



Empowering People



Regenerative Agriculture & Soil Health

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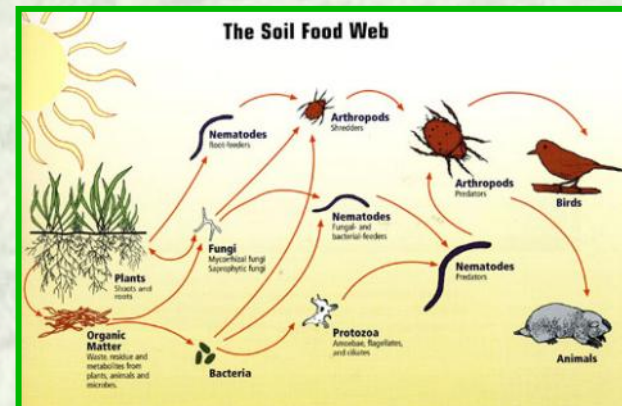
SOIL HEALTH

is a function of:

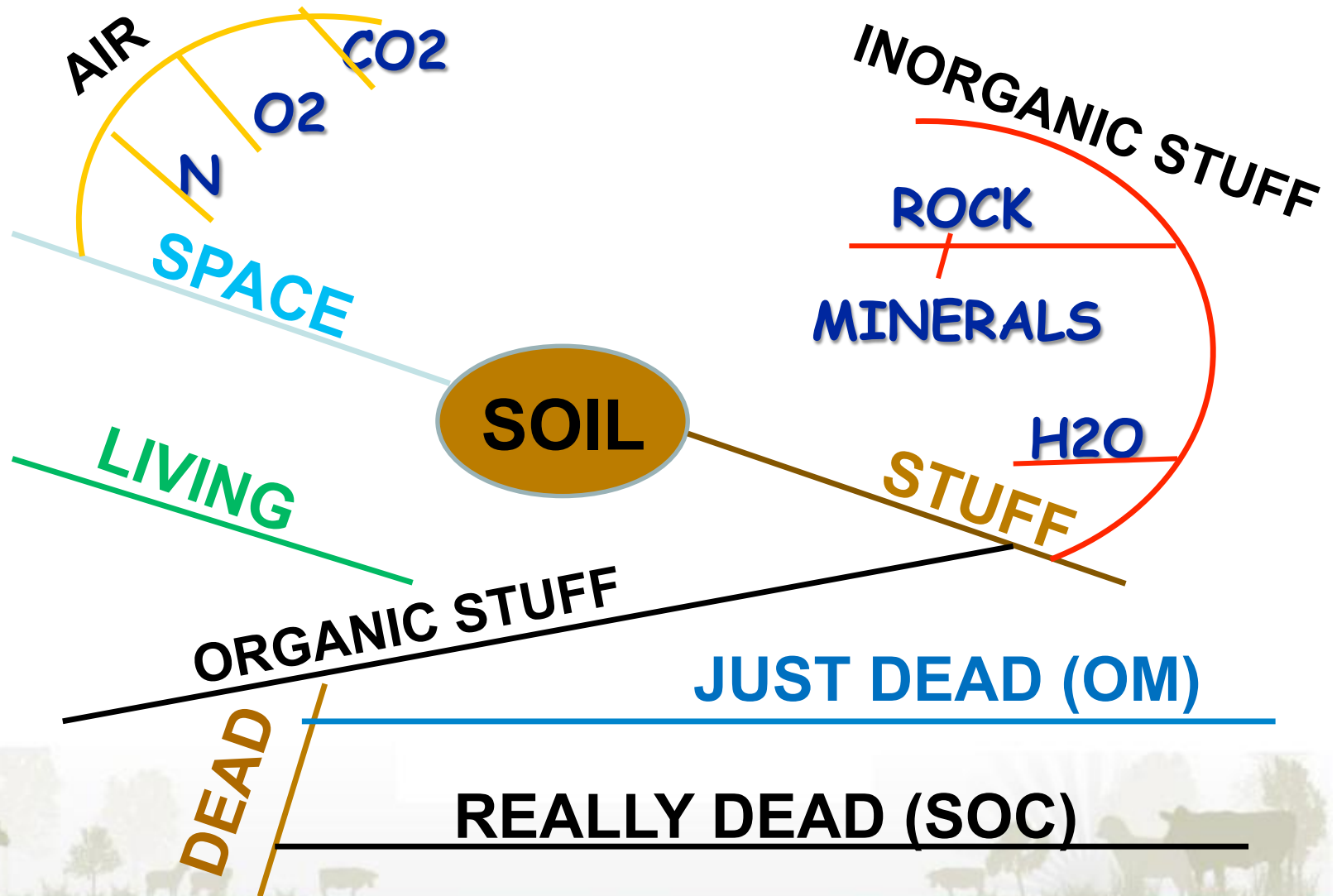
Physical Attributes

Chemical Balance

Biological Activity & Balance

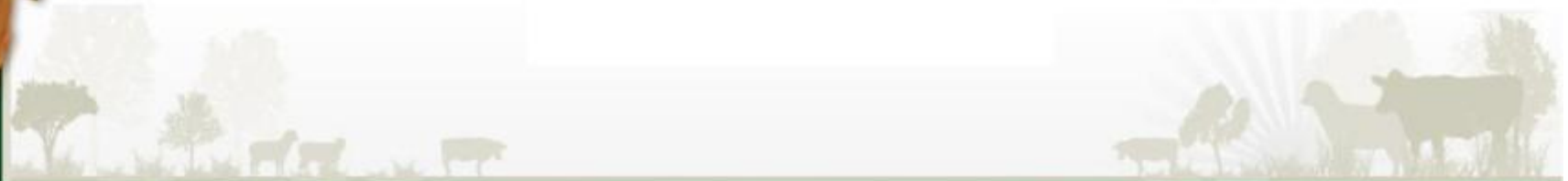


SOILS 101

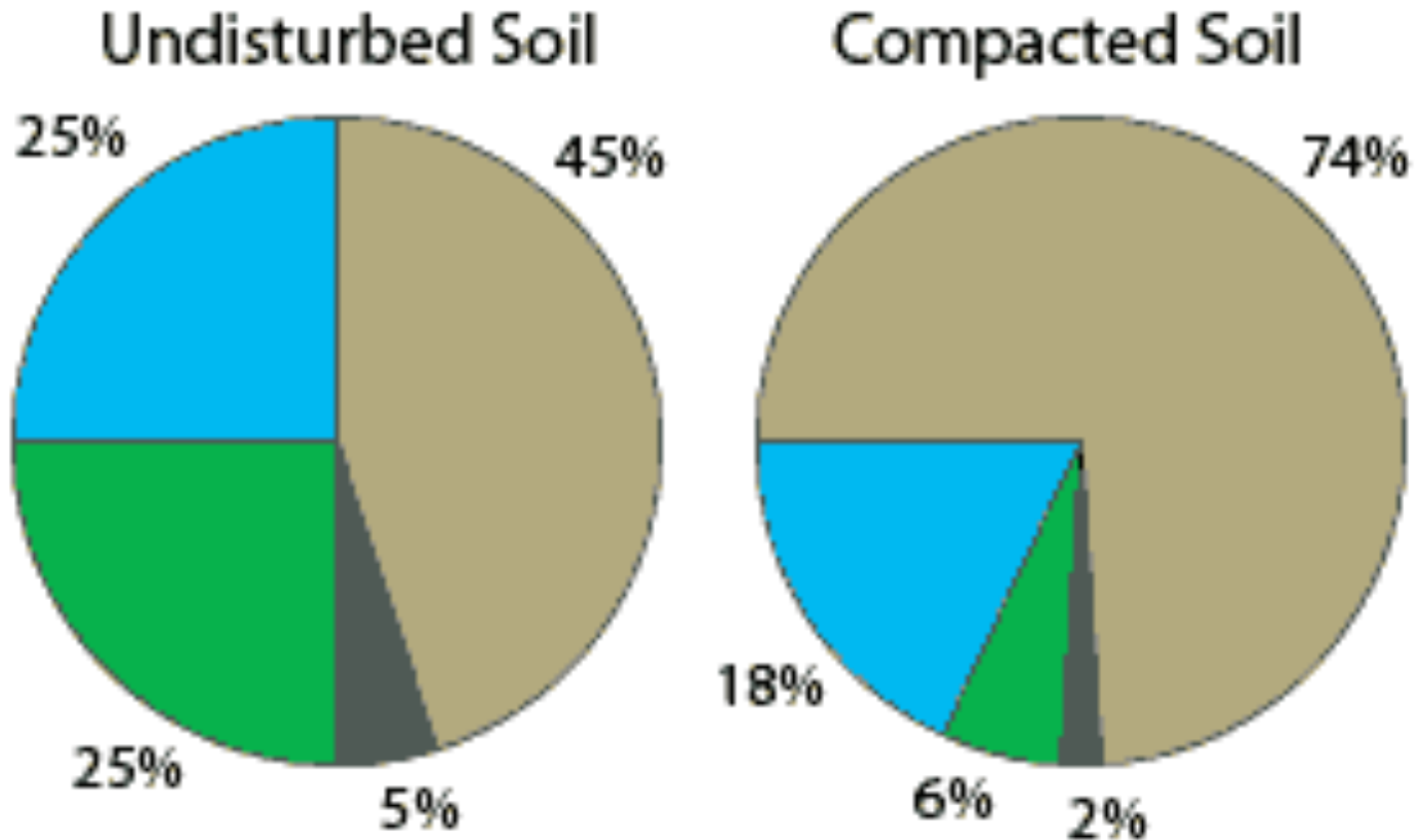




Physical



Typical Composition of Soils



Soil Structure

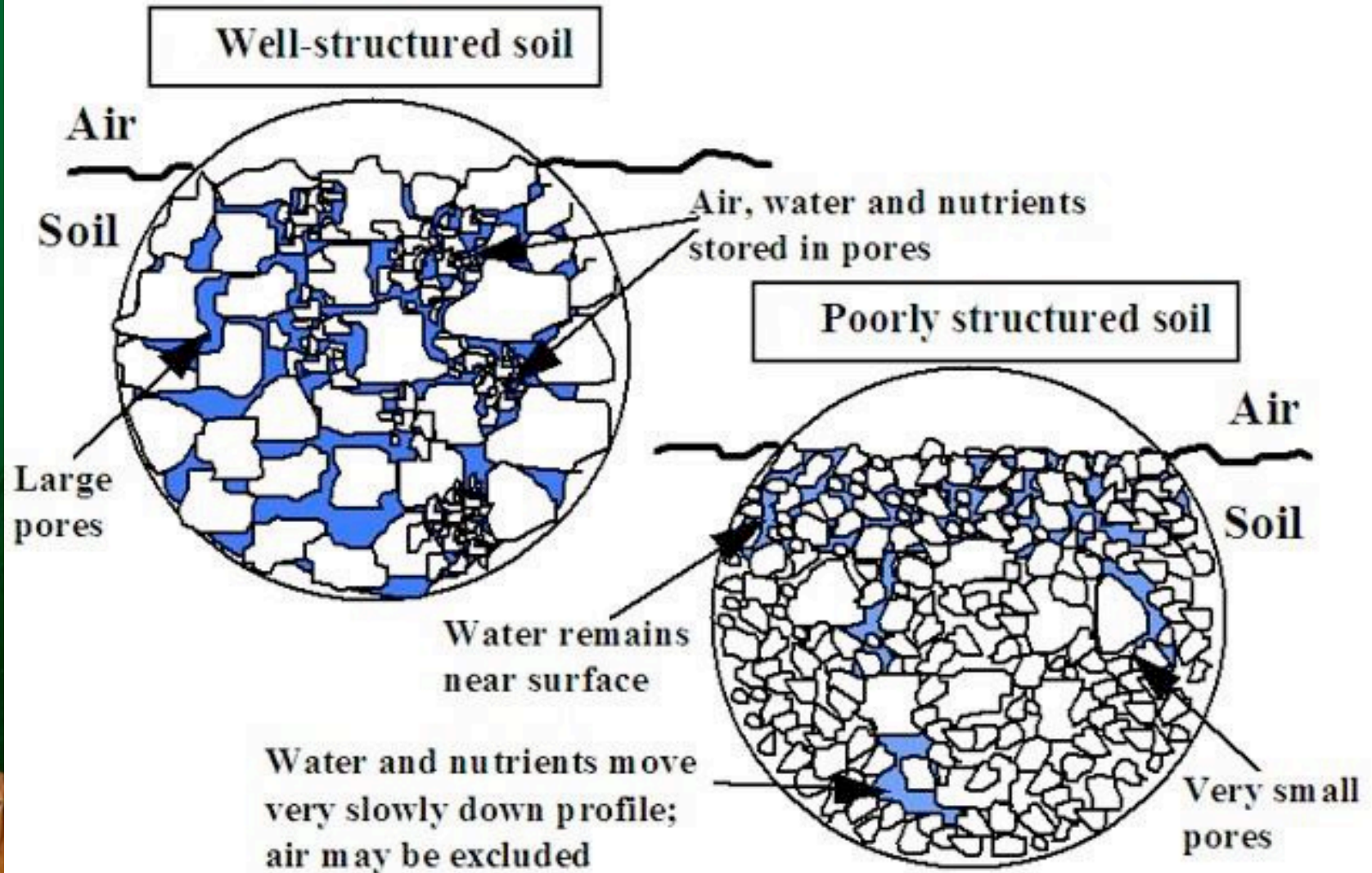


Figure 1. A diagrammatic representation of well structure and poorly structured soils.

Source: Victorian Department of Agriculture.



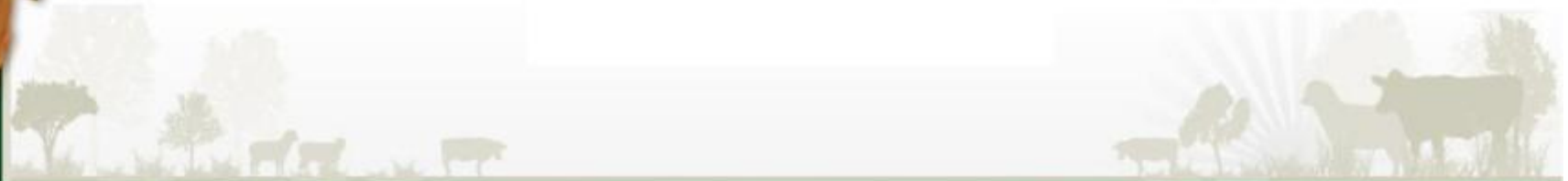
Indicators of poor physical structure

- ❖ **Low infiltration rate**
- ❖ **Waterlogging**
- ❖ **Hardpans**
- ❖ **Cloddy, hard soil**
- ❖ **Poor root systems**





Chemistry





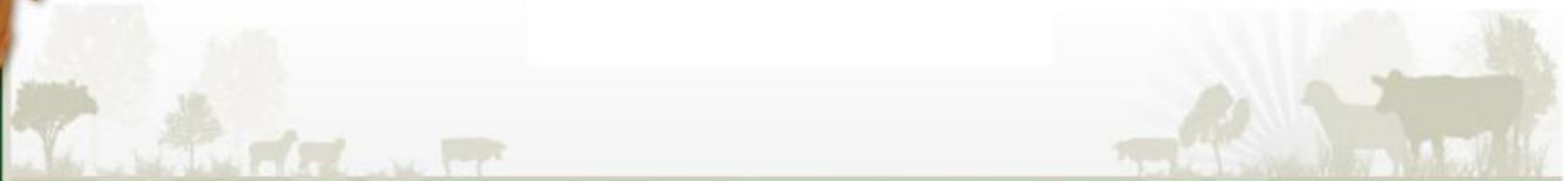
Indicators of poor chemical composition

- ❖ **Weed problems**
- ❖ **Poor root systems**
- ❖ **Low brix level in plants**
- ❖ **Unhealthy plants**
- ❖ **Poor animal & Human health**





Biology



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There is a critical relationship between calcium and fungi.

CALCIUM RETENTION AND FUNGI

Elaine Ingham's Classic Experiment



Sterilised Potting Mix
No Calcium Retention



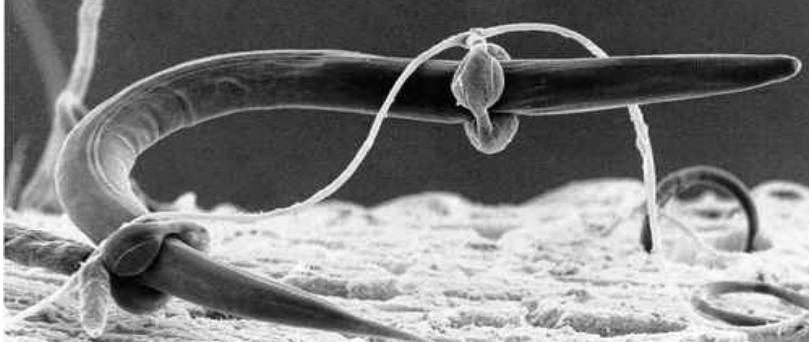
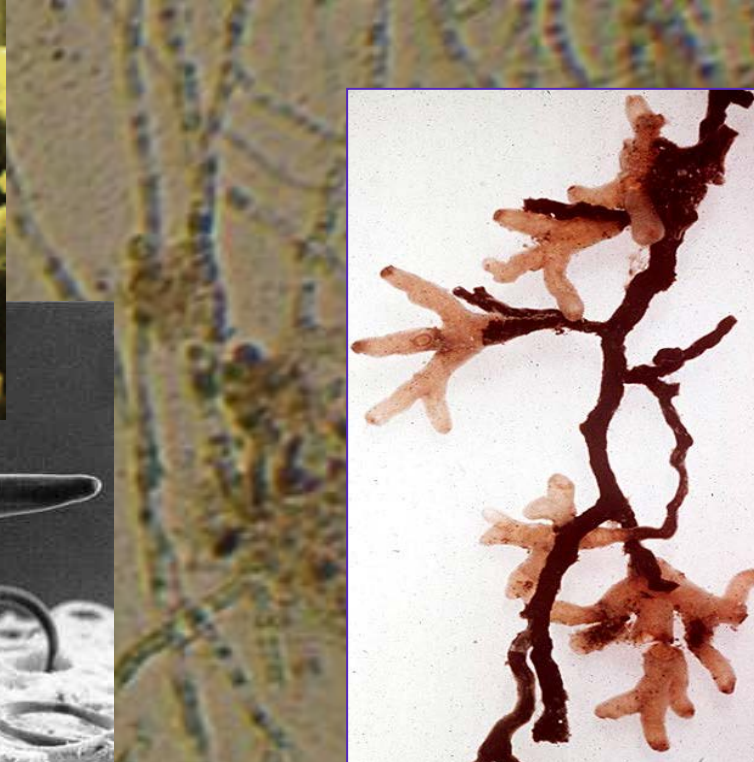
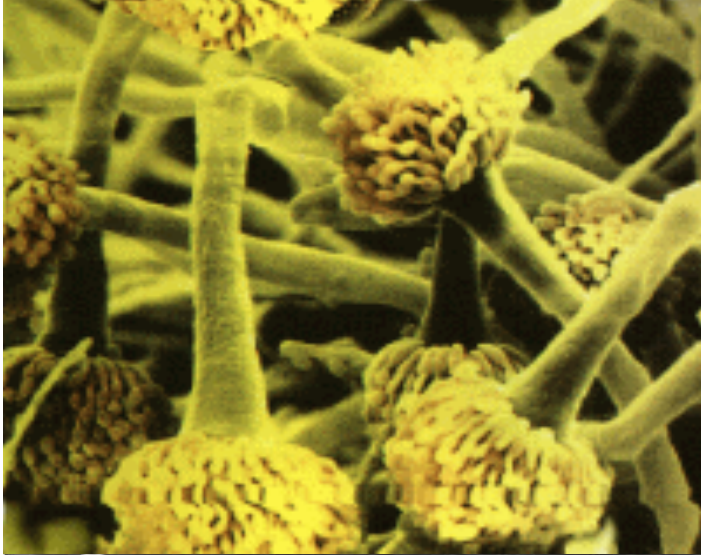
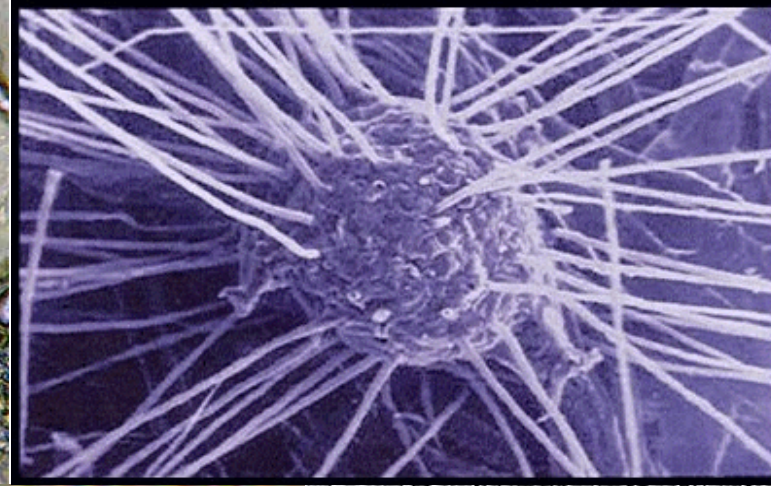
Added Bacteria-Dominated Compost
2% Calcium Retention



Added Fungi-Dominated Compost
98% Calcium retained



Biology we CAN'T see





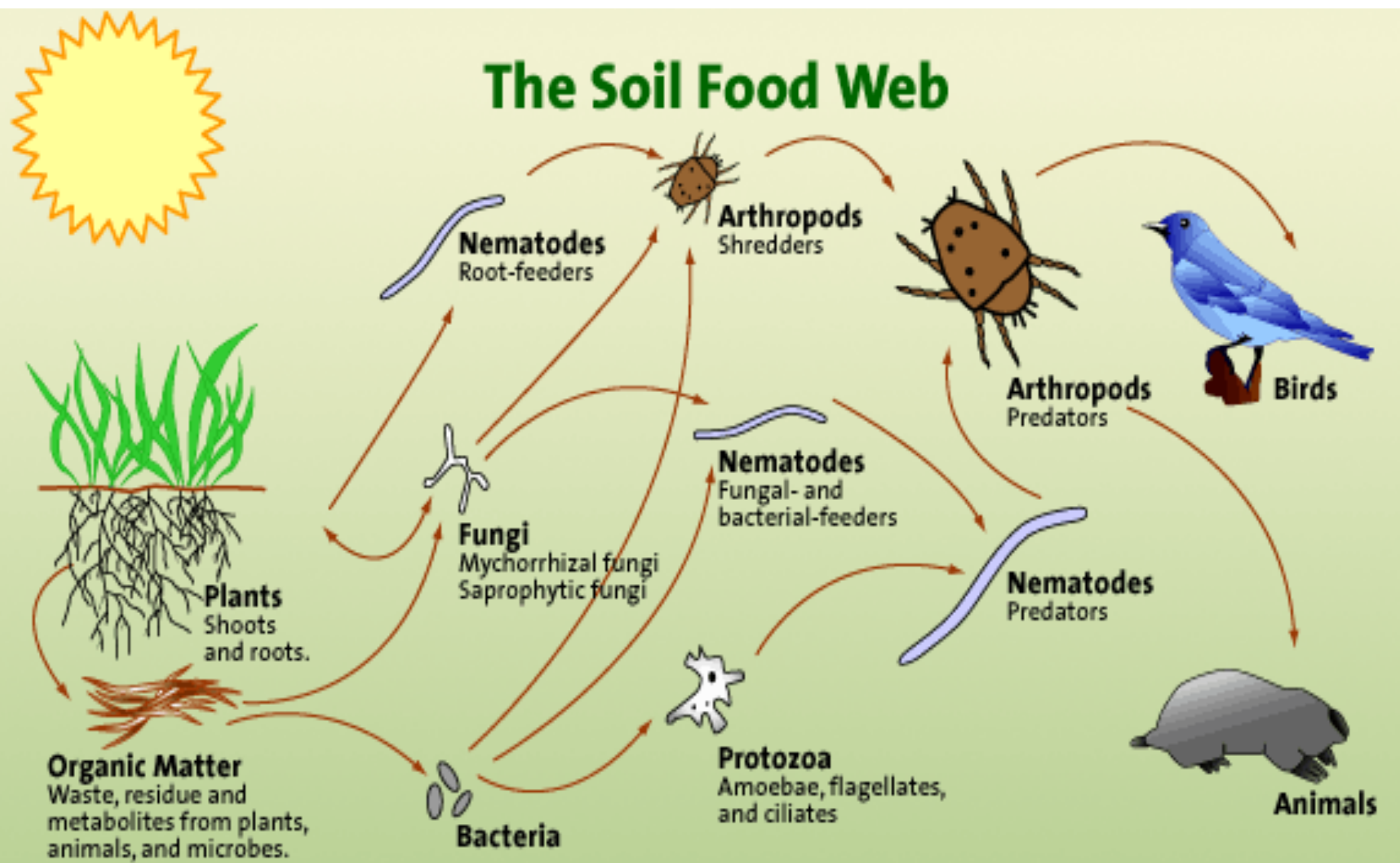
Biology we CAN see





At the Dung Beetle Bar.

The Soil Food Web



First trophic level: Photosynthesizers	Second trophic level: Decomposing Mutualists Pathogens, Parasites Root-feeders	Third trophic level: Shredders Predators Grazers	Fourth trophic level: Higher level predators	Fifth & higher trophic level: Higher level predators
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Source: Soil Foodweb

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The C:N Ratio

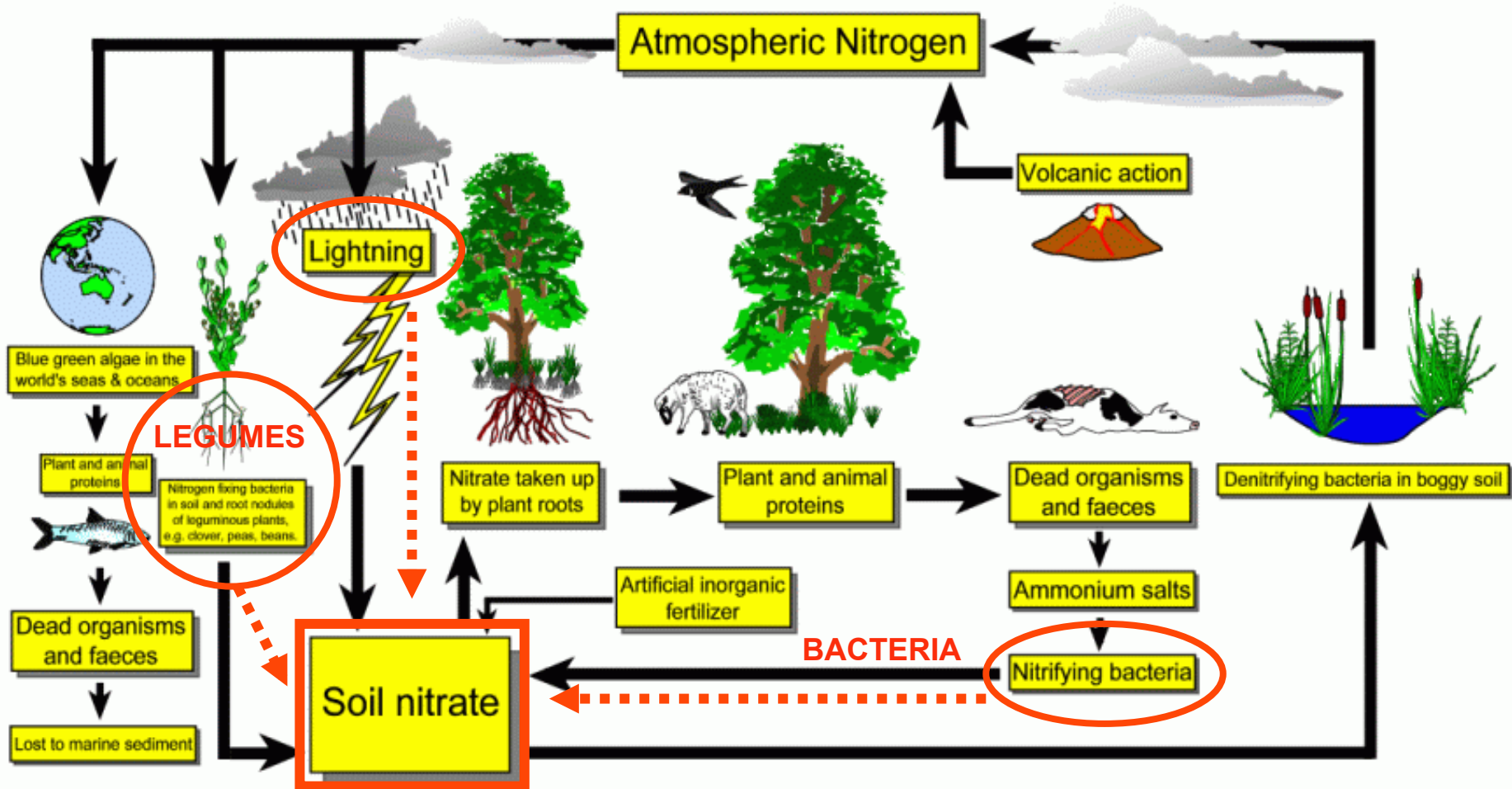
Group	Form	pH	Foodsource	C:N
Bacteria	Decomposer Mutualists Pathogens	Alkali	Proteins, Nitrogen Low MW carbon	5:1
Fungi	Mycorrhizal Saprophytic Pathogen/Predator	Acidic	Carbon	10-20:1
Protozoa	Grazers		Bacteria	50:1
Nematodes	Grazers Predators		Bacteria, Fungi, Protozoa, Nematodes Roots	100:1



NITROGEN from the AIR

The Nitrogen Cycle

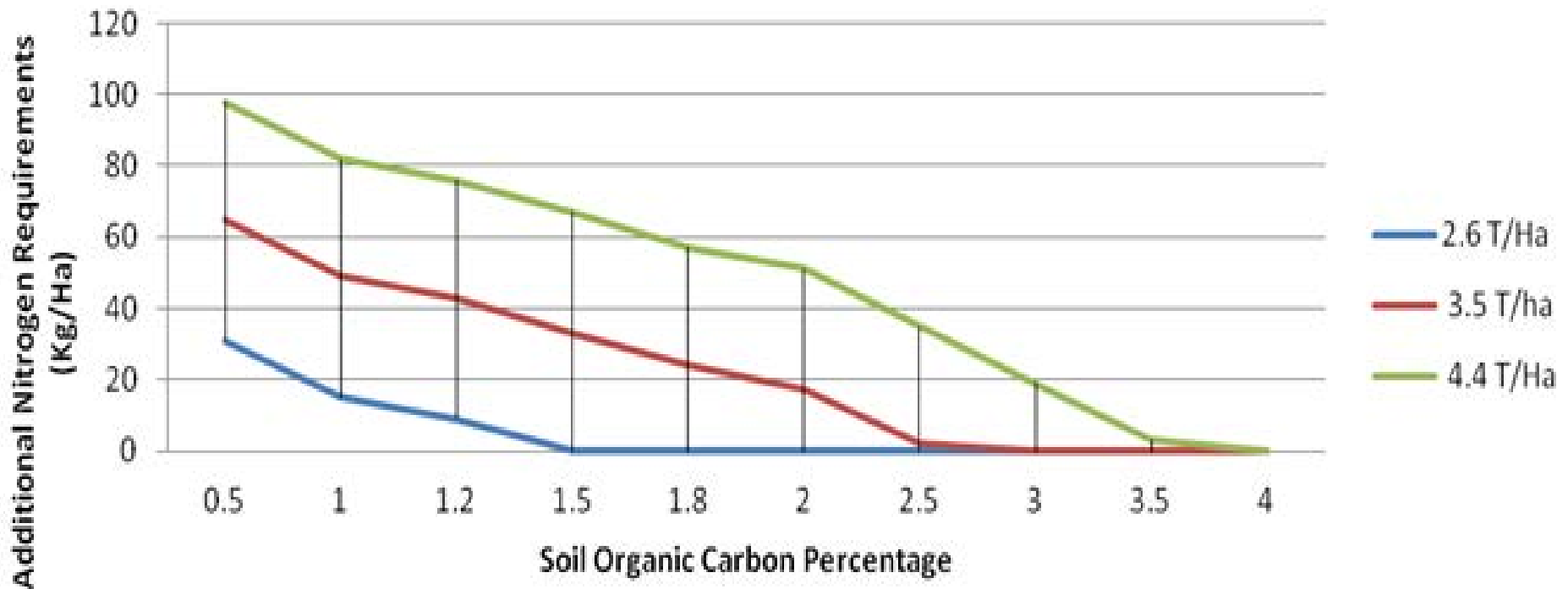
80,000t/ha





Carbon v Nitrogen

Additional Nitrogen Requirements at Varying Wheat Yield Targets and Organic Carbon Percentages



Produced by Guy Webb

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Indicators of poor biological balance

- ❖ **Slow OM breakdown**
- ❖ **Poor root systems**
- ❖ **Low brix level in plants**
- ❖ **Insect & disease issues**
- ❖ **Low nutrient density**





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6 PRINCIPLES of REGENERATIVE FARMING

1. **PLAN, MONITOR & MANAGE SOIL HEALTH**

2. **MAXIMIZE LIVING PLANT PRODUCTION**

3. **A FOCUS on BIOLOGY will REPAIR SOIL HEALTH**

4. **INTRODUCE BIODIVERSITY**

5. **MAXIMUM THICKNESS and AVAILABILITY of GROUND COVER**

6. **LIVESTOCK are NATURE's RECYCLERS**





Modern paradigm

Our ability to change the earth increases at a faster rate than our ability to foresee the consequence of change.





The Conventional approach and Result

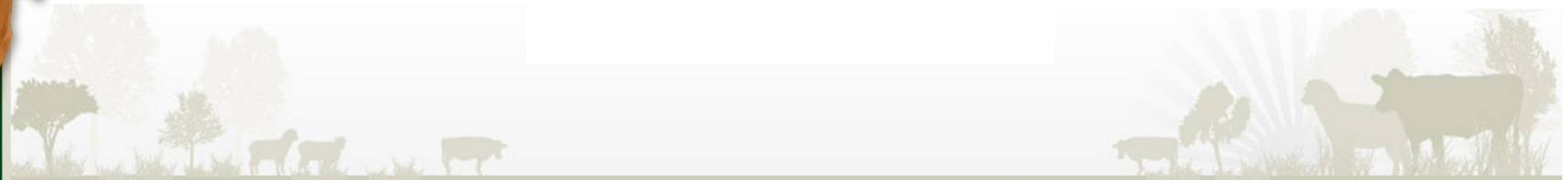


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The essential Components of a regenerative Ecosystem are:

1. **Biodiversity**
2. **Healthy Soil**
3. **Healthy Plants**
4. **Healthy Animals**
5. **Healthy Food Production**
6. **Healthy People**





Principle 1. Plan, Monitor & Manage Soil Health

GOAL:

“To profitably leave our
land in better
condition”



The Linkages

Gross Margin = (f) Plant Productivity

Plant productivity = (f) plant available water and nutrients

Plant available water and nutrients = (f) CeC

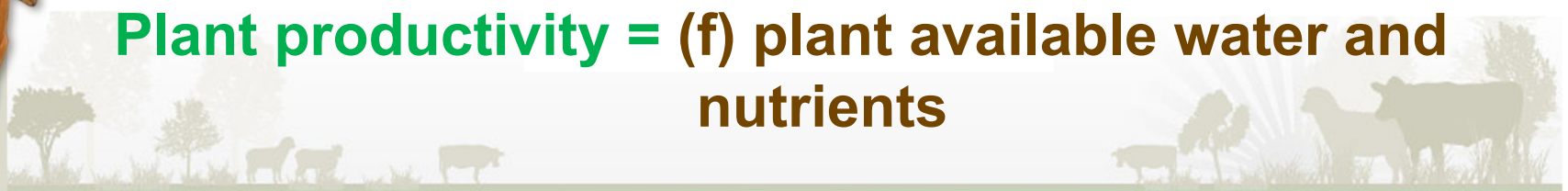
CeC = (f) Soil organic carbon (incl Humus)

Soil organic carbon = (f) biological activity

Biological activity = (f) food, shelter, water & air

Food, shelter, water & air = (f) PLANT PRODUCTIVITY

Plant productivity = (f) plant available water and nutrients



Spiral
up



Spiral
down

WAYS to INCREASE SOIL HEALTH



Biodiversity

CATALYTIC
INPUTS

BIOLOGY

MANAGEMENT

(eg grazing/cover cropping)





COMBINATIONS

Management

- **Grazing**
- **Cover/Green manure Crops**
- **Crop rotations**
- **Continuous cropping**
- **Aeration**
- **Landscape Hydration**

+ Biology

- **Compost & Compost Extract (BEAM)**

+ Fertilizer & Catalysts

+ Perennial Legumes



Compost Extract & Worm Juice on Wheat & Barley - WA

Ian & Di Haggerty





The Underpants underground test





Catalytic fertilizer

- **Boron (Solubor)**
- **Sulphur (Gypsum)**
- **Calcium (Calsap or micro fine lime)**
- **Silica (BD501)**

As foliar applications





Multi Species cover crops



Images by Gabe Brown

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Aeration & Rehydration - Keyline





Hydration

Mulloon Institute



Swales



Gully Repair

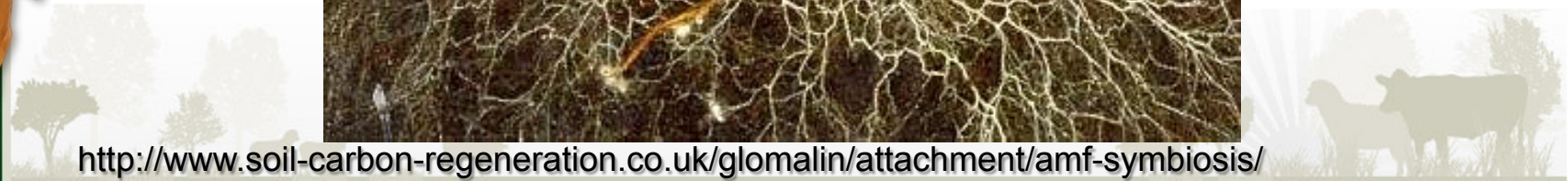


Leaky Weir





Principle 2. MAXIMIZE LIVING PLANT PRODUCTION



<http://www.soil-carbon-regeneration.co.uk/glomalin/attachment/amf-symbiosis/>

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Gabe Brown stock grazing a cover crop



High Density
grazing





Cover Crops and Yield

**0.8% SOC – Legume Cover Crop
YIELD = 1t/ha DM**



Johnson, D, Ellington, D and Eaton, W (2013) Institute for Sustainable Ag Research.

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Cover Crops and Yield

**9.5% SOC – Legume Cover Crop
YIELD = 7.5t/ha DM**



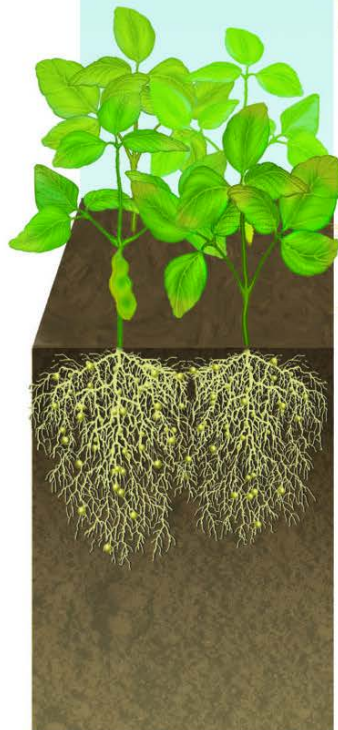
Johnson, D, Ellington, D and Eaton, W (2013) Institute for Sustainable Ag Research.



Iowa corn belt

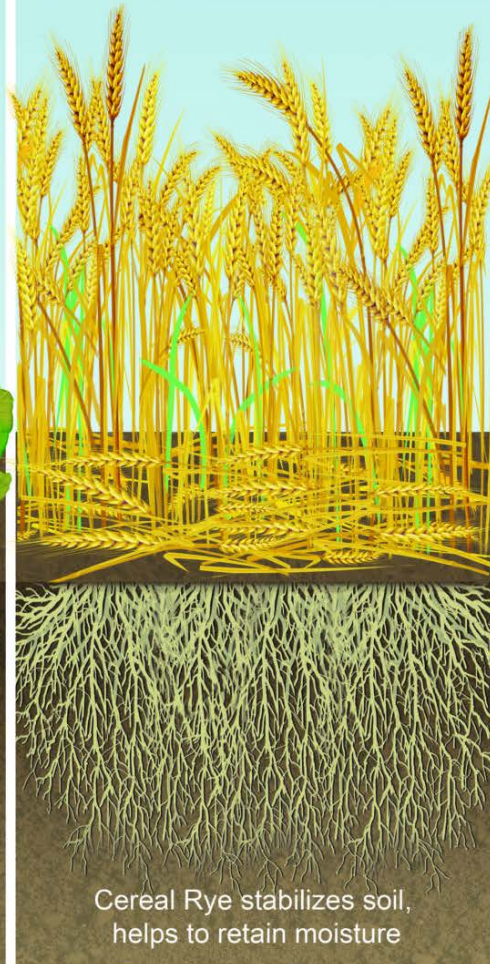
Summer 1

Soybeans
Before Cover
Crop



Fall 1

Cereal Rye Cover Crop



Cereal Rye stabilizes soil,
helps to retain moisture

Summer 2

Soybeans
After Cover
Crop



Soybean plants
rooting more
deeply



Carlyn Iverson and USDA-SARE

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Biology is the ENGINE

Gross Margin = (f) Plant Productivity

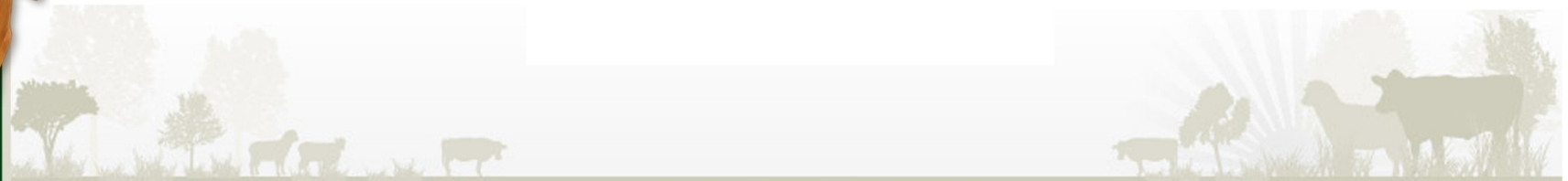
Plant productivity = (f) plant available water and nutrients

Plant available water and nutrients = (f) CeC

CeC = (f) Soil organic carbon

Soil organic carbon = (f) biological activity

Biological activity = (f) food, shelter, H₂O & air



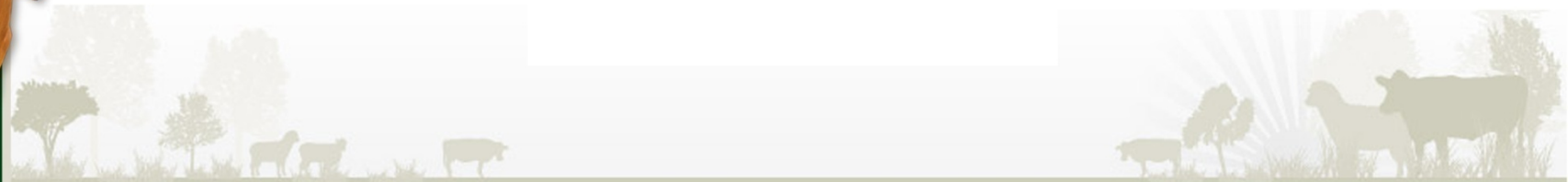
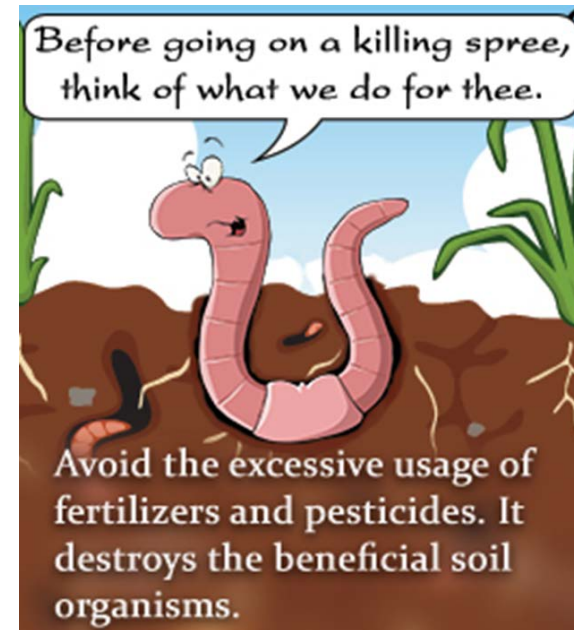
The Essentials of life

✓ **AIR** – especially oxygen and nitrogen

✓ **WATER**

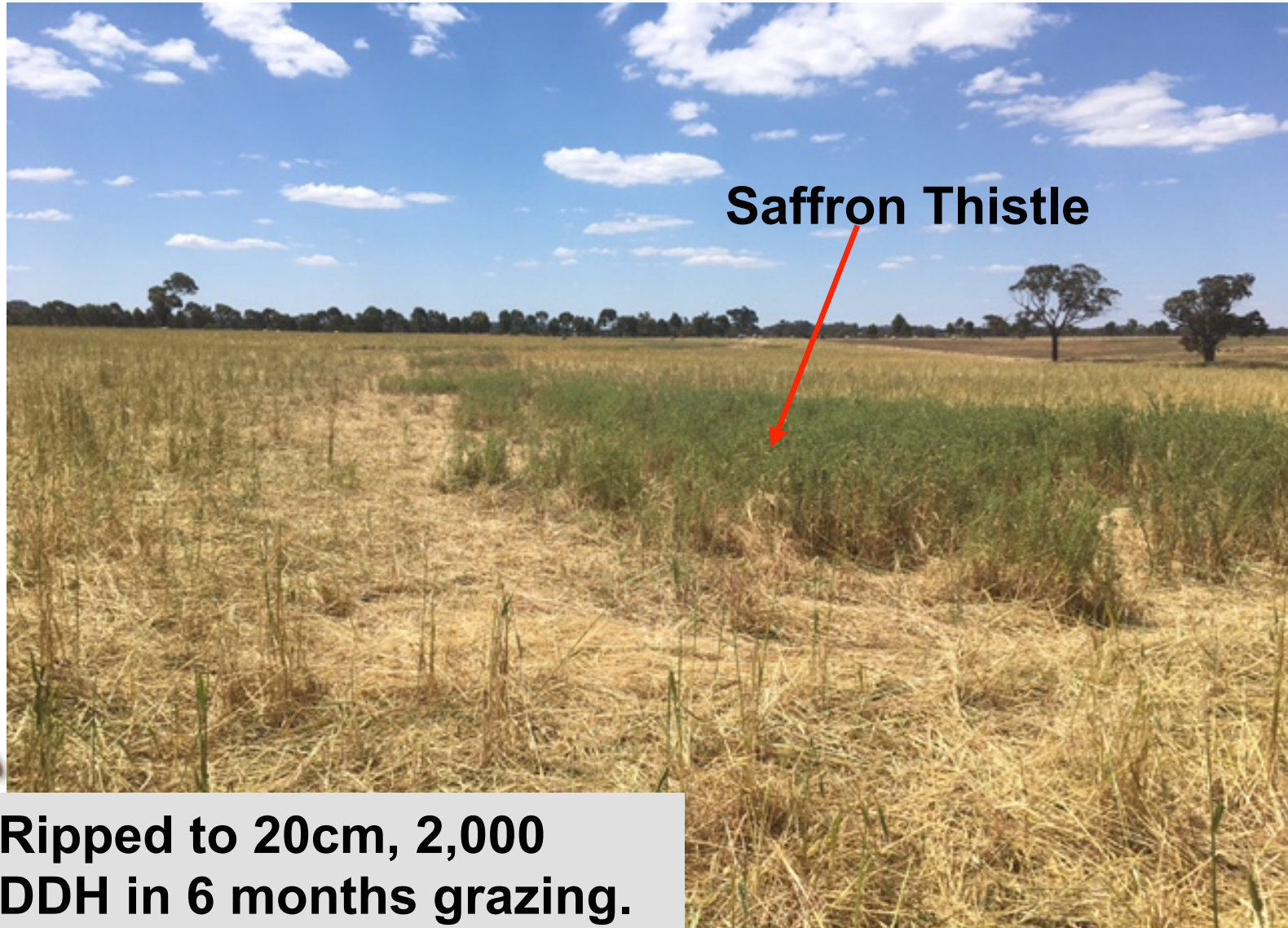
✓ **FOOD** – esp **ENERGY**

✓ **SHELTER** – eg litter, living species





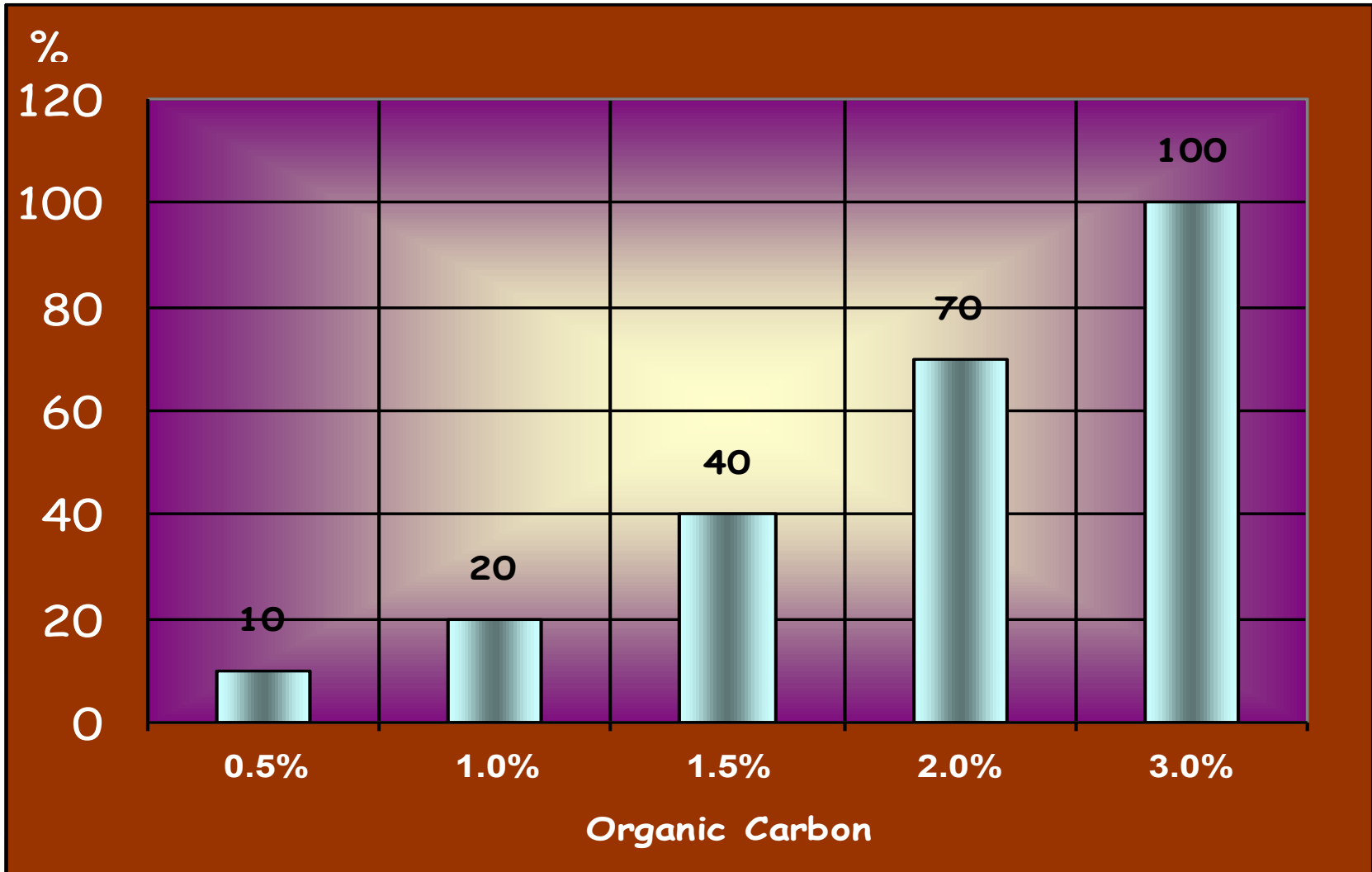
Aeration (Yeomans 20cm)



Saffron Thistle



**Ripped to 20cm, 2,000
DDH in 6 months grazing.**
James Morse, 2016



Relative water holding capacity (litres per 50 kg of soil)



BEAM

BIOLOGICALLY ENHANCED AGRICULTURAL MANAGEMENT

Dr David Johnson, New Mexico



Johnson-Su No-Turn Composting Bioreactor



David C. Johnson- NMSU Institute for Sustainable Agricultural Research (ISAR)
davidcjohnson@nmsu.edu

New Mexico State University



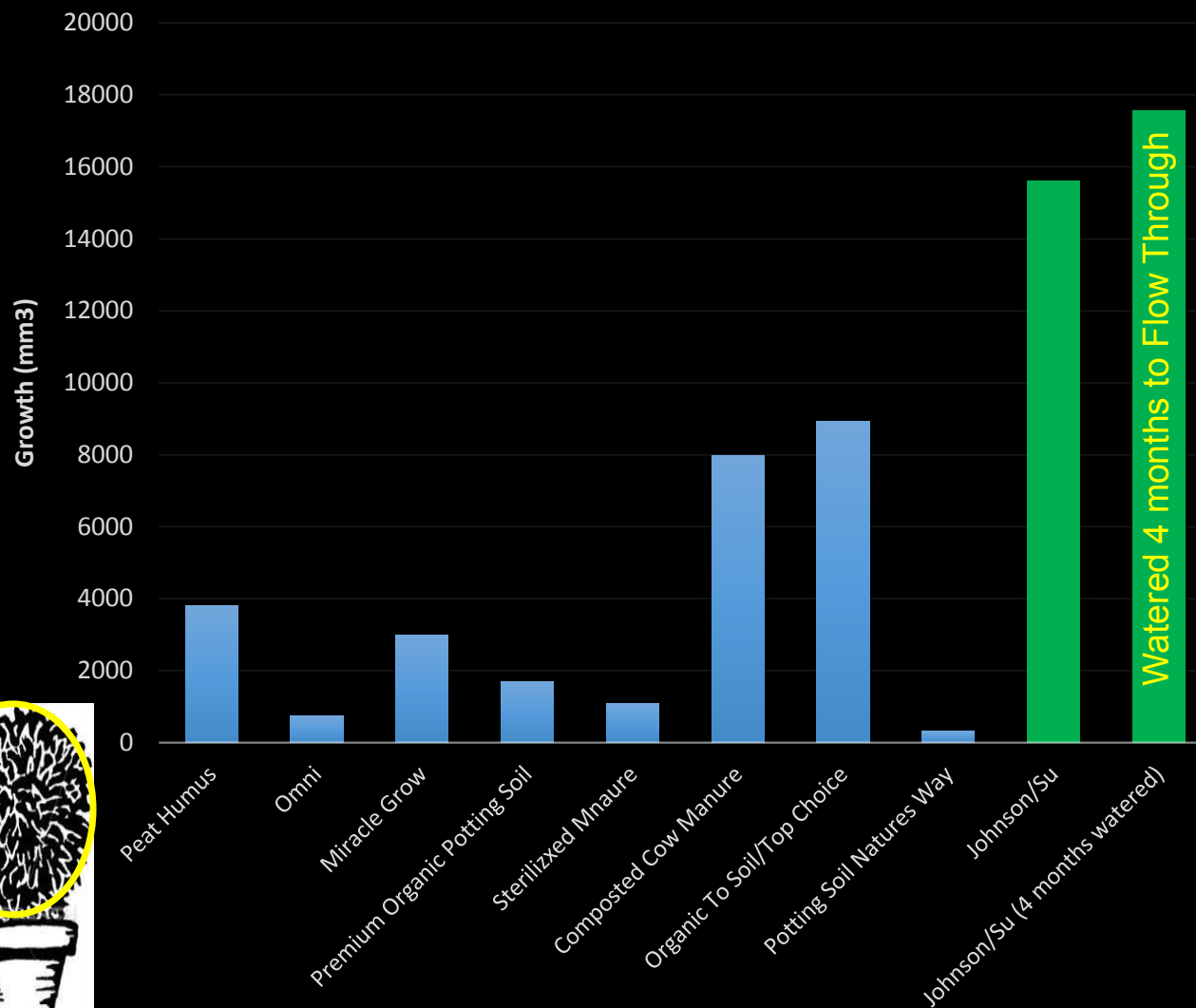


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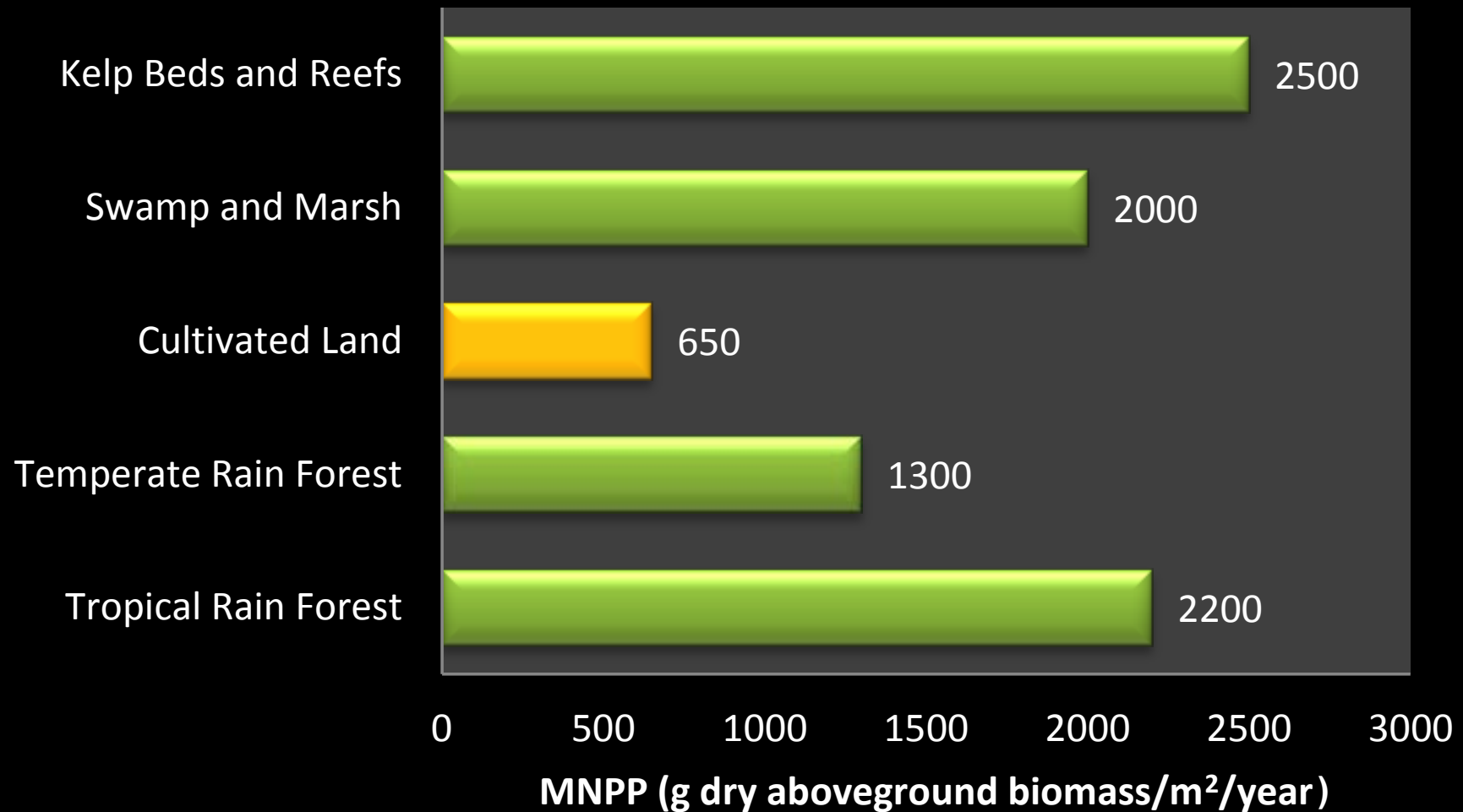
Compost Plant Growth Test (66 day)



**Not All
Composts
Are
Equal!**

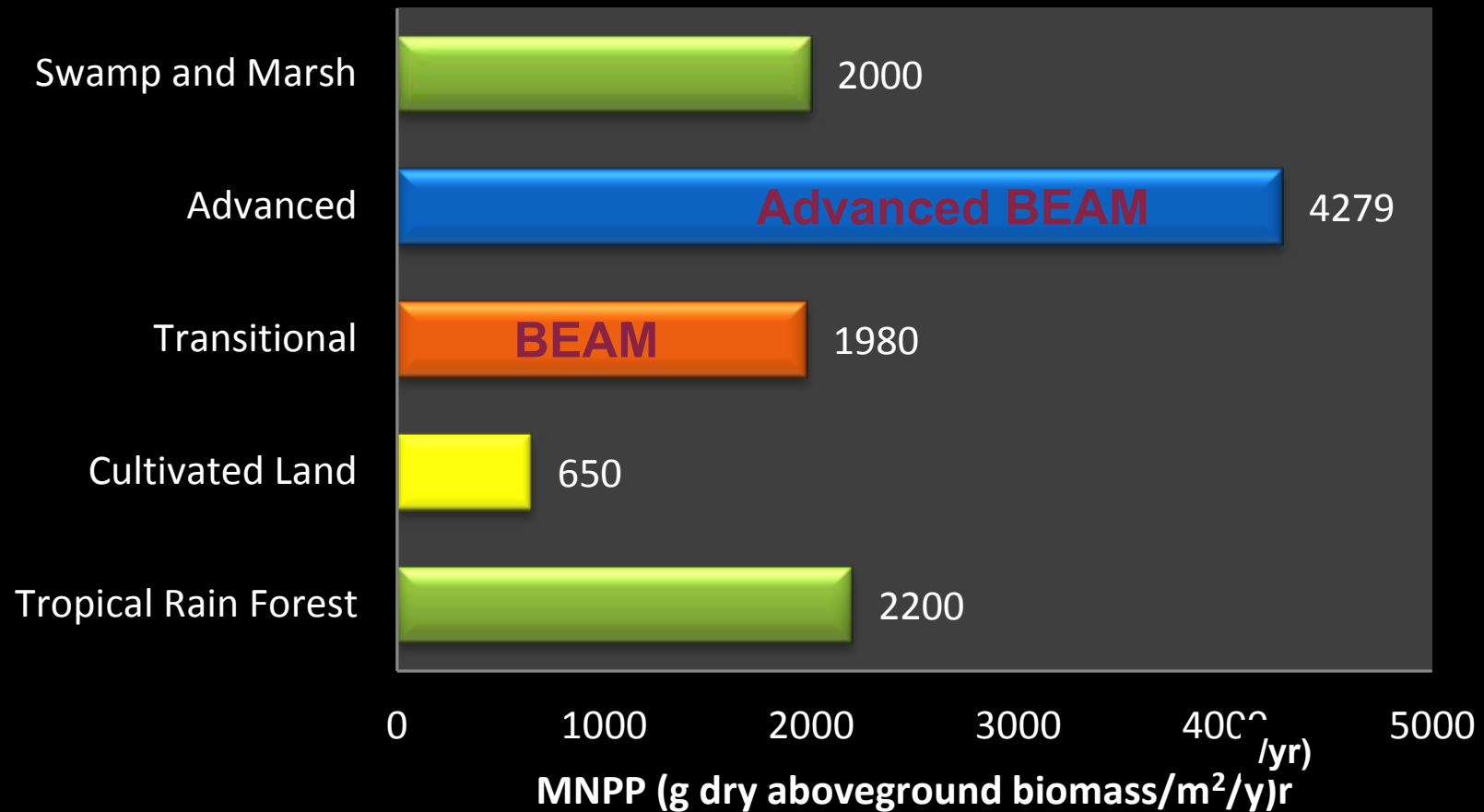


Most Productive Ecosystems



Whittaker, (1978)

How Does a Biologically Enhanced Agricultural Management (BEAM) System Perform?





**Control (No Previous
Covercrop Application)
Total Dry Biomass
Production =
1 ton/Acre**

**1 Year's Previous
Covercrop Application
Total Dry Biomass
Production =
5 tons/Acre**



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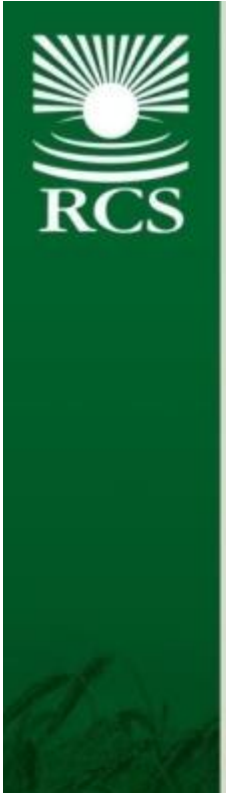
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Sunflower yield as soils improve



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..speed



**Plus 29
days**

**Plus
another 15
days**





2015 Desert Sandy Soil Trial



16t per ha DM



David C. Johnson- NMSU Institute for Sustainable Agricultural Research (ISAR) davidjohnson@nmsu.edu

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2016 Desert Sandy Soil Trial



22t per ha DM

580 kg N/ha



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Changes in Soil Macro and Micro-Nutrients with "BEAM"

Months	0	6	8	15	19	Percent Increase	R ²	Regression
Manganese (mg/kg)	3.25	1.86	1.65	14.31	40.14	1135%	R ² = 0.969	2nd Order
Iron (mg/kg)	4.89	4.12	2.66	27.01	59.19	1110%	R ² = 0.9892	2nd Order
NO ₃ -N (mg/kg)	1.5	1.55	2.00	2.35	3.1	107%	R ² = 0.9847	Linear
SOM (%)	0.75	1.25	1.22	1.49	1.41	88%	R ² = 0.7854	Linear
Magnesium (mg/kg)	1.09	0.075	0.81	1.67	1.99	83%	R ² = 0.7954	2nd Order
Calcium (meq/L)	4.09	2.82	3.00	6.07	7.19	76%	R ² = 0.6367	Linear
Kjeldahl N (mg/kg)	633	719	739.00	752	1041	64%	R ² = 0.8244	2nd Order
Phosphorus (mg/kg)	6.9	12.2	10.00	15.3	11.3	64%	R ² = 0.4624	Linear
Zinc (mg/kg)	0.5	0.63	0.48	0.93	0.81	62%	R ² = 0.6652	Linear
Copper (mg/kg)	1.17	1.1	1.04	1.74	1.64	40%	R ² = 0.6591	Linear
Potassium (mg/kg)	30	33	32.00	42	41	37%	R ² = 0.8712	Linear

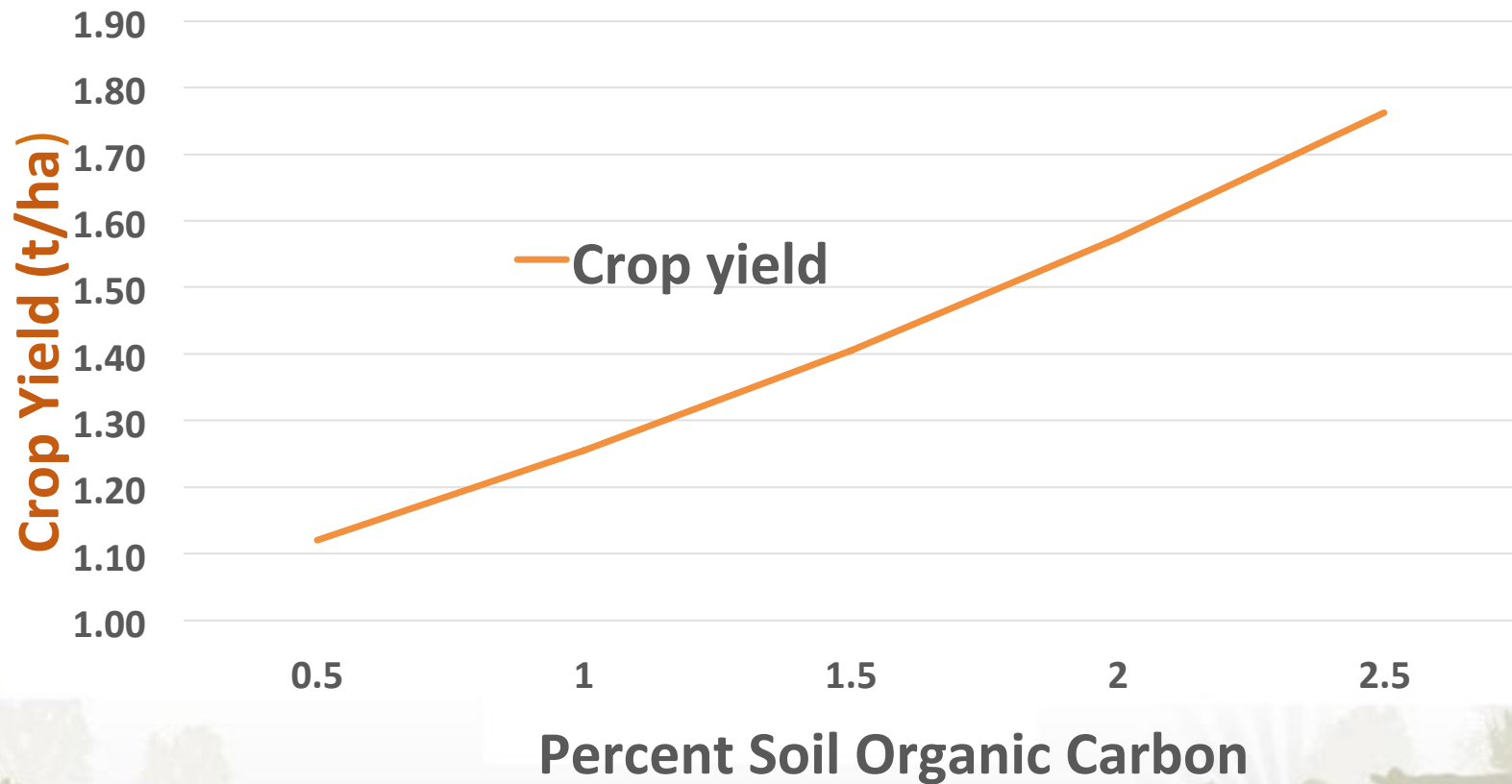
20 month Study, 5 Sampling Periods



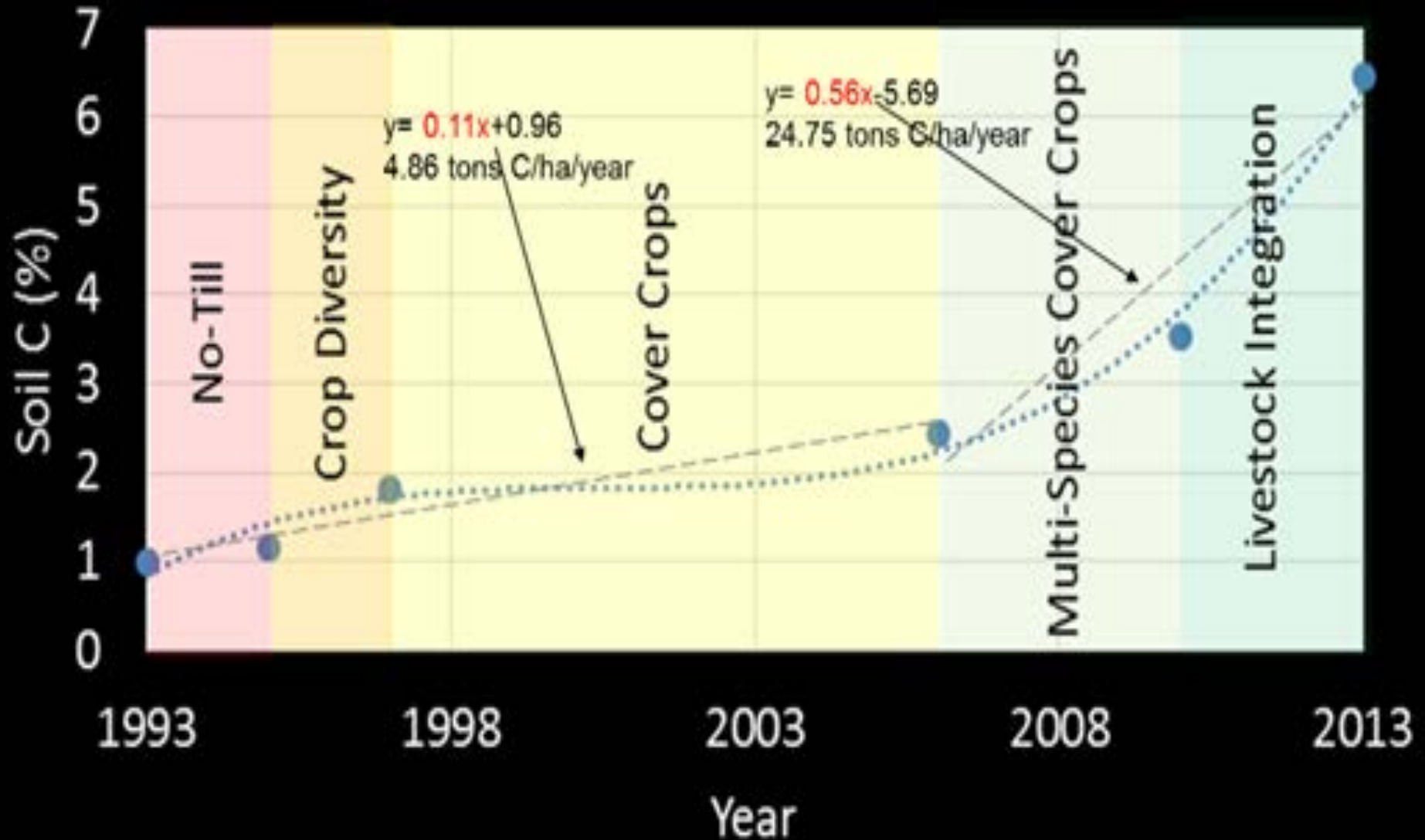
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CROP YIELD INCREASES by 12% for each 0.5% change on soil carbon



Gabe Brown's Soil Carbon Data





Principle 4. Introduce Biodiversity





Different root structures



Photos by Gabe Brown

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The latest research from Europe demonstrates that **RELATIONSHIPS** what enhance health

BIODIVERSITY



Relationships between organisms drives the progress of all. However fungi are the extroverts that get it going.



Ally Cropping





Companion Cropping

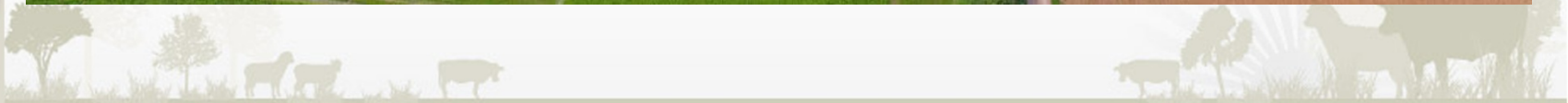


**Soybeans
into wheat**





Ley Cropping





Green Manuring

Planting into crimped rye





Fallow Efficiency

Bare Fallow	21%
Disc Tillage	25%
Blade Tillage	26%
Min/No Till	32%

"Improving fallow efficiency" 23 Feb 2016



Principle 5. MAXIMUM THICKNESS & AVAILABILITY OF GROUND COVER





Iowa Secretary of Agriculture – Sonny Perdue

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Improving groundcover

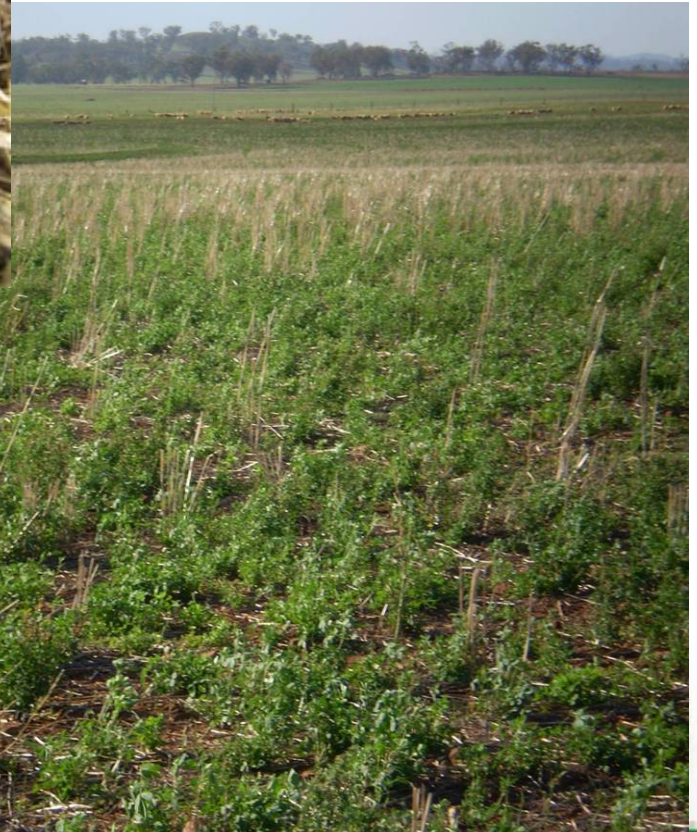
The effect of varying ground cover on water and soil loss in a 650 mm rainfall environment

20% ground cover	40% ground cover	70% ground cover
Runoff water loss = 160 mm/yr	Runoff water loss = 90 mm/yr	Runoff water loss = 10 mm/yr
Soil loss = 85t/ha/yr	Soil loss = 40 t/ha/yr	Soil loss = 3 t/ha/yr
<p>Poor plant production and poor animal production</p>		<p>Good plant production</p>

Source: LeyGrain (2006)



Decaying & Living stubble





Principle 6. LIVESTOCK are NATURE'S RECYCLERS









RECYCLING





Livestock functions

- **Diversity of income**
- **Spread soil biology**
- **Feed soil biology**
- **Recycle waste products eg crop residue**
- **Animal waste is fertilizer & seeding**
- **Animal impact used to put crop residue on the ground**

