in proceeding seasons to improve the soil and create a more favourable species profile for the establishment of perennial species
- We need to allocate longer periods of time between graze events with perennial species, as they require more time for recovery, than annual pasture species



Perennial Pasture Species

Grasses

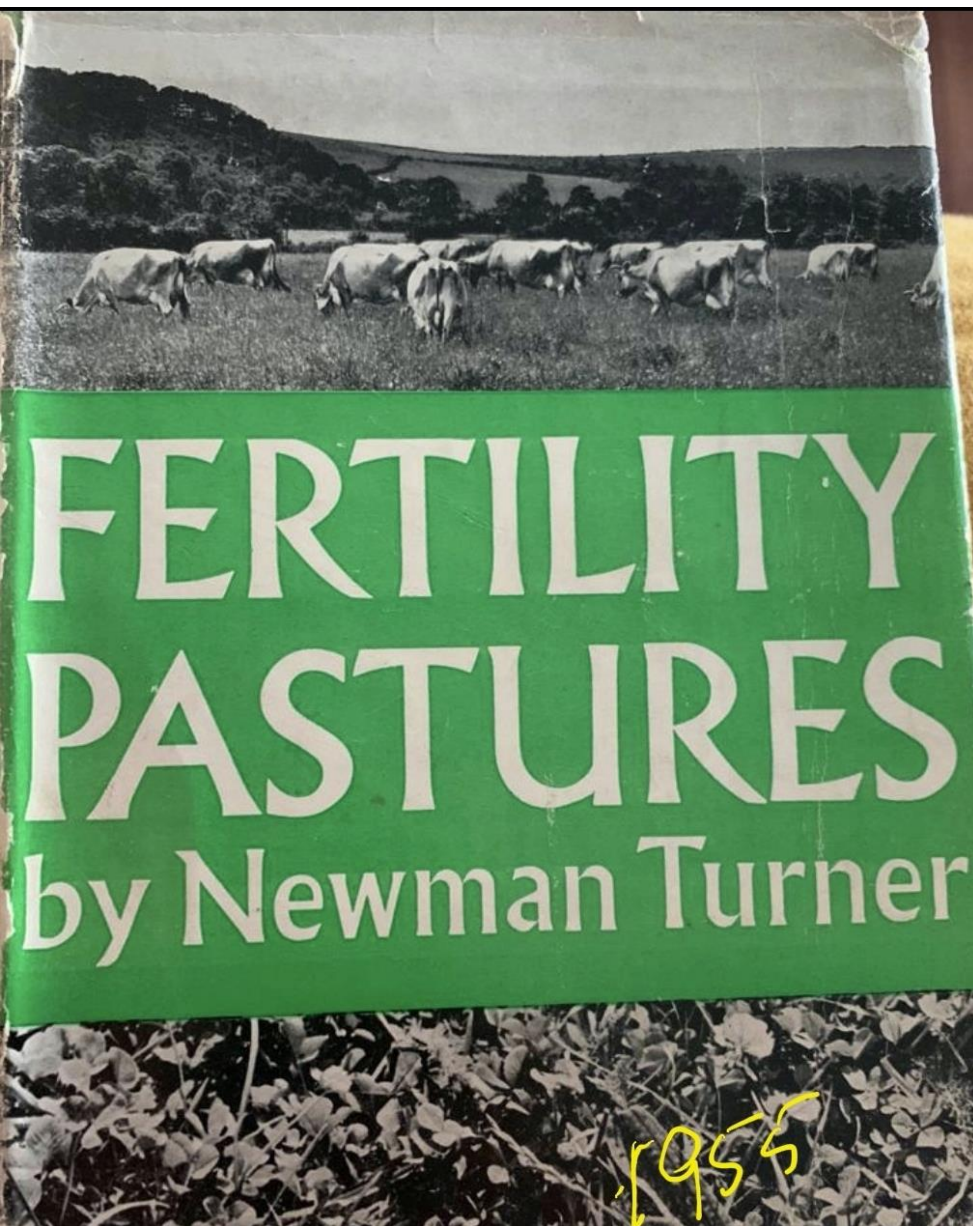
- Cocksfoot
- Phalaris
- Fescue
- Perennial Ryegrass

Legumes

- White, Red and Strawberry Clover
- Lucerne

Broadleaves

- Chicory
- Plantain



HERBAL LEY MIXTURE FOR VERY THIN, DRY SOILS (and to resist extreme drought conditions)

	lb. an acre
Cocksfoot, S.143	5
Crested Dogtail	4
Tall Fescue	4
Lucerne	4
Kidney Vetch	4
Chicory	4
Burnet	4
Ribgrass or Plantain	4
Late-flowering Red Clover	2
Alsike	2
Trefoil	2
S.100 White	1
Yarrow	$\frac{1}{2}$
American Sweet Clover	2
Broad-leaved Plantain	1
	<hr/>
	43 $\frac{1}{2}$
	<hr/>

1955

The main essential of a mixture for thin soils, soils overlying and close to the rock, and in excessively dry countries, is that it should contain a predominance of the deepest-rooting varieties available, consistent with their production *above* the ground. This makes the most of such little moisture as is present in the deeper subsoil; and where the subsoil is largely rock some penetration of the rock can be achieved by the more powerful of the deeper rooters.

Every one of the ingredients of this mixture is an exceptionally deep rooter, except the clovers S.100, Trefoil, Alsike and Late-flowering Red—and even Alsike and Trefoil are reasonably drought-resistant. All prosper on the thinnest soils: but the

1955



Fodder Trees

- Acacias
- Cape Leeuwin wattle
- Tagasaste
- Poplars
- Willows
- Casuarinas
- Carob
- Mulberry
- Oaks
- Ash
- etc...

H e r b i v o r e s



Nature's Way

What is best for livestock health and production
is also what's best for pasture composition and
growth, and soil health

Mob Grazing

The number of animals, and space and time allocated to grazing events can be managed to:

- avoid selective grazing
- avoid grazing fresh regrowth
- better utilize forage
- give grazed plants time for adequate plant recovery
- evenly distribute manure and urine
- minimize compaction

Stockpiling Forage

Letting plants grow without grazing during the growing season:

- creates lots of lignified biomass which provides protective cover, habitat and food for a diversity of life, above and below ground over the hot, dry season
- enables the development of extensive root systems and building of soil at depth
- gives desirable species adequate time to establish and set seed
- provides us with a cheap source of non growing season feed, especially legume species (may need to supplement protein to meet minimum requirements)
- gives us a source of fiber at the beginning of the growing season when new growth is low in fiber and high in sugar and protein
- paddocks that were stockpiled the previous growing season get away to the best start the following growing season



DIY Microbe Culture



Plant Endophytes

- These microbe groups are active in living plants but can survive and spread in dormant states between growing seasons
- Reproductive material is found in root fragments, seeds and soil around plant roots
- Commercial inoculants can be used to introduce endophytes into new growing environments
- Different plant species are hosts to select populations of endophytes
- Legumes host certain rhizobia species i.e. peas, beans, clovers etc...
- Some annual plant species host a wide range of endomycorrhizae fungi species i.e. sorghum, millet, oats, sunflowers etc...
- Some tree families host a wide range of ectomycorrhizal fungi species i.e. Pinaceae, Betulaceae, Fagaceae, Myrtaceae etc...

Composting & Vermiculture



Biological Planting Treatments

A Good Start in Life











Biostimulants

Any substance or microorganism that stimulates biology as a means to enhance plant nutrition, stress tolerance and crop quality traits, regardless of its nutrient content

- Humic substances
- Amino acid hydrolysates
- Seaweed extracts
- Microbial cultures
- Compost
- Manure
- Molasses
- Milk
- Chitosan and other biopolymers
- Wood vinegar
- Etc...

Bio Ferments





Bio-centric Practices

Benefit

- Soil coverage with living plants and organic residue
- Diversity, stacked enterprises
- Biologically friendly nutrition, pest, disease and weed management
- Traffic management
- Conservation, non inversion and no till practices
- Mob grazing

Hinder

- Bare fallow, burning stubble, overgrazing
- Monoculture production
- Salt fertilizers, herbicides, pesticides and fungicides
- Compaction
- Heavy tillage, especially in the warm dry season
- Set stocking



Thank You



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