Sense and Nonsense about Soil Degradation

Nick Uren

Nick Uren, *Reader in Soil Science in the School of Agriculture at La Trobe University,* *argues that apart from some soil erosion there is little evidence that degradation of farming soils is a serious problem in Australia.*

> Soil degradation is a major cause of yield loss in agricultural areas of Australia, costing farmers and the nation an estimated $1.2b each year in lost production. Costs of this magnitude cannot be sustained by any nation, let alone one like Australia, where 40 per cent of gross export earnings are generated by soil-based industries. It is clear we need to preserve our soil resource, both through individual and community-based efforts. A soil is degraded when its structural, biological or chemical properties deteriorate as a result of agricultural practice, other industry or tourist development. Australian soils need special care because they are delicate, being a lot older and less fertile than those of northern Europe, where our farm cultivation practices originated. The main areas of concern in agricultural soil degradation are: erosion by wind or water, loss of good soil structure, nutrient imbalance, salinity, acidity. (CSIRO Division of Soils, 1990)

This passage is typical of the widespread but one-sided and misguided view of the soil-degradation issue in Australia. (I shall call the proponents of this point of view the 'browns' to distinguish them from the 'greens', since the two groups do not completely overlap.) Those on the other side of the debate would agree with Bruce Davidson's statement that 'There is no evidence that farmers have, or would, willingly use the land in such a way as to destroy its productivity' (1991:26). The alarmist tactics of politicians and grant-seeking scientists provide tacit support for the browns, whose propositions are themselves sensationalist, misleading and of little practical value.

The browns were greatly inspired by the dust storm that reached Melbourne in February 1983 and heralded the end of a severe drought. What more graphic evidence could there be of soil degradation than a dust cloud over Melbourne? If the storm had been the first of its kind in living memory or if the drought had led to a series of equally dramatic dust storms, then the browns might have had a case. But it was the first in Melbourne since 1945 (Blackburn, 1983), a year that had been preceded by a period punctuated with droughts and rabbits and associated with low management inputs because of World War II. If the browns had any sense of history they would know that Australia's greatest environmental disasters were probably the rabbit plagues between 1890 and 1950. As well, it was in the 1930s that active moves were taken to conserve soil, and State government bodies such as Victoria's Soil Conservation Authority (now defunct — not needed?) were established. The absence of serious dust storms in Victoria in the last 40 years is evidence of the success of the Soil Conservation Authority and the farmers.

The Meaning of Soil Degradation

Soil degradation can be defined as the irreversible loss of the soil's capacity to be used for a particular purpose. It is usually taken to mean the loss of soil fertility, i.e. the loss of the soil's capacity to support plant growth. But since soils have different uses — farming, engineering, and so on — what is undesirable to one user may be desirable to another, and quite commonly one user may treat soil in a way that represents soil degradation to another user. For example, an engineer may compact soil to build a road or a water storage; but this process discourages plant growth, especially if the compaction reaches the level that is necessary to build a good road or water storage.

Most changes that lead to decreases in soil productivity are not irreversible, and so fall outside the definition of soil degradation given above. For example, saline or eroded soils can be rehabilitated given appropriate management, time and resources (largely financial). An irreversible loss in productivity may occur only in the rare instances when a highly toxic non-biodegradable substance is added to soil at rates sufficient to virtually sterilise it.

The browns' concerns appear to be somewhat confused, but in general they are concerned about loss in soil fertility that leads to a loss in productivity. This is the sense of 'soil degradation' that I adopt for the purposes of this article.

Soil Erosion

The physical removal of soil, as happens in soil erosion, is a clear-cut example of soil degradation in the short term since it is usually accompanied by lower yields. Textbooks tell us that there are two sorts of soil erosion:

geological and man-made. The browns would have us believe that Mother Nature's geological erosion is acceptable because, on average, it is slower than the man-made variety. But some of the best soils in the world are on the flood plains of the world's greatest rivers where for centuries silt and mud (soil eroded from elsewhere) have been deposited; the silting up of the Aswan Dam on the Nile has taken away a source of nutrients — 'natural fertiliser' — from downstream irrigators. Most agricultural soils of the northern hemisphere have formed on the material dumped there naturally through the agencies of ice (glacial till) and wind (loess). The loess deposits in China are hundreds of metres thick; the sedimentary rocks that lie below Melbourne are made up of deposits of eroded sand, silt and clay that are about 10 kilometres thick. Mother Nature is not the sort of mother I would like, since she often deals out environmental disasters without warning and in huge doses, all of which started millions of years ago and long before the advent of the human race. On the credit side, however, since their 'sterilisation' by larva flows in 1883, Mother Nature has rehabilitated the islands of Krakatau with virtual rain forest in some areas (Whittaker et al., 1989).

The single most common predisposing cause of soil erosion is the removal of vegetation. Since the primary purpose of agriculture is to produce vegetation, it coincides with the aim of soil conservation. However, excessive cultivation and over-grazing by any sort of herbivore can lead to soil erosion, representing a form of soil degradation. I really have no argument with this, since these are bad agricultural practices that are in no way condoned by the vast majority of farmers. However, the role of droughts and over-grazing by feral animals in the history of soil erosion in Australia should not be overlooked.

Soil Acidity

For some reason the word 'acid' conjures up meanings or associations of nastiness and sourness, and so, according to the browns, soil acidification must be unquestionably a bad thing. But acidity and acidic compounds are natural and commonplace. Nothing could be more natural than the formation of soils by acid reacting with the constituents of rocks. As the rocks break down, nutrients — the essential elements that we and other living organisms require for life — are dissolved and released in forms that are useful to plants. Similarly, plant roots and soil microbes produce acidic compounds that acquire nutrients from soil. The interaction between food and gastric acid in our stomachs is one of the earliest stages of digestion and of our acquisition of nutrients and energy. Nothing could be more normal.

Soils become progressively acidic over time due to leaching with water and to plant growth, and the loss of nutrients is probably of much greater significance than the acidity that develops. Soils that are strongly acidic are clapped out; their nutrient reserves, if not exhausted, are out of balance for plant growth. When agriculture began in Australia, the bulk of soils were too infertile for the satisfactory growth of agricultural crops. The soils most suitable for agriculture were found in those areas where the rainfall was sufficiently high, and these soils were naturally acidic. During the 20th century Australians have become quite famous for their work on the management of infertile soils, particularly in the area of trace elements such as molybdenum. The issue of whether lime is required to reverse acidification and neutralise the acidity of soils is being actively researched at the moment, but any forecast of the effect of a liming program on productivity would be about as reliable as my attempt to pick the winner of the Melbourne Cup. Given the cost of liming in relation to the prices received by farmers for wool and wheat, it is not a good bet at the best of times. It is even more of a gamble because lime may induce deficiencies of trace elements on many of these strongly acidic clapped-out soils. At present it is preferable to add fertiliser and to grow species of plants and their cultivars that tolerate the acidity.

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Soil-Nutrient Decline

For a long time I was bewildered by the browns' talk of 'soil-nutrient decline'. I suspected that they did not know what they were talking about, since a nutrient is an element that can decline only if there is a decrease in the valency or the atom is split! I knew that the browns probably would not know about valency; and if there had been splitting of atoms, there would have been a lot more radioactivity (which really would have given us something to be miserable about!) Then some enlightened soul told me that 'soil-nutrient decline' meant that soil was being mined and that nutrients were being removed in farm products. It then dawned on me

(and this is a charitable interpretation) that it referred to the decline in the status of the supply of the nutrients present in soil. Having devoted my life to studying nutrient deficiencies associated with soil and teaching students how we deal with them, I was now being told that this was a really serious problem! We know that our soils have been degraded by the ravages of time, even before agriculture; but we also know that plants require nutrients, that harvesting removes those nutrients, and that if productivity is to be maintained those nutrients must be replaced. Fertilisers are very effective at doing the job. It is time that the contribution of superphosphate and other fertilisers to Australian agriculture was acknowledged.

Soil-Structure Decline

Perhaps the most bewildering claim that the browns make is that a major form of soil degradation is 'soil-structure decline'. I admit I have also heard many of my scientific colleagues talk about this dreadful phenomenon; some of them, I suspect, have the ulterior motive of generating anxiety and getting grants to do research.

'Soil structure' commonly and simply means the arrangement of primary soil particles and the pore space between them. Changing the arrangement of the particles alters the structure of soil. This happens frequently as the soil is cultivated and animals walk on it. But, under this definition, it is difficult to see how soil structure could 'decline', since whatever happens to the soil, its particles must always have some structure or pattern of arrangement.

Some confusion stems from adherence to an older definition of structure, according to which soils were said to be structureless if, like sands for example, they did not cohere in aggregates (crumbs). Soil-structure decline in this sense refers to the destruction of the aggregates. But this can be a good thing or a bad thing depending on the use of the soil. Stable aggregations of soil particles can range in size from a few millimetres in diameter to brick-size clods. Since the smaller ones are more suitable for plant growth, one might be inclined to think that the breaking up of clods is a case of soil-structure decline!

Structure is often said to be either good or bad for a particular use or purpose. In agriculture, structure is said to be good for plant growth if it is well-structured! One might therefore assume that a decline in soil structure has occurred if as a result of cultivation or traffic the structure has deteriorated, that is, the yield has decreased. Compaction, which increases bulk density, is said to be a major cause of soil-structure decline. But not all compaction is bad; for example, some current research is aimed at compacting the soil to improve the establishment of wheat seedlings. This would seem to be a silly thing to do if there is any meaning in what the browns call soil-structure decline.

There is not much evidence of soil-structure decline in the sense of decreases in plant yield as a result of changes in soil structure. Yield responses to structural modification are not commonly observed in farmers' paddocks; and compaction by animals with the dreaded cloven hooves has not been shown unequivocally to decrease plant growth since it is not possible to distinguish between the effects of compaction, of trampling, and of the two combined.

One sometimes hears soil conservationists claim that soils with stable structure are desirable because they resist erosion. At the same time the agriculturalist wants soils structures that are good for plant growth. But although soils that set hard like concrete have a 'good' structure in that they resist erosion, they have a 'bad' structure for plant growth. So whether soil structure is in 'decline' depends not only on the definition employed but also on the use or the desired state of the soil.

Soil Pollution

The 'poisoning of our soils' with chemicals is another oft-cited example of soil degradation. But, except for exceedingly rare extreme cases, there is little need for concern. When plant remains such as leaves are added to soil, they are often toxic to plants because their decomposition by microbes in the soil produces toxic organic molecules, consumes oxygen, and decreases the supply of nutrients available to plants. Over time the toxic organic molecules are also consumed, the frenzy of microbial activity decreases, and the competition for oxygen and other nutrients abates. (Compost is deliberately left in heaps as it passes through this toxic phase.) Organic pesticides that are added to soil are progressively degraded by chemical and microbial processes, becoming ultimately harmless, in the same way as the toxic organic molecules in a compost heap are degraded.

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Some pesticides are more resistant to degradation than others, for a number of reasons. One is that the molecule may be rendered unreactive by its close association with soil particles. Even though it persists in the soil for years, that is no cause for concern, since that naturally happens with a whole range of potentially toxic elements, not just pesticides. Many heavy metals

and radioactive elements are present naturally in soils, but in forms that are so insoluble that they cannot do any harm. (The dose of barium in a barium meal for an X-ray is enough to kill, but barium sulphate, being insoluble, is harmless.) Some pesticides are degraded more rapidly the second time they are added to soil. Research in Canada has shown that annual applications for over 30 years of 2,4-D and MCPA (two common weedicides) had no adverse effects on the productivity of wheat (Smith et al., 1991).

In the debate about chemical additions to soil, a distinction should be made between contamination and pollution. **Contamination** occurs when substances are present that are either not normally present or exist in abnormally high concentrations. This is a relatively frequent occurrence. **Pollution** occurs when a potentially toxic substance is present in such forms and activities that it either exerts its toxicity or decreases the quality of the food produced. Whether or not contamination amounts to pollution depends very much on the circumstances. Industrial sites are often contaminated to such a level that pollution exists, but in agriculture pollution is rare, particularly of a kind that is dangerous to human health.

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The European Heritage

Finally, the browns seem determined to blame our European heritage for all of the so-called problems. They claim that land and soil degradation in Australia has been caused by the continued application of European-style agricultural practices over 200 years. That may be true in some respects, but it implies that farmers have not changed since 1788 and that they have relied solely on developments from Europe and North America.

The earliest white settlers had the apparent choice of adopting either aboriginal practices or those with which they were familiar. Quite naturally they applied what they knew (which was very little) and quickly discovered that the climate and soils of Australia were very different from those of Britain and that some European practices did not work. Since that time Australia has developed its own styles of agriculture in a variety of enterprises and environments. This is the result of agricultural research and of farmers adopting and adapting practices such as cultivation, fertilisation, rotations, breeding, irrigation, conservation tillage, and so on, from all over the world and not just from Europe. 'An agricultural system was forged which . . . was vastly different from the farming systems of Europe' (Davidson, 1981:2).

The history of Australian agriculture is replete with discoveries and inventions stemming from the necessity to adapt to the Australian environment, particularly the climate and the infertile soils. The accumulation and dissemination of a vast body of scientific knowledge have made a major contribution to this development (Wadham, 1967). Mistakes were made and will continue to be made. But usually they are gradually rectified because this in the best interest of farmers.

Conclusion

Of the processes that are said to lead to soil degradation, soil erosion is the only one that may do so, but then only in the short term. The soil-degradation debate is annoying because it appears to stem largely from a lack of understanding by well-intentioned people. But in all fairness to the browns, it should be said that they have apparently been misled by the slack chatter and sensationalism of some self-seeking scientists. Problems of salinisation, acidification, compaction, mining of nutrients and contamination do exist, but they are not nearly as extensive or as serious as they are made out to be. Nor are they incurable.

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