PROGRAM 4 SESSION

Lukas Van Zwieten Soil CRC Program Leader	Program 4 Overview
Terry Rose Southern Cross Unviersity	Plant based solutions to improve soil performance through rhizosphere modification
Mick Rose NSW Department if Primary Industries	Developing knowledge and tools to better manage herbicide residues in soil
Jonathan Ojeda University of Tasmania	Improving the representation of soil productivity/constraints in existing decision support systems and modelling platforms
Mehran Rezai Rashti Griffith University	Evaluating soil functional resilience to compaction and drought stresses for developing higher performance soils
Gwen Grelet Landcare Research New Zealand	Regenerative farming systems
Jason Condon*** Charles Sturt Univeristy	Mechanistic understanding of the mode of action of novel soil re-engineering methods for complex chemical and physical constraints

****presented by Program Leader*

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PROGRAM 4

INTEGRATED AND PRECISION SOIL MANAGEMENT SOLUTIONS

LUKAS VAN ZWIETEN

DEPARTMENT OF PRIMARY INDUSTRIES, NSW

3 April 2019

NSW GOVERNMENT | Department of Primary Industries

SOIL CRC

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Program 4

Outputs

1. Novel plant and systems based soil re-engineering methods
2. Novel physio-chemical based soil re-engineering methods
3. Universal soil re-engineering decision support tools

PROJECT 18-2.10

PLANT BASED SOLUTIONS TO IMPROVE SOIL PERFORMANCE THROUGH RHIZOSPHERE MODIFICATION

PROJECT LEADER **ASSOC. PROF. TERRY ROSE**
SOUTHERN CROSS UNIVERSITY

- Investigate options for increasing species diversity in cropping systems
- Examine the link between plant species diversity and soil biology
- Quantify water use, soil function and crop yields in treatments with diverse plant species in rotations and control treatments
- Establish 5 large scale replicated field trials across the country as well as small plot trials at Wollongbar/Wagga Wagga to resolve mechanisms driving change

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PROJECT 18-3.19

CO-INNOVATION IN REGENERATIVE FARMING SYSTEMS: WHOLE SYSTEM APPROACH TO SOIL PERFORMANCE & RESILIENCE

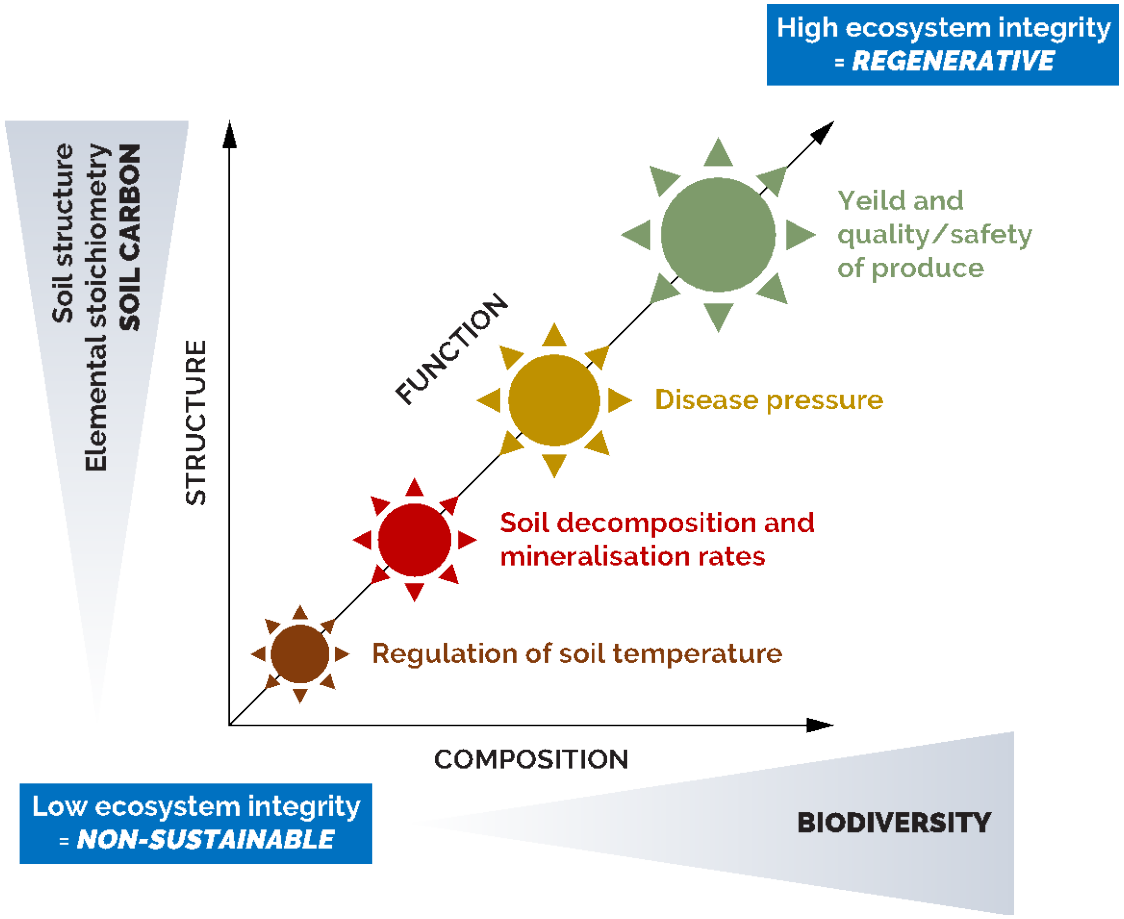
PROJECT LEADER **DR GWEN GRELET**
MANAAKI WHENUA LANDCARE RESEARCH

Co-innovation between farmers and scientists

- Using theory of change, through understanding each other's needs and constraints to define a shared vision

Experimental approach

- Pairwise comparison

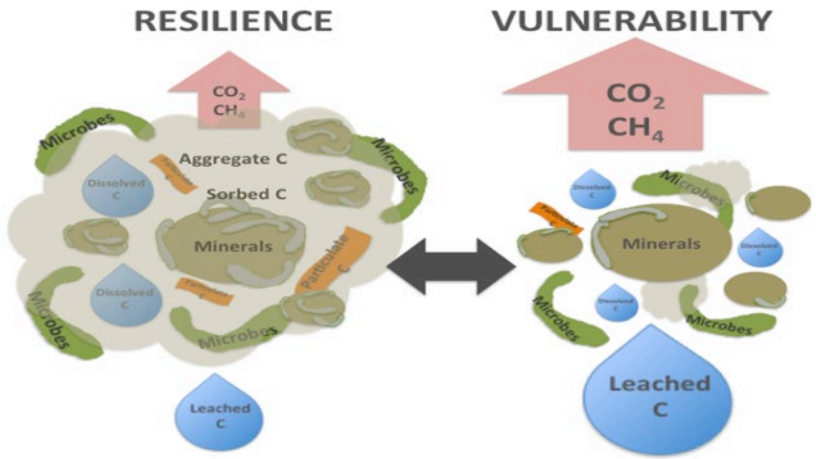


PROJECT 18-3.4.1

EVALUATING SOIL FUNCTIONAL RESILIENCE TO COMPACTION AND WATER STRESSES FOR DEVELOPING HIGHER PERFORMANCE SOILS

PROJECT LEADER **DR MEHRAN REZAEI RASHTI**
GRIFFITH UNIVERSITY

- Assessment of the effect of compaction and water stresses on soil functional processes and microbial community composition and diversity.
- Identification of the main indicators of soil resilience in high performing soils subjected to soil compaction and water stresses.
- Providing new methodology using innovative biogeochemical methods for re-engineering of target soils against compaction and water stresses.
- Providing soil resilience protocols for project leaders within Soil CRC to be used for the development of higher performing soils across different cropping systems.



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PROJECT 18.3-007

MECHANISTIC UNDERSTANDING OF AMELIORATION STRATEGIES FOR MULTIPLE SOIL CONSTRAINTS

PROJECT LEADER **DR JASON CONDON**
CHARLES STURT UNIVERSITY

- Grower groups assist in prioritising soils with multiple constraints for glasshouse/small plot experiments
- Aim: Quantify and understand current and novel amelioration mechanisms for those soils
- Duration: May 2019 – June 2021
- Outcome: Identify evidence based amelioration options for field evaluation in future projects

Partners: CSU, NSW DPI, VIC DEDJTR, FACEY, HART, BCG, CWFS, FarmLink, RivPlains

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PROJECT 18-2.7

DEVELOPING KNOWLEDGE AND TOOLS TO BETTER MANAGE HERBICIDE RESIDUES IN SOIL

PROJECT LEADER **DR MICHAEL ROSE**
DEPARTMENT OF PRIMARY INDUSTRIES, NSW

- Define plant toxicity thresholds
- Develop new tool for estimating bioavailable herbicide levels
- Validate a new model for predicting herbicide persistence in different soil types
- Provide guidance on how to manage potential issues with herbicide carryover and persistence in soil

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PROJECT 18-2.3

IMPROVING THE REPRESENTATION OF SOIL PRODUCTIVITY/CONSTRAINTS IN EXISTING DECISION SUPPORT SYSTEMS AND MODELLING PLATFORMS

PROJECT LEADER **DR KEITH PEMBLETON**
UNIVERSITY OF SOUTHERN QUEENSLAND

Completed activities

- Reviewed existing DSS's identified gaps, what works, what needs improvement and how they support farmer decision making

Current activities

- Adding improved capacity to existing DSSs and models with a focus on proven and used technology

Future activities

- New modelling approaches to handle complex and multiple soil constraints to help on ground decision making

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Output 1 Milestones

1.1 Conceptual framework

1.2 Test methods for indicators of high performance soils

18-3.4.1 ***Mehran Rashti*** Evaluating soil functional resilience

18-3.1.9 ***Gwen Grelet*** Co-innovation in regenerative farming systems

1.3 Soil rhizosphere re-engineering technologies

18-2.10 ***Terry Rose*** Plant based solutions to improve soil performace

18-3.19 ***Gwen Grelet*** Co-innovation in regenerative farming systems

1.4 Deliver data evaluating novel re-engineering methods

18-2.10 ***Terry Rose*** Plant based solutions to improve soil performace

18-3.19 ***Gwen Grelet*** Co-innovation in regenerative farming systems

1.5 Data are delivered into output 4.3

DUE TO COMMENCE | PROJECT ACTIVITIES | FUTURE ACTIVITIES | ACTIVITIES BEYOND DUE MILESTONE | ★ MILESTONE DUE

Output 2 Milestones

2.1 Glasshouse/mechanistic studies used to inform field studies

18.3-007 ***Jason Condon*** Mechanistic understanding of soil re-engineering methods

2.2 Loss of productivity due to herbicides

18-2.7 ***Mick Rose*** Develop tools to better manage herbicide residues in soil

2.3 Six field sites established/devlier data across four seasons

2.4 Data are delivered into output 4.3

DUE TO COMMENCE | PROJECT ACTIVITIES | FUTURE ACTIVITIES | ACTIVITIES BEYOND DUE MILESTONE | ★ MILESTONE DUE

Output 3 Milestones

3.1 Build on and value add to existing tools

18-2.3 ***Keith Pembleton*** Improving the representation of soil productivity/constraints

3.2 Diagnosis frameworks including a hybrid biophysical model – machine learning system for multiple soil constraints

3.3 Deliver nine farm walks (workshops) presenting the most successful soil re-engineering methods

3.4 Universal decision-support tools based on machine learning frameworks that guide decisions and actions

DUE TO COMMENCE | PROJECT ACTIVITIES | FUTURE ACTIVITIES | ACTIVITIES BEYOND DUE MILESTONE | ★ MILESTONE DUE

PLANT BASED SOLUTIONS TO IMPROVE SOIL PERFORMANCE THROUGH RHIZOSPHERE MODIFICATION

TERRY ROSE, SOUTHERN CROSS UNIVERSITY

3 April 2019

Performance through collaboration

PROJECT TEAM

- Terry Rose, Lee Kearney (Field technician), Southern Cross University
- Helen Mcmillan, Central West Farming Systems
- Cassandra Schefe, Riverine Plains Inc.
- John Howieson, Richard Bell, Jason Terpolini, Graham O'Hara, Murdoch University
- Sarah Hyde, Facey Group
- Lukas Van Zwieten, Belinda Hackney, Mick Rose, NSW DPI
- Jason Condon, Leslie Weston, Charles Sturt University
- Lawrence Di Bella, Megan Zamel,
- Sarah Noack, Hart Field Site Group Inc.

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BACKGROUND

- Crop rotations are becoming less diverse in terms of plant species cultivated
- Greater diversity of plant species means greater diversity of carbon inputs into soils, and in theory, greater carbon diversity leads to greater soil biological diversity which in turn leads to more resilient soils.

- 3 main ways to get more plant diversity in rotations:
- * replace existing crop species with alternate crop species – profitability???
- * incorporate diversity in space (e.g. companion planting)
- * incorporate diversity in time (replace typical fallow period with planted field)

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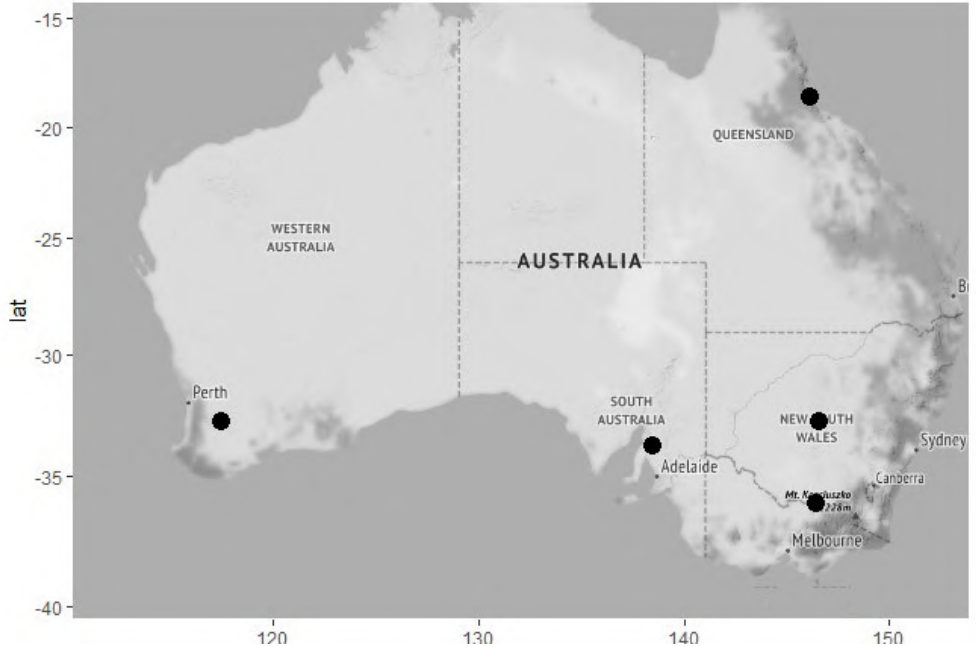
PROJECT ACTIVITIES

- 5 long term field sites established (Hart, Wickepin, Rutherglen, Condobolin, Ingham) examining a range of crop replacement (e.g. substitute wheat for a legume crop), intercrop or companion crop, or summer cover trials
- 2 small plot field trials to examine mechanisms behind soil function changes and to obtain data for modelling – particularly soil moisture dynamics
- One post-doc and three PhD students to support activities
- One field trial already underway in Ingham (Nth Qld) – visited by T. Rose and L. Van Zwieten last month



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PROJECT ACTIVITIES

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PROJECT ACTIVITIES

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WHAT DO WE WANT TO ACHIEVE

- Understand how plant diversity shapes soil biological communities and soil function – how much diversity is needed?
- Determine whether companion crops or covercrops lead to a measureable change in soil function during the season or prior to sowing the next crop
- Resolve whether any changes in soil function translate to impacts on crop yields over a 3-4 year period in semi-arid, winter rainfall environments
- Obtain data on soil physical/chemical/biological changes and soil water dynamics to enable modelling (APSIM?) studies to be conducted
- Engage grower group members throughout the process and generate discussion based on science

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DEVELOPING KNOWLEDGE AND TOOLS TO BETTER MANAGE HERBICIDE RESIDUES IN SOIL

MICK ROSE

NSW DEPARTMENT OF PRIMARY INDUSTRIES

3 April 2019

NSW GOVERNMENT Department of Primary Industries

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PROJECT TEAM

- Mick Rose, Lukas Van Zwieten, Josh Rust, Scott Petty – NSW DPI
- Richard Bell, John Howieson, David Henry, Gavan McGrath – Murdoch University
- Terry Rose – Southern Cross University
- David Minkey – WA No Till Farming Association
- Kelly Angel – Birchip Cropping Group
- Mark Stanley, Amanda Cook – EPARF

NSW GOVERNMENT Department of Primary Industries

Murdoch UNIVERSITY

Southern Cross University

wantfa

BCG SHARED SOLUTIONS

EPARF
Eyre Peninsula
Agricultural Research Foundation Inc.

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BACKGROUND

- ↑ use of residual (more persistent) herbicides
  - diuron
  - pyroxasulfone
  - imidazolinones (Clearfield ®)
- ↑ system diversity
  - Rotations, plant-back?
- Climate and soil variability
  - No site specific info on plant back

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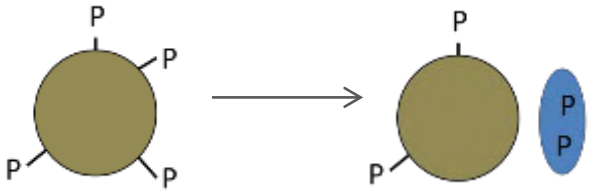
PROJECT ACTIVITIES

Climate and soil properties
Modelling

EXPOSURE



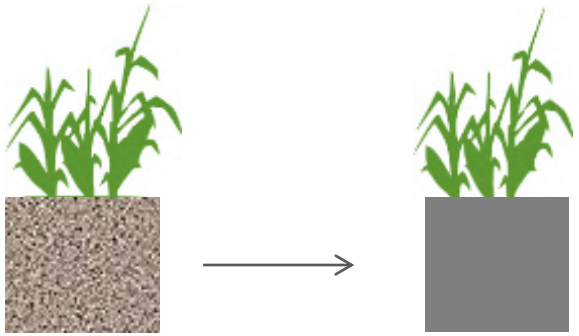
Total herbicide residue analysis
Published methods

Bioavailable herbicide residue analysis

PLANT-BACK RISK

DECISION MAKING

TOXICITY



Crop phytotoxicity – maximum availability

Crop phytotoxicity – soil specific bioavailability

Multiple herbicide residues
Long-term field experiments

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ENGAGEMENT AND COLLABORATION

- Alternative cropping regimes (cover cropping) – effects of herbicides
- Soil management (e.g. amendments) – effect on herbicide persistence
- Designed field experiments with 'biocidal' perturbations – testing arena for soil health/productivity measures
- Decision support tool
- Knowledge transfer – education of researchers, agronomists, farmers
- New products?

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IMPROVING THE REPRESENTATION OF SOIL PRODUCTIVITY/ CONSTRAINTS IN EXISTING DECISION SUPPORT SYSTEMS AND MODELLING PLATFORMS

KEITH PEMBLETON (JON OJEDA)
UNIVERSITY OF SOUTHERN QUEENSLAND

3 April 2019

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PROJECT TEAM

- Claire Browne and James Murray (**Birchip Cropping Group**)
- Nathan Craig (**West Midland Group**)
- Cassandra Schefe (**Riverine Plains**)
- Rob Milla (**Burdekin Productivity Services**)
- Nathan Robinson, Peter Dahlhaus (**Federation University**)
- Simon Clarendon (**NSW DPI**)
- Jonathan Ojeda, Caroline Mohammed (**UTAS**)
- Keith Pembleton (**USQ**)

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BACKGROUND

- Most soil focused decision support tools available in Australia focus on nitrogen, water or pH
- Gap in the DSS's and their underpinning models representation of soil constraints
- Limited ability to create what if scenarios and apply DSS's to tailor rules of thumb
- This project will address this gap in the existing DSS's and models to expand their application and impact

PROJECT ACTIVITIES

- Prioritise soil constraints based on need, data availability and ease of representation
- Develop and build the capacity to represent the prioritised soil constraints in existing models (e.g. APSIM)
- Validate and sensibility test model improvements
- Capture model improvements through developments to existing DSS's (e.g. ARM online, yield profit)

ENGAGEMENT AND COLLABORATION

- Seeking data describing crop responses to soil constraints for model set up and validation
- Sensibility testing of models
- Beta testing of DSS developments and analyses
- Advertising for a project post doc soon (to be based at USQ)
- Contact Keith Pembleton (Keith.Pembleton@usq.edu.au)

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EVALUATING SOIL FUNCTIONAL RESILIENCE TO COMPACTION AND DROUGHT STRESSES FOR DEVELOPING HIGHER PERFORMANCE SOILS

DR MEHRAN REZAEI RASHTI

GRIFFITH UNIVERSITY

3 April 2019

SOiL CRC

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PROJECT TEAM

- Dr Mehran Rezaei Rashti (GU) Project leader
- Prof Chengrong Chen (GU)
- Prof Lukas Van Zwieten (NSW DPI)
- Dr Maryam Esfandbod (GU)
- Dr Michael Rose (NSW DPI)
- Associate Prof Chris Brown (GU)
- Dr Sue Boyd (GU)

- Mr Xiangyu Liu (GU) PhD student
- Mr Josh Rust (NSW DPI)
- Mr Lawrence Dibella (HCPSL)
- Ms Megan Zamhel (HCPSL)
- Ms Sarah Hyde (FACEY)
- Ms Chloe Turner (FACEY)

Griffith UNIVERSITY

NSW GOVERNMENT Department of Primary Industries

HCPSL Herbert Cane Productivity Services Ltd.

FACEY GROUP Shaping the Future

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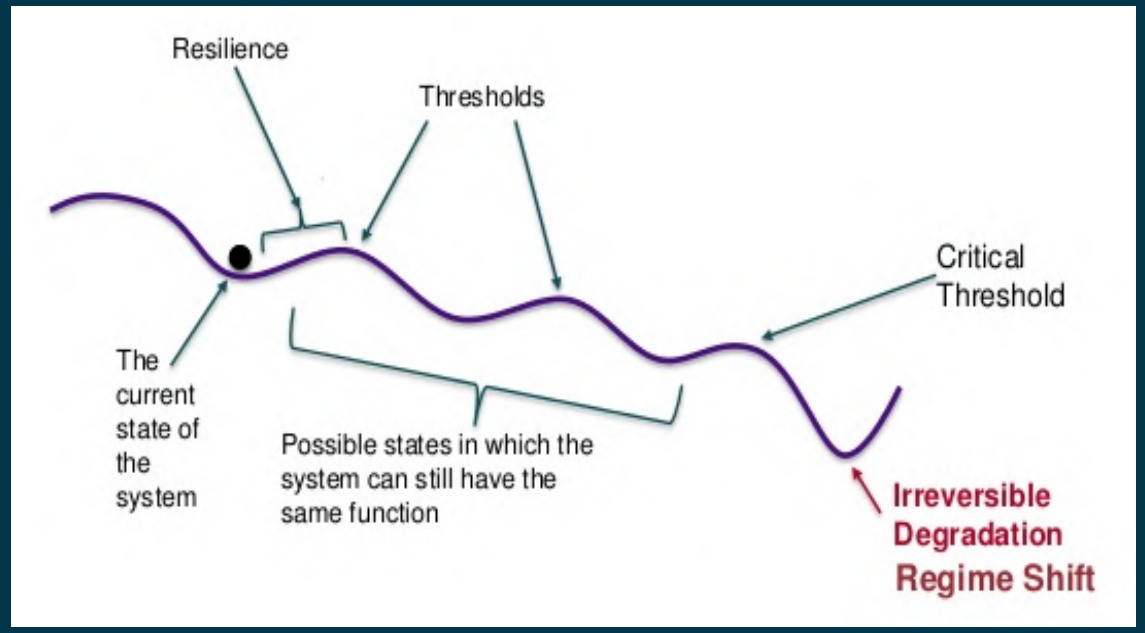
BACKGROUND



- A healthy soil has the continued capacity to supply plants with adequate and balanced nutrients, water and air as a complex biological system in a disease-free environment.
- The decline in crop yield and economical profitability of farming systems is associated with poor soil fertility and soil health which can be exacerbated by environmental stresses such as compaction and drought.
- In order to drive practice change, growers need access to simple, robust and affordable methods for measuring their soil health status.
- Soil resilience is the capacity of a soil to recover its functional and structural integrity after an environmental stress (such as drought and compaction).
- This project will assess the functional resilience of soil biological systems and changes in soil microbial community composition and diversity in response to short- and long-term drought and compaction stresses across multiple farming systems to develop site specific protocols for plant and system based re-engineering of higher performing soils.
- The expected outcomes of this project will lead to broader adoption of better management practices that will ultimately increase production and profitability for Australian agricultural industries.

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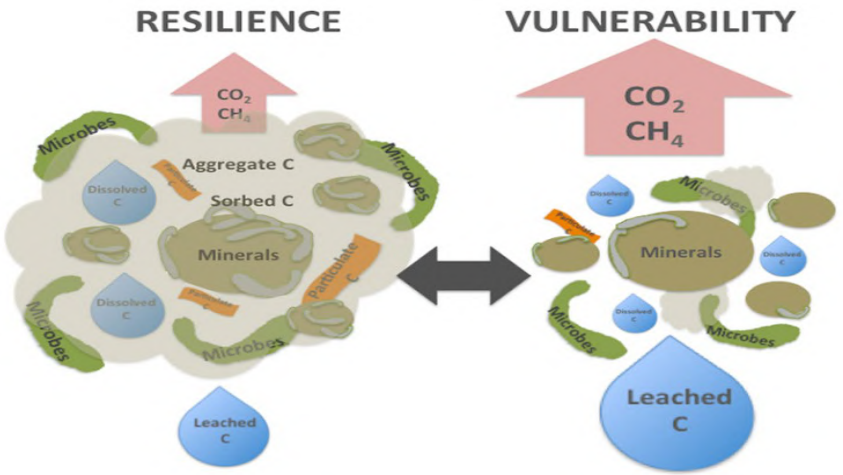
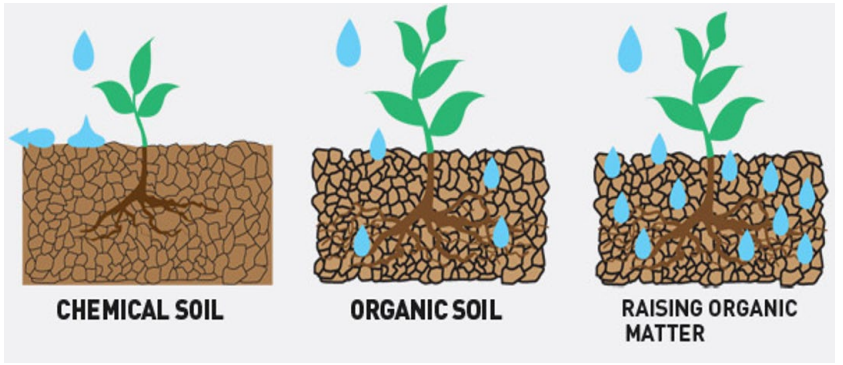
PROJECT ACTIVITIES

- Providing robust and affordable assessment methods and management protocols for improvement of soil functional resilience against compaction and drought stresses in different cropping systems.
- Assessment of the effect of compaction and drought stresses on soil functional processes and microbial community composition and diversity in relation to soil fertility and plant productivity.
- Identification of the main indicators of soil resilience in high performing soils subjected to soil compaction and drought stresses.
- Providing practical methodology using innovative biogeochemical methods for re-engineering of target soils against compaction and drought stresses in sugarcane and regenerated farming systems.
- Providing soil resilience protocols for project leaders within Soil CRC to be used towards the development of higher performing soils across different cropping systems.
- Enhancement of international collaborations with other parts of the world, where the similar soil health issues exist, for further understanding of soil functional resilience against drought and compaction stresses in diverse ecosystems.





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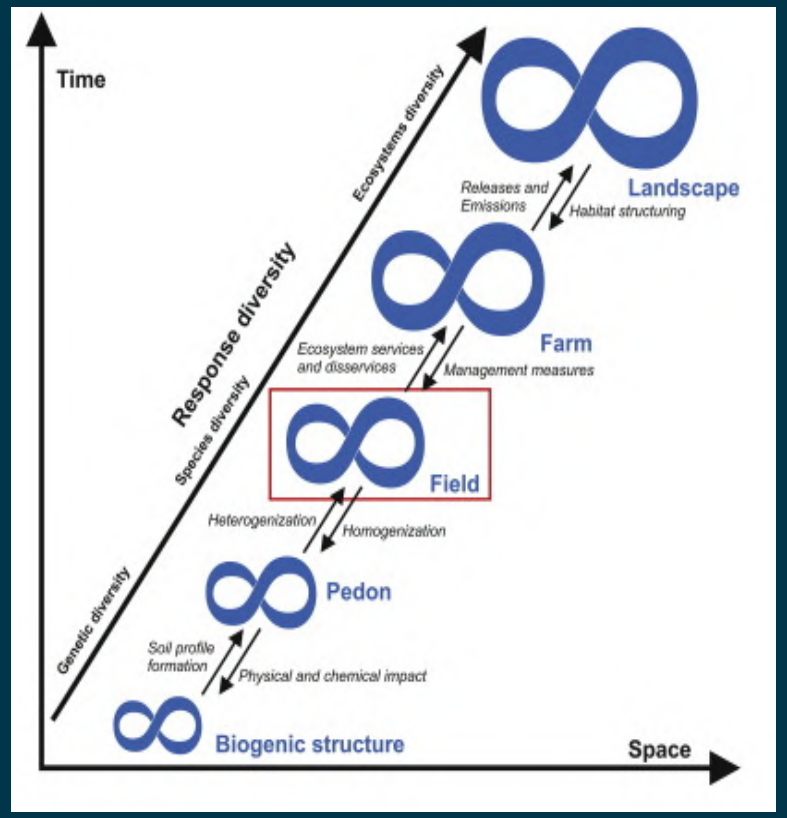
ENGAGEMENT AND COLLABORATION

- Development of research plan and finalising experimental designs (GU, NSW DPI, HCPSL and FACEY)
- Selection of field sites with soil health gradient and different management practices (ongoing short- to long-term field trials) and identification of optimum soil sampling strategy.
- Review publication in an international journal on developing soil resilience against drought and compaction stresses in agroecosystems.
- Scientific paper on providing improved mechanism-based understanding of soil functional resilience against main environmental stressors such as soil compaction and drought stresses in Australian agricultural systems with focus on sugarcane and grain production.
- Technical report on providing innovative biological, chemical and physical methods for assessing the resilience of a target soil against environmental stressors (compaction and drought) in comparison with high performing soils.
- Fact-sheet on management of soil resilience against drought and compaction stresses
- Field experiment on the next stage of the research beyond this project.



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Co-innovation in regenerative farming systems:

whole system approach to soil performance and resilience.

PROJECT LEADER: **Gwen GRELET**

Manaaki Whenua – Landcare Research

CALL 18-3

2018 MAJOR INVESTMENT ROUND 2

3 April 2019

Manaaki Whenua Landcare Research

wheatbelt natural resource management

SoilsForLife

Government of South Australia
Primary Industries and Regions SA

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CORE PROJECT TEAM

- **Soils for Life (SFLT):** Kirsty Yeates
- **Wheatbelt Natural Resource Management Inc (WNRM):** Felicity Gilbert
- **Department of Primary Industries and Regions, South Australia (PIRSA):**

  David Davenport & Claire Dennerly
- **Manaaki Whenua – Landcare Research (MWLR):**

  Drs Gwen Grelet, Paul Mudge, Kate Orwin, Pierre Roudier & Bryan Stevenson, Prof Peter Millard.

  With **Integrity Soils** Nicole Masters and **Learning for Sustainability** Dr Will Allen
- **And most importantly….. Regenerative farmers**

  (5 per region x 3): TBC

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PROJECT RATIONALE

'Regenerative Agriculture' is a holistic land management practice that leverages the power of photosynthesis in plants to **close the carbon cycle**, build soil health, crop resilience and nutrient density. Regenerative agriculture improves soil health, primarily through the practices that **increase soil organic matter**.'

California State University 2017

"Investing in regenerative agriculture has the potential to address not only the food supply but also climate change, peace and conflict resolution

and the water supply to boot.

It also appears to generate healthy financial returns."

Devin Thorpe – Forbes 12/12/18

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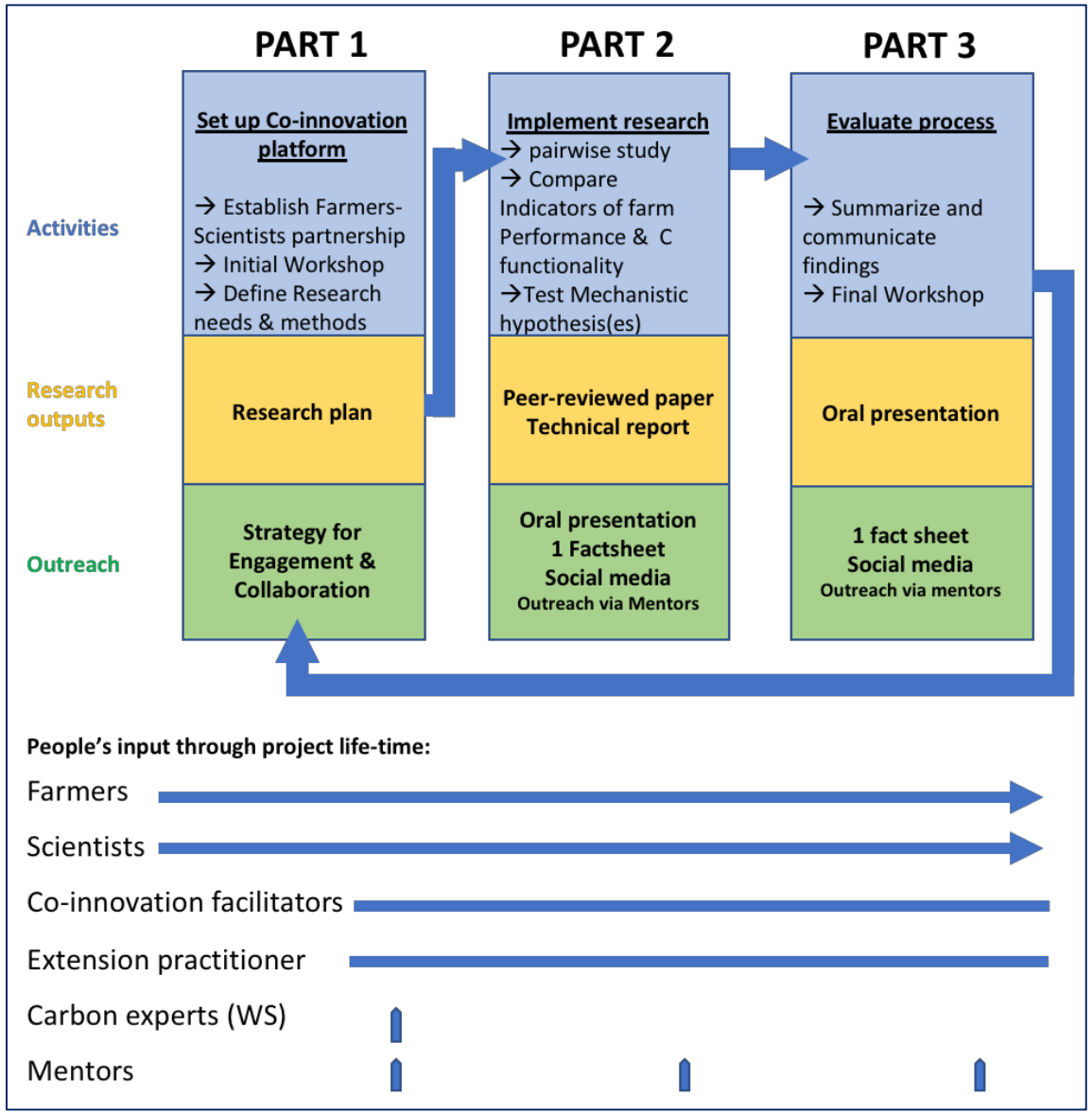
PROJECT ACTIVITIES



Project Duration

07/2019-12/20/21 (2.5 years)

Research Approach

- Transdisciplinary
- Collaborative
- Adaptive

Experimental Approach

- Paired farms ('conventional' – 'regenerative')
- Multi-outcomes farm and soil performance
- Best / most relevant measure(s) of carbon functionality
- 2/3 Regions (WA, SA, QLD/Vic/NSW)

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ENGAGEMENT AND COLLABORATION

Contributors to Co-innovation Approach

- **Soils CRC Programs**

  Leaders Programs 1-4

- **Carbon Experts**

  Drs BP Singh & Naomi Wells (soils CRC), Dr Stephen Joseph (Guest)

- **Sensors and Systems Modelling Experts**

  Dr K Pembleton, A/Prof John Bennett

- **Bioindicators Expert**

  A/Prof Pauline Mele

Mentor Panel

Charles Massy, Peter Marshall (2 others TBC)

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ENGAGEMENT & COLLABORATION

Linkages with other soils CRC projects:

- **Priority 18-3.3.2.**

  Organic and clay amendments for sandy soils) – Prof Richard Bell

- **Priority 18-3.2.6**

  Bio-indicators of High Performing Soils –A/Prof Pauline Mele

- **Priority 18-3.2.1**

  Visualising Australasia's soils – A/Prof Dahlhaus

- **Priority 18-2.4.3**

  Plant based solutions for rhizosphere modification - A/Prof Terry Rose

- **Priority 18-3.4.1**

  Soil functional resilience to compaction and water stresses - Dr Mehran Rashti

Other Linkages:

ANU Precision regenerative agriculture (Prof Justin Borevitz)

Soil C stocks and soil biology in NZ regenerative pastures (Dr Gwen Grelet, MWLR)

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WHAT WOULD SUCCESS LOOK LIKE?

Successful co-innovation:

- Co-innovation = more than cooperation
- Relevant value proposition for ALL parties

Successful research outcomes:

- Regenerative farming systems are better defined and understood particularly around the role of carbon in soil and farm systems performance.

Successful soils CRC project:

- A platform for bringing together different knowledge / experience and enabling paradigm shifts.

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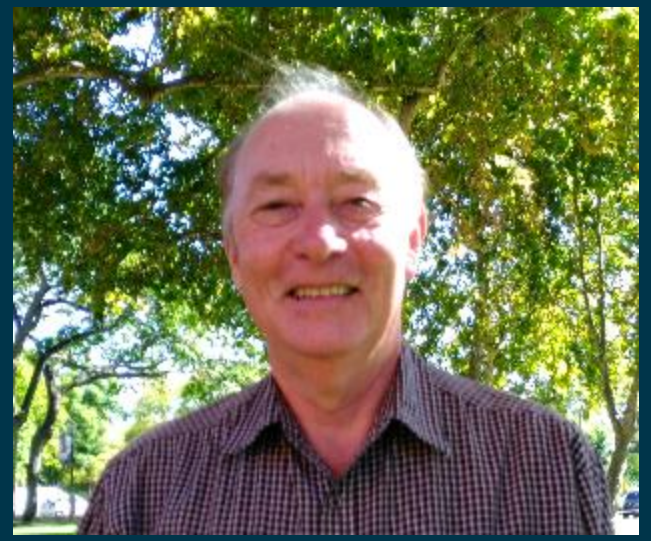
THANK YOU

Manaaki Whenua
Landcare Research

Government of South Australia
Primary Industries and Regions SA

wheatbelt natural resource management

SoilsForLife



INTEGRITY SOILS
The Biological Education Specialist

learning for sustainability
supporting collaboration and adaptation

SOIL CRC
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PROJECT 4.2.002

MECHANISTIC UNDERSTANDING OF THE MODE OF ACTION OF NOVEL SOIL RE-ENGINEERING METHODS FOR COMPLEX CHEMICAL AND PHYSICAL CONSTRAINTS

JASON CONDON
CHARLES STURT UNIVERSITY

Charles Sturt University

NSW GOVERNMENT Department of Primary Industries

VICTORIA State Government | Economic Development, Jobs, Transport and Resources

HART | CWFS Central West Farming Systems Inc. | RiverinePlains | BCG | FarmLink | FACEY GROUP Shaping the Future

SOiL CRC

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PROJECT TEAM

Mark Whatmuff
(NSW DPI)

Ehsan Tavakkoli
(NSW DPI)

Jason Condon
(CSU)

Roger Armstrong
(DEDJTR)

Helen Hayden
(DEDJTR)

Helen McMillan
(CWFS)

Eva Moffitt
(FarmLink)

Cassie Schefe
(Riverine Plains)

Sarah Noack
(HART FSG)

Sarah Hyde
(FACEY Group)

Cameron Taylor
(BCG)

BACKGROUND

- There is a history of conducting research to overcome singular soil constraints
- Benefits of interventions developed are ascribed to removal a constraint
- However, soils almost always exhibit multiple constraints, through the profile or in a horizon
- Interventions may have multiple effects (eg OM on structure, nutrient release, biology, pH)
- A better understanding of mechanisms acting to improve soils is needed to :
    - Create efficiencies of inputs (the right ameliorant, at the right rate, for the right problem)
    - Develop new technologies to rectify targeted constraints

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PROJECT AIMS

- Quantify and understand current and novel amelioration mechanisms to overcome multiple soil constraints
- Select best options for testing in field trials of future projects

PROJECT ACTIVITIES

- Grower groups to prioritise soils with multiple constraints for use in glasshouse/small plot experiments
- i) Pot trials to evaluate effectiveness of soil improvement strategies (relative to untreated control and that of current best practice)
- ii) Detailed mechanistic studies (chemical, physical and biological) and small scale field plot validation of best treatments from (i) .

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ENGAGEMENT AND COLLABORATION

- Identification of ameliorant requirements (Program 3, output 3):
  - New products can be developed to target mechanisms required to combat multiple constraints.

- Biophysical Modelling (Program 4, output 3):
  - Data generation for model development and/or validation
  - Rate responses of ameliorants to over come constraints

- Economic modelling (Program 1, output 3):
  - Quantification of production loss caused by multiple soil constraints
  - Economics of amelioration/re-engineering

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WHAT DOES SUCCESS LOOK LIKE?

- A soil can have its constraints characterised/ identified.
- Modes of action of amelioration are understood, with recommendations to Soil CRC for field evaluation
- the optimal combination of interventions can be recommended (via DSS) to increase performance of the soil

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