SOIL HEALTH

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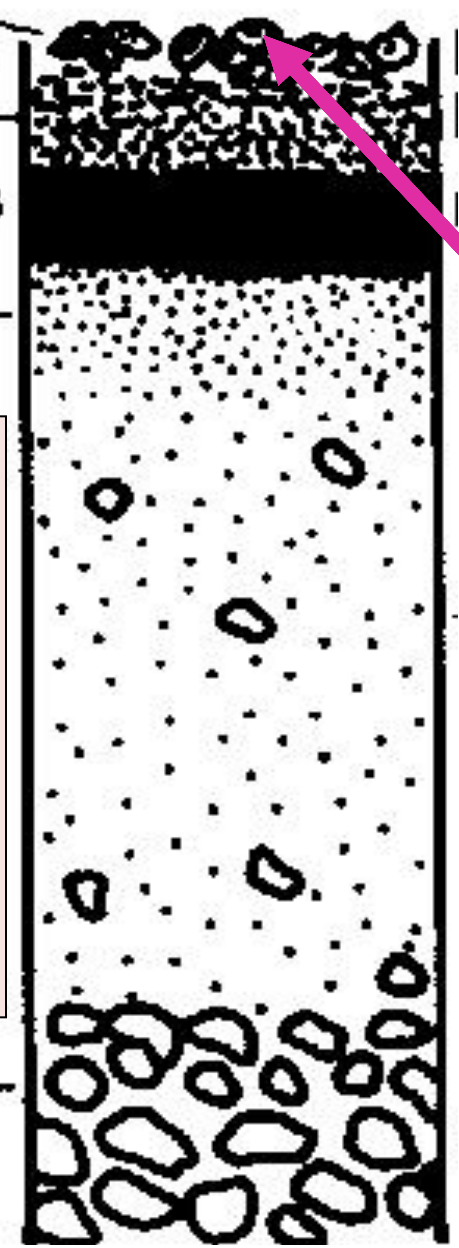
SOIL HEALTH:

Maintaining the vitality of the soil to sustain the environmental, agricultural and economic potential of food and fibre production.

The Nation that destroys its soil destroys itself.

Franklin D. Roosevelt, Letter to all State Governors on a Uniform Soil Conservation Law (26 February 1937)

THE VITALITY OF SOIL



SOIL ORGANIC MATTER (SOM):

- > 2000µm = Litter (mulch)
- < 200 µm= Microbial Biomass

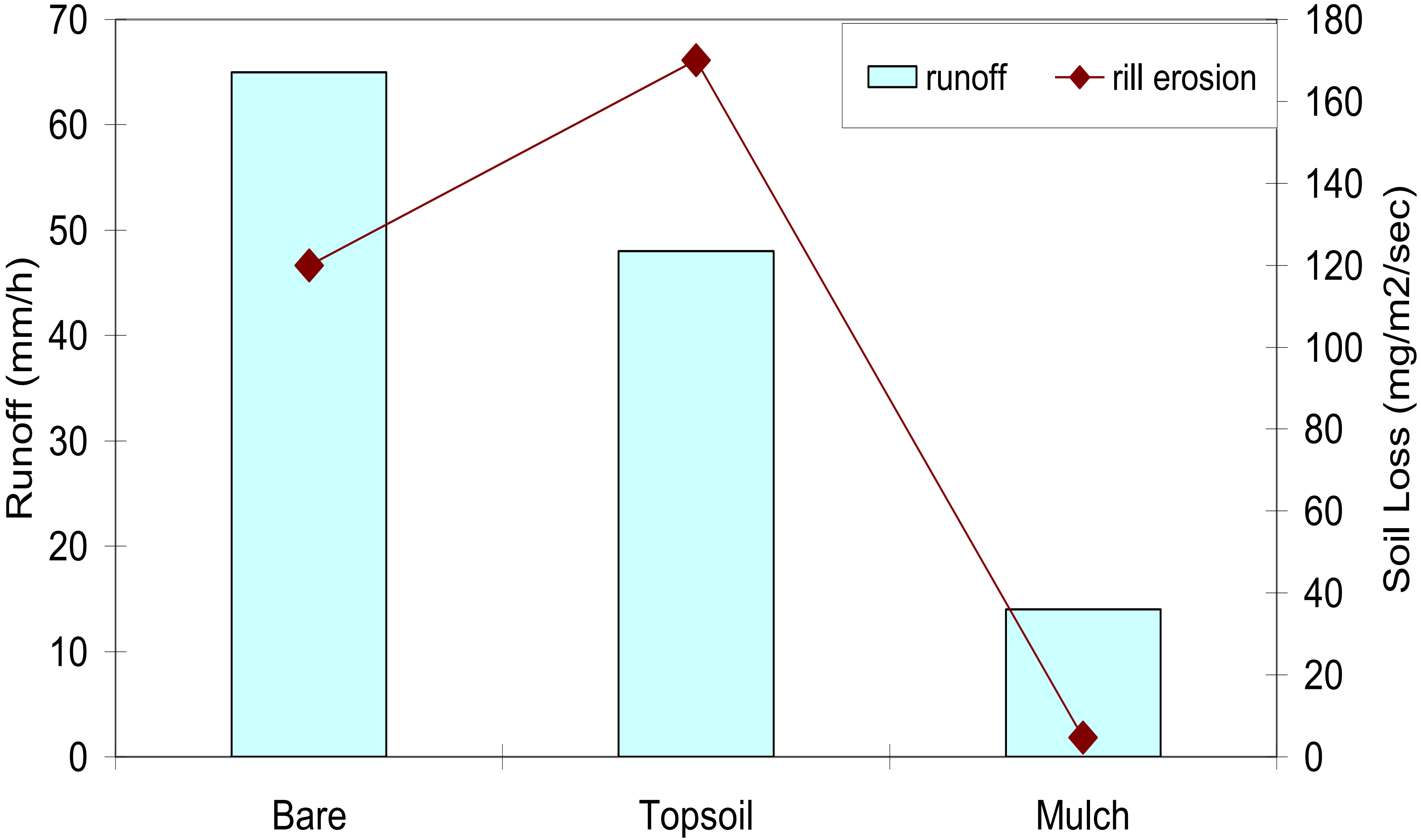
LITTER:

Physical protection

- Large (>20 mm) particles slow to decompose
- Leaf litter shelters & feeds soil arthropods

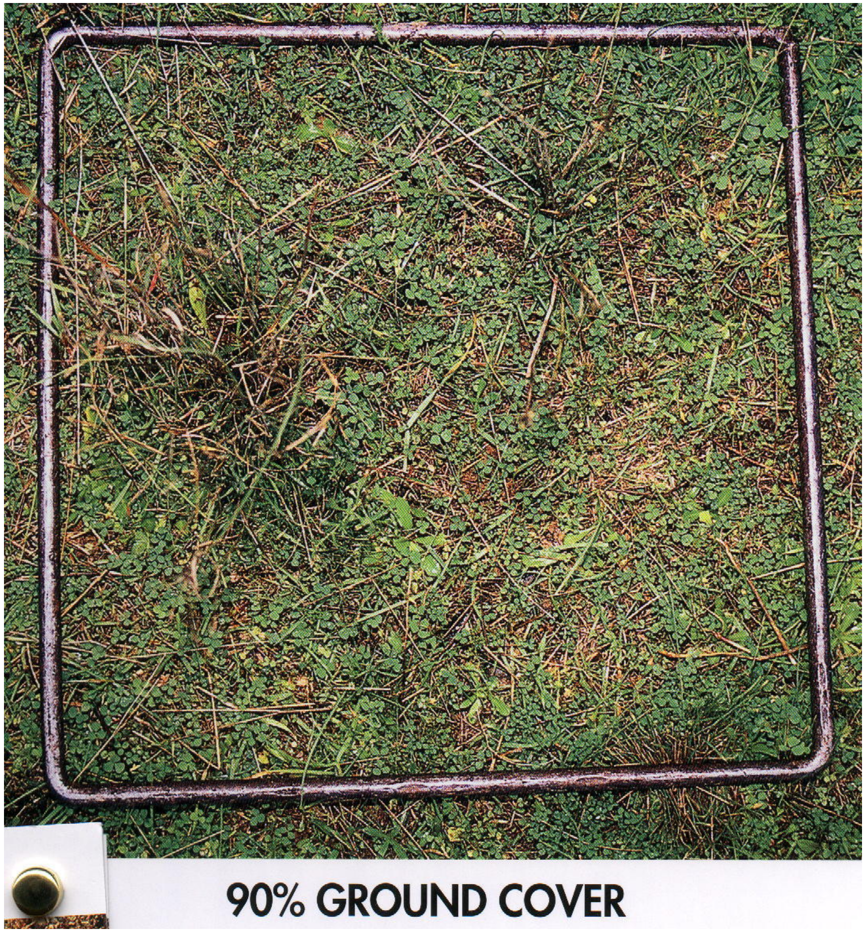
Leadley Brown (1978)

LITTER (>2 mm) PROTECTS TOPSOIL



Persyn et al (2004) Trans Am Soc Ag Eng 47: 463-69

MONITORING GROUND COVER



NW NSW Sustainable Grazing Systems Inc. cover assessment.
@ 20% runoff 160 mm, soil loss 8.5 mm per year
@ 70% runoff 10 mm, soil loss 0.3 mm per year

SOIL COVER & SOIL LOSS IN QLD TROPICS

Rainfall intensity	Soil erosivity	Slope	Poor cover soil loss (t/ha/y)	Good cover soil loss (t/ha/y)
High	Low	low	8	0
		medium	**20**	**1**
		high	**37**	**2**
	High	low	25	1
		medium	**61**	**3**
		high	**112**	**6**
V. high	Low	low	15	1
		medium	**36**	**2**
		high	**65**	**3**
	High	low	44	2
		medium	**107**	**5**
		high	**195**	**10**

Burdekin region, 500 – 100 mm/y rainfall: Karssies & Prosser 1999

ROLE OF LITTER IN SOIL HEALTH

Soil Organic Matter = Organic C + minerals (ash)

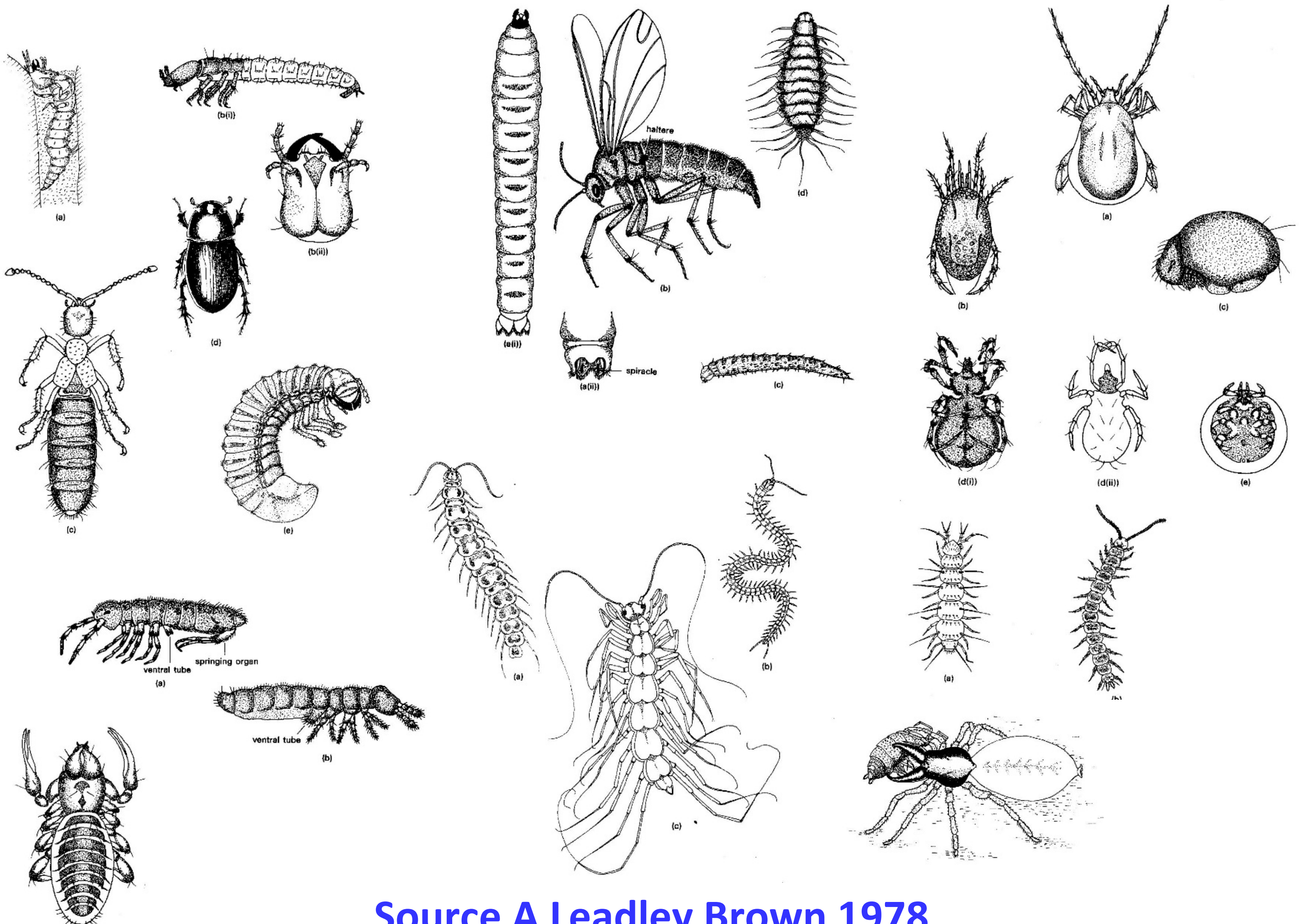
Litter layer (rotting leaves and twigs):

- protects soil from erosion,
- habitat for soil animals
- food source for soil animals

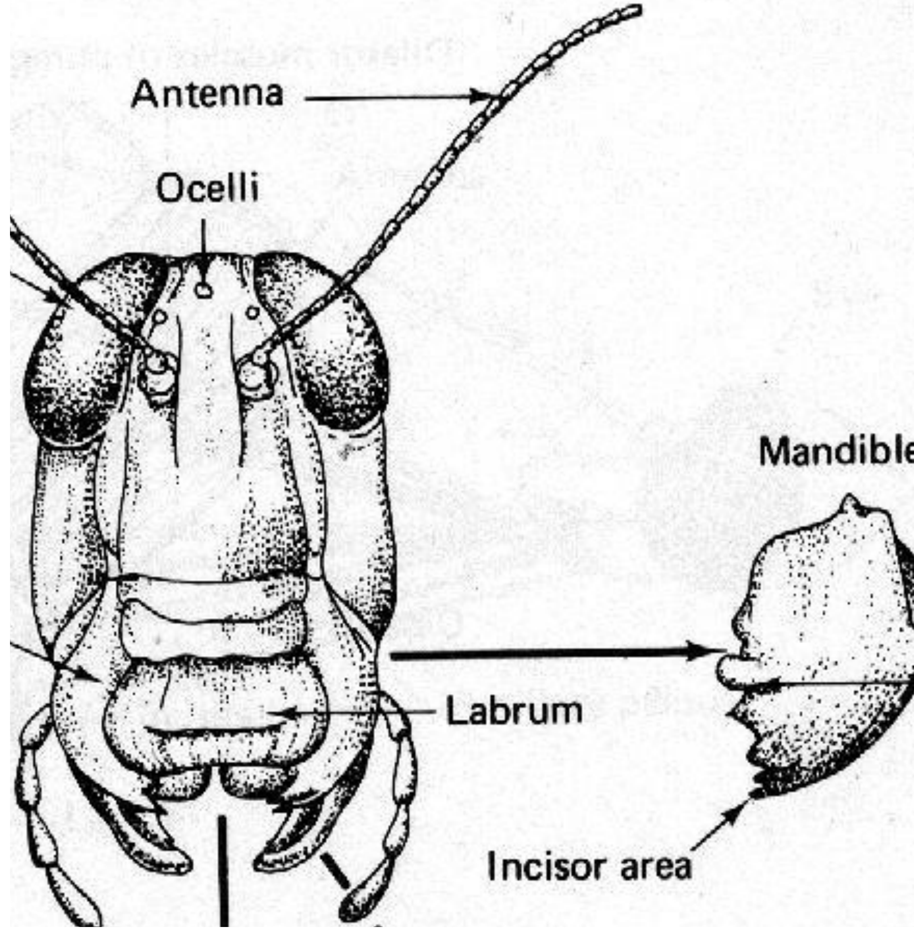
Soil animals in litter:

- Burrowing produces micropores **(water infiltration)**
- Eating fragments litter **('teeth' equivalents)**
- Excreting produces nitrogen **('urine')**
- Hunting is the soil food web **(biological control)**

LITTER AS A HABITAT FOR SOIL ANIMALS

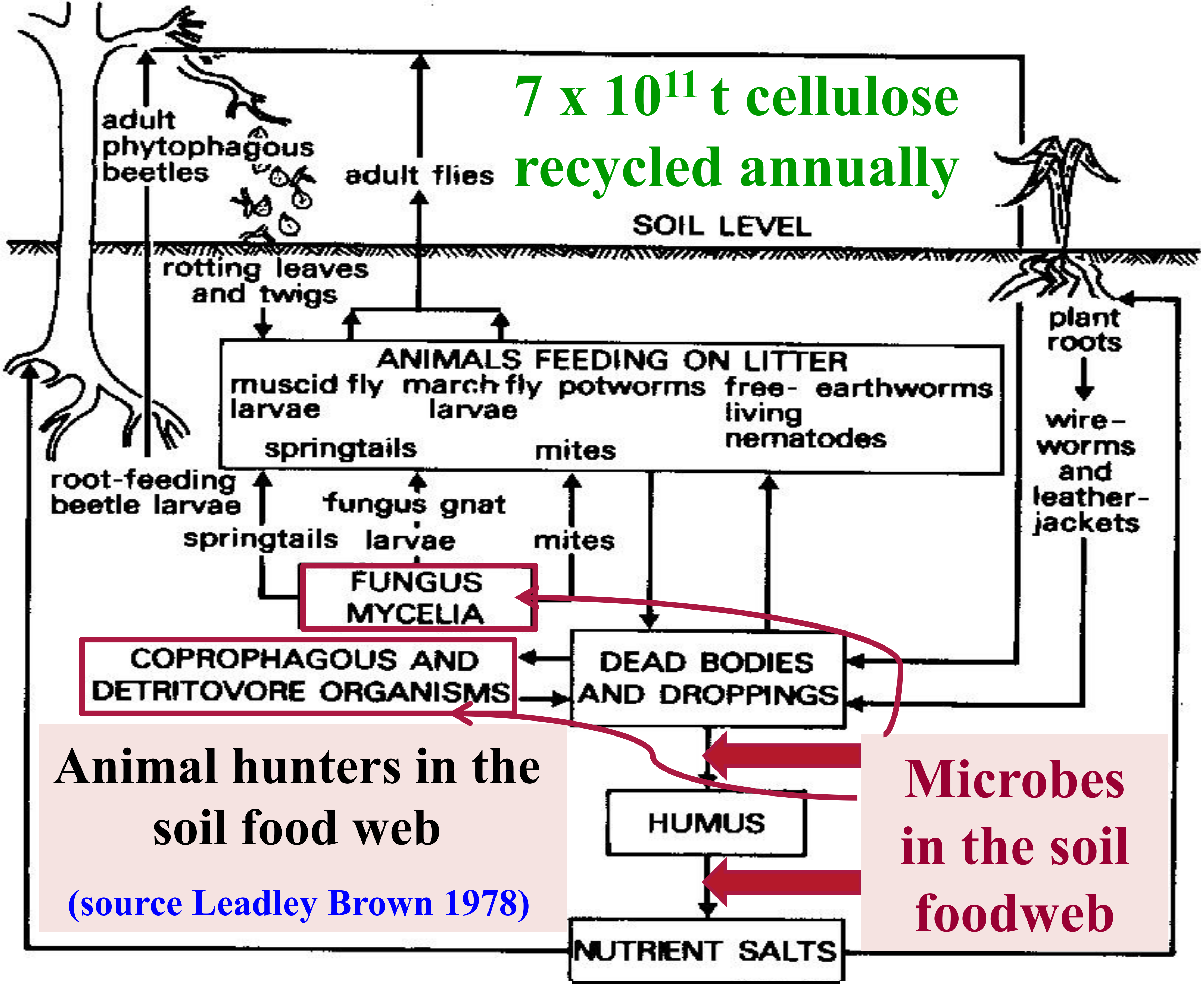


Source A Leadley Brown 1978



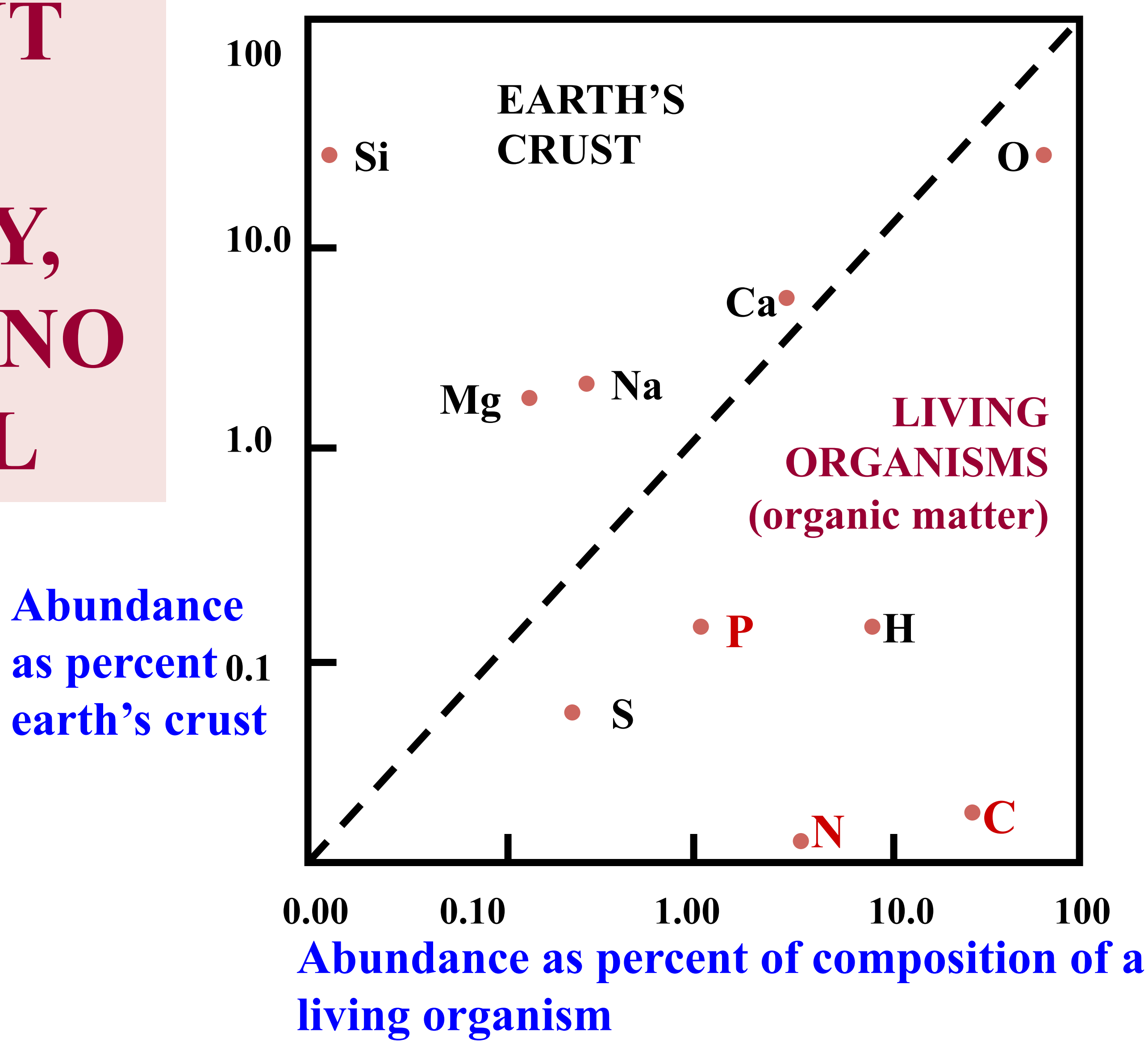
ROLE OF SOIL ANIMALS IN MICROPORE CONSTRUCTION & MAINTENANCE

MONITORING SOIL ANIMAL ACTIVITY: PAINT (water-based) INFILTRATION



7 x 10^{11} t cellulose recycled annually
adult phytophagous beetles
adult flies
SOIL LEVEL
rotting leaves and twigs
ANIMALS FEEDING ON LITTER
muscid fly larvae
march fly larvae
potworms
free-living nematodes
earthworms
springtails
mites
plant roots
wire-worms and leather-jackets
root-feeding beetle larvae
springtails
fungus gnat larvae
mites
FUNGUS MYCELIA
COPROPHAGOUS AND DETRITOVORE ORGANISMS
DEAD BODIES AND DROPPINGS
HUMUS
NUTRIENT SALTS
Animal hunters in the soil food web
(source Leadley Brown 1978)
Microbes in the soil foodweb

WITHOUT SOIL BIOLOGY, THERE IS NO TOPSOIL



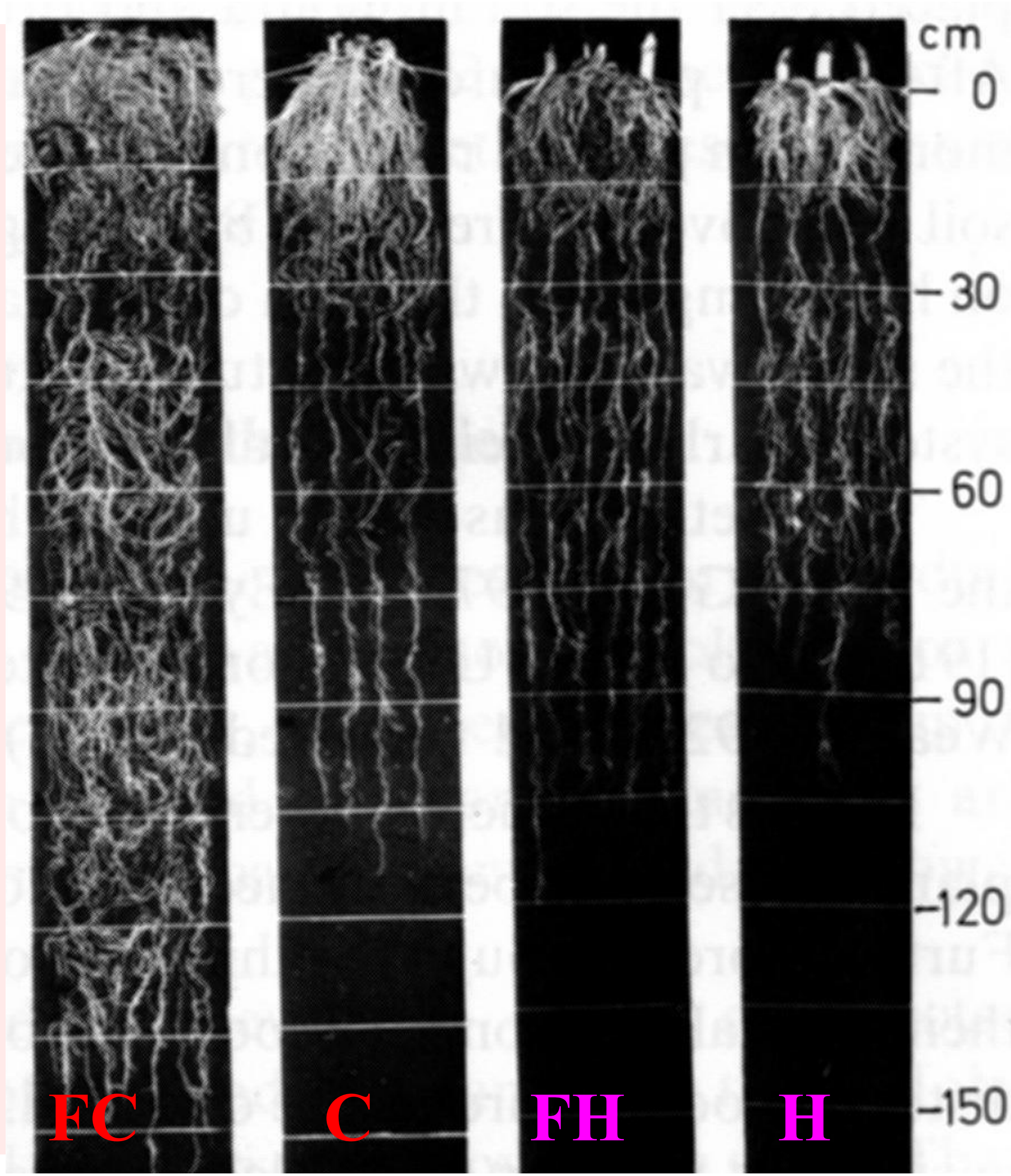
Source: Madigan et al (2003) Biology of Microorganisms

LIMITATIONS OF CLAY SOILS HIGH IN Na (sodium) & Mg (magnesium), ON ROOT GROWTH:

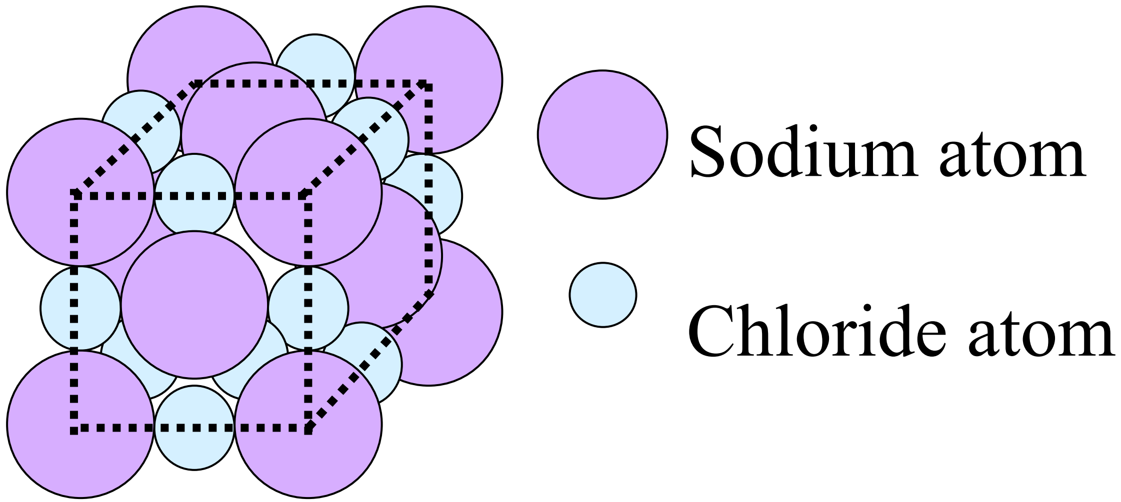
Fertilised (FC) and unfertilised (C) Ciane soil

Fertilised (FH) and unfertilised (H) Huey soil

(Fehrenbacher et al Illinois, USA 1967)



WHY SODIC SOILS 'DISSOLVE'



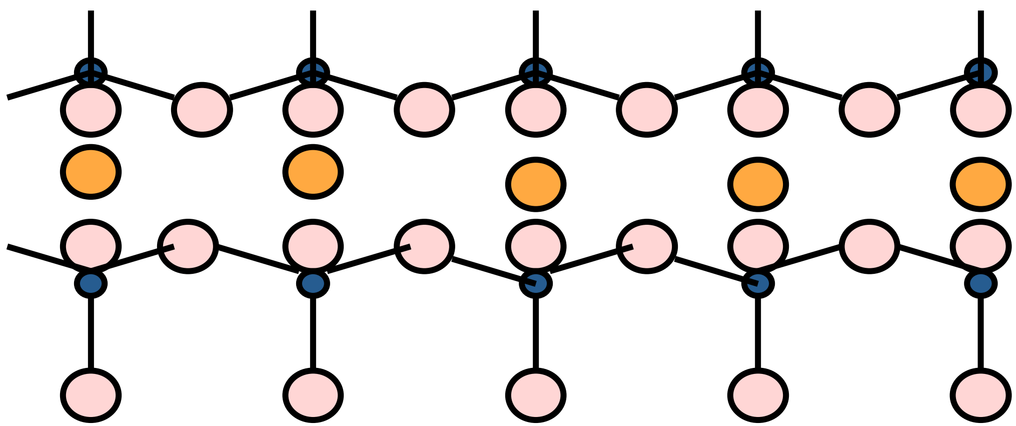
Sodium (Na) **& chloride** (Cl) **ions in rock salt.**

Binding of ions in clays:

Grey = silica cation

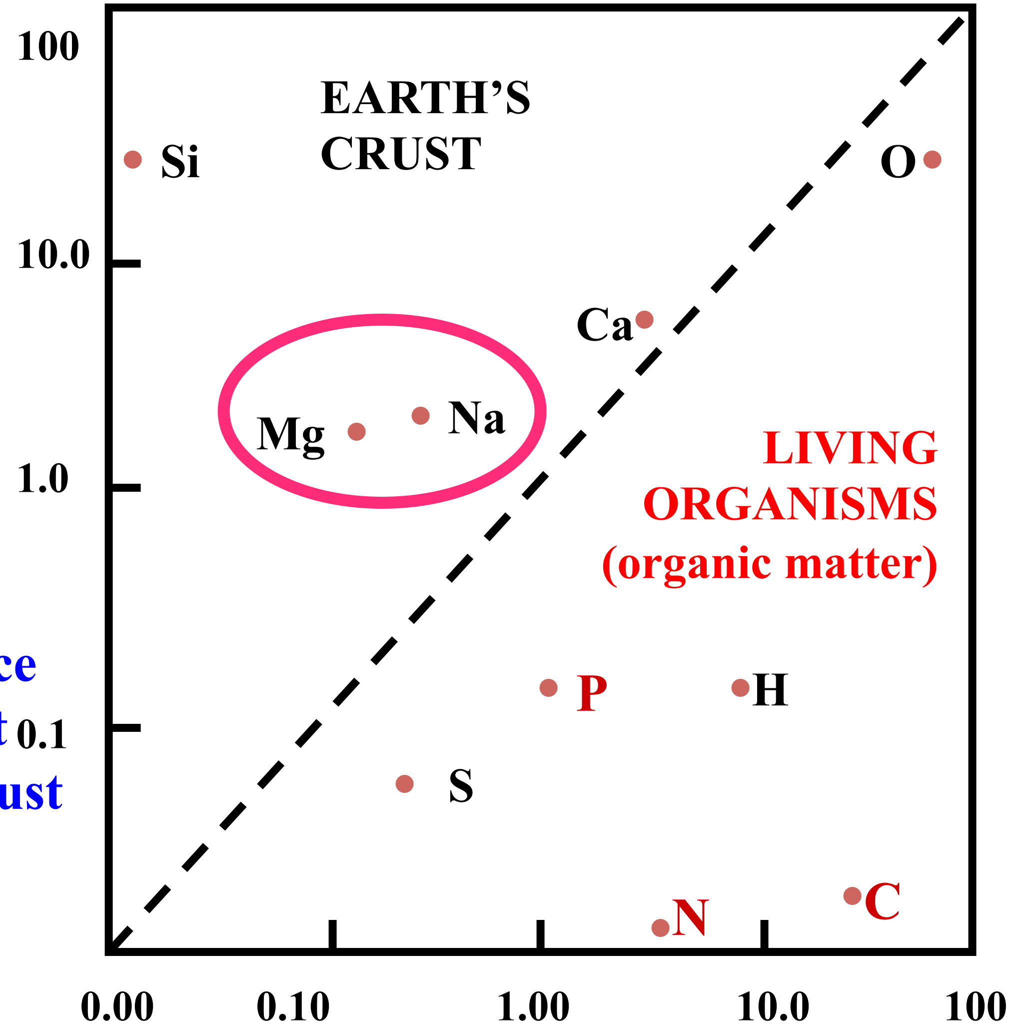
Pink = oxygen anion

Orange = cation



‘DISPERSIVE’ SOILS:

Clay soils high in Mg, Na & Cl ‘DISSOLVE’



Abundance as percent earth’s crust

Abundance as percent of composition of a living organism

Source: Madigan et al (2003) Biology of Microorganisms

TEST DATA FOR 50-60cm SOIL SAMPLE

(Hard-setting black sodosol, mixed sandstone/basaltic alluvium, slowly permeable, poorly drained)

Exchangeable cations	mEq per 100g sample	Cation as percentage of total
potassium	0.71	2.4%
calcium	4.6	15.9%
magnesium	14.7	50.7%
sodium	9.0	31.0%

INTERPRETING TEST RESULTS FOR DISPERSIVE (SODIC) SOILS

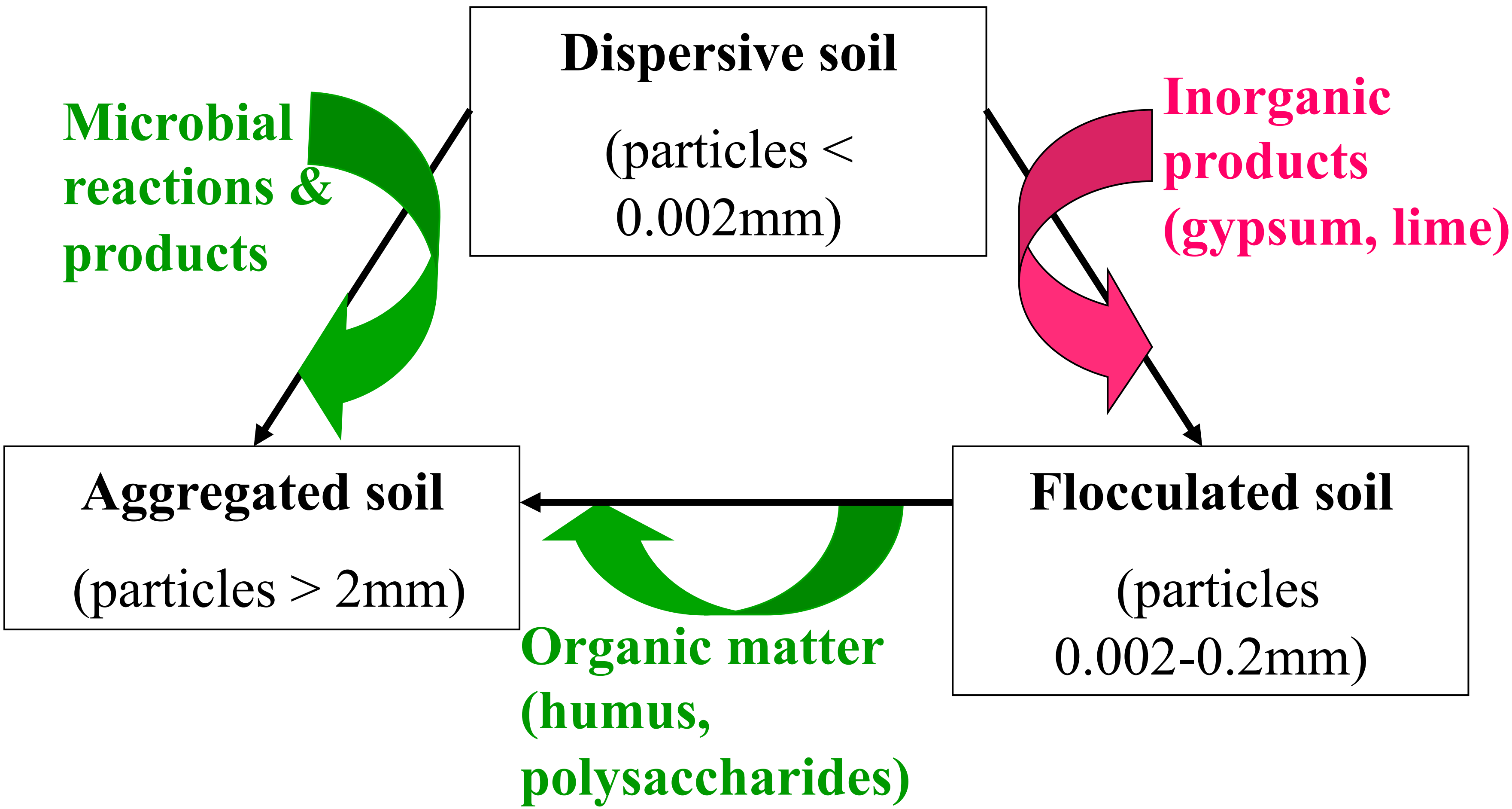
Test soil had >20% clay, ESP was 31%

- **Exchangeable sodium percentage (ESP) >6%, high risk of dispersion,**
- **Dispersivity includes Sodium (Na = 31%), Magnesium (Mg = 51%) & Chloride (Cl).**

IMPACT OF CATTLE TRAMPLING ON A WET, ‘SODIC’ SOIL???

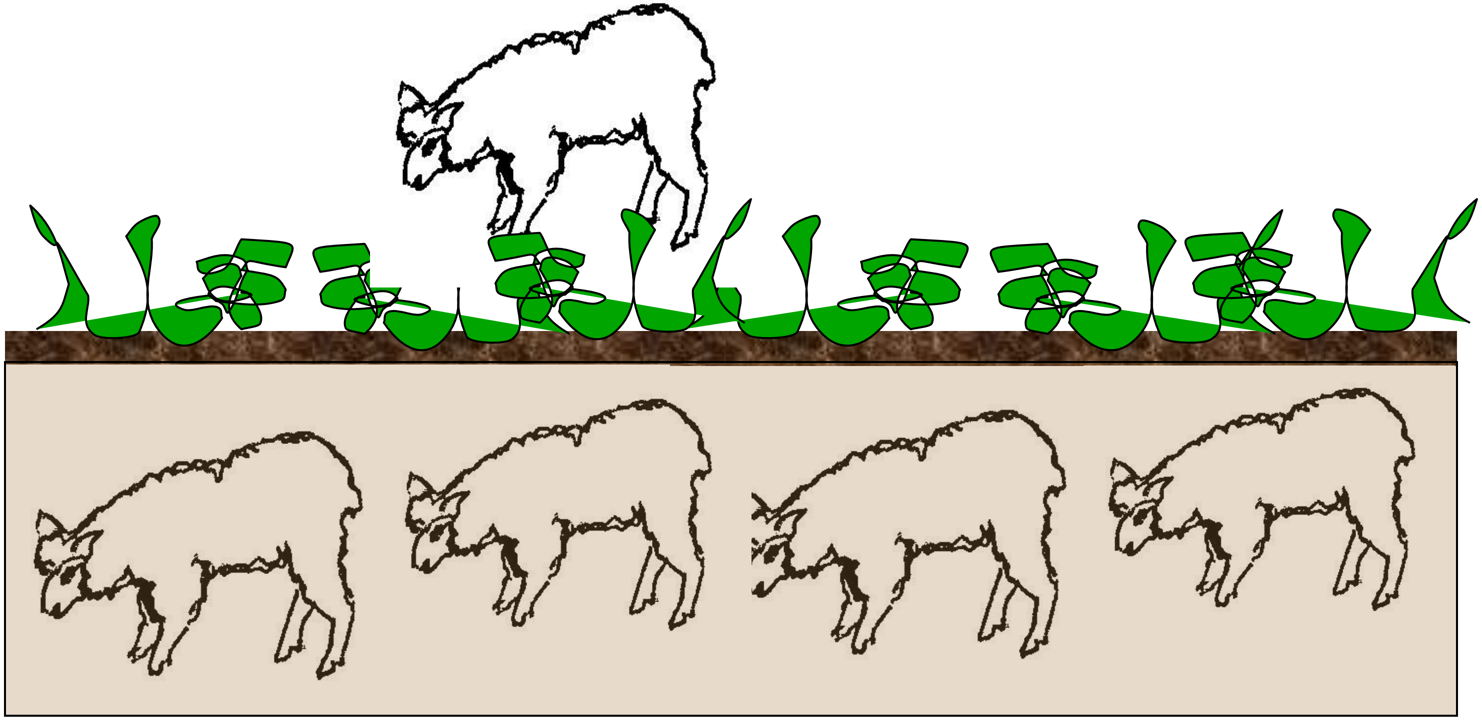
Advantage of fencing to SOIL TYPE, for improved SOIL HEALTH

REBUILDING SOIL STRUCTURE



Source: after Rengasamy & Olsson (1991) A J Soil Res 29: 935-52

MICROBES FEEDING THE SOIL???

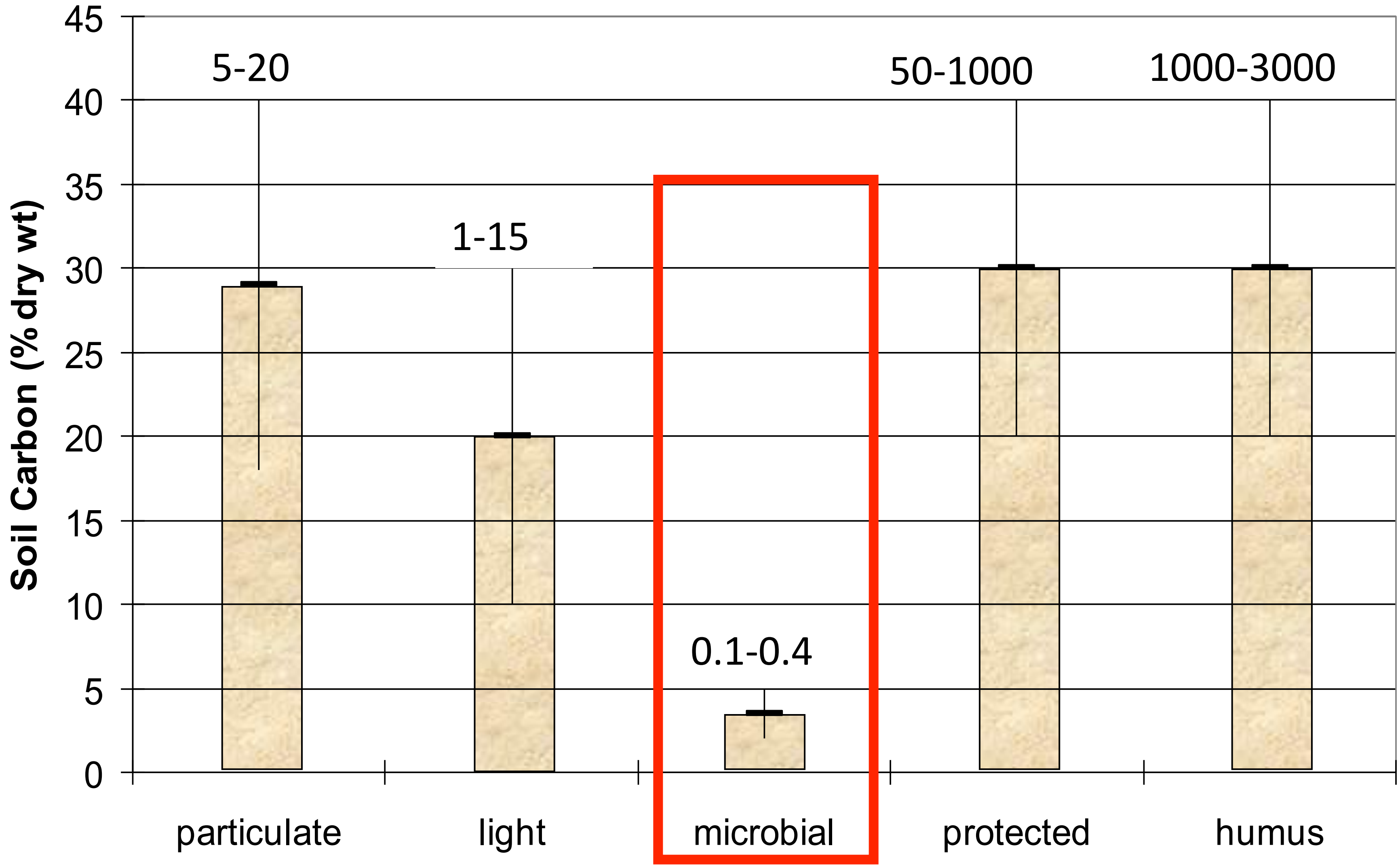


"For each sheep equivalent above the ground, the microbial biomass & activity below ground is 4 times greater"

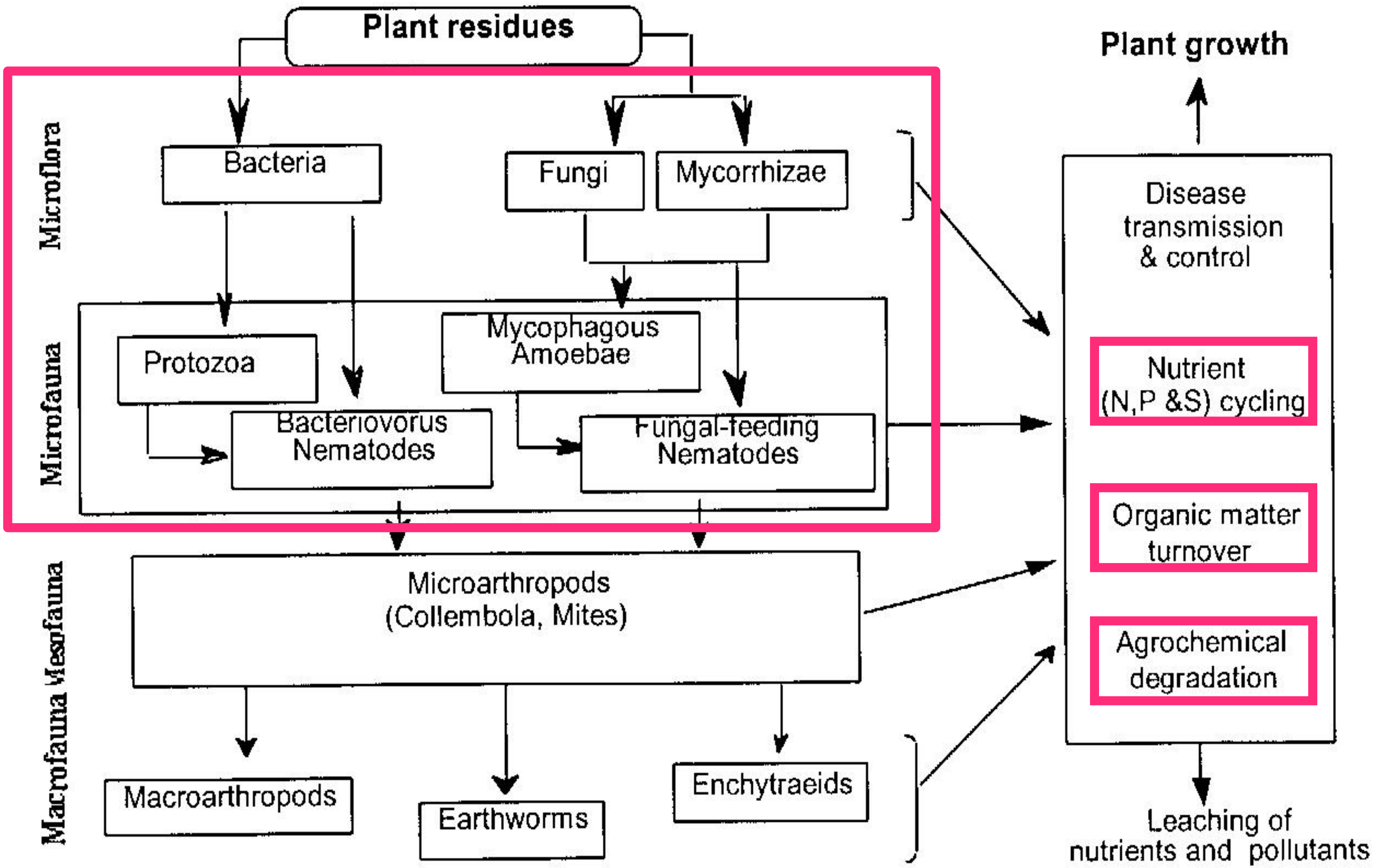
(source King 1996, Armidale region NSW)

ORGANIC CARBON POOLS IN TOPSOIL

Numerals are turnover rate of each fraction in years (Jastrow & Miller 1998)

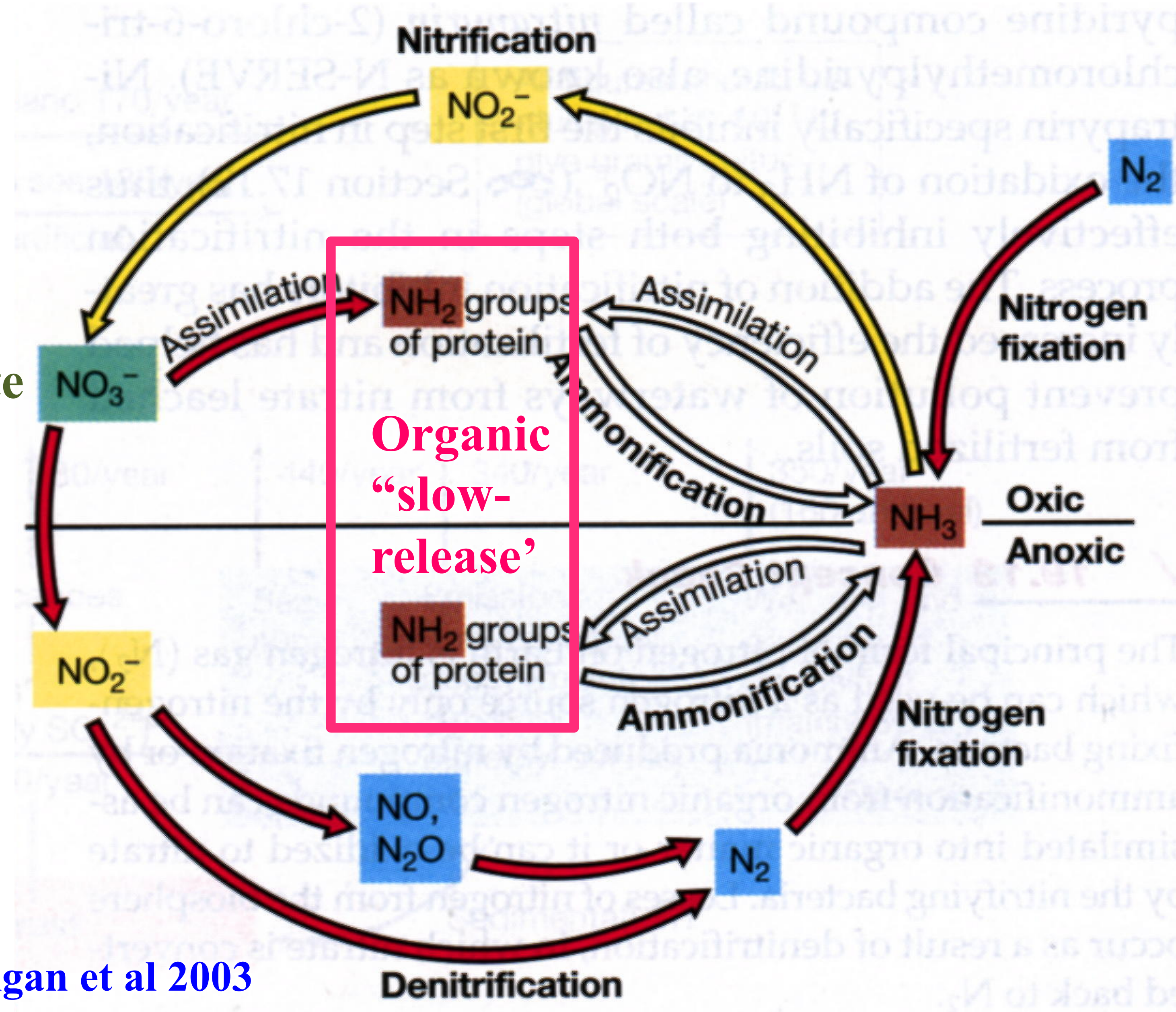


SOIL MICROBES IN NUTRIENT RECYCLING



Source: Roper and Gupta (1995) Aust J Soil Res. 33: 321-9

SOIL BACTERIA IN NITROGEN CYCLE.

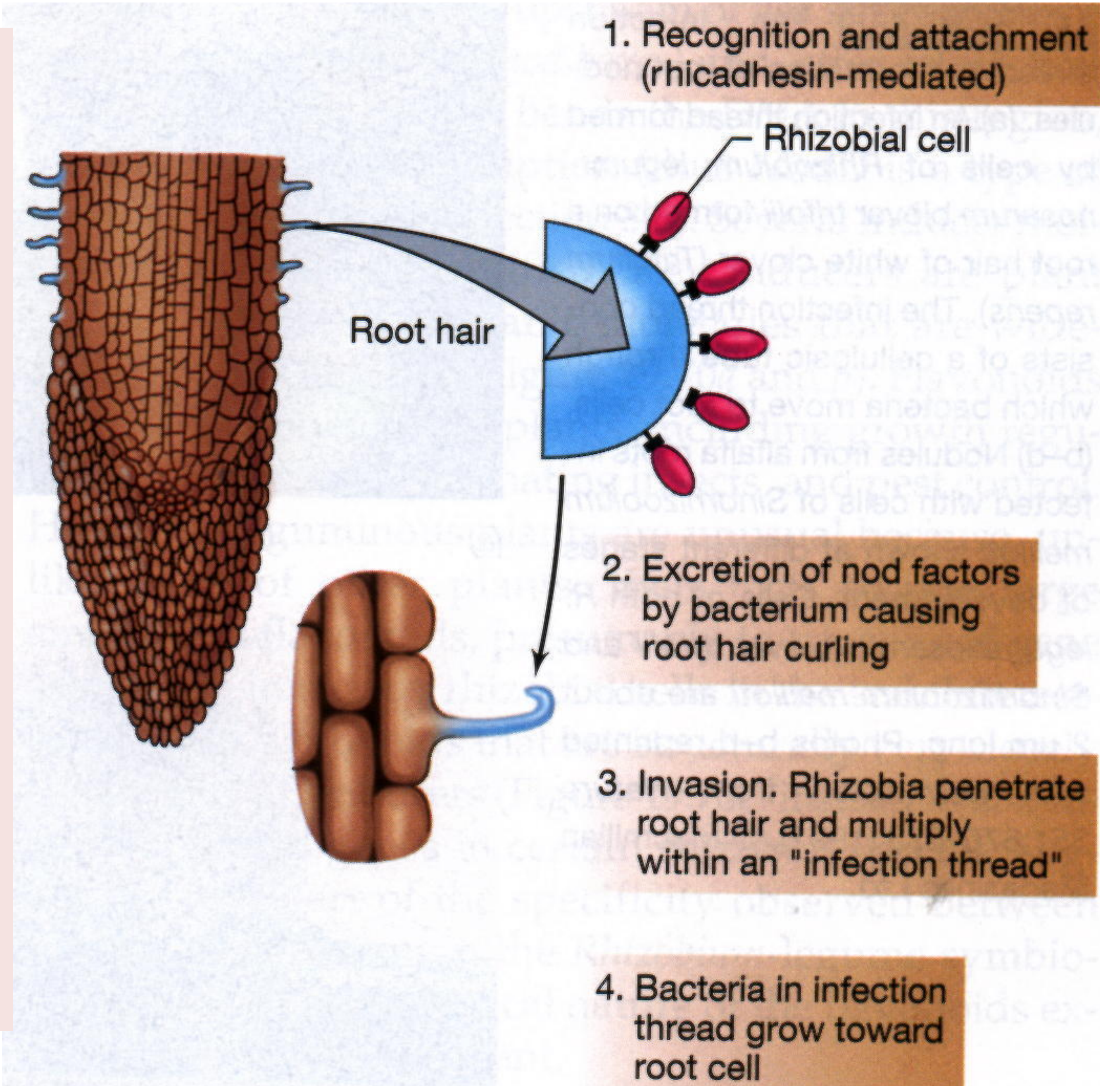


Source Madigan et al 2003

RHIZOBIUM BACTERIA, N-FIXING & LEGUME NODULES

gene-specific bacteria:plant infection (specific inoculant for each legume)

Madigan et al 2003)



MONITORING N-FIXATION IN PASTURE LEGUMES

legume nodules must be red (leghaemoglobin) to fix nitrogen

Source; Russell (1973) Soil Conditions and Plant Growth

DRY MATTER YIELD & N INPUT FROM LEGUME FOR NEXT CROP

Ley Pasture Type	Legume Dry Matter Yield 1987-88 t/ha/y	1988-89 t/ha/y	1989-90 t/ha/y	*Ave N @ 20 kg /t dry matter
Medic	6.32	5.36	3.55	102 kg
Lucerne	5.79	3.57	2.89	82 kg
Grass-legume	7.26	6.39	7.40	na

Dry matter yield data from Dalal et al 1991. * figure for N contribution (Peoples et al 2001) excludes below ground N (eg Khan et al 2003 + 37 kg/ha fababean, + 93 kg/ha chickpea).

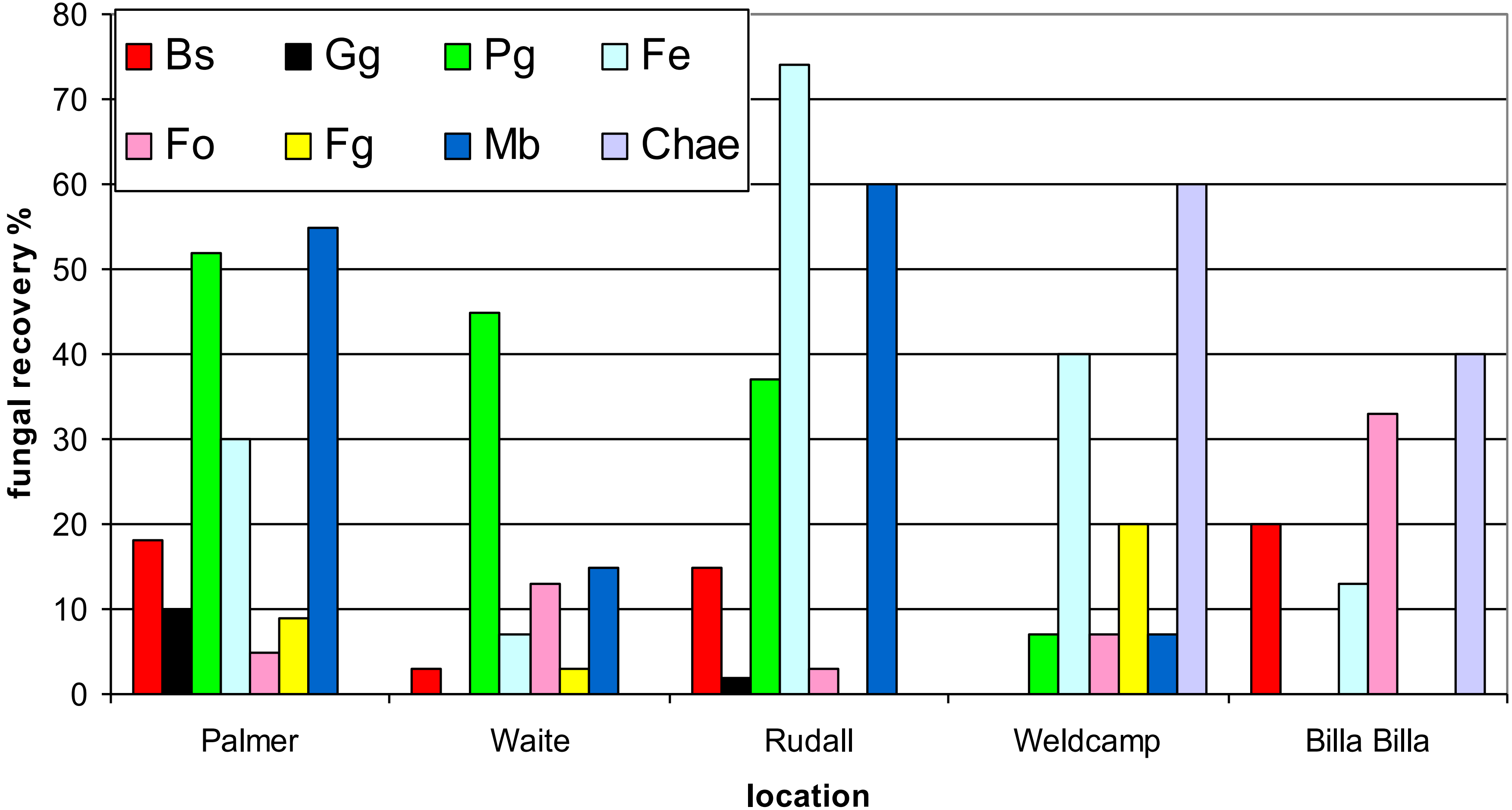
MICROBIAL INOCULANTS FOR SOIL HEALTH??

YES, for legumes (correct Rhizobium strain)

UNLIKELY, for microbial biomass:

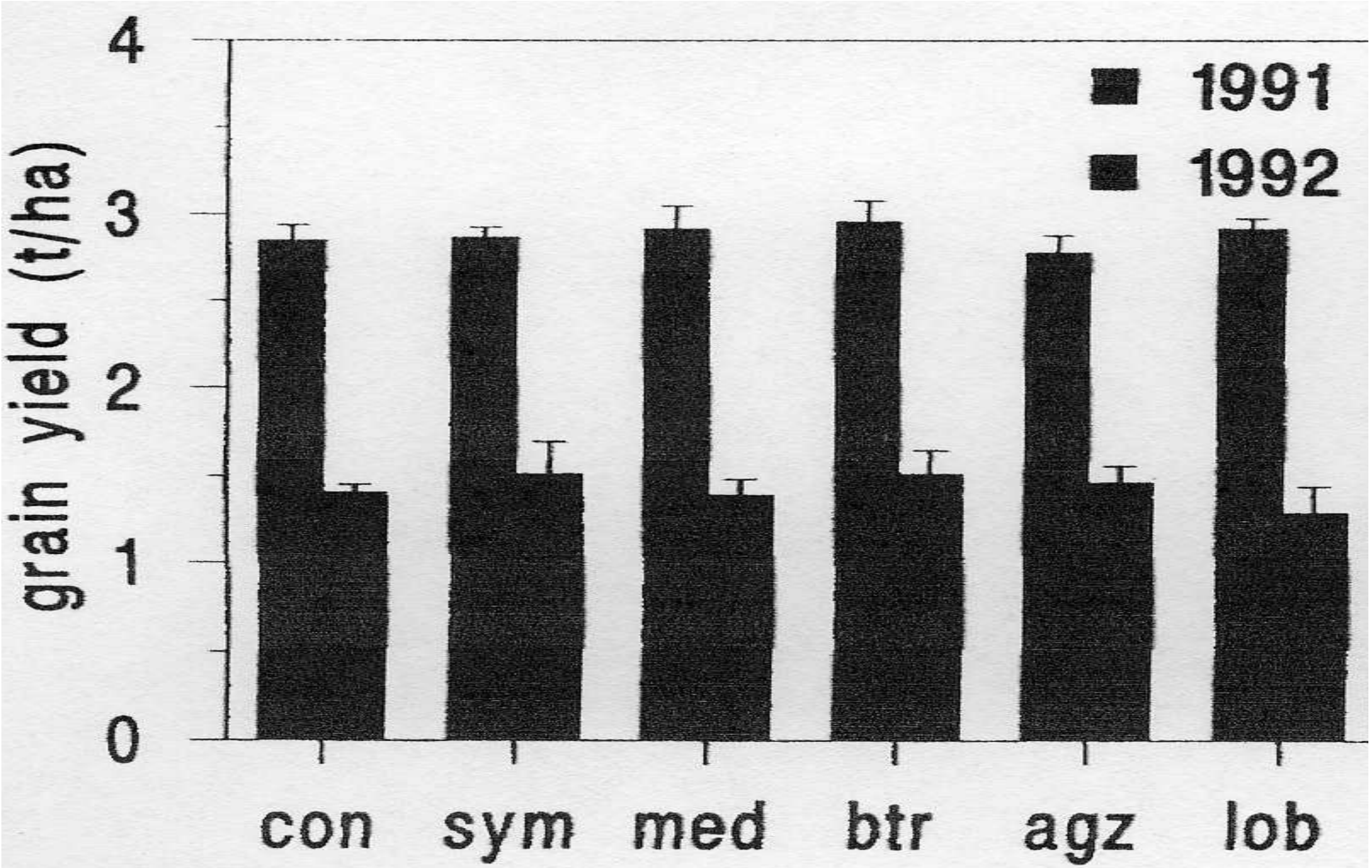
- **Quantity needed for every 0.001 mm topsoil??**
- **Strain selection for out-competing the residents?**
- **Which microbes, at what rate, at what time, where???**

FUNGAL DIVERSITY ON WHEAT ROOTS



Fungi isolated from wheat plants grown 6 weeks in soil from South Australia and Queensland: **Pittaway unpub. data**

MICROBIAL INOCULANTS & GRAIN YIELD??



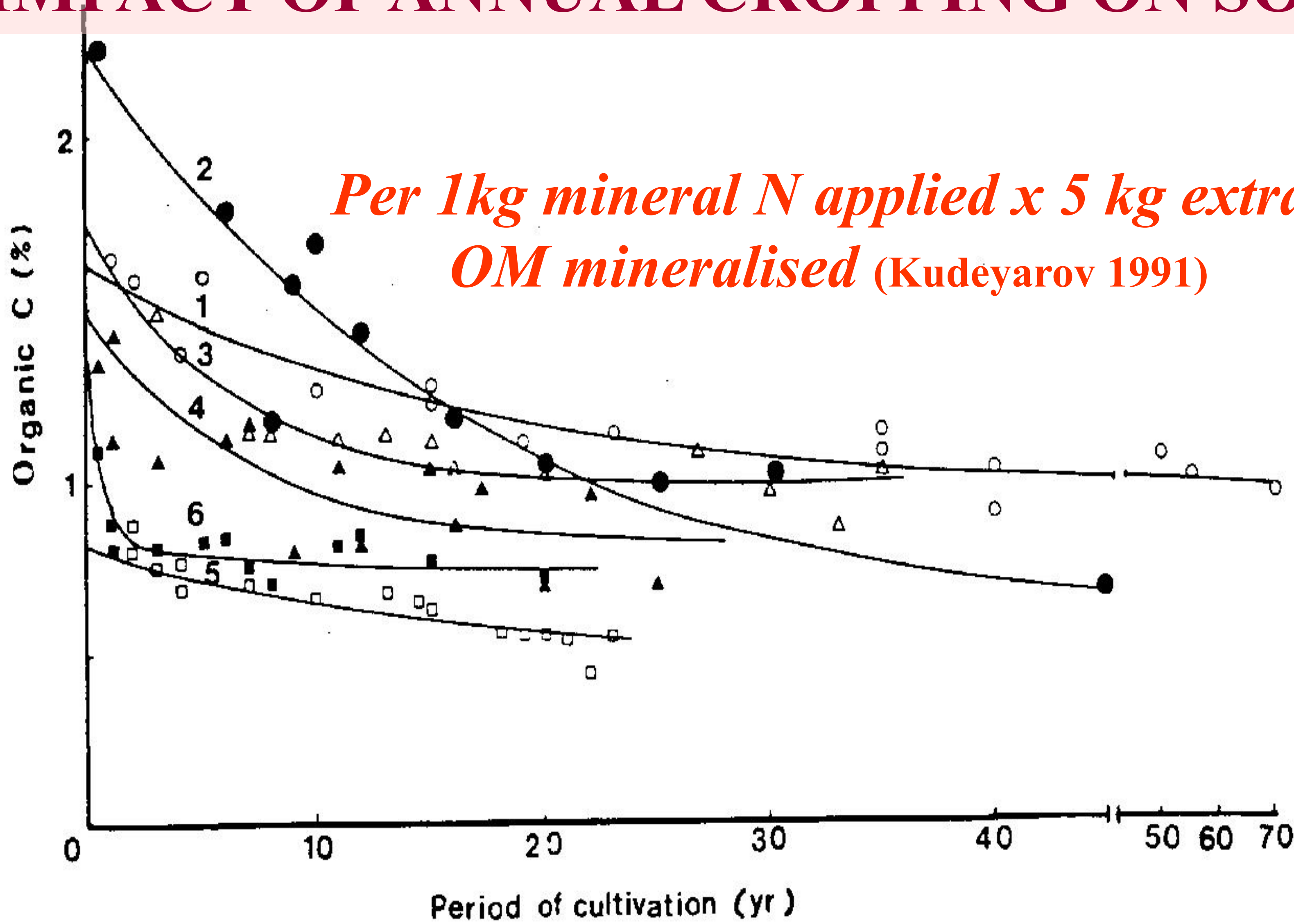
All except Medina & Agzyme have microbes, Agzyme has humic acid.

Con=control,
Symbooster \$80/L@ 10 L/ha, Medina \$22/L@ 10L/ha, BTR \$50/L@ 2L/ha, Agzyme \$75/L@ 5L/ha, Lobsa \$20/L @ 1L/ha.

Dalby & Penfold, Roseworthy SA (1995) Aus Grain

MONITORING MICROBIAL ACTIVITY (CALICO STRIP DECOMPOSITION)

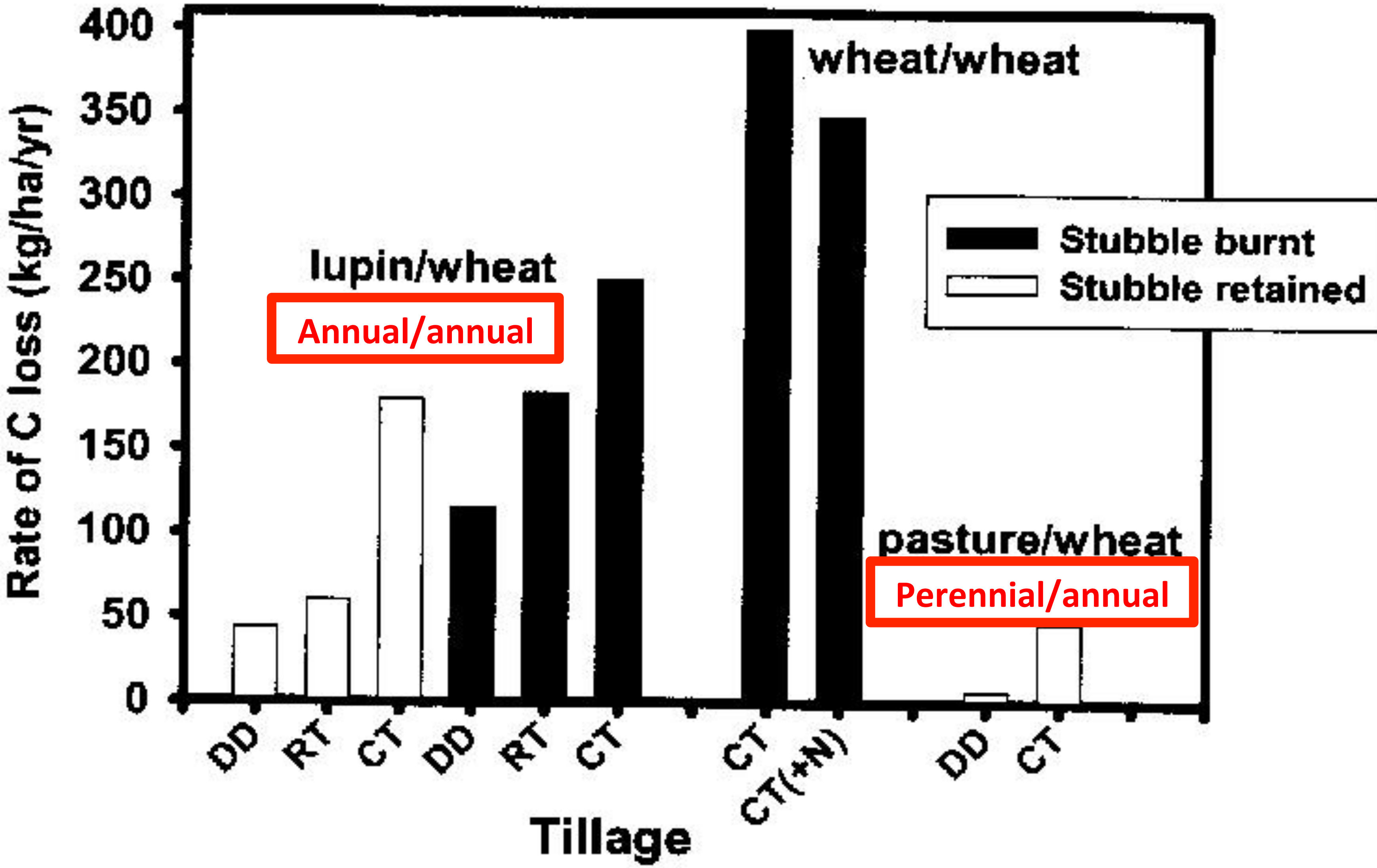
IMPACT OF ANNUAL CROPPING ON SOM



Per 1kg mineral N applied x 5 kg extra OM mineralised **(Kudeyarov 1991)**

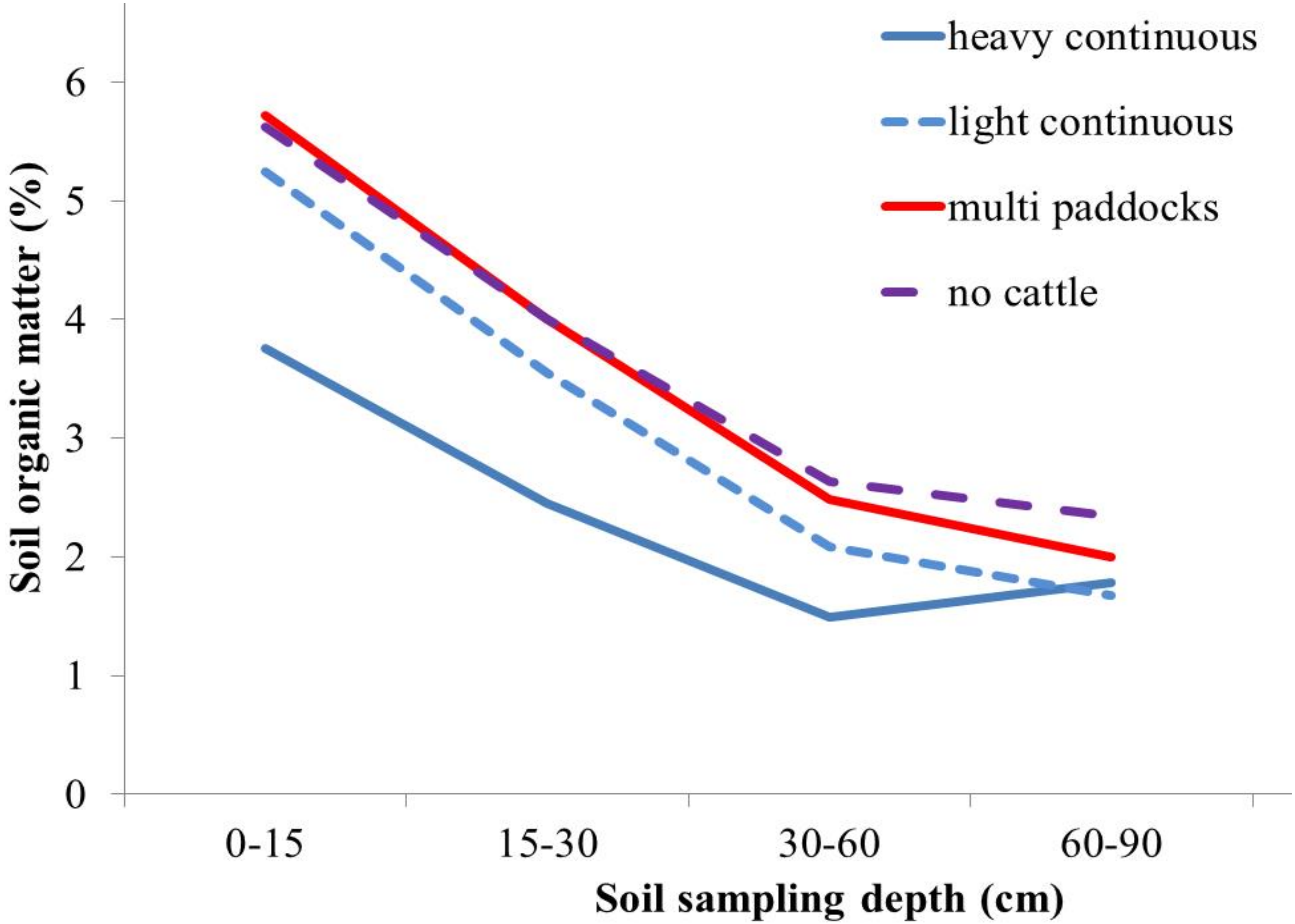
Decrease in organic C levels in cultivated soils over time 1 Waco, 2 Langlands-Logie, 3 Cecilvale, 4 Billa Billa, 5 Thallon, 6 Riverview. (Dalal & Mayer 1986).

LOSING SOM: LESSONS FROM HISTORY

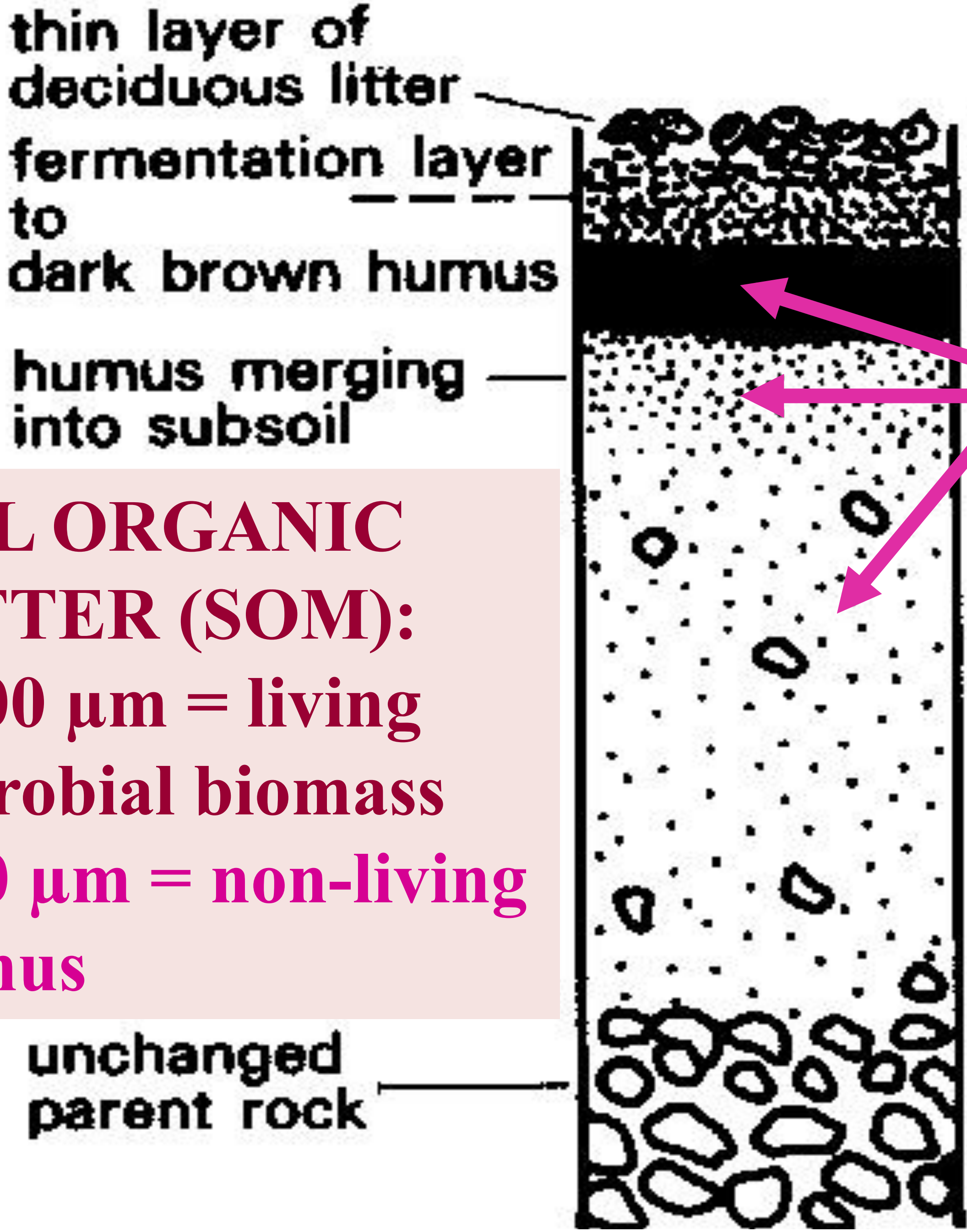


DD=direct drill, RT= reduced cultivation, CT= conventional cultivation Source: Yin Chan (2001)

IMPACT OF CONTINUOUS GRAZING ON SOM



9 Texas prairie ranches after 9 years grazing: data Teague et al. (2013)



HUMUS :

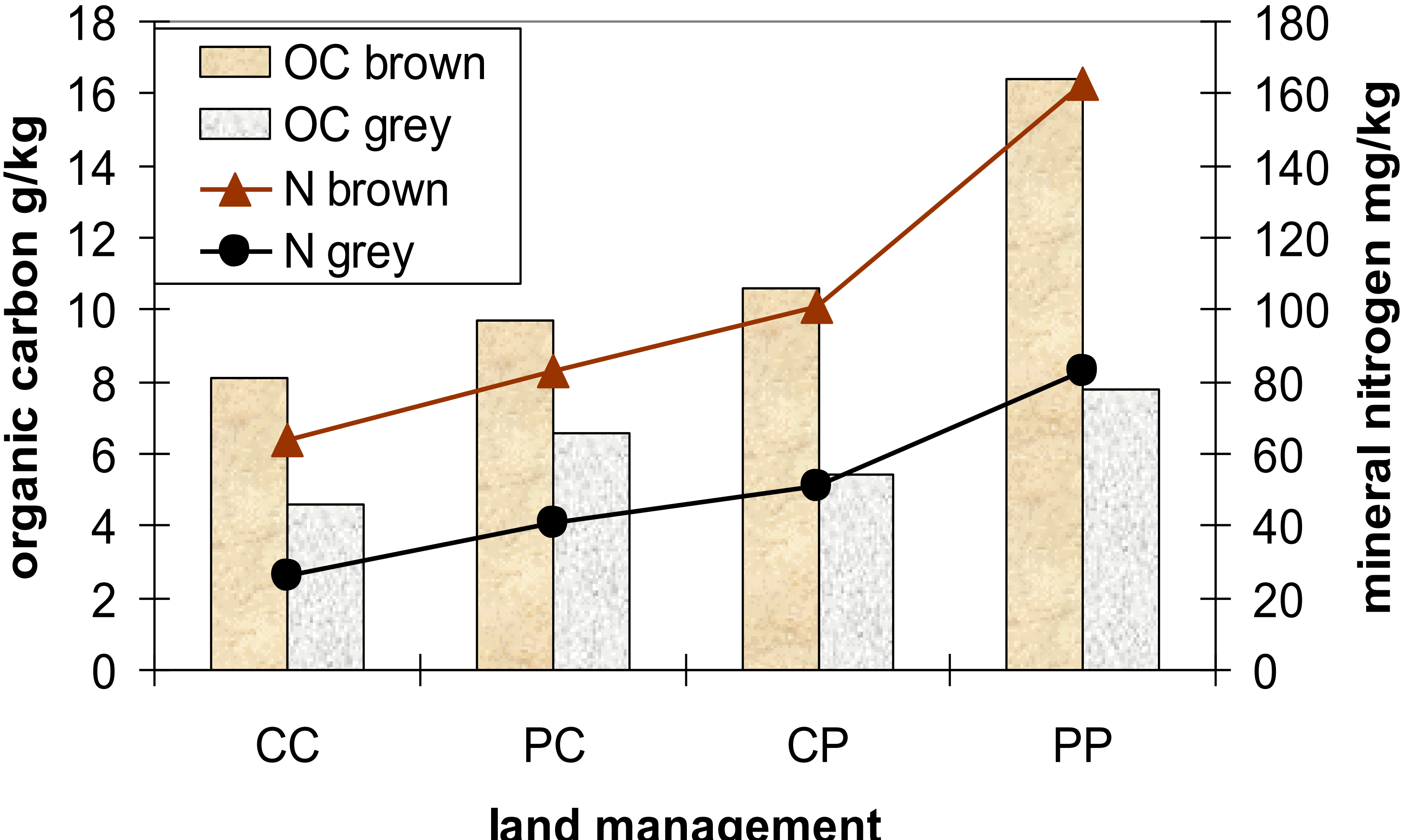
- Buffers & binds soil particles
- Nutrient exchange & water holding capacity (light soils)
- ‘Last resort’ food for microbes

SOIL ORGANIC MATTER (SOM):

- < 200 µm = living microbial biomass
- < 60 µm = non-living humus

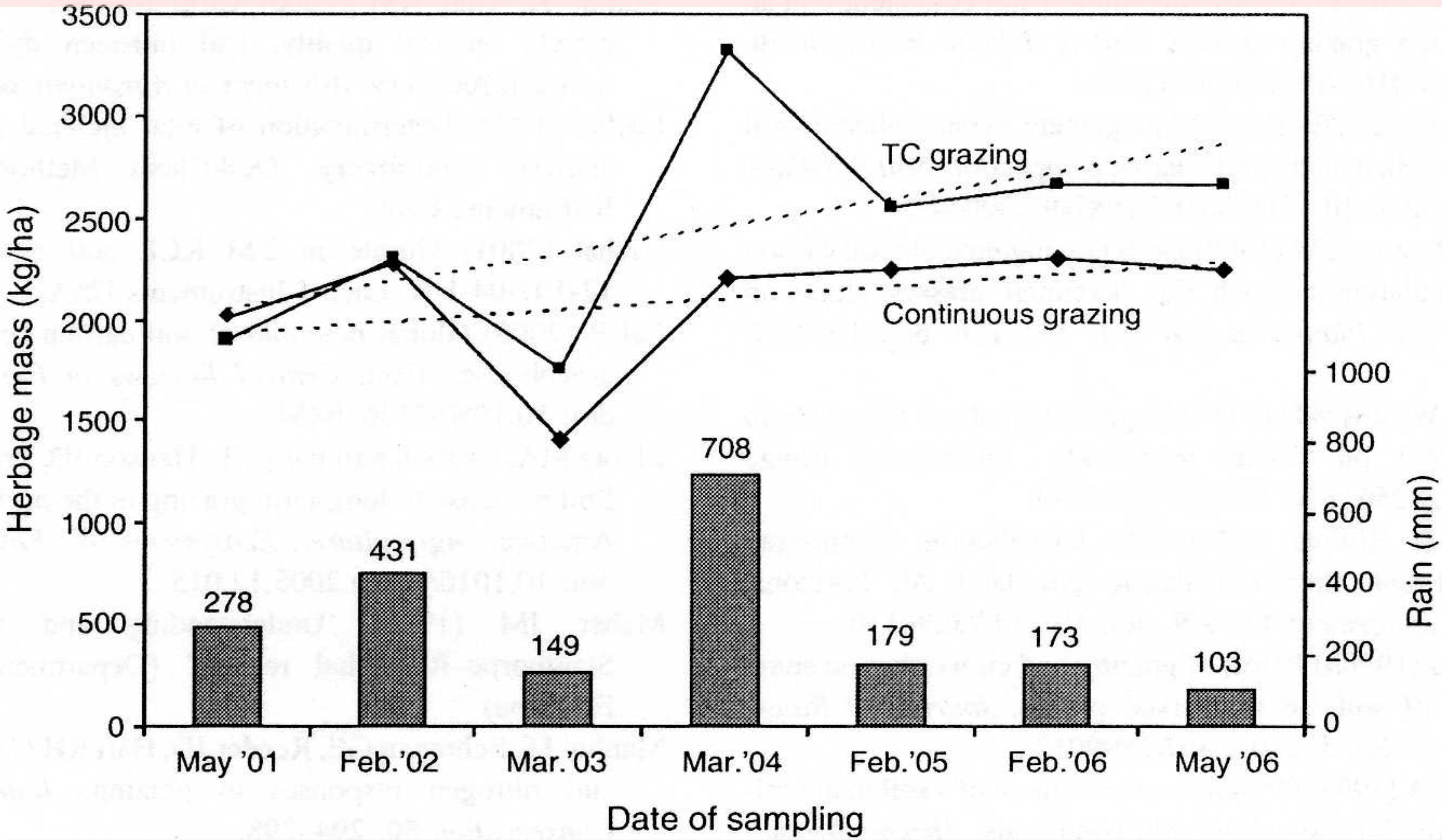
Picture Leadley Brown (1978) Ecology of Soil Organisms

REBUILDING SOM WITH FERTILISER



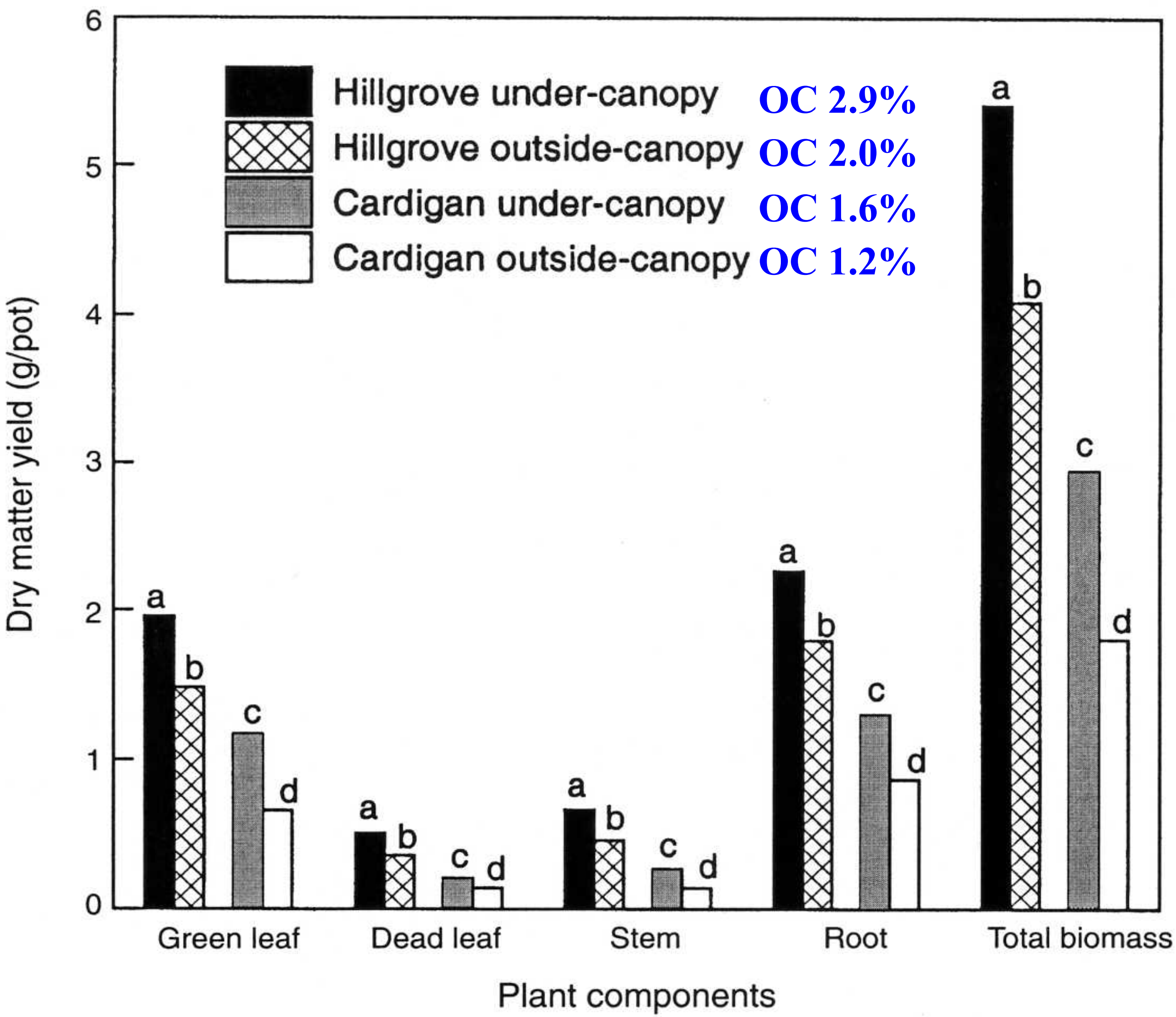
Soil fertility controls organic carbon inputs. C=crop, P=pasture. Source Yin Chan et al (1997).

REBUILDING SOM WITH SPELL GRAZING (TIME-CONTROLLED or TC)



SEQ native perennial grasses (Qld blue grass), TC 12.6 DSE with 14 day on, 101 day off, Continuous grazing 1.6 DSE/ha: Sanjari et al. (2008)

BUILDING SOM WITH SHADE TREES



Burdekin River catchment, eucalypt woodland, native pasture black spear grass, golden beard grass.

Jackson & Ash (2001)

BUILDING SOM WITH PASTURE CROPPING

Wheat crop (WINTER-ACTIVE) into redgrass-dominant pasture (SUMMER-ACTIVE) : Cluff 2003

SPELLING DRYLAND PASTURE OVER DRY WINTER USING WETLAND GRASSES

SUSTAINABLE GRAZING & SOIL HEALTH