Soil Archives: supporting Research into Soil Changes

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Abstract. Soil archives provide valuable support to soil research by making soil specimens and associated data available, reducing the need for labour intensive and expensive fieldwork.

1. International Soil Archives

The usefulness of soil archives has been well demonstrated. Work based on the Rothamsted collection in the United Kingdom provided evidence of steady rates of increase in concentrations of dioxins during the last century [1]. The sample archive of the equally well known Hubbard Brook Experimental Forest in the U.S. led to the discovery of the link between the use of fossil fuels and increased acidification of rain and snow in North America [2]. Soil archives are also the Rosetta stone of terrestrial carbon cycling because atmospheric CO_2 is spiked by radiocarbon from aboveground nuclear weapons testing and offers a tracer for carbon in soil.

2. Australia's National Soil Archive

The CSIRO National Soil Archive was established in 2003 to consolidate several smaller CSIRO collections [3]. The soil specimens from these original collections had been collected for a wide range of research projects and differ in the amount of soil sampled, sampling depth and data collected in the field and in the chemistry laboratories. Since 2003, many state agencies archives and individual projects have contributed soil specimens and data, helping to build a truly National Soil Archive facility. Currently the collection holds 70,000 soil specimens from 9,000 profiles (Figure 1).

The National Soil Archive has protocols both for sample submission and sample use. The National Soil Archive's mission is to provide facilities and protocols for conserving the long-term scientific value of soil specimens and associated soil data. Archived specimens and their data are also made available for public research both now and in the future, when new analytical techniques may be brought to bear on the specimens. Specimens submitted are required to meet a number of criteria such as having adequate location data and other documentation and be non-toxic and in a dry condition.

Sample submissions vary in size from several hundred to several thousand specimens and may originate from national monitoring programs or local studies, soil science research or ecological studies and may be recently collected or several decades old. Sample use requests are even more varied and range from a single, specific sample to hundreds of samples that are reanalysed with modern laboratory methods. Co-located spectroscopy research by CSIRO has already re-analysed thirty-thousand specimens using NIR and several thousand using MIR [4]. Users of the CSIRO National Soil Archive sometimes only request the soil data, in other cases only the soil specimens. Usually the two go hand in hand. The National Soil Archive aims to balance access to the soil specimens to support current research with the need for preservation of specimens for future generations.

To archive soil specimens, air-dried soil material is transferred into standard long-life containers with bar-coded labels. Associated soil site description, morphology and chemistry data is transcribed and loaded into a standardised relational database (NatSoil) [5]. The site locations and data on soil morphology and chemistry can be accessed via the Australian Soil Resource Information System (ASRIS) [6] and through the SoilMapp for iPad app.

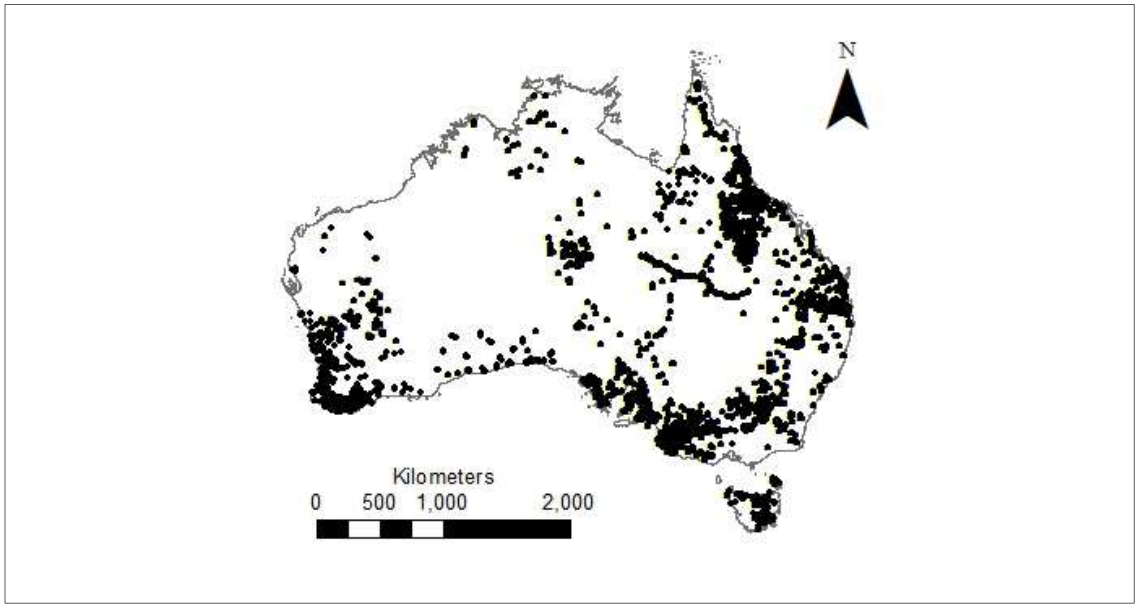

Figure 1. Soil profile locations of archived soil specimens in the National Soil Archive**.**

3. Who contributes to the Collection?

The national collection was started in 2003 by combining all roughly 24,000 specimens from the former CSIRO Divisions of Soils campuses. These specimens are very rich in data, since they were collected specifically for soil research. This part of the collection reflects the changes in research focus over the last 50 years. Older specimens stored by the CSIRO National Soil Archive (from the 1920's and the 1930's) do not have location data of the currently required accuracy and are therefore not archivable, but that part of the collection can still be used, if one is familiar with the publications. These specimens were collected prior to widespread application of pesticides and herbicides and before the start of nuclear testing in 1945, so provide an important baseline of soil condition. The very old specimens and other yet unarchived specimens are referred to as 'stored' specimens.

Large projects such as the Terrestrial Ecosystem Research Network (TERN) which connects ecosystem scientists and enables them to collect, contribute, store, share and integrate data across disciplines have contributed their AusPlots specimens for safe storage and future use [7]. Other national projects such as the Soil Carbon Research Program (SCaRP), which provides a nationally consistent assessment of soil carbon condition across the major land-use/soil type combinations used for agricultural production, have also contributed specimens [8]. Early discussions between the National Soil Archive and these large projects, which may involve tens of thousands of soil specimens, have led to streamlining of the archiving process.

The National Soil Archive holds the data and soil samples that have been captured since 2004 for the Soil Condition Evaluation and Monitoring (SCEAM) Project, which provides benchmark data for a range of soil condition indicators. For this study all major land-uses in Tasmania - intensive cropping, grazing, native and plantation forestry – are targeted and re-sampling occurs at five year intervals [9].

Some examples of retrospective archiving of specimens from the 1990's are provided by the submission of 1200 well-documented soil specimens from the Desert Uplands Strategic Land Resource Assessment (DUSLARA) in north and central western Queensland and a set of over 4,000 soil specimens with complete data from the Western Australian Department of Environment and Conservation whose dozens of ecological studies focus on remote, non-agricultural, remote areas.

4. How is the Collection used?

The National Soil Archive supports many soil research projects, for example –

- A rapid assessment of the distribution of soil with toxic levels of boron, which was completed by analysing existing specimens at half the estimated expense of new field sampling
- Thousands of archived specimens have been scanned and the MIR and vis -NIR spectra obtained. Using existing limited laboratory data and these spectra, models have been constructed and important soil properties predicted
- The Australian Federal Police have used archived soil specimens to examine the potential of new forensic methods
- A study on acid sulfate soils re-analysed archived specimens from the 1920s to compare to current soil conditions in particular locations
- The Victorian DEPI has re-analysed specimens from the 1970s National Soil Fertility program to study changes in soil carbon content since that time

5. An opportunistic Archive

The fact that the specimens in the National Soil Archive derive from a host of projects, agencies and researchers over an 80 year period adds to the breadth of the collection, but it can also cause some difficulties for users. In terms of data, older collections may be geo-referenced post-collection, which may introduce location errors. The data associated with specimens varies widely in its level of detail provided, for example, the precision of the geographic coordinates of the collection location, morphology description, collection method and analytical methods used.

During archiving, legacy soil data needs to be transcribed from paper copies of internal reports, ASCII text, Fortran based non-relational flat file database files or spreadsheets to fit the dedicated relational database. This involves a substantial effort which requires professional staff because the re-interpretation of descriptive codes, recalculation of measurement units, methods and nomenclature requires familiarity with current and previous classification systems.

For example, when Victorian researchers used archived soil data from the 1970's, some serious implications for using legacy data when dealing with Soil Organic Carbon came to light. A shift in Organic Carbon results appeared due to lab-based modifications over a 40 year period of the Walkley-Black method used to determine OC (Robinson, pers. comm.). The researchers decided to re-analyse archived specimens to develop a correction factor, something that has been done before by [10] in the Carbon conversion factors for an historical data project.

6. Partners

The maintenance of soil archives is not trivial and requires continued financial support and institutional commitment [11]. The National Soil Archive is one of the key deliverables of the Australian Collaborative Land Evaluation Program (ACLEP). ACLEP is a partnership between CSIRO, the Australian Government's Department of Agriculture and the state and territory agencies responsible for land resource assessment.

7. Conclusion

The collection of soil specimens in the CSIRO National Soil Archive is an irreplaceable and valuable resource for current future research due to the number of specimens, the quality of the information available for them and the broad range of sampling locations. Archived soil specimens can support problem-solving soil research by allowing calibration of new analytical methods, enabling the

development of baseline national soil property maps and by providing soil material for carbon cycle research.

Care and commitment are needed to establish a world-quality soil archive and the long-term value ought never to be compromised by short-term gains. Decisions of policy makers of the future must rest on the best possible data [12]. To secure the future of the National Soil Archive it is essential that its importance is recognized by the whole scientific community and, importantly, by those who fund the work. This requires foresight, patience and an awareness of the great potential value of the information that can emerge from archived samples. It also involves collections owners taking responsibility for their collections and being held accountable for their long-term care. Besides being an unrivalled resource for addressing many established issues, the National Soil Archive has the potential to provide answers to agricultural and environmental problems not yet recognised.

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