What is causing the loss of biological diversity?

As Fisher (1981, page 75) argues, much of the concern about resource exhaustion appears to involve renewable resource use and the endangerment of species. He quotes one early assessment by a biologist:

> *The worst thing that can happen - will happen [in the 1980s] - is not energy depletion, economic collapse, limited nuclear war, or conquest by a totalitarian government. As terrible as these catastrophes would be, they can be repaired within a few generations. The one ongoing process in the 1980s that will take millions of years to correct is the loss of genetic and species diversity by the destruction of natural habitats. This is the folly our descendants are least likely to forgive us.*
>
> Wilson (1980)

This prognosis is supported by the following assessment that introduces the discussion of diversity found in Chapter 8 of the 1994-95 edition of *World Resources*:

> *By some accounts, the world is on the verge of an episode of major species extinction, rivalling five other documented periods over the past half billion years during which a significant portion of global flora and fauna were wiped out. Unlike previous die-offs, for which climatic, geologic and other natural phenomena were to blame, the current episode is driven by anthropogenic factors: the rapid conversion and degradation of habitat for human use; the accidental and deliberate introduction of exotic species; overharvesting animals, fish and plants; pollution; human-caused climate change; industrial agriculture and forestry; and other activities that destroy or impair natural ecosystems and the species within them.*
>
> WR (1994), page 147.

It is common to have in mind land-based organisms when discussing loss of biodiversity. However, there is evidence that the biodiversity of freshwater lakes,

streams and rivers may be the most threatened terrestrial ecosystem. Furthermore, marine waters, which contain over 90% of the world's living biomass, may be experiencing substantial loss of biodiversity (see WR, 1994, pages 184 and 192).

A general assessment of the nature and extent of biodiversity decline was given in Chapter 2, so there is no need to dwell on this evidence any here. Rather, we turn our attention to the causes of biodiversity decline. It has already been shown that a part of this phenomenon is due to the hunting or harvesting of particular species for recreational or commercial purposes. But this explains only a small part of the total picture.

Far more important are losses associated with general economic activity. The drainage of wetlands for agriculture, dam construction and the flooding of valleys for power generation, the use of pesticides, the development of wilderness areas, and toxic contamination of soils have all been associated with unintended species collapses or extinction. In fact, almost all forms of human activity pose this threat. Incidental and unintended impacts are the most important causes of species extinction, dwarfing in significance species loss arising from excessive harvesting.

The causes of biodiversity decline are, therefore, many and diffuse. It is useful to draw a distinction between *proximate* and underlying or *fundamental* causes. Proximate causes refer to the mechanisms that trigger the loss of biological diversity; the immediate neighbours, if you like, in the chains of cause and effect links. Fundamental causes are those conditions - cultural, economic, and institutional - which generate and sustain the proximate causes. This distinction is important for policy purposes. Attempts to reduce the loss of biodiversity must take account of the fundamental causes. Efforts concentrated on proximate causes may be doomed to failure if the pressures emanating from underlying conditions are not redirected.

Proximate

Even in the absence of human pressures, there are several natural mechanisms that can result in biodiversity loss or species extinction. These include environmental and demographic stochasticity (random variability), genetic failure and natural

catastrophes. Details of the ways in which these mechanisms operate can be found in Jeffries (1997).

But our interest lies in human induced processes. Each of the following processes can induce biodiversity decline:

- land conversion away from high diversity supporting uses
- exploitation of wild species
- introduction of exotic species into new environments
- homogenisation of agricultural practices
- air, water and ground pollution
- climate change.

Some examples of each of these are given in Box 1 below.

Fundamental

While there is little disagreement about the proximate causes of biodiversity decline, there is less consensus about the underlying causes. The explanations given are not mutually inconsistent with each other, however. Rather, they differ in terms of how the problem is conceptualised, and what are perceived as most 'fundamental'. A very useful classification of suggested underlying causes of biodiversity loss was given by Swanson (1995b). He identifies four classes of explanation:

1. The expansion of human society

This explanation is essentially one of scale and dominance. Human population growth and changes in its geographical distribution have dramatically increased pressures on the environment. These pressures have intensified as per capita production and consumption have risen with economic development.

Economic and ecological systems are linked. As the scale of the economic system grows relative to that of the natural environment, the dynamics of both systems are affected. In particular, the dynamics become more discontinuous. Threshold effects become to come into play as assimilative and carrying capacities are exceeded (see Perrings, 1995). In this view, biodiversity and the resilience of ecological and

economic systems interact in a reciprocal causal relationship: biodiversity is a contributor to ecological and economic resilience (and so provides insurance against the loss of ecological services). But at the same time, a loss of ecological resilience tends to reduce the extent of biodiversity.

This perspective gives the greatest cause for concern. It sees human interests as being fundamentally in competition or conflict with the interests of other species. Policies designed to save biodiversity require the general processes of human expansion be stopped.

2. Poverty and underdevelopment

A second candidate for the underlying cause of biodiversity loss is poverty and underdevelopment. There are various mechanisms through which this may act, including deforestation and the loss of soil fertility by an inappropriately managed expansion of extensive margin of agriculture. Essentially, this kind of explanation is one which stresses some form of vicious cycle of poverty. Poverty is associated with extensive, wasteful and short-term use of resources. This has three consequences: first, economic activity is very damaging to the environment, with little or no attention being paid to these impacts; second, environmental damages generates negative feedback on future production possibilities; and third, little value is added by these activities, and so financial resources to break out of underdevelopment are not forthcoming. The initial position of poverty is thereby reproduced over time. Chapter 2 examined several of the links between environmental degradation and poverty. It is the general environmental degradation we discussed there that gives rise to the proximate causes of biodiversity loss.

In one important respect, this explanation is somewhat misleading. There is a reasonable degree of positive correlation between poverty and environmental richness. The more diverse a region is currently, the greater will be the absolute amount of biodiversity loss from any given set of impacts. Most of the industrialised countries are located in northern regions where biodiversity has naturally been lower. Moreover, these countries have already lost many of their large reserves of genetic material, through forest and wilderness conversion.

Having said this, if this explanation does have validity, it does give cause for optimism. Poverty and underdevelopment can be overcome, and major strides in this direction have been taken in recent decades. Matters are far more difficult to deal with where the problem is associated with high levels of economic activity, as in the previous explanation.

3. Human choices about the pattern of development

Biodiversity loss may be viewed as a result of our development choices. In his summary of this perspective Swanson writes:
human society has a choice in regard to the amount of diversity that will be retained along its development path, and ... this choice has thus far been made in a haphazard fashion, resulting in unmanaged diversity depletion Swanson (1995b), page 2.

Swanson uses the notion of society's asset portfolio. Existing plans have a bias towards a low weight being attached to biological assets in that portfolio. We have freely chosen, for whatever reason, a narrowly constructed portfolio. It is perfectly conceivable for us to select a more diverse portfolio '*either through the more intensive use of a smaller area of land or by the more extensive use of a wider range of species'*.

Stressing the role of free choice may be important in putting responsibility firmly on human shoulders, but one cannot avoid feeling that this perspective is a good description of what has happened but does not constitute a satisfactory explanation (much in the same way that to say that peoples' free choices explain population growth).

4. Inappropriate policies and policy failure

It is relatively easy to make a good case for the proposition that consistently poor policy choices, or failures to properly think through the consequences of choices, are causes of biodiversity decline. Examples can easily be cited: development programmes introduced in response to poverty or perceived need to develop quickly; agricultural support programmes; the ineffective use of extensive margins, these are just a few.

The kinds of misguided policy are too numerous to list. But underlying most cases of policy failure seem to be two factors: the presence of formidable amounts of ignorance and uncertainty; and the lack of policy integration - different arms of government pursue what are perceived as independent objectives without coordination, when in reality the objectives are interconnected (and so their pursuit warrants integration).

Anyone trained as an economist is likely, however, to feel that an important element is lacking in this story, plausible as it is in other respects. The explanation does not address the patterns of incentives facing individuals or organisations. Perhaps decision makers are not failing at all in terms of their own objectives. This suggests that we should look at the institutional framework within which choices are made and incentive structures are determined.

5. Institutional failure

Swanson characterises this explanation as 'failure to create institutions that internalise the values of biodiversity within the decision-making of states and individuals making conversion decisions' (Swanson, 1995b).

This brings us back to the ideas of 'market failure' that we discussed at length in Chapter 4. You will recall from that discussion that resources may be inefficiently allocated (in this case, biodiversity being insufficiently conserved) for a variety of institutional reasons. One of these concerns the bias in information property rights towards information deriving from human capital and against information retained in conserved natural capital. Here we have a situation where no institutional framework exists that rewards diversity for its information content.

Many other instances of market failure could be cited, and their linkages to biodiversity decline traced out. We will leave this to your further reading. However, the institutional failure explanation does imply in a fairly clear way some directions forward that might be taken in constructing instruments to stem the loss of biodiversity.

Box 1 Some examples of biodiversity decline

Land conversion away from high diversity supporting uses

Possibility the most well known (and well-researched) example of land use change leading to biodiversity decline is the clearing of rainforests. These ecosystems are the most diverse terrestrial systems; forest conversion breaks up continuous woodland areas into parcels which are unable to support the diversity of species that they held in their natural states. We will look at one example of this.

In 1973, a new species of frog – the gastric brooding frog, named because the female nurtures her young in her stomach – was discovered in the Conondale range of Queensland, Australia. Initial studies suggested that its biological materials were potentially of immense medicinal benefit. However, the frogs' habitat was suffering from severe logging pressures, and fears were expressed that habitat conversion would lead to a loss of the species. The gastric brooding frog became the symbol of an intense local and international conservation campaign, organised under the slogan 'Don't log the frog'. All was to no avail. The last wild gastric brooding frogs were seen in 1979, and the species is now thought to be extinct.

Exploitation of wild species

The role of wild species exploitation is briefly discussed in another document in the *Additional Materials* to Chapter 17, named *Population Collapses.doc*. Several examples are given there, including the passenger pigeon and the near extinction of the American buffalo.

Introduction of exotic species into new environments

The last known member of the *Partula turgida* population, a snail species endemic to French Polynesia, died in London Zoo in 1996 (Jeffries, 1997). This species, along with many other Polynesian island snails, was driven to extinction by the introduction of a predatory snail *Englaninia rosea*. The latter species had, in turn, been introduced as a device to control the population of giant African land snails. These had been imported for human consumption. Escape of African land snails was followed by an explosion in their numbers, with the species becoming a serious pest through crop damage.

Homogenisation of agricultural practices

One component of the so-called green revolution in agriculture has been the selection and development of crop cultivars with high yield characteristics (see the discussion on this in *Agriculture.doc* in the *Additional Materials* to Chapter 17). Using some terminology that we introduced there in Box 2, these crop development processes involve selection of genetic varieties with high primary productivity potential - that is, they grow quickly and deliver high crop yields. Secondary characteristics of plants are of little or no commercial relevance, and are correspondingly selected out of the commercial varieties. But this process leads to crops which are critically dependent upon the maintenance of unchanging environmental conditions. When those change - due to climate change, entry of new diseases or predators, or when soil conditions change, for example - the selected species is vulnerable to collapsing primary productivity or worse. The Irish potato famine of the nineteenth century illustrates the possible consequences of dependence on one genetic variety that is particularly vulnerable to disease.

But more importantly in the long-term, selection processes of this kind promote genetic uniformity; even where species do not become extinct, the extent of genetic diversity can fall significantly. This loss is enhanced by spillover effects on surrounding ecosystems. Monocultural agriculture - be it timber plantations, cereal crops or whatever - tend to be associated with changes in the pattern of land use which cause loss of habitats for other plant and animal communities.

Air, water and ground pollution

Pollution has very pervasive effects on biological diversity. European forests and water systems have been badly damaged by acid precipitation (see Chapter 9), and the use of pesticides and herbicides in agriculture has serious ecological effects (discussed in *Agriculture.doc*), including the loss of several bird species due to DDT impacts. It has been conjectured that the large falls that have been observed in male fertility in many parts of the world is the result of long-term accumulations of pollutants in various environmental media. As yet, it is too early to say whether this speculation is well founded (and whether the human race is near its end as a result!).

Climate change

We know that major episodes of rapid climate change in the past have been associated with catastrophic episodes of biodiversity loss. For example, at the end of the Palaeozoic period (about 250 million years in the past), over 95% of species were lost in the Permian extinction. This is thought to have been caused by major climate change associated with continental plate movements forming the supercontinent, Gondwanaland.

What is not yet clear is whether the current human-caused climate change due to the so-called greenhouse effect (investigated in Chapter 10) will have an effect anywhere near so large in magnitude. Much will depend on the pace of climate change, rather than the level of eventual climate change. If the change is sufficiently slow, natural adaptation and evolutionary processes may be sufficient to avoid a great loss of biodiversity, even though its composition may change. The high degree of homogenisation of land use today, though, suggests that these natural mechanisms may not work very successfully.

End of Box 1