Managing soil biology and feed in dry times

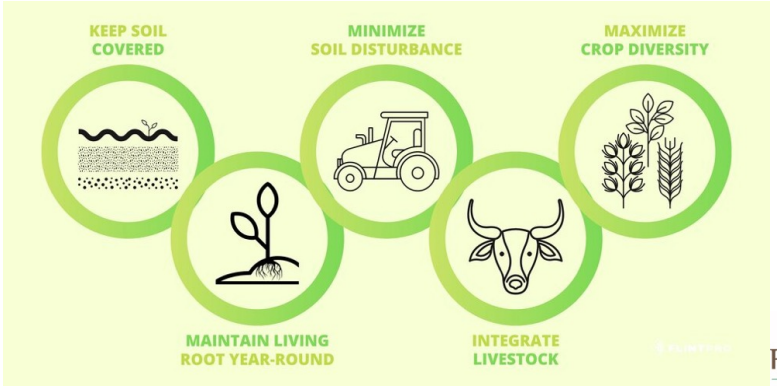
Ruby Hall & Kardella South

Declan McDonald
Principal Soil Scientist

REGEN SOILS
Bringing soils back to life

1

Principles of regenerative farming



REGEN SOILS
Bringing soils back to life

2

Soil health means …

- Regenerating soils
- Bringing nature back into production systems
- Using our powerful tools more strategically
- Tuning the engine (feeding the soil!)
- Reducing costs
- Increasing profit
- Reducing risk
- Reducing stress

REGEN SOILS
Bringing soils back to life

3

How do plants grow?

REGEN SOILS
Bringing soils back to life

4

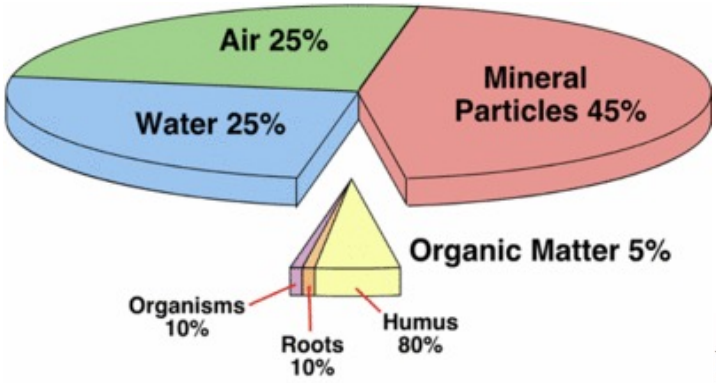
How do plants grow?

The same way they have done since before the dinosaurs

REGEN SOILS
Bringing soils back to life

5

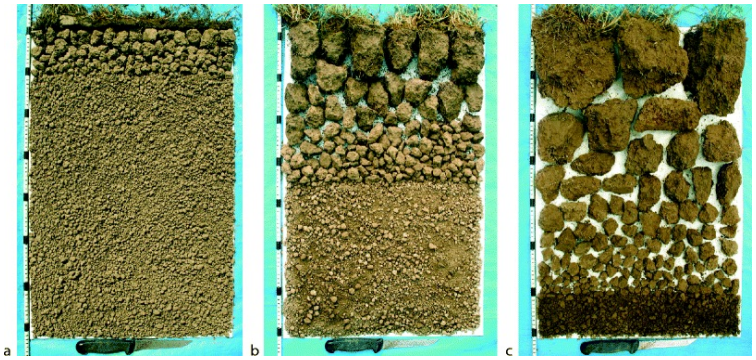
What is the secret to healthy soil and pasture?



REGEN SOILS
Bringing soils back to life

6

Soil structure – aeration and drainage



From VSA (Shepherd, 2008)

REGEN SOILS
Bringing soils back to life

7

Structure vs yield – pushing the proverbial uphill

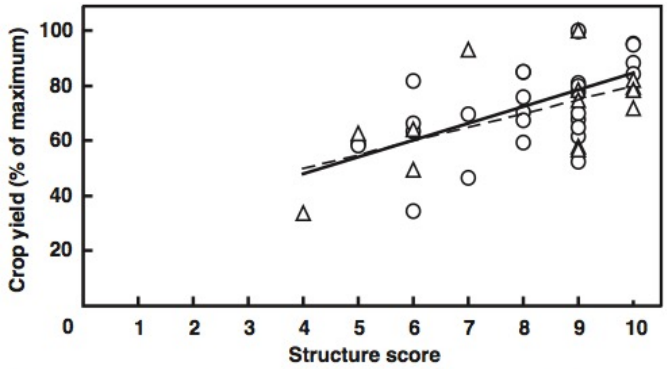


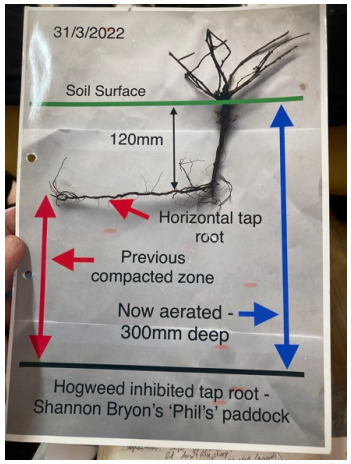
Figure 1. Relationship between crop yield and soil structure score on dermosols and ferrosols. ○ Ferrosol potatoes; △ dermosol poppies.

(Cotching et al., 2004)

REGEN SOILS
Bringing soils back to life

8

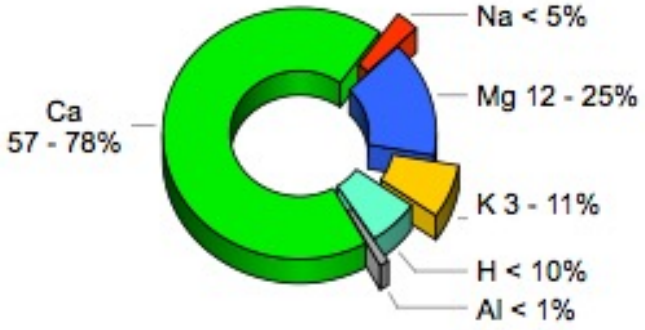
Structure and roots



REGEN SOILS
Bringing soils back to life

9

The ideal soil



IDEAL

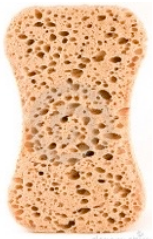
Aggregating power of cations (index values):
Na = 1
K = 1.8
Mg = 27
Ca = 45
(Rengasamy, 2011)

REGEN SOILS
Bringing soils back to life

10

Maintenance of soil structure

Aggregation is flocculation *plus* stabilisation (Bradfield, 1950)

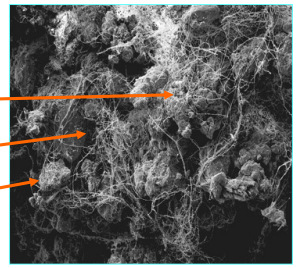


Soil pores
- water
- air

Micropores

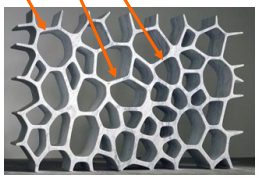
Macropores

Soil aggregate (ped)



OM Mg

Ca



Slide courtesy of VVSR Gupta

REGEN SOILS
Bringing soils back to life

11

Soil aggregation

- Capped soil from rainfall and traffic
- Aggregated soil with high carbon inputs

REGEN SOILS
Bringing soils back to life

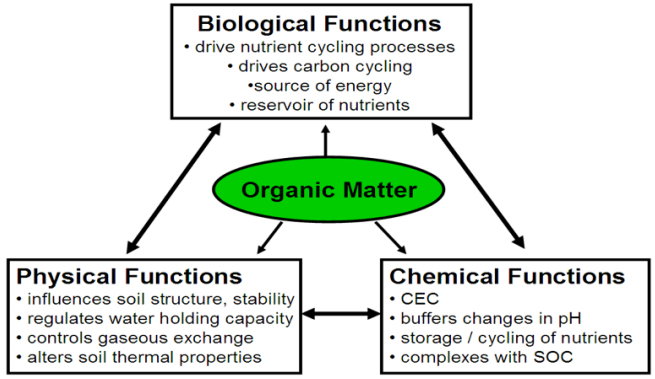
12

Soil aggregation

REGEN SOILS
Bringing soils back to life

13

The central role of Soil Organic Matter in Soil Health



REGEN SOILS
Bringing soils back to life

14

Key questions

- Does carbon exist in isolation?
- What are the principal forms of soil carbon – POC, ROC, HOC
- How does carbon cycle (timeframes, C:N ratio/impact)
- What are carbon sequestration /stabilisation pathways? – biological (microbial and liquid carbon pathway), physical (entrapment), chemical (how does CEC/clays affect SOC storage)
- Which types of Australian soils are best for storing stable carbon? (is there any truth to this question)
- What is the role of fungus in C sequestration?
- What's the quickest way to make humus?
- What's the role of biochar in C sequestration?
- Carbon use efficiency

REGEN SOILS
Bringing soils back to life

15

Stoichiometry of living things

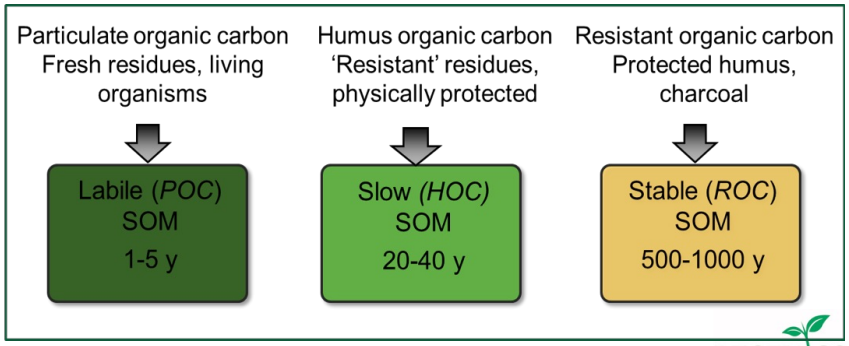
CHNOPS - The OM Building Blocks

Element	Human	Alfalfa	Insect	Bacteria
Carbon	19.37	11.34	6.1	12.14
Nitrogen	5.14	0.83	1.5	3.04
Phosphorus	0.63	0.11	0.13	0.60
Sulphur	0.64	0.10	0.14	0.32
Hydrogen	9.31	8.72	10.21	9.94
Oxygen	62.81	77.90	79.99	73.68
Total	*97.90*	*99.60*	*98.16*	*99.72*

REGEN SOILS
Bringing soils back to life

16

Different forms of Soil Organic Matter



REGEN SOILS
Bringing soils back to life

17

Humification

- Works best in cold, wet climates
- Works poorly in hot, wet climates
- Works least well in hot dry climates
- Works intermittently in brittle climates
- A function of OM input types and microbiological activity

REGEN SOILS
Bringing soils back to life

18

Carbon sequestration

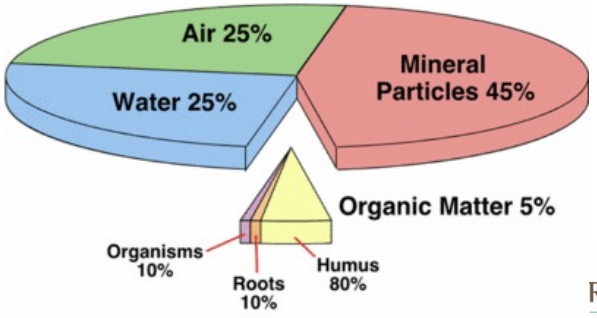
- Soil structure (air)
- Rainfall (water)
- Soil texture (protection)
- Plant diversity (food)
- Microbial stimulation / suppression (workers)
- Plant biomass (food and workers)

REGEN SOILS
Bringing soils back to life

19

Carbon sequestration

- Water

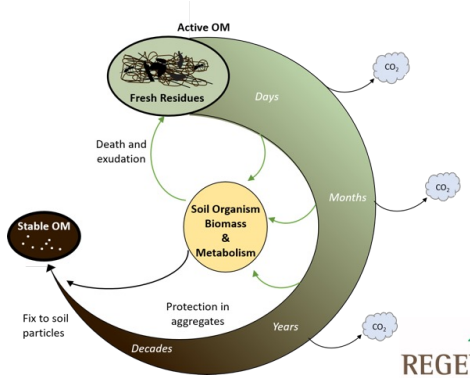


REGEN SOILS
Bringing soils back to life

20

Carbon sequestration

- Soil texture (protection)

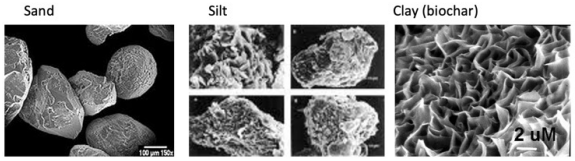


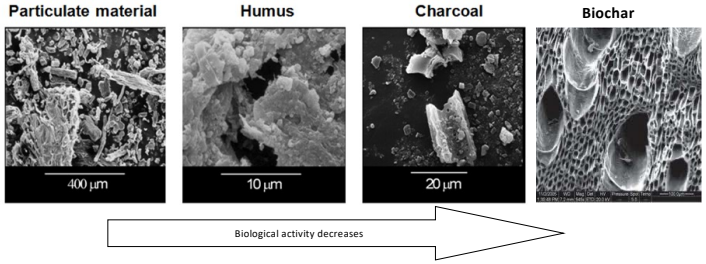
REGEN SOILS
Bringing soils back to life

21

Carbon sequestration

- Soil texture (protection)

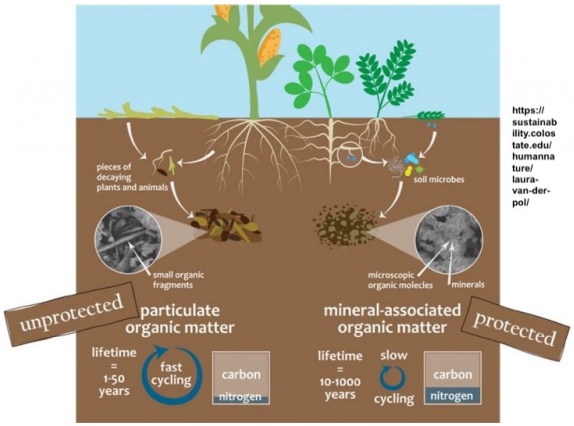




REGEN SOILS
Bringing soils back to life

22

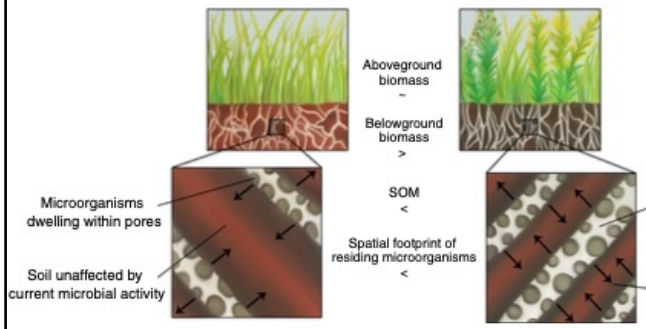
Mineral-associated organic matter (MAOM)



REGEN SOILS
Bringing soils back to life

23

Carbon sequestration



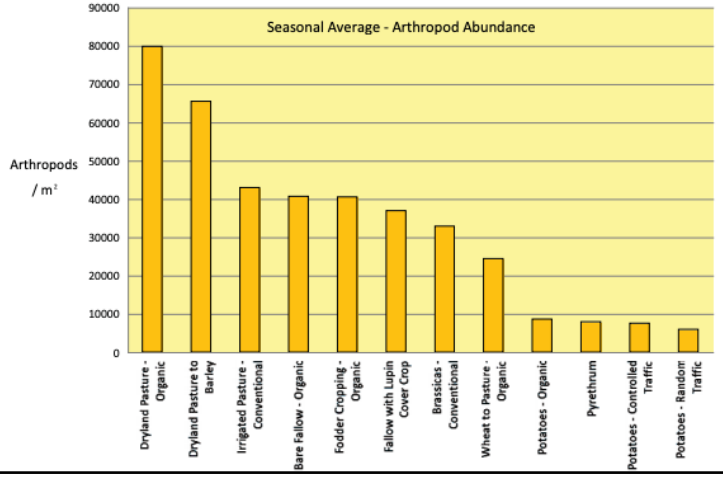
Importance of soil pores 30-150 microns

Kravchenko et al., 2019

REGEN SOILS
Bringing soils back to life

24

Tillage effects on soil



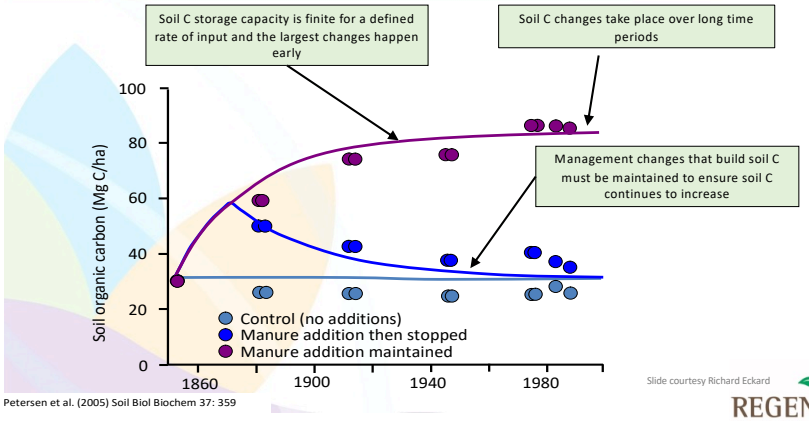
https://dpipwe.tas.gov.au/Documents/Soils-Alive-!.pdf

McDonald & Rodgers, 2010

REGEN SOILS
Bringing soils back to life

25

Management of Soil Carbon – saturation and permanence



Petersen et al. (2005) Soil Biol Biochem 37: 359

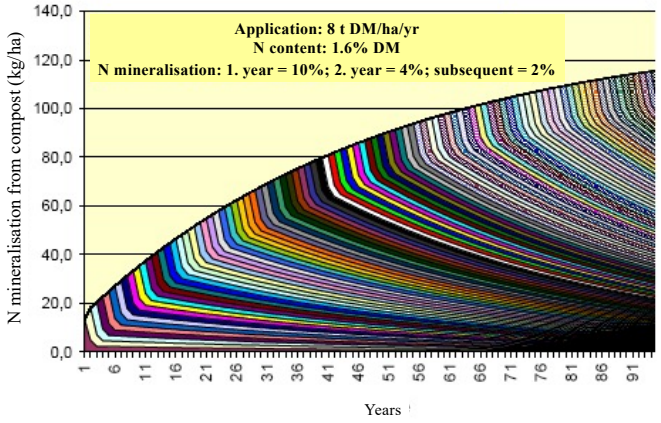
Slide courtesy Richard Eckard

Hoosfield continuous barley experiment, Rothamstead, UK, 1852 – present day

REGEN SOILS
Bringing soils back to life

26

Long-term Nitrogen Supply



Source: Amlinger et al, 2003

EN SOILS
Bringing soils back to life

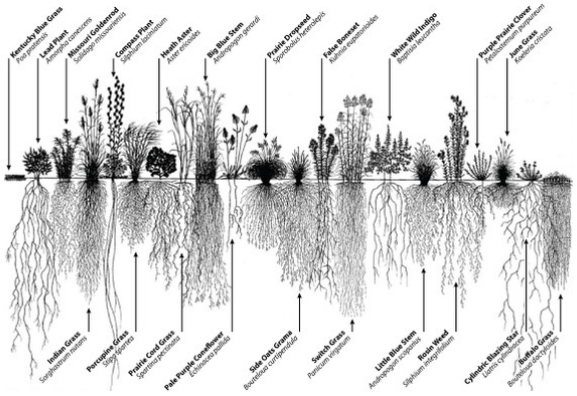
27

Tea Break

28

Carbon sequestration

- Plant diversity (food)

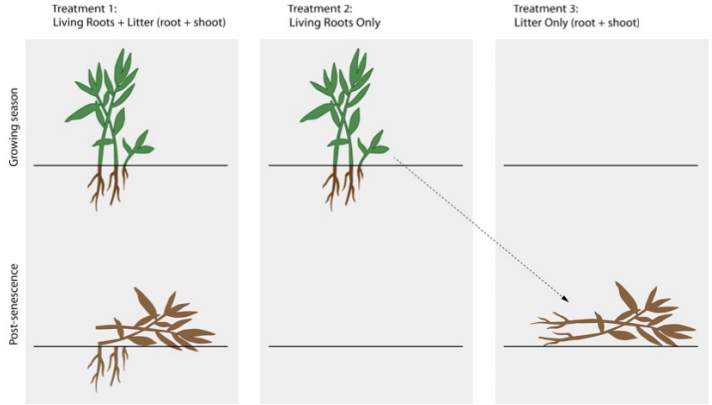


- The 'Elton Principle' holds that the greater the complexity of a microbiological community in terms of total number and diversity of organisms, the greater the stability of the community,
- Diverse swards support diverse biological communities

REGEN SOILS
Bringing soils back to life

29

Carbon sequestration

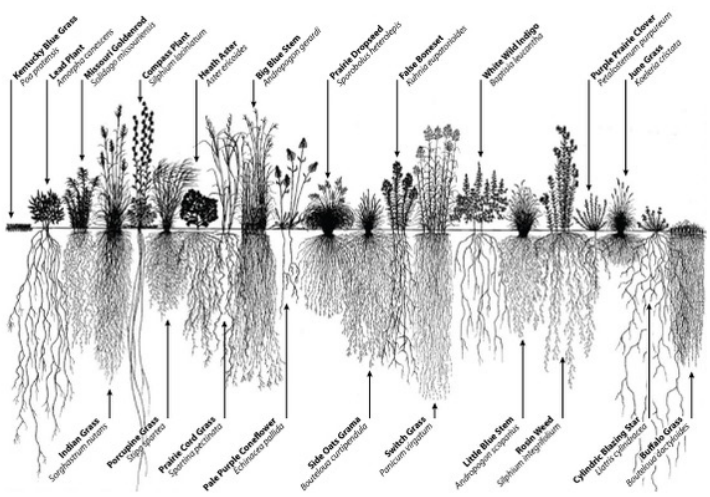


Sokol et al, 2018

Living roots are 2–13 times more efficient than litter inputs in forming both slow-cycling, mineral-associated SOC as well as fast-cycling, particulate organic C

REGEN SOILS
Bringing soils back to life

30



What to sow?

REGEN SOILS
Bringing soils back to life

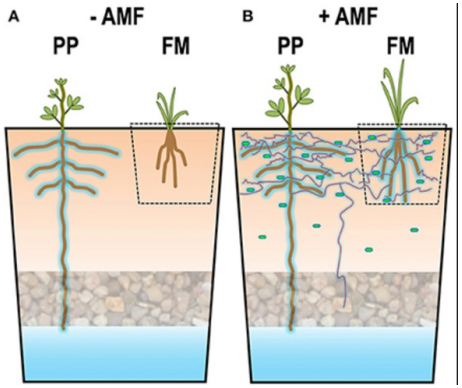
31

Plants and microbes cooperate

(A) In drought, deep-rooting pigeon pea (PP) accesses water but shallow rooting finger millet (FM) does not

(B) In the presence of AMF, their hyphae re-distribute water lifted by pigeon pea to finger millet and to PGPRs (green dots) in the hyphosphere

Saharan et al, 2018
https://www.frontiersin.org/articles/10.3389/fenvs.2018.00046/full



REGEN SOILS
Bringing soils back to life

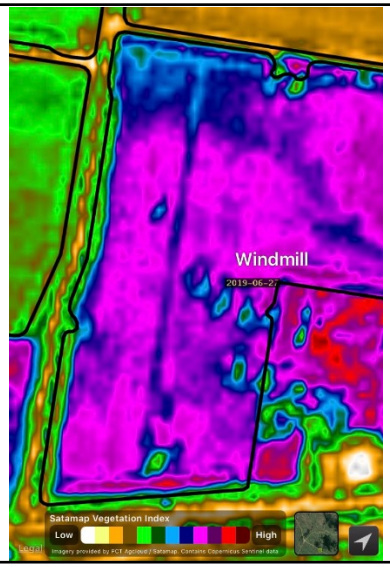
32

Polycultures more productive

- University of Zurich
  - 10 year research study showed higher levels of production from diverse grasslands than monocultures
  - the diversity of plant species in communities ensures occupation of all the niches available in an ecosystem. This enables them to use soil nutrients, light and water far more effectively than monocultures, which ultimately leads to greater yields
  - Lower pest pressure due to less effective parasite spread. Pests are less able to find their special host plant in a biodiverse plant world
  - Short-term evolution leads to a continued increase of crop yield in mixtures. Process called 'character displacement' sees upper canopy plants (grasses) develop thicker leaves to better utilise sunlight while clovers grow larger but thinner leaves for the same reason

REGEN SOILS
Bringing soils back to life

33



Nil companion plot

Warwick Holding via Twitter July 2019

REGEN SOILS
Bringing soils back to life

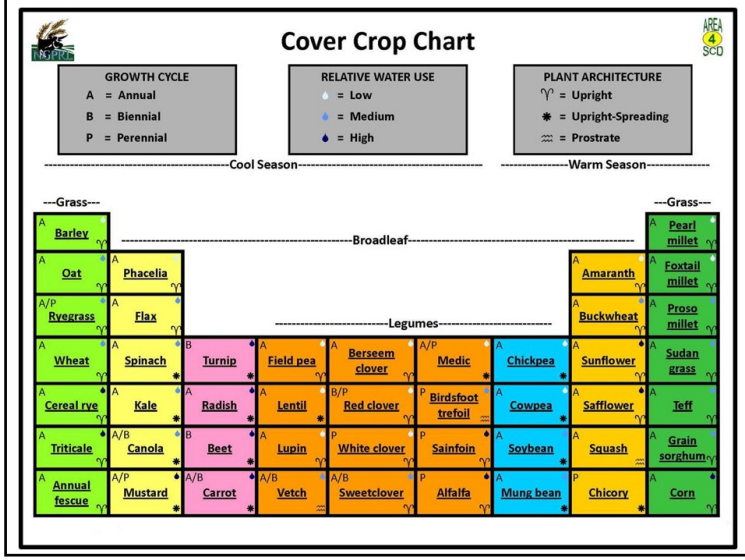
34

Companion crops

- Plant families
  - Grasses, cereals, legumes, brassica and chenopods
  - Grasses and legumes were made in Heaven!
  - Legumes, brassica and chenopods should always be the supporting act
  - Bulk is essential for cover cropping and is always led by grasses and cereals
- Fertilising
  - General recommendation is not to fertilise a diverse cover crop
  - Accumulated root exudates drive soil biological function, fixing nitrogen and sequestering carbon
  - Monocultures can show nutrient deficiencies when polycultures don't

REGEN SOILS
Bringing soils back to life

35



What to sow?

REGEN SOILS
Bringing soils back to life

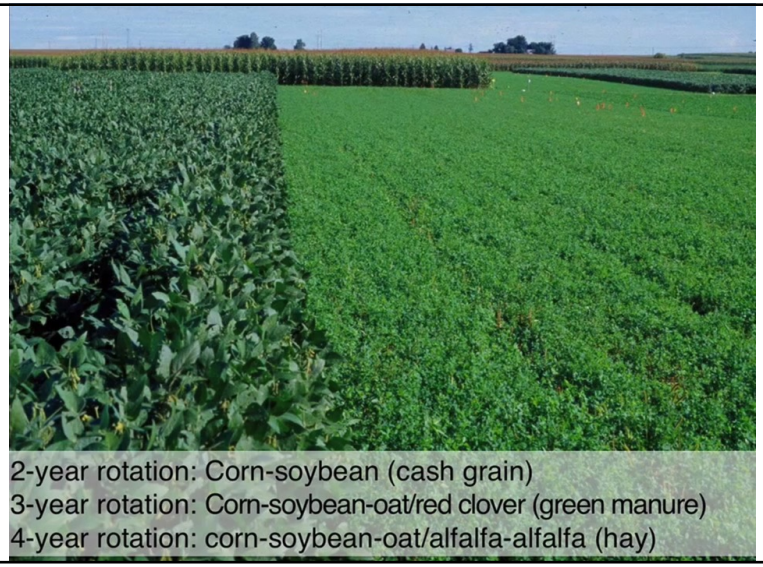
36

Crop improvement

- Research through the Soil Wealth program that looked at cover crops showed:
  - Improved shelf life of capsicums
  - Improved weed control in pastures
  - Improved quality in leeks
  - Improved water infiltration due to better protection of soil surface
  - Potential to purchase a smaller tractor!

REGEN SOILS
Bringing soils back to life

37



Iowa State University.

Use of 3 & 4 year rotations reduced pesticide inputs by 97%, reduced fertiliser requirement by 90%. Iowa farmer increased SOM from 2% to 6.5%, and earthworm count from 18,000 / acre to 1.3m / acre.

REGEN SOILS
Bringing soils back to life

38

Transitioning to Regenerative practices

Integrating animals

Integrating trees

REGEN SOILS
Bringing soils back to life

39

Grazing management for soil health

REGEN SOILS
Bringing soils back to life

40

Grazing management for soil health

REGEN SOILS
Bringing soils back to life

41

Big rain August 2022

REGEN SOILS
Bringing soils back to life

42

Disaster!

REGEN SOILS
Bringing soils back to life

43

Mortality composting

REGEN SOILS
Bringing soils back to life

44

Recovery

REGEN SOILS
Bringing soils back to life

45

Chicory

REGEN SOILS
Bringing soils back to life

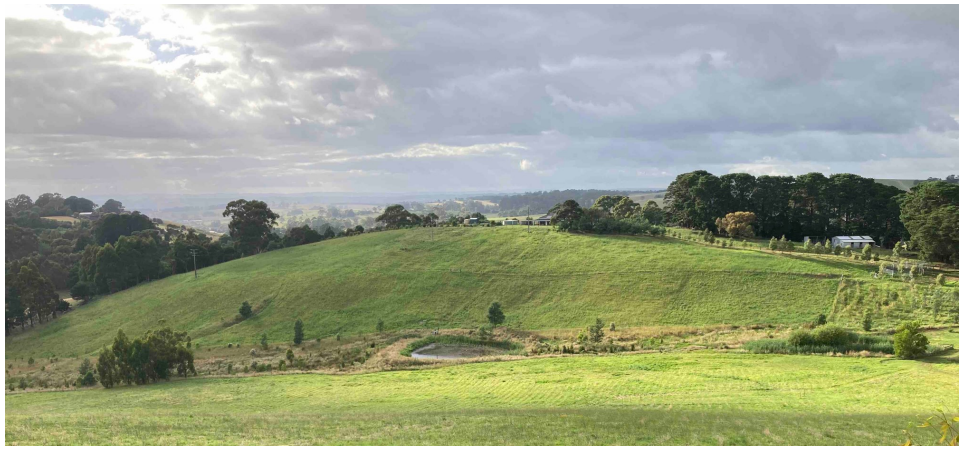
46

February 2023. Dry feed.

REGEN SOILS
Bringing soils back to life

47

December 2025 after 2 months with 22 cattle



48

Feed exhausted Lang lang, May 2025

REGEN SOILS
Bringing soils back to life

49

Kardella, May 2025

REGEN SOILS
Bringing soils back to life

50

Kardella,
May 2025

REGEN SOILS
Bringing soils back to life

51

Transitioning to Regenerative practices

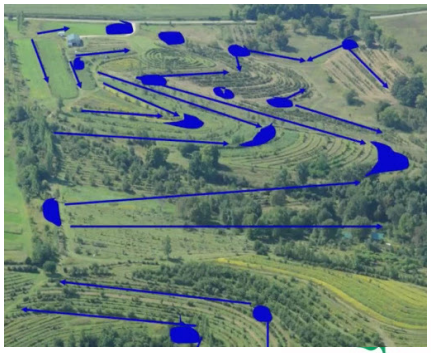
- Hierarchy of actions - Living roots year round
  - What can I do to reduce fallow or dormancy through the seasons?
  - How to manage extended dry times?
  - Complementary summer / winter phenologies
  - Weeds can be useful

REGEN SOILS
Bringing soils back to life

52

Transitioning to Regenerative practices

- Hierarchy of actions - Managing diversity
  - Diversity vs biomass
  - Diversity by design - Design systems aim to mimic nature or work with nature to meet human goals
  - Design for water, alley planting and habitat modification



http://www.eyiinc.org/water-management-workshop-mark-shepard/

REGEN SOILS
Bringing soils back to life

53

Regen in practice

REGEN SOILS
Bringing soils back to life

54

Regen in practice

DeBertoli Wines

Note different sward heights

REGEN SOILS
Bringing soils back to life

55

Regen in practice

DeBertoli Wines

REGEN SOILS
Bringing soils back to life

56

57

On-farm trials

- You are limited only by your imagination
- Be clear about what you want to investigate
- Don’t confound your trial by mixing many different things
- Be clear about your SMART targets
- Avoid vague targets such as ‘I want to increase my soil organic carbon’
- Tap into the group for support / advice / ideas
- Seek professional assistance to help set yourself up

58

Monitoring and Evaluation

- Trialling ideas: Decide what to do and do it only
- Write down what you are going to do and record what you have done
- Know what you need to measure and how you will measure it

		Victoria		
Compost	Biofumigant crop	Green manure	Worm casts	Control
Worm casts	Control	Compost	Biofumigant crop	Green manure
Biofumigant crop	Green manure	Worm casts	Control	Compost

REGEN SOILS
Bringing soils back to life

59

Summary

- Use principles of Regenerative Farming to guide decision-making
- Research is all pointing towards the effectiveness of biomimicry
- Diversity = stability. Plants cooperate more than they compete
- Irony of nutrient deficiencies under monocrops
- Soil test
- Cover cropping must be complemented by improved grazing management
- Groundcover is everything
- Diverse swards = diverse soils = healthy plants = healthy people ☺

REGEN SOILS
Bringing soils back to life

60

THANK YOU

Declan McDonald

Principal Soil Scientist

B.Sc (Urban Hort), M.SustAg (Soils)

REGEN SOILS

Bringing soils back to life

61