Soils of Northern Australia-potential food bowl or dust bowl?

Peter L Wilson[A], Anthony Ringrose-Voase[A], Jason Hill[B], Noel Schoknecht[C] and Bernie Powell[D]

[A]CSIRO Land and Water, GPO Box 1666, Canberra ACT 2601, Australia, Email peter.wilson@csiro.au
[B]Northern Territory Department of Natural Resources, Environment, the Arts and Sport.
[C]Department of Agriculture and Food, Western Australia.
[D]Queensland Department of Environment and Resource Management.

Abstract
There has been interest in developing the agricultural potential of northern Australia for many years. CSIRO, along with relevant Queensland, Northern Territory and Western Australian government agencies undertook an assessment of the suitability of soil and land resources for irrigated agriculture (Wilson *et al.,* 2009). Significant areas of potentially arable soils were identified independent of other limitations such as water availability, flooding, climate, land tenure and economic factors.
National and multi-jurisdictional assessments of soil and land resources are now possible due to ongoing efforts through the Australian Collaborative Land Evaluation Program (ACLEP) to collate the best available data into a consistent national format within the Australian Soil Resource Information System (ASRIS). Gaps in data coverage and attribution exist, and the scales and age of data in ASRIS still present significant issues. Better spatial and temporal coverage of data is required to support evidence based planning and policy decisions. Application of digital soil mapping techniques and remote and proximal sensing technologies will assist in developing an improved national soils information infrastructure.

Key Words
Land evaluation, suitability assessment, limitations, agricultural development.

Introduction
An understanding of the soil and land resources of northern Australia is fundamental to consideration of development options. Soil resources are available for development but they also underpin many landscape processes that provide a range of essential ecosystem services and functions. Thus the soil landscape is essential not only for sustainable agriculture but also to the functioning of water, nutrient and carbon cycles and for supporting the north's unique biodiversity.
Surveys of the soil resources have been conducted in the region over the past 70 years. The first attempt to assess the development potential of the Top End of Australia, was the "General Report on Survey of the Katherine-Darwin Region, 1946" by CSIRO (Christian and Stewart, 1953). With Queensland (Qld) and Western Australia (WA) populations predominantly in the south, few new northern land resource surveys have been conducted since such initial investigations. The Northern Territory (NT) with its population base in the north has generally invested more across the north and in key areas such as the Daly River Basin. Assessments have generally followed recurring periods of enthusiasm by governments over the past 60 years to develop key areas more intensely, but this has by and large not occurred.
This assessment of the north's potential suitability for agricultural development used a collation of the best available data, known as the Australian Soil Resource Information System (ASRIS). ASRIS provides a fundamental information base on which multi-jurisdictional and national land resource assessments can be made. However, data held within ASRIS has considerable gaps both in the extent and scales of mapping and the attribution available. In most locations, national assessments can be considered only as broadly indicative rather than a definitive statement on the soils' properties and their capability.
The study area covers over 120 million hectares of diverse and varied landscapes. Assessment of agricultural suitability is based only on the inherent properties or qualities of the soil and land resources themselves. Significant other limitations such as climate, flooding, water availability and tenure, legislative, social and cultural factors have not been taken into account. This study therefore identifies soil potentially suitable for irrigated crops and does not necessarily define useable land or priority areas for development.
Some general observations of the soils and lands across the north are:

- they are relatively intact with minimal impact from major developments
- they are ancient and generally have low levels of inherent fertility
- soil erosion rates are high even on moderately sloping land and levels of soil development are generally low, particularly on extensive rocky upland areas
- lowland plains are seasonally or annually inundated, often calcareous at depth, with some coastal

areas being potentially saline and containing sulfuric or sulfidic material
- many northern soils are acidic (pH below 6.0), gravelly (5-60%), and shallow (< 0.5m).

Developing a consistent suitability framework

This suitability assessment for agricultural development used the FAO Framework for Land Evaluation (FAO 1976) which includes:

- selecting a range of soil qualities (e.g. erosion hazard, water holding capacity, acidity etc) with potential to limit agricultural development and assessing for each soil type
- developing a suitability framework defining the level of limitation imposed by each soil landscape property on five classes of irrigated land use/crops, covering a range of establishment, management and harvest practices: including - annual crops, perennial crops, rice, forestry and improved pasture
- combining the previous stages to assess the limitations of a soil on a particular land use/crop type
- determining the overall suitability of each soil type from the most limiting land quality.

A consistent northern Australia suitability framework was developed from a collation of existing state and territory project based frameworks. The framework gives consideration to the soil landscape properties used by existing frameworks as well as an assessment of data availability and the degree to which specific qualities were likely to limit the chosen land use/crop types.

Data limitations

Soil landscape mapping data held within ASRIS are a collation of historic surveys undertaken at various scales, with different methodologies and different levels of attribution. To the extent possible, all data have been standardised to match the ASRIS Technical Specifications (McKenzie *et al.,* 2005) but issues remain with matching data between states and surveys. Numerous gaps in attribution also exist and these have been filled using surrogate measures where possible for this assessment. Missing data have impacts on the final suitability assessment, particularly where the land quality has a significant implication for the particular land use and may result in areas being "not assessed". Figure 1 shows the survey scale of the ASRIS data used in this assessment. Note that most of the data is at reconnaissance scales of between 1:250,000 and 1:1,000,000.

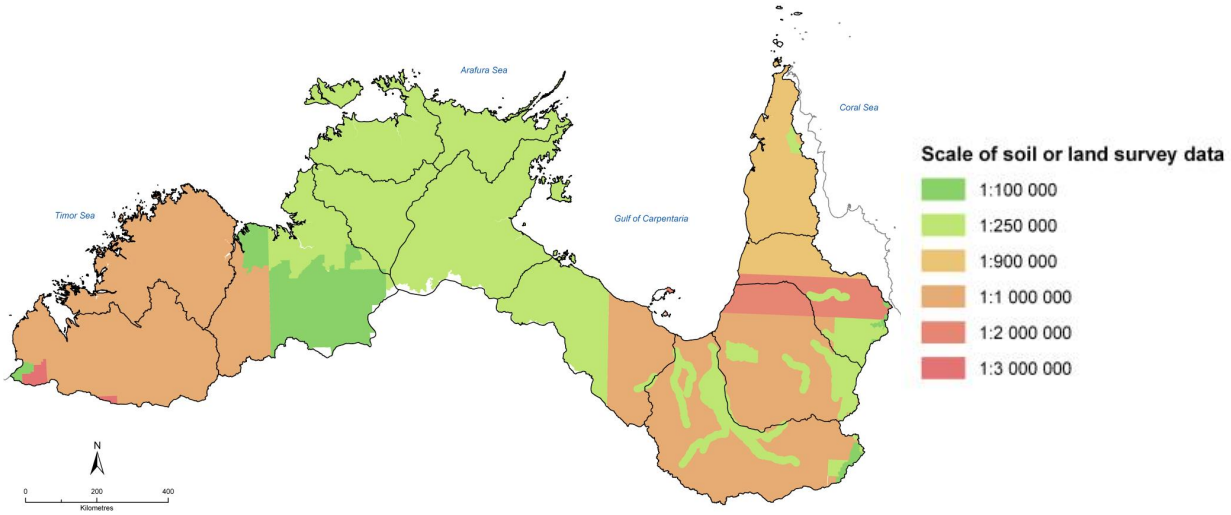

Figure 1. Mapping scales of ASRIS data used in this assessment.

Much of the broad scale mapping used for this study, shows the location of map units (polygons) that comprise a number of soil components which are described but not mapped. While this provides a better assessment of the suitability of individual soils, the specific location of these components is not defined. Development planning and on-ground land management would require data at scales of 1:50,000 or better. Such data exists for only small portions of the study area, particularly in the already developed WA Ord irrigation area and parts of the NT Daly River Basin, Mary River catchment and Darwin region.
Figure 2 shows the variability in intensity of land resource survey mapping across the study area. Note the more intensive surveys in the NT and Cape York (still considered to be reconnaissance scale) and the particularly broad nature of historic mapping in the QLD Gulf and WA Kimberley regions.

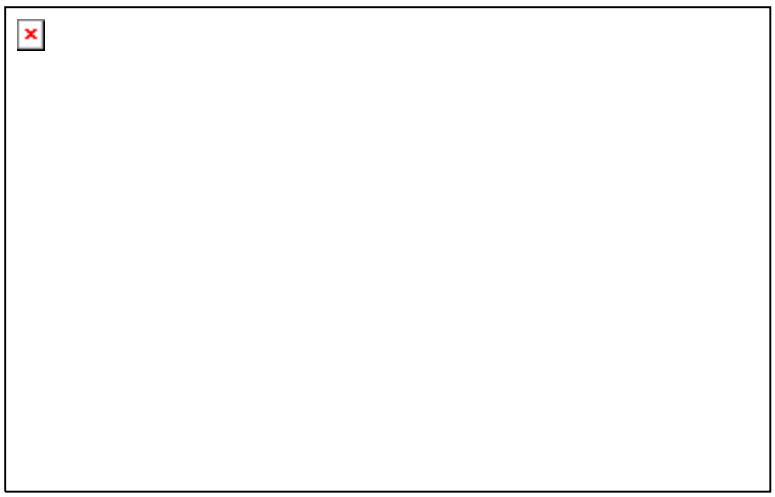

Figure 2. Variable intensity of mapping line work in the ASRIS data sets used in this assessment.

Results

The soils in the north of Australia are ancient and highly weathered. They have generally low base of fertility and poor resilience to impact - particularly compared to many southern Australian agricultural soils. Rates of soil formation are well below rates of soil loss, making the landscape inherently fragile. Extreme and variable climatic events including cyclones, extended wet season flooding and poor soil drainage, high intensity rainfall events, and annual extended dry seasons with high evaporation rates, often exacerbate the impacts of even small soil disturbances. Research, trials and other evidence have shown severe erosion can occur on relatively low slopes where erosion and sediment control measures and/or ground cover management has not been implemented with development (e.g. Robinson, 1976; Dilshad *et al.,* 1996).
Some relatively large areas of soils suitable for irrigation do exist across northern Australia, particularly the Red Kandosols in the Fitzroy River region WA, the Red Kandosols of the Daly River Basin NT and some areas of Red and Brown Kandosols and Orthic Tenosols on Queensland's western Cape York (Figure 3).
While the total area of arable soils across the study region may exceed 5-17 million hectares, it is dispersed across a vast landscape. The total area of soils identified as potentially suitable accounts for only 5-14% of the area assessed.

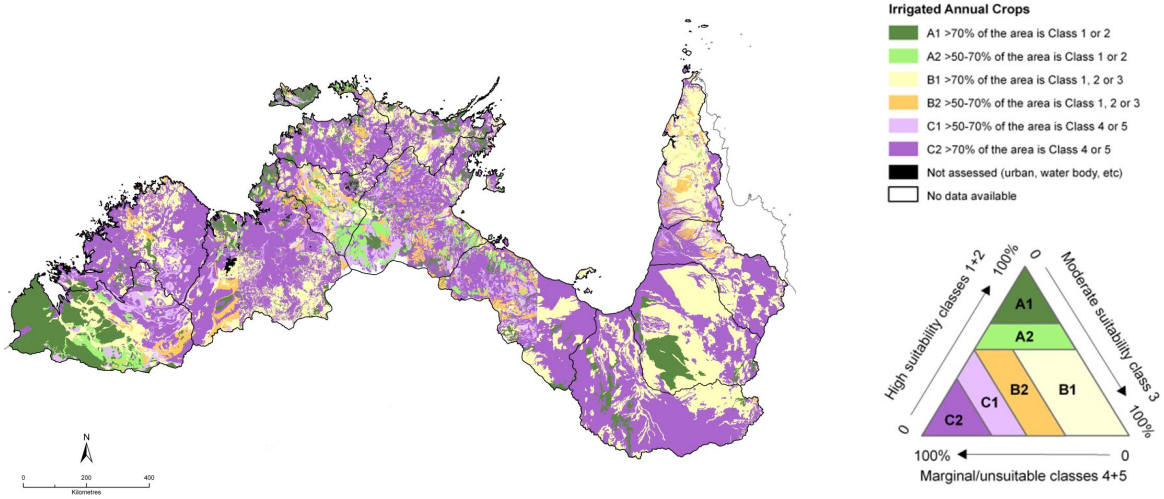

Figure 3. Example suitability map for irrigated annual crops.

The assessment of potentially suitable soils in this study has assumed an adequate availability of water and has not been constrained by existing or future land tenure. Similarly, climatic extremes and variability; regular extensive and prolonged flooding; seasonal inaccessibility; and low soil nutrition have not been considered in this irrigation suitability assessment due to limited data availability. These limitations may render a large proportion of the identified area unsuitable and therefore unusable for development. Therefore the area of suitable land identified is likely to be a maximum estimation rather than a minimum. In the context of the existing 30-60,000 hectares of agriculture in the region, the total potentially suitable area is very large. In the context of the 40-50 million hectares of agriculture already established across the southern states of Australia, it represents a significant potential addition to the national agricultural resource base.

Discussion

History has shown that the north is not an easily developed or commanded environment for intensive agricultural use (Christian and Stewart, 1953; Davidson, 1966). Agricultural developments in the WA Ord have been hampered by wet season accessibility, soil variability, low soil nutrients and increasing salinity issues. Agriculture in the NT Daly River Basin must be managed to reduce soil erosion events which can result from cultivation of even very low sloping land. Other significant management issues arise from soil qualities including - low water holding capacity, soils that require careful moisture management; sandy soils with high nutrient leaching potential resulting in leaky systems and off-site consequences; hard setting soils susceptible to surface sealing and crusting resulting in reduced infiltration rates and increased run-off and erosion. Lessons need to be learnt from history and at least new mistakes made!

Only limited information and understanding exists about the complex landscapes of the north and their sustainable development. Issues of landscape complexity and soil variability are likely to further reduce the areas of potentially useable land. However, this will only become apparent where more intensive soil and land survey is used to properly investigate areas at scales appropriate to development planning. Much of the area is surveyed at reconnaissance scales only (with limited field investigations and limited analytical data). As well, some poor data quality issues are known to exist, particularly in the older, broad scale surveys such as in the Queensland Gulf and the WA Kimberley/Fitzroy areas which may result in inaccurate assessment of agricultural potential.

The nationally collated ASRIS data base does provide a significant information base for large national and multi-jurisdictional assessments. However, gaps in data coverage and attribution exist and the scales and age of data in ASRIS still present significant issues. A multi-jurisdictional, collaborative effort was required to enable the required collation of consistent data for this assessment. Better spatial and temporal coverage of data are required to support evidence based planning and policy decisions. Future application of digital soil mapping techniques and improved remote and proximal sensing technologies will assist in developing an improved national soils information infrastructure.

Conclusion

Future agricultural development options for the north need to be planned wisely and be based on adequate and appropriate soil and land information. Scales of data must be commensurate with any intended intensification of soil and land resource use and the consequential impacts. Minimum scales of survey for proposed developments should be in the order of 1:50,000 with more intensive survey assisting final farm planning and design. A new generation of fine scale, soil attribute surfaces developed from technologically and scientifically advanced digital soil mapping processes will greatly assist and further progress the utility of the Australian Soil Resource Information System.

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