Delivery of soil survey information to non-soil specialists to support land management by means of special purpose classifications and conceptual toposequence models

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Abstract

The link between soil information and good decisions about land use and management, or even the recognition that a decision is needed and that soil information can play a role, needs to be improved. The link between soil information and applying it is critical to maximise the use of the soil resource in a sustainable way.

Good management decisions require correct and understandable soil information for a location; confusing and inappropriate data can lead to suboptimal practices. Uncertainty about appropriate management arises because soils are highly variable both spatially (horizontally and vertically) and temporally. To support land management decisions that are generally made by non-soil specialists, information about the soil needs to be delivered in a format that they can understand, afford and apply.

The aim of this work was to deliver soil information to improve land management by development of an approach to convey soil survey information by means of special purpose soil classifications and conceptual toposequence models. The approach is presented to: (i) salvage and reinterpret valuable soil survey legacy data from the plethora of detailed published soil survey technical reports and their numerous appendices of quantitative and qualitative data for future science and (ii) deliver complex or intricate soil survey information to non-soil specialists using a vocabulary and diagrams that they can understand.

This was achieved by re-interpreting soil survey data in a framework comprising special purpose soil classifications and conceptual toposequence models for specific geographic regions and/or practical applications. The process involved an experienced soil surveyor to acquire and interpret conventional soil data. Then to distil the highly technical soil survey information into a format for a non-soil specialist audience, by constructing simple but readily understandable descriptive conceptual toposequence models and to develop a soil identification key. The soil identification key honours the same international (or national) classification sequence but is constructed in plain language that non-technical people understand and can apply to determine soil types. Soil types classified using the special purpose soil classification systems are correlated to formal international and national soil classification systems allowing technical soil property data and land suitability evaluations to be applied.

To illustrate the wide applicability of this approach, case studies were conducted in three different parts of the world – Kuwait, Brunei, and Australia, each of which exhibit vastly different landscapes, climates, soil types and land use problems. The studies were driven by demands to

contribute to on-going projects, having a direct impact on current and significant investment decisions.

This thesis is submitted in the publication format through six papers as thesis chapters. The chapters and their objectives are as follows:

Chapter	**Delivery objective**	**Location**	**Landscape** *Climate*	**Information is used for**
2	The delivery approach	Diverse	Diverse *Diverse*	Overview of approach, conceptual toposequence models.
3	Improve food security	Brunei	Hill slopes *Tropical*	Recognition of soil types to guide suitable crop selection and their management.
4	Minimise impact on environment	Brunei	Flat *Tropical*	Recognition of acid sulfate soils for the first time here, allows options for management to be prepared.
5	Mitigate land degradation	Kuwait	Desert *Arid*	Rangeland restoration by targeting vegetation communities to soil types to improve success.
6	Maintain water quality	Australia	Wetlands *Mediterranean*	Distribution of acid sulfate soil to assist with wetland management, particularly during drought.
7	Rescue legacy soil survey information	Brunei, Kuwait, Australia	Diverse *Diverse*	Summarizes and describes findings.

The approach improved the delivery of soil information by addressing issues that included: communication - through the use of plain language and simple words; scale - using diagrams to mimic the landscape; identification of soils – by using readily recognisable observable soil features; technology transfer – by associating local soil types with national or international taxonomic soil classifications; and timely –achieved by reworking legacy soil survey data.

Uptake of the information to answer current questions is discussed in the case studies and confirmed the value of this approach for presenting soil survey information in a user friendly non-technical format that a non-soil specialist audience understood.

The approach developed and used is applicable to other locations throughout the world outside of: (i) Brunei, especially in tropical landscapes, (ii) Kuwait, especially in arid and semi-arid landscapes and (iii) Australian winter rainfall landscapes, especially in Mediterranean landscapes - in order to establish similar local classifications and conceptual models.

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Structure of this Thesis

The University of Adelaide encourages the publication of papers during candidature and permits theses to be presented as a collection of published papers. This thesis is submitted in the publication format consisting of five papers and a book chapter (Chapters 2 to 7), plus four refereed and published conference proceedings papers included in the Appendix.

Chapter 1 provides an overview of the need for soil survey information, decision maker requirements, and what part of the soil information delivery this thesis addresses. The objectives and aims of this research are presented.

Chapter 2 provides an overview of the conceptual toposequence model approach, demonstrating how toposequence models describe, explain and predict soil variability in a range of complex landscapes and used to deliver soil information to non-technical users.

Chapter 3 describes the approach to aid the translation of soil survey information into a form suitable for a non soil specialist audience demonstrated with a case study from the hill country of Negara Brunei Darussalam. The soil types are linked to international soil classifications that allow information about crops and their management to be applied, thereby assisting with improving Brunei food security.

Chapter 4 describes for the first time formal recognition of a diverse range of acid sulfate soils in Brunei. Soils were characterised and conceptual soil hydro-toposequence models together with a soil identification key helped to visualize and illustrate the complexities in this low relief landscape. This assisted with targeting management practices towards these potentially hazardous soils.

Chapter 5 applies the approach presented in previous chapters to guide non-soil experts with identifying soil types in Kuwait. Supporting rangeland restoration program that targets the planting of vegetation communities according to identified soil types, assisting with mitigating land degradation.

Chapter 6 demonstrates the approach to provide an understanding of acid sulfate soil distribution for a large regional area of wetlands associated with the River Murray in South Australia, how to recognise these soils and their likely distribution. Supporting the prioritization of areas to be monitored and development of management plans to maintain wetland and river water quality.

Chapter 7 brings the findings from the case studies together, describing the generic approach, the benefits, limitations, possible improvements, and the philosophy underpinning the approach.

Publications arising from this Thesis Research

Included as Chapters forming part of the Thesis work (as senior author)

Grealish G.J., R.W. Fitzpatrick, P. King, S.A. Shahid. 2013. Conceptual Soil-regolith Toposequence Models to Support Soil Survey and Land Evaluation. In: S.A Shahid, F.K. Taha, M.A. Abdelfattah (Eds.), *Developments in Soil Classification, Land Use Planning and Policy Implications: Innovative Thinking of Soil Inventory for Land Use Planning and Management of Land Resources.* Springer Science+Business Media Dordrecht. pp. 165-174. DOI: 10.1007/978-94-007-5332-7_7. Presented as Chapter 2 in this thesis.

Grealish G.J., R.W Fitzpatrick. 2014. Assisting nonsoil specialists to identify soil types for land management: an approach using a soil identification key and toposequence models. *Soil Use and Management* 30: 251-262. DOI: 10.111/sum.12108. Presented as Chapter 3 in this thesis.

Grealish G.J., R.W. Fitzpatrick. 2013. Acid sulphate soil characterization in Negara Brunei Darussalam: a case study to inform management decisions. *Soil Use and Management* 29: 432-444. DOI: 10.1111/sum.12051. Presented as Chapter 4 in this thesis.

Grealish G.J., R.W. Fitzpatrick, S. Omar Asem. 2015. Assisting non-soil experts to identify soil types for land management to support restoration of arid rangeland native vegetation in Kuwait. *Arid Land Research and Management* 29:3, 285-305 DOI: 10.1080/15324982.2014.973620. Presented as Chapter 5 in this thesis.

Grealish G.J., R.W. Fitzpatrick, P. Shand. 2014. Regional distribution of acid sulfate soils in wetlands during severe drought along the Lower River Murray, South Australia: A synthesis to support management. *Geoderma Regional* 2-3: 60-71. DOI: 10.1016/j.geodrs.2014.10.003. Presented as Chapter 6 in this thesis.

Grealish G.J., R.W. Fitzpatrick, J.L. Hutson. 2015. Soil survey data rescued by means of user friendly soil identification keys and toposequence models to deliver soil information for improved land management. *GeoResJ.* 6: 81-91 Special Issue Rescuing Legacy Data for Future Science . DOI: 10.1016/j.grj.2015.02.006. Presented as Chapter 7 in this thesis.

Additional directly related conference proceedings papers refereed and published, included for reference in the appendix of this Thesis (as senior author)

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Grealish G., A. Ringrose-Voase, R.W. Fitzpatrick. 2010. Soil fertility evaluation in Negara Brunei Darussalam. In: R.J. Gilkes, N. Prakongkep (Eds.). *Proceedings of the 19th World Congress of Soil Science; Soil Solutions for a Changing World,* 1-6 August 2010, Brisbane, Australia. pp 121-124.

Grealish G., R.W.Fitzpatrick, P. Shand. 2010. *Acid sulfate soil toposequences in wetlands of the Lower River Murray.* In: R.J. Gilkes, N. Prakongkep (Eds.). *Proceedings of the 19th World Congress of Soil Science; Soil Solutions for a Changing World,* 1-6 August 2010, Brisbane, Australia. pp 17-20.

Grealish G., R. Fitzpatrick, P. Shand. 2012. Wetland acid sulfate soil distribution between Blanchetown (Lock 1) and Wellington, Murray River – is there a pattern to investigate? In: L.L. Burkitt, L.A. Sparrow (Eds.), *Proceedings of the 5th Joint Australian and New Zealand Soil Science Conference*, Hobart, Tasmania. pp. 67-70. ISBN: 978-0-646-59142-1

Additional directly related major reports refereed and published, but not included in this Thesis (as senior author)

Grealish G., R.W. Fitzpatrick, P. Shand. 2010. *Acid sulfate soil assessment of wetlands below Blanchetown (Lock 1), River Murray, South Australia.* CSIRO Water for a Healthy Country National Research Flagship. 210 pages.

Grealish G., R.W. Fitzpatrick, P. Shand. 2011. *Assessment of Acid Sulfate Soil Materials in the Lock 1 to Wellington Region of the Murray-Darling Basin.* Prepared by CSIRO Water for a Healthy Country National Research Flagship for the Murray-Darling Basin Authority (MDBA). Murray-Darling Basin Authority (MDBA). Report & Appendix B1 – B5, 545 pages.

Grealish G., P. Shand, S. Grocke, A.K. Baker, R.W. Fitzpatrick, W. Hicks. 2010. *Assessment of Acid Sulfate Soil Materials in the Lock 1 to 5 Region of the Murray-Darling Basin.* Prepared by CSIRO Water for a Healthy Country National Research Flagship for the Murray-Darling Basin Authority (MDBA). Report - summary overview, & Appendix B1 – B4, 756 pages.

Other relevant additional refereed conference proceedings papers (as co-author)

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Fitzpatrick R.W., **G. Grealish,** A. Chappell, S. Marvanek, P. Shand. 2010. *Spatial variability of subaqueous and terrestrial Acid Sulfate Soils and their properties, for the Lower Lakes, South Australia.* CSIRO Sustainable Agriculture National Research Flagship Client Report R-689-1-15, 122 pages.

Fitzpatrick R.W, **G. Grealish**, P. Shand, R. Merry, N. Creeper, M. Thomas, A. Baker, B. Thomas, W. Hicks, N. Jayalath. 2010. Chip-tray incubation – a new field and laboratory method to support Acid Sulfate Soil Hazard Assessment, Classification and Communication In: R.J. Gilkes, N. Prakongkep (Eds.). *Proceedings of the 19th World Congress of Soil Science; Soil Solutions for a Changing World,* 1-6 August 2010, Brisbane, Australia.

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King P., **G. Grealish**, S.A. Shahid, M. Abdelfattah. 2013. Land Evaluation Interpretations and Decision Support Systems: Soil Survey of Abu Dhabi Emirate. In: S.A Shahid, F.K. Taha, M.A. Abdelfattah (Eds.), *Developments in Soil Classification, Land Use Planning and Policy Implications: Innovative Thinking of Soil Inventory for Land Use Planning and Management of Land Resources*. Springer Science+Business Media Dordrecht. pp. 147-164. DOI 10.1007/978-94-007-5332-7_6.