Scientific rationale for adopting practices to support optimum soil biodiversity and health

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Dairy Australia

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Acknowledgements

Dr Sasha Jenkins

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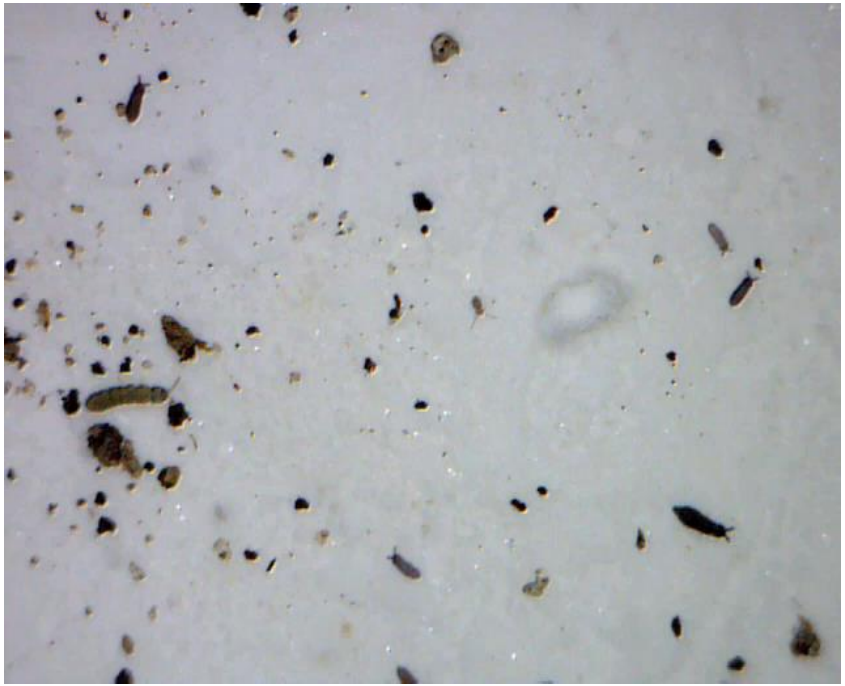
Overview



- Communities of soil organisms provide the backbone of healthy soils
- The abundance, diversity and functional attributes of soil organisms are tied to underlying soil characteristics
- Structural complexity of organic resources in soil creates habitat heterogeneity
- **Healthy soil supports resilience of farming systems via effective soil function**

Characteristics of healthy soil

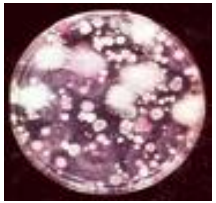
Significance of **soil biodiversity**

Significance of **plant diversity**

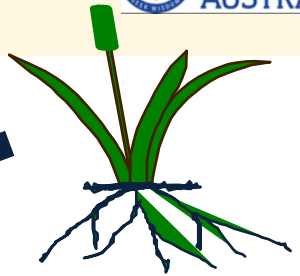
Significance of **local soil type**

Significance of land management (= disturbance)

Significance of soil biodiversity





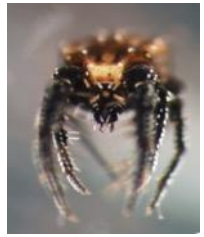



Plant residues / Organic matter

Bacteria

Fungi

Plant symbionts and pathogens



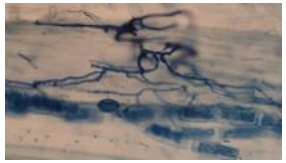
Bacterial feeding Protozoa

Fungal feeding Protozoa

Bacterivorous Nematodes

Fungivorous Nematodes

Plant parasitic Nematodes



Predatory Nematodes

Microarthropods (Collembola, Mites)

Earthworms etc

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After Poster by van Vliet and Gupta

Significance of soil biodiversity

nutrient transformations

nutrient cycling

symbiotic / non-symbiotic nitrogen fixation

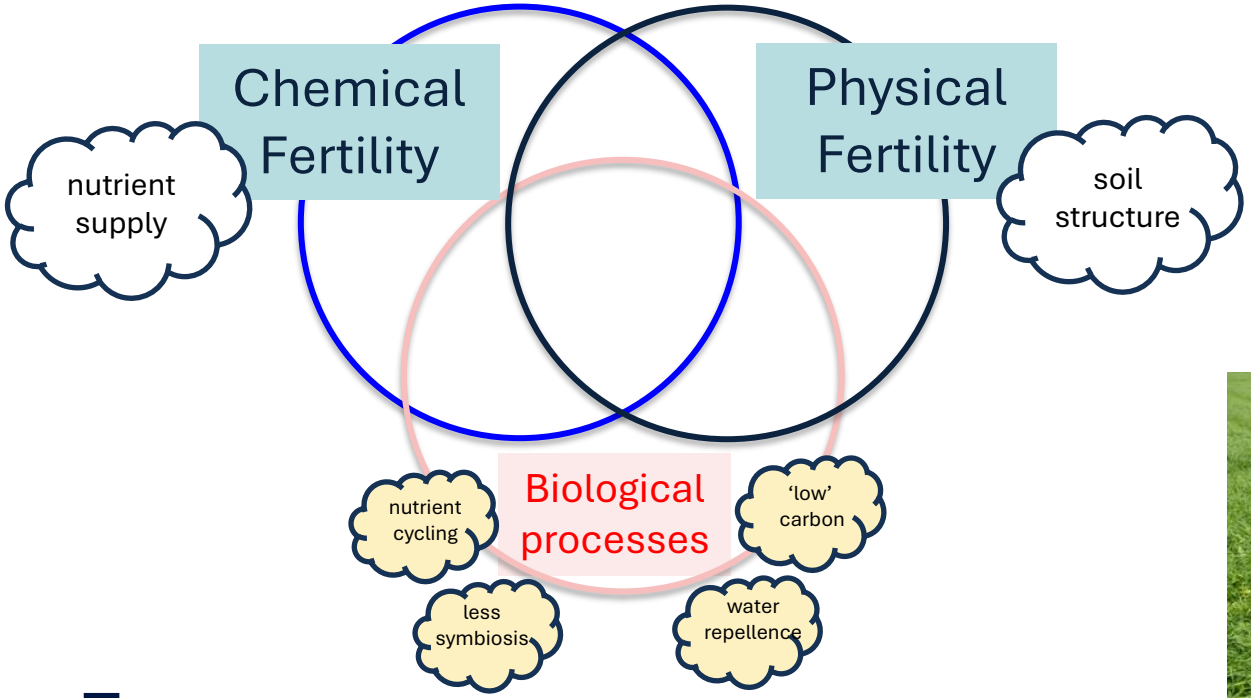
plant disease / plant disease suppression

arbuscular mycorrhizal function

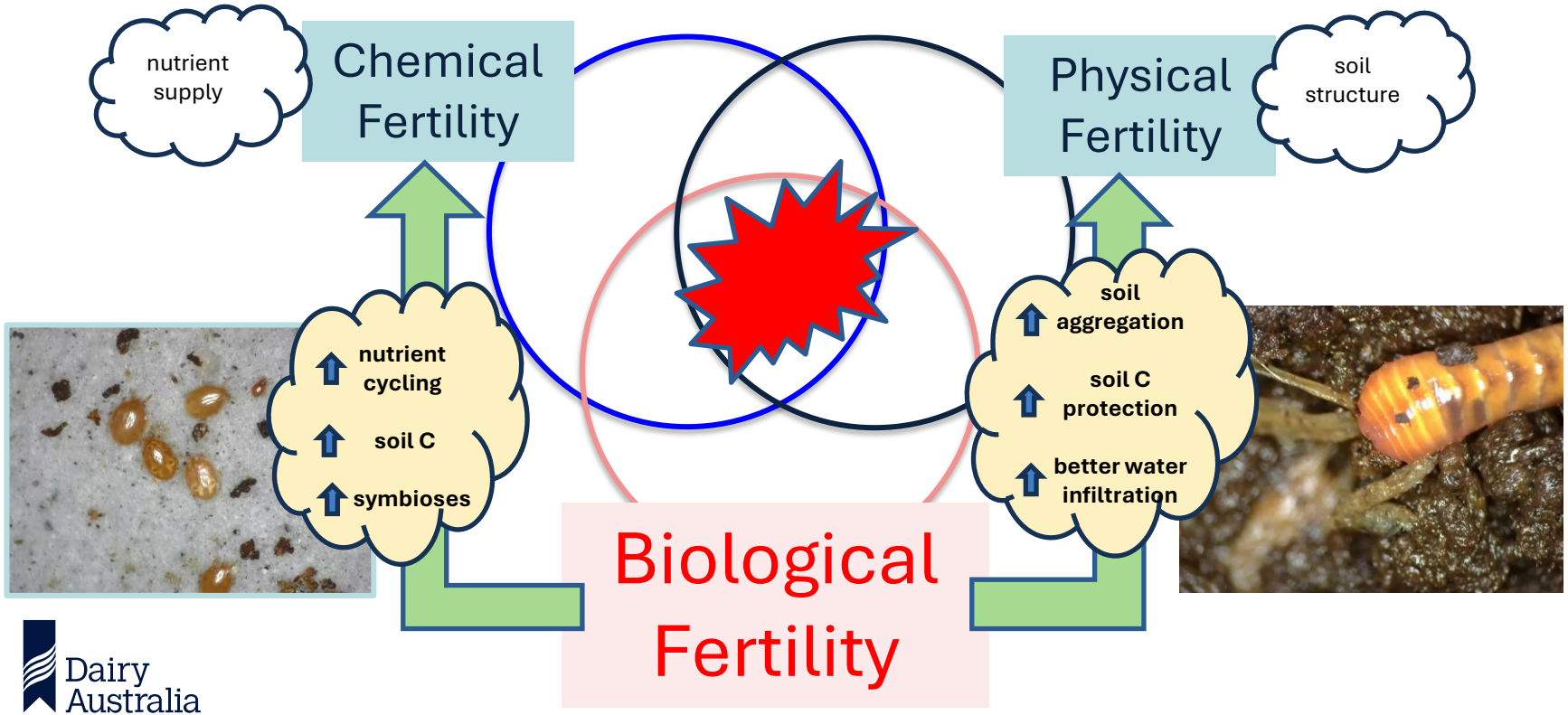
soil structure (soil aggregation)

water repellence / infiltration

Significance of soil biodiversity



Significance of soil biodiversity



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Significance of plant biodiversity

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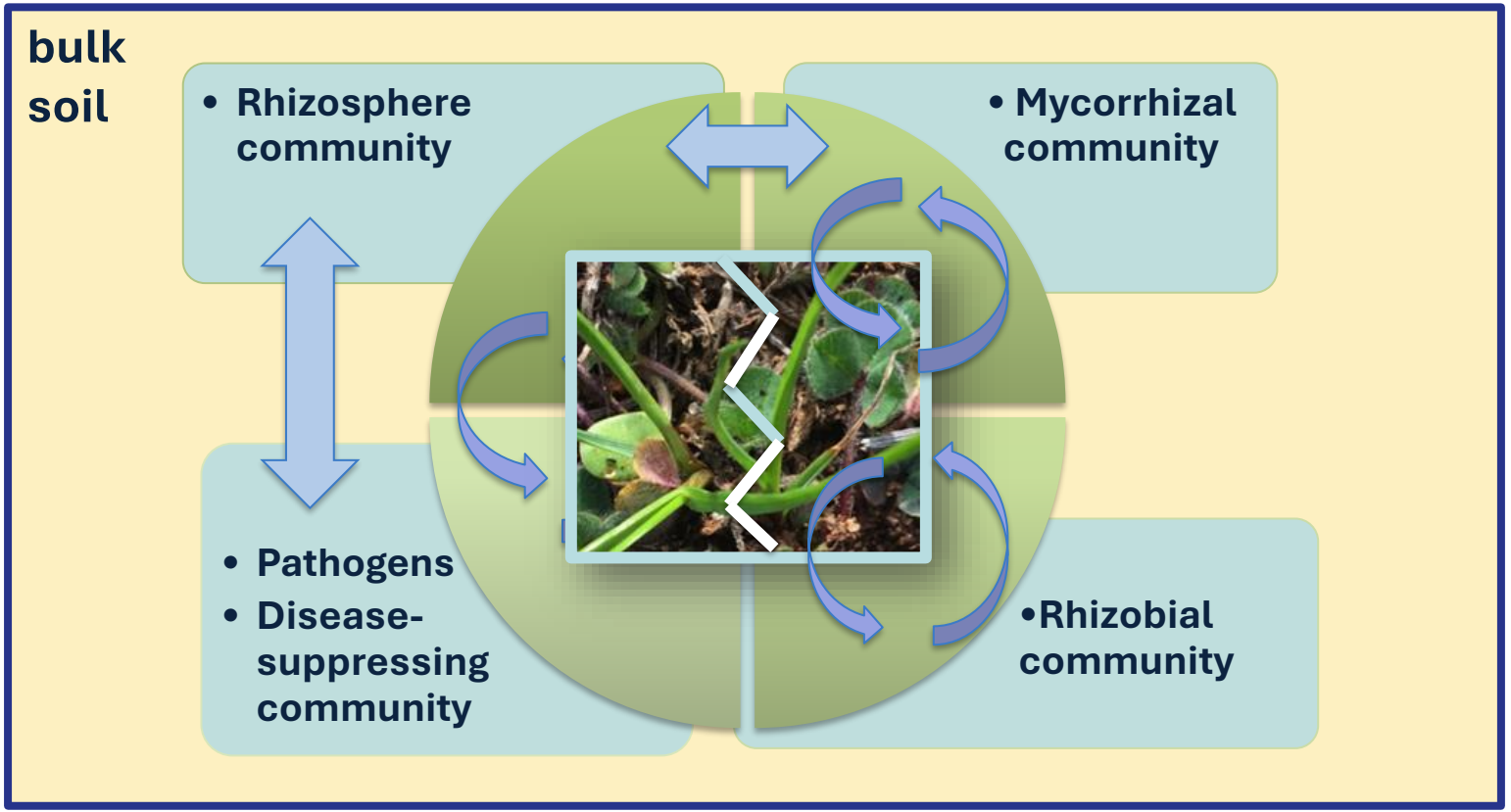
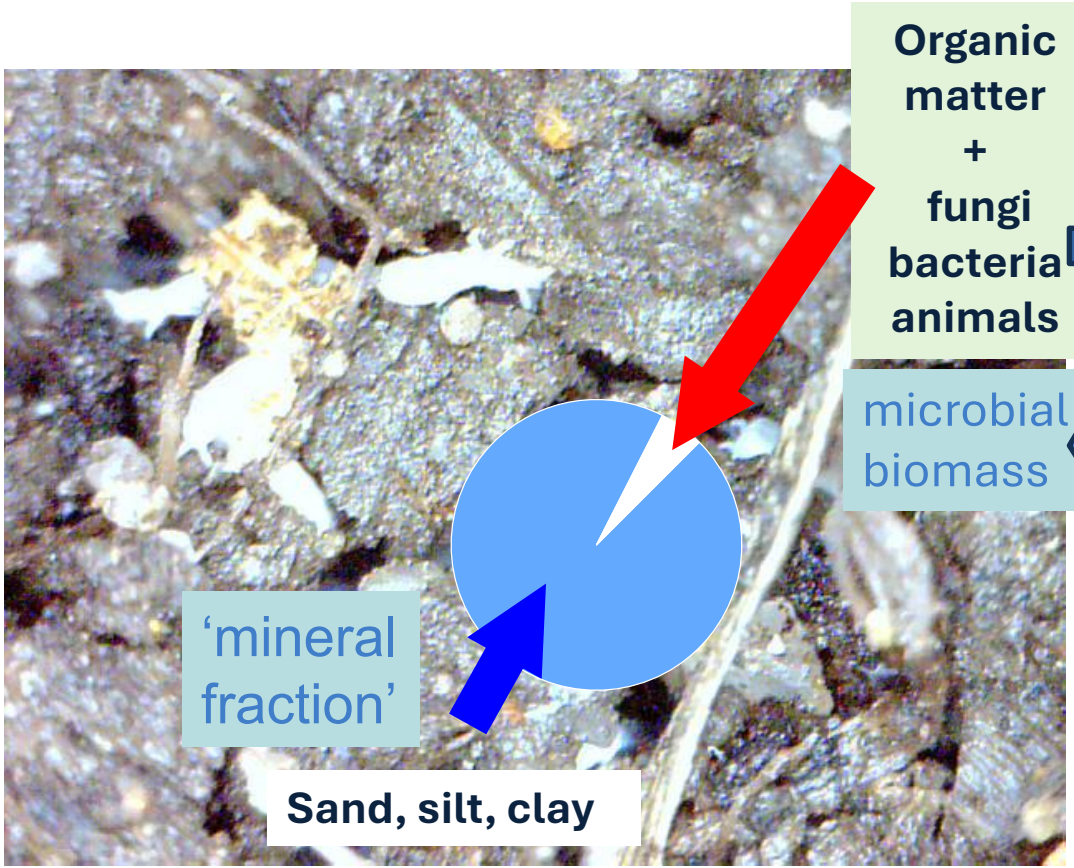
Significance of plant biodiversity



Significance of plant biodiversity



Diverse C inputs

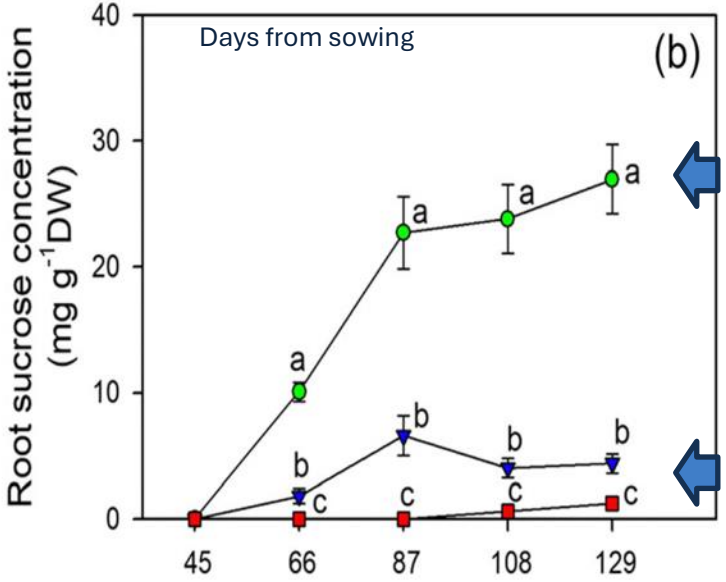
- soil residues
- biological amendments

C retention

- soil type
- protection of C
- soil disturbance (land management practices)

Significance of plant biodiversity

Impacts of grazing (root exudates)



No grazing

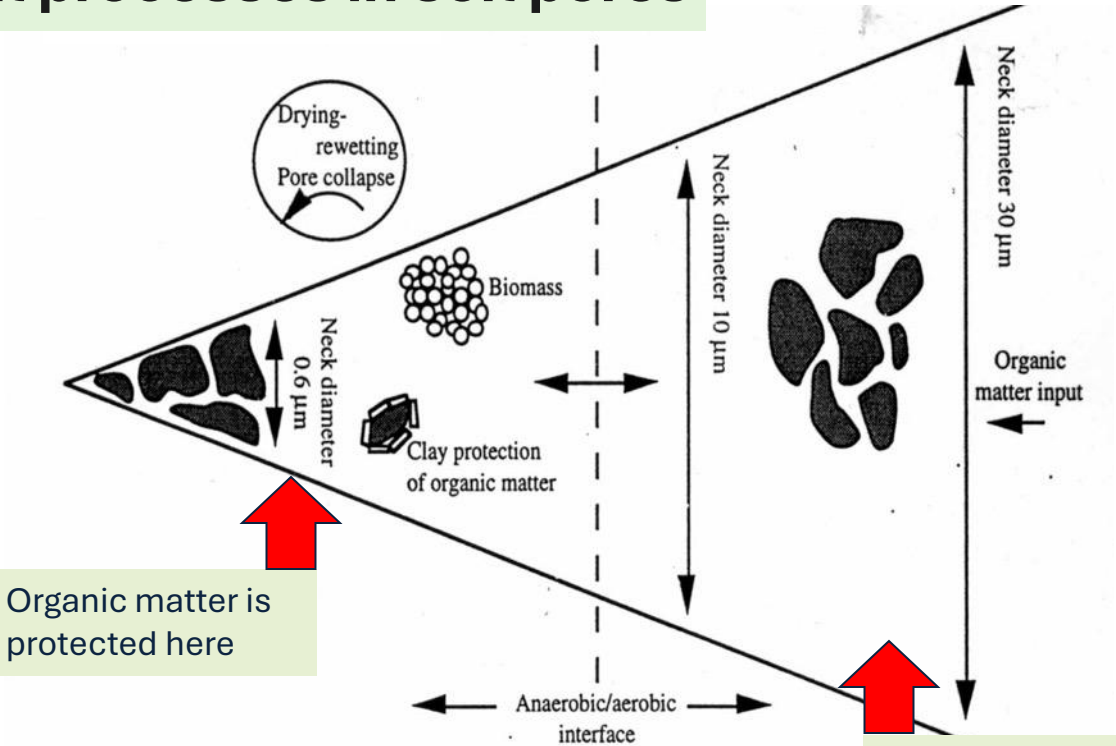
Heavy grazing

Fan et al. (2019)

Significance of local soil type

Significance of local soil type

Microbial processes in soil pores



Strong et al. (1998)

Organic matter is protected here

Organic matter breaks down here and releases nutrients

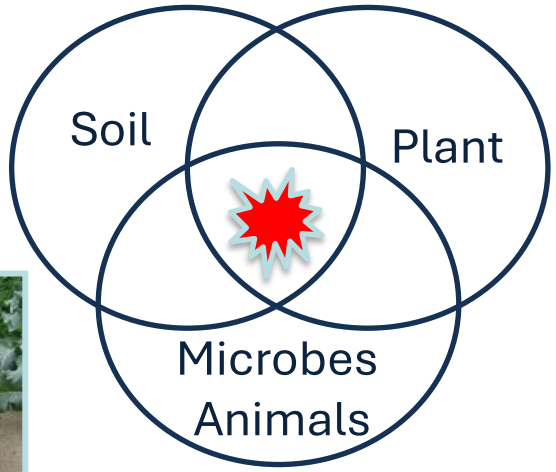
Significance of local soil type

Soil (type) diversity

Plant diversity

Microbial/animal diversity

Interactions



+ interactions with soil amendments

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Significance of land management

= disturbance

Effects of disturbance related to **soil management**
e.g. tillage, deep ripping

Effects of disturbance related to **plant diversity**
e.g. mixed plant species, rotations

Effects of disturbance related to **soil amendments**
e.g. fertilisers and organic inputs

Effects of disturbance related to soil and plant management

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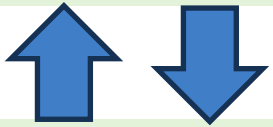
Impacts on habitat of soil organisms



Impacts on soil biodiversity

Impacts depend on soil type

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Effects of disturbance related to soil and plant management

Effects on soil biodiversity

Soil type

hypothesis

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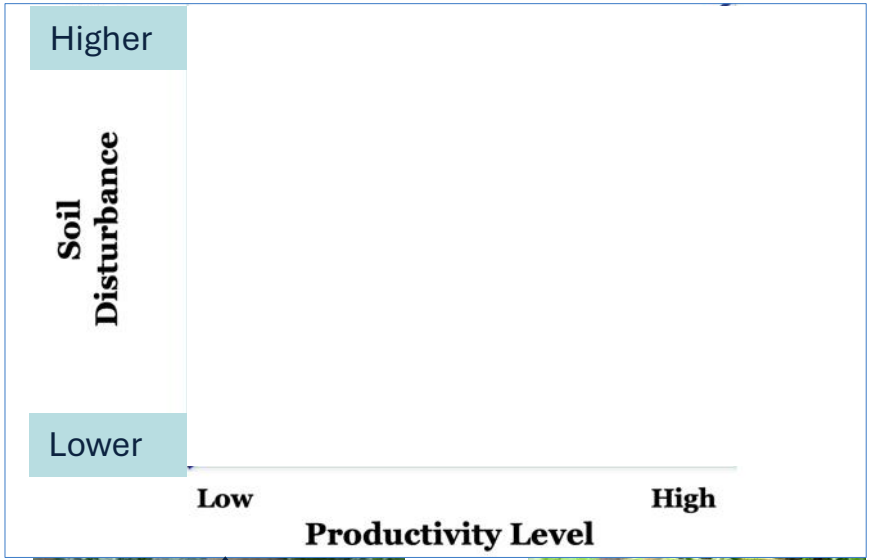
Adapted from (Huston, 1979, 1994) **Dynamic Equilibrium Model**

Effects of disturbance related to soil and plant management

Effects on soil biodiversity

hypothesis



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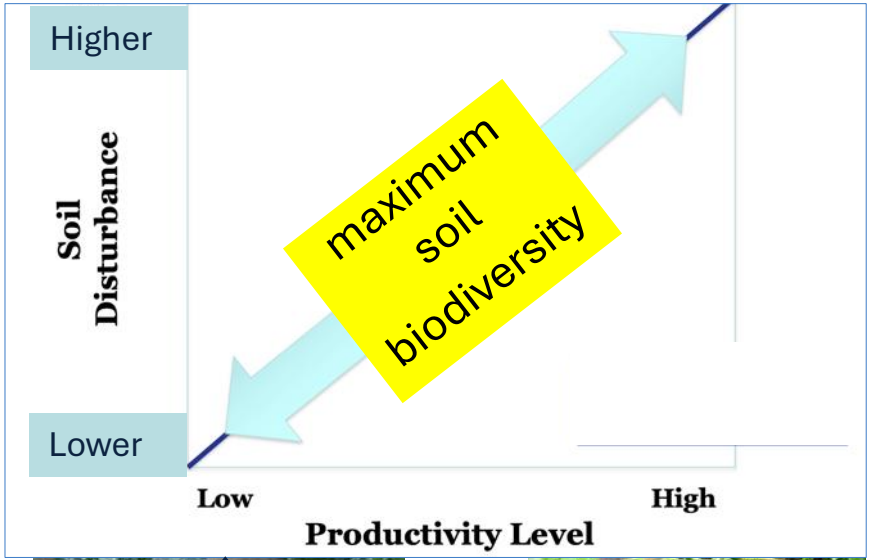
Effects of disturbance related to soil and plant management

Effects on soil biodiversity

hypothesis

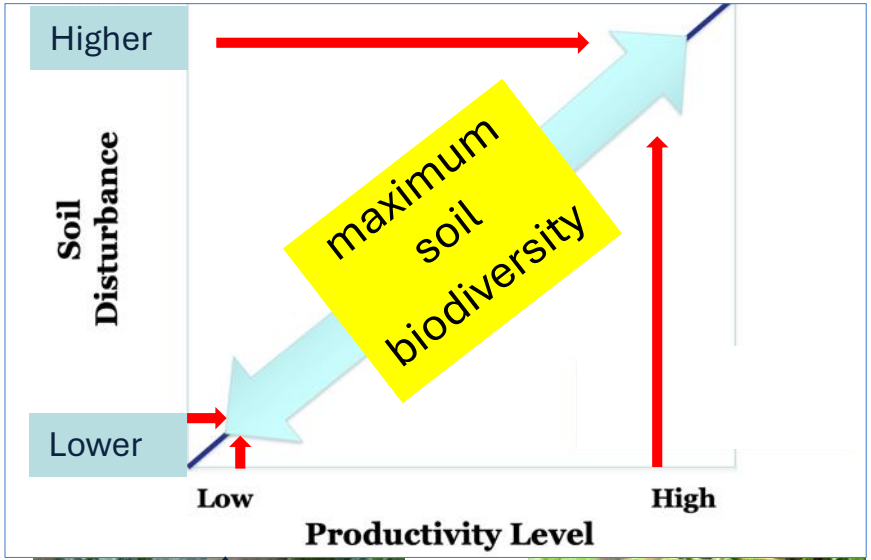


Adapted from (Huston, 1979, 1994) **Dynamic Equilibrium Model**

Effects of disturbance related to soil and plant management

e.g. **more** disturbance

e.g. **less** disturbance



Adapted from (Huston, 1979, 1994) **Dynamic Equilibrium Model**

Effects of disturbance related to soil amendments

Fertilisers

Lime

Humates / biochar etc

Manures / composts

Compost teas / biological extracts

Microbial inoculants

Impacts on soil constraints

Impacts on soil biological processes

Effects of disturbance related to soil amendments

Impacts on biological processes

Change **nutrient supply** to plants

Change **plant physiology**

Change **soil structure** and water movement

Chemical interactions (e.g. changes in **soil pH**)

Biological impacts (e.g.)

- Nutrient cycling
- Disease suppression
- Symbioses (rhizobia, mycorrhizas)

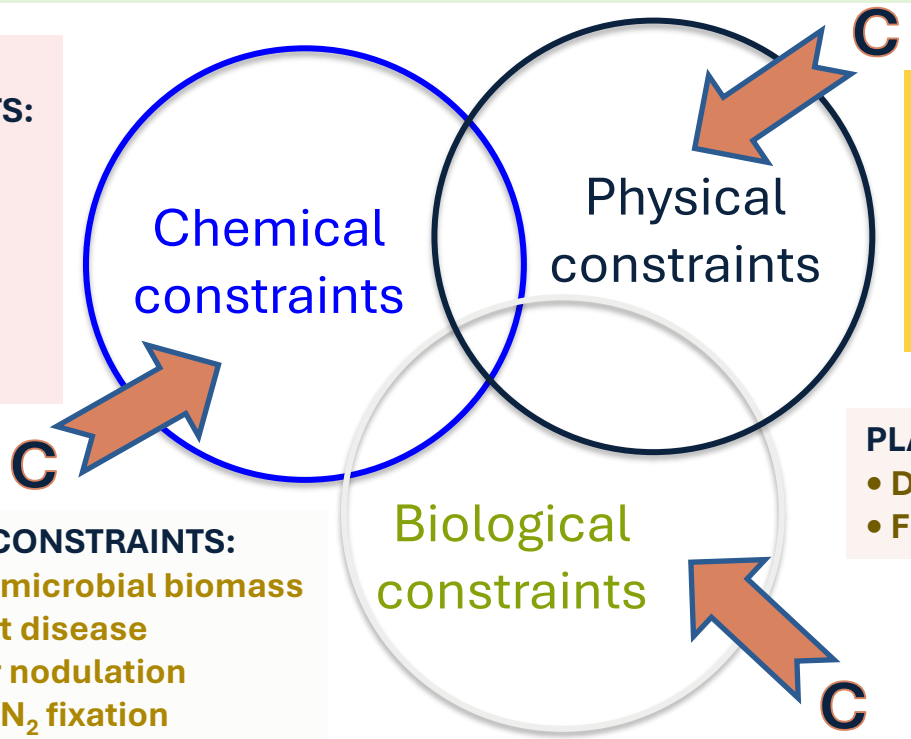
See GRDC website for

"Biological amendments for the Australian grains industry: summary review and framework" Macdonald et al. 2018

https://publications.csiro.au/rpr/pub?pid=csiro:EP184635

Overcoming soil constraints

Impacts of biological amendments on soil constraints



CHEMICAL CONSTRAINTS:
- Salinity
- Low C
- Low N
- Low pH
- High pH
- Low CEC

PHYSICAL CONSTRAINTS:
- Erosion
- Water retention
- Water infiltration
- Soil aggregation
- Compaction

PLANT CONSTRAINTS:
- Drought (seasonal)
- Frost

SOIL CONSTRAINTS:
- Low microbial biomass
- Plant disease
- Poor nodulation
- Low N_2 fixation
- Low levels of AM fungi

* Multiple impacts also likely

Review:
Abbott et al. (2018)

Overcoming soil constraints

Underlying mechanisms involved

- Humates / biochar etc
- Manures / composts /biosolids / effluents
- Compost teas / biological extracts
- Microbial inoculants

Direct effects:

influence nutrient availability
influence microbial function
influence soil structure

Indirect effects:

influence nutrient availability
influence microbial function
influence soil structure

Short term effects:

Long term effects:

Review:
Abbott et al. (2018)

*** Extensive variation within amendment categories**

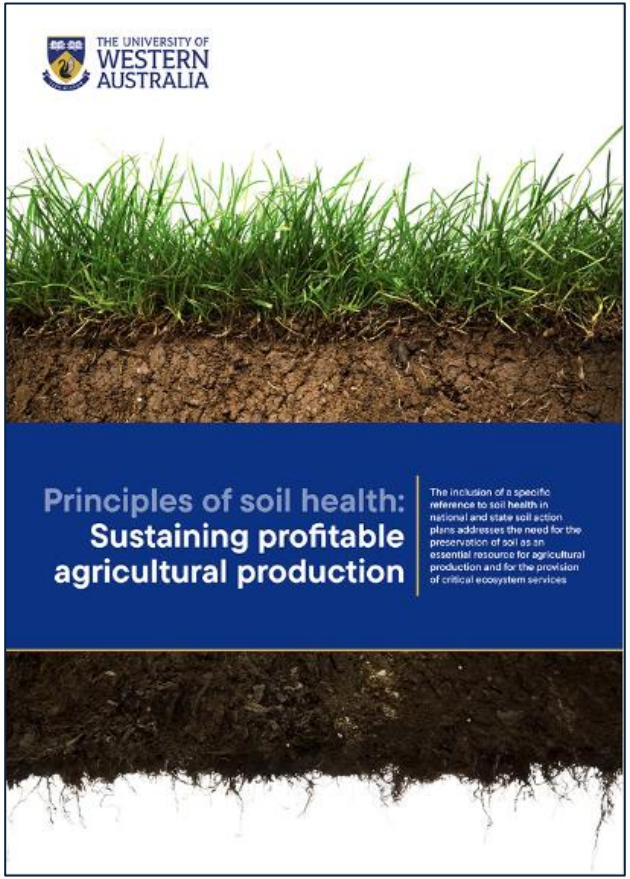
Science underpinning soil health

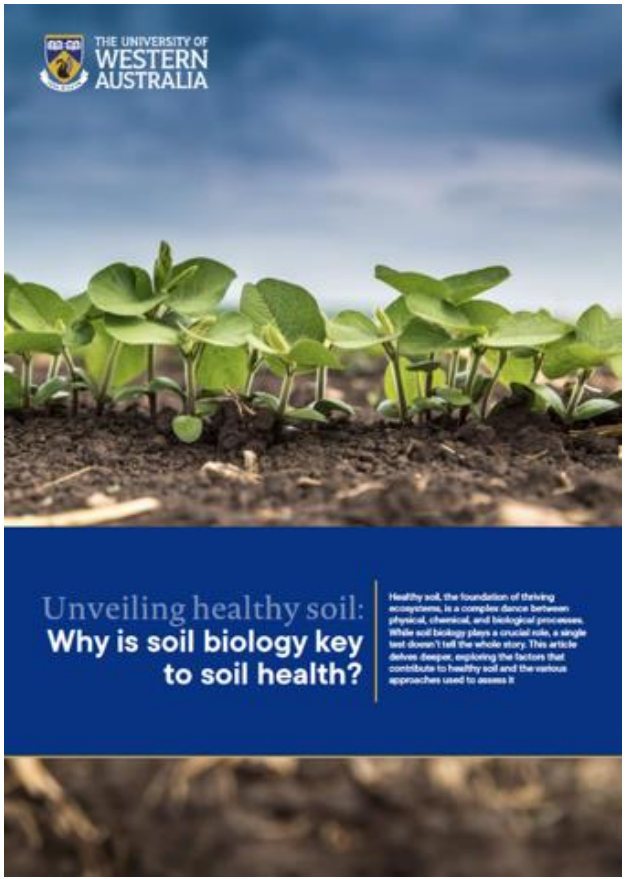
Management based on soil chemical fertility	Management based on soil biological fertility
Nutrients need to be replaced	
Nutrients are supplied rapidly	
Some biological processes can be overridden	

Science underpinning soil health

Management based on soil chemical fertility	Management based on soil biological fertility
Nutrients need to be replaced	Nutrients need to be replaced
Nutrients are supplied rapidly	Nutrients are supplied gradually
Some biological processes can be overridden	**Biological processes establish gradually**
	Potential for greater resilience

Science underpinning soil health





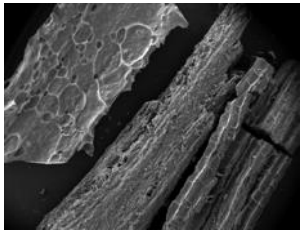
Science underpinning soil health

Land management (e.g.):

- plant (species) / rotations
- grazing / plant cover

Inputs (e.g.):

- organic matter (residues)
- root exudates
- humic substances
- manures / biochar
- inoculants
- fertilisers



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- manures / biochar
- inoculants
- fertilisers

System resilience:

- builds over time **based on** soil biological processes

via

- influences on nutrient supply
- influences on plant physiology
- influences on soil structure (e.g. soil aggregation)

Costs vs benefits spread over time

Science underpinning soil health

Maintain plant diversity and
use fertilisers and other amendments
to complement (**not override**)
beneficial soil biological processes
to whatever extent is locally possible

References

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van Vliet P and Gupta VVSR (based on Poster, CSIRO)