Our Uncommon Heritage

Biodiversity change is the biggest environmental problem of our time. It leads to much more than species extinctions, affecting the food we eat, the diseases we face, our vulnerability to fire and flood, and our ability to adapt to climate change. *Our Uncommon Heritage* explores the many dimensions of human-driven biodiversity change. It integrates ecology, economics, and policy to examine the causes and consequences of changes in ecosystems, species and genes, and to identify better ways to manage those changes. It explores the place of biodiversity in the wealth of nations, the rights and responsibilities people have for natural resources at local, regional, national, and international levels, and the challenges faced in protecting the common good at the global level. This is an important book for students and researchers in the fields of conservation and sustainability science, ecology, natural resource economics and management. It also has much to say to those engaged in international conservation, health, agriculture, forestry, and fisheries policy.

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Charles Perrings
Frontmatter
More information

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Biodiversity Change, Ecosystem Services, and Human Wellbeing

CHARLES PERRINGS

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To Ann, for bringing more than just light into my life

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Foreword

PARTHA DASGUPTA* AND GEORGINA MACE**

The economic development that was initiated by the Industrial Revolution has been self-consciously intensive in the use of natural resources. The pace has not slowed. Since the end of the Second World War, even as world population and average income per person have grown at unprecedented rates, humanity's reliance on natural resources in large measure has increased correspondingly. During the twentieth century world population grew by a factor of four (to more than six billion) and world output by fourteen, industrial output increased by a multiple of forty, and the use of energy by sixteen. Methane-producing cattle population grew in pace with human population, fish catch increased by a multiple of thirty-five, and carbon and sulfur dioxide emissions rose by a factor exceeding ten. Vitousek *et al.* (1986) estimated that some 40 percent of the 45–60 billion metric tons of carbon that was then being harnessed annually by terrestrial photosynthesis (net primary production of the biosphere) was being appropriated for human use.

In this century the pace has accelerated. The release of nitrogen to the terrestrial environment from the use of fertilizers, fossil fuels, and leguminous crops now well exceeds that from all natural sources combined. Carbon concentration in the atmosphere is currently rising at a rate of 1 part per million a year, the concentration having just passed 400 parts per million, a level not reached since more than two million years ago. The scale of the human enterprise is so influencing global environmental change now, that as Ehrlich and Ehrlich (2008)

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documented, we should recognize humankind as earth's dominant species. Humanity would appear to have ushered in a new geological epoch in which our activities are influencing not only local landscapes but also the global processes driving the earth system. Appropriately enough, the present era has recently been christened Anthropocene (Steffen *et al.* 2011).

Nature as an asset

Nature is a mosaic of capital assets. It comprises assets of intrinsic value (sacred groves, for example), those that are direct sources of human wellbeing (the air we breathe and the water we drink), and many others that have indirect value as inputs in the production of goods and services (crops providing food, and trees providing timber and energy). In fact nature's services are inputs in everything we do. The problem is that nature is degradable. Agricultural land, forests, watersheds, fisheries, freshwater sources, estuaries, the atmosphere – more generally, ecosystems – are assets that are self-regenerative, but suffer from depletion or deterioration if exploited without care.[1] The term "self-regenerative" should not be taken to mean that natural resources regenerate in isolation when left untouched by humans; for nature's capital – or natural capital – consists of an interconnected body of assets undergoing change over time in size and character. The potential regenerative capacity of one depends on the mosaic of which it is a part. The processes driving those changes differ in spatial scales, operate at different speeds, interact with each other, and are almost invariably non-linear. It should be no cause for surprise that nature is complex.

Human activities affect nature's processes just as nature's processes influence the choices we humans make. The mutual influence is so powerful today that, for many scientists, talk of "nature's processes" makes little sense. To them "socio-environmental" is a more appropriate way to describe the intertwined processes. A few broad principles underlying the processes are understood; but the devil lies in the details, and the details affect the daily lives of households everywhere.

Stresses in the system are often described as "environmental problems." They are problems of the environment, largely resulting from humans' influences on them; they are rarely also problems due to the

[1] We are ignoring subsoil resources in this account.

environment. Some are global while many are spatially localized, some occur slowly and may therefore miss detection until it is too late, while others are all too noticeable and a cause of persistent societal difficulties. That may be why there is frequently a tension in the sense of urgency people are known to express about carbon emissions and acid rains that sweep across regions, nations, and continents; about the stresses communities face when, say, grasslands transform into shrublands; and about declines in firewood and water sources that are specific to the needs and concerns of the poor in small, village communities. Moreover, socio-environmental processes are very poorly understood. For these reasons environmental problems present themselves differently to different people. Some identify environmental problems with population growth while others identify them with the wrong sorts of economic growth. Then there are those who view the problems through the spectacle of poverty in poor countries. Each of those visions is correct. There is no single environmental problem; there is an innumerable collection of them.

Economics and the environment

These observations may appear as obvious empirical truths, but twentieth-century economics saw them as neither obvious nor, more importantly, truths. Macro-economists, who are in the business of studying production and consumption in the aggregate, went further by building theories of economic growth and development that almost invariably took the inputs necessary in economic activities to be restricted to manufactured capital (roads, building, machinery, equipment), human capital (education, skills, health), and knowledge (arts, humanities, and the sciences). Nature was left out of the account. If the lacuna was mentioned, a typical response from growth economists would be that it was in the character of development processes that technological progress overrides the effects of diminished and degraded natural capital.

To be sure, *micro*-economists have long noted the presence of natural capital. A large, informative body of work in the field of environmental and resource economics has pointed to the need for public policy in the form of taxes and regulations to correct for humanity's excessive use of natural resources. (Economists uncovered reasons why, in terms of human interest, our use of nature is almost always excessive, rarely insufficient.) Nevertheless, even environmental and resource economists have mostly studied natural resources in isolation. Their account could give the impression that in the world we inhabit it is possible to pluck one resource at a time. The interconnectedness of the constituents of natural capital and the mutual (nonlinear) influences among the socio-environmental processes that come allied to it are rarely probed.

It could be that growth and development economists have neglected nature because the services it provides are taken to be luxury consumption goods, as in the view expressed some years ago in two prominent newspapers that "economic growth is good for the environment because countries need to put poverty behind them in order to care," and that "trade improves the environment, because it raises incomes, and the richer people are, the more willing they are to devote resources to cleaning up their living space." The idea here is that environmental degradation is a mere irritant.

The idea is a deep, cosmopolitan misconception. It is a misconception because nature's services are critical inputs in consumption, production, and leisure, a fact that is self-evident to any agrarian person.

Wealth and wellbeing

That mistaken viewpoint has infected the public understanding of economic development. Macro-economic forecasts routinely exclude nature as an input in economic activity. Accounting for nature, if it comes into the calculus of forecasts at all, is an afterthought to the real business of doing economics. That most commonly used economic statistic for judging the progress or regress of nations, gross domestic product (GDP), does not record the use to which nature is put in economic activities. If a wetland is drained to make way for a shopping mall, the construction of the latter (including expenditures incurred for drainage) is deemed to contribute to GDP, but the destruction of the former goes unrecorded. If the social value of the former in absolute terms exceeds the social value of the latter, the economy will have become poorer (wealth will have declined), but GDP will tell us otherwise. The popular and seemingly more humane Human Development Index (HDI) of the United Nations (UN) adopts the same point of view: by neglecting to account for environmental changes, it misleads in the same way.

The rogue word in gross domestic product is "gross." Depreciation of capital is not deducted from final output and this is a reason why the index misleads when used as a reflection of human wellbeing. The point is that an economy's GDP could be made to grow simply by mining its assets. So GDP could grow even as the economy was becoming poorer. The moral is simple, even banal: if we are to study the sustainability of development processes, we should be estimating movements in wealth and its distribution relative to population, not per capita GDP, not the HDI. By a near-identical reasoning it can be shown that the coin with which changes in public policy (such as expenditure on new investment projects) should be evaluated is also wealth and its distribution relative to population.

Ecosystems as assets

An economy's wealth is the societal worth of its assets. It follows that economic problems are asset management problems. Of immediate and direct interest to human populations are ecosystems, which range in spatial extent from biomes, to lakes, to spoonfuls of rainwater collected on leaves of tropical plants and trees. In an important publication, the Millennium Ecosystem Assessment (2005) reported that fifteen of the twenty-four large ecosystems that had been studied in detail were found to be either degraded or subject to unsustainable use.

The character of ecosystems, for example their capacity to supply goods and services of use to humanity, can change relatively fast. Such flips share three important characteristics: (1) they are frequently irreversible (or at best they take a long time to recover from); (2) except in a very limited sense, it is not possible to replace degraded ecosystems by new ones; and (3) ecosystems can collapse abruptly, without much prior warning. Imagine what would happen to a city's inhabitants if the infrastructure connecting it to the outside world were to break down without notice. Vanishing water sources, deteriorating grazing fields, barren slopes, wasting mangroves, and bleached coral reefs are spatially confined instances of a corresponding breakdown among the rural poor in poor countries. Ecological collapse, such as has been experienced in recent years in Rwanda, the Horn of Africa, and the Darfur region of Sudan, can also come about in tandem with rapid civic decline.

A feature of significance of any ecosystem is the diversity of species. In a magisterial treatise on the diversity of life, Wilson (1992) reviewed evidence on current species extinction rates to conclude that humanity has triggered a process that compares with the five great global extinctions that have taken place over geological time. Recent syntheses of data and trends suggest that indeed current extinction rates are on the brink of what would formally count as a mass extinction (Barnosky *et al*. 2011).

Determining the functional value of biological diversity – biodiversity for short – is a deep and difficult matter but the consensus now is that diversity of species and biological forms contributes positively to many ecosystems and functions and to their resilience under changing pressures (Cardinale *et al*. 2012). When ecologists speak favorably of biodiversity, which they do in unison and with regularity, there is an implicit assumption that the diverse species have co-evolved under selection and represent more than a simple headcount of species. When the Nile perch was introduced into Lake Victoria, the diversity of species increased, but did not last for long. The lake, as a fishery, was devastated.

Biodiversity is a key to ecosystem productivity and the resilience (that is, stability) of that productivity. By "productivity" is meant the production of biomass. The total productivity of a population of species is greater than the sum of the productivities of the individual species grown in isolation. This reflects the non-linearity of environmental processes and owes itself in part to the fact that species' populations in an ecosystem play complementary roles; they cannot all be substitutes for one another. This has the corollary that to invoke the idea of substitutability among natural resources in order to play down the usefulness of biodiversity, as is not infrequently done by growth economists, is a wrong intellectual move. For if biodiversity is necessary for an ecosystem to continue providing services, the importance of that same biodiversity cannot be downplayed by the mere hope that for every species there are substitute species lying in wait within that same ecosystem. Here it is useful to recall the analogy in Ehrlich and Ehrlich (1981) relating species populations in an ecosystem to rivets in an airplane. One by one, perhaps, species may disappear and not be missed, for there is spare capacity (in part "species substitutability"). Eventually, though, the cumulative effect of biodiversity loss will lead to the crash of ecosystem functioning ("species complementarity" will kick in), just as the cumulative loss of redundant rivets will lead to the crash of an airplane. In a recent symposium Barrett, Travis and Dasgupta

(2011) reported that biodiversity loss has been closely connected to the persistence of rural poverty in Africa.

It remains a popular belief that the utilitarian value of biodiversity is located primarily in the potential uses of the genetic material it harbors (e.g. for pharmaceutical purposes). Preserving biodiversity is seen as a way of holding a diverse portfolio of assets with uncertain payoff. But biodiversity is vastly more valuable: it is essential for the maintenance of a wide variety of services on which humans depend for survival both now and for the future.

The economics of ecosystems

As ecosystems are assets, why can they not be adequately managed by the kinds of institutions that oversee the production and use of such assets as machinery and equipment? In particular, why can markets not suffice? One reason stands out (there are other reasons): natural capital is often mobile. The wind blows, rivers flow, fish swim, birds and insects fly, and even earthworms are known to move. That means that property rights to prominent classes of natural capital are not just difficult to enforce; worse, they are difficult to define. As no one is responsible for their management, their use gives rise to "externalities," which are the unaccounted for consequences for others – including future people – of decisions made by each of us.

What kinds of institutional arrangements should we seek to create for the management of natural capital? In which ways are they likely to depend on the specific nature of the ecosystem in question? Do institutions governing the management of local ecosystems that have proved to be relatively successful in traditional societies offer hints on how global resources such as the atmosphere as a carbon sink could be governed? If not, why not? Do simulated markets offer humanity a possible mode of governance? If so, which kinds of ecological capital would be most appropriate for them? Why can societies not rely simply on environmental taxes, subsidies, and regulations? Most importantly, who should govern the assets?

Our uncommon heritage

Although environmental and resource economists in recent years have studied many of these questions and have offered tentative answers, they have done so in a case-by-case manner. We do not have a treatise-length account which traces the answers to the socio-environmental processes that are shaping our lives and defining our hopes and anxieties for the future. In his classic work, Wilson (1992) did not offer a study of the human institutions that have permitted, even encouraged, the extinction process to which he was at pains to alert the world. Nor did he seek to identify the kinds of public policy that are now required. But then, neither of these was his goal, which required someone expert both in the science of biodiversity and ecosystem services and in economic analysis.

It is against this background that Charles Perrings's work at the interface of ecology, economics, and environmental policy has been so significant. In this book he has put together the ideas that he and others have developed over the years to present the full breadth and depth of this important science. His book is the natural successor to Wilson's treatise. Perrings offers an account that is lucid throughout and presents analyses that are never beyond the reach of the engaged reader. We write this foreword as chairs of two global environmental change programs, one focusing on biodiversity science, the other on human dimensions. The time has come for these two closely linked streams of science to come together to solve environmental problems for the benefit of current and future generations. Doing this effectively will rest on the foundations, insights, and future directions laid down in this book.

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Preface

This book marks the end of a journey that began twenty-two years ago when I accepted an invitation from Karl-Göran Mäler, the newly appointed Director of the re-formed Beijer Institute at the Royal Swedish Academy of Sciences, to lead an interdisciplinary research program on biodiversity. That program brought together around forty social and natural scientists, and charged them with exploring the anthropogenic dimensions of biodiversity change. The results were summarized in three volumes (Barbier, Burgess and Folke 1994; Perrings *et al*. 1994, 1995).

They were heady times. The 1992 UN Conference on Environment and Development (UNCED) had concluded with a declaration of the intention of the governments represented there to achieve "a new and equitable global partnership through the creation of new levels of cooperation among States, key sectors of societies and people . . .which respect the interests of all and protect the integrity of the global environmental and developmental system." The Conventions on Biodiversity, Climate Change, and Desertification were opened for signature at the conference.

They were also momentous times. The principles that had guided human attitudes to the resources of the common environment since the time of Hugo Grotius[1] were being unraveled. The Rio Declaration endorsed a set of principles that included the following:

> States have, in accordance with the Charter of the United Nations and the principles of international law, the sovereign right to exploit their own resources pursuant to their own environmental and developmental policies, and the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction. (United Nations Conference on Environment and Development 1992)

[1] Grotius enunciated the freedom of the high seas as a fundamental principle of international law in 1608.

That principle was embodied in the Convention on Biological Diversity (CBD), which was opened for signature at the conference.

When the first Global Biodiversity Assessment was initiated a year later, 1,500 scientists contributed to what we hoped would be the start of a constructive relationship with the international policy community. When the report of the Global Biodiversity Assessment was published in 1995 (Heywood and Watson 1995) we discovered just how wrong we were. To borrow the words of Dorothy Parker, the report was not tossed aside lightly by many governments of the day, it was thrown with great force.

The next seventeen years saw repeated efforts to build a science–policy interface that would inform both national governments and multilateral agreements. Whereas the Global Biodiversity Assessment had been sponsored by the UN Environment Programme (UNEP) alone, by the time the Millennium Ecosystem Assessment (MA) was launched in 2000 it had the backing of four UN agencies: the International Council for Science, the Consultative Group on International Agricultural Research (CGIAR), the World Bank, the World Resources Institute (WRI), the World Business Council for Sustainable Development, and the World Conservation Union. Its reports (Millennium Ecosystem Assessment 2005a, 2005b, 2005c), often referred to in this book, were more favorably received than the reports of the Global Biodiversity Assessment. However, the lack of direct engagement of national governments still compromised its effectiveness as a vehicle for bringing international biodiversity science to the policy community.

In a similar attempt to enhance its relevance to the policy community the international biodiversity science program, DIVERSITAS, had reformed itself at the turn of the century around an agenda that was directed to understanding the causes and human consequences of global biodiversity change. I joined the Science Committee of the program at that moment (and later co-directed the ecoSERVICES core project with Shahid Naeem). In 2005, the year the MA reported, DIVERSITAS was asked to carry forward an initiative of Jacques Chirac, then President of France, to test the international community's interest in the establishment of a permanent science-policy body. For two years the initiative, under the name of International Mechanism of Scientific Expertise on Biodiversity, conducted consultative meetings around the world. Once it had been demonstrated that there was at least some appetite for such a mechanism, the effort was adopted by UNEP and merged with a separate effort to follow up the MA and the consultative meetings gave way to formal intergovernmental conferences to explore the establishment of an Intergovernmental Science-Policy Platform for Biodiversity and Ecosystem Services (IPBES). In 2010, at the third such conference, governments agreed to recommend establishment of the body and before the end of that year – the International Year of Biodiversity – the General Assembly of the UN had asked UNEP to initiate the body. In April 2012 IPBES was formally launched.

What has happened to the science in the meantime? The one clear trend has been the rise of ecosystem services: a concept introduced to natural scientists by Westman's 1977 review of the implications of the way that economists approached the valuation of the benefits of ecosystems (Westman 1977). But the concept of ecosystem services has been far from unifying, and has not affected all. Taxonomists and systematists, for example, find little that they can use in the concept. Conservation biology had been developing as a subdiscipline since the late 1970s with a focus on habitat loss, species extinctions, and genetic erosion. It connected ecology and population biology to conservation practice and hence to the non-governmental organizations most directly involved in the conservation effort. Despite the fact that some of these organizations had already embraced a conservation and development agenda, however, conservation biology typically focused only on wild-living species. During the 1990s conservation biologists began to include ecosystem services among the reasons advanced for conservation, but the services considered were only those generated by wild species. Within ecology, the 1990s saw the development of a field of inquiry focused on the relationship between biodiversity and ecosystem functioning that has laid the foundations for a systematic analysis of the linkages between biodiversity and ecosystem services, but this too has largely focused on experimental manipulation of natural systems (Cardinale *et al*. 2012).

The science of managed systems has been just as resistant to change. Before the 1990s, biodiversity in agro-ecosystems largely meant crop genetic diversity and the diversity of pests and pathogens. Since that time there has been growing interest in agro-biodiversity *sensu largo*. DIVERSITAS added a crosscutting network on agro-biodiversity in the early years of this century. Yet interactions between agronomists, pest management scientists, and ecologists have been minimal. The same can be said of human, animal, and plant health science. The science has been caught in stubborn silos.

Within economics, the discipline that spurred interest in ecosystem services in the first place, the 1990s saw the establishment of the field of ecological economics. This was an attempt to create a science of the interactions between human production and exchange and the processes of the biophysical environment. It required collaboration between economists and ecologists (at a minimum) and sought to build new ways of understanding the dynamics of coupled systems. Indeed, the Beijer biodiversity program was an early foray into the field. The reformed Beijer International Institute of Ecological Economics, the International Society for Ecological Economics, and the biodiversity program were all launched in the same year. Much has been achieved. The work of Gretchen Daily and colleagues in the Natural Capital Project is one of the better-known examples, but there are many others. The existence of the field has itself been an irritant to many economists working on problems of the environment precisely because it encourages work across traditional disciplinary boundaries, but it has also changed the way that natural resource economics is done.

Nevertheless, if one has to ask whether the science is ready to contribute policy-relevant knowledge to the new IPBES, the answer has to be "no." The scientists working within particular disciplines and sub-disciplines may well be ready to contribute data and analysis from their own fields. However, our capacity to put the information together in meaningful ways, to undertake meta-analyses across fields, to model the feedbacks between social and biophysical systems well enough to be able to make conditional projections of the consequences of particular policy options, is extremely limited. Biodiversity science may be more challenging than other areas of science in this respect, simply because it covers so many dimensions of both social and biophysical systems. But the fact is that we still have extreme difficulty in working across disciplines. Nor do we have the models of coupled systems needed to undertake the kind of policy experiments called for by the new body.

The problems posed by global biodiversity change demand that we do better. The two decades since the first Rio conference have seen a decline in almost every indicator we have for the diversity of wild-living species. The MA reported that we are currently experiencing extinction rates up to a thousand times the background rate. We now know that these rates are still increasing. There are, however, other similarly