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Box 1. Literary Depictions of a Posthuman Earth

While most literature follows the trope that humans become effectively immortal through technologies enabling colonisation of other planets (e.g., works by Robert Heinlein, Anne McCaffrey, Arthur C. Clarke, and Lois McMaster Bujold), relatively few writers have explored ideas of a posthuman Earth. The first was Mary Shelley's 1826 novel 'The Last Man', which ends with one man wandering the Earth after a plague destroys all human life. H.G. Wells' 1895 novel 'The Time Machine', portrayed a time when all traces of humanity are lost and 'crab-like creatures' live by the light of a dying Sun. Dougall Dixon went further, imagining how existing organisms might evolve in 'After Man: A Zoology of the Future', expanded upon by Kurt Vonnegut's 'Galapagos', which followed the devolution of humans to a nonsapient end. Possibly, the most realistic treatment of human extinction is the television show 'The Inner Light', a 'Star Trek: The Next Generation' episode (1992), which chronicles the extinction of a humanoid species and their world as their sun extinguishes all life in the planetary system. The conclusions of those writers who have pondered a posthuman world converge – while technology may provide a temporary reprieve, the extinction of humanity is inevitable.

that it will outlive us. For us, the lineages we have dedicated our scientific and personal efforts towards are mistletoes (Santalales) and gulls and terns (Laridae), two widespread groups frequently regarded as pests that need to be controlled. The place we care most about is south-eastern Australia – a region where we raise a family, manage a property, restore habitats, and teach the next generations of conservation scientists. Playing favourites is just as much about maintaining wellbeing and connecting with the wider community via people with shared values as it is about maximising future biodiversity. As a crisis discipline, conservation biology takes a toll on its first responders, routinely confronting us with accelerating extinctions and a society increasingly detached from wildlife and nature. Acknowledging humanity's finite future and championing our beloved groups and places affords a reassurance that our individual actions matter. The ultimate form of conservation optimism.

Although our perspective is ecocentric, maximising post-Anthropocene diversity need not be considered selfish nor altruistic. The more lineages and ecosystems that persist, the greater the likelihood that humanity's support systems will continue, extending our remaining time and improving our quality of life in the interim. Collectively, humans have the capacity to do extraordinary things. By considering our finite future and the lasting consequences of the actions we prioritise, we can minimise collateral damage to the biosphere and maximise the raw material for Earth's next phase.

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Science & Society

Funding Conservation through an Emerging Social Movement

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People will pay to protect our environment. To encourage donations, it is fundamental to understand the values that motivate people. Here, we identify a new opportunity to attract donations from an emerging social movement to deliver benefits to the natural world.

Valuing Nature

Nature has intrinsic value. The idea that nature is valuable for its own sake has long found support in philosophical thought, and the concept has been embraced globally in agreements, such as the United Nations Convention on Biological Diversity [1]. The notion of animal welfare emerged from the argument that our moral responsibility extends beyond our species, and encapsulates all animals capable of suffering [1,2]. Biocentrism takes our responsibility further and encourages us to respect all living organisms, regardless of the capacity to suffer [2]. Ecocentrism has the widest scope, recognizing value in all of nature whether biotic or abiotic [2]. It is widely accepted among conservationists that value is inherent in all organisms, the ecosystems in which they are embedded, and the components that sustain these ecosystems (www.ecologicalcitizen.net/statement-of-ecocentrism.php) [1].

Conservation is further justified by the ways in which nature benefits humanity. Nature has instrumental value to society through the ecosystem services that provide our society with food, materials, energy, and recreation, as well as cultural identity and spiritual meaning [3]. Intrinsic, instrumental, and relational values all motivate people to engage with, and donate to, environmental causes [4].

Since conservation has insufficient funding, attracting financial support is critical [4,5]. For an environmental message to attract donors, the message must resonate with the donors' principles [6]. Identifying the values that motivate affluent social groups could unlock an opportunity for conservation.

Effective Altruism

There is a novel social movement that promotes evidence-based charity, called 'effective altruism.' Effective altruists are different from traditional charity donors – they do not give their own emotions a prime position, but rather maximize the good that their charity dollars do using a rational approach to evidence-based giving [7,8]. Effective altruists think like investors; they assess charities' cost-effectiveness based on objective, transparent, and quantitative evidence, utilizing common metrics, such as cost per life or life-year changed. Effective altruism, which is part of the broader shift towards evidence-based practices, has sparked a demand for charities that provide solid evidence of the benefits brought to the charities' beneficiaries.

Effective altruists invest in the charities and causes where each dollar spent will yield the greatest overall benefit. To compare charities, the standard practice by effective altruists is to calculate the number of lives or life-years changed per charity dollar (see www.givewell.org/how-we-work/our-criteria/cost-effectiveness/cost-effectiveness-models) [7,8].

This method assesses value as proportional to the suffering alleviated. In this way, the method shares a philosophical perspective with utilitarianism, which underlies the animal welfare movement [1,2,9]. Humans and animals, with their capacity to suffer, merit the support of effective altruists. However, abstract entities, such as species and ecosystems, cannot experience the emotion of suffering in the same way. Currently, the environment does not appear among lists of charities recommended for effective altruism (one is available at www.givewell.org).

A charity that captures the market of effective altruists could leverage a substantial resource for conservation. In 2017, the organization GiveWell, which maintains one database of charities suitable for effective altruists, alone moved US$117 million to its recommended charities (www.givewell.org/about/impact). Capturing this resource for the environment will depend on refining environmental charities and messages to resonate with the values of effective altruists [6].

Motivating Effective Altruists

Effective altruists use one central criterion to select causes: how effective the cause is at accomplishing good. Alternative causes are assessed using a structured framework, in which the effectiveness is the product of three components: the 'tractability' (how readily achievable it is to make progress), the 'capacity' (the room for extra resources to bring additional benefits, following the law of diminishing returns), and the 'scale' (the number of human or animal lives affected) [8]. Using this framework, effective altruists can prioritize and move between different charitable domains [8,9].

Consider these same three components in the context of conservation. Utilizing charity money for environmental progress is tractable, as demonstrated by the success of programs that interface between donors and land markets to achieve an overall reduction in environmental footprints [10,11]. The capacity for environmental causes to save many lives or life-years per dollar is established by the countless animals that continue to suffer from ongoing degradation and collapse of their ecosystems; and the scale of environmental causes can be immense, which we will illustrate using the example of fisheries.

What a Fish Costs

Fish are an environmental resource, so they have a price. Take the major fishery for anchoveta (*Engraulis ringens*; Engraulidae) in Peru. A fisher typically values the right to catch a ton of anchoveta at around US$33 [12]. Taking 27 grams as a conservative weight of one anchoveta, 1 ton would contain around 37 000 individual fish [13]. These calculations indicate that a donor could pay a fisher just over US$33 and avert the death of 37 000 individual fish. In other words, 1 US dollar buys the lives of over 1100 fish.

From the perspective of the life-years per dollar metric, which perceives the reduction of suffering as the supreme outcome, this is a high return on investment. There is robust scientific evidence that fish are capable of subjective feelings and experiences, at least to the capacity of animals that are already considered by effective altruists to be capable of doing so [14]. Indeed, we are already incorporating fish welfare into our daily lives; for example, biologists are mindful of fish welfare during their research.

The earlier calculations illustrate how 1 US dollar can avert many more deaths of fish (1100) than of cows (eight lives; www.animalcharityevaluators.org/charity-review/animal-equality) or humans (0.00156 lives; www.givewell.org/how-we-work/our-criteria/cost-effectiveness/cost-effectiveness-models). Recall that effective altruists emphasize the use of logic to guide evidence-based giving. Effective altruism is neutral with regard to species identity, but can adjust decisions between alternative species based on expected lifespans and biological capacity to experience emotional states [7,14]. Whilst many donors assign lower value to the life of one fish than to the life of one cow or one human, an effective altruist would be captivated by the opportunity to save a number of lives three or more orders of magnitude higher. Beyond this rational motivation, reduced fishing pressure can reduce suffering in additional species, as the interconnectedness of animals within ecosystems means that depleted resources (e.g., fish stocks as food) can cause widespread suffering (e.g., marine mammals) [15].

Capturing Money for the Natural World

What challenges might emerge from moving down this path? Although effective altruists are motivated by helping individual organisms, this motivation does not consider the role of species in ecosystems. A possible solution to this disparity may lie in selecting a species that not only appeals to effective altruists, but also yields quantifiable benefits for the wider ecosystem. It may not be a great leap to recognize that the diversity and abundances of fish, as members of ecological food webs, not only sustain marine ecosystems, but also an ecosystems' capacity to adjust to future climate [16]. Indeed, the abundance of particular species are often key drivers of ecosystem services [17], many of which are valued by humanity.

Effective altruists need to evaluate the greatest overall benefit, that is, define and measure benefits. Such evaluation will challenge conservation programs. They would need to engage in two components that sway donations: social marketing and impact evaluation. Social marketing acknowledges that the most successful programs are those that resonate with the values of the target audience, enabling donors to evaluate and choose charities that align with their own values [6]. Such choices redistribute funds between competing charities, which raises the ethical dilemma of swaying choice. To guide rational choice between multiple candidate charities, conservation programs would need to engage in impact evaluation. This involves empirically testing the outcomes of policies and programs [18]. To illustrate, consider GiveDirectly. This charity, regarded as a gold standard by effective altruists, has used registered, randomized control trials to demonstrate the benefits of the charity's unconditional cash grants to people in developing countries (see www.givedirectly.org/research-at-give-directly). The appeal of a charity to effective altruists hinges on the charity's capacity to provide access to transparent, quantitative evidence. Therefore, conservation charities that target effective altruists could contribute to the development of these two areas in conservation generally.

Evidence-based donating is likely to grow as more donors seek evidence of their charity's value. To reduce fishing via donations, existing mechanisms range from organizational negotiations with fishers or their parent body to the formal purchase of fishing licenses or tradeable quota. What is now needed is organizations, particularly nonprofits, to enable such exchanges. This would involve collecting the charity dollars from donors, then using this purchasing power to purchase a reduction in fishing effort. There are already organizations that mediate between donors and the environment, such as in The Nature Conservancy's purchases of private land [10]. Organizations that not only adopt this approach, but also show the quantifiable benefits expressed in metrics, such as cost per life or life-year changed, can make the key advance of aligning environmental benefits with the values held by the emerging community of effective altruists.

Effective altruism represents an opportunity to capture a substantial source of funding for environmental conservation. The possibilities go well beyond our oceans; although we have illustrated the opportunity using fisheries, many environmental interventions have the potential to demonstrate a measurable change in lives. Organizations that step in and bridge the gap between effective altruism and ecosystems could leverage millions of dollars to help reduce our burden on the environment.

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Forum

3D Imaging Insights into Forests and Coral Reefs

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Forests and coral reefs are structurally complex ecosystems threatened by climate change. *In situ* 3D imaging measurements provide unprecedented, quantitative, and detailed structural information that allows testing of hypotheses relating form to function. This affords new insights into both individual organisms and their relationship to their surroundings and neighbours.

The Importance of Structural Measurements

Corals and trees form the building blocks of their respective ecosystems. The structural complexity of forests and coral reefs plays an important role in the biodiversity, productivity, and functionality of these ecosystems [1]. Corals and trees have been hypothesised to follow similar architectural growth rules that shape their structures [2]. Structure and function are linked; organisms have evolved under constraints of nutrients, light, water or space limitations, competition, and reproduction strategies (Box 1). Understanding 3D structure will assist in making links between structure and function that are needed to develop a general theory of ecosystem assembly and function [3].

New *in situ* 3D structural measurements from terrestrial LiDAR (light detection and ranging) and Structure-from-Motion (SfM) analysis of digital photography enable precise, accurate, and comprehensive structural measurements. These measurements have already provided unique insights into forests and coral reef ecosystems [3,4], but it is only now that analytical processing methods are sufficiently mature to assist in understanding functional–structural relationships by testing hypotheses relating form and function. Critically, these improved measurement approaches will allow more accurately defined baseline mapping and quantitative monitoring. When combined with traditional ecological and physiological knowledge, along with airborne or satellite remote sensing, such *in situ* observations can revolutionise how we monitor and manage forest and coral reef ecosystems in a changing climate.