Response from the Royal Society of Biology to the Dasgupta Review on the economics of biodiversity

November 2019

The Royal Society of Biology (RSB) is a single unified voice, representing a diverse membership of individuals, learned societies and other organisations. We are committed to ensuring that we provide Government and other policymakers, including funders of biological education and research, with a distinct point of access to authoritative, independent, and evidence-based opinion, representative of the widest range of bioscience disciplines.

The Society welcomes the opportunity to respond to the Dasgupta Review on the economics of biodiversity. We are pleased to offer these comments, which have been informed by specific input from our members and Member Organisations across the biological disciplines. Our Member Organisations are listed in the Appendix.

Part 1: Biodiversity and Ecosystem Service Science and Evidence

Question 1 (Biodiversity and Ecosystem Service Science):
IPBES assessments and GEO6 will form an important part of the Review's assessment of the state of biodiversity, the biosphere and its ability to deliver ecosystem services. What further evidence should the Review consider in this area? What does the scientific evidence on global biodiversity and ecosystem condition decline suggest about the Earth's ability to continue providing services essential to human prosperity over different time periods?

1.1 Human consumption is increasing demand for resources, leading to planetary change. The concept of planetary boundaries provides a framework to assess the risks that human activities could push the Earth into a substantially altered state.[1] The Global Footprint Network assesses and predicts Earth Overshoot Day – the date when human resource demand in a given year exceeds what the Earth can regenerate.[2] The 2018 Living Planet Report provides a science-based assessment of global biodiversity with indicators of the health of our planet.[3]

1.2 Land-use change is a major driver of biodiversity loss. Many agricultural practices are unsustainable. For example, conventional tillage causes soil erosion at rates around 100 times faster than soil formation. The Dasgupta Review should consider recent reports on land use from the IPCC,[4] the FABLE Consortium,[5] and the Food and Land Use Coalition.[6] Agricultural impacts are

[1] Steffen *et al*. 2015. Planetary boundaries: guiding human development on a changing planet
[2] Global Footprint Network 2019. Earth Overshoot Day.
[3] WWF 2018. Living Planet Report 2018: Aiming higher https://wwf.panda.org/knowledge_hub/all_publications/living_planet_report_2018/
[4] Intergovernmental Panel on Climate Change, 2019. Climate Change and Land.
[5] The Food, Agriculture, Biodiversity, Land-Use, and Energy (FABLE) Consortium, 2019. Pathways to Sustainable Land-Use and Food Systems.
[6] Food and Land Use Coalition, 2019. Growing Better: Ten Critical Transitions to Transform Food and Land Use

partly a function of human population growth,[7] which will continue this century at least, expected to reach 9.7 billion in 2050,[8] and partly a function of use inefficiency and significant waste.

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1.3 In the UK, one third of insect pollinator species showed declines in the areas in which they were found, while one tenth increased, between 1980 and 2013.[9] UK biodiversity is described in the State of Nature 2019 reports[10] and publications by the Joint Nature Conservation Committee (JNCC).[11] England, Scotland, Wales and Northern Ireland have biodiversity strategies.[12] The JNCC holds a wealth of relevant data and expertise. The Natural Capital Committee (NCC) report on management of the UK's natural capital and its role in supporting economic growth.[13] The UK National Ecosystem Assessment,[14] and the 2014 Follow-On reports[15] are valuable, relevant resources.

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1.4 The link between biodiversity and ecosystem services and function is much debated.[16,17,18,19,20,21,22,23] Recent general reviews on valuing ecosystems are provided by Tinch *et al.*,[24] and Helm.[25]

1.5 It is important to consider the complications and restrictions of using the ecosystem services approach to biodiversity.[26] The use of natural capital valuation methods have tremendous potential and value but there are some important caveats to bear in mind (see response to Question 20).

1.6 The RSB does not use the term "value" in relation to natural capital to mean solely financial or tradeable economic assets. It incorporates other worth including cultural and intrinsic values, and believes that there is a continuing requirement to further our understanding of such values.[27]

[7] Marques *et al.*, 2019. Increasing impacts of land use on biodiversity and carbon sequestration driven by population and economic growth
[8] United Nations, 2019. World Population Prospects 2019
[9] Powney *et al*. 2019, Widespread losses of pollinating insects in Britain.
[10] The State of Nature partnership, 2019. The State of Nature 2019.
[11] JNCC, 2019. UK Biodiversity Indicators 2019.
[12] JNCC, 2018. Country biodiversity strategies.
[13] GOV.UK, 2019. Natural Capital Committee documents
[14] The UK National Ecosystem Assessment, 2011. Understanding Nature's Value to Society. Technical Report.
[15] The UK National Ecosystem Assessment, 2014. Follow-on.
[16] Harrison *et al.*, 2014. Linkages between biodiversity attributes and ecosystem services: A systematic review
[17] Bennett *et al.*, 2015. Linking biodiversity, ecosystem services, and human well-being: three challenges for designing research for sustainability
[18] Eastwood *et al.*, 2016. Does nature conservation enhance ecosystem services delivery?
[19] Cardinale *et al.*, 2012. Biodiversity loss and its impact on humanity
[20] Bartkowski *et al.*, 2015. Capturing the complexity of biodiversity: A critical review of economic valuation studies of biological diversity
[21] Tilman *et al.*, 2014. Biodiversity and Ecosystem Functioning
[22] Soliveres *et al.*, 2016. Biodiversity at multiple trophic levels is needed for ecosystem multifunctionality
[23] Schwarz *et al.*, 2017. Understanding biodiversity-ecosystem service relationships in urban areas: A comprehensive literature review
[24] Tinch *et al.*, 2019. Economic valuation of ecosystem goods and services: a review for decision makers
[25] Helm, 2019. Natural capital: assets, systems, and policies
[26] Vira and Adams, 2009. Ecosystem services and conservation strategy: beware the silver bullet.
[27] Royal Society of Biology, 2018. Response from the Royal Society of Biology to the Defra consultation on Environmental Principles and Governance after EU Exit

Question 2 (Limits):
What is the best available evidence on the regenerative rates and carrying capacity of ecosystems e.g. fisheries? What is the best evidence on, and most compelling examples of, maximum sustainable yields, and where ecosystem thresholds and tipping points have been shown to affect sustainable economic growth?

2.1 Fisheries management should move from mathematical views of maximum sustainable yield (MSY) for single species, towards use of the concepts of 'maximum economic yield',[28] considering multiple species, habitats and ecosystems, including local social and economic factors.

2.2 Identifying MSY is difficult:

- The MSY is usually considered a target, which is overshot or poorly understood.[29]
- Natural baselines as targets for recovery are hard to determine.[30]
- Fishing at maximum sustainable rates causes ecological damage beyond direct effects on fished species – e.g. fishing gears can destroy habitat.[31]
- Fisheries monitoring usually considers species in isolation;[32] multi-species or ecosystem-based assessments are rare.[33] Biological interactions make it complex to obtain MSY for multiple species.

2.3 Long-term, coastal communities will likely benefit from fishing well below MSY – with low-impact, smaller scale approaches that directly support communities, rather than large scale, high-impact fisheries.

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2.4 Biodiversity loss in marine fisheries is likely to continue,[34] but populations can recover if managed sustainably. The EU Common Fisheries Policy (CFP), has enabled partial recovery in key species, (ICES, 2018), increasing the value of fisheries. The gross value added for fishing was £682m in 2016.[35]

2.5 When fully protected from exploitation, Marine Protected Areas increase abundance and reproductive rates effectively. The 30x30 Report calls for at least 30% of the oceans to be fully protected by 2030 to optimise biodiversity and fishing.[36]

2.6 Fishing of long-lived, slow growing and deep-sea species should be discouraged in favour of more regenerative fisheries. Different habitats provide nursery areas, supporting fisheries indirectly, including estuaries, seagrasses, kelp forests and saltmarshes.

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[28] Dichmont *et al*., 2010. On implementing maximum economic yield in commercial fisheries.
[29] Mace, 2001. A new role for MSY in single-species and ecosystem approaches to fisheries stock assessment and management.
[30] Greenstreet & Rogers, 2006. Indicators of the health of the North Sea fish community: identifying reference levels for an ecosystem approach to management.
[31] Kaiser *et al*., 2003. Impacts of fishing gear on marine benthic habitats. In Sinclair & Valdimarsson (Eds.), Responsible fisheries in the marine ecosystem, FAO, Rome (2003), pp. 197-217
[32] ICES, 2018. Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK), 24 April - 3 May 2018, Oostende, Belgium. ICES CM 2018/ACOM:22. pp
[33] ICES, 2017. Report of the Working Group on Mixed Fisheries Advice (WGMIXFISHADVICE), 22–26 May 2017, Copenhagen, Denmark. ICES CM 2017/ACOM:18. 128 pp.
[34] Worm *et al*., 2006. Impacts of biodiversity loss on ocean ecosystem services.
[35] GOV.UK, 2017. UK sea fisheries annual statistics report 2016.
[36] Greenpeace, 2019. 30x30: A Blueprint for Ocean Protection.

2.7 Tipping points in ecology are difficult to define precisely. However, degraded land generally fails to recover to pristine states over human time scales.

2.8 The concept of regenerative rates should be applied to other habitats. For example, ancient woodlands contain plant and invertebrate species that are very slow to disperse into secondary woods. Ancient woodlands are irreversibly harmed through bisection by roads and railways. They are also threatened by the spread of pests and diseases; biosecurity and vigilance are essential.[37]

2.9 Beyond biodiversity, ancient woodlands provide significant cultural ecosystem services through their human history and landscape meaning, which is not substitutable. Cumulative attrition of these woods leads to the tipping point of lost meaning;[38] on the timescale of human lifespans, ancient woodlands are irreplaceable.

Part 2: Biodiversity and Economic Prosperity

Question 3 (Biodiversity and Economic Prosperity – Conceptual Framework):
Biodiversity supports the provision of many ecosystem services, which are important for economic prosperity and growth. Economic growth also affects the demand for, and supply of, the Earth's resources. What conceptual frameworks and typologies clearly describe the relationship between biodiversity, ecosystem productivity and resilience, ecosystem services, economic prosperity and economic growth? Where have these frameworks been applied to reveal critical relationships? What are the most critical aspects of these relationships for the Dasgupta Review?

3.1 The cascade model is a popular framework that describes the ecosystem services, benefits and value that arise from biophysical structures or processes.[39] While widely used, limitations of the model have been described,[40,41,42,43] and the original authors have concluded that such models need to be supported by other types of material that link to broader societal issues. [44]

3.2 Social-ecological systems (SESs),[45] and social-ecological networks (SENs),[46] are also important frameworks, though like all frameworks, they have their strengths and limitations.

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3.3 The Review may wish to consider a distinction between cases where:

- a market does or could exist (e.g. carbon prices or REDD+)
- approximate shadow prices revealed by economic analysis, e.g. willingness to pay models, can produce cost-benefit analyses that inform policy, but functioning markets are not possible (e.g. the work of the Natural Capital Committee)

[37] Forest Research, 2019. Biological damage
[38] Rackham, 1986. History of the Countryside. J.M. Dent & Sons Ltd. ISBN 0-460-04449-4.
[39] Haines-Young & Potschin, 2010. The links between biodiversity, ecosystem services and human well-being In: Raffaelli & Frid (eds.) Ecosystem Ecology: a new synthesis. BES Ecological Reviews Series, CUP, Cambridge.
[40] La Notte *et al*., 2017. Ecosystem services classification: A systems ecology perspective of the cascade framework
[41] Spangenberg *et al*., 2014. The ecosystem service cascade: Further developing the metaphor. Integrating societal processes to accommodate social processes and planning, and the case of bioenergy
[42] Thorén and Stålhammar, 2018. Ecosystem services between integration and economics imperialism
[43] Boerema *et al*., 2017. Are ecosystem services adequately quantified?
[44] Potschin-Young *et al*., 2018. Understanding the role of conceptual frameworks: Reading the ecosystem service cascade
[45] Ostrom, 2009. A General Framework for Analyzing Sustainability of Social-Ecological Systems.
[46] Sayles *et al*., 2019. Social-ecological network analysis for sustainability sciences: a systematic review and innovative research agenda for the future.

- meaningful shadow pricing is not possible, and policy will need to rest not on economic arguments but on shared social values,[47,48,49] social justice or other wider social arguments, such as cultural ecosystem services).

3.4 There is a growing literature on cultural ecosystem services and the inappropriate use of economic frameworks for them,[50,51,52,53,54,55] as well as on the aesthetic value of landscapes and ecosystems.[56,57,58]

3.5 There are also critiques of the application of economics to biodiversity.[59,60,61,62,63,64,65,66] Ecosystem service valuations have been criticised for promoting the view that nature is just another commodity without recognising its intrinsic value, and for emphasising the importance of services for humans above their necessity to other species.[67]

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3.6 We do not consider that economic prosperity is dependent upon increasing economic growth, and see it can arise from achieving wellbeing overall. We encourage the Review Team not to focus on conventional economic growth for two reasons. First, the global population and overall material consumption are both rising, but the Earth's capacity to meet human needs is finite.[68] Second, increases in GDP beyond a threshold of basic needs do not necessarily translate into improved wellbeing.[69]

3.7 When identifying measures that enhance biodiversity while delivering economic prosperity, it will be important to consider elements of prosperity that do not rely on consumption. Additionally, substituting material consumption with environmentally sustainable consumption and sustainable behaviours involving non-material consumption can improve wellbeing and natural and social capital.[70] The 'Prosperity without Growth' report addressed these issues.[71]

[47] Kenter *et al*., 2016. Shared values and deliberative valuation: future directions
[48] Wainger *et al*., 2018. Evidence of a shared value for nature
[49] Irvine *et al*., 2016. Ecosystem services and the idea of shared values
[50] Stalhammar and Pedersen, 2017. Recreational cultural ecosystem services: How do people describe the value?
[51] Gould and Lincoln, 2017. Expanding the suite of Cultural Ecosystem Services to include ingenuity, perspective, and life teaching
[52] Dickinson and Hobbs, 2017. Cultural ecosystem services: Characteristics, challenges and lessons for urban green space research
[53] Bullock *et al*, 2018. An exploration of the relationships between cultural ecosystem services, socio-cultural values and well-being
[54] Satz *et al*., 2013. The Challenges of Incorporating Cultural Ecosystem Services into Environmental Assessment
[55] Milcu *et al*., 2013. Cultural Ecosystem Services: A Literature Review and Prospects for Future Research
[56] Tribot *et al*., 2018. Integrating the aesthetic value of landscapes and biological diversity
[57] Cooper *et al*., 2016. Aesthetic and spiritual values of ecosystems: Recognising the ontological and axiological plurality of cultural ecosystem 'services'
[58] Posey (ed), 1999. Cultural and Spiritual Values of Biodiversity; United Nations Environment Programme
[59] Hejnowicz and Rudd, 2017. The Value Landscape in Ecosystem Services: Value, Value Wherefore Art Thou Value?
[60] Batavia and Nelson, 2017. For goodness sake! What is intrinsic value and why should we care?
[61] Neuteleers and Engelen, 2017. Talking money: How market-based valuation can undermine environmental protection
[62] Wegner and Pascual, 2011. Cost-benefit analysis in the context of ecosystem services for human well-being: A multidisciplinary critique
[63] Parks and Gowdy, 2012. What have economists learned about valuing nature? A review essay
[64] Schroter *et al*., 2014. Ecosystem Services as a Contested Concept: A Synthesis of Critique and Counter-Arguments
[65] Jackson and Palmer, 2015. Reconceptualizing ecosystem services: Possibilities for cultivating and valuing the ethics and practices of care
[66] Sullivan and Hannis, 2017. "Mathematics maybe, but not money": On balance sheets, numbers and nature in ecological accounting
[67] Morelli & Møller 2015. Concerns about the use of ecosystem services as a tool for nature conservation: From misleading concepts to providing a "price" for nature, but not a "value".
[68] The Royal Society, 2012. People and the planet.
[69] Jackson, 2009. Prosperity without growth. London: Earthscan.
[70] Pretty *et al*., 2015. Improving health and well-being independently of GDP: dividends of greener and prosocial economies.
[71] Jackson, 2009. Prosperity without growth.

Question 4 (Biodiversity and the SDGs):
What are the links between biodiversity and economic prosperity that are most critical to synergies and trade-offs across the SDGs? How should sustainable economic growth be defined and measured given the evidence of how the SDGs and economic prosperity are affected by biodiversity loss? The review is interested in relevant links with biodiversity and economic growth across all the SDGs, particularly climate mitigation and adaptation, poverty reduction, food production, human health and wellbeing, consumption and production, and gender and broader inequalities.

4.1 Biodiversity is linked with several SDGs:

- Natural water filtration contributes to providing clean water and sanitation.
- Biodiversity is central to carbon sequestration to achieve climate action.
- Two SDGs are directly about biodiversity: life below water and life on land.
- Biodiversity is important for agricultural yields to achieve zero hunger and good health and wellbeing.

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4.2 Biodiversity supports agriculture through the provision of natural enemies, pollination and healthy soils.[72,73]

4.3 The diversity of agricultural produce is also important: healthy diets require a diversity of foods, particularly a large proportion of fruits and vegetables. Industrial farming and commodity crop-based agriculture have eroded this diversity. Around 75% of global calories come from 8 crops, with 90% from the top 18 crops, yet humans have cultivated 3,500 crop species.

4.4 Crop wild relatives – the ancestors and close relatives of modern crops – help to protect future food security. The diversity within crop wild relatives is adapted to a broad range of environments, providing variation with which breeders can enhance crops with new, useful traits. This source of diversity can restore plant resistance to diseases, eroded by successive rounds of selection.[74,75]

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4.5 There is evidence that biodiversity is better protected overall when producing a given quantity of food by land-sparing approaches – concentrating production on a smaller area of land with high-yielding methods while conserving land elsewhere, rather than land-sharing approaches that produce less intensively on a larger area.[76] As agriculture is the greatest driver of biodiversity loss, further expansion of agricultural land should be curtailed.

4.6 If there is an increasing demand for food, we will need to grow more on the land currently used for agriculture, necessitating a sustainable intensification of farming,[77] as well as reducing food waste and moving to more plant-based diets. Besides protecting natural areas for biodiversity, producing more food using less land will allow some land currently in cultivation to be used for afforestation or bioenergy with carbon capture and storage (BECCS), necessary to meet the goals of the Paris Climate Agreement.

4.7 However, it is worth noting that while land-sharing generally leads to worse outcomes for biodiversity, it is likely to lead to greater delivery of ecosystem services such as water quality,

[72] European Commission, 2010. The factory of life: why soil biodiversity is so important.
[73] Trivedi *et al*, 2016. Response of Soil Properties and Microbial Communities to Agriculture: Implications for Primary Productivity and Soil Health Indicators.
[74] Dempewolf *et al*., 2017. Past and Future Use of Wild Relatives in Crop Breeding.
[75] Mammadov *et al*., 2018. Wild Relatives of Maize, Rice, Cotton, and Soybean: Treasure Troves for Tolerance to Biotic and Abiotic Stresses
[76] Balmford *et al*., 2015. Land for Food & Land for Nature?
[77] Pretty *et al*., 2018. Global assessment of agricultural system redesign for sustainable intensification.

pollination and pest control, at least in some landscapes,[78] which can even increase overall crop yields.[79] There is debate about the merits of land-sparing vs land-sharing approaches, and rural communities will need to be part of any decision-making.[80]

Question 5 (Impacts of Biodiversity Loss on Sustainable Economic Growth):
What is the best evidence on the sustainability of current global economic growth, based on current rates of biodiversity loss? How much (if any) biodiversity loss needs to be stopped and/or reversed to achieve sustainable economic growth? Please reference any evidence or analysis that underpins your answers.

5.1 Current rates of biodiversity loss are extremely concerning. For instance, coastal and marine ecosystems in the Asia-Pacific region are threatened by unsustainable practices to the extent that there could be no exploitable fish stocks left by as early as 2048. Up to 90% of coral will suffer severe degradation by 2050 even under conservative climate change scenarios.[81]

5.2 In the EU, 73% of freshwater habitats have an unfavourable conservation status. Lakes, ponds and streams are altered and disappearing across Europe and Central Asia; the Aral Sea – once the fourth largest lake in the world – has now almost disappeared, owing to water abstraction for crop cultivation. Wetlands in Western, Central and Eastern Europe have shrunk by 50% from 1970, while 71% of fish and 60% of amphibians with known population trends have declined over the last decade.[82] Without healthy freshwater systems, human life will become untenable, making 'economic prosperity' a far stretch.

5.3 There is considerable uncertainty around levels of biodiversity loss that are compatible with safeguarding of the biosphere. A planetary boundary approach suggests biodiversity levels of 90% of naturally occurring local species of abundance as a precautionary safe level.[83] Modelling has suggested that a maximum of 4.62–11.17% of the global ice-free land can be allocated to cropland and 7.86–15.67% to pasture to ensure acceptable levels of biodiversity.[84] Current levels of land-use for cropland and pasture are considerably higher than these values: the IPCC estimate that in 2015, 12% of Earth's global ice-free land surface is used for cropland and 37% for pasture.[85]

5.4 For some ecosystem services, greater biodiversity promotes both productivity and resilience – for example being associated with fluctuations and a greater total plant biomass.[86] High levels of biodiversity also provide an 'insurance' capacity for some ecosystem services. For example, most crop pollination in Europe is currently carried out by relatively few species that are not particularly threatened, but diversity enables other species to provide the same function when fluctuating population sizes or adverse weather impacts the principal species, providing resilience.[87] However, for other ecosystem services, especially cultural ecosystem services, particular species are not substitutable.[88] This is particularly true of species facing extinction; that other species are conserved is no substitute.

[78] Manning *et al*., 2018. Redefining Ecosystem Multifunctionality.
[79] Pywell *et al*., 2015. Wildlife-friendly farming increases crop yield: evidence for ecological intensification
[80] Santos-Martín *et al*., 2019. Protecting nature is necessary but not sufficient for conserving ecosystem services: A comprehensive assessment along a gradient of land-use intensity in Spain.
[81] IPBES, 2018. Summary for policymakers of the regional assessment report on biodiversity and ecosystem services for Asia and the Pacific.
[82] IPBES, 2018: Summary for policymakers of the regional assessment report on biodiversity and ecosystem services for Europe and Central Asia.
[83] Steffen *et al*. 2015. Planetary boundaries: guiding human development on a changing planet.
[84] Usubiaga-Liaño *et al*. 2019. Limits to agricultural land for retaining acceptable levels of local biodiversity.
[85] Intergovernmental Panel on Climate Change, 2019. Climate Change and Land.
[86] Caldeira, *et al*., 2005. Species richness, temporal variability and resistance of biomass production in a Mediterranean grassland.
[87] Ecosystems Knowledge Network, 2019. Supporting pollinators and pollination.
[88] Hiron *et al*., 2018. Species contributions to single biodiversity values under-estimate whole community contribution to a wider range of values to society

Question 6 (Benefits of Tackling Biodiversity Loss and Costs of Inaction):
What is the best evidence on the economic benefits of biodiversity? What evidence exists on who benefits from biodiversity? What positive business cases (win-wins) exist for tackling biodiversity loss e.g. impacts on jobs, productivity, income, human health outcomes? Conversely, what is the best evidence on the costs of current trajectories of biodiversity loss? What evidence is there of the distribution of these costs within and between countries?

6.1 Global ecosystem services in 2011 were valued at $125 trillion, but annual losses due to land-use change amounted to $4.3-20.2 trillion.[89] Global regulating services in 2015 were valued at over US$29 trillion.[90] Marine fisheries provide 203±34 million jobs globally.[91]

6.2 Greater biodiversity increases provision of many (though not all) ecosystem services.[92] Niche partitioning between tree species in native rainforests provides greater carbon storage than planted forests. Biodiversity enhances pollination and pest control provision, increasing crop production.[93,94]

6.3 Around 300-350 million people – half of whom are indigenous – depend almost entirely on forest biodiversity for subsistence.[95]

6.4 Nature-based tourism contributes substantially to economies in biodiverse areas. In the Caribbean it contributes US$49bn, supporting 11% of jobs.[96]

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6.5 Biodiversity affects human health:

- Natural products and genetic resources provide new medicines and therapies.[97]
- Diverse food sources help to meet micronutrient requirements and, at times of instability or scarcity, nutritional needs. A tuber foraged from forests in Zambia is crucial to diets for 96% of rural families and supplements incomes for over half in the dry-season.[98] Importantly, the reliance on this single element of biodiversity was unknown (except to the foragers themselves) until recently. Its value could not have been included in natural capital valuations.
- Trees remove air pollution, creating health benefits. In the UK, tools such as i-Tree Eco calculate the value of benefits according to the amount of pollution and the population density in a given place.[99]
- Experiencing nature and physical activity in green spaces benefit physical and mental health.[100] Green settings provide opportunities to build social capital, which benefits health. Many behaviours associated with modern lifestyles give rise to health conditions; their costs might be saved by undertaking activities in green places.[101,102,103]The National Ecosystem Assessment

[89] Costanza *et al.* 2014., Changes in the global value of ecosystem services
[90] Balasubramanian, 2019. Economic value of regulating ecosystem services: a comprehensive at the global level review.
[91] Teh and Sumaila, 2011. Contribution of marine fisheries to worldwide employment
[92] Cardinale *et al*., 2012. Biodiversity loss and its impact on humanity.
[93] Dainese *et al*., 2019. A global synthesis reveals biodiversity-mediated benefits for crop production.
[94] Pywell *et al*., 2015. Wildlife-friendly farming increases crop yield: evidence for ecological intensification
[95] World Bank, 2016. Enhance Livelihoods of Forest Communities.
[96] World Bank, 2015. Stunning Sights, Wild Experiences: Nature-Based Tourism A Boon for Emerging Economies
[97] Neergheen-Bhujun *et al*., 2017. Biodiversity, drug discovery, and the future of global health: Introducing the biodiversity to biomedicine consortium, a call to action
[98] Zulu *et al*., 2019. Collection, consumption, and sale of lusala (*Dioscorea hirtiflora*)—a wild yam—by rural households in Southern Province, Zambia.
[99] Forest Research, 2019. i-Tree Eco.
[100] Clark *et al*., 2014. Biodiversity, cultural pathways, and human health: a framework.
[101] Natural Capital Initiative, 2019. Valuing our life support systems 2019: summary report
[102] Pretty *et al*., 2015. Improving health and well-being independently of GDP: dividends of greener and prosocial economies.
[103] Pretty *et al*., 2017. Green Mind Theory: How Brain-Body-Behaviour Links into Natural and Social Environments for Healthy Habits.

gives an overview (from the time) of health services from nature.[104] It notes that access to biodiverse areas is easiest for the richest. Poorer people and other minority groups are often excluded from the benefits by the cost or availability of transport.

- Biodiversity loss frequently increases transmission of infectious diseases of humans, other animals and plants, although areas of naturally high biodiversity may serve as a source pool for new pathogens.[105]

6.6 Awareness of environmental degradation may harm mental health.[106] People enjoy knowing that elements of biodiversity exist, even in remote locations. Loss of iconic or charismatic species could be impoverishing.

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6.7 Payments for Ecosystem Services (PES) approaches offer potential win-wins. In a Defra pilot project, South West Water allowed farmers to bid for capital investment, which delivered cost-effective water quality improvements.[107] However, PES schemes have been criticised.[108]

6.8 Cutting vegetation on road verges twice a year, instead of four times, offers savings to councils and increases biodiversity in these important wildlife corridors.[109] The principle also applies to hedgerow management.

6.9 Healthy, stable ecosystems can protect against natural or human induced disasters.[110] Failure to act to protect biodiversity increases ecological, liability, regulatory, reputational, market and financial risks to businesses.[111]

Question 7 (Cost and Risks of Action): What evidence exists of 'transition risks' from moving to actions needed to protect, restore and enhance biodiversity? What is the best evidence on the costs of these actions? What evidence suggests who will be most affected by these costs and risks?

Question 8 (Opportunities from Tackling Biodiversity Loss):
How can new technology assist with restoring biodiversity, while simultaneously delivering economic prosperity? e.g. artificial intelligence, biotechnology. What economic opportunities exist from protecting, restoring and enhancing biodiversity? e.g. learning from nature (biomimicry), biopharma, among others.

8.1 Technology presents opportunities to reduce biodiversity loss without restricting economic activities, for example through new crop and livestock varieties with higher and more stable yields and quality, and resistance to pests and pathogens. The development of drought-tolerant maize and blight-resistant potatoes are examples of crops created using new plant breeding methods.[112]

[104] The UK National Ecosystem Assessment, 2011. Understanding Nature's Value to Society. Technical Report.
[105] Keesing *et al*., 2010. Impacts of biodiversity on the emergence and transmission of infectious diseases.
[106] Speldewinde *et al*., 2009. A relationship between environmental degradation and mental health in rural Western Australia
[107] Defra, 2016. Defra's Payments for Ecosystem Services Pilot Projects 2012-15.
[108] Solazzo *et al*., 2015. Revising Payment for Ecosystem Services in the Light of Stewardship: The Need for a Legal Framework.
[109] Plantlife 2019. Managing Grassland Road Verges.
[110] JNCC, 2014. Ecosystem Services.
[111] OECD 2019. Biodiversity: Finance and the Economic and Business Case for Action, report prepared for the G7 Environment Ministers' Meeting, 5-6 May 2019.
[112] UK Plant Sciences Federation 2019. Growing the future

8.2 Communities of soil microbes can promote plant growth and defence against diseases, potentially reducing pesticide and fertiliser requirements when crops are inoculated.[113]

8.3 Technologies can further improve farming to reduce impacts on biodiversity through data-driven precision approaches. Examples include targeted application of inputs and drone-based hyperspectral imaging for early detection and management of pathogens or water-stress.[114]

8.4 More broadly, replacement of hydropower with other sustainable energy sources can allow freshwater habitats to be restored.

8.5 Nature has provided many of our most effective medicines, including antibiotics, and could provide potential new sources of medicine if protected. There may also be molecules or organisms in nature that can provide solutions to important problems, such as reducing the persistence of plastic waste, or offering effective means to control harmful crop pests.

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8.6 Various technologies will enhance our understanding of biodiversity and how to protect it. For example:

- genetic methods (including portable machines) are used in the discovery of new species and taxonomic identification of specimens
- remote sensing allows monitoring and detection of habitat destruction
- devices can detect and reveal movement of nocturnal mammals
- more advanced and affordable methods of acoustic detection and classification of animals can generate large and informative datasets.[115]

8.7 There may be an important role for artificial intelligence and machine learning in unlocking value from large datasets, detecting and monitoring land-use changes or illegal fishing from remote observations, and optimising decision making, for instance in food production.[116,117] There is value in linking datasets and systems internationally. Using computer vision and artificial intelligence, CEH is developing a tool to recognise and identify different species, enabling biodiversity mapping from videos and images.[118]

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8.8 Care should be taken to ensure that transitions to new technologies do not exacerbate and entrench existing inequalities, and that access to the technologies and the benefits that flow from them are distributed fairly.

8.9 We wish to emphasise that every species represents a way of living that has evolved over millions of years, from which we can learn, even if there is not economic value to be extracted.

Question 9 (Economic and Finance Decision Makers):
Which sectors of the economy rely most on biodiversity and ecosystem services? How are they affected by biodiversity decline? Please provide strong case and/or sectoral examples and evidence on how changes in biodiversity (loss or gain) has affected, or been affected by, economic and finance decision-making.

[113] Besset-Manzoni *et al*., 2018. Exploiting rhizosphere microbial cooperation for developing sustainable agriculture strategies.
[114] Parliamentary Office of Science and Technology, 2015. Precision Farming.
[115] Bat Conservation Trust, 2019. British Bat Survey.
[116] PWC, 2018. Fourth Industrial Revolution for the Earth Harnessing Artificial Intelligence for the Earth
[117] Willcock *et al*, 2019. Machine learning for ecosystem services
[118] CEH, 2019. Artificial Intelligence can enable better understanding of flora and fauna.

Part 3: Causes of Biodiversity Loss

Question 10 (Market and Institutional Failures):
What are the main market and institutional failures affecting biodiversity? What is the best evidence (including case examples) that illustrate these failures?

10.1 The principle market failure is that externalities are not reflected in the price of goods. Global trade and competition thus provide economic incentives for unsustainable practices in fisheries, aquaculture, forestry and agriculture, among other industries, with a market benefit for any producer that can put costs onto the environment or use an environmental subsidy.

10.2 The value of these externalities in the global food system is estimated at $US12 trillion annually.[119] Annual worldwide externalities of pesticide use are in the range of US$10-60 billion, excluding private costs borne by farmers such as incidents of personal ill-health caused by exposure and increased resistance of pests, weeds or fungi.[120] These high costs underscore the benefits of moving towards sustainability.

10.3 New Zealand has developed a carbon market that includes environmental costs in food prices, with consumers paying more for agricultural produce that causes more pollution or environmental damage. Using electronic reporting, agricultural inputs are monitored directly. It is now possible to use databases to see trade flows between countries and estimate the embedded water and embedded biodiversity. It would be feasible to estimate the external costs of trade-flows and incentivize ways to reduce them.

10.4 Subsidies for farming often represent poor value for money in natural capital accounting, with the vast majority failing to incentivise sustainable practices that create positive outcomes for the environment.[121] However, initial reports suggest that the UK Government's 'Payment by Results' pilot offers a promising opportunity to improve on agri-environment schemes based on actions taken.[122]

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10.5 Resources may be allocated inefficiently where potential opportunities to conserve and increase biodiversity are not taken because the initial and ongoing costs would fall to one organisation, while benefits and avoided-costs that would flow from those opportunities are enjoyed by other organisations. Voluntary payments for ecosystem services (PES) schemes provide one means to address this (but see response to Question 6).

10.6 Smallholder farmers who don't receive a fair share of the upstream value created from their products are unable to invest in their land or in improved methods. Farmer cooperative programmes, producer responsibility and effective engagement and agricultural extension services all have a role to play to mitigate this.

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10.7 Governments, including the UK, continue to provide fossil-fuel subsidies for oil and gas operators, as well as support for fossil fuels through overseas development assistance (ODA), despite contributing to the enormous costs of climate change.[123,124] The UK's export credit agency, UK Export Finance (UKEF), gave £2.6 billion to support fossil fuel projects between 2013/14 and

[119] Food and Land Use Coalition, 2019. Growing Better: Ten Critical Transitions to Transform Food and Land Use
[120] Pretty, 2018. Intensification for redesigned and sustainable agricultural systems.
[121] Food and Land Use Coalition, 2019. Growing Better: Ten Critical Transitions to Transform Food and Land Use
[122] GOV.UK, 2019. New report shows pilot scheme farmers boost environment outcomes
[123] European Commission, 2019. Energy prices and costs in Europe
[124] House of Commons International Development Committee, 2019. UK aid for combating climate change.

2017/18, comprising 96% of its support for the energy sector.[125] In low- and middle-income countries, 99.4% of UKEF's energy support in 2017/18 went to fossil fuel projects.

Question 11 (Economic Sectors):
Which economic sectors have the biggest impact on biodiversity loss? Which economic sectors are most affected by biodiversity loss? Please reference evidence and analysis (including case examples) that underpin and illustrate your answers.

Question 12 (Time):
What evidence exists to suggest that balancing short and long timescales is a challenge for decision-making affecting biodiversity? Please provide evidence (including case examples) where short-term decisions have harmed biodiversity. How does this vary for different ecosystems and/or sectors? What should be the approach to discounting for actions that affect biodiversity?

Question 13 (Business):
What is the best evidence on the role the private sector (including the financial sector) plays in driving biodiversity loss and the direct and indirect impacts it has on biodiversity loss? What evidence shows the effect of biodiversity on firms' and investors' risks and/or returns in the short, medium and long term?

Part 4: Actions to Tackle Biodiversity Loss and Support Economic Prosperity

Question 14 (Valuation and Accounting):
Please provide evidence (including case examples) where marginal valuation, natural capital assessments and accounts are helping policy-makers and the private sector to improve decision making in ways that enhance biodiversity and deliver economic prosperity. What evidence exists on the factors that are most critical for this type of information to improve decision-making?

Valuation:

14.1 Methods have been developed to estimate the value of non-market environmental benefits.

14.2 In principle, methods to measure non-market benefits in economic units offer potential advantages: demonstrating the enormous value of biodiversity in common-unit comparison with other contributions to human wellbeing would enable policymakers to allocate resources accordingly.

14.3 The application of these valuation methods has been encouraging. For example, there has been research on the value of wild species to agriculture, although gaps in understanding of pollinator populations remain. Similarly, methods for understanding the contribution of wild species to recreation and health are established, although a dearth of well-designed, high quality applications needs to be addressed. More recent economic valuation research has begun to incorporate real world environmental complexities, such as interdependence and the variation in biodiversity across locations and over time.

[125] House of Commons Environmental Audit Committee, 2019. UK Export Finance.

14.4 The value of biodiversity as a source of genetic material is much more uncertain, due both to scarce scientific information and our limited ability to value this. Given the potentially massive value of this aspect of biodiversity, this is a serious concern.

14.5 The issues above concern the 'use' value of biodiversity. There are not yet reliable methods for estimating the 'non-use' value. Of the potential variants of non-use value, the most obvious is 'existence value': the value people obtain from knowing that wild species continue to exist in their natural habitat. Existence value is challenging to measure; unlike use values, it is not well reflected in people's behaviour. For example, while we can observe people going to watch birds, the value someone gains from knowing that polar bears still roam the Arctic is (usually) not reflected in their behaviour.

14.6 Attempts to develop methods for estimating non-use values with questionnaires have revealed inconsistencies in responses, making derived values difficult to compare with, say, the costs of action.

14.7 A recent, alternative approach is to use existing legislation to impose 'biodiversity targets' on decision appraisals, justified by other measures of the strong preferences people hold for ensuring the continued existence of species.

14.8 For example, placing 'no-loss' or 'net gain' biodiversity targets on the appraisal of public or business investment options rules out options that reduce biodiversity, *yet al*lows economic assessments of remaining options.[126] This ensures efficient use of resources while maintaining biodiversity. This approach avoids reliance on inconsistent valuations without precluding the use of robust economic values that should include all other major market and non-market (e.g. other environmental) costs and benefits. The scale at which assessments should be made needs careful consideration.

Accounting:

14.9 The Natural Capital Initiative held a dialogue session in 2018 for land-based businesses in Scotland. The experiences of the Crown Estate's pilot project trialling the Natural Capital Protocol was discussed.[127]

14.10 Natural capital accounting was used to develop an investment plan for the Greater Manchester area.[128]

14.11 Different approaches to natural capital accounting were compared for Dartmoor and Exmoor National Park Authorities.[129]

14.12 Figures from the Office for National Statistics show that proximity to green spaces elevates urban property values.[130]

[126] Bateman *et al*., 2013. Bringing ecosystem services into economic decision making: Land use in the UK.
[127] Natural Capital Initiative, 2018. Promoting Natural Capital Asessment in Land and Water Management.
[128] Eftec, 2019. Greater Manchester Natural Capital Investment Plan.
[129] Sweep, 2019. Delivery of environmental, economic and social benefits in Dartmoor and Exmoor National Parks through the use of natural capital approaches
[130] Office for National Statistics, 2019. Urban green spaces raise nearby house prices by an average of £2,500.

Question 15 (Behaviour):
What are the critical factors affecting people's behaviours that affect biodiversity? What affects the speed and scale of this behaviour change? What evidence exists for individual preferences versus social or 'socially-embedded' preferences (to conform or compete with others)? Please provide the strongest examples where policy makers and the private sector have effectively incentivised behaviour change to reduce biodiversity loss.

15.1 The global food system, with its enormous negative externalities (see question 10), is largely designed by policy, and not by consumers. It is unreasonable to expect consumers to solve the problems it creates. Rather, policy is needed to address them. The main problem from a citizen perspective is a lack of transparency: consumers have no way to tell the biodiversity footprint of products.

15.2 The 5p tax on plastic bags that came into force in England in 2015 has reduced the number of bags used by 80%, reversing a trend that had seen five years of annual increases up to 2014.[131] This simple measure reduces waste that harms marine ecosystems. Similar small levies have been recommended on other single-use items, such as disposable coffee cups,[132] but the Government has been unwilling to introduce them.[133] While welcome, these initiatives do not represent an endpoint; a commitment to overarching policy goals is needed, with holistic, coordinated actions implemented.

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15.3 Social science research has investigated the effects on citizens' attitudes of providing information about different attributes of biodiversity in agricultural landscapes.[134] Researchers found that the most effective way to influence attitudes was to provide information emphasising the value of protecting natural areas and biodiversity for its own sake (intrinsic values). Presenting information that emphasised the value of biodiversity for ecosystem services (instrumental values) did not increase citizens' evaluation of the importance of ecosystem services, but reinforced appreciation of the intrinsic value of biodiversity. Public support is important because it enables political leaders to support bolder policies.

15.4 Valuation of nature is incomplete without adequately considering non-use, intrinsic, intangible and cultural values. There is a growing literature on shared values.[135,136,137,138,139] The Follow-On Phase of the UK National Ecosystem Assessment included work on social shared values.[140]

15.5 The Review team should also consider alternatives to economic incentives. There have been cases in other areas where economic incentives have not worked or had inimical effects (for instance in blood donation and after-school childcare). Two organisations using alternative approaches are Values and Frames[141] and Climate Outreach,[142] both of which are trying to motivate people to change their behaviours without the use of financial incentives.

[131] GOV.UK, 2018. Carrier bags: why there's a charge.
[132] Environmental Audit Committee, 2018. MPs call for "latte levy" on coffee cups.
[133] Environmental Audit Committee, 2018. Government promises no effective action on UK's mountain of coffee cup waste
[134] Runhaar *et al*. 2019. The power of argument: Enhancing citizen's valuation of and attitude towards agricultural biodiversity
[135] Wainger *et al*., 2017. Evidence of a Shared Value for Nature
[136] Ravenscroft, 2019. A new normative economics for the formation of shared social values
[137] Massenberg 2019. Social values and sustainability: a retrospective view on the contribution of economics
[138] Hansjürgens *et al*., 2017. Justifying social values of nature: Economic reasoning beyond self-interested Preferences
[139] Shared and Social Values, 2019. Frontiers in theories and methods for valuing nature
[140] The UK National Ecosystem Assessment, 2014. Follow-on.
[141] Common Cause Foundation, 2019. Values and Frames.
[142] Climate Outreach, 2019. Climate Outreach.

Question 16 (Fiscal Policy and Regulation):
What are strong examples of fiscal and regulatory policy instruments that have simultaneously enhanced biodiversity and supported economic prosperity? What is the best evidence on the impact and effectiveness of these actions? The review is interested in examples at all scales, including regulation, planning, taxation and government spending, including subsidies.

Question 17 (Trade, Aid, International Finance and Climate):
What measures can be taken to bridge across geographic boundaries when biodiversity loss in one location is driven by action or consumption elsewhere? What evidence exists on how international trade policy, aid policy, and international financial transfers can tackle biodiversity loss? What are the potential win-wins in also tackling climate mitigation and adaptation with such policies and transfers?

17.1 A recent study reported that 30% of global species threats arise because of international trade, finding links between 25,000 threatened animal species and more than 15,000 commodities.[143] It is therefore essential that biodiversity loss is examined at a global level, and countries' biodiversity footprints are understood according to their global impacts.

17.2 The authors suggest several means to address the problem, including: extending domestic standards to producers abroad; harmonising regulations between countries; developing producer-side sustainability initiatives such as the Roundtable for Sustainable Palm Oil; devising international agreements analogous to CITES that prohibit trade in commodities the production of which threatens biodiversity; and extending labelling and certification to enable consumers to make informed choices.

17.3 Technology also offers solutions. With the development of a transparent methodology and sharing of data, trade databases could be used to estimate the environmental damage or biodiversity footprint of goods coming into a market. Chatham House has developed an example of such a database called resourcetrade.earth.[144] Using this information, it would be possible to levy proportional tariffs on goods that have a high carbon cost as they enter a market.

17.4 In addition to preventing outsourcing that impacts biodiversity overseas, it is vital that the UK takes responsibility for the biodiversity under its guardianship in the UK Overseas Territories.

Question 18 (Private Sector and Finance):
What are the most effective actions that the private sector generally, and finance sector specifically, can take and have taken that both enhance biodiversity and deliver economic prosperity? What actions should government take to enable the private sector and finance to take these actions? What evidence exists on the impact on biodiversity loss and economic prosperity of rules on financial disclosure, standards and certification schemes, and policies affecting investment decisions?

[143] Lenzen *et al*. 2012. International trade drives biodiversity threats in developing nations
[144] Chatham House, 2019. resourcetrade.earth

Question 19 (Technology):
What technologies are proving effective for ecosystem restoration and management while also supporting economic prosperity? What is the role for technological change in the short, medium and long-term to improve consumption and production efficiency? Note the review is interested in technologies across a broad range of sectors that have implications for biodiversity e.g. food production technologies.

19.1 Plant breeding enables growers to select crop varieties with higher and more stable yields and quality than have previously been available, reducing the footprint needed to produce a given quantity of food and protecting further land from the need to be productive. Modern plant breeding methods include genetic modification and genome editing. GM crops are grown in many parts of the world, accounting for approximately 83% of soybeans, 75% of cotton and 29% of maize grown worldwide.[145] Genome editing has been used to develop maize with improved drought-tolerance,[146] which could help to maintain or increase productivity in a changing climate. It has been used to produce wheat with resistance to a major fungal disease,[147] powdery mildew, which could reduce food waste, and the need for pesticide applications.

19.2 Novel genetic technologies have the potential to deliver parallel advances in livestock species, accelerating the pace of genetic improvement in more efficient ways than through conventional breeding methods.

19.3 Modern breeding methods raise issues pertaining to effective regulatory frameworks, public attitudes, and ethical and welfare considerations.[148]

19.4 There are examples of some established biotechnologies that are very effective for remediation and restoration and with added benefit, involving phytoremediation, vermiremediation, mycoremediation and composting. At a larger scale, constructed wetlands are engineered systems that use wetland vegetation, soils and their microbial populations to treat contaminants in surface water, groundwater or waste streams.

19.5 It is important to note that technological interventions are only one facet of more complex management strategies. Additional and alternative approaches must also be considered and compared to avoid apparent “quick fixes” for issues, which may not tackle the often multiple and distinct underlying causes.

Question 20 (Other Comments):
Please provide any other comments or evidence you think the Dasgupta Review should consider in its advice on how simultaneously to enhance biodiversity and achieve economic prosperity. The review welcomes evidence on where economic and financial decision makers in both the public and private sector can have the greatest impact.

20.1 We are facing multiple environmental crises besides biodiversity loss, including climate change, soil loss, and pollution. There are contemporaneous crises in the health system, including the effects of unhealthy diets, poor air quality, and mental health. These issues are interlinked, and driving

[145] European Commission Scientific Advice Mechanism, 2017. New Techniques in Agricultural Biotechnology.
[146] Shi *et al*. 2016. ARGOS8 variants generated by CRISPR-Cas9 improve maize grain yield under field drought stress conditions
[147] Zhange *et al*. 2017. Simultaneous modification of three homoeologs of TaEDR1 by genome editing enhances powdery mildew resistance in wheat
[148] Royal Society of Biology 2019. Royal Society of Biology response to the Nuffield Council on Bioethics call for evidence on ‘Genome Editing and Farmed Animals’

improvement in one area can benefit others. We should recognize these links, rather than attempting to tackle biodiversity loss – and other challenges – in isolation.

20.2 For example, encouraging people to eat more diverse diets without excessive calories could lead to more diversified agricultural landscapes, reduced demand for feed, lower healthcare costs and less of the pollution associated with livestock farming. Land could be taken out of production, and with some afforestation providing carbon storage and creating habitats.

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20.3 Systematics and taxonomy are central to discovering, defining and understanding biodiversity. Measuring progress towards halting biodiversity loss requires the availability of taxonomic expertise across all kingdoms of life.[149] The physical standards for biodiversity are held in dedicated archives (museums, herbaria and their specimen collections), which require funding and professional staff. Conducting meaningful work on biodiversity requires close integration with taxonomic institutions.

20.4 Science, civil society, media and social media can all contribute to conservation. These institutions have critical roles as investigators, watchdogs and campaigners, as well as educators of the general public, including in their role as consumers and voters.

20.5 Citizen Science can particularly contribute. Volunteer, amateur (but expert) naturalists have conducted much of the mapping of biodiversity, including the time series demonstrating its decline. The wider concerned public plays a significant role in large-scale surveys such as the Big Garden Bird-Watch, the Butterfly Monitoring Scheme and the National Bat Monitoring Programme, and is alert for invasive species, for example through the Observatree programme.

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20.6 Natural capital valuations are just one tool to evaluate the benefits that nature provides to humans.[150],[151] They cannot fully capture nature's "worth" and have particularly large uncertainties when used in assessments of aesthetic, spiritual and cultural values.[152],[153],[154] There are diverse ways to value nature; indigenous people are likely to value biodiversity in different ways to economists or governments, yet their territories cover up to 24% of the world's land surface and include 80% of the remaining healthy ecosystems. Therefore any valuations are likely to depend on who is conducting them.[155]

20.7 The IPBES assessment has sought to include a diversity of viewpoints, including philosophers and historians, alongside ecologists and economists.[156,157] This has raised the profile of reciprocal values[158] and reciprocal duties.[159,160] IPBES is structured such that the perspectives of researchers in developing countries and of indigenous peoples' organizations are central, rather than marginal. IPBES has also moved away from a conceptual framework that assesses 'ecosystem services' to

[149] House of Lords Science and Technology Committee, 2008. Systematics and Taxonomy: Follow-up.
[150] Kenter *et al*. 2019 Loving the mess: navigating diversity and conflict in social values for sustainability
[151] Van Riper *et al*., 2017. Incorporating Sociocultural Phenomena into Ecosystem-Service Valuation: The Importance of Critical Pluralism
[152] Kirchoff, 2019. Abandoning the Concept of Cultural Ecosystem Services, or Against Natural–Scientific Imperialism
[153] Thorén and Stålhammar, 2018. Ecosystem services between integration and economics imperialism
[154] Sullivan, 2017. Noting some effects of fabricating 'nature' as 'natural capital'
[155] Kenner, D. 2019 Who should value nature?
[156] Peterson *et al*., 2018. Welcoming different perspectives in IPBES: "Nature's contributions to people" and "Ecosystem services".
[157] Christie *et al*., 2019. Understanding the diversity of values of "Nature's contributions to people": insights from the IPBES Assessment of Europe and Central Asia
[158] Stålhammar and Thorén, 2019. Three perspectives on relational values of nature
[159] West *et al*., 2018. Stewardship, care and relational values
[160] Jax *et al*., 2018. Caring for nature matters: a relational approach for understanding nature's contributions to human well-being

'nature's contribution to people'; and recognises the intrinsic worth of nature and relational values.[161,162,163,164,165,166,167,168,169,170]

20.8 The Dasgupta Review should avoid adopting narrow conceptions of ecosystem science and economics, and consider ways to ensure that UK and international efforts can each take account of complexity and contribute to sharable understanding (for example with IPBES and the Values Assessment it is currently undertaking). Interoperability, or the potential for dialogue and interrogation across the data systems initiated by such major reviews would be an advantage for the future.

[161] Díaz *et al*., 2015. The IPBES Conceptual Framework — connecting nature and people.
[162] Díaz *et al*., 2018. Assessing nature's contributions to people
[163] Pascual *et al*., 2017. Valuing nature's contributions to people: the IPBES Approach
[164] Arias-Arévalo *et al*., 2017. Exploring intrinsic, instrumental, and relational values for sustainable management of social-ecological systems
[165] Ishihara, 2018. Relational values from a cultural valuation perspective: how can sociology contribute to the evaluation of ecosystem services?
[166] West *et al*., 2018. Stewardship, care and relational values
[167] Himes and Muraca, 2018. Relational values: the key to pluralistic valuation of ecosystem services
[168] Stålhammar and Thorén, 2019. Three perspectives on relational values of nature
[169] Chan *et al*., 2018. Relational values: what are they, and what's the fuss about?
[170] Klain *et al*., 2017. Relational values resonate broadly and differently than intrinsic or instrumental values, or the New Ecological Paradigm

Appendix: Member Organisations of the Royal Society of Biology

Full Organisational Members

Agriculture and Horticulture Development Board
Amateur Entomologists' Society
Anatomical Society
Association for the Study of Animal Behaviour
Association of Applied Biologists
Bat Conservation Trust
Biochemical Society
British Association for Lung Research
British Association for Psychopharmacology
British Biophysical Society
British Ecological Society
British Lichen Society
British Microcirculation Society
British Mycological Society
British Neuroscience Association
British Pharmacological Society
British Phycological Society
British Society for Cell Biology
British Society for Developmental Biology
British Society for Gene and Cell Therapy
British Society for Immunology
British Society for Matrix Biology
British Society for Neuroendocrinology
British Society for Parasitology
British Society of Plant Breeders
British Society for Plant Pathology
British Society for Proteome Research
British Society for Research on Ageing
British Society of Animal Science
British Society of Soil Science
British Society of Toxicological Pathology
British Toxicology Society
Daphne Jackson Trust
Drug Metabolism Discussion Group
The Field Studies Council
Fisheries Society of the British Isles
Fondazione Guido Bernardini
GARNet
Gatsby Plant Science Education Programme (incl. Science and Plants for Schools)
Genetics Society
Heads of University Centres of Biomedical Science
Institute of Animal Technology
Laboratory Animal Science Association
Linnean Society of London
Marine Biological Association
Microbiology Society
MONOGRAM – Cereal and Grasses Research Community
Network of Researchers on the Chemical Evolution of Life
Nutrition Society
Quekett Microscopical Club
The Rosaceae Network
Society for Applied Microbiology
Society for Experimental Biology
Society for Reproduction and Fertility
Society for the Study of Human Biology
SCI Horticulture Group
Systematics Association
The Physiological Society
Tropical Agriculture Association
UK Brassica Research Community
UK Environmental Mutagen Society
University Bioscience Managers' Association
Zoological Society of London

Supporting Organisational Members

Affinity Water
Association of the British Pharmaceutical Industry (ABPI)
AstraZeneca
BioIndustry Association
Biotechnology and Biological Sciences Research Council (BBSRC)
British Science Association
CamBioScience
Envigo
Ethical Medicines Industry Group
Fera
Institute of Physics
Ipsen
Medical Research Council (MRC)
MedImmune
Northern Ireland Water
Porton Biopharma
Royal Society for Public Health
Syngenta
Understanding Animal Research
Unilever UK Ltd
United Kingdom Science Park Association
Wellcome Trust
Wessex Water
Wiley Blackwell