Correspondence

Ernst Haeckel's prescient view

Last month's vote to formally recognize the 'Anthropocene' epoch (see *Nature* https://doi.org/10.1038/d41586-019-01641-5; 2019) recalls the visionary work of Ernst Haeckel, who died 100 years ago this August. In his book *The History of Creation*, published in 1868, he introduced the idea of an 'Anthropozoic age' to highlight humans' profound impact on the environment.

More than a century later, the atmospheric chemist and Nobel laureate Paul J. Crutzen coined the term 'Anthropocene' to denote our present geological epoch, marked by humans' ongoing effect on Earth's atmosphere (see *Nature* **415**, 23; 2002 and *Nature* **467**, S10; 2010). For Crutzen, this started in the eighteenth century, but Haeckel maintained that human influence began much earlier, with the "era of cultivated forests".

Haeckel's view is borne out by modern evidence that our impact on the environment began with agriculture, well before the Industrial Revolution. For example, the massive decline in Indigenous populations in the sixteenth century, particularly in South American native cultures such as the Inca Empire, led to a dip in global CO_2 concentrations (7–10 parts per million) and air temperatures (about 0.15 °C) as land cultivation ceased (see A. Koch *et al. Quat. Sci. Rev.* **207**, 13–36; 2019).

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Heritage research to underpin restoration

Two months on from the tragic fire at Paris's Notre Dame Cathedral, we hope that restoration efforts will draw on scientific-heritage research.

Multidisciplinary research can guide historical interpretation and restoration, and inform the public's subsequent perception of the building's authenticity. It also helps to limit potentially irreversible damage to the world's heritage in the future.

The European Commission's 2021–27 Horizon Europe programme recognizes the importance of heritage research to societies and economies. And an international declaration signed in Paris at this year's World Meeting on Heritage, Sciences and Technology aims to improve the understanding, preservation and enhancement of heritage and to illuminate how heritage research can inspire scientific discoveries (see go.nature.com/2kpnjxj). To this end, the declaration calls for heritage studies to be included in the mission statements of research organizations, cultural institutions and funding agencies.

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Forests: incentives for regeneration

In our view, it is unrealistic to expect countries to achieve forest-restoration targets by prioritizing natural forest regeneration over tree plantations in all cases (S. L. Lewis *et al. Nature* **568**, 25–28; 2019).

Monoculture or mixed-species tree plantations could be better alternatives in highly degraded areas that are distant from native seed sources. Financial compensation for landowners who conserve carbon, water or biodiversity in regenerating forests might not match incomes from agriculture or commercial forestry. And the global demand for wood fuel and fibre means that these are increasingly sourced from tree plantations.

Different types of native forest, tree plantation and agroforest are acceptable restoration interventions, on the basis of the needs of local communities and national aspirations (see go.nature.com/2wpcybe). Commercial tree plantings, including mixtures of native and exotic species, can be managed to foster natural regeneration, providing direct financial benefits to farmers (N. T. Amazonas *et al. For. Ecol. Mgmt* **417**, 247–256; 2018).

Innovative practices and policies are needed to make natural regeneration profitable over huge scales. We also need to determine where such regeneration is likely to succeed, and where it can offer benefits beyond carbon storage (P. G. Molin *et al. J. Appl. Ecol.* **55**, 2767–2778; 2018).

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Forests: in defence of the Bonn Challenge

Although natural regeneration can be ecologically effective in the right environmental and socio-economic contexts, the importance of the Bonn Challenge should not be downplayed (see S. L. Lewis *et al. Nature* **568**, 25–28; 2019). Its aim is to promote the recovery of degraded and deforested lands (see go.nature.com/2jc5it3), rather than solely to mitigate climate change, as the authors imply.

Some of the land pledged in response to the challenge will consist of plantations, but not to the extent suggested by the authors. Brazil, for example, is committed to regenerating 12 million hectares (not 19 million hectares), which includes restoration of native forest as well as new plantations. Also, given that restoration must accommodate a multiplicity of needs, including those of smallholder farmers, we disagree that agroforestry should be confined to treeless regions. And some agroforestry systems use native species for restoration — Evergreen Agriculture integrates crops with *Faidherbia albida* trees, for example.

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Beware small dams as well as large

Artificial barriers across rivers can reduce freshwater biodiversity by fragmenting habitats. According to Günther Grill and colleagues, dam construction has disrupted two-thirds of large rivers worldwide (*Nature* **569**, 215–221; 2019). We have found that many more rivers have been disrupted by hundreds of thousands of smaller artificial structures such as weirs, ramps, culverts and fords.

With the help of volunteers, we discovered 23,618 artificial barriers to free-flowing rivers in Great Britain (J. Jones *et al. Sci. Tot. Environ.* **673**, 756–762; 2019). Across Europe as a whole, we have so far recorded more than 415,000 barriers, 85% of which are small structures (see go.nature.com/2kc1orn). Many of those we surveyed are no longer in use and so could be removed.

Essentially uninterrupted rivers do still exist in Europe — in the Balkans, for example — so it is important to safeguard their biodiversity by keeping them free of barriers large and small.

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