BIODIVERSITY AND AGRICULTURE[1]

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BIODIVERSITY: WHAT IS IT AND WHY IS IT IMPORTANT?

The term "biodiversity" was coined by E.O. Wilson, an evolutionary biologist from Harvard University, as an easier way of saying "biological diversity". It is defined simply as the variety of all life forms and their patterns in space – the different plants, animals and micro-organisms, the genes they contain and the ecosystems of which they form part. Importantly, it consists not only of the genes and the life forms themselves, but also includes the interactions between them and the environment. Thus there are three interactive levels of biodiversity; diversity at the genetic, the species, and the ecosystem levels. The term therefore covers a large array of ecological complexity and it is in general poorly understood.

To most people, biodiversity is taken to mean species diversity. In fact, it is sometimes even more narrowly defined to cover just the conservation of rare or endangered species, usually the conspicuous flowering plants or vertebrates (known in conservation circles as the "charismatic megavertebrates"). This erroneous interpretation leads to biodiversity being seen in an extremely restricted way. For example, in agricultural landscapes, many people assume that biodiversity is found only on conservation reserves, on uncleared agricultural land, or on remnant patches of bush on farming land, that may or may not be fenced-off (see Figure 1).

Of course, this view ignores the fact that agriculture is an ecological enterprise. Agriculture is totally dependent on ecosystem processes and functions such as soil formation, nutrient cycling, maintenance of hydrological cycles, pollination of crops, etc. These processes and functions are all driven by interactions between elements of biodiversity. The narrow species-focussed view of biodiversity gives rise to the notion that landscapes can be compartmentalised and that protection of remnant native vegetation is therefore the primary action required to conserve biodiversity. This attitude does not take into account the majority of biodiversity, and it is leading to continuing loss of its essential elements.

Before going further into the role of biodiversity in agriculture, it is informative to briefly review its international and national status. What standing does it have in the eyes of the world, our own citizens, and the three levels of government in Australia?

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[1] Saunders, D. and Walker, B. (1998). 'Biodiversity and Agriculture'. *Reform* Spring issue 6: 11-16, NFF.

The 1992 International Convention on Biological Diversity was one of the important outcomes of the Earth Summit held in Rio de Janeiro. Australia ratified this convention in June 1993, one of 172 countries to do so.

Building from that, in 1996 the Commonwealth and all Australian State and Territory governments signed the National Strategy for the Conservation of Australia's Biological Diversity. Amongst a range of objectives in the Strategy, Objective 2.2 aims to "Achieve the conservation of biological diversity through the adoption of ecologically sustainable agricultural and pastoral management practices."

The Strategy concludes with a series of priority goals to be achieved by the years 2000 and 2005. Several of these have direct relevance to agricultural and pastoral enterprises and it is worth stating them here."By the year 2000 Australia will have: implemented institutional arrangements and programs to ensure and monitor the ecologically sustainable development of Australian industries based on the extraction or use of natural resources; arrested and reversed the decline of remnant native vegetation; and avoided or limited any further broad-scale clearance of native vegetation, consistent with ecologically sustainable management and bioregional planning, to those instances in which regional biological diversity objectives are not compromised." By the year 2005 Australia will have: "established a system of voluntary or cooperative reserves, or both, and other management schemes on private lands to complement the protection provided by the public estate in protected areas; and demonstrated maintenance of regional floras and faunas."

Local government was not a signatory to the Strategy, but the Strategy has individual objectives to have by the year 2000: "implemented programs consistent with this Strategy to encourage local government to play a major role in nature conservation in Australia" and by 2005 to have created: "local governments that have assumed a major role in the conservation of Australia's biological diversity."

These objectives provide a background for the way our country has established conservation of biodiversity as a national goal. But our concern here is to consider it from the perspective of farmers, and the interests of the agricultural industry. Why is it important to you?

WHY IS BIODIVERSITY IMPORTANT?

Conservation and maintenance of biodiversity are important for four reasons.

Life support: From an anthropocentric viewpoint, our survival depends on biodiversity as some of its elements provide the critical life support systems that make human life possible. These are the healthy, functioning ecosystems that maintain the atmosphere, including the air we breathe, regulate the climate, produce fresh water, form soils, cycle nutrients, and dispose of wastes. This ecosystem-services reason is of critical importance to agriculture, and we'll return to it shortly.

Economics: Biodiversity provides us with great economic returns, for example the provision of food and fibre, medicines, control of pest organisms, building materials and crop pollination. It is an essential element of tourism which is rapidly increasing in economic importance. For example, it is estimated that in 1991-92 tourists to six areas

in Australia protected to preserve their biodiversity spent more than 2 billion dollars during their visits.

Aesthetics and culture: Many people obtain cultural identity, spiritual enrichment and recreational activities from elements of biodiversity. For example, much of the Australian "sense of place" comes directly from biodiversity. This is not only of fundamental importance to Aboriginal and Torres Strait Islander peoples, but is also true of most rural people. Our unique native vegetation with its associated native fauna is what gives Australia its distinctive character and colouring. For example, the mountains or hills on the horizon of many Australians get their distinctive blue colouring from light being refracted through the volatile oils given off by the eucalypts growing on them. At a level that is not trivial to the culture of some people, many of our sporting teams are named after components of our biodiversity (Wallabies, Socceroos, Magpies). The green and gold of our Olympic uniforms are derived from the predominant colours of elements of our flora.

Ethics: Conservation and maintenance of biodiversity are also important for ethical and inter-generational equity reasons in that no generation has the right to appropriate Earth's resources solely for their own benefit. We cannot adopt the Marxian philosophy (we are not referring to Karl but to Groucho Marx, who said: "Why should I care about future generations? What have they ever done for me?"). This is one of the major platforms behind the need to develop enterprises that are ecologically sustainable. It is also an important element of the desire of many farmers and graziers to leave the land in "better condition than when they started managing it."

STATUS OF BIODIVERSITY

Like most other countries Australia's record for managing its biodiversity is not great. We're getting better, but our early impacts were very severe. Basically, often without realising it, we have been taking a free ride on the back of our biodiversity and we are still too much in the mode of mining it. The 1996 Australian State of the Environment Report stated that loss of biodiversity:

"is perhaps our most serious environmental problem. Whether we look at wetlands or saltmarshes, mangroves or bushland, inland creeks or estuaries, the same story emerges. In many cases, the destruction of habitat, the major cause of biodiversity loss, is continuing at an alarming rate."

It has been estimated that there are more than one million species living in or around Australia. However, less than 15% of these have been scientifically described. It is safe to say that we have no idea what was present in or around the continent in the late-1770s when the major human-induced changes to the Australian environment began. We don't have a very much better idea of what is present now. We know the identities of most of the vertebrates (mammals, birds, reptiles and amphibians). We know much less about the plants, and we know only a small percentage of the invertebrates, including the thousands of tiny organisms in our soils and waters. Those plant and animal groups we do have information on are all showing alarming trends. For example, the State of the Environment Report notes that:

"For the land animals and plants about which we know enough to assess their current state, the trends are disturbing. Some 5 per cent of higher plants, 23 per cent of mammals, 9 per cent of birds, 7 per cent of reptiles, 16 per cent of amphibians and 9 per cent of fresh-water fish are extinct, endangered or vulnerable. Australia has the world's worst record of mammal extinctions. In the past 200 years, we have lost 10 of 144 species of marsupials and 8 of 53 species of native rodents."

These losses will continue. And the worry is not just that we are losing some precious heritage, or that we have fewer biodiversity "goods" to commercialise. It is the breakdown in ecosystem processes that supply the support systems on which we depend, and the changes in the way they function that pose the most critical environmental issues Australians face.

BIODIVERSITY AND THE SUPPLY OF ECOSYSTEM GOODS AND SERVICES

The phrase "ecosystem goods and services" is appearing with increasing frequency in debates about alternative forms of land use. The "goods" are the products we harvest from ecosystems, and include an increasingly wide array, as landowners begin to find value in natural products in addition to the traditional livestock and agricultural crop products. The "services" are more difficult to define, but include such things as regulation of the hydrological cycle, maintenance of nutrient cycling, removal of carbon dioxide, production of oxygen, and disposal of wastes.

Biodiversity "goods"

Pastoralism and forestry depend heavily on biodiversity goods. Pastoralism in the rangelands is based on production of forage by native plants. Forestry, both public and private, when based on harvesting native forests depends exclusively on biodiversity goods. Extensive agriculture also depends heavily on biodiversity goods, but in the main, they are goods originally from outside Australia. For example, cereal crops, domestic livestock, fruit, etc are all derived from elements of the biodiversity of areas other than Australia.

However, in the quest for ecological sustainability and the need for economic and ecological diversity, there is a small but increasing interest in extending the use of biodiversity goods beyond grazing native grasses and harvesting native forests. There are a number of ventures based on these goods. These include the obvious ones such as harvesting of kangaroos and other animal species from the wild. However, they also include honey production from native vegetation, harvesting of native flowers from bush patches for the cut flower market (see Figure 2), farming native species (like kangaroos, emus and crocodiles), and the 6 million tonnes of firewood cut annually from remnant woodland. There have been calls for the legalising of harvesting galahs from nest sites on farmland to supply the avicultural trade and to help regulate the numbers of what many people regard as a pest. In June this year the Australian Senate published its 418 page report "Commercial Utilisation of Australian Native Wildlife". It is the outcome of a two-year inquiry, and is a comprehensive account of the many commercial uses that are being made of elements of the country's biodiversity.

There is an increasing interest in using local plant species as part of landscape reconstruction to address some of our land degradation problems. This will require vast quantities of seed and the development of seed nurseries may be useful adjuncts to more traditional farming activities. In addition, cashing in on the tourist boom using native plants and animals as value adding to the tourist experience may also be profitable adjuncts.

Using biodiversity is not a panacea for all economic woes in rural areas, and (as highlighted by the Senate inquiry) it will also not necessarily lead to improved conservation of biodiversity. But integrated with other farming activities it can add to the financial viability of an enterprise that otherwise would be below the threshold for being jointly economically and ecologically sustainable.

Of the 12 recommendations in the Senate report, the first is for an experimental management trial, preferably in the rangelands region of the country, to replace traditional farmed animals with native wildlife in marginal agricultural lands. We strongly support such trials, since there are too many factors involved in determining the outcome for the question to be approached in a piecemeal fashion. It can only be done in a real management context, at a management scale, under a number of different biophysical-economic combinations.

Biodiversity "services"

Every farmer knows that maintenance of soil fertility is the basis of all agriculture. (S)he also knows that it is expensive to keep applying fertilizer, and that problems of soil acidification, salinization, compaction, loss of structure (and therefore water infiltration) and soil loss (erosion) are serious problems that greatly reduce profitability. A common reason for these various forms of soil degradation is loss of soil biodiversity – the loss of "free" ecosystem services that biodiversity provides.

Because it is minute, many people do not realise the wealth of biodiversity that exists in the soil. In fact, the majority of biodiversity in agricultural landscapes occurs in the soil. For example, in every hectare of soil in temperate regions there are about:

- 20000 kg of microscopic organisms (such as bacteria, fungi, etc);
- 50 kg of microfauna (organisms less than 2mm in length, such as nematodes and protozoa);
- 20 kg of slightly larger organisms (2-10 mm, such as microarthropods); and
- 900 kg of organisms greater than 10 mm (such as earthworms and termites).

This mass of living organisms is as much or greater than the mass of most of the agricultural products standing on the surface of that same area of land. For example a crop of wheat in eastern Australia that produces 5000kg/ha of grain may have had a total biomass before harvesting of about 15000kg/ha compared with around 21000 kg of soil organisms/ha.

The millions of organisms making up this huge mass of thousands of different species don't just sit quietly in the soil. They are highly active, burrowing, moving soil around, ingesting it and mixing it with their intestinal juices before defaecating it, consuming rotting dead roots and litter, absorbing hard-to-get-at-phosphates (mycorrhizal fungi do this job excellently), and performing a host of other soil forming processes. Soil pores bigger than 2mm in diameter are all biologically determined, and these pores

play a major role in the water infiltration properties of soils, and in determining such things as bulk density and water-logging. Without the soil biota nitrogen would not be mineralised, and under reduced soil biodiversity soil fertility declines rapidly and markedly.

More broadly than soil, native species play a major role in the control of agricultural pests. Pesticide resistance is an increasingly worrying problem and in southeast Asia, for example, there is a move to switching from chemical to biological control; not because of the costs of pesticides (which are high) but because it is the only successful way to control a number of insect pests. A colleague of ours, Max Whitten, (a consultant with the International Rice Research Institute) told us of a farmer he visited who had successfully made the switch, and who pointed to his healthy rice crop and said "Look out there! I have a million spiders working for me – for free!" Under chemical pesticide control there were no spiders. In Australia there is now a significant and growing move towards "conservation farming", with a recognition that it leads to the use of less pesticide, and therefore to lower costs of production.

The issue of biodiversity services needs to be borne in mind when making decisions on land use. For example, a patch of remnant vegetation may provide more than aesthetics, shade and shelter. It is removing carbon dioxide, producing oxygen, using water, and may have some role in controlling water tables, and the movement of wind and water over the surface of the land. At present, these services tend not to be included in the cost accounting for agricultural production.

CHANGES IN BIODIVERSITY AND THEIR CONSEQUENCES

As biodiversity is lost, ecosystems become less complex. This sets in train a cascading sequence of events that can result in changes that can have important and long-lasting consequences. Simplified ecosystems become less resilient, meaning that they are less able to absorb environmental shocks and disturbance and still continue to maintain their original levels of function (processes like rates of growth, transpiration, fixation and uptake of nitrogen). There is mounting evidence that many of the minor species that occur in ecosystems in very small numbers are ecological analogues of their relatively few abundant (and therefore obvious) counterparts; and in the event that the abundant species are reduced or eliminated the minor species expand to take over their functional roles. This phenomenon of substitutability among species is like an insurance policy for ecosystems, enabling them to keep performing at high levels under a wide range of environmental conditions. Reducing biodiversity means that there are fewer components to buffer the blows inflicted by drought, fire, exotic species and climate change.

Extensive agriculture in Australia illustrates some of these changes and demonstrates some of the obvious consequences of loss of biodiversity. In the early 1950s agriculture accounted for nearly 80% of our export earnings and much of Australia's present prosperity has its roots in those extremely prosperous times. Although there has been a major decline in the contribution of agriculture to our export earnings, today it accounts for about 25% of our export earnings and is therefore still a major and very significant industry.

The extensively cleared wheat-sheep zone occupies about 15% of Australia. In many areas less than 10% of the original vegetation remains, with the cleared areas being used for production. What have been the consequences of these extensive alterations to the landscape? Vast areas were changed from being clothed with deep-rooted perennial vegetation that used most of the water that fell on it, to shallow-rooted annual vegetation that was inefficient in water use. In addition, the loss of 90% of natural habitat has resulted in the loss of a major portion of the organisms dependent on it.

For example, in the wheatbelt of southwestern Australia, 30% of the 43 species of mammals present before the area was cleared for agricultural development have disappeared from the region. Other mammal species are still contracting in range and/or abundance. Birds are demonstrating the same declining trends with half of the 195 species recorded from the region declining in range and/or abundance.

Does it matter if we lose these species? How many can we afford to lose? The trouble is, we simply do not know how many species we can lose before ecosystem function is significantly affected; yet we do know that some species have direct functional significance. As one small example, the honeyeaters are important for plant pollination and their loss will mean that many species of native plant will not reproduce.

The extensive loss of native vegetation is now having major impacts on ecosystem functioning in many parts of Australia. The hydrologic balance of the wheatbelt regions has been radically changed. Water that was used by perennial native vegetation when it covered the region is now entering the groundwater, and water tables are rising, bringing salt stored in the subsoil to the surface. Current estimates are that up to 25% of all cleared land in the Western Australian wheatbelt could be so affected, and it will be useless for cereal cropping within the next 50 years. In some parts of the landscape up to 50% could be affected by soil salinity.

Changes in vegetation have also led to changes in surface flow of wind and water and these have become severe degrading forces. In addition, there is now evidence that these extensive changes to the landscape may be resulting in changes in the radiation balance, in turn leading to alterations to the macro- and micro-climate. Changes in micro-climate may mean the vegetation that formerly grew in an area may not be able to grow there because conditions are no longer suitable. There is some evidence from rainfall records over the past 80 years and more recent analyses by Richard Smith and his colleagues in Western Australia of cloud formation using satellite imagery suggesting that changes to the radiation balance are leading to reductions in rainfall in southwestern Australia.

Many of these degrading forces are also affecting drainage systems. The problems are so severe in southwestern Australia that there are no surface potable waters in the wheatbelt, and a similar situation is developing in the Murray-Darling Basin.

FAILURE TO VALUE BIODIVERSITY

A recent review of the sustainability of agriculture noted that loss of production through the degradation of natural resources through rising groundwaters, soil salination, erosion, acidification and decline in soil fertility is a major cost to agriculture and to the entire Australian economy.

While the area under cultivated crops in Australia has fallen only slightly since the mid-1990s, the index of real net value of farm production has fallen markedly from near 400 in the mid-1950s to slightly less than 200 in the mid-1990s. The economic calculations used to construct this index are misleading and probably provide a gross under-estimate because the real figures of costs of production are not available. How is real net farm income defined? Real net farm income consists of the real value of farm income minus the real value of farm costs. Farm income is taken to include receipts from agricultural production, rents, interest and other revenues, and farm costs include marketing expenses, purchases of inputs (stock, seed, services, chemicals, etc), rates, taxes, interest and other charges, as well as wages paid by the farm business. Note that in these calculations there is no mention of any costs associated with environmental degradation resulting from the farming enterprise. For example, the costs of remediation are not built into the costs of production.

The scope of our environmental problems is already affecting us economically. However, we are still not paying sufficient heed to the fact that it is the ecological realities which we need to address if we are to remain economically viable in the long-term.

THE WAY AHEAD

Until we include biodiversity in our management and our accounting systems we will not develop sustainable primary production. This means developing systems of integrated management that treat the ecological realities as of equal importance to the economic realities. As pointed out by the 1996 State of the Environment Report "Progress towards ecological sustainability requires recognition that human society is part of the ecological system and integration of ecological thinking into all social and economic planning."

This comprehensive report provides food for thought as one of our concluding remarks:

"Overall, economic planning appears to take little account of environmental impacts. It is assumed that the first priority should be a healthy economy, and that problems can always be solved using the wealth created. The economy is a subset of human society which, in turn, is part of the environment. Progress towards sustainabilty requires recognition of this fundamental truth, and a willingness to build environmental thinking into our economic planning."

It may at first seem from what we have written in this article that we are members of the "doom and gloom brigade." We're not. Agriculture in Australia has a proud record in many respects, and still has a great future. But it is hard to avoid raising a "wake-up" call when biodiversity is considered. Given its direct potential economic value, and its enormous secondary "ecosystem service" value, Australians owe it to themselves to pay it more and better attention.

Agriculture is essential to Australia and all elements of society need to support the development of ecologically sustainable primary production. At present many people believe that food comes from supermarket shelves; they have no idea of the difficulties or the environmental costs of production. Accordingly, we need a better educated community who are aware of the problems being faced by the rural community and of the need for addressing these problems. We also need to develop an economic system that accounts for the environmental costs of production and a way of ensuring these costs are met and used to remediate those problems.

FURTHER READING

Commercial Utilisation of Australian Native Wildlife. Report of the Senate Rural and Regional Affairs and Transport References Committee. June 1998. Commonwealth of Australia, Canberra.

Standing Committee on Agriculture and Resource Management (1998). Sustainable Agriculture: Assessing Australia's Recent Performance.

State of the Environment Advisory Council (eds). (1996). Australia: State of the Environment Report 1996. An independent report to the Commonwealth Minister for the Environment. CSIRO Publishing, Melbourne.

Saunders, D. A. and Hobbs, R. J. (1993). Reintegrating Fragmented Landscapes: Towards Sustainable Production and Nature Conservation. Springer-Verlag, New York.

Figures:

Figure 1: To many people biodiversity is found only in remnant vegetation such as this patch in the Western Australian wheatbelt. This interpretation ignores the majority of biodiversity that exists in the soil and is principally responsible for the maintenance of soil productivity.

Figure 2: Honey production from native plants and harvesting flowers like these beautiful *Banskia prionites* flowers from native vegetation for the cut flower market are alternative uses for biodiversity "goods."