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ASRIS / ACLEP User Needs Analysis

Australian Collaborative Land Evaluation Program

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Auricht Projects

ASRIS / ACLEP User Needs Analysis

Final Report

2011

aclep
Australian Collaborative Land Evaluation Program

The Australian Soil Resource Information System (ASRIS)

ASRIS collates and maintains the best available, nationally consistent soil and land resource information for Australia. It provides a scientific information infrastructure for assessing and monitoring the condition of Australia's soil and land resources.

Using ASRIS

ASRIS contains a set of spatial and temporal databases that maintain national soil and land information in a consistent and usable format.

Commonly requested data and information are displayed through an online geographic information system using coloured maps, photographs, satellite images, tables and graphs (www.asris.csiro.au).

The ASRIS mapping website supports a broad range of users including natural resource managers, educational institutions, planners, researchers, and community groups. Users can zoom into a region of interest, turn data sets on and off, produce customised maps and print the results. ASRIS works best with a broadband connection and complies with standards for online geographic information so is compatible with many of the rapidly expanding data sources available via the Internet.

Complex analysis and integration of ASRIS and other data for national assessments is done collaboratively by CSIRO and other partners.

The ASRIS web mapping interface showing data relating to landforms, geological regions and the location of analysed specimens.

Partners

Australian Government, state and territory agencies co-operate through the Australian Collaborative Land Evaluation Program (ACLEP) (www.clw.csiro.au/aclep) to maintain and improve ASRIS. ACLEP is a partnership between CSIRO; the Australian Government Department of Agriculture, Fisheries and Forestry; and the state and territory agencies responsible for land resource assessment.

CSIRO

Australian Government Department of Agriculture, Fisheries and Forestry

www.asris.csiro.au

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Disclaimer

The views represented in this publication may not be shared by any or all of the members of the National Committee on Soil and Terrain or any of the State, Territory or Australian Governments.

The information contained in this publication is intended for general use by ACLEP and the NCST to help improve the sustainable management of Australian soil resources. It includes general statements based on the findings of interviews and scientific / policy research conducted by the authors. Readers are advised and need to be aware that this information may be incomplete or unsuitable for use in specific situations. Prior to taking any action or decision based on the information in this publication, readers should seek expert professional, scientific and technical advice.

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Preface from ACLEP

The Australian Collaborative Land Evaluation Program (ACLEP) commissioned this report to provide direction for the future development of national soil data products so that they would meet specific user requirements and be applicable to a broad range of soil data users.

The National Committee on Soil and Terrain (NCST) guides the strategic directions and annual workplan of ACLEP. Following presentation of this review to the NCST, ACLEP was asked to formulate a list of recommendations. For future consideration and action, these are listed below:

- ACLEP should develop an initial set of national soil data products at a grid resolution of 250m to be based on the best data sets currently available in the Australian Soil Resource Information System (ASRIS). These products should provide attributes and depths commonly used for soil carbon modelling and accounting and then be extended to include those attributes proposed by GlobalSoilMap.net (http://www.globalsoilmap.net/), the Terrestrial Ecosystems Research Network (TERN) Soil and Landscape Facility and other users.
- National soil data products should be 'endorsed' through a process implemented by the NCST, as authoritative national estimates of soil properties. ACLEP should facilitate a process of continual improvement for these products and release future versions. National soil data products should be made available for public download from the ASRIS website under licensing with minimal restrictions on access and use.
- ACLEP should initiate a national collation of available soil site data to assist future modelling and improvement of national soil data products. This could initially deliver just the site location and ownership/attribute metadata so that users could readily discover potentially available data. Eventually, it would include a minimum data set consistent with requirements for input to digital soil mapping, modelling and validation of key soil attributes.
- ACLEP should refine existing ASRIS soil site data models and collate available national site data within this new framework, including capacity to include monitoring data and other observations not adhering to traditional soil survey/classification site concepts (i.e. Soil and Land Field Survey Handbook – "the Yellow Book" NCST 2010). The national site data collation should be made available to other users following clearance from relevant state agency representatives where required.
- ACLEP should collaborate with the TERN Soil and Landscape Facility, GlobalSoilMap.net and other initiatives to further refine the spatial and temporal components of national soil data products and promote NCST endorsed soil data as part of a national environmental information infrastructure.

Peter Wilson

ACLEP Coordinator

CSIRO Manager, National Soil Information.

June 2011

Executive Summary

This report documents a project to assess '*existing needs'* of key users of the Australian Soil Resources Information System (ASRIS). In particular the attributes of soil that would be most relevant to their particular need.

The project was not an exhaustive evaluation of all users' requirements within a structured framework nor was it a technical review of the ASRIS delivery mechanism, or an exercise to provide quantitative information. Its primary purpose was to capture and identify the needs of some 'key' users - in the form of a report documenting the broad 'current and developing' capacity of ASRIS to deliver key datasets and products, to provide a gap/fit type analysis, and identify any consistent issues.

Several methods were employed to obtain background information and ensure the efficient delivery of milestones. These included the following:

- *Governance and Reporting* related issues – on-site visits to Canberra, plus email and phone hook-ups for consultation re; the approach (work plan), stakeholder interview process, and reporting.
- *Desktop review* – collation of existing jurisdictional, national and international documentation on soil and land resource needs, plus information available on web sites and other initiatives.
- *In-depth Interviews* – held in person or via phone conservation with 'key' users.

The approach provided the information base from which a synthesis of existing user needs was undertaken and the identification of 'key issues'. Note: although data and information delivery aspects were not within the scope of this project numerous comments were received from stakeholders on this topic. Where relevant these comments were integrated into the report.

Main Findings

1. Most users agree with and require information pertaining to the key soil attributes delivered (current and proposed) by ASRIS. Information requirements that are currently not met by ASRIS occur with respect to soil moisture, nutrition, toxicity, biology and carbon (and associated fractions).
2. The ongoing collection of site information is considered essential.
3. Users want an easily accessible source of nationally consistent, authoritative, trusted, and well documented soil attributes available as downloadable data sets.
4. ACLEP, through the NCST, should provide authoritative national soils data through ASRIS, or risk users developing and propagating their own, potentially resulting in a plethora of possibly conflicting national data. Until ASRIS becomes a transparent and rigorously defined database (i.e. the point-of-truth), modellers will continue to require access to raw (primary site) data and continue to develop their own derived information and data surfaces.
5. ASRIS should provide links to comprehensive meta-data, including method descriptions, error and uncertainty and input source data (especially as it relates to any derived data layers) so that users can assess the fitness for purpose of national data and further refine data sets for their specific needs. In this respect 'errors and variation' within a polygon, or within any grid surface, should be clearly defined and undertaken by soil specialists – not users of the information.

6. ASRIS should link to information sources considered appropriate to support key contextual or reference needs (e.g. land cover, land use, land management, remote sensing, and other key natural resource databases e.g. NVIS, climate, water resources), but should not attempt to become the point of truth for these datasets.
7. The current ASRIS web interface is problematic for many users and frustrating as it provides only limited direct access to data.
8. The general understanding of the full scope of ASRIS data managed by ACLEP is low.

Opportunities and Challenges

The current review identified a number of opportunities and challenges. These include:

1. Providing more information on soil site location. The location of all sites (and associated custodian agency) should be displayed as a layer – even if the related data is not held on ASRIS.
2. Many key researchers extract site information and reformat it within their own databases to suit their particular application. Access to site information is a key element and improved functionality needs to be addressed.
3. Soil biological information (particularly microbial biomass) is not currently held in ASRIS and this should be considered.
4. The current ASRIS web-site is a challenge to navigate and often leads to unsuccessful external searches for soil data – the strategic direction of ASRIS should be reviewed to determine what model or system (centralised, hub or totally distributed) will satisfy key users and management requirements.
5. ASRIS management should proceed in developing a set of authoritative surfaces for key attributes with a priority being those necessary for input to the global mapping initiative GlobalSoilMap.net http://www.globalsoilmap.net/.
6. The development of soil information based around a standard national grid is supported by the research stakeholder community.

Acronyms

ACLEP – Australian Collaborative Land Evaluation Program (http://www.clw.csiro.au/aclep/)

ANRA – Australian Natural Resources Atlas (http://www.anra.gov.au/topics/soils/overview/index.html)

ANRDL – Australian Natural Resources Data Library (http://adl.brs.gov.au/anrdl/php/anrdlSearch.html)

APSIM – Agricultural Production Systems sIMulator (http://www.apsim.info/Wiki/)

APSRU – Agriculture Production Systems Research Unit

ASRIS - Australian Soil Resource Information System (http://www.asris.csiro.au/index.html)

BFD - Better Fertiliser Decisions Project

BRS – Bureau of Rural Sciences (http://www.daff.gov.au/brs)

CANRI – Community Access to Natural Resources Information

CEC – Cation Exchange Capacity

CfoC – Caring for our Country (http://www.nrm.gov.au/)

CIAR – Community Information Access Research

CMA – Catchment Management Authority

CMB – Catchment Management Board

CSDMS – Community Surface Dynamics Modelling System

CSIRO - Commonwealth Scientific and Industrial Research Organisation (http://www.csiro.au/org/About-CSIRO.html)

DAFF – Department of Agriculture, Fisheries and Forestry (http://www.daff.gov.au/)

DAFWA –Department of Agriculture and Food, Western Australia

DEM – Digital Elevation Model

DENR – Department of Environment and Natural Resources

DfW – Department for Water, South Australia

DPI – Department of Primary Industries, Victoria

DSE – Department of Sustainability and Environment, Victoria

DSEWPaC – Department of Sustainability, Environment, Water, Population and Communities

EC – Electrical conductivity

ECBN – Environmental Change Biodiversity Network (http://www.ecn.ac.uk/targeted_monitoring/intro.htm)

ERIN – Environmental Resources Information Network (http://www.environment.gov.au/erin/about.html)

FNLI – Farm Nutrient Loss Index

ILUZ – Intensive Land Use Zone

Ksat – Saturated Hydraulic Conductivity

LTER – Long-term Ecological Research Network

MERI - Monitoring, Evaluation, Reporting and Improvement

NAP – National Action Plan for Salinity and Water Quality

NEON – National Ecological Observatory Network (http://www.neoninc.org/)

NHT – Natural Heritage Trust

NLWRA – National Land and Water Resources Audit

NRCS – Natural Resources Conservation Service (USA)

NRM – Natural Resource Management

NRPPC - Natural Resources Policies and Programs Committee

NCST – National Committee on Soil and Terrain (http://www.clw.csiro.au/aclep/contacts.htm)

PBI – Phosphorus Buffering Index

PTF – Pedotransfer Function

RDC – Rural Development Corporations

RMQS – French Soil Quality Monitoring Network

SoE – State of Environment report

USDA – Unites States Department of Agriculture

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1 Introduction

1.1 Background – Why soils and land resources are important

Along with air and water, ***soil*** is one of the major ingredients to sustain life and our most fundamental natural resource. The Millennium Ecosystem Assessment (2005)[1] provided a solid account of the importance of soils and land resources in providing a wide range of ecosystem services to society. For example:

- Regulating services – buffering and moderating the hydrological cycle (climate and floods)
- Supporting services (nutrient cycling, soil formation, primary production and restoration); and
- Provisioning services (sustaining the production of food and other products)

Globally soils also sustain a major portion of the world's overall biodiversity.

Australian soils have many distinctive features. Surface layers have low contents of organic matter and most are often poorly structured - a condition that can pose a risk for various agricultural practices. Subsurface layers with sharp increases in clay content are widespread which can restrict drainage and root growth. In these soils, bleached layers with very low nutrient levels are also common. Soils affected by salt, either now or in earlier geological times, cover large portions of the arable lands of the continent and have various nutrient and physical limitations. Australia also contains very large areas of cracking clays. These are relatively fertile but also can exhibit physical limitations. Soils formed in aeolian sands are extensive in semi-arid areas and also fringe the southern cropping lands. Finally, the remaining ancient land surfaces, particularly in northern Australia have very deep and strongly weathered soils with very low levels of nutrients (ANRA)[2].

Access to soil and land resources related data (and derived information) in a timely fashion; and, in a format that is readily available (fit for purpose) and easy to interpret are key elements to the successful management of natural resources i.e. by reducing uncertainty in planning and helping to identify issues and analyse situations. Strategies (based on the best available science, models and knowledge) to overcome various issues can then be developed with the impacts monitored as part of an overall system approach.

The ***Australian Collaborative Land Evaluation Program*** (ACLEP) provides the framework for the collection, collation, management, dissemination and analysis of national consistent, integrated data and information on soil and land resources. In this respect, ACLEP delivers on the vision that '*natural resource management in Australia is underpinned by appropriate soil and land resource information (and knowledge) to ensure sustainable economic and environmental systems*'. The strategic direction for ACLEP is provided by the National Committee on Soil and Terrain (NCST) – comprised of representatives from key federal, state and territory agencies.

A central component of ACLEP involves the continued development and on-going delivery of the Australian Soil Resource Information System (ASRIS) – an online information system aimed at providing the best available soil and land resource information across Australia.

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[1] http://www.maweb.org/en/index.aspx

[2] For a more complete overview of Australian Soils refer http://www.anra.gov.au/topics/soils/overview/index.html

1.2 Project Objectives

The overall goal of this project was to assist ACLEP evaluate the key soil data needs of a targeted set of users and to determine the extent to which ASRIS is currently fulfilling key user requirements.

In this regard, some form of 'User Needs Analysis' was required to inform ACLEP of the current situation. To this end, Auricht Projects (in cooperation with Blair Wood Consulting) was engaged by CSIRO to undertake a project to assess '*existing needs'* of key users. The specific objectives of the project were to:

- review existing reports to determine the current level of documented understanding of specific needs for soil data and information in Australia;
- undertake a number of targeted interviews with selected user groups to explore specific needs of some 'key' users; and,
- based on the above, undertake a short gap analysis to identify consistency between needs, and the existing and developing capacity of ASRIS data and national information products.

Importantly, the project was not an exhaustive evaluation of all users' requirements within a structured framework (i.e. detailed literature review, workshops and focus sessions, survey instruments etc.). Similarly, it was not a technical review of the ASRIS website delivery mechanism, nor an exercise to provide quantitative information. ***Its primary purpose was to capture and identify the specific data needs of some targeted 'key' users*** - in the form of a report documenting the broad '*current and developing*' capacity of ASRIS to deliver key datasets and products, to provide a gap/fit type analysis, and identify any consistent issues[3]. In this sense, it is understood that the target audience of this report is somewhat familiar with ASRIS and as a result only a brief background is presented.

1.3 This Document

The purpose of this report is to document findings from the project tasks outlined above for consideration by ACLEP (and the NCST) as it relates to the future development of ASRIS.

This report is structured into Sections as follows:

- ***Section 1*** presents Background information
- ***Section 2*** outlines the Approach adopted for the project
- ***Section 3*** provides a Review of Existing Information on ASRIS
- ***Section 4*** presents the Results of a Desktop Review of existing documented information, plus selected websites and initiatives in the soils and land resource field
- ***Section 5*** presents the Results of Targeted 'Key' Stakeholder interviews to identify current level of awareness and needs. This section also presents a review of recent email 'traffic' to CSIRO related to ASRIS. The results of the above process are summarised in a table of needs by key domain groups
- ***Section 6*** provides a comparative Gap/Fit Analysis based on the findings of the above sections.
- ***Section 7*** identifies Issues based on the project Terms of Reference.
- ***Section 8*** describes Key Findings
- ***Appendices:***

[3] Note: Key in this context means the major or fundamental users and their needs

- Terms of Reference
- List of key stakeholders / users consulted

2 Approach

The method employed for the project has been both analytical and descriptive, adopting a thematic approach in line with the scope of the Terms of Reference (Refer Appendix 1). This involved the development of a work plan (and milestones) in which the consultant team worked in close cooperation with CSIRO. Several methods were employed to obtain background information and ensure the efficient delivery of milestones. These included the following:

- *Governance and Reporting* related issues – on-site visits to Canberra, plus email and phone hook-ups for consultation re; the approach (work plan), stakeholder interview process, and reporting.
- *Desktop review* – collation of existing jurisdictional, national and international documentation on soil and land resource needs, plus information available on web sites and other initiatives – Refer Sections 3 and 4.
- *In-depth Interviews* – held in person or via phone conservation with 'key' users. Refer Section 5.

To assist in the above process a share-point web site was established to enable those involved in the project to obtain access to relevant documents and progress.

The above approach provided the information base from which a synthesis of existing user needs could be undertaken (including a Gap/Fit analysis) and 'key issues' identified. Note: although data and information delivery aspects were not within the scope of this project numerous comments were received from stakeholders on this topic. Where relevant these comments have been integrated into this report.

3 Review of existing information

The following review provides a brief overview of ASRIS and ACLEP.

3.1 The Australian Soil Resources Information System and supporting program

The ***Australian Soil Resource Information System*** (ASRIS) was initiated through the National Land and Water Resources Audit (NLWRA) in 1999. The initial release (ASRIS 2001) provided primary inputs for a broad range of simulation modelling studies supported by the NLWRA. These studies provided continental perspectives (reports and 1.1 square kilometre grid datasets) on erosion, sediment delivery to streams, nutrient cycling, acidification, net primary productivity, and water quality[4].

ASRIS is described as providing '*online access to the best available soil and land resource information in a consistent format across the country. ASRIS has been developed for a broad range of users including natural resource managers, educational institutions, planners, researchers, and community groups*'[5]. As mentioned above, this report is primarily targeting a '*key*' group of users i.e. researchers and modellers using soil data as input to their activities, with only secondary consideration given to other users.

[4] Refer http://www.anra.gov.au/topics/soils/index.html Note: The outputs of these studies are viewable within the Australian Natural Resources Atlas (ANRA) with datasets downloadable from the Australian Natural Resources Data Library. Refer http://www.anra.gov.au/topics/soils/asris/index.html

[5] Refer http://www.asris.csiro.au/about.html

An important function of ASRIS is to be in a position to provide reliable input data for various computer simulation models of landscape processes – these tools are now indispensable for many aspects of natural resource management. In this respect, soil and land information is integral to analyses relating to sustainable use of natural resources because productivity and profitability are strongly related to soil condition and land capability. Additional information is available online at http://www.asris.csiro.au/index_ie.html .

Such information is also becoming increasingly important to understand and predict critical issues such as impacts of climate change and carbon accounting etc.

The ***Australian Collaborative Land Evaluation Program*** (ACLEP) supports the development of ASRIS. The Program provides resources to coordinate online access to soil and land resource information and assessments of land suitability to land managers, regional organisations, industry partners, policy specialists and technical experts in natural resource management. ACLEP is a partnership between CSIRO, the Department of Agriculture, Fisheries and Forestry (DAFF) and the state and territory agencies responsible for land resource assessment. While ACLEP is funded principally by CSIRO and the Australian Government, strategic direction is provided by the National Committee on Soil and Terrain (NCST)[6], comprised of representatives from key federal, state and territory agencies. Considerable support, in-kind resources and expertise are provided by state/territory agencies to undertake related project activity.

Additional information on ACLEP is available at http://www.clw.csiro.au/aclep/index.htm

3.2 Soil and Land Information held on ASRIS

ASRIS is an '*Information System'* comprised of a number of components. Of interest to the current project is its' role in providing access to data and information. This is achieved by presenting soils and land resources related data and information via a number of different mechanisms. These include spatial data and information presented within a web ***mapping*** application; and, information presented using a 'streamlined fashion' based on various ***themes*** (viz., Nutrient Management, Crop Modelling, and the Atlas of Australian Soils). ASRIS also contains information on ***methods and standards*** related to the seven levels within the spatial hierarchy, the actual attributes and soil model (comprising 5 layers within a profile)[7]. Specifically, within the above framework ASRIS hosts (or is directly linked to) the following;

3.2.1 Primary Mapping Application Information

Mapping of landscape and soil types

These are presented within a hierarchical information framework with six levels of generalization. The upper three levels (L1–L3) provide descriptions of soils and landscapes across the complete continent, while the lower levels (L4–L6) provide more detailed information for areas where field survey have been completed.

Site information

The lowest level (L7) of the information framework relates to the identification of an individual site in the field.

3.2.2 Thematic Information

Themes have been developed to assist users to quickly view data for a topic of interest without having to negotiate the many data layers on the ASRIS web mapping application.

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[6] Refer NCST http://www.clw.csiro.au/aclep/contacts.htm

[7] For additional information on methods refer: http://www.asris.csiro.au/methods.html

For example, the link to maps on the Crop Modelling theme page optimises the ASRIS mapping application to include only those layers pertinent to the theme (i.e. it significantly reduces the number of layers).

The current Themes List includes;

Nutrient Management Information

The current data and interpreted information available relates to the '*Better Fertiliser Decisions*' project (BFD) (2003-2007). The BFD project compiled and interpreted results from pasture-fertiliser experiments and information on nutrient loss processes from all pastoral regions in Australia. Actual information provided includes;

- *Soil test* – pasture response relationships and critical soil test values for phosphorus (P), potassium (K) and sulphur (S) differentiated at regional, state and national scales, and also by soil characteristics such as soil texture and P buffering index (PBI)[8];
- The *Farm Nutrient Loss Index (FNLI)* - a decision support tool to assess the risk of nutrient loss from the paddock to the off-farm environment in the format of a user-friendly computer program[9].
- An interactive *national database* containing all the data submitted on pasture responses to applied nitrogen (N), P, K and S fertiliser[10].

Crop Modelling Information

ASRIS hosts datasets that can be used as inputs to the tools developed by the Agricultural Production Systems Research Unit (APSRU), based in Toowoomba. The location of reference sites contained in the APSRU soil database can be viewed (either in the ASRIS Mapping Application or via Google Earth), and input files for the Agricultural Production Systems sIMulator) APSIM cropping system simulator can be downloaded. The data for the ASRIS Level 5 (finest scale) soil units can be downloaded in an APSIM compatible format. Information provided within the soil database (and for reference sites) includes characteristics of soil water, soil nitrogen, soil organic matter, soil phosphorous, erosion and land management[11].

Atlas of Australian Soils

A continent wide map of Australian soils together with descriptions of variability of soils within the map units and two sets of interpretations and presentations of soil attributes. The more detailed mapping on ASRIS does not cover the entire continent and is often limited to the Intensive Land Use Zone (ILUZ).

The ASRIS website is linked to a range of historical and more recent national datasets. The older datasets include the Digital Atlas of Australian Soils (1:2,000,000 scale) compiled in 1969 with limited soil attribution[12]. The following soil characteristics were assigned to relative classes - *soil permeability, water holding capacity, texture, reaction trend, nutrient response and depth* (McKenzie and Hook 1992).

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[8] PBI http://www.asris.csiro.au/themes/nutrient.html#Nutrient_Soil_Test

[9] FNLI http://www.asris.csiro.au/themes/nutrient.html#Nutrient_FNLI

[10] National Database http://www.asris.csiro.au/themes/nutrient.html#Nutrient_National_Database

[11] Crop Modelling http://www.asris.csiro.au/themes/model.html

[12] Digital Atlas of Australian Soils – refer http://www.anra.gov.au/topics/soils/overview/index.html#dig_atlas and http://adl.brs.gov.au/data/warehouse/daaslr9abd_001/daaslr9abd_00111a05rtf_____/csiro2m.rtf an

McKenzie et al. (2000) provide additional attributes for A and B soil horizons linked to the Atlas of Australian Soils maps. These interpretations are for each soil type based on the range of attributes observed in approximately 7000 soil profiles held within the CSIRO National Soil Database, with ancillary data from Northcote et al. (1975).

Soil properties were estimated using a simple two-layer model of the soil consisting of an A and B-horizon. The following properties were estimated for both the A and B-horizon: horizon thickness, texture, clay content, bulk density, grade of pedality and saturated hydraulic conductivity. The thickness, texture, bulk density and pedality have been used to estimate parameters that describe the soil water retention curve - these allow calculation of the available water capacity for each layer. Interpretations relating to the complete soil profile are presence or absence of calcrete and gross nutrient status. ASRIS modelled surfaces of soil properties can be viewed through ASRIS and downloaded from the Australian Natural Resources Data Library[13].

3.2.3 Map layers and Interpreted surfaces

Several types of layers are available including map information layers, images, tract layers and soil attributes. Specifically,

Tract Layers: Show the boundaries of soil map units. Tract layers are defined at Levels 1-5 in the ASRIS hierarchy.

Soil attribute layers: provide a consistent set of land qualities or attributes described for land-unit tracts at levels 3-6. Descriptions from the lowest level units feed into summaries at higher levels. These are displayed in the online maps as area-weighted means. The land qualities relate to soil thickness, water storage, permeability, fertility, salinity, and erodibility.

Table 1 below shows the main soil and land attributes described in ASRIS and their significance as presented on the ASRIS web site.

Table 1: ASRIS Attribute Surfaces
Source: http://www.asris.csiro.au/methods.html#ASRIS_Attributess

Attribute	*Significance*
Texture	Affects most chemical and physical properties. Indicates some processes of soil formation.
Clay content	As for texture.
Coarse fragments	Affects water storage and nutrient supply.
Bulk density	Suitability for root growth. Guide to permeability. Necessary for converting gravimetric estimates to volumetric.
pH	Controls nutrient availability and many chemical reactions. Indicates the degree of weathering.
Depths to A1, B2, impeding layers, thickness of solum and regolith	Used to calculate volumes of water and nutrients (e.g. plant available water capacity, storage capacity for nutrients and contaminants).
Volumetric water content (–10 kPa)	Field capacity, used to calculate water availability to plants and water movement.

[13] For additional information on modelling properties refer http://www.anra.gov.au/topics/soils/asris/index.html#modelling

Attribute	*Significance*
Volumetric water content (–1.5MPa)	Wilting point, used to calculate water availability to plants and water movement.
Plant available water capacity	Primary control on biological productivity and soil hydrology.
Saturated hydraulic conductivity	Indicates likelihood of surface runoff and erosion. Indicator of the potential for water logging. Measure of drainage.
Electrical conductivity	Presence of potentially harmful salt. Indicates the degree of leaching.
Aggregate stability	Guide to soil physical fertility. Potential for clay dispersal and adverse impacts on water quality.
Sum of exchangeable bases	Guide to nutrient levels. Indicates the degree of weathering.
Cation exchange capacity	Guide to nutrient levels. Indicates the degree of weathering. Guide to clay mineralogy (when used with clay content).
Exchangeable sodium percentage	Indicator of dispersive clays and poor soil physical properties.
Australian Soil Classification	Shorthand for communication of soil type across Australia.
World Reference Base	Shorthand for communication of soil type internationally.
Substrate type	Control on soil formation, landscape hydrology, groundwater movement, nutrients and solutes.
Substrate permeability	Affects landscape hydrology and groundwater movement.

4 Current Level of Documented Information on Soil and Land Resources Needs

A considerable amount of documented material is available in relation to soil and land resources needs at the state/territory, national, and international levels. A desktop review based on selected material covering general '*documented material*'; '*critical parameters*' to support modelling; and, '*parameters reported on selected soil and land resource information system web sites*' is presented below.

4.1 Documented Material

Numerous documents clearly articulate the need for soil and land resource data and information. These range from generic high level type needs (e.g. national reporting), to specific requirements for particular models (e.g. yield and carbon models). In relation to generic needs, many of the documented drivers for soil and land resources information are required for planning, management, reporting and policy purposes. These needs occur at various scales and were succinctly captured by the National Land & Water Resources Audit (NLWRA), 2002 publication '*Australian Natural Resources Information 2002*'[14] and are summarised below with some modification.

National / State / Territory Governments and Regional Planning Bodies

Governments at all levels, and groups such as Regional Planning Bodies, require access to soil and land resources data and information at a range of scales and for a variety of reasons. Some of the main drivers include underpinning program delivery, guiding policy, developing and evaluating programs, improving coordination and cooperation, and meeting regional, national and international reporting obligations and other commitments. For example, the State of Environment (SoE) Report and input to global studies, such as the Millennium Assessment etc - all of which have indicators or themes relating to soil and / or landscape health, condition and trend. [15]

Scientific Community

The scientific community requires access to soil and land resource data and information to:

- better understand biophysical processes under current and future climate scenarios;
- create improved landscape management tools (e.g. better simulation models); and,
- develop improved natural resources management systems.

(Source: adapted from http://www.anra.gov.au/topics/publications/national/building.html)

Specific Documented Initiatives

Specific initiatives that clearly document the need for soil and land resource information include various programs related to ***Monitoring and Evaluation***. An illustration of such initiatives follows:

- in October 2008, the National NRM Monitoring and Evaluation Framework identified the following as part of the ***fundamental data*** to support national monitoring and evaluation indicator reporting[16]:

[14] Refer http://www.anra.gov.au/topics/publications/national/index.html

[15] For example refer http://www.maweb.org/en/index.aspx, http://www.fao.org/ag/agl/agll/lada/glada.stm and http://www.dpi.nsw.gov.au/environment/mer#MER-products

[16] Refer Soil Condition http://lwa.gov.au/products/pn21200 Fundamental Data http://lwa.gov.au/products/pn22032 and Salinity http://lwa.gov.au/products/pn20386

- Extent and distribution of soil types, including:
  - all soil types,
  - acid sulfate soils
  - acid and alkaline soils
- Soil properties, including:
  - pH, carbon content, nutrients, salt stores
  - texture, porosity, depth and cation exchange capacity
  - surface roughness and particle sizes
  - erodibility and erosivity
  - soil moisture and temperature
- Geomorphic attributes including:
  - Landforms and drainage lines
- Extent and distribution of wind and water erosion
- Location of soil conservation structures
- Dryland Salinity – location and extent of dryland salinity, including:
  - outbreaks and intensity
  - discharge zones
  - areas of hazard

- the current Caring for our Country 'Monitoring, Evaluation, Reporting and Improvement' (MERI) Framework in which soil and land resources are considered foundational activities. (Refer for example, Australian Government 2010, CfoC MERI Plan 'Sustainable Farm Practices' Theme)
- the Natural Resources Policies and Programs Committee (NRPPC) / NCST commissioned report on Managing Australian Soils: A policy discussion paper[17]
- State of Environment Reporting under the 'Land' Theme, which includes soil loss, dust storms, soil carbon, salinity and soil acidity. SOE reporting also has included the need for soil toxicity – contaminant and pollution data and information.[18]

Recent Soil and Land Resource Related 'User Needs' Reviews

In addition to the above, a number of documented reports are available that provide an insight on the range of users; where they get their data and information; and, the actual themes of interest. These include, for example:

- Auricht (2004) Natural Resources Atlas and Data Library – User Review for the NLWRA[19]
- CANRI (2003a) *CMB CANRI Communication Strategy. 2002/2003 Final Report.* Community Access to Natural Resources Information, CANRI

  http://www.canri.nsw.gov.au/activities/projects/2002/report/09_0203_comm_final.doc
- CANRI (2003b) *CANRI Communication Strategy to Engage Catchment Management Boards.* CMB Survey Report. Project 9, 2002-2003. Community Access to Natural Resources Information, CANRI

  http://www.canri.nsw.gov.au/activities/projects/2002/comm_strat/commstrat_survey_report_4.doc
- CANRI (2003c) *Natural Resources Information Access by Catchment Management Board Members and Support Staff.* Survey Report Summary. Community Access to Natural Resources Information, CANRI

[17] Refer http://www.clw.csiro.au/aclep/publications/reports.htm

[18] Refer http://www.environment.gov.au/soe/2006/publications/report/land-2.html

[19] Refer http://lwa.gov.au/products/er040794

http://www.canri.nsw.gov.au/activities/projects/2002/comm_strat/commstrat_survey_report_summaryfor%20general.doc

- Eureka (2002) *Research with involved users of Natural Resources Information.* Final Report to the NSW NPWS and the Board of the CANRI Program. Consultancy carried out under CARNI Project Number 09 'Community Information Access Research (CIAR) refer http://www.canri.nsw.gov.au/activities/projects/2001/index.html and http://www.canri.nsw.gov.au/activities/projects/2001/ciar/9_CIAR_eureka_report.pdf
- Hassall and Associates (1998) *The National Land and Water Resources Audit, Needs Analysis, Final Report.* Report for the National Land and Water Resources Audit, Canberra.
- NLWRA (2002) *Australian Natural Resources Information 2002.* National Land and Water Resources Audit. http://www.anra.gov.au/topics/publications/national/index.html
- NLWRA (2008) Soil Condition – Status of information for reporting against indicators under the National Natural Resources Management Monitoring and Evaluation Framework. Jim Dixon (Author), NLWRA, Canberra http://lwa.gov.au/products/pn21200
- Michalski (2000) *Evaluation of Regional GIS Needs. Workshop and Feasibility Study Overview – Information Support for Regional and Local Project Planning.* PIRSA Land Information report under funding from the Natural Heritage Trust.
- RM Consulting Group (2006) Evaluation of Sustainable Agriculture Outcomes from Regional Investment (NAP and NHT). RM Consulting Group with URS, Rural Directions, Griffin NRM and Mark Gardner & Associates. Australian Government, Canberra http://www.nrm.gov.au/publications/books/evaluation-agriculture.html

An analysis of the references above illustrates that users of natural resources information (including soil and land resources) represent a wide cross-section of the community including the Australian, State and Territory Governments, research organisations, NRM regional bodies, resource information centres, local government, Landcare (and community) groups, educational and tertiary institutions, landholders and the private sector.

The above studies also indicate that users of NRM data and information require access to a wide range of datasets (at a variety of scales) of which soil and land resources feature prominently. For example, indicators of catchment condition, salinity and profit function surfaces (which are dependent on soil and land resource inputs) were within the top 15 downloads from the Australian Natural Resources Data Library between July 2001 and October 2003 (Auricht, 2004).

Also of interest in the above, is the reported perceived ***current lack of soil data and information suitable to meet existing needs***. For example, Auricht (2004) reported that whilst there was no major gaps in thematic content, the '*major limitation of data and information currently held within the Atlas and Data Library relates to scale – in most cases data is not at sufficient resolution to enable application at a local or catchment level, while a number of users reported that the varying scales of datasets made direct comparison between themes difficult*'. Similarly, in reviewing the knowledge base underpinning the regional planning process as part of an evaluation of regional NRM Plans the RM Consulting Group (2006) reported that '*the most common areas needing more work in regional plans were soil condition and land use matched to capability (land capability).*

In this respect the report recommended that the '*Australian Government should consider how NRM regional bodies can be supported in better accessing current science and best*

practice to apply in regional planning. In particular NRM regional bodies should be supported in developing their knowledge base in the areas of soil health and land use capability'. [20]

This 'gap' between existing needs and current supply was also identified in the recent report commissioned by the Natural Resources Policies and Programs Committee (NRPPC) and the NCST refer Campbell (2008) 'Managing Australia's Soils: A Policy Discussion Paper', and, the recent Australian State of the Environment 2006 report which highlights the current gap in delivering soil related information. Campbell (2008) mentions ….*'that the most recent Australian State of the Environment Report*[21] *could not report with any authority on trends in resource condition across Australia because of the inadequate state of monitoring, assessment and inventory systems and efforts across all jurisdictions. While at the headline level there has been widespread divestment in the basic monitoring systems and effort needed in order to be able to track resource condition, evaluate the effectiveness of NRM programs, and determine priorities for new investment. Again, soils data and soil monitoring systems have been seriously affected by this malaise, but are far from alone'.* [22]

The above provides an overview of the generic requirements for soil and land resources information across a wide range of user groups (including the science community). Further, it also illustrates that ***a lack of data at the appropriate scale is an issue***.

The task of the current project was to focus particular attention on the targeted needs of the scientific community (based on a group of senior modellers) and to a lesser extent those related policy / program officers that may make use of such outputs.

4.2 Critical Soil Attributes to Support Modelling

A considerable amount of documented material is available (both in hard copy and web related sources), related to the actual attributes or 'soil and land resource parameters' for modelling purposes. These cover a broad spectrum of models ranging from hydrological to growth (e.g. crop, pasture or forestry), ecological and biodiversity, and more recently carbon and climate change. Nichols (2005 and 2006) and DPI (2010) reviewed many of the models associated with the above domains.

The key soil attributes relative to their sensitivity in various modelling domains is presented in Table 2 based on the findings of Nichols (2006) and DPI (2010).

[20] Refer http://www.nrm.gov.au/publications/books/pubs/evaluation-agriculture.pdf Pages 5 and 6.

[21] Refer http://www.environment.gov.au/soe/2006/index.html

[22] Refer http://www.clw.csiro.au/aclep/documents/Soil-Discussion-Paper.pdf

Table 2: Highly sensitive soil parameters for various models
(Source DPI 2010)

		Model Domain			
		Hydrological	Growth / Yield	Carbon	Other
Hydrological parameters	Air-dry moisture content	✓	✓	✓	✓
	Critical Lower Limit / Permanent Wilting Point	✓	✓	✓	✓
	Drained Upper Limit / Field Capacity	✓	✓		✓
	Saturated Hydraulic Conductivity K_{sat}	✓	✓		✓
	Infiltration rate	✓	✓		✓
	Rooting depth	✓	✓		✓
	Moisture characteristic	✓	✓		✓
Physical parameters	Clay %	✓	✓	✓	✓
	Sand %	✓			✓
	Silt %	✓			✓
	Coarse fragments %	✓	✓	✓	
	Bulk density	✓	✓	✓	✓
	Soil Structure				✓
	Soil Texture				✓
Chemical Parameters	C/N ratio	✓	✓	✓	
	CEC			✓	✓
	NH_4	✓	✓	✓	✓
	NO_3	✓	✓	✓	✓
	Organic carbon	✓	✓	✓	✓
	P	✓	✓	✓	✓
	Total N	✓	✓	✓	✓
Others	Carbon fractions			✓	
	Soil Depth	✓			✓

Analysis of the above reveals a strong consistency with the attributes contained within ASRIS – refer table 1.

4.3 Review of Information on selected soil and land resources information systems.

A brief perusal of some global and other national soil information systems would suggest that the soil and land attributes thought to be important in those environments to characterise soils and landscapes are consistent with those identified on ASRIS.

For example, the Global Soil Mapping Project (http://www.globalsoilmap.net/) - an initiative that Australia is a participant - will require information from Australian soil repositories. Key minimum data variables include; clay content, organic carbon, pH, CEC, Bulk density and EC, and via pedo-transfer function (PTF) rules various derived information related to soil function - water holding capacity and various nutrient and chemical processes. Most of these attributes are included in the ASRIS set. Developing digital soil surfaces (based on a global 90 metre grid) with clearly described variability and confidences will be a key aspect of the global digital soil mapping program. [23]

Attributes identified in other national and internationally databases are also generally consistent with those identified on ASRIS (refer Table 1). The only exception being that soil carbon and in some cases soil biological characteristics are currently not well covered within the ASRIS attributes presented in table 1. Some key systems reviewed include:

- the FAO - Harmonized World Soil Database http://www.iiasa.ac.at/Research/LUC/External-World-soil-database/HTML/index.html?sb=1
- the European Soil Data Centre http://esdac.jrc.ec.europa.eu/
- the USDA Natural Resources Conservation Service (NRCS) http://soils.usda.gov/
- the New Zealand Soils Portal http://gisportal.landcareresearch.co.nz/webforms/home.aspx

A more detailed list of sites reviewed is on the project share-point at http://www.auricht-projects.com/csiro_asris/p_web_others.html user = asris pass = asris_10

In addition to the above, a quick overview of general soil and landscape Models e.g. – the Community Surface Dynamics Modelling System (CSDMS) http://csdms.colorado.edu/wiki/Models plus Soil Moisture and Temperature Correlation and Classification Models http://www.il.nrcs.usda.gov/ demonstrate consistency with ASRIS.

Collectively the above findings demonstrate that ASRIS has a sound fundamental set of attributes to satisfy generic user needs (i.e. input to current modelling activity across a wide range of modelling domains), though as reported in Section 4.1 the lack of data at appropriate scales is an important issue for many users.

As indicated above however, there is a ***critical gap in biologically related soil information***. In this respect it was noted during consultations with key users that there is some Australian activity in developing a set of information requirements to determine biological indicators and related information http://soilquality.org.au/ , however there is no Australian equivalent of the data held on the UK, *Environmental Change Biodiversity*

[23] Agreed *GlobalSoilMap.net* soil parameters http://www.globalsoilmap.net/Rome/May20_2010_Macmillanra_Production_Mapping_Background.pdf Specification for *GlobalSoilMap.net* products http://www.globalsoilmap.net/Rome/May20_2010_Final_Specifications_for_Output_Products_GSM_Nov_2009_V8.pdf

Network (ECBN) http://www.ecn.ac.uk/targeted_monitoring/intro.htm [24] The ECBN program divides the UK into grids of 10 x 10 km and measures soils within these areas for a range of biological properties. Similarly, the French *Soil Quality Monitoring Network* (RMQS); http://www.gissol.fr/index.php involves soil sampling on a 16 x 16 km systematic grid covering the whole country and has a significant set of biological data. The USA has two major monitoring networks, one, the *Long-term Ecological Research Network* (LTER), which has been used extensively over its almost-30-year history to map the biogeography of soil invertebrates biodiversity and decomposition rates http://www.lternet.edu/sites/ and, more recently, the *National Ecological Observatory Network (NEON)* http://www.neoninc.org/

[24] See also http://www.ecn.ac.uk/targeted_monitoring/CR0322_Targeted_Mon_Air_Poll_CC_Impacts_Biodiv_v3.pdf

5 Results of Targeted Stakeholder Consultation

This project looked at two main areas of activity to obtain a view of key user needs:

- interviews with selected environmental and production modellers, plus some key policy and program delivery individuals; and
- recent email requests to ASRIS - that would suggest some of the questions that the ASRIS team were required to answer.

5.1 Selected Stakeholders

This review was commissioned, not to obtain a consensus of soil attributes required for use in modelling over a wide range of organisations, but rather those required by individuals thought to "represent" an overview of current modelling activity involving landscape, soil and biological modelling (mainly CSIRO), where soil and land attributes are obviously essential model inputs. We also discussed information needs with some key policy users, and advisory/technical staff that have previously and would possibly in the future rely on the outputs of such modelling activity.

The categories of research activity that we sought advice from were:

- Agricultural production systems (e.g. APSIM)
- Biological researchers including those involved in carbon sequestration, forestry modelling and conservation planning, (for example ERIN Landscape analysis and ecological section, plus the National reserve system and Aquatic ecosystem group, along with DAFF/BRS)
- Programs and Policy areas (e.g. the Department of Sustainability, Environment, Water, Population and Communities DSEWPaC)
- Soil monitoring (e.g. Caring for Our Country /State of Environment reporting)
- Hydrology process modelling
- Rangelands and northern savannas researchers
- International needs (e.g. Global Soil mapping requirements).

A list of those individuals contacted is appended.

It should be clear however, that while individuals identified their soil and land resource attribute needs, they were not asked to, and did not, formally represent a consensus of their colleagues or organisation.

All stakeholders were asked to provide comment on the following aspects of the Australian Soil Resource Information System. (Note: whilst it was made clear that the review was centred on data and information aspects of ASRIS, it was also pointed out that any other aspects of the system considered an issue would be brought to the attention of the ASRIS managers).

The following issues were discussed with each group;

Awareness of ASRIS

Relevance of the current soil and site attributes hosted on ASRIS

Any additional or changed information that is required and currently not available on the system

- Any additional data and information products that satisfy needs (now and into the foreseeable future) for example - point source soil characteristics / transformed information or derived information,

- the scale or resolution (paddock / farm / Regional / catchment / state / soil type / national)
- temporal requirements
- accuracies required –including how to deal with uncertainty
- file formats required

Any other issues.

A summary of responses is identified in Table 3 with the results discussed in the Gap Analysis and Analysis – refer Sections 6 and 7.

5.2 Recent email "traffic"

For some additional insight into the issues facing those that use ASRIS, and those that respond to user requests, a sample of email "traffic" over the last 6 months was reviewed to determine the type of questions being asked, and whether these align with any other needs identified from the stakeholder interviews. The following is a summary of the key issues identified.

- **Access to information** requests. Most were "cold" requests - i.e. the person had not tried to access information but was asking if information could be provided. Some did try to use the system and were frustrated with the process. Requests included information pertaining to acid sulfate soils, site information (particle size distribution, N), and various layers of derived information. It was interesting to note that the Australian Natural Resources Data Library (ANRDL) is the location for many layers of soil information and that the ANRDL site was regularly referred to in email responses from CSIRO. Likewise, much of the detailed soil information required by users was actually state/territory data. As such the initiator of the request was advised to contact the relevant jurisdictional contact. Collectively, this provides some confusion within the user community as to what ASRIS actually is and where its scope starts and stops e.g. does it include the Australian Natural Resources Atlas and Data Library?
- Requests regarding **the content of the system**. Specific queries related to whether there was information on the system concerning trace elements, metals, and the corrosive nature of soils. In many cases the request was redirected to the jurisdictional contact.
- **Download / Linking formats** –indications were that individuals wanted to download in ASCII and shape files. A number also asked for the ability to link to existing ARSIS layers via web services. (It is understood that the latter functionality is currently available, however it is not well publicised or common knowledge. Refer section 7.1.8 and figure 1).
- **General requests.** There were a number of "general" requests: These covered messages relating to users wanting to store info within ASRIS, while others pointed out the current 'poor navigation' of the site leading to general frustration in use. Similarly, a number of emails related to information regarding potential errors in mapping; requests for additional information on methodologies; or users requiring assistance with displaying information in another format – for example, wanting to create a 25km grid of soil information.

In general terms the issues raised align with some of the comments provided by the stakeholders interviewed.

Table 3: Summary of Soil and Landscape Attributes and Identified Requirements

Results of Interviews with 'key' stakeholders

Legend – as indicated by shading

Current list of ASRIS information as per Table 1
Additional information required

Note - unshaded cells only means that the attribute was not mentioned during interviews

ASRIS \ Application		Climate Change / Hydrological Modelling	Crop / Yield modelling	Biodiversity modelling	Forestry	Rangelands / Tropical Savannas	Land and Soil Degradation Modelling (NLWRA)	Program ** / Policy Development, and Env Reporting (SoE)
Soil description Spatial coverage	Levels 0-3	All require contextual information at a broad-scale to define areas of interest and relate to regolith and physiographic features and national soil type descriptions.						
	Levels 3-6	Users needs relate to the type of activities they are interested in – Crop modelling is undertaken in the ILUZ, rangeland activity is only related to the "non" ILUZ by definition. All would like information across the continent at a consistent scale within levels 3-6. Priorities would relate to the intensity of land use.						
Soil Profile Location Data	Level 7	All require access to site information across their areas of interest - the more the better – both knowledge of where sites are as well as being able to access the data contained at the site. A list of reference sites (like the Crop modellers have) with detailed primary attribution.						
	CSIRO Archives							
	APSRU Rep sites							
	State/Territory Collections							
Soil Classification								
Physical attributes	Depth of horizons							
	Depth to impeding layer							
	Depth of regolith							
	Texture class							

ASRIS \ Application		Climate Change / Hydrological Modelling	Crop / Yield modelling	Biodiversity modelling	Forestry	Rangelands / Tropical Savannas	Land and Soil Degradation Modelling (NLWRA)	Program ** / Policy Development, and Env Reporting (SoE)
	Bulk density							
	Aggregate stability							
	Coarse fragments %							
	Clay %							
	Sand %							
	Silt %							
	Soil Temp							
Hydrological Attributes	Vol water content (wp)							
	Vol water content (fc)							
	Plant available water holding capacity							
	Moisture retention curves							
	Profile Water holding capacity							
	Soil water balance (plus a temporal component – monthly?)							
	Ksat							
	Substrate permeability							

Chemical attributes	pH							
	Carbon fractions (inc Total C and Organic carbon %)							
	Total N							
	Soil nutrient balances (NPK)							
	Sum of Exc Bases							
	Cat Exc Capacity							
	EC							
	Exc Na %							
	An expression of toxicity (Cl, B)							
	Cs137 *							
	Acid Sulfate							
Biological Attributes	Microbial biomass							
Site attributes	Slope (DEM)							
	Landscape temp							
	Surface roughness							
	Erosion hazard (potential)							
	Drainage/Waterlogging							
	Total carbon t/ha							

	Land use and management practice							
	Land cover / bare ground (Monthly time steps)							
	Crop yield							
	Spectral characteristics related to/of site and soil attributes (e.g.NIR / radiometric/landsat)							

* Dataset exists that has been used within erosion assessment monitoring. This dataset needs to be integrated into ASRIS

** Includes technical advisors (i.e. field officers) and senior program staff

6 Gap Analysis

The current list of soil and land attributes identified as being available on ASRIS (refer to table 1), were endorsed by all of the individuals interviewed. As expected, some attributes were more relevant to some researchers than others, but there were none that were identified as having no value.

All participants were aware of ASRIS, but the actual expectations of what the system was - and was able to deliver - varied between users. Most had either accessed/viewed data or information on the system or tried to.

Information gaps can be summarised as follows;

Coverage:

Australia wide consistent coverage of soil mapping at a variety of scales was a worthy goal, however priorities varied depending on the research initiatives – those interested in crop growth and performance wanted increased coverage and resolution for those areas currently being cropped (or with potential of being cropped), whereas those with research activities in the rangelands and savannas obviously had a priority for information over these area (although they accepted that the resolution of such data did not need to be as fine as that for the more intensively managed areas of the continent).

What was of particular interest was an expressed need for the identification of the sites that underpinned the associated polygon mapping and any generated grid surfaces.

In general there was an acceptance of the need for high resolution data and information in areas of intensive land use, high heterogeneity and areas where there was a high public investment.

The current lack of complete coverage of soil data and information particularly in levels 4, 5 and 7 is a constraint to many modellers – this was identified as a major knowledge gap. As a result, many indicated they had to ‘dumb’ the data down to the lowest common denominator which subsequently meant that in some cases the finer data could not be used to its full potential.

Attributes:

Soil physical and chemical attributes

Current knowledge gaps with respect to individual soil profile attributes are identified in Table 3. A consistent theme across those interviewed was gaps in knowledge on the amount of carbon in soils (and the subsequent breakdown into particular carbon fractions), and coverage of attributes related to the water balance and water holding capacities. Others included; total N, soil nutrient balances (NPK), some expression of plant toxicities (including specifically B, Cl, and Na) and soil temperature. There was also interest in ASRIS providing a repository for soil surface Cs137 data previously collected for use in soil erosion studies.

Site attributes

Many of the knowledge gaps related to site information (paddock and “local” scale) are not primarily related to soil characterisation or function, but are nevertheless essential information for modelling soil condition change, or for interpreting and transferring soil function to landscape function. Knowledge needs identified include; rock outcrop, carbon at the paddock scale (t/ha), slope (DEM), drainage and associated expressions of water logging. Land cover, land use and land management descriptions were considered particularly useful.

While links to radiometric, NIR and MODIS / Landsat data were specifically mentioned a general increase in knowledge regarding the spectral characteristics of soil and landscape surfaces was required along with a recurrent temporal requirement for monitoring. Links to specific information regarding crop yield was also mentioned.

Soil biological attributes

Many of the identified soil physical and chemical attributes are considered useful to soil biologists – in particular pH, texture (particle size distribution) and total C and fractions, as they help to define the environment controlling most species. However, information on species (biota) composition and abundance has in general been overlooked in land resource assessment. In many instances, descriptions of soil fauna have been limited to specific large often iconic organisms e.g. worms, ants, termites etc.

A specific soil attribute relevant to soil biological characterisation is *microbial biomass*. Priority coverage for collection of this information should be focussed on where there is a high risk of soil biology decline – i.e. in the intensively used areas, although it is considered beneficial to get biological information from reference sites all over the continent for benchmarking purposes. Similar work has is currently taking place in Europe and the USA.

Expression of data confidence

There is a large gap in information related to the confidence of the soil descriptions and derived information. This leads to a lack of confidence in the datasets being fit-for-purpose and was a major reason why many researchers request access to the underlying site information in order to develop their own specific surfaces. Feedback from users indicate that clear method and associated error statements are required for any attribute and pedo-transfer function derived information. Such statements or figures could be presented as error surfaces or as individual levels, however they should be clearly stated and the method made available.

It is noted that whilst estimates of uncertainty are a feature of the current system, and a distinction is made between attribute uncertainty (due to measurement for a given soil material) and spatial uncertainty (due to natural variation across a landscape), these estimates need to be further documented.

7 Issues and Discussion

7.1 Key Issues

This report was commissioned to compare soil data and information needs for a range of selected individuals thought to represent various areas of activity. The following are a list of issues that have been generated from interaction with these individuals. All were aware of ASRIS and each had either accessed or viewed information on the system or at least tried to.

7.1.1 Soil profile site identification

Most researchers involved in developing models want to be able to access individual site records to obtain attributes. Ideally at reference sites there are full primary data records, pedo-transfer results with clear methodological references and dialogue as to the ability to extrapolate the results within the mapping polygon framework (the complexity of the mapping unit).

It was pointed out by users that information exists for a number of sites that are not on the ASRIS (i.e. not samples in the National Soil Archive but profile data from other soil descriptive activity and projects) – primarily state and territory data. Complete capture and knowledge of jurisdictional data continues to be important.

A master layer of sites, identified by custodian and attributes available (for access to data where relevant) would satisfy users. As CSIRO (ASRIS managers) are not the custodians of much of the data within the system, once knowledge of the location of the sites is obtained, and custodians of the information clearly identified, access to the data can be an arrangement between the user and the custodian unless otherwise agreed.

Some stakeholders identified that a “Google” surface /interface to identify soil site locations (and associated attribute data and custodian details) would be beneficial.

7.1.2 Soil profile data access

Researchers identified access to a full range of soil data on ASRIS as a significant challenge. Most advised that they have extracted soil info with some difficulty and that there needs to be a clearer path to access individual soil profile data. It was “*a frustrating and inefficient experience*” advised one respondent.

The data in ASRIS is mostly a collation of data sets provided by the individual state and territory governments and as such CSIRO does not necessarily have the right to re-distribute the data. Therefore, much of the data can be made available for viewing through ASRIS but not for download. The currency of data within ASRIS does not always match that available from the agencies as supply and collation into the national data set is a time consuming activity. Nevertheless, access to data that underpins the derived layers and thematic information is an expressed requirement.

Users also pointed out the need for improved metadata descriptions for many ASRIS datasets, particularly those not managed explicitly by ACLEP.

7.1.3 Soil profile attributes

The stakeholders interviewed have confirmed the current list of attributes identified on ASRIS as important.

Soil Physical and Chemical Attributes

In general, modellers require data that relate to the functional characteristics of soils, rather than purely descriptive attributes. In particular, there are knowledge gaps in carbon content (organic and other fractions), soil fertility and toxicity information, and on how soils are likely to function under changing climatic (water) regimes – i.e. more information on moisture retention and water balances was identified as a requirement.

There was a recommendation that ASRIS should be a repository of national data related to any soil attribute i.e. '*a repository of last resort*' e.g. to provide secure storage for the CS137 database being developed to determine soil erosion.

Soil Biological aspects

Obtaining information on soil biodiversity and biological function, and being able to correlate these to individual and linked physical and chemical properties (e.g. soil carbon, pH water balance) is a key gap in the current knowledge base. This is considered an emerging science, soil microbial biomass is currently a critical gap in information related to characterising and understanding the biological functioning of the soil. Considering the role that soil biota plays in providing ecosystem services, and the extent to which soil biota contributes to total biodiversity this 'oversight' needs to be acknowledged and addressed.

This has also been observed in a recent high level policy document prepared for NCST (Campbell (2008) page 15).

> *Soil conservation, at least as practised by dedicated agencies and professional bodies, for too long ignored developments in ecology at scientific, policy and management levels. Soil science remained primarily concerned with physical and chemical attributes of soil. Soil ecology and soil biodiversity remained at the fringes of soil science, when they could have been a bridge to the broader (much more powerful and influential) conservation movement.*

7.1.4 Monitoring information

Recent work by the Audit and the NCST (and associated expert groups) has identified needs in this area - whilst these are not reproduced in this report, they were confirmed during this study. Information associated with the main land degradation types and issues, (acidification, erosion by wind and water, and soil carbon decline) are required. Collection points and associated data should be identified (e.g. dust watch collection points etc).

It was reinforced that there should be linkages to contextual information e.g. to water information to determine monthly soil water balance data.

7.1.5 Soil mapping - spatial information

Coverage and scale requirements differed with the interests of the stakeholder. There is generally a requirement for higher resolution data where there is intensive land use (ILUZ) and/or where there is high public investment in land management. For example, those interested in crop modelling were interested in the ILUZ of the continent, and in particular identified cropping areas; other's interests were wider to national coverage. All were interested in the most detailed available mapping (although rangeland users were happy with "broader scale" information relative to the ILUZ).

Results of previous user reviews e.g. that conducted by Auricht (2004) on information provided by the Australian Natural Resources Atlas and Data Library also identified scale of existing data as an issue. I.e. finer scale data is needed.

It was also noted during the stakeholder consultation that the changing emphasis on research into land management issues in northern Australia (e.g. fire management, carbon sequestration) is producing an additional need for information in those areas not necessarily assessed as of high agricultural capability – e.g. some aboriginal lands.

Similarly, within the emerging ecological modelling domain the existence (and or lack of access) to fine scale data posed a limitation to researchers. For example, in some cases research has found that predicting the occurrence/distribution of certain species is strongly correlated to soil and land resource attributes, however such data is not always available. In this respect it was mentioned during interviews that it has not been possible to model (habitat suitability and distribution) for several hundred species (as required to support legislation/regulatory requirements) due to the lack of data. An example of how such data is relevant to ecological modelling is demonstrated in the case of the Ornamental snake where recent research found that it is the Brigalow-gilgai formations rather than the adjacent environment that provide the micro-habitats for the snake. As such in this example there is a need for good information on gilgai soil formations.[25]

All individuals contacted wanted consistent national (Australia wide) coverage as provided by levels 1-3 of the mapping hierarchy – either to use directly within their own modelling activities or as a contextual background to their work.

7.1.6 Soil attribute derived surfaces

Most models require access to data at described levels. As such, it was reported by modellers that any continuous depth data (as proposed for ASRIS) would most likely be re-classified to provide data at specific depths that are currently used in their own models. Key depths identified by researchers include 0-15, 15-30, then in 30 cm increments down to an impeding layer (chemical or physical). Some researchers (e.g. foresters, hydrologists and others) identified a need for information at depths usually considered beyond those commonly used to describe soils i.e. depth of the regolith.

Most stakeholders were more interested in obtaining primary data and derived information (with associated detailed meta-data) from sites for use in their own models rather than obtaining interpreted surfaces of information, especially where accuracy or confidence levels were unknown. In this respect, numerous stakeholders indicated they were however interested in derived surfaces as long as they could also access the underlying primary data including the number of records and their distribution. This issue concerns the need to determine fitness-for-purpose and credibility of the delivered datasets. It was mentioned that many of the existing derived surfaces from Audit 1 do not have a high degree of credibility and as such, many researches are somewhat sceptical and prefer to generate their own surfaces. The danger of this is that it can rapidly lead to problems with numerous surfaces for the same theme being generated and ASRIS losing some authority as a point of truth for soil information.

Methods used for deriving any surfaces of gridded soil data should be included within a methods section in ASRIS and tagged to relevant metadata statements.

As a generalisation, policy users and those involved in extension (or providing land management advice) were more interested in continuous, national data than others. Actual datasets for many of the maps and derived surfaces are not however available for download

[25] Refer http://www.acarp.com.au/Downloads/ACARP2009AnnualReport.pdf and http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?showprofile=Y&taxon_id=1193

from the ASRIS interface, due to licensing restrictions from the jurisdictional owners. The Atlas of Australian Soils (1:2,000,000) compiled in 1969, and more recent interpretations, is available through ASRIS. It was also from DAFF (http://www.daff.gov.au/brs/data-tools/daas-download), although ongoing management of this site and links to correct meta-data are sometimes questionable. Similarly the ASRIS 2001 datasets are freely available from the Australian Natural Resources Data Library. (http://adl.brs.gov.au/anrdl/php/advance_brief_result.php?syntax=xml&number=9999&target=anrdl&title_search=soil&cat_flag=off).

The issue remains whether these information and data sets should reside in another management regime, or within the CSIRO managed ASRIS where the access to the information can be managed as a priority. At the time of undertaking this review the links to the DAFF library were down (subsequently restored), however this "remote" location presents a risk to the function of the system if the links are not maintained. Similarly all of the links from within the Australian Natural Resources Atlas (which is now no longer being maintained) to the Data Library are out of date and therefore do not link to the respective dataset held in the DAFF library resource. (Note – Atlas of Australian Soils data sets are available for download through ARSIS).

7.1.7 Accuracy / confidence/ error

In the absence of clearly defined and documented estimations of derived soil information and its spatial variability, researchers will require primary soil data to develop their own confidence information.

The challenge for soil descriptive scientists is to produce their own error surfaces and boundaries around the measured soil attribute and then the derived information and place these estimates within the spatial framework (either a polygon or grid). The work of McKenzie (2000) with respect to documenting soil variation within the digital soil map of Australia was often cited by researchers as being highly relevant to their work.

The need to report such uncertainty is also consistent with the agreed specifications for the Global Soil Map products. For example, at the Globalsoilmap.net consortium meeting in Seoul (October, 2009) it was agreed that '*A spline function will be fitted to the soil property values for each depth increment to permit depiction of continuous variation in soil properties with depth (Malone et al 2009). An estimate of the uncertainty associated with each prediction at each depth will accompany each property value'*.[26]

In this respect the digital (and raster based) mapping input to the Global soil initiative should be used to redevelop a set of robust mapping surfaces of key soil attributes for the entire continent at the highest possible resolution (25-50m grid were identified by some, while the proposed Global Soil Map 90 metre grid was considered appropriate by others). In this respect it was also noted that standard coarser grids e.g. 250 meters could be generated from the finer grids based on predefined aggregation rules, or alternatively generated from the same input reference site information.

A number of researchers also identified that a series of standard and defined reference map grids for Australia should be identified as soon as possible to ensure a standard registration between different datasets and themes. (Note – progress towards this through the ANZLIC and the CRC-Spatial Information project on The National Data Grid).

7.1.8 Access/presentation format

As previously mentioned, obtaining access to data and information from ASRIS was an issue for most of those interviewed. Importantly however, the actual format of the information was

[26] http://www.globalsoilmap.net/Rome/May20_2010_Macmillanra_Production_Mapping_Background.pdf

not i.e. most modellers required data for use in their own applications and so reformatting was probably expected (and not an issue).

Some users however, only required viewing capability for presentations and / or contextual information. There were a few suggestions regarding making more ASRIS data and information available to other applications and users. For example, the current availability of key ASRIS Level 4&5 data as kml files for use in the “Google Earth” API (see the link on the ASRIS home page), and Web Map Services to present and identify soil sites and to present information. In relation to the later it is understood that the full list of ASRIS data layers is currently available as a web map service - refer figure 1 below. The concern is that this service is not fully promoted within the current ASRIS system and so many don’t know the functionality is available. (Note – this is due to a concern for current ASRIS systems capacity to support a potentially large group of direct online users).

In some cases e.g. those of the National Reserve System within DSEWPaC and Aquatic Ecologists involved in national classification work were interested in themes such as the physiographic layer to provide contextual information and thereby inform work related to classification systems, and/or improving the line work of existing datasets e.g. IBRA. Some aquatic ecologists identified the need for accurate high level information on hydric soils to assist in the identification of wetland boundaries, however they also indicated that this was often best handled on a case-by-case basis using field visits.

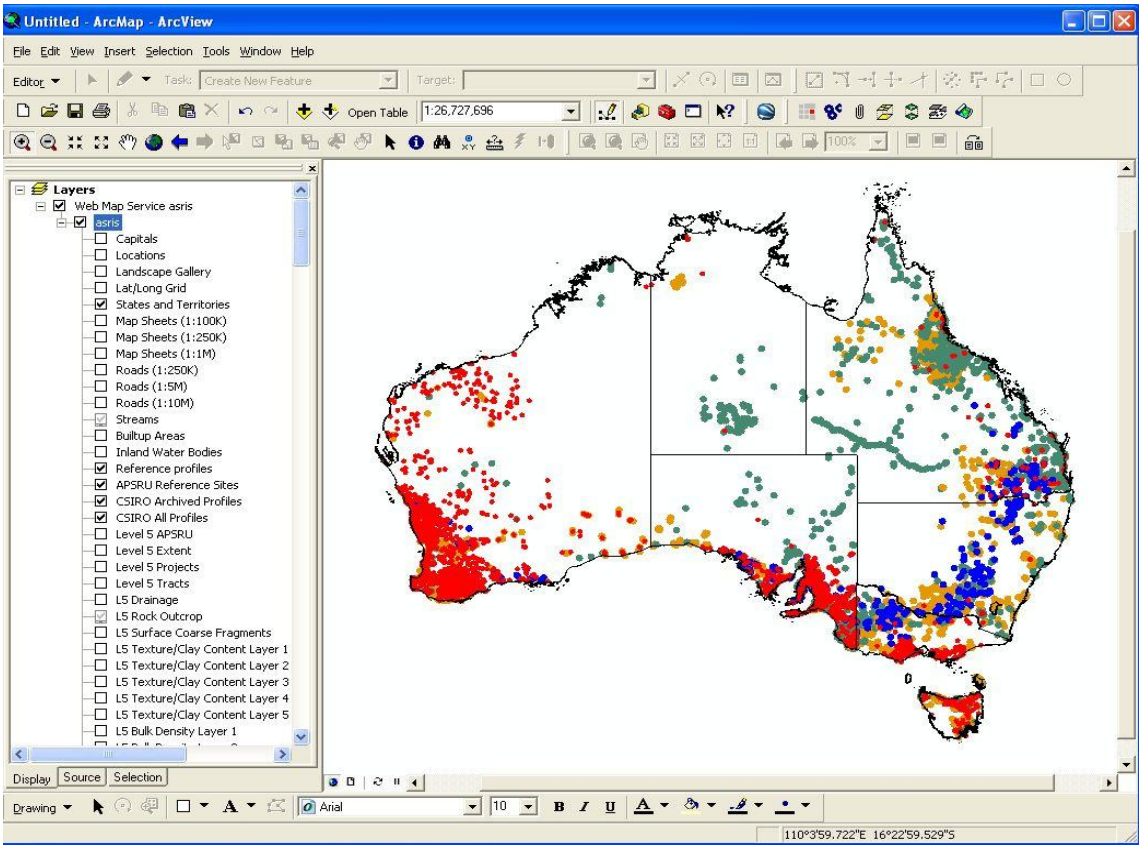

Figure 1: Demonstration of ASRIS Web Map Services within ArcView.

7.1.9 Ancillary information

While recognised as not the primary responsibility of ASRIS, most individuals contacted considered links to other data and information repositories essential. The issue is whether ASRIS should migrate updated versions of information products directly into the ASRIS (e.g. land cover, land use) or provide web links into the systems where the information has been

generated. Alternatively, such data layers could be made available as a WMS service by the custodian in which case the ASRIS interface just links to the custodians' service to display the theme.

Best management practice would indicate that links should be provided to the source of the information where the responsibility for data currency and management is the custodian. Coordination across these systems to ensure that the format, scale and resolution and presentation of information met corporate needs was seen as essential. The following ancillary information needs were identified during the course of the project:

- Climate (rainfall),
- Land use
- Land management practice,
- Satellite information (and other time series remote sensing),
- Electromagnetic Induction Mapping (EM38) and radiometric surfaces
- Ground cover (fractional surface cover)
- Slope characteristics (DEM)
- Crop yield information (for example that being collected by RDCs involved in crop research).

7.1.10 Glossary of terms / methods identification

Apart from the clear identification of any pedo-transfer functions and derived surfaces individuals identified that links to a glossary of terms would be useful. Many researchers that use soil and landscape information are not necessarily pedologists or land capability experts – as such, they want ready access to the various references to terms and general methodology in common language formats. It would be useful to have the various methodological handbooks available on-line.

7.1.11 Expectations of ASRIS

Most stakeholders were aware of ASRIS, and assumed that the site hosted the (a) national soil information base.

The issue is that there is some question as to what ASRIS actually is – e.g. a hub that can link to other soil databases and / or a repository of soil and land resources information. There is an expectation by some that ASRIS is a 'one-stop-shop' for soil and land resources data and information, and they did not expect to have to go outside of ASRIS (e.g. the Data Library) to obtain data. Frustrations often occur when such data links are not operable or maintained. One person expressed concern that there appeared to be a series of soil databases and layers being developed by modellers and various organisations with no clear link between them. This could lead to problems of 'point-of-truth' of some soil datasets e.g. an authoritative national carbon surface.

As mentioned previously, some users expressed a concern with numerous metadata statements related to existing data layers displayed within ASRIS being incomplete. International best practice dictates that all layers should have a complete metadata description associated with them. The expectation is that as part of the discovery and access process users should be able to view a dataset then obtain complete metadata to determine fitness-for-purpose.

Throughout the study there was a consistent message – ***access to data and navigation is currently an inefficient and challenging experience***.

8 Key Findings

The following presents the key findings from the needs analysis.

- The current and developing capacity of ASRIS has been designed to provide primary data on soil and land resources to meed the demands of a broad range of users including natural resource managers, educational institutions, planners, researchers and community groups.
- The current list of ASRIS attributes is supported by the stakeholders interviewed and consistent with those provided by similar systems internationally.
- Additional chemical and physical attributes identified for inclusion in the system are: Carbon and associated fractions, information on nutrient status and some index or estimate of toxicity (or growth impeding chemical attribute), and soil temperature. Moisture holding capacities were seen as a critical soil parameter and reference sites should include full moisture retention curves.
- The collection and collation of soil biological information (particularly microbial biomass) should be considered.
- The ongoing collection of site information is considered essential. The location of all sites (and associated custodian agency) should be displayed as a layer – even if the related data is not held on ASRIS.
- Access to site information is a key requirement – many key researchers extract site information and reformat it within their own databases tailored to suit their particular application.
- ASRIS management should proceed in developing set of authoritative surfaces for key attributes with a priority being those necessary for input to the Global mapping initiative GlobalSoilMap.net (http://www.globalsoilmap.net/)
- ASRIS should link to information sources considered as appropriate to support key contextual or reference needs (e.g. land cover, land use, land management, remote sensing, and other key natural resource databases e.g. NVIS, climate, Water resources), but should not attempt to become the point of truth for these datasets.
- Any surfaces – or derived layers of information should be rigorously defined and include detailed metadata.
- Errors and variation within a polygon or within any grid surface should be clearly defined and undertaken by soil specialists – not users of the information.
- Most researchers interviewed do not have an issue the soil attributes identified on ASRIS (subject to the addition of some parameters e.g. carbon). A key finding however is that until ASRIS becomes a very transparent and rigorously defined database (i.e. the point-of-truth) then modellers will continue to require access to raw (primary site) data and continue to develop their own derived information and surfaces.
- A standard national grid based system is supported.
- The current ASRIS web-site is a challenge to navigate and often leads to unsuccessful external searches for soil data – the strategic direction of ASRIS should be reviewed to determine what model or system (centralised, hub or totally distributed) will satisfy key users and management requirements.

Appendices

A Terms of Reference

Output - A report on targeted analysis of specific users needs for specific soils data and information products.

Activities -

1. Review and analyse existing and associated user needs report to determine the current level of documented understanding of needs for soil data/information

2. Define a targeted set of users covering particularly the modelling and policy needs for soils data and information. Broader users may include research, education, industry, community but these should be addressed in a general sense from existing information sources

3. Develop a set of questions designed to explore the specific data/information needs of users in terms of soil attributes/characteristics and spatial and temporal resolutions

4. Conduct a set of interviews with targeted user groups to document with as much specificity and detail as possible the current and future soil data and information needs, including a capacity to utilise both classified/summary type data and complex/detailed data sets

5. Document the current and developing capacity of ASRIS to deliver specific data seta and products and analyse the likely availability and gaps of user required data/information

6. Provide a report on user's needs, availability and gaps, and recommendations for future development options.

B. List of Contacts

List of names and organisations that were contacted:

Andrew Moore (CSIRO) vegetation / water/ carbon

Brett Bryan, Neville Crossman, David Summers and Martin Nolan - CSIRO, Sustainable Agricultural Flagship / Climate Adaptation Flagship

Claire Howell, Jim Walcott, Tim Clancy and Lee (DAFF)

Cuan Petheram (CSIRO), Hydrological Modelling

Gary Bastin (CSIRO) Rangelands

Garry Cook (CSIRO) Northern Savannas

Glen Scholz DfW Sth Aust

James Hall, DENR Sth Aust

Kristen Williams, (CSIRO)

Linda Gregory (soils CSIRO)

Matt Bolton, Jeffrey Tranter, Maris Ozolins, Robert De Vries, Randall Storey, Jason Ferris, Colin O'Keefe, Cherie Hart, Marcus Baseler, Annette Philippa, Ingrid Wootton, Chris Meakin, Simon Bennett from ERIN Landscape Analysis and Ecology Section. Also Dayani Gunawardana from Strategic Information and Environmental Reporting Section (Responsible for SOE Reporting) SEWPaC

Mary-Anne Young, Rural Solutions PIRSA

Max Finlayson (Prof), Institute for Land, Water and Society (Charles Sturt University, Albury)

Megan Lewis, Adelaide University Mike Grundy (CSIRO) Sustainable Agriculture Flagship

Michael Battaglia (CSIRO) Forestry applications / carbon accounting CABALA Model/3PG)

Michele Barson (Aust Government CfoC) Program/Policy and Evaluation Land Degradation monitoring

Mike Ronan QLD, DERM

Nathan Robinson, (Vic, DPI)

Neal Dalgleish / Neil Huth (CSIRO) APSIM Crop production/yield modelling

Neil McKenzie (CSIRO), Chief L&W

Noel Schoknecht (WADAF) NCST

Pauline Mele (Vic DPI)

Richard Thackway, (plus group discussion with BRS staff) - Sustainability modelling - Land cover

Stewart Pilman (DENR, South Aust)

Tim McVicar (CSIRO) - remote sensing applications

Tim Bond, NRS, SEWPaC, National Reserve System

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