Land Degradation

What is Land Degradation?

There are many definitions of land degradation but all share the idea that detrimental changes to the condition of land have occurred because of the many ways land has been developed and used. The term 'degradation' is used to describe changes that are additional to those occurring naturally and carries with it the notion of change that is undesirable and brought about by humans. Land degradation then refers to chemical and biophysical changes in land that reduce both its quantity and quality. Frequently, these changes are linked to a reduction in the productive capacity of land and its economic value.

The term 'land' generally includes rocks, soils and minerals and the vegetation and animal habitats it supports – the combination of all these elements form landscapes. The condition of land or 'land health' invokes the concept of ecosystems – the interactions and connections between the living and non-living components of the environment. In degraded land, where ecosystems have been changed, the altered ecosystems continue to function but have a reduced capacity to supply the goods and services we are seeking, for example, food, habitat for threatened species and landscape amenity.

In addition to providing for the physical needs of increasing populations, land has a spiritual and cultural significance for many but in particular Indigenous people. The changes in the condition of land following settlement by Europeans in 1788 have diminished these values in many parts of Australia although some older cultural sites have only been revealed following disturbance by the new settlers.

While this fact sheet deals with detrimental changes to land over the past 200 years, land degradation in Australia has also resulted in extensively degraded waterways and estuaries, the need to treat most of our drinking water and the continuing decline in Australia's biodiversity. These latter connected issues are dealt with in separate fact sheets.

Extent and Type of Degraded Land

Land degradation is a global issue for a number of reasons but most significantly because productive land is one of several resources where a reducing supply threatens our capacity to feed a growing world population estimated to be over 9 billion by 2050. In his book *'Coming Famine'*, Julian Cribb points out that of the 1.5 billion hectares of global farmland, a quarter is affected by serious degradation, up from 15% two decades ago. The seriousness of this is clear when we are told that the world demand for food is growing many times faster than the area of land being farmed.

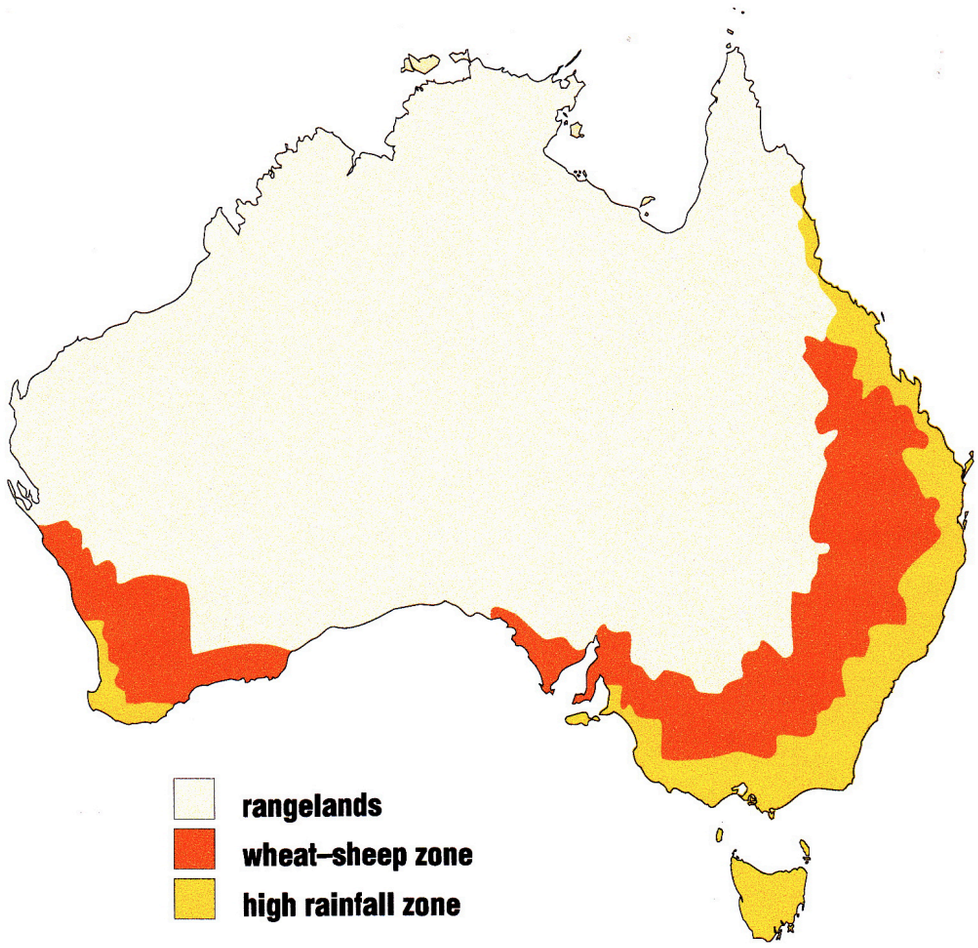
In Australia, about two thirds of agricultural land is degraded. The major types of land degradation are soil erosion, soil salinity, soil acidity and soil contamination. Also mentioned when discussing these are nutrient loss and soil structure decline.

Soil Erosion

When vegetation is removed from soil surfaces they become susceptible to erosion either by wind or water and frequently both these agents of erosion combine to remove surface soil. It is important to appreciate that soil erosion is a natural phenomenon and has occurred in Australia over the millennia. But since European settlement *Australia State of the Environment* reports have indicated that the rate of soil loss has increased by orders of magnitude, doubling in the inland rangelands, being five-fold greater where native pastures have been replaced by introduced pasture species in higher rainfall areas and being up to 50 times greater on sloping land used for cereal cropping (see map).

Water Erosion. Water erosion occurs in different ways that vary according to vegetation cover, soil type and structure and slope. The severity of rainfall events is a major factor in determining how much soil is transported down a slope.

Major Agricultural Zones



Source: ABARE.

Reproduced in a modified form in *Australia, State of the Environment*, 1996

Sheet Erosion occurs in some locations when the energy of rain drops and water flows moves thin, relatively uniform layers of soil particles down slopes depositing them at the base or carrying them to waterways, where these suspended particles (sediments) are carried to lakes or the sea. This is a natural process needed to transport nutrients to fresh water and marine organisms but sediment loads over the past 200 years have frequently caused damage to these organisms with turbidity (murkiness and loss of transparency) reducing capacity for photosynthesis or smothering aquatic plant foods.

Where the movement of soil is not uniform, small gullies or rills can form. On average, about 14 million tonnes of soil in Australia is moved by water down slopes each year. According to the *1996 Australia State of the Environment* report, this is about 19% of the global total even though Australia has only 5% of the earth's total surface.

Gullying occurs in some soil types when surface and sub-surface water flows are combined by topography into drainage lines. Usually a gully deepens over time and frequently headward erosion also occurs (the gully moves up the slope) together with later branching. Generally the extent of gullying stabilises within 50 years after the vegetation has been removed but gullying is the major source of soil transportation into rivers and streams. When water flows beneath the soil surface, sub-surface tunnels may be formed which are often only obvious when the land surface collapses. This frequently leads to further collapse and the exposure of small gullys.

Streambank erosion is also seen along most waterways running through agricultural land. This is increased by clearing riparian (stream side) vegetation that, when intact, slows flows into waterways and captures sediments thereby reducing stream turbidity and the mass transfer of soil to dams, lakes and estuaries.

Water and soil particles moving down slopes also transport nutrients, both dissolved and attached to (adsorbed on) the moving sediments. The major source of nutrient loss is from agricultural products, mostly consumed in towns and cities. However, catchments do leak nutrients, mainly nitrogen and phosphorus and, under eutrophic (depleted oxygen) conditions, phosphorus can lead to algal blooms in fresh water with nitrogen loads being responsible for blue-green algae in seawater on occasions.

Local storm events are the major causes of water based soil erosion; climate change scenarios warn that we can expect the frequency and intensity of such events to increase.

Wind Erosion. In many respects, wind erosion is similar to sheet erosion caused by heavy rain. Uniform layers of particles are stripped from the soil surface by wind and transported over long distances. Again, as with water erosion, nutrients adsorbed to soil particles are also transported. Larger particles are blown along the surface becoming air borne for short distances then impacting and loosening other particles. The largest particles roll along the ground for only short distances.

Salinity

Soil salinity in Australia is not a new phenomenon. Salt derived from the oceans has been deposited by rain, wind and marine ingressions (land previously submerged beneath the sea) over millions of years then leached through soils into underground aquifers and ground water until natural equilibria have been established.

Secondary salinity has been brought about by vegetation clearance and the way land has been used in the past 200 years. The National Land and Resources Audit in 2001 estimated that about 2.4 million ha of land across Australia is saline with a total of 5.4 million ha deemed to be at risk.

There are two types of salinity – dry land salinity and salinity caused by irrigation practices.

Dry Land Salinity. At various locations in the landscape, geology and hydrology combine to provide a point at which water enters and flows underground. When these recharge areas are cleared of deep rooted vegetation, the balance between evapotranspiration (the movement of water from soils, through plants, and then evaporation from the leaves into the air) and the quantity of water naturally flowing underground down the slope is disturbed. The volume of water moving through the soil profile increases and the water table containing dissolved salts rises. Frequently, soil waterlogging is the precursor of salinity. Dry land salinity occurs mainly in the dryer sheep/wheat zones in south western Western Australia, South Australia and the Murray Darling Basin (see map).

Irrigation Induced Salinity occurs when the irrigation water percolating through the soil exceeds the dispersal capacity of underground aquifers and drainage systems. Ground water containing dissolved salts rises and once within a metre of the soil surface, growth of the least salt tolerant plants is impaired. Irrigation induced salinity occurs mainly in South Australia and the Murray Darling basin but the data is poor for Queensland and much of New South Wales.

Soil Acidification

Acid soils (pH below 7) occur naturally over only a relatively small part of Australia, mainly in the higher rainfall areas of New South Wales, Western Australia and Victoria, but in these areas soils are becoming more acid as a result of current farming practices.

Induced acidification occurs when anions such as nitrate (NO_3^-) from nitrogenous fertilisers and the nitrate-producing process in legume based pastures, leach through the soil profile accompanied by positively charged cations (eg, K^+, Ca^{++}) leaving behind an excess of positively charged hydrogen ions (H^+) (the more hydrogen ions, the lower the pH). Changes in soil acidity can occur quite quickly but as plants grow readily between pH 5-8 it can take decades before declining productivity becomes obvious. In some soils, once the pH falls to 4 the fine fractions are mobilised in the soil profile leaving infertile coarse sands at the surface.

Other causes of acid soils include an increase in organic acids arising from accumulated organic matter and the removal of plant products that tend to be alkaline, leaving soils more acid. The easiest solution to the problem of acid soils is to add lime but this is expensive and does not deal with the underlying causes.

Contaminated Soils

In rural Australia, relatively limited data has been collected on soil contamination. We know there are heavy metal impurities in fertilizers with cadmium being of greatest concern because it is the one that moves most readily from soils to edible food crops. Residues of pesticides commonly used in the past continue to be detected in agricultural products but some believe that the benefits of pesticide use outweigh the risk, especially since the risks are better known, usage is better regulated and integrated pest management practices are more widely used. However, interest in both growing and eating foods produced without pesticides is growing.

In urban Australia contaminated land is the aftermath of earlier service industries, manufacturing and industry. Many of these historical contaminants are now found in the accumulated sediments dredged from harbours, bays and estuaries. The residual toxicities of these urban soils is now subject to environmental regulation. Site remediation is a significant economic factor in the increasing use of these lands for both commercial and residential purposes.

A form of land degradation associated with the coast is acid sulfate soils. Naturally occurring, iron-sulphides underlie large areas of Australia's low-lying coastal areas. When these normally waterlogged soils are exposed to air by drainage or drought, the iron sulphides oxidise producing acids which can then leach into marine or estuarine environments killing vegetation, fish and other organisms.

What Causes Land Degradation

The predominant cause of land degradation in Australia has been the permanent removal of native vegetation particularly in the wheat/sheep and higher rainfall zones (see map) and the way this cleared land has been used.

While dramatic vegetation changes occurred during the 40,000 years or more of Indigenous occupation due to climate variations and to a lesser extent the Aboriginal use of fire, no permanent loss of vegetation occurred due to human intervention. Over the 200 plus years since European settlement, about 13% of Australia has been cleared with much greater rates of clearance in the sheep/wheat and higher rainfall zones (see map). The condition of the remainder is variable and masks underlying decline in many ecological communities.

Broadscale mechanical removal of vegetation allowed cropping and the establishment of introduced pasture species. Past cropping practices usually involved long fallows, frequent cultivations for weed control and stubble burning resulting in soil structure decline. These are ideal conditions for soil erosion to occur, especially in periods of drought, Often, widely adopted practices that promised significant productivity gains have been found to bring with them perverse outcomes such as rising water tables and soil acidity because an understanding of existing ecosystems was lacking.

Other examples of unintended consequences are the introduction of animal pests such as the rabbit and management failures that have allowed other feral animals (goats, pigs, camels, etc) to increase in numbers and exert grazing pressure on plant communities already stressed due to grazing by domestic animals, particularly in periods of drought. Pest plants have been a major cause of a decline in the quality of native vegetation over substantial areas of public land and were the major reason for frequent cultivation of fallows, now replaced in many instances by weedicides.

Land degradation is rarely caused by a single factor. Usually it is a combination of factors including traditional farming without understanding regional or local limitations. As pointed out in the *National Land and Water Resources Audit* in 2002, we are operating in a resources continuum where human activities are inevitably influenced by and linked to landscape, infiltration, run-off, vegetation cover and soil structure. Soil structure responds to soil disturbance that in turn influences erosion and soil loads entering waterways. The overriding factor is climatic variation.

Sustainable Landscapes

The need to slow and repair land degradation is now built into Australian legislation, secondary and tertiary education, rural production systems and community programs.

These are guided by an appreciation of landscape vulnerability to change as we now understand that some land is less tolerant to agricultural practices because of slope, soil characteristics and rainfall. The other important characteristic of land is its resilience – a capacity to absorb change and return to a pre-altered state following change. These understandings are complemented by a greater appreciation of managing land to achieve multiple objectives that include productivity gains without impairing rural environments, treating soils as a non-renewable resource, minimising off-site impacts and using land in ways that do not reduce options for future generations. Clearly however, some land use choices do close off options in practical terms for future generations such as the use of rural land for human settlement.

A further principle also applies – it is more cost effective to manage land to achieve the above objectives than to repair it one it is degraded.

Fortunately, there have been significant changes in farming methods with new technologies now being used that have increased our capacity to produce agricultural products with reduced impacts on landscapes. Laser grading of irrigation land, minimum tillage, reduced use of pesticides and trash retention are some of the methodological changes that have occurred. Vegetation clearance and retention legislation and policies have had a significant influence on slowing land degradation throughout Australia. Research continues into ways of limiting leaky soils from discharging nutrients, the creation of salt tolerant pastures and the development of catchment performance modelling tools, to name a few areas of current research.

Change in the way land should be used and managed has been promoted by national state and territory strategies and numerous landholder and community programs but with funding only slowly increasing over the past two decades.

But despite changes in attitudes and practices, we are still experiencing a net loss of native vegetation throughout Australia. And while soil loss is occurring at a lesser rate now, it is still faster than the rate at which soil is formed which means that soil-based agriculture is not sustainable in the long term, water quality cannot be restored to that found before European settlement and a net loss of biodiversity is continuing.

Useful Sources

Australian Bureau of Agricultural and Resource Economics (ABARE). *Australian Farm Surveys – survey methods and definitions 2009.*
www.abare.gov.au/publications_html/economy/
The map showing the agricultural regions of Australia has been modified when published in Australia State of the Environment 1996.

Australia State of the Environment 1996 and 2006.
www.environment.gov.au/soe/1996 or 2006
These reports describe the various forms of land degradation in Australia, their extent and, where data is available, trends.

Cribb, J (2010). *The Coming Famine.* Free public lecture 21st April 2010
www.sustainable.unimelb.edu.au/contents/pages/freepubliclecture
An interesting presentation that summarises the status of global natural resources.

National Land and Water Resources Audit, 2002.
www.anra.gov.au/topics/publications/final-report
This and other reports by Land and Water Australia provide comprehensive data bases on Australia's natural resources.

Stocking, M and Murnaghan, N, 2000. *Land Degradation – guidelines for field assessment.*
www.archive.uni.edu./env/plec/l-degrade/
This publication provides a good understanding of land degradation, its causes and analyses of risks drawing on global examples.

Author

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