QUANTIFYING TRENDS IN SOIL CONDITION: GATHERING BASELINE DATA FOR DEVELOPING TARGETS AND SUPPORTING INFORMED LAND MANAGEMENT DECISION MAKING

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INTRODUCTION

Currently, across Tasmania there is little available data identifying the impact of land use and land management on soil condition. Agricultural production in Tasmania is economically important, contributing in excess of $903 million (gross value) in 2001/02 (DPIWE 2004). The value of primary industries in Tasmania has grown significantly since 1998, returning an additional $204 million at the farm gate over the period of 1998-2002 in agricultural production alone (DPIWE 2003). Whilst this growth is economically impressive, such an increase in production can place pressure on valuable natural resources. Furthermore, rural Tasmania has recently been experiencing significant land use change. Conversions of land from grazing to cropping and the introduction of centre pivot irrigation systems warrant investigations into the impact of current land management on soil condition. If such growth, production intensity and land use is to be sustainable, the impacts on soil condition need to be assessed and desirable threshold targets established to avoid degradation of a resource essential to Tasmania's agricultural industry. Therefore, there is an urgent need to establish preliminary benchmarks for the major indicators of soil condition to assist and benefit land management decisions.

The Soil Condition Evaluation and Monitoring (SCEAM) Project commenced in June 2004, is funded by the Natural Heritage Trust and is a joint initiative between Tasmania's Cradle Coast, Northern and Southern Natural Resource Management (NRM) Committees. In each of these NRM regions, SCEAM aims to: a) identify priority soil type and land use combinations at risk from degradation; b) collect information to indicate soil condition for key land uses; and, c) set-up a network of reference sites for future monitoring. It is anticipated that SCEAM will provide the appropriate system for monitoring soil condition and offer baseline data and critical thresholds essential to assessing and managing the health of Tasmanian agricultural soils.

SOIL CONDITION IN TASMANIA

Soil condition under agricultural production

While research has been undertaken in specific locations across Tasmania, there is no comprehensive network of reference sites that provide the necessary assessment or monitoring of soil condition. Previous investigations have focussed on assessing a range of soil physical, chemical and biological properties. Results indicate significant differences between cropped and long-term pasture paddocks with the particular differences dependent on soil type. For example, lower soil organic carbon and microbial biomass carbon levels in cropped compared to long term pasture paddocks on similar soil types are of concern, particularly as many other soil properties are found to be correlated to these particular attributes (Cotching *et al* 2001).

Recent work by Sparrow *et al* (1999) and Cotching *et al* (2001, 2002) indicate that most soils used for cropping in Tasmania are in reasonable condition. However, one third of paddocks on the four soil types investigated showed signs of soil structure decline associated with long-term cropping. Cotching *et al* (2002) found that a number of soil properties and agronomic variables were significantly correlated with crop yield and assay, but that these varied depending on crop and soil type. Sparrow *et al* (1999) suggest that interpretation of soil condition measurements as a result of their research, are difficult due to a severe lack of data. The authors recommend more comprehensive soil data be collected to indicate the capacity of Tasmanian soils to sustain productive agriculture.

Land management issues

Grice (1995) estimated that approximately 15% (317,000 ha) of private land in Tasmania is affected by moderate to severe soil structure decline. A more recent comprehensive assessment of the condition of Tasmanian soils has not been undertaken. The National Land and Water Resources Audit (2002) presents soil information for Tasmania derived from the Atlas of Australian soils including pH, salinity and sodicity. The topsoil pH suggests that most of Tasmania's cropping land has low soil pH. Limited work by Sparrow *et al.*

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(1999) and Cotching *et al*. (2001 and 2002) indicate that the trend for topsoil pH in cropping areas is for increasing pH due to the history of lime applications in these areas, in contrast to large areas of cropping country on mainland Australia.

Sparrow *et al* (1999) report on their concern for the unsustainable loss of topsoil in cropping paddocks that occur on slopes. They advise the need for research addressing the quality of eroded soils and the comparisons of these with soils where significant loss is not apparent. This is supported by research on the long-term management of soils (Cotching 1995). Sparrow *et al.* (1999) and Cotching *et al*. (2001, 2002) detail that management history has significant effects on certain soil attributes, particularly infiltration rates. Furthermore, Cotching *et al* (2002) also verify that features of farming systems and soil type/land use combinations can explain adverse or favourable characteristics of soil condition. For example, their research reveals that decreasing organic matter levels are associated with cropping on Dermosols, which show negative correlation of organic content with the number of years cropped.

The priority issues for the SCEAM project have been identified as:

- Erosion (and subsequent soil loss via wind and/or water);
- Structural decline;
- Salinisation;
- Soil pH changes;
- Decrease in soil organic carbon content; and,
- Nutrient depletion.

It is anticipated that through monitoring and understanding the trends associated with soil condition decline, land management decisions can be better informed for a more sustainable agricultural industry.

SCEAM PROJECT

The SCEAM project is a priority action project supporting the needs of NRM strategies across all three NRM regions in Tasmania. SCEAM sets out to gather baseline soil data for 100 sites identified within key soil/land use combinations across the State, through the compilation of a network of reference sites. When compared with future monitoring at the same sites the data will enable identification of changes and trends in soil condition. The soil/land use combinations targeted have been identified on the basis of importance to the respective regions. Figure 1 gives a representation of dominant land use within each of the three NRM regions.

Soil condition indicators

The primary aim of indicators is to enable a means of measuring changes in soil condition. The identification of relevant indicators together with the methodology for data collection has been derived from several existing methodologies and adapted for use with this project. These are:

- National Natural Resource Management Monitoring and Evaluation Framework, NRM Ministerial Council 2002. SCEAM incorporates the relevant "Statements of Desired National Natural Resource Outcomes" integrating objectives of both the National Action Plan and the Natural Heritage Trust. SCEAM addresses the following relevant aspects of the "National Outcomes and Minimum Set of Regional Targets" set by the Natural Resource Management Ministerial Council (NRMMC 2003): i) "Soil condition"- as a resource condition matter for target, ii) "Sustainable production systems"- as a desired national natural resource outcome, and iii) "Critical assets identified and protected" and "Improved land management practices adopted"- as a management action matter for target. For each of the ‘Matters for Target’ indicators have been developed. The recommended indicators for soil condition (McKenzie *et al.* 2002, NRMMC 2003) are soil acidification, soil erosion- water, soil erosion- wind, and soil carbon content. These have been an integral component to the development of this project; and,
- National Soil Quality Review and Programme Design (The "500 Soils Project", New Zealand, Sparling *et al.* 2003). This project outlines a suite of soil characteristics used to assess the issues in soil condition. The characteristics recommended for soil monitoring include: total nitrogen; Olsen phosphorus; quick test cations; total carbon; mineralisable nitrogen; heavy metal analyses; chemical residues; bulk density; aggregate stability; and, macroporosity.

SCEAM objectives

The objectives of the SCEAM Project are to:

1. Identify priority soil/land use combinations potentially at risk from degradation;
2. Establish a network of soil reference sites for future monitoring,;

3. Collect baseline information on selected soil types;
4. Develop and test a methodology that will allow the evaluation and future monitoring of soil condition;
5. Evaluate the usefulness and applicability of the data collected for reporting on soil condition at the regional scale;
6. Identify and prioritise soils and areas at risk or susceptible to a decline in soil health and erosion;
7. Identify beneficial and sustainable soil condition management practices and targets; and,
8. Establish preliminary benchmarks for major indicators of soil condition, hence develop critical soil condition thresholds for land management.

RESEARCH DESIGN, SITE SELECTION, AND SAMPLING PROCEDURES

Research Design

The NRMMC (2003) framework has identified some possible key indicators of soil condition. In addition, the monitoring protocols developed by McKenzie *et al.* (2002) have provided guidelines for sampling, site selection, data interpretation and analyses. Protocols from the "Soils 500" project New Zealand, (Sparling *et al.* 2003) also formed the basis for much of the SCEAM project template, as this was developed for a complex soils system in a cool temperate climate (NZ), similar to Tasmanian conditions.

The priority soil/land use combinations have been identified on the basis of importance to the respective NRM region. Sites are selected to represent major soil types and land uses identified during the priority selection process for each of the three NRM regions (Table 1). Selected sites do not necessarily reflect sites known to be at risk of degradation but instead sites that meet the soil/ land use criteria. The current monitoring is aimed at setting up the soil reference sites and collecting information to indicate soil condition for the key land uses. Sites will be revisited on a 5 yearly basis to monitor soil condition (McKenzie *et al.* 2002, NRMMC 2003). The authors acknowledge that, for some indicators, it may not be until subsequent rounds of monitoring that significant changes are observed.

Additional funding will be sought with the intention of establishing 300 reference sites across Tasmania by 2007.

Site Selection

One hundred sites will be sampled across the whole state of Tasmania. Although this is only a relatively small number of sites, it is anticipated that these will be of sufficient density to provide an initial baseline figure to enable reporting on soil condition. Thorough identification of soil type and land use may be used for spatial extrapolation to sites with similar characteristics. The reconnaissance level site selection initially involves a GIS and desktop analysis to identify the priority soil/land use combination. Representative soil polygons are selected where detailed and 1:100,000 soil coverages exist. Where data are limited, geology and land system maps compliment field observations to locate probable sites. Land use is determined using existing land use maps, relevant departmental and local knowledge and field observation. Landholder consultation secures access to the site for confirmation of soil type/land use, and then if the site meets the criteria, the sampling procedure takes place. Where possible, site details such as: cropping history, crop rotations, management approaches, fertiliser history, irrigation rates, and water quality are obtained from the land holder.

Sampling Procedures

There are two main aspects to the sampling:

1. Soil sampling for chemical and physical analysis. A 50 m transect is layed out along the contour of the selected site. Samples are taken every 2 m with a 50 mm diameter hand auger along the transect and bulked together for chemical analysis. Sampling depths are determined through test auger holes. All sites have the 0-75 mm fraction sampled, and cropping sites also have subsoil samples taken. The depths for the subsoil samples depend on the site characteristics with importance placed on not crossing soil horizons and generally < 300 mm. At the depths specified for the bulk chemical analysis, bulk density and aggregate stability samples are taken at three equally spaced positions along the transect.
2. Soil description. A soil pit is constructed at each site to a depth of approximately 1.2 m to allow full description of the soil profile as per McDonald *et al*. (1998). The soil profile is then classified according to the Australian Soil Classification System (Isbell 2002). Samples are collected from sub-soil horizons that were not included in transect sampling for chemical analysis.

METHODS

Consideration was given to the time and expense involved with individual procedures currently used to provide soil condition data throughout Australia and New Zealand, weighted against the provision of most useful information, to identifying the methods and procedures to be adopted for this project. It is imperative that the analytical techniques chosen cover the suspected land management issues. A range of chemical and physical techniques are used to investigate Tasmanian soil condition through SCEAM, including:

1. *Chemical tests*. Conducted at CSBP Wesfarmers Soil & Plant Laboratory, Western Australia, with procedures following those detailed by Rayment & Higginson (1992). Chemical analysis includes: organic carbon; total nitrogen; Colwell phosphorus and potassium; soil pH ($CaCl_2$ & H_20); electrical conductivity; exchangeable cations (calcium, magnesium, sodium, potassium); exchangeable aluminium; hydrogen; acidity; nitrate nitrogen; ammonium nitrogen; copper; zinc; manganese; sodium, potassium; reactive iron; boron; and, Sulphur;
2. *Physical tests.* Conducted at DPIWE Mount Pleasant Laboratories, Launceston, Tasmania. Physical analysis includes: a) bulk density samples collected in stainless steel cylinders (75 mm length by 75 mm diameter), emptied into trays, dried at 105°C and weighed; b) Aggregate stability samples carefully collected in the field, and procedures followed are that detailed by Laffan *et al.* (1996); c) macroporosity, with procedures taken from Klute (1986).

IMPLICATIONS

The SCEAM project will provide a sound methodology for the on-going evaluation and monitoring of soil condition, together with key baseline soil condition data, for key soils and land uses considered susceptible to degradation in Tasmania. Although this is only the first phase of monitoring, it is anticipated that when data are compared with future monitoring results at the same sites, it will be possible to identify any changes and trends in soil condition. Comparison of longer-term monitoring results with baseline data will thus allow an assessment of how current land use practices are impacting on soil condition. SCEAM meets national Monitoring and Evaluation requirements and supports implementation of State and Regional NRM strategies. Where necessary, land management practices can be modified and adapted to adjust trends established through the soil data collected. Additional funding will be sought with the intention of establishing 300 soil reference sites across Tasmania by 2007.

As soils are an essential primary component of our natural resources, soil condition and appropriate monitoring systems are necessary to assess the health of and threat to natural resources and associated biodiversity.

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