

# Companion for Chapter 13

## Saving Biodiversity and Protecting Ecosystem Services

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### SUMMARY

- An ecosystem is the collection of plants, animals, microbial life, and the abiotic (nonliving) part of the local environment, all interacting in a system. Ecologists study ecosystems by studying the fluxes and dynamics of the system.
- A core concept of an ecosystem is its biological diversity, or "biodiversity": the variability of life both within and across species. The interaction of diverse species determines fundamental characteristics of an ecosystem, such as whether the ecosystem is biologically productive or if it is resilient to shocks.
- Ecosystems affect human wellbeing through four categories of ecosystem services: provisioning services (providing food, fresh water, wood, and fiber for building structures and clothing, and biomass for fuels), regulating services (controlling the basic patterns of climate, disease transmission, and nutrient cycling such as water, nitrogen, and oxygen), supporting services (nutrient cycling and soil formation), and cultural services (enhancing human values, aesthetics, and religion).
- There is an important link between biodiversity and ecosystem services. Biodiversity promotes the health, vitality, and productivity of ecosystems, and hence enables ecosystems to deliver their services. When biodiversity is threatened, the ecosystem functions are diminished, and the services they provide are undermined. Protecting biodiversity is therefore key to protecting ecosystem services, which are vital for human survival and well-being.
- Biodiversity is under unprecedented threat as a result of human activity. Humanity is putting so much pressure on the Earth that it is causing a dramatic increase in the rate of species extinction, resulting in a decline in genetic diversity and the abundance of particular species. The combined effect is so large that it is causing what could be the sixth great extinction on the planet.
- The human ecological footprint is a measure of human influence around the world which combines several indicators such as population density, land-use change, infrastructure coverage, railroads, and roads. It shows that human impact is significant in all parts of the world, except in most extreme environments.
- Humans have appropriated a massive amount of land for human use. Adding up the human control of photosynthesis on all farms, pasturelands, and forest regions, as well as the photosynthesis lost when humans cover the land with urban settlements, humanity is taking as much as 40-50 percent of Net Primary Production (NPP), where the NPP is the total output of photosynthesis worldwide. This appropriation of NPP is devastating for biodiversity.
- Human impact does not stop with land use. Humanity has fundamentally changed the carbon cycle, appropriated huge amounts of water, come to dominate the nitrogen cycle, introduced

many invasive species into ecosystems, driven many other species to extinction, and deeply undermined the abundance of fish in all parts of the world.

- Humanity is destroying the habitats of many species and appropriating their water and food supplies. As a result, huge numbers of species are collapsing. The International Union for the Conservation of Nature has a special classification called the "Red List" of the most endangered species. The number of species on the Red List has soared.
- Humanity is changing basic ocean chemistry, poisoning the ocean with pollution, and degrading the biodiversity in the oceans through overfishing and overharvesting of marine life.
- Our technological know-how in harvesting ocean services has improved enormously just in the last sixty years, which has resulted in a dramatic increase in the wild catch. Overfishing has led many fisheries into decline or complete collapse. Aquaculture has been able to grow to meet humanity's growing demand for fish, but it threatens the environment in many ways.
- In many fisheries around the world, the level of human appropriation of marine primary production amounts to 30 percent, meaning that 30 percent of the total photosynthesis in that part of the ocean was necessary to feed the wild fish catch.
- Not only is humanity driving down levels of fish abundance to the point of threatening their very survival, it is also changing the structure and functioning of marine ecosystems. For example, humanity is "fishing down the trophic chain": first we eat and deplete the large fish at the top of the food chain, then after exhausting the supplies of large fish, we eat fish lower down the food chain.
- Marine ecologists try to estimate the maximum sustainable yield (MSY) of a fish type in order to determine a safe level of wild catch. The MSY indicates how much of a specific type of fish can be taken safely from a fishery without depleting the fish stock.
- The MSY is a policy tool, telling commercial fishers how many fish it is safe to catch each year. Each individual might still try to maximize his or her own catch, however, while hoping the others will abide by the limits. The result would be a "tragedy of the commons," wherein every commercial fisher overfishes and the combined effect drives the fishery to exhaustion.
- For this reason, the government might need to enforce a maximum level of total fishing by giving out permits that tell each fishing vessel how many fish it is allowed to catch, with the sum of the permits equaling the MSY of the fishery.
- Humanity has also been in the business of clearing forests for thousands of years. When we lose forests, we degrade ecosystems and lose a tremendous amount of biodiversity.
- Today, most deforestation is taking place in the fast-growing tropical and subtropical regions, and notably in the rainforests, where population densities were traditionally low but are now rising. The rainforests, regions of astounding biodiversity, are now facing major disturbances and human impacts. Rapid deforestation is occurring in the Amazon, Congo Basin, and the Indonesian archipelago. The resulting losses of biodiversity will be phenomenal in terms of the regulatory functions of these ecosystems and the threats to survival of key endangered species.
- Some of the human impact of deforestation is internally driven, mainly by growing populations within countries. Yet a huge amount is also coming from international trade—from the demands halfway around the world for forest products.

- A notable effort to link the conservation of forests with the climate change agenda is called UN-REDD+, Reduced Emissions from Deforestation and Forest Degradation; the idea is to give financial incentives to local farmers and communities to protect the forests.
- Two of the most important attempts to protect biodiversity have been through international treaties: the 1992 Convention on Biological Diversity (CBD) and the 1973 Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).
- The CBD has accomplished a bit, but it has fallen far short of what it should be doing. Although the treaty contributed to a rise in protected areas, in particular of marine protected areas, it has not slowed the loss of biodiversity. Its implementation was gravely weakened by the fact that the United States, guided by a "free-market" sentiment, never signed the treaty.
- The idea of CITES is to reduce the pressures and dangers of species extinction by regulating trade specifically in endangered species. The pressures of the global economy are so strong, however, that even when treaties and regulations are put in place, vested interests are often a powerful counterforce, controlling mechanisms at the mercy of illegal activities.

## REVIEW

### Concepts and Definition

Can you define or explain the significance of these concepts?

Ecosystem	Aquaculture
Biodiversity	Autotrophs
Sixth great extinction	Heterotrophs
Ecosystem services	Trophic Level
Provisioning services	Maximum Sustainable Yield (MSY)
Regulating services	Tragedy of the commons
Supporting services	UN-REDD+
Cultural services	CBD (Convention on Biological Diversity)
Human ecological footprint	CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora)
Red List	
Net primary productivity (NPP)	

### Check your facts

- 1) What is the estimated range of the number of species on the planet?
- 2) Approximately how much of the total output of photosynthesis worldwide is humanity now taking?
- 3) By how much did the wild catch increase from 1950 to 1990?
- 4) What was the level of the wild catch in 1990 (in tons)?
- 5) What was the level of aquaculture in 1950 (in tons)?
- 6) What was the level of aquaculture in 2010 (in tons)?
- 7) What trophic level is associated with plants that produce their own food (autotrophs)?
- 8) What percentage of total land area is covered by forests?

- 9) What percentage of the total carbon dioxide emissions each year comes from land-use change?
- 10) In what year was the Convention on Biological Diversity adopted?
- 11) In what year was the Convention on International Trade in Endangered Species adopted?

Answers: 1) 10 to 100 million; 2) 40-50%; 3) up four times; 4) 80 million; 5) near 0; 6) 75 million; 7) 1.0; 8) 31 percent; 9) 15%; 10) 1992; 11) 1973

### **Review questions**

- Name and explain the four categories of ecosystem services.
- How are biodiversity and ecosystem services related?
- How is biodiversity and human well-being related?
- What are the factors putting biodiversity under threat?
- How can we measure the human ecological footprint?
- What does the IUCN's Red List consist of?
- How have wild catch and aquaculture evolved through time?
- How does aquaculture threaten the environment?
- How have fishing technologies evolved? What have been the consequences?
- How much of primary ocean production are humans appropriating?
- Why and how can the maximum sustainable yield be a useful policy tool?
- What is the tragedy of the commons? Provide an example in everyday life.
- What does a tradable permit system consist of?
- Where are the major rainforests located around the world?
- Where is deforestation happening today?
- What are the main drivers of deforestation?
- How is deforestation related to climate change?
- Discuss how trade is related to endangered species and provide relevant examples.
- What are the main international treaties covering biodiversity?
- What was *Nature* magazine's main conclusion regarding these treaties?

### **DATA ACTIVITIES**

EASY

#### **A. Ecosystem Services**

Explore table 2.2 "Trends in the Human Use of Ecosystem Services and Enhancement or Degradation of the Service Around the Year 2000" on page 33 of the 2005 report from the Millennium Ecosystem Assessment, entitled "Ecosystems and Human Well-being: Biodiversity Synthesis." (<http://www.millenniumassessment.org/documents/document.354.aspx.pdf>)

- 1) Which provisioning services were degrading while being increasingly used by humanity?
- 2) Which ecosystem service was degrading even though its human use was decreasing?
- 3) How many regulating services were enhanced?

Answer: 1) Genetic Resources, Biochemicals, natural medicines and pharmaceuticals, and fresh water; 2) Capture fisheries; 3) One

**EASY****B. Deforestation**

Explore the global forest change maps at: <http://earthenginepartners.appspot.com/science-2013-global-forest>. Take a look at the "Forest Cover Loss" map, and at the "Forest Cover Gain" map.

- 1) Which countries have experienced high deforestation?
- 2) Which which countries have experienced high reforestation?

*Answers: 1) Brazil, Indonesia, Russia, U.S. and Canada; 2) Russia, Indonesia, U.S. and Canada*

**MEDIUM****C. Fish Catch & Aquaculture**

From the UNEP website (<http://geodata.grid.unep.ch>) download data on total global fish catch and total global aquaculture production. You should be able to find data ranging from 1960 to 2011. By total, we mean both marine and inland waters production. By global, we mean all countries. The easiest way to get this data is to select the national dataset, and when you get to the window where you can download the data, you will have the option to select which levels to include (national, subregional, regional, and global). Select national and global, and download the excel file. Your excel file should have two tabs: one with data for each country and one with the global data.

- 1) Plot the annual fish catch and aquaculture production in million metric tons from 1960 to 2011 using a stacked column chart.
- 2) Describe and comment on the graph. How does the graph relate to sustainable development?

**HARD****D. Renewable Resources**

Several years ago, the World Bank released a dataset entitled: The Changing Wealth of Nations. Download it here: <http://data.worldbank.org/data-catalog/wealth-of-nations>. Carefully read the information in the Notes tab to get a better understanding of the data, its sources, and how indicators have been constructed.

- 1) Select ten countries spanning a range of per capita income levels which have complete data records in the "Wealth per Capita, 2005 tab." Calculate timber's share of total wealth by dividing the former by the latter. Then generate a scatter plot with wealth on the x-axis and the timber share of total wealth on the y-axis. What do you observe?
- 2) For the same countries follow the same process but now for "protected areas." What do you observe?
- 3) Now switch to the "Trend Total Wealth, PC Values" tab where data has been aggregated into geographic and economic blocs, using the 2005 data. As before, calculate timber's share of total wealth and produce a scatter plot with total wealth per capita on the x-axis. Do the results mirror your earlier graph? Describe what this graph indicates regarding the role of one renewable resource (timber) in economic development.
- 4) Lastly, we'll be returning to the World Bank World Development Indicators database: <http://data.worldbank.org/indicator/all>. Use the Data Bank to download two series: Forest Area (% of Land Area) and Time to Prepare and Pay Taxes (hours), the latter which may be a good proxy for quality of governance and potential for corruption. Download data for 2004-2013 for all countries.
  - a. Calculate the average time to prepare and pay taxes for each country over the period.
  - b. Calculate the percent change in forest cover over the available period.

- c. Make a scatter plot of average time to prepare and pay taxes on the x-axis and change in forest cover on the y-axis. Describe what you observe and draw key conclusions.

## DISCUSS AND DEBATE

- 1) How might ecosystems and their services change in the future under various plausible scenarios?
- 2) How can we measure the human ecological footprint? Discuss some ideas and evaluate the feasibility of these ideas.
- 3) Using the case study below, discuss various policy approaches to protect biodiversity.
- 4) Discuss how fishing, wood harvesting, and GHG emissions can lead to a "tragedy of the commons."
- 5) Discuss what can be done to avoid the tragedy of the commons.

## CASE STUDY

# Some national approaches to public engagement on biodiversity

Belgium: The campaign 'I give life to my planet' aims to engage people with biodiversity by inspiring individuals to take small and simple steps that will have long-term positive impacts. The campaign presents tools and information about potential actions—for each day or week of the year—relating to issues including overconsumption, over-exploitation, awareness of biodiversity values and invasive species. By 2014, nearly 24,000 people had signed up to more than 87,000 actions for biodiversity. The campaign is a close collaboration between the Royal Belgian Institute of Natural Sciences, the Ministry for Public Health, Food Chain Safety and the Environment and several partners at the regional, provincial, local and NGO-level.

Benin: The Ministry of Environment of Benin initiated a project "12 gestes pour la biodiversité" (12 actions for biodiversity). The project presents information in the form of a wall calendar, and a booklet showing a set of actions that can be carried out each month, as well as some of the important international days. The product has been used in schools and linked to capacity development activities. Plans are under way for an SMS text messaging service and other ways of spreading the message through social networks.

India: The Science Express Biodiversity Special (SEBS) is a mobile exhibition mounted on a specially designed train for creating awareness about biodiversity and other environmental issues in the country. The first phase of SEBS was launched on World Environment Day on 5th June 2012, and was the brand ambassador of the CBD's COP-11 meeting hosted by India in Hyderabad in October 2012. The SEBS, during its first phase from June to December 2012, travelled to 51 locations and received over 2,300 000 visitors, including students and teachers from 7,000 schools. The second phase of SEBS travelled from New Delhi and visited 62 stations from October to April 2013.

Japan: The Japanese Committee for the United Nations Decade on Biodiversity (UNDB-J), established in 2011 by a range of stakeholders to promote action to achieve the Aichi Biodiversity Targets, operates a "My Declaration" programme to help people understand the connections they have with biodiversity, and to take positive action in their everyday lives. Participants choose from a list of five actions and make a declaration explaining their choice. During 2012, the programme was used at 91 events including national meetings and regional seminars, attended by a total of around 20,000 people.

Source: *Global Biodiversity Outlook 4*. Box 1.2. <https://www.cbd.int/gbo/gbo4/publication/gbo4-en-hr.pdf>

## FURTHER READING

- **Preserving biodiversity**

This document is a mid-term assessment of progress toward the implementation of the Strategic Plan for Biodiversity 2011-2020.

Secretariat of the Convention on Biological Diversity (2014) Global Biodiversity Outlook 4. Executive Summary and Introduction (8 pages) <http://www.cbd.int/gbo/gbo4/publication/gbo4-en-hr.pdf>

This report estimates the cost of desertification, land degradation, and drought for different parts of the world.

UNCCD background document. (2013). The Economics of Desertification, Land Degradation and Drought: Methodologies and Analysis for Decision-Making. Read the executive summary, chapters 1, 2, 5, 6 and conclusion (26 pages)

[http://2sc.unccd.int/fileadmin/unccd/upload/documents/Background\\_documents/Background\\_Document\\_web3.pdf](http://2sc.unccd.int/fileadmin/unccd/upload/documents/Background_documents/Background_Document_web3.pdf)

This report investigates how ecosystems and their services have changed, what has caused these changes, how these changes affect human well-being, and what options exist to enhance the conservation of ecosystems and their contribution to human well-being.

Millennium Ecosystem Assessment. (2005). Ecosystems and Human Well Being: Summary for Decision Makers (24 pages) <http://www.unep.org/maweb/documents/document.356.aspx.pdf>

These "Rio report cards" published in Nature magazine in 2012 argue that the world has failed to deliver on many of the promises it made 20 years ago at the Earth summit in Brazil.

Tollefson, Jeff, and Natasha Gilbert. 2012. "Rio Report Card." Nature 468: 20–23.

This study shows that a significant number of species are threatened as a result of international trade along complex routes, and that, in particular, consumers in developed countries cause threats to species through their demand of commodities that are ultimately produced in developing countries.

Lenzen, Manfred, Dan Moran, Keiichiro Kanemoto, Barney Foran, Leonarda Lobefaro, and Arne Geschke. 2012. "International Trade Drives Biodiversity Threats in Developing Nations." Nature 486:109–112.

This book is a collaborative survey of biodiversity issues written and reviewed by more than 100 scientists. It provides a detailed account of the threats to biodiversity and biodiversity's contributions to medical and biomedical research.

Chivian, E. & Bernstein, A. (2008). Sustaining life: how human health depends on biodiversity. W.W.Norton Co., 1999.

- **Human appropriation of biosphere**

This article examines human impact on the biosphere by calculating the fraction of net primary production (NPP) that humans have appropriated.

Vitousek, P. M., Ehrlich, P. R., Ehrlich, A. H., & Matson, P. A. (1989). Human appropriation of the products of photosynthesis. BioScience, 36 (6).



The Living Planet Report relates the Living Planet Index – a measure of the health of the world’s biodiversity – to the Ecological Footprint and the Water Footprint – measures of humanity’s demands on the Earth’s natural resources.

WWF International. (2010). [Living planet report 2010: biodiversity, biocapacity and development](#).

- **Fisheries**

This article analyzes the geographical expansion of the global marine fisheries from 1950 to 2005. Swartz, Wilf, Enric Sala, Sean Tracey, Reg Watson, and Daniel Pauly. 2010. “The Spatial Expansion and Ecological Footprint of Fisheries (1950 to Present).” *PLoS One* 5(12): e15143.

This article argues that continuation of present trends will lead to supply shortfall, for which aquaculture cannot be expected to compensate. It further argues that reducing fishing capacity to appropriate levels will require strong reductions of subsidies as well as zoning the oceans into unfished marine reserves.

Pauly, Daniel, Villy Christensen, Sylvie Guenette, Tony J. Pitcher, U. Rashid Sumaila, Carl J. Walters, R. Watson, and Dirk Zeller. 2002. “Towards Sustainability in World Fisheries.” *Nature* 418: 689–695. Reprinted with permission from Macmillan Publishers Ltd.

- **Others**

In this book, evolutionary biologist E. O. Wilson highlights that the degradation of natural environments can deeply upset our cultures, our mental wellbeing, our sense of aesthetics, and thus our overall quality of life.

Wilson, Edward O. 1984. *Biophilia*. Cambridge, Mass.: Harvard University Press.

In this article, James Lovelock gives a brief description of the Gaia hypothesis: he proposes that organisms interact with their inorganic surroundings on Earth to form a self-regulating, complex system that contributes to maintaining the conditions for life on the planet. Lovelock, James E. 1991. “The Earth as a Living Organism.” In *Learning to Listen to the Land*, ed. Bill Willers, 11–16. Washington, DC: Island Press.

- **International treaties**

Convention on Biological Diversity (CBD), 1992:

<https://www.cbd.int/doc/legal/cbd-en.pdf>

Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), 1973:

<https://cites.org/eng/disc/E-Text.pdf>