CHAPTER 4
Biodiversity and Industry

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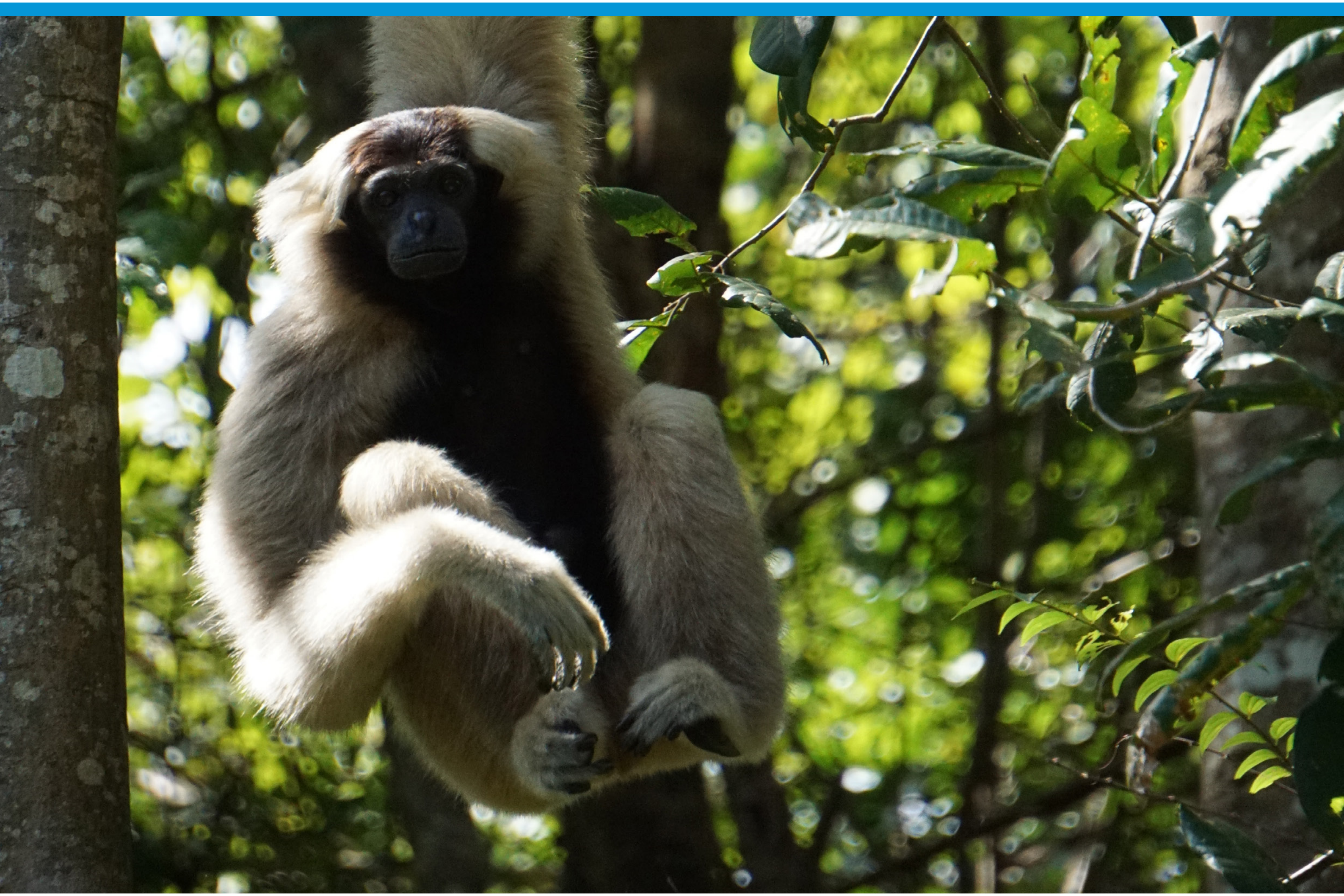

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KEY QUESTIONS

- As we are in the midst of the sixth mass extinction of species, what is driving biodiversity loss – deforestation, climate change, over-exploitation, land-use change, lost connection between humans and nature, poaching, hunting, etc. – and what is the prognosis for the Asia-Pacific region?
- What are the implications for humans if this biodiversity loss is not reversed?
- To what extent can in-situ and ex-situ protection – natural parks, gene banks, zoos, etc. – offset the inexorable species decline?
- New technological techniques such as gene editing, CRISPR (clustered regularly interspaced short palindromic repeats), artificial organisms, lab-grown meat, artificial photosynthesis, etc. have begun to emerge. What is their potential role in addressing biodiversity loss? What are some of the potential dangers as well as opportunities for these technologies?
- What are the implications for industry? Can we envisage a future where many of the ecosystem services provided by nature are replicated, and perhaps improved, by new start-up industries?
- What are the implications for governments? Should we begin to envisage a 50/50 world, where nature is assigned half the global area, or accept that industry will have to replace some of the ecosystem services being lost or diminished due to biodiversity loss?
- What is needed to ensure that industry is environmentally responsible, supporting rather than harming biodiversity?
- How can industrial production be linked with responsible consumption that reflects concerns for biodiversity?

Industry, in the context of this chapter, is mostly confined to the strict definition of the word: -"economic activity concerned with the processing of raw materials and manufacture of goods in factories" (OUP 2018). Industry has a major impact on nature and its biodiversity in Asia and the Pacific, as it does elsewhere in the world. Industry impacts biodiversity especially through the airborne, waterborne and soil-borne pollution that it produces, but also in other ways as elaborated upon in this chapter. At the same time, industry is reliant on biodiversity for goods and services. Many of these contributions from nature can be artificially replicated once they have been discovered and studied, and innovation is producing a growing selection of design solutions that may also benefit biodiversity. Nevertheless, on the current trajectory, it is unlikely that industry and technology will ever be able to replace all of nature's potential contributions before their full potential for industry is lost.

Industry is a driver of biodiversity loss. Globally, biodiversity is being lost very much faster than the rate that would be expected without human interference. The current rate of loss is believed to be on a par with the previous five extinctions experienced over the hundreds of millions of years of the life of our planet (Barnosky *et al.* 2011; Leakey and Lewin 1992).

In Asia, economies are growing rapidly overall, while China, India, Japan and the Republic of Korea alone already account for more than 40 per cent of all global R&D investment (Industrial Research Institute 2016). In the Asia-Pacific region the terrestrial, freshwater and marine environments have been severely degraded, and this decline is expected to continue given the current trajectory of development (Omar 2018). The value of the loss of biodiversity and ecosystem services under business-as-usual scenarios could be of the order of US$5 trillion per year (Omar 2018). The main direct drivers of this loss have been land degradation and land-use transformation, climate change, pollution, over-exploitation and invasive alien species (Bustamante *et al.* 2018). Industry is indirectly or partially complicit in some of these, and directly complicit in others. Land-use and land-cover change associated with rapid industrialisation have degraded land resources through pollution and soil erosion (Bustamante *et al.* 2018). Air pollution from the combustion of fossil fuels in industrial areas is responsible for forest damage and industrialisation has resulted in increased atmospheric nitrogen deposition, which threatens some marine environments (Bustamante *et al.* 2018). The major sources of water pollution, other than agriculture, are from industries involved in the production of metals, paper and pulp, textiles, food and beverages, and mining (Bustamante *et al.* 2018). Quarrying for cement threatens the survival of about 30 species in Southeast Asia alone (Clements *et al.* 2006), while eight out of 10 most polluted rivers in terms of plastic waste are in Asia (Lebreton *et al.* 2017). Yet, the scientific literature is brimming with a multitude of examples in medicine and in technology, of how society and industry rely on nature's phenomenal diversity for materials and ideas.

New threats are emerging. Unfortunately, it is not only established threats that endanger biodiversity – new ones are also emerging, such as industrial-scale manufacturing and use of nanomaterials. Some nanomaterials have the potential for bioaccumulation in plants and microorganisms as well as through the food chain (IPBES 2018; CDC-NIOSH 2014; Kwazo *et al.* 2014; Scrinis 2006). Biotechnology is another modern phenomenon that is widely considered to threaten biodiversity. Although well established, advances in this field are rapid, further fuelling concern. And yet its proponents suggest that it may offer the best solutions for some of biodiversity's greatest challenges, as discussed later.

Our reliance on biodiversity is not diminishing. Biodiversity consists of ecosystem diversity, species diversity and genetic diversity. Ecosystems, and the species and genes that constitute their living components, provide a variety of services to humankind. These are commonly referred to as ecosystem services and, more recently, nature's contributions to people (IPBES 2018). These services, or contributions, include raw materials such as the processed timber used for building and the raw timber used to produce heat and energy in many of the developing parts of the region. They also include the provision and flow regulation of water that is required by all industries in their manufacturing processes and the plants that help to purify water polluted by industry. It is expected that water withdrawals in the region will increase by 55 per cent due to growing needs for domestic water, food production, manufacturing and thermal electricity generation (IPBES 2018; ADB 2016).

Medicinal advances rely on biodiversity. Biodiversity includes the genetic resources that constantly fuel the pharmaceutical industry's quest for more and better medicines, with an estimated minimum of 70 per cent of new small-molecule drugs introduced worldwide from about 1982 to 2007 originating from, or inspired by, a natural source (WWF 2018; Newman and Cragg 2007).

Another interesting emerging example of mimicking nature is artificial photosynthesis. Traditional photosynthesis is the process by which plants convert carbon dioxide from the air into carbohydrates and oxygen, in the presence of water and sunlight. Artificial photosynthesis is a synthetic process that replicates this, typically to store energy from sunlight in fuel – a new method with promising potential (Fukuzumi *et al.* 2018; El-Khouly *et al.* 2017).

Mobilising industry for sustainability transitions is an urgent challenge. Sustainability transitions are widely recognised as essential to address biodiversity loss and to the achievement of the SDGs. They have been defined as fundamental changes in socio-technical systems towards sustainability (Bijker *et al.* 1987). As socio-technical systems are the configurations of hardware, software, social, psychological, political, policy and legal systems that underpin economies (Whitworth and de Moor 2009), industry clearly has a critical role to play in sustainability transitions.

Technological transitions are extremely complex. Studies of historical technological transitions, for example from sailing ships to steamships, have found that movement towards the widespread acceptance of innovative technologies requires more than just the technology; it also requires changes in user practices, regulation, industrial networks, infrastructure and culture (Geels 2002). To support sustainability transitions, policy mixes that destabilise established unsustainable regimes and promote radical green niches as well as their mainstreaming are needed (Smith *et al.* 2010). Opportunities, incentives, controls, support mechanisms and cross-sectoral policy coordination are all important for mobilising industry for sustainability transitions.

Responsible consumption and production can be linked through sustainability certification. A wide variety of voluntary schemes that certify the sustainability of industrial processes exist. These can be found in the forestry sector, where they have been strongly promoted as a way of reducing the harm done by industrial-scale logging in natural forests on biodiversity and ecosystem services. Some schemes require the identification and preservation of areas with high conservation values, while allowing reduced-impact logging in other areas. There is evidence that such schemes can contribute to improved biodiversity outcomes (Dasgupta 2017). When these schemes include product labelling, they link responsible consumption with production with (SDG 12: Responsible consumption and production) by enabling buyers to identify products from sustainable sources.

While voluntary sustainability-certification schemes have been around for several decades, their uptake has been slow, especially in developing countries. This is evident in the forestry sector, with Africa, Latin America, Asia and Oceania accounting for only 15 per cent of the total global certified forest area (UNECE/FAO 2018). The reasons for this slow uptake include lack of attractive price premiums to offset the high costs of certification (UNECE/FAO 2009) and continued existence and growth of new markets that do not demand sustainable extraction (Scheyvens *et al.* 2015).

New technology may enhance sustainability certification. For certification to be instrumental in a sustainability transition towards responsible consumption and production, rethinking of technical elements and the concept itself are required. In terms of technical improvements, there may be potential for blockchain technology, made famous by the crypto-currency Bitcoin, to replace the complex chain-of-custody processes that certification schemes use to control and document the movement of materials (Figorilli *et al.* 2018). As a blockchain is a decentralised ledger, anyone can access transaction records. This opens up the tracking process of materials and products to scrutiny and does away with the need for a third-party monitor. Government support would also help certification realise its full potential. Certification can help governments achieve their own objectives for biodiversity and economic sustainability in specific sectors, so there are good reasons for governments to promote certification. They can explore the possibility of various incentives for companies to acquire certification, such as tax exemptions and public procurement policies for sustainable materials and products.

Wastes and cultivated building materials can be used in architectural applications. In the Asia-Pacific region, waste generation is increasing and poor waste management has resulted in harm to biodiversity and degradation of ecosystems (Davies *et al.* 2018). At the same time, the region is experiencing growing demand for housing and other buildings as a result of population growth, urbanisation and rising affluence (UNEP 2016). Using waste residues as inputs for building materials could both help mitigate the harm caused to biodiversity by waste and address the housing problem.

Biomass residues are a potential source of new building materials. In particular, residues from the harvesting of cereal crops and agro-industrial processes are a huge potential source of fibres that could be used to produce environmentally-friendly building materials (Hebel and Heisel 2017). This notion has been supported by various research into bio-composites that have led to new environmentally superior, high quality building materials. With funding from the European Regional Development Fund, for example, a team of materials scientists, architects, product designers, manufacturing technicians, and environmental experts collaborated to develop a new material for façade cladding using raw agro-fibres. Agro-fibres from barley, maize, oats, rice, rye and wheat straw can be used and contribute up to 90 per cent to the final material by weight (Dahy and Knippers 2017). This project developed a type of bioplastic granule that can be extruded into sheets and further processed. The sheets were used to develop a flexible, recyclable and compostable high-density fibreboard for use in buildings. Another example is the structural composite panel ECOR manufactured by Noble Environmental Technologies using forest waste, agricultural fibres, bovine process fibre, and paper and cardboard waste. ECOR has been commercialised and used in a broad spectrum of industries and applications by global brands wanting to promote their environmental credentials. Applications include wide format printing, furniture and fixtures, and building interiors (https://ecorglobal.com). Production of such bio-composites does not rely heavily on petroleum-based components and additives, which means they can contribute to a healthy living environment, at the same time as reducing harmful waste from farming, forestry, manufacturing and building demolition.

There is also a strong argument for the cultivation of building materials. This means not just the growing of trees, but also new ideas such as purpose built breeding farms, using micro-organisms that until recently had not been considered useful for the building industry (Hebel and Heisel 2017). Using recycled agricultural fibres and cultivated building materials would help the construction sector move away from a system that relies on the unsustainable mining of materials, which harms biodiversity, to a closed loop system using renewable and recycled materials ((Hebel and Heisel 2017). Further research into the use of recycled agricultural fibres and cultivated building material is likely to be most productive when conducted by teams of scientists from various disciplines, product developers and practitioners. In addition to new product breakthroughs, modification of the existing industrial setting to accept new materials and construction methods will be needed for bio-composites to contribute to a sustainability transition in the building industry.

Synthetic biodiversity is also developing rapidly. The rapid advancement of biotechnology and its potential risks to biodiversity led governments to adopt the Cartagena Protocol on Biosafety to the Convention on Biological Diversity (CBD 2000), which aims to ensure the safe handling, transport and use of living modified organisms (LMOs) resulting from modern biotechnology that may have adverse effects on biological diversity, also taking into account risks to human health. More recently, advances in gene editing and CRISPR technology have revived these concerns, with successive decisions on the topic of synthetic biology featuring at the three most recent meetings of the Conference of the Parties to the Convention on Biological Diversity (CBD 2014; 2016; 2018).

Synthetic biology both offers great hope and raises great concern. Synthetic biology is defined as "a further development and new dimension of modern biotechnology that combines science, technology and engineering to facilitate and accelerate the understanding, design, redesign, manufacture and/or modification of genetic materials, living organisms and biological systems" (CBD 2016). It involves the alteration of natural genomes with extremely precise editing (Piaggio *et al.* 2017). On the one hand ¬this creates the possibility of natural organisms being "tweaked …to allow for patent monopolies beyond the reach of state sovereignty or of indigenous peoples" (ETC Group 2010). On the other, it holds the potential to resolve some persistent conservation problems, such as invasive species. Certain species of rodents, for example, have been responsible for the extinction of hundreds of species of birds, especially on islands where fauna is more susceptible to aggressive introduced species (Blackburn *et al.* 2004). Current methods are limited in their effectiveness and have proven side effects, so work is being conducted to explore the feasibility of creating mice with a gene from the Y chromosome inserted onto chromosome 17 (autosome) that results in the production of only male offspring – thereby rendering the island population eventually incapable of reproducing (Piaggio *et al.* 2017). An even more controversial application involves de-extinction, bringing back animals that no longer exist by editing the genome of similar extant species to incorporate genetic code from the extinct species (Piaggio *et al.* 2017; Redford *et al.* 2014; Sutherland *et al.* 2014).

Lab-grown meat is a potential solution to excessive livestock rearing. Lab-grown meat is an example of how biodiversity provides the seeds of a solution to a problem that threatens biodiversity itself. Meat production, especially through large-scale industrial agriculture driven by the increasing global demand for meat, has a major impact on biodiversity simply through the amount of land it requires. Globally, the land area taken up by the pasture required by livestock is double that of the area taken up by crops grown directly for human consumption. In addition, livestock consume around a third of the crops harvested specifically as feed (Alexander *et al.* 2017; Machovina *et al.* 2015; FAO 2006). Land-use change, and other aspects of livestock production also contribute significantly to the emission of greenhouse gases (FAO

2006). These considerations make meat consumption a major environmental concern as well as an ethical and health-related one. One innovative solution is the production of meat in the laboratory using only cells from the original animal. This approach requires significant reduction of land use, (Stephens and Ruivenkamp 2016; Tuomisto and de Mattos 2011). The cost of lab-grown meat is still prohibitive at about US$ 600 for a hamburger. This is, however, down from a somewhat more expensive US$ 340 000 only five years ago (Stephens and Ruivenkamp 2016) and is expected to reach US$ 5 in the foreseeable future. Another challenge is unsurprising conservatism of cultural norms in accepting such an unusual alternative, but this is expected to change gradually. A final challenge regards the climate impacts of lab-grown meat. The new technology may offer a significant improvement over traditional meat production only if it is accompanied by sustainable forms of energy production.

Implications for industry.

While the externalisation of costs benefits the profit margins of industry in the short term, it poses a risk to industry – and society as a whole – over the long term by reducing the potential to use biodiversity for R&D. The planetary boundary for biodiversity may already have been passed and without transformational changes in industrial production systems and consumption patterns, the basic functioning of vulnerable ecosystems could start to break down. The likelihood of exceeding a 1.5ºC increase in global temperature above pre-industrial levels (IPCC 2018) is a high-profile and macro-scale example of the serious consequences of transgressing these boundaries.

Policy implications.

With 60 per cent of the world's population, 52 per cent of the global poor and a rate of economic growth double that of the global average, Asia and the Pacific's significance in the planet's future is not to be underestimated. Technological advances and progress in economic development ignoring consideration of biodiversity and ecosystem conservation is unlikely to lead to improved human well-being and a good quality of life (IPBES 2018). Policymakers and industry will need to work together towards a more desirable scenario of progress. While industry is a driver of both biodiversity loss and of innovation that may contribute to conserving biodiversity, biodiversity is a driver of industrial innovation and a resource base for industry. A relationship of such crucial mutual interdependence, and such consequential risks and benefits, is deserving of special attention.

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