Future Directions international

INDEPENDENT STRATEGIC ANALYSIS OF AUSTRALIA'S GLOBAL INTERESTS

Strategic Analysis Paper

29 April 2015

# The State of Australia's Soils

**Christopher Johns**
*Research Assistant*
*Northern Australia Research Programme*

**Key Points**

- Australian soils differ from those of northern America or Europe, where much scientific study on soil regeneration is taking place. Australian soils are generally older and have been exposed to constant weathering.
- Knowledge of the importance of soils and soil science is seen to be declining.
- Soils play an important role in three of the key debates of our time: food security, water quality and climate change.
- Soil degradation is the decline in soil quality caused by its improper use, usually for agricultural, pastoral, industrial or urban purposes. This is a serious global problem and is being exacerbated by climate change.
- A significant proportion of the cropland and improved pasture in Australia is affected by some form of soil degradation.

**Summary**

A detailed knowledge of the state of Australian soils is currently difficult, if not impossible, to ascertain. The vast size of the country, climatic variation, the complexity of measurement and cost are just some of the reasons why the task is prohibitive. This situation notwithstanding, it is vital we develop such knowledge so as to inform key policy and decision makers of the state of our soils and what needs to be done to address the continued decline in their fertility. Soil has fundamentally important role in three of the key debates of our time: food security, water quality and climate change. There are a number of degraded soil conditions currently causing environmental and economic concern in

Australia: acidification, erosion, salinity, depletion, structural decline and compaction are just some of them.

**Analysis**

In March 2014, the Minister for Agriculture, the Hon. Barnaby Joyce, released the National Soil Research Development and Extension Strategy. This Strategy, combined with the extended appointment of Major General the Hon. Michael Jeffery as the National Advocate for Soil Health and the leadership, coordination, direction and advocacy provided by the National Committee for Soils and Terrain, for the first time provides Australia with a national, coordinated and forward thinking approach to managing our soil. One of the most important and challenging tasks they face is the provision of an accurate and current assessment of the state of Australian soils.

Soils are complex and Australian soils differ from those of northern America or Europe where much scientific study on soil regeneration is taking place. Australian soils are generally older and have been exposed to constant weathering. Unlike Northern Hemisphere soils, which have been farmed for centuries, Australian soils have only been cultivated since British settlement and, as a result, have been exposed to influences widely different from those under which they were formed.

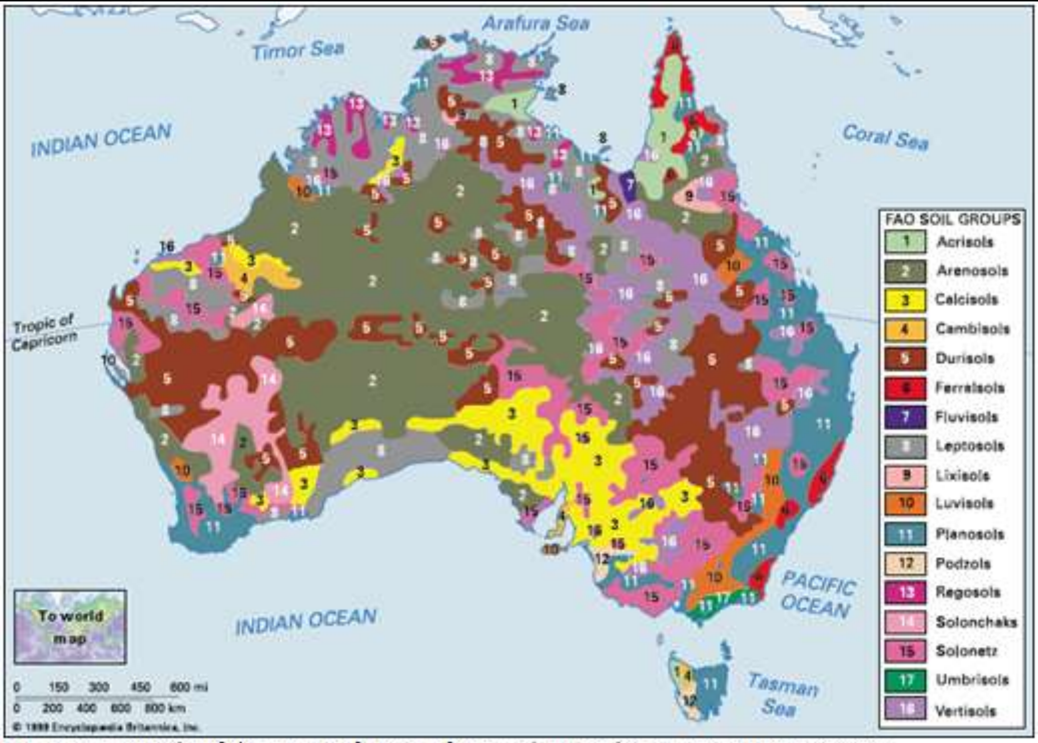


Fig. 1. An example of the range of types of Australian Soils. *Source*: Britannica.com

Within Australia soils also differ widely. Spread over 7,692,024 square kilometres, approximately one-third lies in the tropics. Soil types vary from alpine regions in parts of south-eastern Australia and Tasmania, through the Mediterranean zones of southern and south-western Australia to the wet and dry tropics of Queensland and very low rainfall areas of the centre. Indeed, over one million square kilometres of the Northern Territory and the northern part of Western Australia are almost devoid of soil and what exists is usually shallow, leached and mildly acidic. This diversity adds to the complexity of analysing soils and determining what needs to be done to regenerate them.

To compound these problems, knowledge of the importance of soils and soil science is also seen to be declining. The gradual contraction and demise of soil conservation surveys, or their equivalent have, resulted in the loss of a generation's worth of knowledge. Even the teaching of soil related sciences, in our tertiary institutions, has declined. Government agencies are decreasing their involvement in soil research, and communication of soils-related knowledge to land managers and the community is declining. Instead, consultants are hired to answer a specific problem resulting in piecemeal solutions which are not shared throughout the agricultural community.

The National Soil Research Development and Extension Strategy and other recent, soil related initiatives, acknowledge the important role soils play in three of the key debates of our time: food security, water quality and climate change. Along with air and water, soil is one of the essentials of life and among our most basic natural resources. It supports the overwhelming majority of our terrestrial biodiversity and it contains vast quantities of carbon and water. It plays a fundamental role in the water and carbon cycles as well as being the engine room for food production. As a recent publication from the Federal Government Department of Agriculture stated, healthy soils grow healthy foods, which grow healthy rural and urban communities.

Fig. 2. Types of Australian Soil. Source: Flickr/JerseyRed and abc.net .au

In the public domain, opinion on the state of Australian soils is diverse and, at times, polarised. The first national audit of Australian soils in 2000 found they were declining due to processes such as erosion, acidification and salinisation. A second national audit in 2008 concluded that soils need long term monitoring, consistent information and a data baseline in order to monitor changes. In the report, *Australia: State of the Environment 2011*, the Federal Government Department of Environment found that in general, soils are 'in good shape'. There is a warning, however, that there are adverse trends and degradation of soil is environmentally and economically significant in many areas. The WA Department of Agriculture and Food and the NSW Department of Primary Industries, in particular, highlight areas of significant concern.

Soil degradation is the decline in soil quality caused by its improper use, usually for agricultural, pastoral, industrial or urban purposes. This is a serious global problem and is being exacerbated by climate change. Examples of soil degradation include the loss of organic matter, decline in soil fertility and its structural condition, wind and water erosion, adverse changes in salinity, acidity or alkalinity and the effects of toxic chemicals and pollutants. A significant portion of the cropland and improved pasture in Australia is affected by some form of soil degradation. Australian soils, therefore, are in trouble. Not only are they degrading more quickly than they can be regenerated, but there is also a sense that Australian land managers are losing the capacity to even know what state they are in.

In general, soil productivity is largely determined by moisture absorption and retention which can vary greatly depending upon soil types and the timing of the rainfall. On only about 10 per cent of the continent is rainfall sufficient for plant growth for more than nine months of the year. On the other hand, low and unreliable rainfall over the greater part of Australia results in no arable agriculture or sown pasture production. As a result limited pastoral activities are the most likely outcome. In some areas, particularly in New South Wales and Western Australia, the degradation of once productive soils is limiting productivity further.

The following is a description of just some, though certainly not all, of the key forms of soil degradation experienced by Australian agricultural soils.

***Acidification***

The acidity and alkalinity of soil is expressed using the chemical term pH where, on a scale of 0 to 14, less than seven represents acidity, seven neutrality (such as distilled water), and more than seven, alkalinity. Soils acidify naturally as they weather over millions of years. The acidity of any soil varies according to the type of rock it comes from, the length of time it has weathered, the native vegetation and the local climate. As a result, some soils can be naturally very acidic (low pH) while others are much more alkaline (high pH).

Agricultural production systems can increase the rate of soil acidification and it has become an environmental and economic concern in parts of the country. Approximately 50 per cent of Australian agricultural land has surface pH values less than or equal to 5.5, which is below the optimal level to prevent soil acidification. If untreated, acidity will become a problem in the subsurface soils, which are more difficult and expensive to treat. Subsurface acidity is already a major problem for large areas of Western Australia and New South Wales. It is estimated that 12 to 24 million ha are highly acidic with pH values less than or equal to 4.8.

Acidic soils cause significant losses in production. Where the choice of crops is restricted to acid tolerant species and varieties, profitable market opportunities may be reduced. In pastures grown on acidic soils, production will be reduced and some legume species may fail. Deep-rooted species, such as native trees, required to increase water usage may not thrive, increasing the risk of salinity. Increased run-off and subsequent erosion has detrimental impacts on streams and water quality. Increased nutrient leaching may pollute ground water.

The Federal Department of the Environment in its publication, *Australia State of the Environment 2011*, found that a deteriorating trend in soil acidity was being experienced in almost every agricultural region in the nation.

***Erosion***

Erosion is defined as the removal, by wind and water, of the upper layers of soil. When it occurs at a faster rate than the soil forming processes, it leads to a loss of topsoil, organic matter and nutrients. This leads to a loss in fertility. When unchecked it can lead to both desertification and the removal of topsoil through flooding.

Fig. 3. Gully and Sheet Erosion West of Charters Towers, Queensland. *Source*: CSIRO Image Library.

The key to preventing both water and wind erosion is the maintenance of a protective cover on the surface of the soil. This cover can be living plants, plant litter or mulch. Agricultural practices such as contour banks, filter strips and controlled traffic are important, secondary ways of preventing or reducing erosion.

Fig. 4. Sydney, Australia, covered in a blanket of dust during an extreme dust storm. *Source*: G Tipene/Shutterstock

Improved land-management practices have, in recent decades, reduced the impact of erosion in many agricultural areas; however, our knowledge of the extent of the problem is still incomplete and trends in many areas still indicate unsustainable rates of erosion.

***Salinity***

Salinity refers to the quantity and availability of salt in soil. Primary salinity is produced by natural processes such as weathering of rocks and wind and rain depositing salt over thousands of years. Salt deposits are unevenly distributed throughout Australia and the patterns and impacts of salinity vary in eastern and western parts of the country because of different topography and the age of the landscapes; salinity in the west tends to be more pervasively spread across the landscape, whereas salinity in eastern regions is more localised. The amount of salt in the Australian environment is not increasing; it is being brought towards the surface as a result of extensive land clearing and farming methods practised since European settlement.

Fig. 5. Dryland salinity. *Source*: CSIRO Land and Water.

High concentrations of salt pose hazards for the environment as well as affecting agriculture and infrastructure and, therefore, the wider economy. High levels of salinity in soil may cause native vegetation to become unhealthy or die and lead to a decline in biodiversity through dominance of salt-resistant species, potentially altering ecosystem structures. Increased salinity can reduce crop yields when it impairs the growth and health of salt-intolerant crops and may result in corrosion of machinery and infrastructure such as fences, roads and bridges. These impacts of salinity can be extremely costly, ranging from impaired agricultural production and additional water treatment costs to the replacement of corroded agricultural and other infrastructure.

Unfortunately, there is no simple, single solution to salinity, and it continues to pose a grave threat to the productivity of a significant portion of Australian agricultural land.

***Fertility Depletion***

Soil depletion occurs when the components which contribute to fertility are removed and not replaced, and the conditions which support soil's fertility are not maintained. The fertility components most commonly depleted from soil are nutrients, soil flora and fauna (including microbes) and organic matter such as carbon and humus. In agriculture, depletion can be due to excessively intense cultivation and inadequate soil management. Soil fertility can be severely challenged when land use changes rapidly. Depletion may also occur through a variety of other effects, including over-tillage (which damages soil structure), underuse of nutrient inputs which leads to mining of the soil nutrient bank, and the salinity of soil.

In Australia, our ancient soils were inherently depleted prior to the introduction of European agricultural practices. Our knowledge of the extent and the impact of soil depletion is incomplete. Limited also is our knowledge of ways to reverse soil depletion. Nutrient depletion is not being sustainably treated by adding more or different fertilisers. Our understanding the complex role of biodiversity and ways of promoting the beneficial interrelationships between agricultural plants and soil fungi and bacteria requires significant further research. The capacity to restoring and increase organic matter, particularly soil organic carbon and humus is also in need of further research. Soil depletion is perhaps the area of greatest challenge and greatest potential in sustaining and increasing agricultural production.

***Soil Structural Decline and Compaction***

Soil structure is determined by the volume and arrangement of air spaces or pores in the soil. This dictates how easy it is for water and air to flow into and through the soil. It also influences the way soil particles are held together. This affects the soil's friability, the ease with which soil particles are detached by raindrops and runoff, and the resistance of the soil to the growth of roots and shoots.

Fig. 6. Over-cultivation with implements, such as the disc plough, is a major cause of soil structure decline. *Source:* www.agric.gov.au

Organic matter is critical for maintaining good soil structure as it helps bind the soil together. Each time the soil is cultivated, soil microbes attack the freshly exposed organic matter. Much of the organic matter is then lost as carbon dioxide, and clumps of soil (aggregates) lose their stability. Cultivation also pulverises the soil, destroying the continuous fine channels (bio-pores) created by plant roots and soil dwelling animals. It is these bio-pores that allow rapid infiltration of water and air.

The presence of certain chemicals stimulates the generation of compounds that act as bonding agents for the basic particles of soil. Roots and fungal filaments can enmesh particles together while realigning them and releasing organic compounds that hold particles together, a process with a positive impact on soil carbon sequestration. Soil structure can be significantly modified through management practices and environmental changes. Practices that increase productivity and decrease soil disruption enhance aggregation and structural development.

Our knowledge of the extent and the impact of soil structural decline in Australian is limited. It is assessed, however, that soil structure has declined in the majority of our cultivated soils.

Compaction is the change of soil volume caused by compression and shear forces that increase bulk density and decrease the air spaces between soil particles. With compression, the air is squeezed out of larger soil pores. Shear forces are caused by the traction of wheels, hooves and tracks and are mainly confined to the surface soil. Compression forces affect surface and subsurface soil and have the greatest influence on soil that is moist and soft. Compact soils can also be cause by the loss, through erosion, of the less dense upper layers of soil, leaving the more densely packed sub-surface layers.

In Australia, agricultural soil compaction is usually the result of a combination of the action vehicle traffic from farm machinery and the movement of livestock. In most circumstances animal hooves will only cause surface compaction but the weight of a large item of machinery can cause more serious sub-surface compaction.  Affected soils become less able to absorb rainfall, thus increasing runoff and erosion. Plants have difficulty in compacted soil because the mineral grains are pressed together, leaving little space for air and water, which are essential for root growth. Burrowing animals necessary for soil health, also find it a hostile environment, because the denser soil is more difficult to penetrate.

Much of Australia's agricultural land is assessed to be at risk of compaction though the extent of the problem is not widely known and varies significantly from State to State. In recent decades, the introduction of limited and no till farming techniques and the introduction of precision vehicle navigation aids such as GPS have assisted in reducing some of the common causes of compaction.

***Conclusion***

An understanding of the current state and condition of Australian soils requires an appreciation of their diversity and capability to support different forms of land use. It also requires an appreciation of human impacts, not only in recent years and decades, but also on longer timescales of centuries and millennia. The effects of some forms of land use can be long lasting and some rates of change are very slow. Remediation, therefore, can take decades or longer.

Presently, we perhaps have a better understanding of the specific ailments of our most degraded soils rather than the complex interactions at play in healthy soil. There exists an increasing need for strategic investment to better understand what is happening to all our soils. Coordinated initiatives such as the National Soil Research Development and Extension Strategy will play an essential role in improving our understanding of soils and our response to the challenges of food security, water quality and climate change.

*****

*Any opinions or views expressed in this paper are those of the individual author, unless stated to be those of Future Directions International.*

Published by Future Directions International Pty Ltd.
80 Birdwood Parade, Dalkeith WA 6009, Australia.
Tel: +61 8 9389 9831 Fax: +61 8 9389 8803
E-mail: cjohns@futuredirections.org.au
Web: www.futuredirections.org.au