



Supplementary Material for
**Pervasive human-driven decline of life on Earth points to the need for
transformative change**

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Table S1
References

Table S1. Brief explanation of the 18 categories of nature’s contributions to people distinguished by IPBES (1), and some illustrative indicators and references used in the systematic review of their global trends from the 1970s, summarized in Figure 1. See (1) for fuller description of the 18 categories and (8) for details on indicators and methods and complete list of references.

Natures contribution to people	Brief explanation	Examples of trends in selected indicators since the 1970s	Realms assessed in cited examples
1. Habitat creation and maintenance	The formation and continued production, by ecosystems or organisms within them, of ecological conditions necessary or favorable for living beings of direct or indirect importance to humans.	Significant global habitat declines (5) with differing magnitudes across regions.	Terrestrial
2. Pollination and dispersal of seeds and other propagules	Facilitation by animals of movement of pollen among flowers, and dispersal of seeds, larvae or spores of organisms beneficial or harmful to humans.	Global decrease in pollinator diversity (10, 120, 121), most of them in industrialized regions; little evidence elsewhere (122-126). Habitat destruction indicates decrease (10, 127)	Terrestrial
3. Regulation of air quality	Regulation by ecosystems, of CO ₂ / O ₂ balance, O ₃ , sulphur oxide, nitrogen oxides, volatile organic compounds, particulates, aerosols, allergens. Filtration, fixation, degradation or storage of pollutants that directly affect human health or infrastructure.	Increase in air pollutants from biomass burning, deforestation, and agriculture, but increase in plant leaf area increases pollution retention and vegetation protects soils and prevents dust (128). Unresolved urban impact (129).	Terrestrial
4. Regulation of climate	Climate regulation by ecosystems (including regulation of global warming) through: (a) effects on emissions of greenhouse gases, (b) effects on biophysical feedbacks from vegetation cover to atmosphere, such as those involving albedo, surface roughness, long-wave radiation, evapotranspiration (including moisture-recycling) and cloud formation, (c) processes involving biogenic volatile organic compounds, and regulation of aerosols and aerosol precursors by terrestrial plants and phytoplankton.	Stable but spatially variable terrestrial sequestration of carbon in biomass and emissions from land use change, substantial interannual variation (27,28, 130). Precise contributions of ecosystems incomplete.	Terrestrial
5. Regulation of ocean acidification	Regulation, by photosynthetic organisms (on land or in water), of atmospheric CO ₂ concentrations and therefore seawater pH; this affects associated calcification processes by many marine organisms important to humans (such as corals)	Stable terrestrial greenhouse gas emissions from land use change and sequestration in biomass (130). Increase in ocean carbon sequestration (130). Warming of upper ocean increases area of nitrogen-fixing phytoplankton, increasing ocean net primary productivity (131, 132).	Terrestrial and marine

6. Regulation of freshwater quantity, location and timing	Regulation, by ecosystems, of the quantity, location and timing of the flow of surface and groundwater used for drinking, irrigation, transport, hydropower, and as the support of non-material contributions.	Increased runoff quantity and flow speed due to deforestation, expanding (un-irrigated) cropland, and urbanization (133, 134). Ecosystem change impact on water regulation established but incomplete (135).	Terrestrial
7. Regulation of freshwater and coastal water quality	Regulation (through filtration of particles, pathogens, excess nutrients and other chemicals) by ecosystems or particular organisms, of the quality of water used directly (e.g. drinking, swimming) or indirectly (e.g. aquatic foods, irrigated food and fiber crops, freshwater and coastal habitats of heritage value).	Decreased filtration potential due to increased impervious surfaces and vegetation removal (136, 137), though varies globally (138). Mechanisms well understood but filtration effectiveness varies widely among studies (136, 137).	Terrestrial
8. Formation, protection and decontamination of soils and sediments	Formation and long-term maintenance of soil structure and processes by plants and soil organisms. Includes: physical protection of soil and sediments from erosion, and supply of organic matter and nutrients by vegetation; processes that underlie the continued fertility of soils important to humans (e.g. decomposition and nutrient cycling) filtration, fixation, attenuation or storage of chemical and biological pollutants in soils and sediments.	Global decline in soil organic carbon, regional variation (139-143).	Terrestrial
9. Regulation of hazards and extreme events	Amelioration, by ecosystems, of the impacts on humans or their infrastructure caused by e.g. floods, wind, storms, hurricanes, heat waves, tsunamis, high noise levels, fires, seawater intrusion, tidal waves. Reduction or increase, by ecosystems or particular organisms, of hazards like landslides, avalanches	Decreased natural hazard regulation from land use change including shoreline hardening, floodplain development, and detrimental forest management (144). Reduced in most cases, but there have been positive changes (144, 145). Mechanisms understood but poorly studied <i>in situ</i> (144).	Terrestrial, marine
10. Regulation of detrimental organisms and biological processes	Regulation, by organisms, of pests, pathogens, predators or competitors that affect humans or plants or animals of importance for humans. Also the direct detrimental effect of organisms on humans or their plants, animals or infrastructure.	Decline in natural enemies of pests, and in competent hosts of vector-borne and zoonotic diseases in all regions, with larger declines in the tropics and sub-tropics (146, 147). Decreased natural habitat in agriculture to support pest predators (148).	Terrestrial
11. Energy	Production of biomass-based fuels, such as biofuel crops, animal waste, fuelwood, agricultural residue pellets, peat.	Increasing extent of agricultural land, with regional variation (149). Global decrease in forested area to provide fuelwood, with regional variation (27, 28).	Terrestrial
12. Food and feed	Production of food from wild, managed, or domesticated organisms. Production of feed (forage and fodder) for domesticated animals or for aquaculture, from the same sources.	Increase in harvested area, yields, and meat and milk production, with regional variation (149). Decrease in fish catch potential (150), but increase in aquaculture, with regional variation (151).	Terrestrial, freshwater, marine

13. Materials, companionship and labor	Production of materials derived from organisms in cultivated or wild ecosystems, for construction, clothing, printing, ornamental purposes. Live organisms being directly used for decoration, transport, and labor.	Increasing extent of agricultural land, with regional variations (149), and area of cotton remained stable. Global decline in forest area; much spatial variation (27, 28).	Terrestrial
14. Medicinal, biochemical and genetic resources	Production of materials derived from organisms used for medicinal, veterinary and pharmacological purposes. Production of genes and genetic information used for plant and animal breeding and biotechnology.	Declining fraction of known medicinal species due to decline in indigenous and local knowledge, including access to customary territories; this reduces capacity to identify new drugs from nature (152). Declining measures of phylogenetic diversity (153).	Terrestrial
15. Learning and inspiration	Provision, by landscapes, seascapes, habitats or organisms, of opportunities for the development of the capabilities that allow humans to prosper through education, acquisition of knowledge and development of skills for wellbeing, information, and inspiration for art and technological design (e.g. biomimicry)	Declining population living in direct proximity to nature due to urbanization and migration (154, 155). Reduced human-nature interactions (156). Declining diversity of life from which to learn, measured as phylogenetic diversity (153).	Terrestrial
16. Physical and psychological experiences	Provision, by landscapes, seascapes, habitats or organisms, of opportunities for physically and psychologically beneficial activities, healing, relaxation, recreation, leisure, tourism and aesthetic enjoyment based on the close contact with nature	Declining area of natural intact and traditional landscapes and seascapes due to urbanization and land use change (157, 158).	Terrestrial
17. Supporting identities	Landscapes, seascapes, habitats or organisms being the basis for religious, spiritual, and social-cohesion experiences.	Stable human environments provide culture with the possibility to attribute value to it and form identities (159-161). Increased globalization, urbanization, and environmental degradation deterioration had leads to decreased stability of land use and land cover (161, 162).	Terrestrial
18. Maintenance of options	Capacity of ecosystems, habitats, species or genotypes to keep options open in order to support a good quality of life.	Increasing species extinction rates; major regional variation (55, 163). Decreasing phylogenetic diversity (153). Trends based on data but the places and species for highest diversity loss are not well established.	Terrestrial

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