Australian Government
Department of Agriculture, Fisheries and Forestry

A stocktake of Australia's current investment in soils research, development and extension: a snapshot for 2010-11

Research by the Sustainable Resource Management Division

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Extract

Box 1: Building the national soils information infrastructure

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Box 1 Building the national soils information infrastructure

The soil information Australia needs describes the soil present, soil qualities, how they respond to management, and how they are changing. This information will reduce the risks of poor decisions, locally, regionally and at the national scale. Soils change across space, over time and in complex ways as they are managed.

The information describing these dimensions of change can be broadly grouped as mapping, modelling and monitoring. These are interdependent approaches to obtaining and using soil information; together they provide the information necessary to improve land management and soil health over time and across landscapes. The information products needed are site data of various forms, maps, images and spatial data, trends and projections and models, tools and analytical approaches. The full set covers soil processes (such as the biological drivers of soil health, nutrition and carbon cycling, physical aspects of soil water movement, storage and plant use, chemical activity on clay and humus surfaces and the combined factors which constitute a soil's capability for agriculture and wider ecosystem functions), and their distribution over time and space.

Australia has had excellent programs in land resource assessment, soil and crop modelling and some components of soil monitoring. There is a strong legacy of process knowledge and world leading model capability, leadership in remote sensing and in data which provides context for soil information (e.g terrain, climate), a long legacy of on-farm soil RD&E, and good support services including laboratories and soil archives.

Appendix 5 illustrates some major gaps in quality and coverage. Only 30-40 percent of the nation's dryland cropping lands have coverage at an adequate spatial resolution, and much of this lacks the full suite of attributes (soil type; major functional attributes such as chemical and physical fertility, water holding capacity and rooting depth; information on variability within map units; interpretation for land capability/suitability; soil quality statements). There is good coverage of the intensive sugar and horticulture areas in Queensland, but inadequate information for the Murray-Darling irrigation areas and new areas in Tasmania. Australia's rangelands have been mapped to broad land systems and land capability, but there is little information about their soils.

Soil profile (site) data are the basis of the soil information system. State/territory agencies and CSIRO have collected site data, stored samples in archives and established data systems to manage them; site data are also collected by agribusiness. The table below illustrates the types of sites, their purpose in the soil information system and an estimate of the numbers available.

Soil site collections	Estimated number	Characteristics	Main purpose
Descriptive survey sites	290,000	Observations of soil type and position in landscape. Over half in databases – these have location, soil type and qualitative measures	Used in original soils mapping. A small number have use in digital soil mapping
Industry sites	Unknown (> 1million?)	Used for fertiliser recommendations and land management extension	Short term original use, if collated, have value in broad trend analysis
Analytical survey sites	Approx 30,000	Analysed sites with a full suite of chemical data; a small fraction have physical or biological data	Used to define soil types in mapping; now a key data set for digital soil mapping
Key soil parameter sites	<1000?	Sites measured to support mechanistic models – have measures of soil water and soil rooting depth	Support modelling (APSIM, PERFECT and similar models)
Monitoring sites	Unknown - <100?	Revisited sites which establish a baseline for trend detection	Monitoring
Long term detailed study sites	<10	Fully characterised sites measured over time	Long term process studies

A key problem for Australia is the comparatively small number and distribution of key soil parameter sites with the full range of soil attributes which are needed in conjunction with analytical survey sites (location, time sampled, soil type, organic carbon, clay content, bulk density, soil depth of these attributes and rooting depth) to predict more difficult-to-measure features such as water holding capacity through pedotransfer functions. Most key sites are in the dryland cropping areas, there is underrepresentation in the intensive zones, and the broad soil variability is not covered. As a result, this limits confidence in scenarios using spatial and temporal modelling over much of Australia – at a time when these analyses are increasingly important. For example, high confidence is needed to identify areas where soil carbon sequestration investment could give the best returns, and to quantify the likely impact of shifts in the amounts and seasonality of rain on plant available water for crop growth.

New soil assessment techniques offer a cost-effective opportunity to fill the information gaps. These have used the revolution in information technology to apply improved statistical approaches, more powerful and ubiquitous soil covariates (such as digital terrain data) and better measures of uncertainty to improve the efficiency of soil mapping and to focus on the key functional soil attributes (http://www.digitalsoilmapping.org/). There are also new laboratory techniques such as mid-infrared spectroscopy and a new and large suite of in-field sensors (such as electro-magnetic induction, gamma radiometers and micro-electrodes). A nationally planned and coordinated soil survey program is needed to apply these approaches to address Australia's soil information deficiencies.

Appendix 5 The national soil information base

Introduction

Until about 1990 the collection of soils information in Australia was primarily for agricultural land development which ranged from extensive rangeland pursuits, dryland farming through to intensive, usually irrigated horticulture. The assessment methods developed in the 1940s and 50s were used, plus the new capabilities of air photo interpretation; information was based on soil properties obtained at numerous points, and landscape features used to help interpolate between these points for soil mapping.

More recently, in addition to these increasing agricultural demands (now focussed on resource use efficiency), new applications for soils data have emerged in areas such as climate change mitigation and adaptation, town planning, civil engineering, environmental management and even forensics. Examples range from planning the Ord River Stage II expansion, identifying potential shire council waste disposal sites, planning the trajectory of transnational fibre optic cables to avoid predatory wombats or shrink/swell soils, managing locust plagues, and modelling and understanding the environmental services provided by the land and associated issues such as soil erosion, surface hydrology and flooding.

The demand for good soils information will continue to expand as new planning issues emerge, and as competition intensifies for land and co-located water, and between beneficial uses and environmental demands. Soils information will have a big role to play in the modelling of phenomena such as climate change and in understanding, and perhaps ultimately predicting the impact of natural disasters such as droughts and floods.

Soil information research and practice has left significant legacy data which represent a large cumulative investment. The components of the nation's soils knowledge base are the data held on soil properties at individual points (soil profile data), the physical samples collected at these points (the soil archive) and the soil mapping which gives the spatial dimension. These data are primary sources for answering the array of questions on soil function and land management.

Soil maps (and their GIS representations) provide the capacity to understand the distribution of soils and their functions, the means to extrapolate from site or plot based observations and experiments across a region or wider, allow cumulative calculation (for example the quantum of carbon or nutrients or the combined effect of degradation processes), and are an effective way to communicate soil issues. Soil site data and archived soil samples complement soil mapping information, and provide broader functionality to support new mapping (using digital soil mapping approaches), answer new questions and, when stored appropriately, the opportunity to analyse for different properties.

To fulfil these roles, these forms of soil information need to meet two key criteria:

1. cover the landscape at an appropriate scale for the key questions being asked;
2. provide consistent information content so that they can be easily used for these purposes.

A good example of this reapplication of soil data comes from The Northern Australian Task Force which was charged with developing a 'better understanding of opportunities for new sustainable economic development in the north'. The Task Force drew heavily on historical information including soil and landscape maps, reports and data bases (Wilson 2009), and was challenged by data which fell short of the two criteria above in key places.

Coverage and effort

Soil information requires coordinated programs of soil survey and assessment. In Australia, apart from early broad scale land system surveys by CSIRO, these programs have been based in the states and territories. As the analysis below indicates, the programs have proven difficult to sustain. Generally Australia's soil surveys did not achieve coverage at the required scale before the programs were scaled back or discontinued. This is in marked contrast to countries such as the USA, Korea, Japan, Canada and many others where long term programs have achieved substantial coverage, and underpin effective answers to the new set of land management questions.

To gauge the adequacy of, and issues associated with the national soil knowledge base, state/territory agencies and CSIRO were asked to advise the Soils RD&E Working Group on the extent of the soil profile data, the archived storage of samples and the current extent of soil mapping. They were also asked for an analysis of adequacy in coverage, timeliness and data systems.

Figure 1 shows the required coverage of soil information for Australia. It is substantially less ambitious than has been achieved in similar countries, but is well beyond the current coverage. It needs updating include new irrigation areas around Carnarvon and the Kimberley. This figure is used later in the document illustrate progress against the required level of soil information coverage.

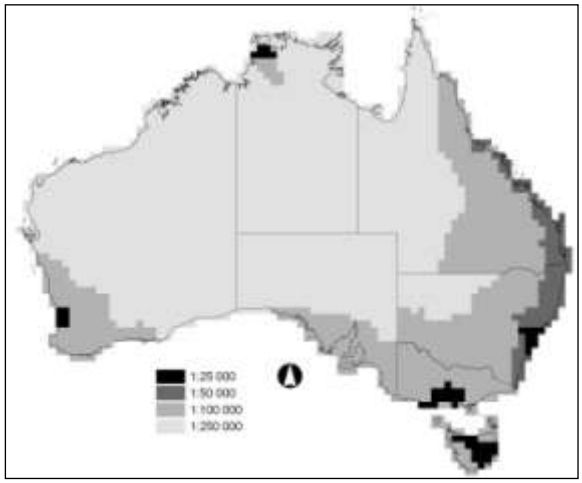

Figure 1 Suggested level of soil mapping for Australia

The national soil information effort

Projects which have contributed significantly to the national soil knowledge base are the agricultural and research projects (prior to 1985), and thereafter the joint Australian Government/ state/ territory projects funded under the National Soil Conservation Program, the National Landcare Program and the Natural Heritage Trust. As these projects tapered off after 2000, the rate of data base entry and sample collection and archiving slowed. Hence the median age of samples is in the order of twenty years. The limited contemporary collection of soils knowledge is for soil condition monitoring or research into soil carbon behaviour.

Soil profile data

The two decades between 1985 and 2005 represented a peak of effort in soil inventory.
Between 1985 and 1999 data from over 10 000 sites per year were entered into data bases. Figure 2 shows that by 2010 this had dropped to only 1370 sites per annum.

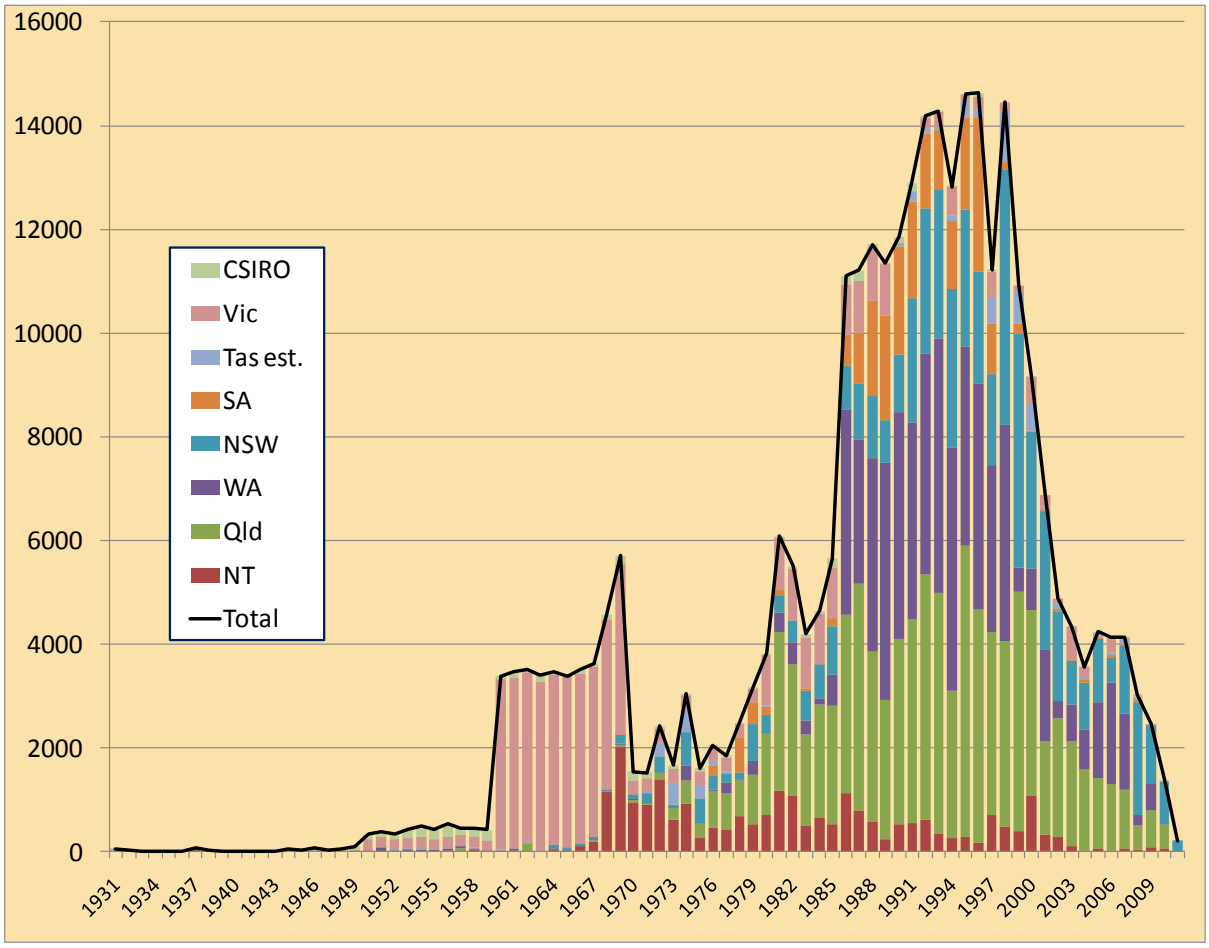

Figure 2 Soil Profile Data Collection Rates

Most states have their own data bases from which data can be uploaded to the national data base (NatSoils) managed by CSIRO. Queensland uses its Oracle based Soils and Landscape Information (SALI) system and NSW has the Soil and Land Information System (SALIS). Tasmania bases its data holdings on CSIRO's NatSoils Access Database and Victoria's Soils Information System (VSIS) is sympathetic to NatSoils, but has additional elements for time series and state-based soil classifications.

States and territories have been aware of the data standards based on the Australian Soil and Land Survey Handbook (2009) and Rayment and Higginson (1992), as well as the need for data base inter-operability. Maintaining compatibility across eight jurisdictions requires constant effort as the recommended minimum data set evolves.

Australia's soil profile data and some of its limitations are discussed in Box 1 page 25-26.

The soil sample archive

McKenzie et al (2002) observe:

Most soil properties do not change when soil is stored in dry containers. International experience has demonstrated that archives have great scientific and economic value. They allow:

- *retrospective studies of nutrient balances and pollutants*
- *calibration of new measurement methods against previous procedures*

- *substantial cost savings when new methods of analysis become available or unforseen soil properties have to be measured (e.g. unusual industrial contaminants – field work does not have to be repeated).*

Between 1985 and 2005 soil projects collected representative samples with the express purpose of developing a well described, analysed and maintained archive. At present there are approximately a quarter of a million samples held in what could loosely be described as a 'national' soil archive. These may represent in the order of only 50 000 sites, as typically 3 – 6 layers or horizons are collected at each site.

While all states and territories except the ACT have a soil archive, for reasons of efficiency and security NT and WA recently transferred their collections to CSIRO. Tasmania has a small collection (1400 samples) based on a monitoring project, and WA also has a small and newer collection (200 samples) developed for soil monitoring purposes. SA holds 5000 samples and CSIRO approximately 70 000, of which a third are adequately packaged. The balance requires new containers, labels, shelving and metadata. Significant portions of the archives held by Victoria (30 000 samples) and NSW (88 500 samples) are currently being re packaged, re labelled and placed in improved storage.

Most soil data/samples have been collected in the more intensively used arable farming and peri-urban areas, although the precise geolocation of these is poor as their collection predated the advent of GPS. Less intensively used areas are significantly under represented, a limitation for national scale projects such as those modelling carbon fluxes and regional hydrological modelling.

Consistent information content

Australian soil survey is notable for a patchwork of survey approaches, scales and varying information content. This is especially true between states and territories, but also applies within many states. Some agencies have correlated information across significant areas (South Australia, Western Australia and the Northern Territory) but these are not connected nationally. The Australian Soil Information System (ASRIS) is a collaborative initiative across the responsible agencies, CSIRO and the Federal Government to develop a common data standard to which all significant surveys can be migrated. This is described below, and in the discussion one measure of the degree of consistency achieved is the capture within ASRIS.

The Australian Soil Resource Information System

The Australian Soil Resource Information System (ASRIS) is the national repository and access point for the key sets of Australian soil information. It has been collated through a collaborative process across the Australian soils community. The systematic collection and management of soil information is, for most purposes, the responsibility of state and territory governments. Agencies within these governments have collected and stored this information through soil survey programs over many decades. While agreement on national standards has been achieved for many aspects of soil survey, there remain substantial differences between the states (and in many cases within the states over time) in how soils are mapped, and in the way soil map information is described and stored.

To achieve this, a collaborative process was established (with CSIRO, Department of Agriculture, Fisheries and Forestry and state agency funds for the Australian Collaborative Land Evaluation Program) to devise a common data model and a hierarchy of soil and landscape concepts into which the nation's soil data could be migrated. The collaborators have worked over the last decade to develop the model and translate information with disparate histories and qualities into the system. ASRIS collates the existing soil survey data in a consolidated on-line system, and creates a path from the plethora of soil survey formats and outputs to a national ASRIS standard for soil information. ASRIS provides a national window into the best soils information, and is increasingly being used for national and cross-regional issues.

ASRIS has an incomplete capture of existing data from across the soil agencies and incomplete mapping coverage of the country. The former situation exists because the funding to collate and transform the data has been insufficient; the process is complete in some states and has stalled in others. Investment in soil survey will be needed to complete the mapping coverage.

Coverage within ASRIS

ASRIS has seven levels. For the purposes of this discussion, emphasis is placed on Levels 4 and 5. Level 5 conceptually maps land units with characteristic landforms, soil associations and, where present, vegetation communities. At Level 4, units mapped as Level 5 are grouped. Most of the mapping now captured in ASRIS was undertaken with some general agreement around these concepts, but there was substantial variation. The collation and interpretation of this mapping and its use in ASRIS has involved substantial data manipulation and expert involvement in the process. Significant areas of Australia with adequate mapping are not in ASRIS because sufficient resources to complete this process have not been available.

State by State analysis of soil mapping and progress in ASRIS Levels 4 & 5

All agencies responsible for soil survey have collated information from the history of effort within the state or territory. Effort has varied substantially across the country, as have the resources available to produce correlated and consistent map coverage. Additionally, the extent to which data have been collated and converted into ASRIS Levels 4 and 5 has also varied. Both aspects of coverage are discussed below.

Western Australia

Western Australian soil survey and soil information management is a core role for the Department of Agriculture and Food Western Australia (DAFWA). DAFWA has a complete coverage of soil related mapping for the state (Figure 3A). The intensive agricultural areas (south west) have reconnaissance scale soil-landscape mapping (in general at a scale of 1:100 000, but varying from 1:50 000 to 1:250 000). This mapping is correlated, and each mapped unit has a database recognising unmapped components. These data have been converted to the ASRIS data model (Level 5 in ASRIS; Figure 3B).

The more extensive agricultural areas are covered by land system mapping, generally at a scale of 1:250 000. Unmapped soil types are described and these data are Level 4 in ASRIS (Figure 3C). However, the unmapped soil units are not supported by adequate observations of soil points, particularly chemistry. The best mapping of the arid interior of Western Australia is the Atlas of Australian Soils (1:2.5m). DAFWA has interpreted unmapped soil units within this broad mapping; this is also stored at Level 4 in ASRIS.

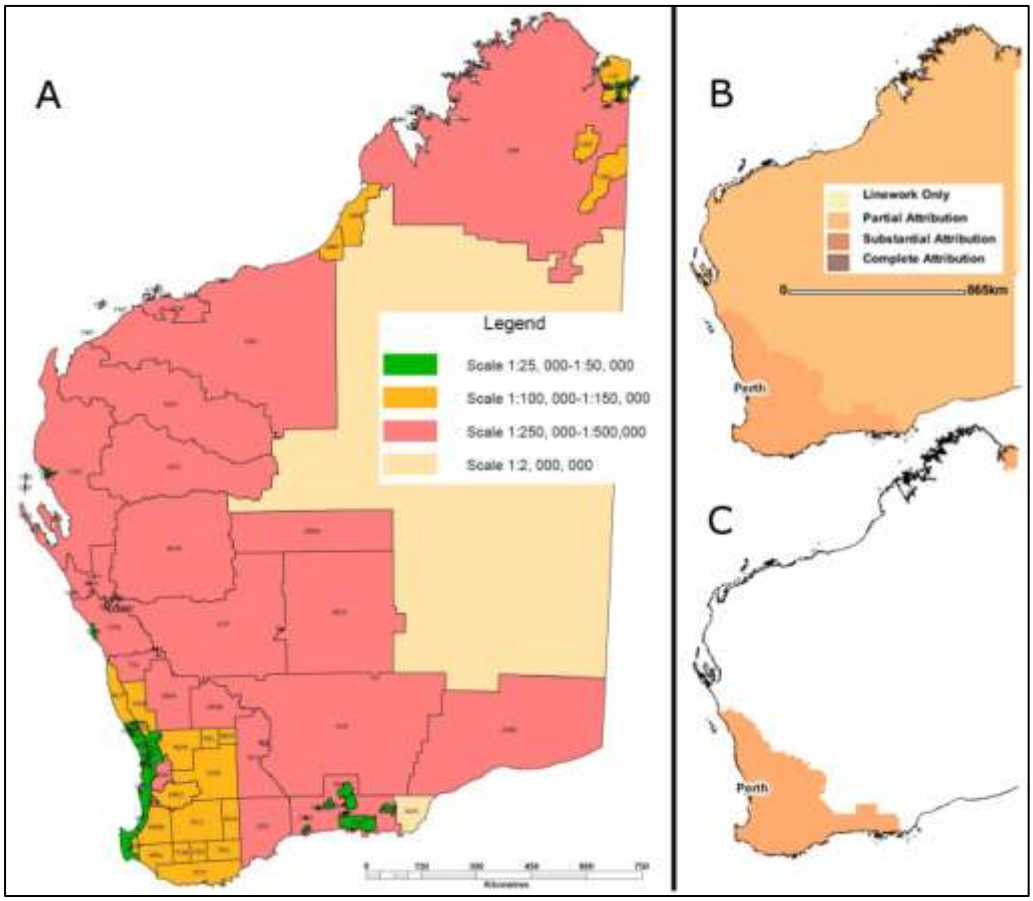

Figure 3 Extent of soil mapping by scale in Western Australia (A); ASRIS capture and attribution Level 4 (B) and Level 5(C)

Summary of mapping adequacy:

- Western Australian agencies have completed correlated soil survey for the south-west cropping lands: about 60% of these lands are mapped to the suggested national coverage; around half of the arid interiors is mapped to the suggested 1:250 000 although many of the unmapped lands are reserves. However, the soil attribution of the extensive pastoral area is rudimentary.
- ASRIS coverage: the Western Australian mapping has been substantially converted to ASRIS format; there are deficiencies in attribution due to a mismatch between the Western Australian program and the ASRIS specifications. ASRIS attribution is as complete as possible with existing data; further development of ASRIS requires new survey effort.

South Australia

South Australia is divided into arid and temperate zones for natural resource management and soil survey purposes. The temperate zone (Southern SA), commonly called the 'agricultural areas', includes all arable land (Figure 4A).

A comprehensive set of landscape and soil attributes have been mapped at 1:100 000 or 1:50 000 across the temperate zone, using both SA format and ASRIS attribute criteria. Attribute features are described for soil landscape map units (ASRIS Level 5) and their unmapped but proportioned landscape components for the SA format attributes; and for soil landscape map units and their unmapped but proportioned soil components (using the SA format subgroup soil attribute) for the ASRIS format attributes (Figure 3C).
In SA's arid zone, a very limited set of attributes have been described at the land system level (ASRIS Level 4, Figure 3B) in the pastoral leasehold lands, or land zone level (ASRIS Level 3) in the Aboriginal lands, for unmapped but proportioned soil components (using Northcote principal profile forms). These include landform and land surface descriptors, and substrate material, as well as estimates of soil texture and clay content.

Summary of mapping adequacy:

- South Australian agencies have mapped all of the southern cropping lands to the suggested national scale; around half of the arid interior is mapped to the suggested 1:250 000, many of the unmapped lands are reserves.
- ASRIS coverage: the South Australian mapping has been converted to ASRIS format. There are deficiencies in attribution in the arid lands due to data limitations in the old land system mapping; further development of ASRIS in these areas would require new survey effort.

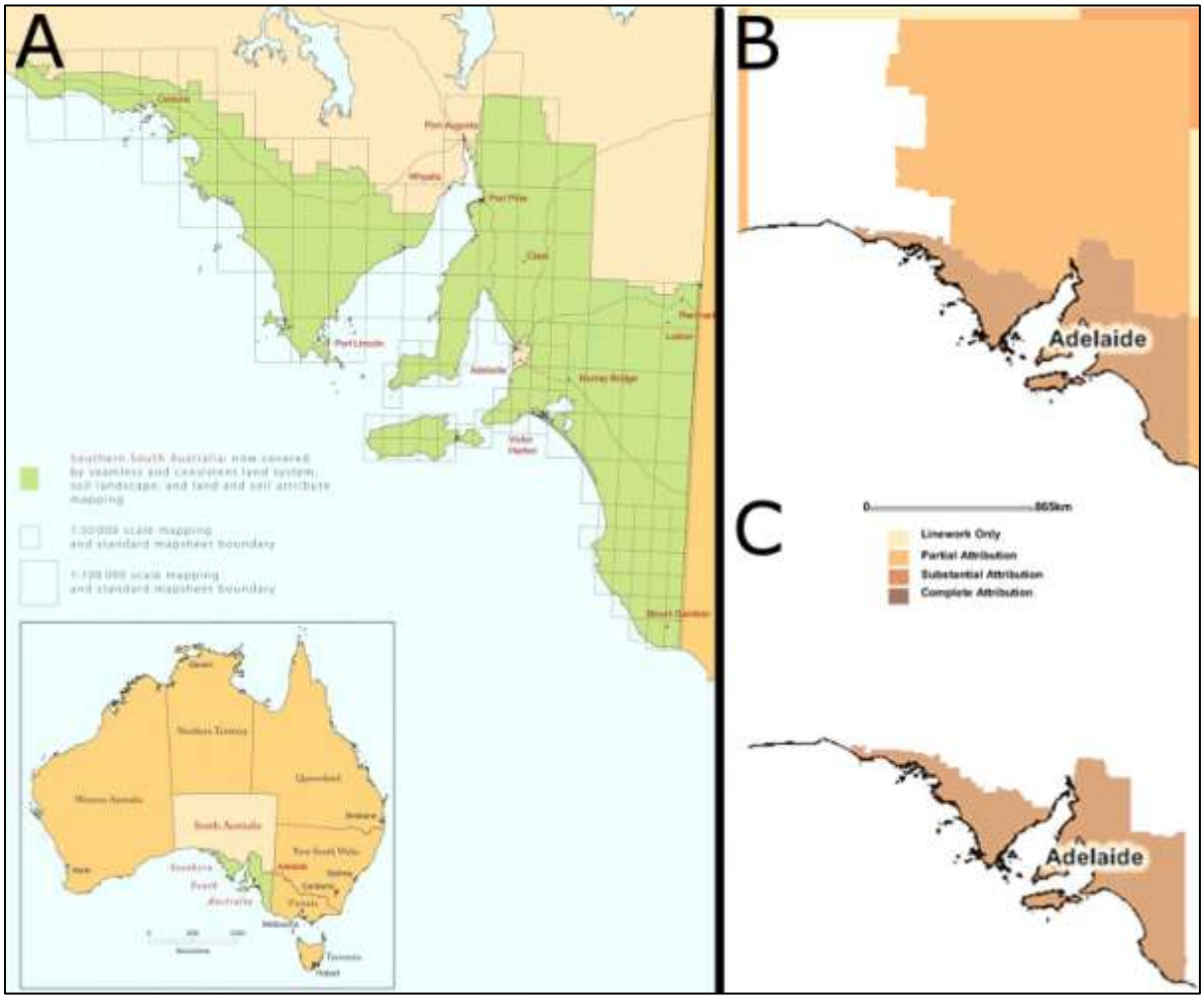

Figure 4 Extent of soil mapping by scale in south Australia (a); ASRIS capture and attribution level 4 (b) and level 5(c)

Victoria

Soil coverage in Victoria has a complex history and is not easily summarized (Figure 5A). Some data have been captured at Level 4 in the ASRIS format, although there is only partial attribution (Figure 5B). This is based on statewide broadscale land systems mapping.

This mapping is currently being revisited, but a lot more work needs to be done. Attribution is rudimentary for most polygons and does not provide consistent state wide coverage, apart from 1:250 000 geomorphic mapping and Land Systems.

Summary of mapping adequacy:

- Since Victoria is almost completely outside the arid /rangeland zone, the soil survey specification is for 1:100 000 throughout, with a significant area of 1:25 000 mapping in the south. Existing 1:100 000 mapping covers around 50% of the state, although there remains considerable work to do in correlation and validation; the finer scale data are not generally available as specified. There are many reserve

areas in the east of the state which have had less mapping effort and so lower the overall coverage.

- ASRIS coverage: sufficient resources have not been available to collate and convert Victorian soil data into the required ASRIS coverage. This has required an initial effort in correlation, data harmonisation and validation which is now happening in Victoria.

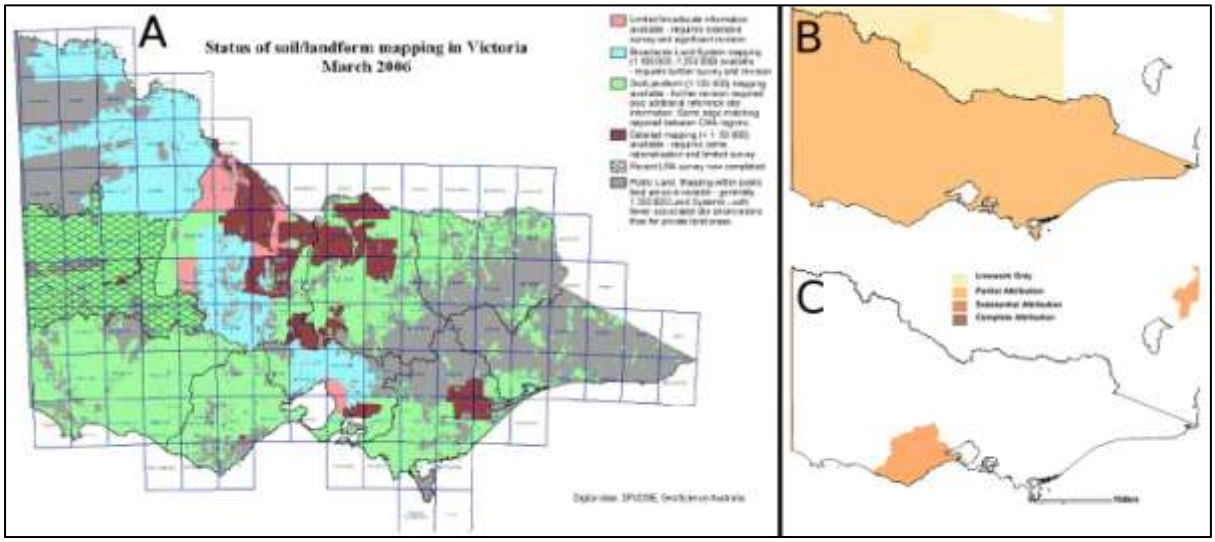

Figure 5 Extent of soil mapping by scale in Victoria (A); ASRIS capture and attribution Level 4 (B) and Level 5(C)

Tasmania

Tasmanian major soil mapping is summarised in Figure 6A and the extent of conversion to ASRIS in Figures 6B and C.

1:100 000 soil mapping covers a large proportion of Tasmania's main agricultural land. It includes two broad categories:

- 1:00 000 Correlated Soil Mapping: these maps were based on the CSIRO Soil Reconnaissance 1:63 360 Series, mapped from the 1930s through to the 1970s. In 1999/2000 the maps and reports were "correlated" (edge-matched), rectified and updated to the Australian Soil Classification System using a combination of field and desktop enhancements. The mapping includes the DPIPWE South Esk 1:100 000 soil map, mapped during the mid 1990 s, and 1537km2 of state forest mapping. The total coverage is around 13,900 km^2 or 20% of the state.
- 1:100,000 Non-Correlated Soil Mapping: these maps are based on the CSIRO Soil Reconnaissance 1:63 360 Series, mapped from the 1930s through to the 1970s. They have been digitised and rectified, but not correlated. These cover a much smaller area (around 3800 km^2 or 6% of the state).

Land Systems of Tasmania have been fully attributed to ASRIS Level 4 for the majority of the State's agricultural land. The nominal scale of mapping is 1:250 000. With a combination of expert opinion, existing soil maps, point location data, and pedotransfer functions, the ASRIS data now cover 48,900 km2 or 72% of the state. The soil order has been predicted for each land system component using existing soil mapping, point data and expert opinion. This is the only full coverage for the state, and includes all land systems data.

There are numerous ad hoc and relatively small detailed soil maps throughout the state, ranging in scale from 1:50 000 to 1:25 000. These were commissioned for a range of different projects and requirements. The Tasmanian Department of Primary Industries, Parks, Water and Environment (DPIPWE) is mapping up to 70 000 ha in newly commissioned irrigation areas, at 30 m resolution, for a range of land suitability soil property parameters during 2011/ 2012 as a pilot project. Planning is also underway for mapping irrigation areas post-pilot.

Summary of mapping adequacy:

- Since Tasmania is outside the arid /rangeland zone, the soil survey specification is for 1:100 000 throughout, with a significant area of 1:25,000 mapping in the cropping areas through the middle of the island. Virtually all mapping effort has been at broader scales than this, so mapping specifications for Tasmania are not met. The immediate goal in Tasmania is to complete effort at 1:100 000 scale in the cropping lands; it is unlikely that the current specifications will be met in the forseeable future. Nonetheless, there has been a revival of effort in Tasmania, in contrast to many other agencies.
- ASRIS coverage: a substantial effort to correlate existing soil information has led to more useful information within the state, and means that the current ASRIS coverage is a good as possible given the current information base.

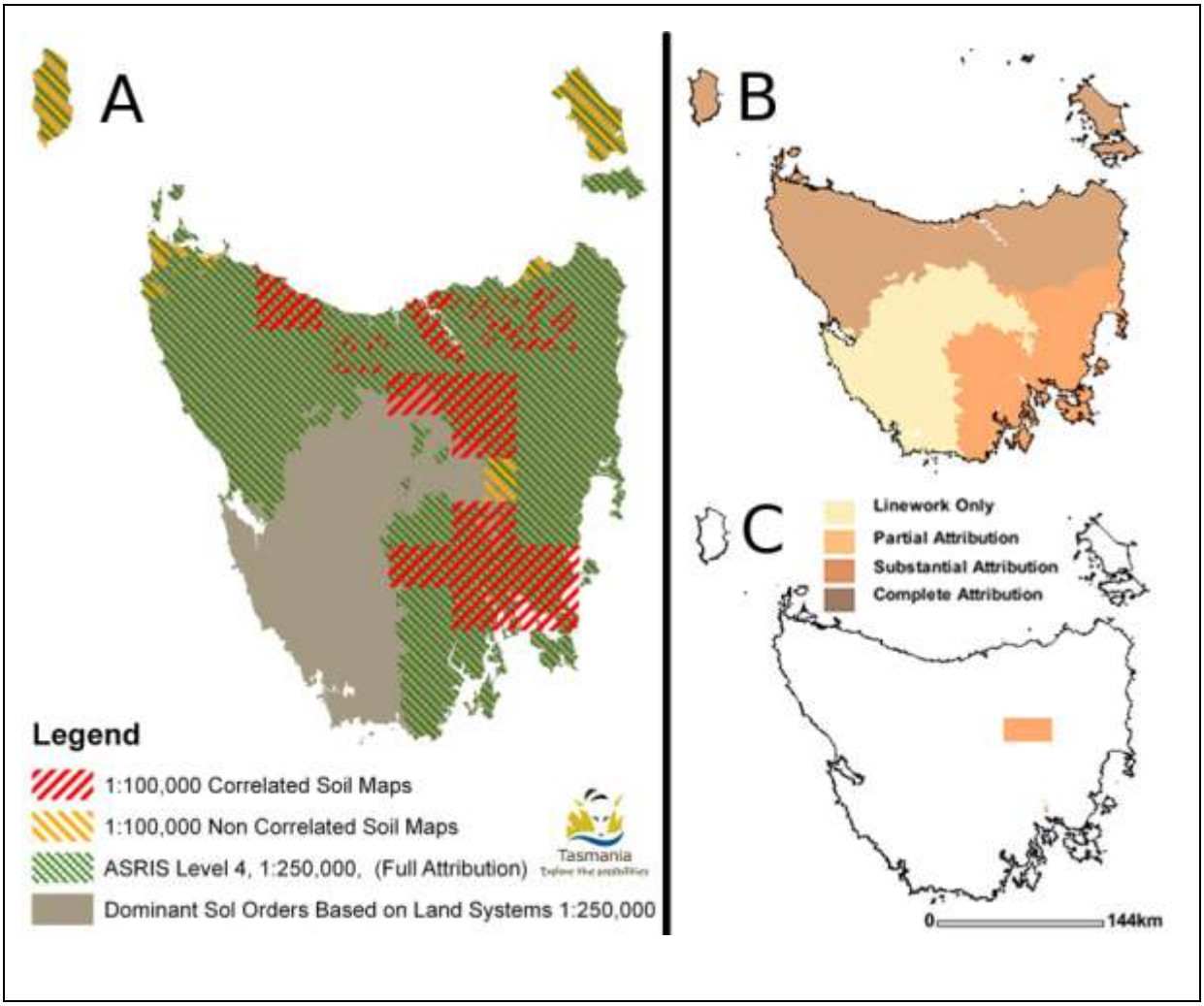

Figure 6 Extent of soil mapping by scale in Tasmania (A); ASRIS capture and attribution Level 4 (B) and Level 5(C)

New South Wales

Soil information in New South Wales is the responsibility of the Office of Environment and Heritage (OEH). It is held within the Soil and Land Information System (SALIS) which has descriptions of soils, landscapes and other geographic features from across NSW supplied by OEH staff and accredited agency and private sector contributors. As of end October 2010, SALIS contained 70 556 soil profile observations (see below), of which some 37 982 are publicly available.

OEH is also the custodian of the soil surveys undertaken by NSW Government agencies. The published mapping is illustrated in Figure 7A. From these data, OEH has produced state wide soil information products based on a compilation of the highest-quality soil map coverage. The completed coverage encompasses more than 4 000 individual mapping units, each of which has been assessed for key soil properties (e.g. erosion, acidity and salinity). The mapping also uses Department of Industry and Investment (Geological Survey) Surficial Geology mapping for the Central West portions of Walgett, Nyngan and Gilgandra 1:250 000 sheets. This information is stored in a database, which encapsulates the extensive and complex rule set. The information classifies land based on an eight class land limitation system, taking into account land use and

management applications. Using the above state wide coverage, other derivative products have been produced for internal OEH purposes (e.g. fertility, hydrological groundwater, estimated plant available waterholding capacity), primarily for vegetation mapping and in groundwater / recharge models. Conversion of the New South Wales data into ASRIS is incomplete, so the coverage in the national system does not yet reflect the data available for the state (Figure 7 B and C).

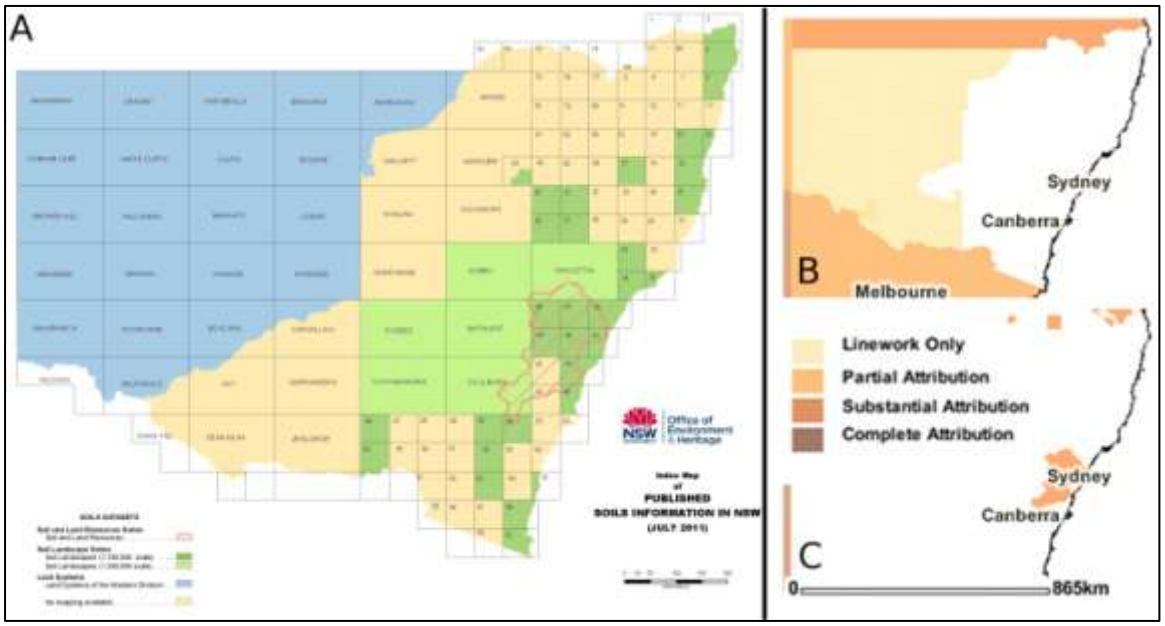

Figure 7 Extent of soil mapping by scale in New South Wales (A); ASRIS capture and attribution Level 4 (B) and Level 5(C)

Summary of mapping adequacy:

- New South Wales (and Queensland) have challenging requirements; relatively high resolution mapping is needed over much of their area, and there remain large areas with inadequate mapping. Completing the coverage will require significant additional survey.
- ASRIS coverage: OEH and its predecessors have invested resources into deriving as much value as possible from the existing map coverage which substantially increases its utility. As yet, only a small fraction of these data have been converted into the ASRIS data system.

Queensland

Queensland has the whole state covered with level 4 ASRIS data with substantial attribution (Figure 8B). At the more detailed level 5, the areas available are much smaller and scattered (Figure 8C).

This reflects the underlying mapping (Figure 8A) which is patchy, reflecting a long history of project based soil survey. Significant sections of the high land use intensity coastal zone are covered by mapping at better than 1:100 000, especially in the sugar and horticultural zones. Coverage is limited across all of the broadacre cropping zone; several 1:100 000 scale land resource studies have been completed in these areas, but these are supplemented by land systems mapping often at scales of 1:500 000. In the state's western rangelands the mapping requirements are adequately covered by

broad scale land systems mapping. In the northern rangelands the coverage often relies on very old and sparse datasets at scales up to 1:2 million.

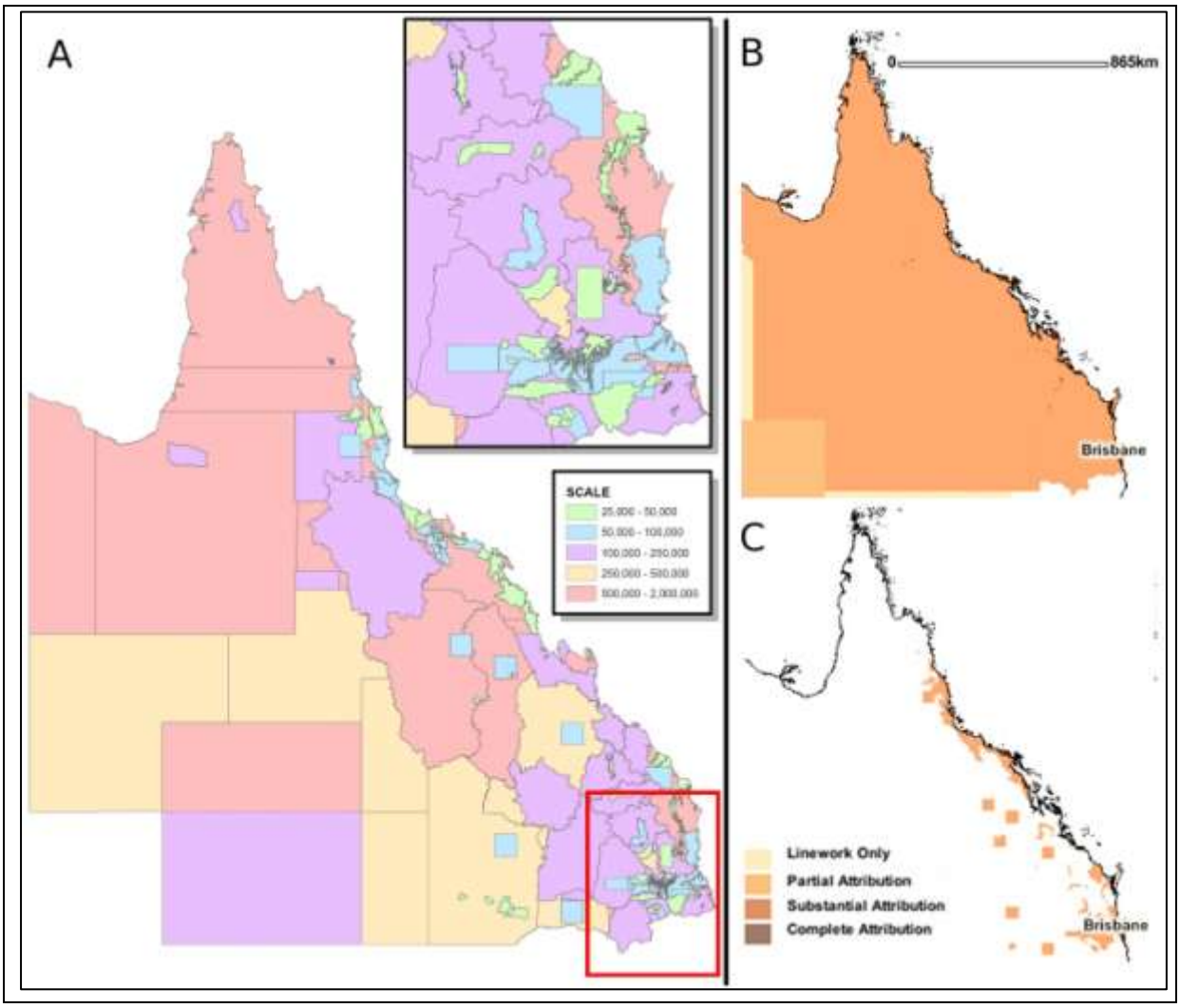

Figure 8 Extent of soil mapping by scale in Queensland (A); ASRIS capture and attribution Level 4 (B) and Level 5(C)

Summary of mapping adequacy:

- Queensland has large areas which need relatively high resolution mapping and there are large areas with inadequate mapping. The notable successes are in the high intensity coastal agricultural areas and in the south-west of the state. Completing the coverage requires significant soil survey.
- ASRIS coverage: DERM and its predecessors have invested substantial resources in an effective information system aimed at drawing as much information as possible from the existing coverage. This has been converted into the ASRIS format to the extent possible given the coverage.

Northern Territory

The original focus of soil survey and investigation in the Northern Territory was on the agricultural lands in the Daly and the northern coastal plains. Intensive mapping (1:25 000) has also been undertaken in the Darwin region to better plan peri-urban and intensive horticulture development. Regional 1:50 000 mapping also covers significant areas of the Mary and Daly River Catchments. In the 1990s there was also considerable broad scale mapping undertaken across the pastoral lands of the Victoria River District and semi arid and arid lands of the southern region and Barkly Tableland (Figure 9A).

In collaboration with ACLEP and ASRIS, considerable work has been undertaken to join the broad scale land system mapping across the northern part of the NT. The Barkly Tableland and information further south will be added in the future. This work has created better connected information within the Territory and was a necessary first step to converting soil data in the Territory into the ASRIS format. Much of the northern section has good attribution at Level 4; there are relatively small areas of Level 5 in the Daly and Mary River catchments (Figure 9B and C).

Summary of mapping adequacy:

- Survey effort, albeit at a low base, has continued in the Northern Territory, and given the large areas and sparse population, the territory is closer to meeting information requirements than many others. There remain significant challenges in completing the mapping across the rangelands.
- ASRIS coverage: there has been a concerted effort in the Northern Territory to use the ASRIS opportunity to correlate and convert disparate surveys into a better correlated information system. Consequently, ASRIS coverage reflects the level of information available.

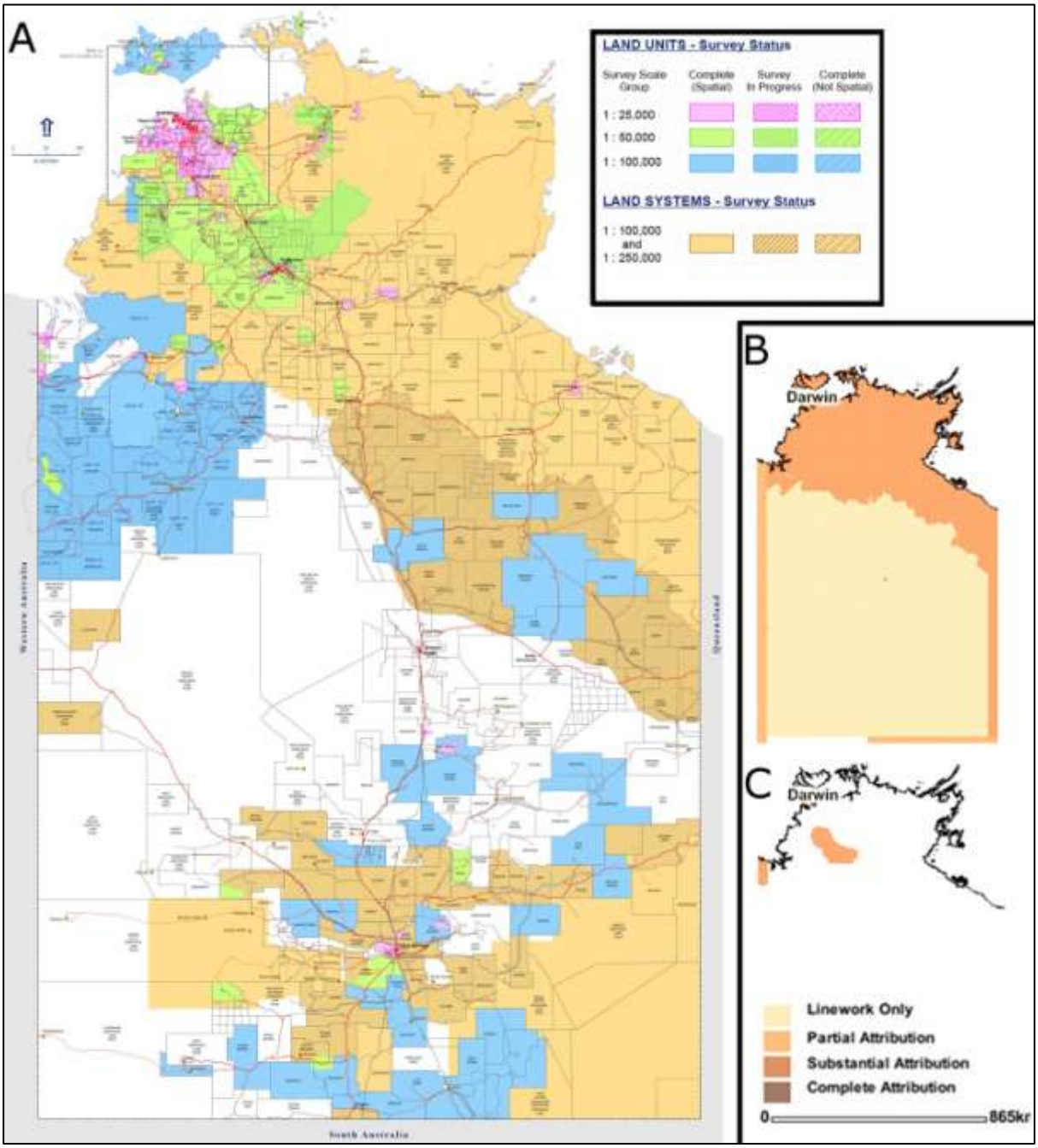

Figure 9 Extent of soil mapping by scale in the Northern Territory (A); ASRIS capture and attribution Level 4 (B) and Level 5(C)

Conclusions

Australian soil science agencies have made significant use of information technology and advances in soil survey science to make the most of a scattered and discontinuous legacy. Nonetheless, the lack of a sustained and coordinated survey effort has left the nation with soil information coverage well below minimal needs, as illustrated in Figure 10 and the rate of soil profile data collection in Figure 1. It is also significantly below that achieved in comparable developed nations.

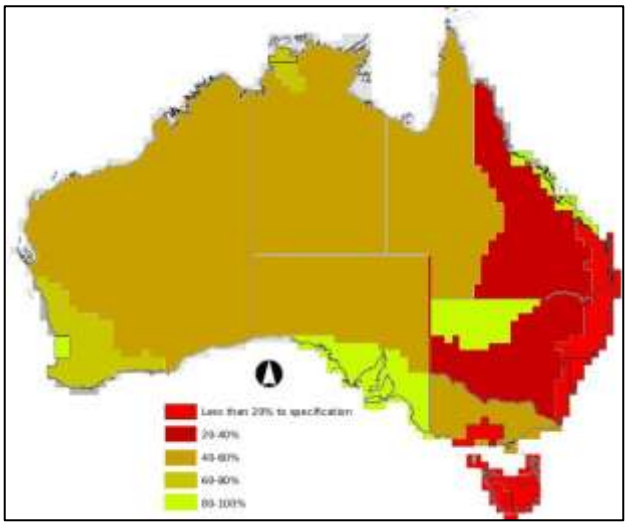

Figure 10 Broad estimate of the extent to which current soil information coverage has yet to meet required coverage and resolution

All states and jurisdictions maintain their own soil profile data base, and most maintain some form of soil archive. This has the advantage that the information is maintained where it is collected, but is also means that bringing it together in a complete and standard format for national purposes requires commitment, effort and funding. CSIRO has accepted responsibility for coordinating the national soil profile data base and the national soil archive, but funding for this is project based and not secure.

The archives are an important resource where there are such information shortfalls. There is a strong case for more structured coordination across the archives to strengthen the national ability to access these samples for new analysis and planning.

Substantial efforts within state and territory agencies have made the most of the information available through standardisation and correlation processes, and through a commitment to the ASRIS concept which provides a standard soil information model through the country (Figure 11 and Figure 12). The capture and conversion to ASRIS is not yet complete, the process requires a substantial commitment of resources within agencies and this has not always been possible when facilitating funds have been available. Nonetheless, the extent of ASRIS data now makes significant national use of the collated data for responsible agencies possible.

More use of agency and ASRIS data is planned to providing national estimates of soil functional attributes on a consistent grid to meet the needs of modellers, planners, ecologists and the earth observation community (through Australian Collaborative Land Evaluation Program and Terrestrial Ecosystem Research Network).

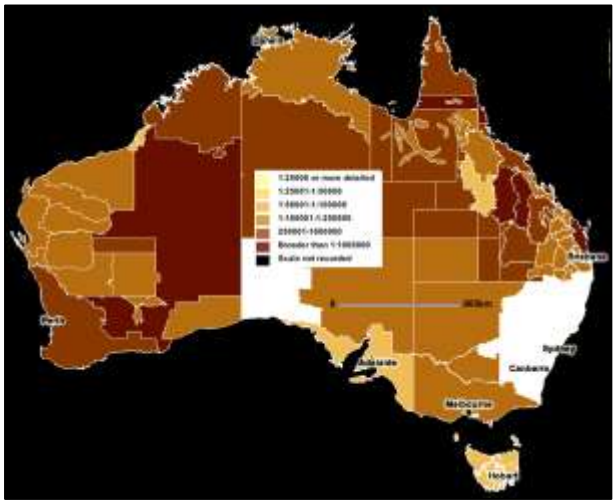

Figure 11 Extent of capture and attribution of information within ASRIS level 4

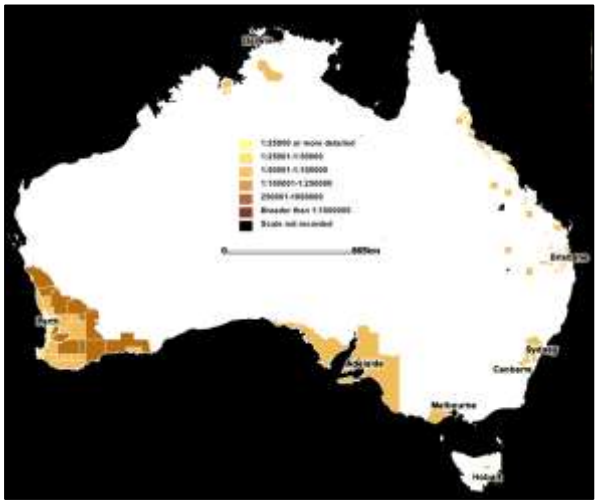

Figure 12 Extent of capture and attribution of information within ASRIS level 5

The adequacy of the national soils knowledge base depends on comparing the current data with future and as yet unknown demands. When a new priority emerges, such as the Northern Australian Task Force Review, it is impossible to collect new soils information within the available time frame. The existing soils knowledge base must be used; then the shortcomings limit the response. Best practice suggests that areas should be remapped after about 25 years, as some soil properties change and as new technologies offer additional or more precise information. This means that for many areas remapping is already overdue. The fundamental need is a renewed and consistent effort to capture soil data where the current coverage is inadequate.

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