

THE AUSTRALIAN COTTON SOIL DATABASE AND GEOGRAPHIC INFORMATION SYSTEM

Inakwu O.A. Odeh¹, Stephen Cattle¹, John Triatafilis^{1,2} and Alex B. McBratney¹
Australian Cooperative Research Centre¹, Faculty of Agriculture, Food & Natural Resources,
Ross Street Building A03, The University of Sydney, NSW 2006

²Present Address: School of Biological, Earth and Environmental Sciences (BEES)
Biological Sciences Building (Room 633), University of New South Wales NSW 2052

Summary

In modern society there has never been more emphasis placed on the accuracy and reliability of spatial information used for management of natural resources. As management decisions regarding environmental and built resources are being more closely scrutinised, so too are data used for decision-making based on alternative land uses. Therefore the collection of accurate natural resource data and their processing into useful information are of utmost importance. In recognition of these requirements, the **Australian Cotton Cooperative Research Centre** funded (total funding: \$3.7 million) a number of research projects since 1994 to make inventories of soil of the cotton-producing regions of Australia. The outcome of this project is a large amount of both quantitative and qualitative soil data covering much of the northwestern New South Wales and southwestern Queensland.

The soil data covers, among others soil quality indicators, soil salinity, soil physical and chemical properties, and descriptive properties of the soil. There are over 90,000 records covering over 1,500 sites located in the Namoi, Gwydir and Macintyre valleys, and the Bourke and St George Irrigation districts. This is unprecedented in the realm of land resource survey in Australia, as no other industry has such wealth of soil data in a given region. The soil data provide the benchmark of soil quality for future monitoring of the land resources and catchment health. The soil data have also been processed to extract useful information for decisions regarding alternative management practices. Useful products, such as digital soil type and attribute maps, are being used for environmental modelling and regional planning.

To facilitate access to the information and ease of use and manipulation by the end users, the soil data have been put together into a simple-to-use database, which we termed as **Australian Cotton CRC Soil Database Assistant**. Potential users of this database include: land managers, agronomists and farm managers, environmental analysts and planners, government employees in EPA, DIPNR (NSW), NSW Agriculture, and Land and Water Researchers.

An adjunct to the soil database is **Cotton CRC Soil Information System (CRC-SIS)** which could be used as an agricultural and environmental decision support system. Combined with the easy-to-use soil database, the CRC-SIS, when mounted in a server, provides a much more dynamic tool than a static (analogue) map. Based on a geographic information system (GIS), the CRC-SIS Internet Server could deliver interactive query capabilities such as

- Searching for site locations of interest

- Displaying and viewing multiple data sets and maps
- Conducting queries for specialised analysis
- Retrieving specialised data services and information

These capabilities of the CRC-SIS are very appropriate for a rural-based group such as cotton-farming community. The CRC-SIS allows for simple query, retrieval and other customised operations specific to the land management requirements under cotton production systems. Digital soil type and soil attribute maps, describing the spatial patterns of soil attributes and associated soil quality indicators, have been incorporated into the CRC-SIS. The resulting easy-to-use map format would allow researchers, farmers and other stakeholders have access to the soil databases, and the soil maps incorporated into the GIS-based CRC-SIS through the freely available ArcReader software (developed by ESRI®). Both the soil database and CRC-SIS, along with the easy-to-use ArcReader, are published on CD-ROMs for distribution to the users, and thus provides added flexibility to technological diffusion of our research results.

Background: what was lacking prior to the soil inventory project

There is a growing need for accurate soil information for modelling soil processes, land use planning and environmental protection. Such quality information for environmental modelling are generally lacking for most of the arable land of Australia. This was the case with the cotton-producing regions of Australia until recently. Prior to this project, reliable soil information was lacking or existed in scattered and uncoordinated patterns in the cotton-growing regions. Because of this inadequacy, a project was initiated and funded by the Cooperative Research Centre for Sustainable Cotton Production and later continued and maintained by its successor, the Australian Cotton Cooperative Research Centre.

Aims

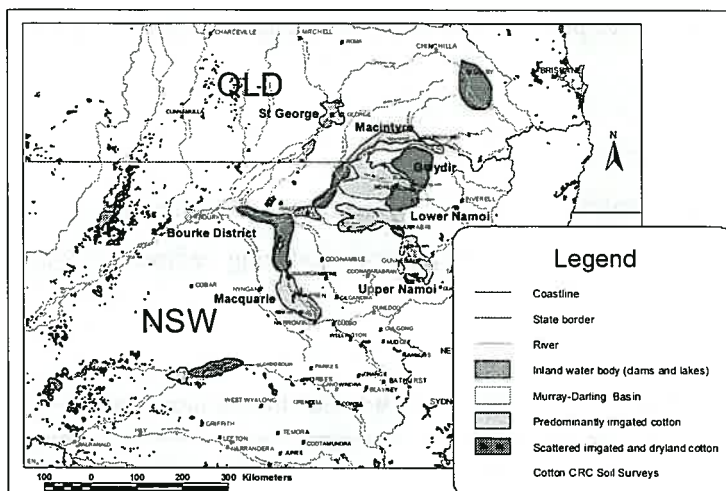
The main aims were to

- Efficiently sample the soil of the regions and provide **soil data** that would provide reliable information on soil quality.
- Collate the soil physical, chemical and qualitative data into a queryable database for use by the stakeholders.
- Develop an integrated soil information system for the analysis of, easy access to and retrieval of the soil physical-chemical data by the stakeholders.
- Publish the database and the soil information system for easy distribution to the stakeholders

Sampling began in early 1995 in the lower Macintyre Valley, and was later extended to the lower Gwydir (1996), lower Namoi (1997) and upper Namoi (1998). Surveys were carried out in St George Irrigation District (1999), Bourke Irrigation District (2000) and Lachlan Valley (2001). Soil colour, structure and other morphological properties were observed in the field. Thousands of soil samples were

collected and analysed for chemical and physical properties in the laboratory. This resulted in over 9,000 measurements for the combined regions.

Figure 1. Map of New South Wales showing the Cotton CRC soil survey site



Soil properties measured and included in the database

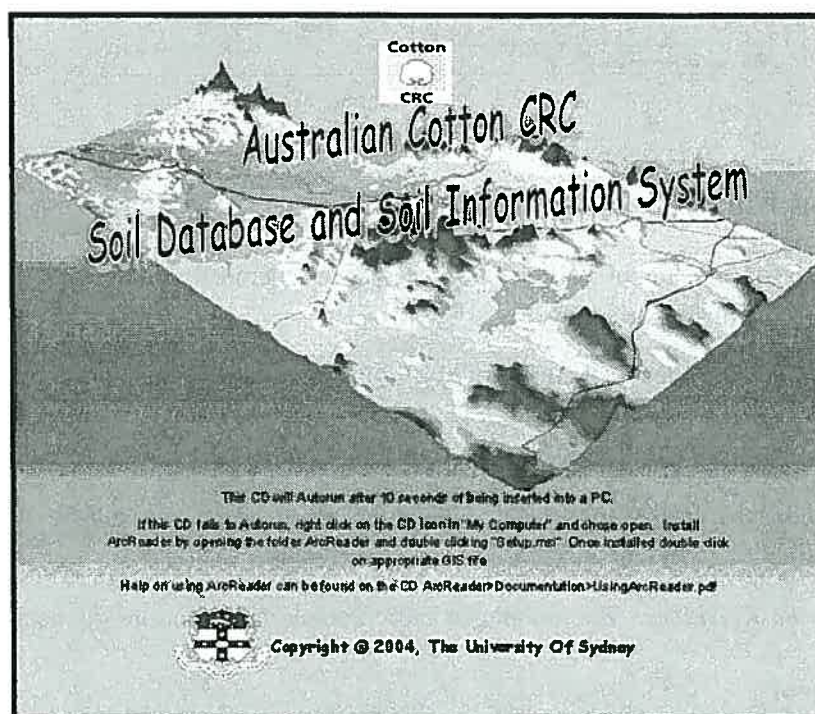
- *Soil pH:* pH is a measure of soil reaction; it affects chemical activities in the soil, hence availability of some plant nutrients.
- *Electrical conductivity:* Electrical conductivity (EC) is a measure of salt concentration in the soil which, in turn, is determined by intensity of salinisation processes; the amount of salts in the soil has some physiological effects on certain crops to a varying degree.
- *Bicarbonate extracted phosphorus (P):* Soluble P is a measure of available P, and hence P fertility. Soluble P is also a measure of P-sorptivity of the soil.
- *Exchangeable basic cations:* The amount of basic cations is a measure of their availability to plants;
- *Effective Cation Exchange Capacity (CEC):* CEC influences physicochemical processes in the soil and, in conjunction with *exchangeable sodium*, can be used to quantify sodicity which affects structural and physical processes in the soil.
- *Organic carbon (OC):* The amount of OC is important as a structural constituent in addition to its usefulness as a nutrient source for plants and soil microflora and fauna important for overall soil health. Also carbon sequestration through soil management is important for limiting greenhouse effect.

- *Total organic nitrogen*: Like OC, it is a measure of soil fertility and the ratio of it to OC reflects biological activities in the soil.
- *Particle-size fractions (clay and silt and sand)*: The particle-size distribution of a soil affects the physical and chemical processes of the soil and hence the latter's overall fertility and degradability. The consequence of flux of contaminant into the water system is also important.
- Additionally, field soil description important for soil classification is included.

Outcome

- A major outcome of the large amount of both quantitative and qualitative soil data incorporated in a **Soil Database** covering much of the cotton-producing regions of New South Wales and southwestern Queensland.

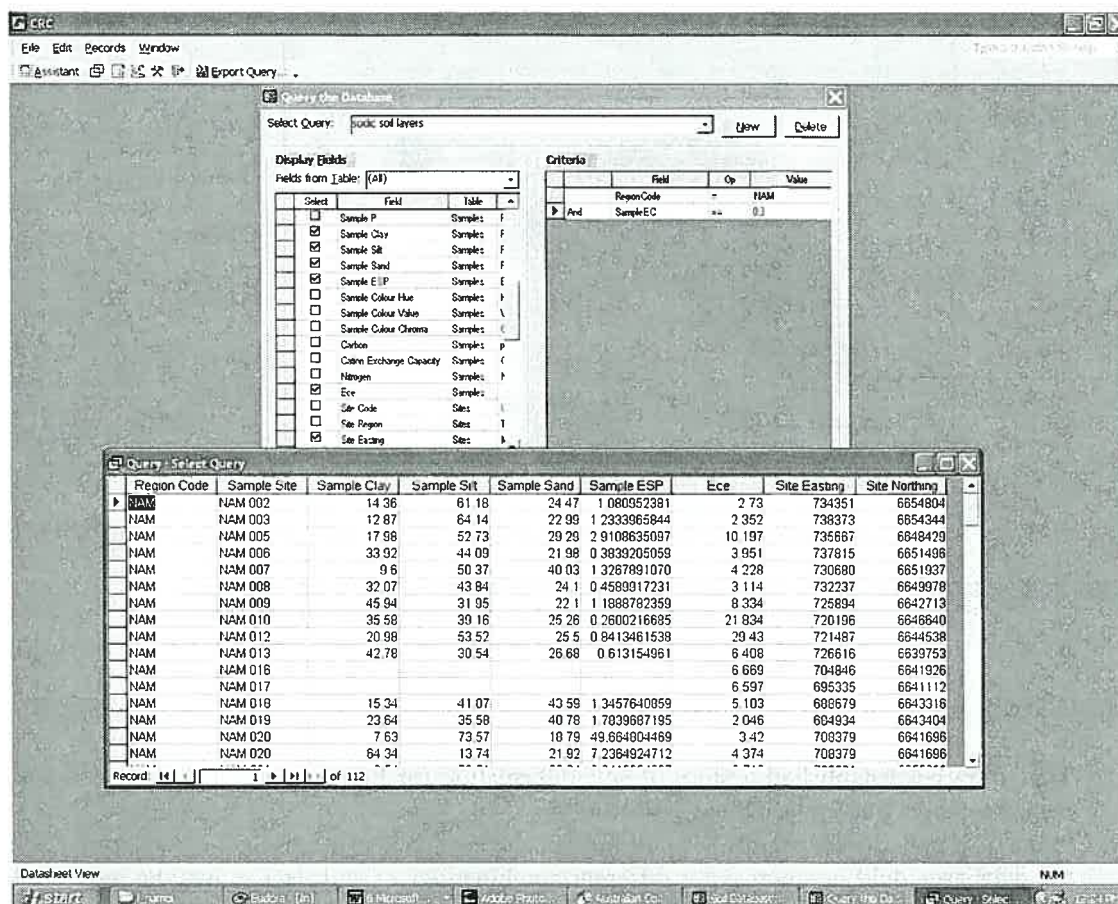
Figure 2. The Australian Cotton CRC Soil Database and Soil Information System (CDROM)



- The database initially covers the cotton-producing areas in three NSW northern and boarder river valleys: the Macintyre, Gwydir and the Lower Namoi (Figure 1), in addition to the Lachlan valley. The database will be updated with data from other regions.
- The data have been incorporated into a Microsoft Access database form. This form includes a 'Database Assistant' to make it easy to retrieve appropriate soil data for a specific region/area and purpose. The Database Assistant, which is written into CD-ROMs (Figure 2) for easy distribution to the end-users, also facilitates the updating and maintenance of the database itself.

- Soil Information System, which incorporates digital soil property maps into a Geographic Information System.

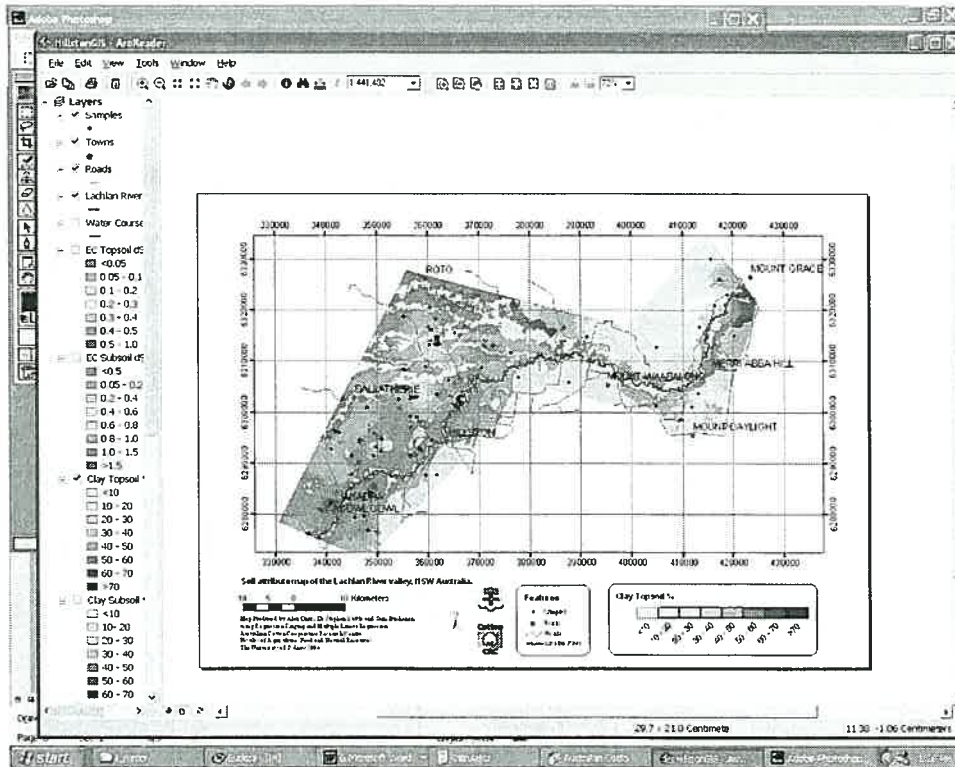
Figure 3. The Query result screen from the Soil Database Assistant.



Funding and Implementation

- The Australian Cotton CRC and its predecessor, the CRC for Sustainable Cotton Production, largely funded the project. The combined investments by the two CRCs amount to over \$1.2 million.
- National Heritage Trust provided funding of some adjunct projects to the tune of \$1 million.
- This was supplemented by Cotton Research & Development Corporation's funding of about \$1 million.
- Additional funding and in-kind contributions from the University of Sydney sum to over \$1.5 million.
- The project was initiated in mid-1994 and it is still ongoing.
- Implemented in Namoi, Gwydir, Macintyre, St George irrigation District, Bourke Irrigation Districts and the Lachlan cotton-producing areas (See map in Figure 1).

Figure 3. Topsoil clay map of cotton-producing areas of the Lachlan Valley



Benefits

- The study has established a store of soil information (of known precision) that is required for decision-making on environmental protection.
- A major product of this project is the soil database containing the huge stores of useful soil data; the database could be queried for different combinations of soil data as may be required by the end-user.
- The soil data could be used in future to assess and monitor agriculturally-induced environmental impacts.
- Both the soil data and the GIS maps are being used for environmental modelling and land management planning.

Examples: Using the Soil Database and Soil Information System

Querying the Soil Database:

A simple example will suffice. An end-user who wishes to extract data on sites that are saline in both topsoil and subsoil in the Namoi Valley would query the Soil Database as:

Select Region Code = NAM

And

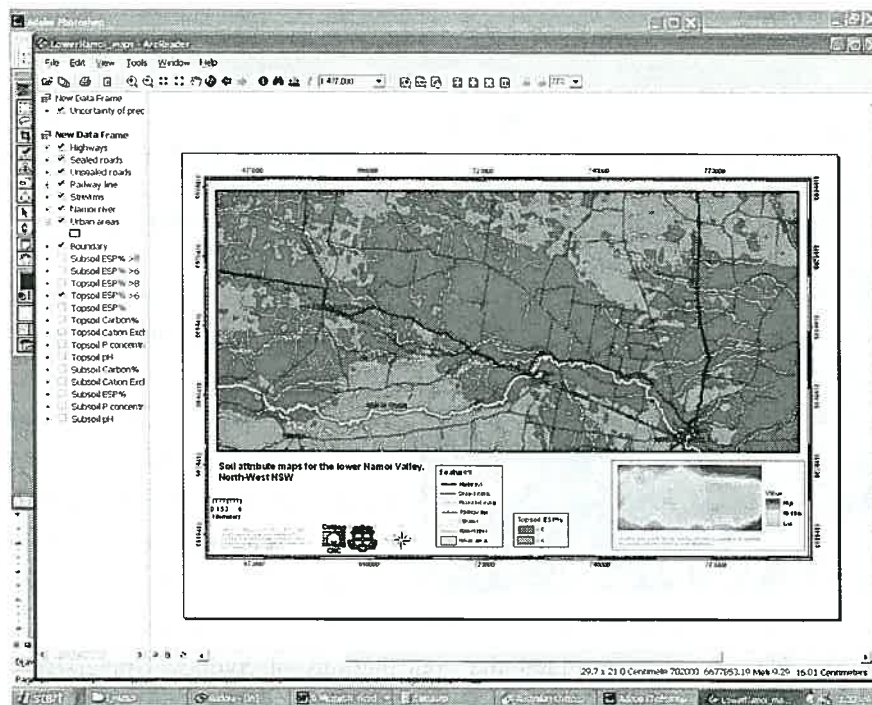
Select Sample EC \geq 3 dS/m

This example is given in the “Query the Database” window as shown in Figure 3. The result of the query is shown in the second window in Figure 3 as “Query: Select Query”. The user can also select other relevant site information including soil data that may be useful. For example, “Eastings” and “Northings” if selected may be useful for GIS analysis of the extracted soil data. Multiple queries are also possible within the Soil Database Assistant.

Examples of soil GIS layers:

- Many digital GIS maps for both the topsoil and subsoil have been produced for the regions included in the first version of the CDROM. Examples include:
- Displaying Topsoil clay map of cotton-producing areas of Lachlan Valley (Figure 4)
- Displaying Topsoil sodic layer (ESP > 6) in the lower Namoi Valley (in red as shown in Figure 5).

Figure 4. The topsoil layer showing incidence of sodicity (in red) in the Lower Namoi Valley



Many soil property layers can be displayed, viewed and printed for management purposes or for use by the policy makers.

The Future

- Much of the results of this project will provide future use for:
- Monitoring purpose (comparing the past soil condition with future conditions)

- Catchment modelling when aggregated and incorporated into other landscape information. This will lay the foundation for the “Catchments and Landscapes” program of the Proposed Cotton Catchment Communities CRC
- Continued refinement of the Soil Database is ongoing.

New South Wales Minister for Primary Industries Launches the Australian Cotton Soil Database and Soil Information System

The Australian Cotton Soil Database and Soil Information Systems (ACRC-SDB & SIS) were recently launched by the NSW Minister for Primary Industries, The Hon. Mr Ian MacDonald at this year’s Moree Cotton Trade Show. The show was held on the 26th of May 2004 at the Moree TAFE Agricultural Centre. In lively atmosphere of the Show, the Database and GIS were launched in the midst of enthusiastic growers and cotton industry consultants. In his speech he Minister pledged the NSW government continued support for science backing agricultural production in the State. He praised the efforts of the Cotton CRC, the University of Sydney and of the researchers who carried out the work of soil inventory in the Cotton Producing regions of NSW that has culminated in the building of the Soil Database.



Picture Left: Dr Odeh showing the Minister how the Cotton CRC Soil Information System works

In his vote of thanks speech, the Dean Faculty of Agriculture, Food & Natural Resources, Professor Les Copeland thanked the Minister for making the time to launch the Soil Database. He further acknowledged the contributions of the funding agencies to the success of the soil inventory project, in particular, the Australian Cotton CRC and

it’s predecessor the CRC for Sustainable Cotton Production, the CRDC, the National Heritage Trust and the NSW Salt Action. He also acknowledged the contributions of Sydney University’s Faculty of Agriculture Food and Natura Resources researchers to the success of the project, in particular Dr Inakwu Odeh, a senior research fellow who led the field team as well as led in the execution of the project, Professor Alex McBratney who initiated and supervises the various aspects of the project, Dr John Triantafilis and host of others, including Sydney University postgraduate and honours students- past and present.

Dr Odeh gave brief history of the core project, which started in 1994. He emphasised that there was lack of reliable soil information in the cotton producing regions prior to the start of the project. “This has all changed now”, he said. He briefly demonstrated the package to the attentive onlookers and the Minister’s entourage.

Acknowledgements

Professor Alex McBratney and others started this project at then CSIRO Division of Soil in the 1980's when the Cotton Research & Development Corporation provided funding to carry out detailed soil survey of the Edgeroi area. Later the project was extended to cover all of the cotton-growing valleys of NSW and southern Queensland, with funding from the Australian Cotton Cooperative Research Centre (and its predecessor, the Cooperative Research Centre for Sustainable Cotton Production).

Much of this work was carried out using facilities based at the University of Sydney. Data were obtained by various groups led by Dr Inakwu Odeh and with the assistance of students at the Faculty of Agriculture, Food and Natural Resources:

Macintyre Valley Data: Inakwu Odeh, Peter Johnson and Alison Todd

- Gwydir Valley Data: Inakwu Odeh, Hagen Ganahl, John Triantafilis, Mohammad Faruque Ahmed
- Lower Namoi Valley Data: Inakwu Odeh, Eugenia Figueroa, and Andrew Huckel and John Triantafilis
- Edgeroi Topographic Map Sheet Area: Alex McBratney, William Ward and Desmond McGarry
- Lachlan Valley Data: Alex Onus and Stephen Cattle

Copies of the CD-ROM could be obtained from David Larson of the Cotton CRC Technology Resources Centre on (02) 6799-1500.

