1 Introduction to conservation

1.1 General introduction

Conservation is one of the most important subjects to understand. In this book we present arguments which suggest that causing substantial and irreversible change to the living world will be severely detrimental to the welfare and prospects of huge numbers of people. Future generations will judge us in the way we judge those who wiped out the dodo or extinguished their own societies through resource depletion. Fortunately, there is still time to make a big difference, and this book will illustrate the methods that are used with great success.

Conservation means different things to different people, but is relevant to all. It interlinks fields as diverse as biology, philosophy, economics, chemistry, welfare, governance and human rights. Conservation deals with issues that are urgent and that lie at the core of environmental and societal concerns.

In combination with science, conservation includes many personal and subjective opinions. The reader should see a book on conservation as an introduction to the debates rather than as a statement of facts and solutions. It is important that voters, policy-makers and developers find the strongest arguments supported by the best evidence. Notably, the opinions of conservation scientists are sometimes in conflict with other 'environmentalists', because of different perceptions, priorities and scales of analysis but, by being explicit about the roles of science and values, we hope this book will help clarify and bridge this gap.

In this chapter we examine the meaning and growth of nature conservation. We ask if conservation is necessary and discuss the concept of biodiversity as a way to 'measure' nature. We consider the rate of loss of biodiversity and evidence of a mass extinction. The second chapter considers the general threats to wildlife and the third discusses the way priorities are set. We will then move in Chapter 4 to methods for monitoring and for environmental impact assessment. Having selected sites and species to conserve, people may need to manage them as described in Chapters 5 and 6. In Chapter 7 we examine the possibility and problems of sustainability and traditional use. Chapter 8 outlines the potential for restoration of habitats and species. In Chapter 9 the role of social factors, such as economics, law and education, is presented. We conclude with a synthesis of the

whole process of conservation, illustrated by a case study on elephants in Mali, and an overview of successes and prospects.

Conservation is a mix of disciplines linked by a common philosophy. The basic and central aim of conservation is to prevent irreversible loss of the life on this planet. This can be achieved through policy and management, which influences species, or habitats, or both. Through conservation we will certainly influence present generations, but conservationists hope to leave the world a better place for future generations.

1.1.1 Origins and meaning of conservation

Conservation has developed over thousands of years, in a variety of different forms and in many parts of the world. The word has been used in connection with nature for about 100 years, after Theodore Roosevelt popularised its use in the USA as 'the wise use of the Earth and its resources'.

It is hard to find a definition of conservation that suits everybody. We suggest that: 'conservation is the protection of wildlife from irreversible harm'. Wildlife includes all non-domestic species and populations of plants, microorganisms and animals, and their habitats. By 'harm' we mean damage or declines due to people. We should also consider harm that is irreversible within one human generation: as well as protecting species of no use, and habitats, this will reduce the effects of one human generation on future generations.

The World Conservation Strategy of 1980 defined conservation as: 'The management of human use of the biosphere so that it may yield the greatest sustainable benefit to the present generation while maintaining its potential to meet the needs and aspirations of future generations'. The three main aims of the Strategy were: (1) to maintain essential ecological processes and life support systems; (2) to preserve genetic diversity; and (3) to ensure the sustainable utilisation of species and ecosystems. This definition has been criticised because it is centred on the usefulness of nature to humans rather than on protecting nature for its own sake.

The main themes in conservation have been the protection of spiritual and aesthetic features, preservation of fish and game, maintenance of forest resources, protection of soils and water supplies, animal welfare and, more recently, concerns for genetic resources, the atmosphere and numerous other ecosystem and evolutionary processes. Conservation can include protection of geological features and soils, 'geodiversity' (which often has relevance to the study of life and the environment) and archaeological features (which can yield information regarding past environments).

The words of early conservationists are often astonishingly similar to those of today. Yet despite such longstanding concern, and indeed action, many problems such as loss of forests, fish and soil have often proved unstoppable, and the warnings of many farsighted leaders, authors and philosophers have proved correct. We need to understand why past awareness has not translated into successful action.

Philosophies and activities that are recognisable as conservation can be found in early writings in many parts of the world. Many ancient cultures, having recognised overuse of resources, took action to try to conserve forests, soils or game. In Ancient China 2600 years ago, rulers enclosed forested lands for protection of selected species from overhunting and protected some individual species by laws. Some 2450 years ago, Artaxerxes I tried to control the felling of Lebanese cedar. About 2400 years ago, in Ancient Greece, Plato lamented the loss of attractive forest and the subsequent soil erosion, which he saw as a consequence of population growth. Some 2000 years ago, Pliny the Elder was concerned that the Romans were desertifying the Mediterranean area through deforestation, and Varro noted that overgrazing by goats was destroying vegetation. In Britain and France in the Middle Ages, many poachers were trapped in man-traps or executed and, in 1060, King Edward ordered the removal of fishing weirs on the Thames, Trent and Severn rivers. Legislation has regulated salmon fishing in Scotland since the fifteenth century. In Russia, laws protecting game were signed in the eleventh century; in the seventeenth century, felling of trees was forbidden in Siberia (to protect the sable) and forests were protected to conserve individual tree species or to reduce flooding. In Germany in the sixteenth century, several princes revoked community land rights that were leading to forest destruction. Some 200 years ago, King Andrianampoinimerina of Madagascar punished people who wilfully destroyed forests.

What might be described as a *scientific* effort to manage forest resources for the long term, with protection or re-planting, was evident in Sweden by 1752. An awareness of environmental consequences of deforestation developed in numerous places. A link between deforestation, reduced rainfall and increased erosion was suggested on British colonies in the Caribbean, and in 1776 an Ordinance was signed to protect the Tobago Forest Reserve '. . . for the purpose of attracting frequent Showers of Rain upon which the Fertility of Lands in these Climates doth entirely depend'. This is an example of conserving what we today call 'ecosystem services' such as water supply and soil binding.

The early history of awareness of the need for *global* conservation is dominated by Britain and the USA, reflecting their extensive territories. The British Empire, covering a quarter of the Earth's land in the nineteenth century, suffered many environmental problems which came to the attention of both colonists and government in Britain. In an early example of international conservation, colonists persuaded the government to protect forests in Madras, India, through a law in 1847, whilst aesthetic and scientific concern over the loss of the soils and vegetation of the Cape of South Africa led to protective legislation from 1846. In 1873, the American Association for the Advancement of Science presented Congress with a petition calling on the Federal Government to take some action to conserve natural resources. In the USA, the conspicuous loss of populations of species such as the bison, redwood, Carolina parakeet and the passenger pigeon, combined with the fragmentation of the once huge wilderness and the decline of game species, led to an ethic of protection of species and land on a large scale. In the USSR, the Geographical Society

formed a Nature Conservancy Committee in 1907, which initiated legislation for nature reserves.

We suggest that the dawn of scientific conservation biology was linked to the dawn of understanding of evolution. The founders of modern biology – Charles Darwin, Alfred Russel Wallace, Thomas Huxley and others – gained the background to conservation by their observations on their travels, by their wonder at extinct fossil forms and by their realisation that the world is a changeable place. In 1863, Wallace warned of:

> extinction of the numerous forms of life which the progress of cultivation invariably entails . . . If this is not done, future ages will certainly look back upon us as a people so immersed in the pursuit of wealth as to be blind to higher considerations. They will charge us with having culpably allowed the destruction of some of those records of Creation which we had it in our power to preserve; and, while professing to regard every living thing as the direct handiwork and best evidence of a Creator, yet, with a strange inconsistency, seeing many of them perish irrecoverably from the face of the earth, uncared for and unknown.

Darwin and colleagues noted with concern the overhunting of the giant tortoises on Aldabra, in the Indian Ocean, which held the last wild population in the region: in 1874 they wrote to the Governor of Mauritius, expressing their concern over:

> the imminent extinction of the Gigantic land Tortoises of the Mascarenes in the only locality where the last remains of this animal form are known to exist in a state of nature.

They continued:

> The rescue and protection of these animals is recommended less on account of their utility . . . than on account of the great scientific interest attached to them. With the exception of a similar tortoise on the Galapagos Islands (now also fast disappearing), that of the Mascarenes is the only surviving link reminding us of those still more gigantic forms which once inhabited the continent of India in a past geological age . . . It flourished with the Dodo and Solitaire, and while it is a matter of lasting regret that not even a few individuals of these curious birds should have had the chance of surviving the lawless and disturbed conditions of past centuries, it is confidently hoped that the present Government and people . . . will find a means of saving the last examples of [their] contemporary.

These quotes illustrate that, by the end of the nineteenth century, some people were already aware of the utilitarian, scientific and moral importance of saving distinctive species – and, indeed, these remain the major themes in modern conservation.

Scientific education in conservation was evident by 1914 when W. Hornaday wrote the book *Wild Life Conservation in Theory and Practice* based on his lectures in Yale University. However, conservation has many elements other than science. The philosophical and aesthetic basis of conservation varies amongst cultures, places and times, as will be seen in Section 1.3.

Many religious practices have led incidentally or deliberately to conservation (Sections 1.3.1 and 9.2.1). Many shamanic healing practices require respect for particular

places and medicinal species. Animal welfare philosophies and sentiments have been entangled with wildlife conservation for some time. Although conservationists are more likely than most to be sensitive to animal suffering, the two issues are separable and, indeed, animal suffering can happen as a result of conserving as well as not conserving. It is ironic that this early force for conservation sometimes leads to problems in modern conservation management; for example, in control of exotic species, in game-hunting for revenue in reserves and in culling to prevent overpopulation. One British hunter operating in North America in the 1920s became sensitised to the decline of his prey (such as beaver and lynx) and to the suffering inflicted by traps. The concerns of his native American wife for animal welfare helped to convert him from killing animals to protecting them. The trapper renamed himself Grey Owl. His lecture tours and books were very popular and encouraged the British royalty to take an interest in conservation. He was the first popular ecowarrior. Animal welfare grew to be a driving force for conservation in the 1970s. Some of the earliest public campaigns for conservation, and the first high-profile 'direct-action', came after television pictures of the appalling cruelty of whaling. These led to the initial popularity of Greenpeace, who placed their boats between harpoon gunners and whales.

Globally, hunting was – and is – part of the reason for protection of many private lands that remain relatively rich in wildlife. Pressure from sport hunters (concerned mainly with the loss of their prey, rather than welfare) led to many early game parks and national parks, and continues to protect sites for game birds in Europe. Although some would deny it, this pressure has saved many species. The word 'park' comes from the Norman hunting 'parcs'. The forested parc de Fontainebleau near Paris was a royal hunting site. The best preserved forest in Europe is Białowieża. In 1538 the death penalty was used to deter poaching of bison in this forest, and a reserve was established in 1564 to attempt to save aurochs (wild cattle). Białowieża was protected from the stripping of forests for timber in the World Wars because the German leaders intended it to become their hunting preserve. By 1900, there were some 500 game parks in the USA, mostly maintained as private hunting clubs, and, from 1900, colonial powers in Africa and India established many game reserves. The origins of conservation of freshwater and marine systems are also generally linked to the hunting and fishing lobby. Concern about declining fish stocks, including salmon, prompted legislation to keep rivers clean, whilst concern about the loss of game fish such as marlin and sailfish has recently led to outlawing of long-line fishing in some oceanic areas.

The first recognisable modern 'national parks', which were set up partly for protection of landscape heritage for the public good, rather than just for hunting, were in the USA, USSR and Europe. Aesthetic concerns for wilderness are evident in the writings of the Romantic poet William Wordsworth, who was inspired by the beauty of the English Lake District. Wordsworth wrote in 1810 of the need to protect the Lakes as 'national property' for all to enjoy, and this ideal of national heritage was echoed when Judge Cornelius Hedges opposed private ownership and development in the Yellowstone area of America. There was concern in America in the late nineteenth century about many of the Federal lands being lost through

theft or destroyed through overuse. Yellowstone Park was created by an Act in 1872, to be 'dedicated and set apart as a public park or pleasuring ground for the benefit and enjoyment of the people; and all persons who shall locate or settle upon or occupy [it] shall be considered trespassers and removed therefrom'. The impetus for this park came primarily from the eastern sports enthusiasts and from an intent to save the interesting and beautiful scenery of the region, including the geysers. National parks were also seen as refuges from hunting from which game animals would spill over into adjacent lands. By 1900 there were 14 national parks in the USA, becoming models for other nations. In 1916, America's National Parks Service was created:

> to conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations.

Sweden created nine national parks in 1909, the first in Europe. In the USSR, Lenin created a number of nature reserves by decree, such as the VI Lenin Nature Reserve, which was founded in 1919 to protect waterfowl and spawning grounds of commercial fish in the Volga Delta. The State Committee for the Conservation of Nature was formed in 1921. The Soviets protected very large areas for genetic resources, unique landscapes and the study of processes in completely natural communities. Britain designated its first national parks (including the Lake District) in 1951. Both the British and American parks reflect the widespread desire for a 'wilderness experience'. However, whilst America has some large – depopulated – areas that at least appear wild, Britain is more densely populated, and so the focus there was on amenity and 'quiet enjoyment'. The British parks are unusual compared with those in many other countries because they were created in, and retain, a landscape that is highly managed for agriculture and residential use.

Societies dedicated to conservation grew from the middle of the nineteenth century. In Britain, the Commons, Open Spaces and Footpaths Preservation Society was founded in 1865. The first private nature reserve in the USSR (Askania-Nova) was founded in 1874 to protect steppe habitat. The plight of birds, with their exceptional beauty and fascination, led to the formation in the USA of the Audubon Society in 1886 and Sierra Club in 1892. Their members were outraged by the slaughter of birds such as the passenger pigeon, and various species of egret which were being overexploited for their fashionable feathers. In Britain, The Royal Society for the Protection of Birds (RSPB) grew for similar reasons from the Fur and Feather Group, which was founded in 1889, and became the first conservation society to act internationally. The Society for the Preservation of the Fauna of the Empire was also among the first international conservation organisations, founded in 1903 and now renamed Fauna and Flora International (FFI). The members' journals of the FFI and RSPB, *Oryx* and *Birds*, were amongst the first periodicals to promote and discuss conservation.

International organisations now dominate the conservation process. The International Union for the Conservation of Nature and Natural Resources (IUCN) was founded in 1948

'... to promote or support action which will ensure the perpetuation of wild nature and natural resources on a world-wide basis, not only for their intrinsic cultural or scientific values but for the long-time economic and social welfare of Mankind'. Major conferences began to draw nations together in conservation. In 1948, there was a multidisciplinary Inter-American Conference on Conservation of Renewable Natural Resources, which met at Denver, Colorado, '... to discuss one of the greatest of all problems of our times'. The World Wildlife Fund (WWF) was established in 1961, partly to help raise funds for IUCN.

The multidisciplinary periodical *Biological Conservation* was launched in 1968 as 'The international Quarterly Journal devoted to scientific protection of plant and animal wildlife and to the Conservation or rational use of the biotic and allied resources of the land and fresh waters, sea and air, for the lasting cultural and economic welfare of Mankind'. In 1970, an international conference dedicated to conservation biology was organised by the British Ecological Society, leading to the book *The Scientific Management of Animal and Plant Communities for Conservation*, edited by two pioneers of conservation biology, Eric Duffey and Allan S. Watt. A meeting in America in 1985 established the Society for Conservation Biology, and thence the journal *Conservation Biology*.

The 'Earthrise' images from the Apollo missions in the 1960s raised public awareness of our limited environment. A global perspective is emerging, facilitated by developments in technology, that is revolutionising our understanding of the planet (Section 1.4.2). Conservation has become a mainstream political issue since the publication of the World Commission on Environment and Development in 1987, and the United Nations Conference on Environment and Development (UNCED or 'Earth Summit') in Rio in 1992. Conservation is usually a legal requirement, with various international and national mechanisms and treaties (Section 9.4), including the Convention on Biological Diversity (CBD) which has been signed by almost all governments. There has been a great rise in public discussion of the issues, and new, vague and risky terms such as 'biodiversity', 'sustainability' and 'ecosystem services' have become buzzwords.

Although the surge of global environmental awareness is recent, we should always remember that conservation has a *very* long history. For thousands of years, there have been conservationists championing the idea of sustainable use, and the idea of protection of other species for their own sakes. These aims will be discussed in Section 1.3, after considering what diversity there is that may need conservation.

1.2 Introduction to biodiversity

Biodiversity is the variety of life on Earth. A fuller definition is given in the Convention on Biological Diversity: 'the variability among living organisms from all sources, including, amongst others, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part; this includes diversity within species, between species

and of ecosystems'. The loss of diversity of animal culture and ecosystem functions are now also a concern (Laiolo & Jovani, 2007; Cadotte *et al.*, 2011). The diversity of indigenous human cultures is sometimes included – although, as future chapters demonstrate, the protection of culture and the protection of non-human species are sometimes in conflict.

One of the values of the word 'biodiversity' is that it covers genes and ecosystems as well as species, and 'diversity' has great political appeal. However, serious problems arise when people assume that diversity is always desirable for conservation – as will be discussed in Section 3.2.3. Furthermore, some damaging activities are claimed to benefit 'biodiversity', even when just a few common species gain. We prefer to use the term 'wildlife' when possible.

Measurement of biodiversity is one of the greatest scientific challenges, and is also one of the most urgent. With many species becoming extinct without trace, we may never know, even roughly, how many species there were on the planet when humans first evolved about two million years ago. The longer we delay an attempt to answer this question, the less accurate our answer will be.

1.2.1 Diversity of species

Fortunately it is not essential to conservation that we know the number of species on the planet. Many of the processes that conservation seeks to protect depend on an unknown or changing number of species. However, we might want to know the number of species in an area to help us assess extinction rates, to guess the value of sites for useful products or to assess the impact of different land uses and policies.

The diversity of species, or 'species richness', is the simplest aspect of biodiversity to understand and quantify, although even this can be complicated by the difficulty of defining a species. Ideally, a species is a group of organisms that can interbreed to produce fertile offspring, and that are reproductively isolated from other species; however, some species reproduce asexually. Some groups, such as ducks, dogs and cats, can hybridise amongst the 'species', and microorganisms such as bacteria and viruses can exchange genetic material between distantly related forms. There is a spectrum of ability to hybridise, ranging through races and subspecies, and the distinctions are subjective. Some biologists believe that Evolutionarily Significant Units (ESUs) should replace the concept of species.

One of the main problems in estimating the richness of species on Earth is knowing how many species of microbe there are – if indeed the term can be applied to them (Eisen, 2007; Pedrós-Alió, 2007). Microbes occur in enormous abundance in most habitats, but the biomass of microbes in the deep biosphere, kilometres below the seabed or land surface, may far exceed that of all bacteria elsewhere (Parkes *et al.*, 2011) and be half the Earth's total mass of living matter. Many – if not most – organisms may be almost independent of sunlight and other living things! In 1 gram of soil, there may be more than a million species of bacteria (Gans *et al.*, 2005), but because most of them are too specialised to grow in

culture we know of their existence only through detecting genetic sequences. There may be over 700 000 species of fungi globally (Schmit & Mueller, 2007). There is also a high diversity of protists, such as ciliates, in forest soils and the ocean (Foissner *et al.*, 2005; Stern *et al.*, 2010). In the marine environment there can be about 1 million microbes (including viruses) per cubic centimetre of water, and over 20 000 bacterial species per litre (Sogin *et al.*, 2006). Results from the Census of Marine Life suggest that there might be a billion microbial species in the oceans, including many with restricted ranges (Desnues *et al.*, 2008; Baross, 2010). Crucially, it is not clear how widespread a typical microbial species is: do the same ones occur in soil in New Zealand, Europe and the Amazon? The great distance over which some microbes can disperse (as they float or are blown around the world) suggests that such species might be widespread, and, indeed, many are (Angly *et al.*, 2006). Alternatively, rapid evolution amongst microbes might lead to many distinctive local populations or species.

It is possible that there are specialist microbial organisms parasitic in, or symbiotic with, every multicellular organism. One sponge species from the Great Barrier Reef hosts some 3000 microbial species, and there are many rare species in corals (Sunagawa *et al.*, 2010). The diversity of microbes is an important conservation issue, because they are fundamental to ecosystem services, to disease, to the stability of ecosystems, and are the sources of numerous medicines such as antibiotics (e.g. Cotterill *et al.*, 2008; Cockell & Jones, 2009).

Despite the possibly overwhelming diversity of microscopic life, the estimates of the Earth's species richness have so far focused on the larger terrestrial invertebrates, and particularly the more conspicuous insects. However, the diversity of the nematodes and mites, which are hugely abundant, might one day be found to exceed the better known groups. On land the tropical forests appear to be the most species-rich habitats, and in the oceans the coral reefs appear the richest sites. However, one of the greatest uncertainties in estimating the richness of the Earth is the richness of the deep ocean and the sea floor, which are largely unexplored. Species of tiny mollusc can be unique to individual submarine ridges, and marine nematode diversity is potentially very high. We do not know how isolated and distinctive different regions of the ocean floor are, and how well many marine organisms can disperse. We therefore cannot know the richness of species on Earth – even within a factor of ten!

Estimated figures for the total richness on Earth usually fall in the range from 3 million to 100 million species, and many specialists have suggested a figure in the range of 5–15 million (May, 2000). Robert M. May argues that global species richness is not as high as some scientists claim. If we have only identified a tiny fraction of the species on the planet, then most of the species in a random sample from the ocean floor, or from a coral reef, or a rainforest, should be new to science. Yet usually taxonomists find they can already identify a few per cent of them. As yet, only some 1.5–1.8 million species have been described by taxonomists (some more than once). Even this figure is uncertain, because there is no central database of species that have been described – although The Encyclopedia of Life aims to do

this. Many thousands of new species are being described each year. Considering the discovery rates of species and higher taxa and the consistent branching patterns of phylogenetic trees, there may be about 7–10 million species of eukaryote (Mora *et al.*, 2011). Of these, about 8 million are animals, 300 000 are plants, 600 000 are fungi and 64 000 are other eukaryotes; over 2 million species are marine. Alternative methods estimate the number of tropical arthropod species to be around 1–8 million (Hamilton *et al.*, 2010).

A diversity of species may approximate to a diversity of genes, and genes are the most fundamental unit of both biodiversity and evolution. Genes are even harder to count than species. In Sections 3.1.5 and 6.2 we will examine the measurement and importance of genetic diversity.

1.2.2 Diversity of habitats and ecosystems

Habitats are far more difficult to define and distinguish than species. Habitat types are usually subjectively defined by something humans find conspicuous, such as the dominant vegetation or physical substrate, and by the climate of an area. People speak of habitats such as deserts, sand dunes, wetland, woodlands, kelp, corals and seagrass. On a smaller scale, habitats can be divided into 'microhabitats', such as tree-holes, bark or rotting wood. Many species use only one or a few of these, yet depend on the wider habitat to maintain the microhabitat. The term habitat is also used to describe where a species lives, or what it needs.

The use of the dominant vegetation and climate to label and map habitats is a convenience based on our own body size and sensory methods – and we should always remember that other organisms may partition the world in different ways from us. Organisms may need more than one 'habitat'. For example, a newt needs a pond to breed in, and grassland or woodland to grow and hibernate in – yet we would generally list and map these three as separate habitats. Similarly, to a microbe, the edge of the pond may not be where the human eye sees it, but may be in what we call soil. A number of other terms are used rather loosely when describing the combination of species in an area, and some of these may be interchanged with the word 'habitat'. The 'ecosphere' (or 'biosphere') is the entire ecosystem on the planet. 'Ecosystems' are generally seen as large areas, in which energy from the Sun or a geochemical source is dissipated as heat as it moves through a relatively self-contained food chain. Ecosystems have numerous recognisable processes or 'functions' (Jax, 2010), which, if beneficial, are also called 'services'. People sometimes talk of relatively isolated small areas, such as ponds or tree-holes, as ecosystems. 'Biomes' are large areas (often belts around the globe) with a broadly similar habitat, which some scientists divide into 'ecoregions'. An 'assemblage' is the mix of species found in an area (without assuming strong interactions between them). A 'community' is a group of species in an area, many of which interact with each other – for example, through mutualism, competition, parasitism or predation.