SOIL KNOWLEDGE FOR SUSTAINABLE GRAIN PRODUCTION

Summary – project development and progress, September 2016

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GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION

THE UNIVERSITY OF SYDNEY

Project title: *Enhancing human capacity for soil knowledge transfer and decision making for a sustainable grains industry*

GRDC project number: *US00069*

Take home message:

A need to improve soil knowledge for grains industry advisors was recognised (National Soil Research, Development and Extension Strategy). Stakeholder advice indicated that industry acceptance required:

- *Problem based learning, ideally on site*
- *Short course configuration, timed to suit industry schedules*

This led to the development of a learning program based on in situ workshop events (scenarios), where the focus is on unravelling perceived problems (soil constraints) with farmers and advisors, rather than learning a discipline. Extensive (app/ eBook) soil science reference material is available for participants to dig deeper or just satisfy their curiosity.

→ *Who we are, what we did, and why we did it*

→ *Where to from here – the next step*

→ *Detail – (a lot) more particulars about how we did it*

Who we are, what we did, and why we did it

Team (who we are)

Program Leader	Professor Alex McBratney
Chief Investigator	Dr. Damien Field
Chief Researcher	Dr. Derek Yates
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Project

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Background (why we did it)

The National Soil Research, Development and Extension Strategy –
'Securing Australia's soil for profitable industries and healthy landscapes'

↔ GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION

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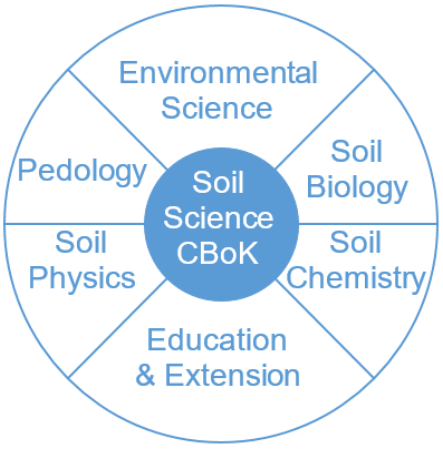
Soil education is a priority for new graduates and those working in industry

'a Core Body of soil Knowledge, skills and other factors (CBoK) relevant to sustainable grain production is required'



→ **23 soil science topics considered essential knowledge by academics from institutions teaching agriculture**

The grains CBoK (what we did)

Soil CBoK

What does the industry want ?

REFINE IT ! Advisors, Farmers, Teachers

23 → 13 topics,

Grains CBoK

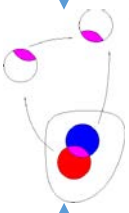
Soil reference material

CHECK IT !

Advisors
Farmers
Teachers

MAKE IT USEFUL/ AVAILABLE !

Soil reference material



REORGANISE IT ! Industry preferences

Farmers & advisors

Soil constraints, single issues, problem soils, YIELD!

5 concept groupings:

- **Soil water**
- **Crop nutrients**
- **Soil biology**
- **Systems/ management**
- **Variability**

MAKE IT WORK !

Farmers & advisors

Time constraints, value, local relevance

SCENARIO BASED LEARNING

- **Short, local focus**
- **Issues not discipline**
- **Farmer, advisor, expert involvement**
- **Credit/ accreditation**

Where to from here

SCENARIO BASED LEARNING

THE BUSINESS CASE

An (expanding) library of single issue scenario/ workshop learning experiences in soil science:

- Short, local focus,
  - marketable - conforms to GRDC/ industry preferences
  - fits RD&E desired outcomes
  - grains CBoK reference material
- Compliments traditional discipline focussed learning
  - field trips/ technical exercises
  - a component of courses/ research projects
  - build industry/ expert/ student relationships
  - transferrable to institutions/ remote markets
- Credit/ accreditation possibilities
  - credit points to appropriate AQF level subject/ course
  - specific constraint resolution 'licences'
  - align with SSA accreditation objectives

GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION

2017

- **Trial workshops, university farms, northern NSW, February 2017**
- **First workshop, Wagga Wagga April 2017**
- **Workshop series (3x1 day events), issues and locations by consultation with training providers, GRDC**
- **Continue development of resources and scenarios**

Detail

Informed by the National Soil RD&E Strategy.

The GRDC has found from an investigation in soil research development and extension that soil education is a priority for new graduates and those working in industry. Several reasons have been given.

- There has been a significant loss of skills and capacity in recent years, especially from government agencies, and this has not been replaced from other organisations
- New skills and information will be required to meet future challenges, such as food security

- Retiring experienced soil scientists are apparently not being replaced
- Users of soil knowledge need a strong integrated grounding in pedology, soil chemistry, soil physics and soil biology
- Users of soil knowledge also need to be able to integrate this with other disciplines relevant to agriculture and the environment to be able to apply meaningful solutions
- Skills needed include the ability to make evidence-based judgements to solve problems and clearly communicate solutions in context

To adequately advise growers in the grains industry, a core body of soil knowledge, skills and other factors (CBoK) relevant to sustainable grain production is required.

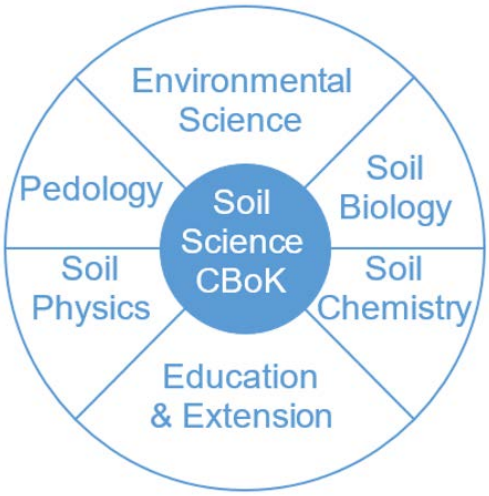
The CBoK should define the essential elements from traditional soil science disciplines, while drawing on related fields to maintain a strong industry or problem solving focus.

The figure below displays the traditional discipline areas that could contribute to a soil science CBoK.

A previous project with participants from Universities teaching soil science and companies performing tasks requiring soil science knowledge defined 23 topics or discipline areas required for a soil science CBoK.

This project will determine the required (grains) CBoK in consultation with the Australian Council of Deans of Agriculture, advisors, growers, consultants, academics, and the CPSS (Certified Practicing Soil Scientist) professional body.

The resulting CBoK along with suggested customisable teaching methods will be available to all Australian universities teaching soil as part of the undergraduate curriculum. This should ensure a lasting legacy for the training of soil scientists, agronomists and advisors needing core soil science skills.



In addition and as a high priority, the CBoK will be made available to in- service industry advisors who may not be graduates from a soil program.

Program

To achieve the outcomes stated above, the program of activities (2014 to August 2016) was:

1. Forum 1
    a. An initial stakeholder meeting designed to define appropriate teaching material content and potential delivery methods
    b. Consultant interviews
    An attempt to obtain information similar to forum 1 from industry personnel not included in forum 1

2. Soil Science Australia input
    a. Consultations with soil science professionals, testing their assessment of information provided by forum 1

b. Mapping of professional soil science accreditation requirements with teaching material defined by forum 1
c. Consultations with soil science professionals testing their opinion on ways to improve advisor knowledge

3. Development of teaching material and teaching framework based on stakeholder input (activities 1 and 2)

4. Forum 2
   A stakeholder update, presenting (for discussion):
   a. a draft example of teaching material and
   b. a proposed teaching framework

5. Further refinement or redefinition of the teaching material and framework developed prior to forum 2.

1. Forum 1

'Enhancing human capacity for soil knowledge transfer and decision making for a sustainable grains industry'
Project working title: 'Soil knowledge for grains'.
Venue: Room 422 biomedical building, ATP.
Date: 23rd April 2014

Participants

- Australian Council of Deans of Agriculture (ACDA)
- Grains Research and Development Corporation (GRDC)
- Soil Science Australia (SSA) - Certified Professional Soil Scientist (CPSS) board members
- Growers

Attendance

Industry/ institution		represented
ACDA	Charles Sturt University	yes
University	Curtin University	yes
list	James Cook University	
	La Trobe University	yes
	Murdoch University	
	Southern Cross University	
	University of Adelaide	yes
	University of Melbourne	yes (2)
	University of New England	yes
	University of Queensland	yes
	University of Southern Queensland	
	University of Sydney	yes
	University of Tasmania	
	University of Western Australia	
	University of Western Sydney	yes
SSA (CPSS)		
Farm	NSW	yes (2)
GRDC	North (NSW)	yes

Due to the difficulty for Advisors to commit time to events not directly work related, 8 of 50 advisors contacted were interviewed, as summarised below.

	Company	City	State	Role[1]
1	Landmark	Goulburn	NSW	agronomist
2	McGregor Gourlay Agricultural Services	Croppa Creek	NSW	
3	Dalby Rural Supplies Pty Ltd	Dalby	QLD	agronomist
4	Alltech Crop Science	Dandenong South	VIC	advisor, sales
5		Korora	NSW	
6	Planfarm	Geraldton	WA	agronomist, consultant
7	Bedbrook Johnston Williams	Wembley	WA	consultant
8	ConsultAg	Dongara	WA	agronomist, consultant

[1] 'Role' was assigned by University of Sydney staff, and is only an indication of the advisors' perceived role.

Important SS CBoK items as selected and ranked by various forum participants.

SS CBoK items (numbers from original list, in order of perceived importance)		Noted by
	From forum – 3 groups	
4	Understand the basic soil chemical components (e.g. macro and micro elements/nutrients), properties (e.g. CEC, pH) and process (e.g. surface exchange) and relate these to chemistry concepts and the periodic table	3/3
7	Understand soil physical properties and characteristics (e.g. texture, porosity, temperature, structure, stability, strength)	3/3
10	Understand how soil water is measured, (lab and field instrumentation), how data is expressed (e.g. units) and used in soil water concepts (i.e. AWC, hydraulic conductivity, etc.)	3/3
15	Explain how soil physical properties affect different soil behaviours and create different soil environments in terms of structure and its effect on processes	3/3
16	Understand how soil water affects soil properties and how to design sampling strategies and its assessment, including water holding capacity, hydraulic conductivity, etc.	3/3
22	Be able to explain in writing and/or verbally the meaning and importance of various soil measurements to a range of different audiences	2/3
	From interviews – 8 advisors	
4		7/8
6	Explain how soil chemistry contributes to soil problems, such as alkalinity, acidity, and problem soils e.g. Acid sulphate soils	7/8

9	Understand the soil ecology, including the soil-root interface	3/8
22		3/8
16		2/8

In relation to issues or problem, defined at forum or in interview

3	Understanding soil variability and how this affects soil sampling and mapping	3/3
4		3/3
7		3/3
16		3/3
22/ 23	Be able to design and conduct an experiment to evaluate the importance of different factors in plant production (e.g. earthworms, organic matter, salt, water status, etc.)	2/3

Described as missing, in relation to issues or problems, forum 1

1	Soil Landscapes and soil forming processes	2/3
2	Describe and classify soil profiles in different landscapes and environments	2/3
6		2/3
18	Understand how soil chemistry is managed	2/3

Teaching the new Grains CBoK

The following points emerged in regard to forum participants' views about teaching a grains CBoK :

Note the use of words such as subject does not imply any structure or relationship with existing teaching material or methods.

- Subject(s) should be available for online learning
  - There should be some form of residential component, involving practical or problem solving exercises, encouraging participant interaction and communication
- Subjects / courses should be at certificate level (initially)
  - Some form of accreditation or licencing is necessary to make the subject(s) worthwhile
  - GRDC is keen on the subject(s) being at least part of or capable of contributing to a degree program
  - Subjects should be project based, possibly involving participant's work issues or focus
- Subject(s) should be available for part time study
  - Possibly investigate existing short courses or workshops, would an intensive three day (for example) course be an option ?

2. SSA input

Ranking essential soil science CBoK topics and delivery

As an extension of forum 1, twenty three members of the Soil Science community not included in forum 1 were asked to rank the importance of a combination of CBoK topics, industry related issues and grains CBoK delivery options.

Venue: NSW BRANCH, ORDINARY GENERAL REGIONAL MEETING: Bathurst (Panthers Club)
Date: 10th to 11th July 2014
20 people attended the meeting, 11 of whom participated in the exercise.

All matters to be ranked were indicated as relevant to the CBoK, industry issues/ problems and delivery options at forum 1 and/ or subsequent advisor interviews. The topics based on the most significant soil science CBoK items selected were:

1. Interpretation of soil test results
   [encompassing the five most significant Soil Science CBoK topics and the two most important industry issues]
2. Pedological interpretation
   [encompassing the top two and third most significant Soil Science CBoK topics and the second most important industry issue]
3. Interactions between soil properties and management
   [encompassing the six most significant Soil Science CBoK topics and all important industry issues]

Additional topics which were highlighted as problems for the industry or mentioned by participants were:

4. Soil at depth (subsoil) properties, particularly constraints and their diagnosis and amelioration
5. Critical levels of nutrients under different conditions and soil types
6. Interaction of roots, soil microbial populations, and root lesion nematodes
7. Information for measuring and managing soil carbon

Participants were also asked to rank options for delivering the teaching material. While no framework had been formalised, various preferences had been expressed by participants at forum 1, relating (for example) to timing and duration (see 'Teaching the new Grains CBoK').

Suggestions for teaching material and methods were rated from highly important to not important, by participants, using a Likert style scale (rank out 5, highly important to not important).

Rankings summary

The soil science industry rankings reinforced the findings from forum 1:

- The topic based on the most significant soil science CBoK topics from forum 1 was rated highest ('interpretation of soil test results')
- Topics also based on significant soil science CBoK topics from forum 1 were rated higher than other topics that were mentioned at forum 1 or in interviews, but were less well defined such as 'nutrients' and biology'
- Delivery of the material should be in short, issue based format

CPSS competency mapping to grains CBoK

In consideration of the stated appeal of some form of certification or accreditation outcome for the grains CBoK training (forum 1), any correlation between professional soil science accreditation and the teaching material being developed to suit a grains CBoK needed definition.

Soil Science Australia (SSA) provides a list of 'minimum professional competencies required by soil scientists working on environmental and agricultural problems in Australia.' These competencies form the basis of the Certified Professional Soil Scientist (CPSS) accreditation exam. CPSS competency areas are listed in the document 'Certified Professional Soil Scientist PERFORMANCE OBJECTIVES Soil Science Australia Fundamentals Exam Effective October 1 2013 '.

The 582 competencies, grouped 45 into competency areas, were examined and rated by the research team for relevance to a grains Core Body of Knowledge (CBoK). Competency areas with at least 1 competency judged to be an essential component of the grains CBoK, and therefore the most relevant for advisors to the grains industry to understand, were selected.

Fifty delegates at the SSA Melbourne conference in November 2014, from all states except Tasmania were asked to validate the list of competency areas, deleting any they thought unimportant.

While all competency areas were generally included as relevant, the competency areas judged as relevant by all of the participants were (also showing relation to previously designated significant Soil Science CBoK topics, numbers as above):

competency	soil science CBoK topics
Roles of Nutrients in Plants and their Availability in Soils	4
Nutrient Management	4
Soil-Water Relationships	10
Water Movement and Transport Processes	10, 16
Soil Organic Matter	4, 9

Improving advisor knowledge

As part of a separate session at the Melbourne SSA conference, 25 delegates were asked to provide advice on 'improving soil science knowledge amongst agronomy advisors for grain production'. They were presented with the following scenario:

> *A colleague who is an agronomy advisor has approached you about wanting to improve his soil science knowledge because he is concerned that he doesn't know enough about the soil when giving management advice to grain growers.*

The delegates sorted the suggestions into the following order of decreasing preference (letters refer to original list order):

1. (C) Seek a local mentor who has good soil science knowledge
2. (D) Enrol in the 2-day intensive soil science refresher course for agronomists at the nearest university
3. (A) Buy a soil science textbook
4. (B) Enrol in a post-graduate soil science degree at the nearest university
5. (E) Undertake the CPSS Competency Exam for soil scientists
6. (F) Stop giving soil management advice

80% of delegates ranked C or D as 1 or 2

3. Teaching material & framework

Stakeholder input provided a list of soil science CBoK items considered essential for the grains CBoK and therefore the teaching material to be developed, as noted above.

Stakeholders also clearly stated that CBoK delivery should be in a short, issue based format, relevant to local problems. It was believed that this approach would demonstrate the value to the potential target audience, who, at this stage, had been defined as industry advisors. It was therefore appropriate to understand the relationship between the CBoK items and industry issues and terminology.

Content

From this background, the research team developed a set of issue based topics or unifying concepts, which allowed the material to be arranged under headings which directly relate to industry. For example, 'Subsoil constraints act to prevent the crop from making full use of potential water and nutrients in the profile' (Price, 2010). Clearly 'water' and 'nutrients' represent unifying concepts relevant to the industry.

The soil teaching material will therefore be categorised relevant to soil science knowledge for problem solving in these unifying concept or topic areas:

1. Soil water
2. Crop nutrients
3. Soil biology
4. Systems/ management
5. Variability

The first three themes, water, nutrition and biology can be dealt with in a traditional manner, with quite specific content written or compiled as required, relating to identifiable soil properties which are the focus of soil testing.

The management and variability themes have two roles as part of the teaching material:

1. To define topics requiring specific tools or technologies, e.g. precision agriculture,
2. To provide entry points for users into the learning system, reducing 'background reading' and avoiding information that users already understand or know is not relevant

The table below lists the CBoK items with simplified descriptions and the appropriate concept area groupings.

Soil science CBoK items 22 and 23, while considered significant by stakeholders are considered to be professional development items not applicable to specific soil science knowledge essential to grains industry advisors. They were therefore omitted from the teaching material in terms of identifiable subject matter.

Item	topic / discipline area	**grouping**
1	Soil Landscapes and soil forming processes	**variability, biology**
2	Soil profiles in different landscapes and environments	**variability, systems**
3	Understanding soil variability	**variability, systems**
4	Basic soil chemical components, properties and process	**nutrients**
6	Soil chemistry, soil problems, and problem soils	**nutrients**
7	Understand soil physical properties and characteristics	**nutrients, water**
9	Understand the soil ecology, including the soil-root interface	**biology**
10	Understand soil water its measurement and use (AWC etc.)	**water**

15	Soil physical properties, behaviours, effect on processes	**nutrients**, **water**
16	How soil water affects soil properties, sampling strategies	**water**
18	Understand how soil chemistry is managed	**nutrients**

The teaching material is intended to be a resource to support learning the soil science knowledge necessary for sustainable grain production. As such the most basic resource is an electronic document utilizing extensive linking and referencing to component and external reference, instructive or illustrative material. The extensive reference material will be included as links to freely available material wherever available, online or as local copy, ensuring that all relevant material is available to users.

Scenarios – soil constraints

The themes defined above allow concentration of learning material into subject areas familiar to users and relevant to existing resources and literature, a framework within which soil knowledge can be housed.

However, the Sydney Forums and other stakeholder consultation indicated that the preferred form of learning was short 1, to 3 day sessions relevant to local issues, and worked examples demonstrating problem solving.

To match this stakeholder preference, learning scenarios will be used to focus the appropriate learning material on specific issues of local significance to users. For example acidity and compaction are two issues commonly accepted as soil constraints to agriculture.

While the fundamental soil knowledge involved in or relevant to remediation of these constraints may be universally applicable, local resolution will depend on local conditions (soil type, climate) and management influences such as cost of materials/ transport.

It is anticipated that development of scenarios will be a long term program, with the scenarios becoming another component of the GRDC knowledge library. In practice, the scenarios will involve local workshops to:

- examine the local soil
- discuss the issue with practitioners and suitable specialists
- explore options for constraint resolution or remediation

A scenario proforma has been developed to allow definition of the material required and design of the scenarios. This proforma is an MS WORD form, which users can complete when considering the development of a new scenario.

4. Forum 2

‘Update and consultation on GRDC ‘soil knowledge for grains’ project: current outcomes and future developments’

Venue: Room 422 biomedical building, ATP.
Date: 8th April 2015

Participants:

As for forum 1, representatives from ACDA, CPSS, GRDC and advisor communities were invited.

All forum 1 attendees were invited.

Attendance

Company Name	Forum 1 participant	attendance
University of Queensland		✓
University of Adelaide		✓
University of Tasmania		✓
University of Western Australia		✓
SSA		✓
University of Melbourne		✓
University of Melbourne		✓
La Trobe University		✓
Charles Sturt University	✓	✓
GRDC	✓	✓
Curtin University	✓	✓
University of New England		✗

Discussion/ feedback

Mentors

- Value of mentors appreciated
- Soil Science Society as a source of mentors?

Project Book

- book demo well received, positive aspects:
  - structured so that users explore depth in relation to personal need
  - users pick what they want to know about
  - online
  - relevant topics
  - hyperlinks connecting materials
  - worked examples
  - real-world issues
  - include scenarios
  - include multimedia
  - must be regularly updated
- Ideally one place for all relevant soil science info – not widely distributed as at present; all to be on the GRDC website in "Knowledge Library"

Scenarios

- Scenarios–Resources–Assessment was a new concept that challenged the participants but they took to the idea
- 'they would work provided the Book was available', and building the scenarios will take time
- Scenarios themselves are a resource
- Scenarios linked with real-world pits
- Ability for advisors to upload their own scenarios, including photos and videos
- Include high-yield sites not just problem sites

Further consultations

- **Unanimously considered as unnecessary and definitely don't interview individual growers**

- Could use adult learning specialists ICAN – specifically John Cameron – (http://icanrural.com.au/about.html) to road test work produced

Training model

- Proposal (short duration with face to face, field and online) may not fit the university business model; there are no short (days) university courses
- Book and scenarios will be part of "GRDC Knowledge Library"
- CPSS exam may work; Fertilizer Industry Federation of Australia (FIFA) uses FertCare exam for accreditation and leads to better fertiliser decisions
- CPSS writing to universities to ask them [in SS 101] to align with CPSS exam

5. Refinement/ redefinition

The stakeholder feedback from forums 1 and 2 indicated that:

- The teaching material developed and presented was suitable
- The teaching framework of scenario workshops or learning experiences was appropriate for in service advisor training
- The teaching framework may require some modification or reorganisation to suit university subject requirements

From this background, the following tasks emerge:

1. Ongoing development and completion of teaching material content
2. Ongoing development of teaching scenario model

Current documents

The electronic document referred to above is manifest as a document entitled 'Soil knowledge for sustainable grain production 1 – reference text'. The document is available in MS WORD, ADOBE PDF and electronic publication (EPUB) formats.

As a first step towards modularization, to make the material available in topic or chapter formats, the document is also available as an MS WSORD Master document. A master document is a container for a set of separate files (or subdocuments) which can be used to set up and manage a multi-part document, such as a book with several chapters. The topic areas, or chapters in the original document are available as separate files referenced by the master document.

The orientation of the resource and teaching framework is that the material will provide the knowledge about soil required by growers and advisors to optimize the productivity and sustainability of their enterprises. Soil parameters or properties considered in this document are restricted to those commonly included in soil tests, documented in readily available source material and/ or accepted as common knowledge by industry operators.

This document is intended to serve as a reference for an issue based, locally focused, short course or modular style learning process. Scenarios relating to topics of significance to users will be used to identify key soil knowledge areas or techniques required for problem resolution or as examples of best practice.

These scenarios and knowledge themes can be developed into subject modules suitable for gaining credit towards entry into more formal tertiary courses, or used as components of such courses.

One scenario example has been prepared, available in a document entitled ‘Soil knowledge for sustainable grain production 2 – acidity scenario’, which is also available in MS WORD, ADOBE Portable Document Format (PDF) and EPUB formats.

As noted above, a scenario proforma document has also been created. The proforma demonstrates the information required for new scenario development, including learning objectives as well as scenario content and subject material. This approach will standardise the scenarios and cast the material as subject matter in a format suitable for inclusion into more formal, extended learning programs. This document will be available as an ADOBE PDF form.

The possibility of using ‘app’ style data presentation and collection methods for scenarios is being investigated.

References

Price, P. (2010). Combating Subsoil Constraints: R&D for the Australian grains industry. *Australian Journal of Soil Research* **48**, I-Iii.