ISSN 2398-5496

Vol 4, No 1, 2019
SPECIAL ISSUE: BIODIVERSITY

the journal of population and sustainability

Information

ISSN 2398-5496

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Acknowledgements:

The editor would like to thank Hilary Anderson, Bill Anderson-Samways, Peter Slater and our anonymous reviewers for their help in producing this issue.

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The Journal of Population and Sustainability

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Editorial introduction – special issue: biodiversity

David Samways – Editor

The focus of this issue of the JP&S is biodiversity. While anthropogenic climate change has become the dominant issue in public environmental discourse, and is increasingly recognised as an existential risk, loss of biodiversity has received less public attention (Veríssimo, et al. 2014; Legagneux et al., 2018). Indeed, climate change has come to so dominate discourses about human environmental impact that rather than being seen as just one of many impacts it is sometimes employed as a *synonym* for environmental impact per se, with the implication that solving the climate change problem solves all other environmental problems. However, while climate change is undoubtedly an urgent and critical issue, the wider human impact on the earth's ecosystems may represent as great, if not a greater, risk (Ehrlich and Ehrlich, 2012) that will not vanish once anthropogenic carbon emissions have abated. Climate change is itself an important driver of species extinction, but it is only part of the story; as the contributors to this issue attest, in general, it is the sheer size and extent of human activity that is driving species extinction. The 2019 Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) reported the main drivers of species extinction as: land-use change and the direct overexploitation of animals, plants and other organisms; climate change; pollution including the introduction of invasive alien species; human population growth and economic growth (IPBES, 2019).

Legagneux et al. (2018) report that between 1991 and 2016 climate change received up to eight times more media coverage than biodiversity, a finding that they argue cannot be explained by differences between the number of scientific papers published or the level of research funding. They identify a number of reasons for this discrepancy including the fact that the causes, consequences and possible solutions to climate change were simpler to communicate than the more complex and diverse dimensions of biodiversity loss and its consequences for human beings.

> Attempts to reduce global warming can easily be summarized as any action that will limit it to 1.5 or 2°C. However, there is no clear biodiversity benchmark to meet that can easily be translated to policy. (Legagneux et al., 2018 p.4)

Climate change is frequently regarded as an essentially technological problem, which has, as with almost all previous environmental challenges, technical solutions. While potential policies to reduce national carbon footprint entail a range of social changes to reduce consumption as well as technical fixes, it is the latter in the form of transitions to low and zero carbon technologies that grasp public attention. Policies built around these technical fixes have obvious attractions to politicians too since they hold out the hope of mitigating climate change without either having to attempt to change their constituents' behaviour by intervening in choices previously regarded as entirely personal and self-regarding (e.g. what people eat, the size of their family, etc.), or moving to an alternative economic model. Such a view sees technological progress, in the form of greater efficiency, renewable energy, energy storage systems, new technology for increased agricultural production, carbon capture and storage (CCS)[1] and so on, as the solution to our environmental problems. However, while these technical fixes are essential to curbing carbon emissions they are unlikely to meet IPCC targets if we do not simultaneously address consumption - of which population growth is an important multiplier. Moreover, and perhaps most significantly, the dominance of climate change in public environmental discourse has eclipsed other more apparently intractable and possibly more critical problems, the foremost of which is loss of biodiversity and species extinction. One reason for this may lie in the fact that loss of biodiversity, as the recent IPBES report shows, has so many causal factors that no simple technical fixes analogous to those for decarbonising of the economy appear to be available.

The Norwegian eco-philosopher Arne Naess characterised mainstream environmentalism as "shallow ecology" since its aim was to:

1 Indeed the 2016 Paris UNFCCC agreement on climate change relies on as yet unsubstantiated CCS technology and systems to achieve the zero emissions target by 2060–70.

> Fight against pollution and resource depletion. Central objective: the health and affluence of people in the developed countries. (1973 p.95)

One does not have to subscribe to Naess' "deep ecology" to concur with his general observation that a significant part of environmental concern has largely been oriented to these narrow anthropocentric objectives. The recent growth in environmental concern, while dominated by the "climate crisis", has also included anxieties about the fate of other species, much of which might be attributable to the "*Blue Planet* effect"[2] (Gell, 2019). Environmental concern is at the highest level ever recorded (Smith, 2019). But does this represent a clear indication that narrow anthropocentrism is being softened and that people might be open to significant changes in lifestyle and curbs on their personal autonomy to protect the environment? A brief overview of the history of environmental concern shows shifts in attitudes but also little appetite for bearing the cost of action.

Arguably, the environmental movement, and indeed popular environmental consciousness, as we know it today began in the 1960s with the serialisation in *The New Yorker* of Rachel Carson's *Silent Spring* (1962). Carson's focus was on the effect of pesticides on what we would now call biodiversity, a term only coined in the mid 1980s, but the movement she inspired went beyond this to mobilise against the impact of anthropogenic pollution in general on the natural world. However, in contrast with many environmentalists, much of the general public's concern with the environment, as in earlier times, myopically focused on the shorter-term consequences of such pollution for themselves, their families and communities. In the developed world, public concern about environmental degradation was largely pacified by regulatory measures and technical fixes which cleaned up the most obvious local pollutants or shifted them elsewhere. Over the next half-century or so the environment waxed and waned in the anxieties of the general public, arguably mirroring the ups and downs of the economy (Kahn and Kotchen, 2011; Scruggs and Benegal, 2012). However, during this time the longer-term and global nature of human environmental impact flagged up by books like the Club of Rome's *Limits to Growth* (Meadows et al., 1972) slowly seeped into public environmental discourses, and latterly the issue of climate change with its global scope and impact on future generations has taken centre-stage.

2 BBC television's Blue Planet II first broadcast on 29 October 2017 highlighted the impact of plastic pollution.

It might be argued that this transition from a local and short-term focus to a global and long-term one represents a paradigm shift in public environmental consciousness. However, a number of studies show that despite this broadening of scope and the currently very high levels of concern, local and short-term environmental issues such as water and air quality are of at least equal importance in people's minds (IPSOS, 2018; McCarthy, 2019). Moreover, although survey data shows that people are genuinely concerned about the plight of other species and biodiversity (see for example European Commission, 2015), evidence also indicates that issues such as wildlife conservation can rank well below climate change, air pollution and dealing with waste (IPSOS, 2018). The results of survey data and polls need to be treated with some degree of caution since attempting to get a firm handle on public attitudes to the environment is extremely difficult. Media coverage of particular issues at particular times, such as plastic pollution, has a massive influence on public perception of the importance of an issue in terms of its overall environmental impact (Henderson, 2019). Moreover, where it comes to individual behaviour, people are obviously much more likely to engage in an action that is easily achieved without personal cost (be it monetary, time, convenience or personal autonomy), like declining a plastic carrier bag, than more fundamental and costly changes to their lifestyles such as eating less meat, driving fewer miles or taking fewer flights[3] (see Taylor, 2012; Alcock et al., 2017; Fisher et al., 2018; Hill, 2019). Moreover, a number of studies have shown that personal experience of extreme weather events increases concern about climate change and also increases the likelihood of changing personal behaviour (Spence et al., 2011; Broomell et al., 2015; Demski et al. 2017). Such studies indicate that threats that are far-off in time and space are unlikely to motivate significant behavioural change until the effects are immediately obvious and costly.

Despite these caveats, it is clear that the environment has become a narrative that is an important dimension of public discourse – with the 2019 UK general election attesting to this. However, it is also clear that these high levels of anxiety are not only fairly readily eclipsed by other factors such as economic recession or security issues (Scruggs and Benegal, 2012; Taylor, 2012), but are also still primarily concerned with human well-being. The picture is made more complex since this relatively narrow anthropocentrism is tempered with a genuine interest in the fate

3 Notably, the question of having fewer children to save the planet has yet to make it onto the pollsters' questionnaires.

of other species – even if this has largely been with those that people find most appealing. Whether this concern with the condition of nature can be elevated to the same level as that of climate change is yet to be seen. Where it comes to concrete action, the public still has great faith in technological solutions and is resistant to restrictions to their personal autonomy. Technology will play a critical role in mitigating climate change, but without also simultaneously addressing the two other terms in the IPAT equation (impact = population x affluence [consumption] x technology) the existential threat of ecological collapse will remain.

When it comes to species extinctions, public concern has largely been focussed on the so-called 'charismatic' vertebrate species such as the giant panda, tiger, rhino, elephant, leatherback turtle, birds of prey and so on. In the first paper in this issue, Fred Naggs draws on his extensive knowledge of land snails (probably counted by most as amongst the least charismatic of animals) as barometers of biodiversity to illustrate the contrasting effects of population growth on the islands of Madagascar and Sumatra. Naggs points out that while public concern about vertebrates is legitimate, invertebrate extinctions are massive and particularly worrying since they are part of the ecological foundation on which creatures higher up the food chain are reliant. He writes: "If we are concerned about biodiversity loss then their story needs to be told and their fate needs to be a focus of our attention." Examining the islands of Sumatra and Madagascar individually, Naggs concludes that the driving forces of biodiversity loss in each are a product of endogenous and exogenous factors. In the case of Sumatra exogenous demand for natural resources has been the major factor, while in Madagascar it has been endogenous population growth that has led to deforestation and ecological destruction. Naggs finds conservation responses to the developing anthropogenic mass extinction wanting. He argues that the objective of 'sustainable development' has subordinated and compromised conservation programmes. But in particular Naggs finds that the notion of 'sustainable development' fails to address the combination of overconsumption and overpopulation as the ultimate drivers of the sixth mass extinction. Given the pace of species loss, Naggs argues that there is an urgent need for a zoological species inventory. While technology cannot halt species extinctions, the preservation of biological material offers the technological means of underwriting traditional conservation and may offer the possibility of species restoration if future environmental conditions permit.

Like Fred Naggs, Freya Mathews is critical of the notion of 'sustainable development'. In our second article she examines how the concept of biodiversity conservation has unwittingly been complicit in the expansion of human numbers and the decline of populations of wild species. She begins with the observation that anthropocentrism, or human-centeredness, has been the organising principle of global developmental modernisation enabling the growth of human numbers and ecological footprint leading to the ever-greater "annexation" of the habitats of wild species. Mathews suggests that the shift from the concept of 'wilderness' conservation, which contained a moral pushback against anthropocentrism, to the conservation of 'biodiversity' entailed an unintended contraction of scope so that conservation became popularly understood as the prevention of species *extinctions*. Thus, rather than enabling the flourishing of species populations, conservation was only triggered by critical endangerment of particular species that fell below 'minimum viable populations' – ones which were only a fraction of their pre-disturbance numbers. The eventual mutation of *viable* populations into *sustainable* populations permitted further modernisation and industrialisation clothed with a veneer of 'sustainability' in terms of biodiversity. This validated human populations in the billions while accepting wild species populations at minimal levels. For Mathews, biodiversity conservation is clearly self-defeating and requires replacement with a concept that protects earth-life in its own right beyond anthropocentric concerns. While biodiversity, she argues, is a necessary but not sufficient condition for the flourishing of earth-life, proliferation and abundance is also necessary for optimal and ecologically proportional species populations. Mathews refers to the latter as *bioproportionality* and is a principle which requires humankind to allow species to optimise their populations in accordance with their inherent ecological dynamics. However, it follows that humankind must also optimise our own numbers in ecological proportion with those of other species, which, Mathews argues, requires a massive consensual or incentive-driven reduction in human numbers.

Articulating similar themes to Freya Mathews' paper, Philip Lymbery focuses on how the growing footprint of humankind's food system has marginalised wilderness and wildlife contributing to the creation of the Anthropocene. Critically, he shows that the huge populations of animals kept for food has a direct effect on biodiversity. More than 27bn domesticated animals are living at any one time with more than 65bn slaughtered for meat every year (Ritchie and Roser, 2017). And these numbers are growing rapidly, with population growth, rising incomes and urbanisation as the driving forces (WHO, ND; Godfray et al., 2018). Supporting an ever-increasing and more affluent human population, agriculture has crowded out wilderness until it now only represents a fraction of the earth's land area. Intensification of livestock production in factory units rather than in open farmland has gone hand-in-hand with the industrialisation of the production of crops used to feed them, which in turn has led to the destruction of habitats and loss of biodiversity. Moreover, Lymbery warns that "the way we produce food alone could take us to the brink of catastrophic global heating".

To achieve a sustainable global food system three factors must be addressed: the level of meat consumption, the method of production, and the size of the human population[4]. All three require programmes of action dealing with underlying drivers: for population reduction these include poverty, poor education, and inadequate access to contraception. Reducing consumption of animal-based foodstuffs requires governments and food businesses in the high-consumption regions to lead the transition by encouraging adoption of a greater proportion of plant-based foods and the setting of targets to reduce the proportion of meat and dairy products consumed. Lymbery calls "on the United Nations to forge a global agreement to create a regenerative food system without factory farming and excessive meat production". With fewer humans consuming smaller amounts of high-quality meat, factory farming can be abandoned and animals returned to the pastures. Lymbery argues that returning to mixed, rotational agriculture brings a host of environmental benefits including increases in biodiversity.

While the previous articles have primarily focused on biodiversity loss, Philip Cafaro and Frank Götmark's paper examines the impact of immigration, and consequent population increases, on both climate change and biodiversity policy objectives of the individual nation states of the European Union (EU) and the region as a whole. They argue that there is a shared implicit assumption amongst environmental groups and the EU policy community that "*population size and immigration rates have no important roles to play in the efforts of EU nations to meet their environmental challenges and create ecologically sustainable societies*". Examining projected European population growth under five

4 These factors map nicely onto the I=PAT equation mentioned above: environmental impact of the food system = human population x meat consumption x technology of food production.

immigration scenarios, they establish that relatively small annual changes in the rate of immigration have the potential to accumulate into large overall differences in population in the relatively near future. Applying these demographic scenarios as multipliers of three possible trajectories of per capita greenhouse gas (GHG) emissions, Cafaro and Götmark demonstrate that "in every case, increased immigration leads to larger populations, which in turn lead to smaller decreases in total GHG emissions, in individual countries and in the EU as a whole". Similarly, population growth has negative effects on biodiversity, although they admit this is more difficult to quantify than for GHG emissions as the relationship between population density and biodiversity is complex and they are therefore unable to show the effect of their five population scenarios. However, using a number of different examples they make a convincing case to show that the pursuit of policies designed to preserve and enhance Europe's biodiversity is made all the more difficult with an increasing population. They state: "while the complexity of the phenomenon prevents us from affirming a strict 1:1 inverse relationship [between population density and biodiversity], the overall trend is clear: greater human numbers reduce biodiversity". Cafaro and Götmark conclude, therefore, that the implicit assumption is false and that population growth through immigration represents a serious impediment to the realisation of both GHG and biodiversity policy objectives.

We close with Herman Daly's thought provoking review of Bill McKibben's *Falter: has the human game begun to play itself out?* – a book that counters the Panglossianism of writers like Steven Pinker without losing a degree of optimism and a sense that resistance to the dangers humankind faces is possible.

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INVITED ARTICLE

A tale of two islands. The reality of large-scale extinction in the early stages of the Anthropocene: a lack of awareness and appropriate action.

Fred Naggs

Fred Naggs is a Scientific Associate at the Natural History Museum, having retired after 42 years at the Museum in 2016. Initially the Curator of non-marine Mollusca, Fred was appointed as the Biodiversity & Conservation Officer in 2003. He established international collaboration and ran programmes throughout south and much of tropical south-east Asia. He is a visiting professor at Chulalongkorn University, Bangkok.

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Abstract

The endemic biotas of oceanic islands were vulnerable and many have been lost. The more ancient, complex and dynamic biotas of continents were more resilient but are now being obliterated. Sumatra and Madagascar are large continental plate islands with very different histories and biotas that exemplify the situation on continental land masses. Both tropical islands have suffered massive habitat loss and species extinction from human population pressure, Sumatra mostly from global and Madagascar from local pressure. Snails demonstrate the complex history of faunal origins as illustrated by the relationships between Madagascan, Indian and southeast Asian snail faunas and their plate tectonic geological history. Snails also reveal our limited *knowledge of the details but not the scope of extinctions through habitat loss. International agencies are failing to address the root causes of natural habitat loss and consequent extinctions, which are overpopulation and an economic system based on perpetual growth. The fallacy of sustainable development and the limitations of current conservation practice are addressed. Recognition that we cannot stop extinctions in the immediate future demands a new, supplementary approach to conservation based on advances in molecular technology.*

Keywords: Sumatra; Madagascar; conservation; sustainable development; land snails; cryo-banking.

Introduction

From a negligible figure just a few thousand years ago humans and their livestock now constitute over 95% of mammalian biomass (Bar-On et al., 2018). From an ecological perspective, there are simply too many of us. The biodiverse world that we were born into is disappearing and many branches of life will not be with us in the future. Much attention is focussed on the threats to a few iconic species but the extent of extinctions remains largely hidden, unknown in detail but indisputable in scale. We need to be aware of what we are losing. The earliest undisputed evidence of life on Earth dates from at least 3.5 billion years ago and there is evidence that life began much earlier. We, together with all complex multicellular organisms, belong to the eukaryotes and each individual is the end product of 2.7 billion years of eukaryote evolution. To appreciate the wonder of each group of animals and plants, we need to consider their history, and how they came to be where they are. The history of life is an interaction of biotic evolution with the complexities of the planet's geological history, continuous fluctuations in climate and vast spans of time, punctuated by frequent local and rare global cataclysmic events.

Despite the numerous perils facing marine environments, most extinctions in the current episode have been confined to terrestrial and non-marine aquatic environments. Many vertebrates are under intense threat, populations have crashed, some have become extinct, others are close to extinction (Ceballos et al., 2015). This justly generates much human anguish. However, over 99% of animals are invertebrates (Tetley et al., 1999). Invertebrate extinctions are massive, most notably in the biodiverse terrestrial faunas of tropical forest. Invertebrates form the foundation on which ecosystems and many life forms are totally reliant. If we are concerned about biodiversity loss then their story needs to be told and their fate needs to be a focus of our attention.

Different invertebrate groups can provide different perspectives. Numerous insects have become extinct without the losses being recorded (Hochkirch, 2016). Insect populations have crashed in many parts of the world, from Europe (Hallmann, et al., 2017) to the tropics (Lister and Garcia, 2018), along with their associated predators such as many reptiles, amphibians and birds. However, some of these results are controversial (Willig et al., 2019; Lister and Garcia, 2019) and although chemical controls are the main suspects, notably neonicotinoids, there is often no proven link to causes of declines in abundance. Despite overwhelming subjective evidence for massive drops in insect numbers (Vogel, 2017), we have a problem in that despite numerous recording schemes of insect species occurrence, there have been few long-term studies of insect species abundance.

Molluscs can provide a different perspective. They are a major invertebrate group in terms of both biodiversity and biomass (Bar-On et al., 2018), and land snails can be particularly informative about patterns of diversity and current extinction events (Lydeard et al., 2004). I am interested in and concerned about the whole of living diversity but land snails have several attributes that render them particularly informative about all scales of evolution and changes in the environment, such as climate and habitat changes through time. Good examples of this were made available when the channel tunnel was excavated, giving access to previously hidden fossil-rich deposits (Kerney et al., 1980; Preece and Bridgland, 1999), and examples of successive horizons are equally informative in tropical ecosystems such as in Jamaica (Goodfriend and Mitterer,1988, 1993; Paul and Donovan, 2005; Donovan et al., 2013).

Land snails are not what is termed a 'natural group'. In the distant past, several aquatic and only distantly related snails colonised the land independently (Little, 2009). Some such as the terrestrial Caenogastropoda are derived from winkle-like ancestors, they have separate sexes and seal the apertures of their shells with a plate that is attached to the top of their tails; they are numerous in parts of the tropics, less so in temperate regions. The other main groups included in the

Pulmonata have more developed lungs and are hermaphrodites, they occupy all habitat types in which land snails occur from deserts to marshland, from leaf litter to the heights of tree canopies.

Snails generally have relatively poor powers of dispersal but, given sufficient time, a few are passively dispersed over long distances, by hurricanes for example. There is also strong evidence of long-distance dispersal of snails by birds (Gittenberger et al., 2006; Leeuwen et al., 2012). In the short to medium term, most snails are confined to their location in ways that many other organisms are not. Unlike the majority of terrestrial arthropods, they cannot run or fly; the vulnerability of their delicate bodies is primarily offset by retracting and taking refuge within their shells. This limited motility makes them vulnerable to extinction when conditions change. However, where natural habitats are continuous, they can successfully change their distributions, including latitudinal and altitudinal changes, with the shifting of ecosystems in response to climate change. The shells may sometimes be delicate but many are robust and may survive long after the snail has died. In several lineages the shells are vestigial or lost altogether. There is a continuous transition between snails, semi-slugs and slugs but for convenience and to allow generalisations to be made, slugs are not considered here.

Whatever the season, a good measure of what snails are present in an extant habitat can be gained by collecting their shells. Thus, natural history museums around the world often hold extensive collections of shells that require no special procedures for their preservation and storage. Where well documented, these collections provide a partial record of where snail species were found in the past. Day to day routine identifications and classifications may be carried out solely by examination of snail shells. However, more sophisticated methods of morphological study of internal organs and molecular methods are essential for more critical studies. Such studies have shown that numerous cryptic species and even higher taxonomic categories can be recognised compared to identifications based solely on shell characters.

Extinctions on oceanic islands and on continents

The unique radiations of animal diversity that occurred on oceanic islands, most less than 10 myr old, took place in habitats that were free of the taxonomically diverse and highly evolved systems of predators and competitors that had developed on continents through tens and hundreds of millions of years. This contributed to island biotas' vulnerability to human introductions of continental species that had attuned to the harsh selective pressures from which the evolution of oceanic island species had been sheltered. The arrival of humankind on oceanic islands has progressively led to the widespread loss of oceanic island species, their unique habitats and ecosystems (Fordham and Brook, 2008). Recorded extinctions of land snails on oceanic islands exceed those of all other groups combined (Lydeard et al., 2004).

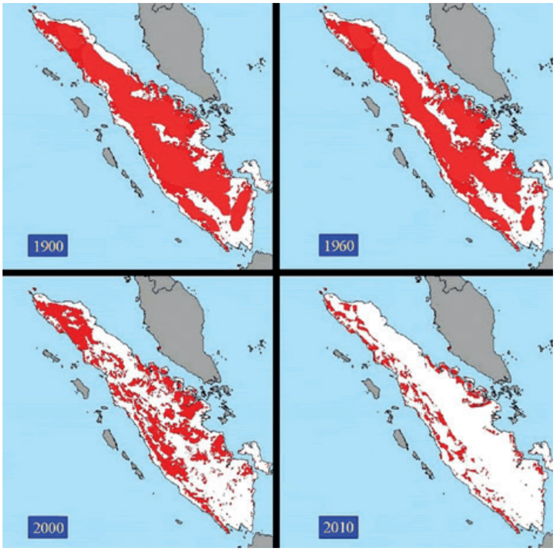
Losses on continental land masses through human activity also have a long history but they have generally been less visible. We are now losing continental species at an unprecedented rate, with complete and complex ecosystems that have evolved over many millions of years. This is a growing tragedy of the Anthropocene. Although these large-scale extinctions are now taking place on continental land masses, the circumscribed nature of continental islands (fragments of continental tectonic plates) allows them to be examined as discrete units and used as exemplars for what is going on in continents as a whole. To this end, aspects of the fauna of two of the world's largest and very different tropical islands, Madagascar and Sumatra, are considered here in the context of regional faunas with particular reference to their land snails.

Sumatra

Sumatra epitomises a manifestation of the sixth mass extinction and demonstrates the disaster that is rapidly unfolding in southeast Asia (Sodi et al., 2004; Hughes, 2017). What has happened in Sumatra has significantly influenced my thinking on extinction because nearly all of the lowland and much of the montane forest habitats, which previously blanketed the landscape, have been lost in my lifetime (figure 1). At 443,066 square kilometres, an area greater than twice the size of Great Britain, Sumatra is a large, geologically complex island about 3.3 times the area of Peninsula Malaysia. It was repeatedly connected to the continental land mass as an integral part of Sundaland, a southeast Asian global biodiversity hotspot, throughout glacial episodes. Thus, during the past 2.6 million years of ice ages, its biotic history and composition was as a part of continental southeast Asia (Woodruff, 2010).

Figure 1.

Forest loss on Sumatra due to logging and conversion to agriculture. The red depicts remaining forest cover.



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Straddling the equator at an angle of about 45°, Sumatra is geologically a part of continental Eurasia and part volcanic in origin, its southern border lies along the subduction zone of Sundaland and the Indo-Australian plate and it is part of one of the most tectonically active areas in the world. Frequent volcanism, earthquakes and tsunami impact on the biota. Notably, the explosive eruption of Mount Toba 73,500 years ago must have had a massive impact on southeast Asia and peninsula India's biota through ash deposition (Bühring and Sarnthien, 2000; Jones, 2007). Nevertheless, a mixture of plains and complex mountain systems offered a diverse array of forest habitats in Sumatra providing it with some of the richest biodiversity on the planet. Despite enormous expenditure on conservation effort, lowland forest was close to being entirely lost at the end of the twentieth century (Whitten, et al., 2001), just a few diminishing patches remain. Iconic mammals such as the Sumatran tiger, rhinoceros, elephant and orangutan are all widely recognised as being critically endangered.

Benthem Jutting (1959) listed just 192 species of land snails from Sumatra and a few have been described since (Maassen, 1999, 2000; Páll-Gergely, 2017). However, we have little idea of how many species might have been present in Sumatra 60 years ago; it is likely to have been closer to 2,000 than 200. What is clear is that with most natural habitat destroyed in Sumatra, many of the endemic species will be extinct. The invertebrate diversity of Sumatra's lowland forests was never studied methodically and now never can be. This demonstrates what scientists mean when they speak of species going extinct before they have even been described. The loss of 98% of forests in large parts of Indonesia is projected by 2022 (Hughes, 2017, 2018). Sumatra stands out because the scale of destruction has been so rapid. It is not just forests that are disappearing. Limestone hills are habitat islands rich in biotic diversity with particularly high snail diversity and density. The more isolated a limestone hill, the greater the likelihood that it possesses high levels of biotic endemism and the greater the risk of its destruction for limestone extraction.

In Sumatra the main driver of habitat loss and consequent extinctions was explicitly and succinctly identified by Whitten et al. (2001), three pages of essential reading for anyone who wants to understand where conservation efforts in Sumatra stood at the turn of the century. What happened in Sumatra should and could have been avoided, and at least mitigated, but it wasn't. Despite massive conservation effort, all of the management plans, political accords and expenditure of unknown millions of US dollars, deforestation continued unabated. Big business and political corruption, both equally ruthless, rode over any conservation efforts. The whole purpose of the flourishing academic field of conservation was questioned by Whitten et al. (2001, p.1):

> In these same three decades we have also seen conservation biology rise as a respected and attractive discipline, with great successes in producing journals, books, and students. But if conservation biology is ineffective in helping to stop something as globally significant as the devastation of Indonesian forests, then what, please, is the point of it?

Sumatra has a human population of approximately 52 million, around 90.5 people per km^2; the human population of Indonesia as a whole has increased to 3.5 times its 1955 level. For comparison, consider Sri Lanka, which has a population of just over 20 million, 340 per km^2, about twice its 1955 level with 82% living in rural areas. Much forest has been lost in Sri Lanka but it has a number of relatively well-protected areas and has so far retained a rich biota including large mammals such as thriving populations of elephants and leopards. It appears that local human population pressure in Sumatra, with 6.75 times the area of Sri Lanka, might not have been the major driver of habitat loss and extinctions. It is in fact clear that the primary driving force of habitat loss and extinctions in Sumatra is external, consumption of its resources around the world, an insatiable demand for its products, notably palm oil and timber, facilitated by greed and corruption.

Madagascar

With an area of 587,041 km², Madagascar is a large continental fragment of Gondwana, one of the two great landmasses that separated from the single land mass of Pangaea with the opening of the Tethys Ocean about 175 million years ago. The southern continent of Gondwana was separated from the northern land mass of Laurasia for about 100 myr. During the subsequent breakup of Gondwana, Madagascar together with India, separated from Antarctica about 125 mya, having separated from Africa some 20 myr earlier. Around 88 mya, India separated from Madagascar. Madagascar moved slowly north to its current longitude whereas India was drawn north much more rapidly until it collided with Eurasia (Smith et al., 1994). India is still thrusting into Asia and continues to force up the Himalaya.

The world was a much warmer place throughout most of Madagascar's existence and large tracts of what is currently dry land were covered in shallow sea. The limestone deposited during these marine incursions provided a particularly rich habitat for limestone biotas including land snails. 88 myr of isolation have endowed Madagascar with a truly unique biota. Unlike Sumatra, Madagascar is an ancient land mass and geologically is relatively stable, although there is some tectonic activity and it possesses dormant volcanos (Pratt et al., 2016). The closest Indian coastline is now some 3,800km away but it was of course closer throughout much of the past 88 myr and there were periods when a series of islands, now largely submerged, provided potential stepping stones for biotic transfer. Mainland Africa, currently some 450km away at its closest point, has remained in relatively close proximity throughout.

Whereas the climate in Sumatra is hot and wet throughout the year, the climate in Madagascar is much more complex being dominated by the joint action of the moist southeast trade winds and the wet northwest monsoon. The east coast has a high annual rate of precipitation but on reaching the plateau prevailing winds have lost much of their humidity resulting in only light rain and mist, leaving the west in a rain shadow; areas of the southwest are semidesert. Madagascar's biota has exploited the diverse range of habitats that are strongly influenced by this climate. For agriculture, the climatic variations across Madagascar present challenges ranging from severe drought to deluge flooding.

A large proportion of Madagascar's biota is endemic but, during its 88 Ma of isolation, rare dispersal events across the seas introduced new biotic elements from further afield, some of which radiated into significant new components of Madagascar's biota. A classic example is the lemurs, now confined to Madagascar. Molecular phylogenetic and anatomical evidence suggests that the ancestor of the currently recognised 111 species and subspecies, 20% of the world's primate species, reached Madagascar from Africa at around 54 mya (Martin, 2000; Mittermeier et al., 2008). Following the loss of natural habitats (figure 2), some 95% of lemur species are on the threshold of extinction. The IUCN Species Survival Commission (SSC) raised over US$8 million to spearhead efforts to save them with a 3-year conservation plan in 2013 (IUNC, 2013). An IUCN updated assessment in 2018 (Bristol Zoo, 2018) showed that, despite some local successes, the threat of lemur extinction has increased.

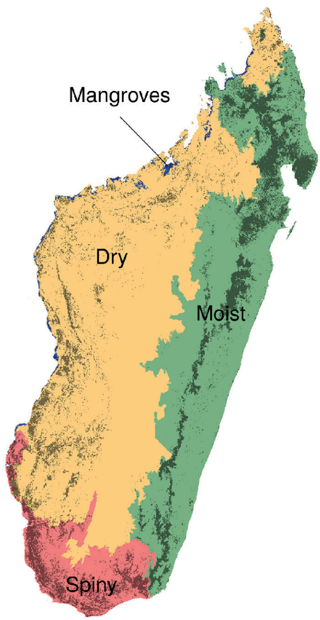

Figure 2.

Ecoregions and forest types in Madagascar. Madagascar can be divided into four climatic ecoregions with four forest types: the moist forest in the East (green), the dry forest in the West (orange), the spiny forest in the South (red), and the mangroves on the West coast (blue). The dark areas represent the remaining natural forest cover in 2014. Forest types are defined on the basis of their belonging to one of the four ecoregions. (Reproduced from Vieilledent et al., 2018).

Evidence strongly supports two Africa-to-Madagascar dispersal events for chameleons across the Mozambique Channel, one at about 65 mya, the second at about 47 mya (Tolley et al., 2013). These two rare events gave rise to the amazing diversifications of chameleons in Madagascar, about half of the world's chameleon species diversity. According to an assessment by the SSC, 52% are threatened, including 5 species that are critically threatened and 18% are near threatened (Hance, 2014).

As with Sumatra, by the middle of the twentieth century, some 200 species of land snails had been recorded from Madagascar. However, following intensive studies, notably by Emberton between 1990 and 2009, the total number reached about 1100 (Slapcinsky, 2014). Despite their commendable efforts, it is impossible for a handful of people to have described most of the land snails of the 587,041 km² of Madagascar. With no one dedicated to their study, there is unlikely to be the same pace in new species descriptions. Many will now be extinct but there may have been about 2,000 species in total.

Despite its 88Ma history as an isolated land mass, Madagascar's snail fauna has origins that extend across all directions of the Indian Ocean. The most distinctive components, the 115 described species of Acavidae, are considered to be Gondwanan relicts (Emberton, 1999). Their ancestors were distributed across Gondwana prior to its breakup and acavids are now found only on continental fragments of Gondwana: South America, Africa, Madagascar, the Seychelles, Sri Lanka and Australia. The mode of dispersal of acavids is to sit tight on continents for tens of millions of years and wait for plate tectonics to do the work for them. The acavids possess large, often brightly coloured shells and produce disproportionally large, bird-like eggs. With even their hatchlings being relatively large, their size seems likely to have contributed to the fact that they appear not to have spread across oceans by natural means.

The genera *Kalidos*, *Boucardicus* and *Tropidophora* have radiated into numerous Madagascan species. There is evidence that the ancestor of *Kalidos* made its way to Madagascar from southeast Asia, possibly via India. *Boucardicus* shows similarities with genera found in south and southeast Asia but, with similar looking fossils in 100 myr old Burmese amber, it is clear that these groups have been around for a very long time and their relationships need to be established by molecular methods A different distribution pattern is shown by *Tropidophora,* which also occurs on the opposite land area of Africa, on the Comoros and the Seychelles. Related genera are found around the Indian Ocean from Socotra, mainland Yemen and Oman, with a separate genus and two species occurring in the Western Ghats, India (Raheem et al., 2014).

They may be more ancient arrivals but the radiations into numerous species within single genera such as *Kalidos* and *Tropidophora* are suggestive of relatively recent arrivals of these genera into Madagascar, possibly during the Miocene (23 mya to 5.3 mya).

What the lemurs, chameleons and land snails have in common with much of Madagascar's and other tropical biotas is that most species have very restricted distribution ranges within the complex mosaic of naturally diverse habitats. The majority of Madagascar's land snails have been described on the basis of a few individuals from a single locality, some from partially weathered shells of species that may have already been extinct at the time of their description. Habitats cannot be transformed by human activity without the consequent wholesale loss of localised species. The composition and diversity of land snails conveys the long biotic history of Madagascar better than any vertebrate group and their Anthropocene extinction is already well underway.

There have been years of debate and a lack of consensus on the causes of tropical diversity but, whatever the mechanism, high diversity dominated by limited range distributions is widespread in the tropics and has been for millions of years (Brown, 2013). Despite the age of this biotic diversity of lineages in the wet tropics, they are now extremely vulnerable to habitat loss and transformation because of their often-restricted distributions and their being surrounded by a matrix of human transformed habitats.

With well-established recognition of its incredibly rich biodiversity and extreme levels of endemism, Madagascar has been a priority target of international research and conservation effort for decades (National Research Council, 1980; Myers, et al., 2000; Goodman and Benstead, 2005). Efforts reached a height during the implementation of a series of National Environment Action Plans between 1993 and 2008, when hundreds of millions of US$ were spent on over

500 environmentally-based projects. Eight Millennium Development Goals were established for a fifteen-year period from 2000, supported by the Madagascar Millennium Development Goals National Monitoring Survey (INSTAT, 2014) and the protected areas network was expanded threefold. Projects aimed at sustainable development and reducing poverty have failed, in fact none of the Millennium Development Goals were met nor was progress made towards them, and relentless deforestation continues unabated (Waeber et al., 2016; Vieilledent et al., 2018). The protected area network is widely ignored.

Madagascar is larger than Sumatra but has a smaller human population estimated at 20-27 million, approximately half that of Sumatra (population density of Madagascar some 46 per km^2; Sumatra 90.5 per km^2). It might be thought that human population levels would have less impact. However, Madagascar is in a sorry state (UNIC, 2019):

> The country's health and education systems are not really working, they are crumbling; In the last two years 77 % of the population have been living on less than 1.25 dollars a day.

More than 92% of Malagasy live on less than US$ 2 a day (World Bank, 2013). Madagascar's infant mortality rate is over 5% and three-quarters of the population live in rural areas. The estimated median age in 2017 was 18.7, compared with 40.1 for the UK, indicating that population growth is hardwired into the immediate future. Although the total fertility rate (TFR) has fallen from 7.3 in 1960 to 4.18 in 2016, Madagascar's TFR is still nearly double replacement level. Logging and mining controls are ineffective. Large numbers of people have little choice other than to take what they can from their environment, regardless of any conservation needs. Traditional slash-and burn agriculture is increasingly practiced in desperation and on a completely unsustainable scale, destroying natural habitats. They are not alone. As pointed out in the executive summary of the World Conservation Strategy (IUCN-UNEP-WWF, 1980, p.vi):

> ... hundreds of millions of rural people in developing countries, including 500 million malnourished and 800 million destitute, are compelled to destroy the resources necessary to free them from starvation and poverty.

Reponses to the biodiversity crisis

> "It is far better to grasp the Universe as it really is than to persist in delusion, however satisfying and reassuring." – Carl Sagan

The cases of Sumatra and Madagascar demonstrate both the scale and causes of biodiversity loss. In Sumatra conservation efforts have failed in the face of insatiable global demand for its resources along with greed and corruption, while in Madagascar endogenous factors, including poverty and population growth, have been the most significant causes of habitat destruction. Given the scale of biodiversity loss as exemplified by these islands, the following sections go on to consider some aspects of the global responses by governments, conservation agencies and academics.

Earth Optimism was launched in 2017 with a series of meetings including in Washington (Smithsonian Conservation Commons, 2017), in Cambridge (Cambridge Independent, 2017) and London (ZSL Institute of Zoology, 2017). The momentum of Earth Optimism continues and a Conservation Optimism summit was held at Oxford in 2019 (University of Oxford, 2019).

A number of justifications for Earth Optimism have been put forward. One suggestion is that such an approach is essential in order to engage with the public. Others suggest that people who are seeking careers in the field need to be encouraged by a sense of optimism and that it is needed to secure corporate and government funding. To quote from the ZSL Institute of Zoology (2017):

> Budding and perennial conservationists need to feel inspired and continue in the profession, not put off by pessimism. The public, businesses and government need to know that their actions can make a difference.

However, promoting optimism in this way exaggerates successes in relation to the size of the problem and ultimately is not only inappropriate but misleading. Importantly, it infantilises the public by assuming that they will only engage with optimistic information and runs the risk of undermining trust in scientific integrity. Perhaps the most worrying aspect of Earth Optimism is that in focussing on the celebration of those success stories the overriding issues of human overpopulation and overconsumption that are driving mass extinction are ignored.

The Convention on Biological Diversity (CBD) grew around the concept enshrined in Article 1 of the Convention (CBD, 1992, p.3):

> The objectives of this Convention, to be pursued in accordance with its relevant provisions, *are the conservation of biological diversity*, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources, including by appropriate access to genetic resources and by appropriate transfer of relevant technologies, taking into account all rights over those resources and to technologies, and by appropriate funding.

With almost universal celebration and after years of preparation, the CBD was launched in Rio de Janeiro in 1992. Bureaucracies proliferated and numerous agencies were created so that many thousands are employed at great cost in developing both national and international plans and in attending massive international conferences. From a brief initial focus on conservation it soon became a behemoth of international agencies seeking to extract funding resources for development, programmes that had little if anything to do with biological conservation. It is an empire of vested interests that has failed to deliver conservation objectives. Extinctions continue unabated (Anon, 2016) and bio-nationalism has impeded international conservation efforts. The United Kingdom's flagship CBD programme, the Darwin Initiative, epitomises the change in direction that effectively constitutes a high-jacking of the CBD agenda from a biodiversity capacity building focus to a development agency based on poverty alleviation. Worthy as these objectives may be in their own right, they have not even slowed the current scale of biodiversity loss.

Brown (2015, p.1) provided an impeccable and succinct demolition of the notion of sustainable development:

> Unfortunately, "sustainable development," as advocated by most natural, social, and environmental scientists, is an oxymoron. Continual population growth and economic development on a finite Earth are biophysically impossible. They violate the laws of physics, especially thermodynamics, and the fundamental principles of biology. Population growth requires the increased consumption of food, water,

> and other essentials for human life. Economic development requires the increased use of energy and material resources to provide goods, services, and information technology.

Sustainable development goals can provide neither sustainability nor a pathway to halting the sixth mass extinction. However, governments, numerous agencies and commercial enterprises around the world, together with academics, fail to acknowledge their flawed nature. For example, the UN Sustainable Development Goal 15, life on land (UN, 2019), should be of key importance to biodiversity loss. Goal 15 seeks to sustainably manage forests, combat desertification, halt and reverse land degradation and halt biodiversity loss. However, there are no realistic mechanisms or new ideas put forward of how this could be achieved on a scale commensurate with the problem. Reference is made to the Lion's Share Fund, a worthy programme but one that can only have a tiny, if useful, impact on biodiversity loss.

A wide range of conservation activities are pursued by the IUCN including the formulation and development of international agreements such as the 1974 Convention on International Trade in Endangered Species, and the CBD. Together with partner organisations the IUCN is pursuing a pathway to conservation based on the concept of sustainable development. However, their Red Listing system (IUCN, 2019) is unique in aiming to provide hard data of extinction risk in support of conservation and, particularly for large vertebrates, has many merits. An example of an outstanding achievement with invertebrates is the IUCN Red List of European Terrestrial Snails (Neubert et al., 2019), which was developed from many years of recording schemes and input from numerous contributors. However, the situation for a single species, the world's largest cat, the tiger, is illustrative of the problematic nature of the IUCN's approach. Project tiger (National Tiger Conservation Authority, 2019) has been running for nearly 50 years, has cost millions of US$, involved thousands of people and supported numerous careers. Yet controversy surrounds the results of surveys and in obtaining accurate figures of tiger numbers (Karanth, 1995; Karanth et al., 2017; Mazoomdar, 2019). In contrast, only a handful of people have been dedicated to surveying land snails in the tropics, a totally inadequate number for assessing the status of numerous often tiny snails in the world's rainforests. For most species and areas, it is not remotely possible to obtain accurate information within a timeframe commensurate with the urgency imposed by the rate of habitat loss and extinctions. We remain in ignorance or, in Red List terminology, data deficient. The WWF sets out its agenda in the *Living Planet Report 2018: Aiming higher*. This would be a highly commendable document but for the fact that it ignores the major underlying causes of the problems it identifies: human overpopulation and the ecologically impossible concept of sustainable development. Together with overpopulation, economics is at the heart of our current unsustainable trajectory. Global economics is currently based on growth and benefits from population growth and increased wealth with consequent increases in consumption. Clearly, this is not to suggest that reduction in poverty is in itself undesirable but that it has inevitable, undesirable and unsustainable consequences. Much can be done to mitigate but not remove the impact of increased consumption, for example, by the reduction and ultimate elimination of the use of fossil fuels and by modifications to diets. However, the human ingenuity argument fails to recognise that improvements that science and technology have brought to human welfare have not been shared with the natural world. While economic growth is necessary to improve the welfare of the world's poor, endless economic growth to satisfy the wants of an ever-increasing global consumer class is simply unsustainable.

The desperately urgent need for a strategy aimed at establishing an inventory of what remains of living diversity has been recognised for some considerable time (Wheeler, 1995). It is utterly shameful that this has not happened. The Earth Biogenome Project (2019) is wildly overambitious to the extent of being utterly unrealistic in aiming to sequence, catalogue and characterize the genomes of all of Earth's eukaryotic biodiversity over a period of ten years. This to include what it estimates as the 80-90% of eukaryotes that have yet to be described. Over two centuries of just searching out living diversity has left us with a long way to go and locating the whole range of species is a long way off, even though that unknown number is rapidly declining. The Earth Biogenome Project (EBP) is described as a 'moonshot for biology' (EBP, 2019). It might have launched but it cannot reach its ten-year scheduled destination. Despite its extravagant claims as a means of contributing to the conservation of species (Lewin, et al. 2018), as it stands, it will not do so. Sequencing eukaryote diversity might provide employment for numerous scientists, if only for a decade; it can satisfy human curiosity and yield new means of exploiting natural resources but it will not contribute to preventing the loss of natural habitats or reduce human driven climate change. Their analogy with space exploration seeks to link the EBP with human achievements that are widely celebrated and have numerous indirect benefits. However, all such scientific endeavours should be judged by the proportionality of effort and cost in the context of priorities on our own planet and the destruction we are collectively inflicting on it. In the context of the sixth mass extinction, the disappearance of its subject matter, and unless balanced in new directions, the EPB objectives are a self-satisfying indulgence. This is analogous to a consortium of hospitals of global prestige around the world being obsessed with gaining academic stature while ignoring countless thousands of dying patients.

Curiosity driven research provides inspiration and motivation for learning about the universe and the EPB has the merit of recognising the scale of the issue and timeliness, if not the constraints. In addition, the EPB fails to accept the requirement for voucher collections that are needed to support the molecular sequencing. Unless intended as an abstract exercise, or an exclusively molecular based alternative to existing concepts, it is meaningless to sequence samples without being able to relate them to physical entities. Voucher specimens are the preserved samples linked to the genomes to be sequenced. Some species might be sufficiently well known for their identity to be accepted but such are insignificant compared to the vast majority of described but poorly understood species and for undescribed species. Traditionally, voucher samples were whole preserved specimens and there is still a place for these but detailed images could in many instances be a practical option in combination with tissue sampling. In addition to traditional methods of preservation and frozen tissue collections, it is possible to prepare specimens in an ultimate state of preservation by preserving viable cells, cell lines, without sacrificing or harming the animal. Most importantly such preservation can underwrite all traditional conservation efforts. If this were included in the EBP protocols then it would completely transform the value of the programme. This is the obvious direction in which resources and research efforts should be directed. It is early days and there are numerous difficulties in extending the practice to a wide range of species but cryogenically stored viable sperm and egg cells are already being used as a measure to conserve species close to extinction (Hermes et al., 2018) and viable somatic cells can potentially be cloned. Thus, it is not only possible to conserve and utilise genetic diversity of threatened species but preservation of viable cells offers the potential to restore species if they should become extinct (Naggs, 2017), together with associated organisms such as their gut biota. Viable cells of extinct species are already being stored. The Hawaiian tree snail *Achatinella apexfulva,* supposedly the first recorded extinction of 2019, was given extensive media coverage including by the National Geographic (Wilcox, 2019) and the Natural History Museum (Pavid, 2019). Living cells of *Achatinella apexfulva* are cryogenically stored in the San Diego Zoo Institute for Conservation Research's (2019) Frozen Zoo. As with Kew's Millennium Seed Bank, this material could potentially be cryogenically stored for hundreds of years and should be the routine mode of preservation. Who can say what future capabilities might be but, if we do not act now, whatever current and future potential value they might have will be lost forever and options for their use will not exist.

One hurdle to surmount is that access to specimens has become much more difficult and complicated. The way forward is to establish and nurture long-term relationships, particularly with biodiverse countries. The pilot project that I ran in 2013 demonstrated the value of collaboration and that viable cell preparation could be routinely added to existing field practice (Naggs, 2017). The sixth mass extinction should position natural history in the forefront of scientific endeavour to record and conserve living diversity in an urgent structured, focussed and relevant way.

The Intergovernmental Panel on Climate Change (IPCC) is the United Nations body invested with the task of evaluating the science related to climate change. Scientific evidence is not determined by consensus but the overwhelming assessment of scientific information is clear and cannot be ignored, humankind is causing global warming. Where the IPCC has failed is in recognising that by our very existence and ever-growing numbers, we cannot avoid global warming. Indeed, there is clear evidence that the rise in CO_2 and CH_4 began some 7,000 years ago with human driven deforestation and the development of agriculture and livestock tending (Ruddiman, 2014, and references therein). Furthermore, Ruddiman presents the case that without anthropogenic influence, we would already have entered a new ice age. We undoubtedly need to take steps to mitigate global warming but, even when we deal with eliminating fossil fuel, as we must, the transformed landscapes and biomass of humans and their livestock will continue to deliver elevated CO_2 and CH_4 above natural levels.

Climate change is integral to earth history and happens regardless of human activity, sometimes very rapidly. It is instructive to recognise that throughout much of earth's history CO_2 levels have been much higher and global temperatures have been much higher than they are now and natural events could overwhelm any anthropogenic changes. We should be prepared for the inevitability of climate change in one direction or another. Living diversity has accommodated to climate change throughout its existence. What is unique about the current situation is that natural forest landscapes have been transformed into a mosaic of modified (largely agricultural) habitats and fragmented natural forest, the forest remaining as isolated and shrinking patches. Combined with climate change, the barriers to dispersal will precipitate a new catastrophic wave of extinctions and there is an urgent need to provide habitat corridors and to be prepared to intervene with the seeding of new habitats that develop in response to climate change.

Taking stock

The history of life on earth shows it to be a dynamic mix and match of blending and separating of biotas through time. In addition to the many other human impacts on the natural world is an acceleration of this mixing to a global scale and breakdown of geographical isolation. In the mixing of biotas there are a few winners and numerous losers. Increased mixing leads to a reduction in local endemism and thus a reduction in biodiversity.

Sumatra and Madagascar demonstrate that both local and global human population pressures produce the same outcome, habitat loss and extinction. Socioeconomic factors and human numbers present an unsolvable conundrum. There is a widespread belief that human ingenuity can solve such problems. Proponents of this view correctly point out that living standards throughout much of the world have improved dramatically through the application of science and technology. The same cannot be said of natural environments that have suffered as a consequence. We are already a long way down the road of destroying the natural world. Habitat fragmentation combined with climate change will precipitate a surge of extinctions in the near future. Conservation is thriving as an academic discipline and can point to success stories but overall it is a failure. Such an assessment is often dismissed as a doom and gloom scenario but there are many opportunities to act in positive ways. There are too few habitats approaching pristine condition for them to be the sole focus of conservation effort and some transformed habitats retain significant subsets of biological diversity and need to be integrated into conservation practice. Again, snails show the way in demonstrating that some forest fragments and transformed habitats can still support a significant subset of forest species (Raheem et al., 2008, 2009; Triantis et al., 2008), although such transformed habitats are being rapidly lost to more intensive modes of agriculture.

We have to accept that we cannot halt large scale extinctions and act accordingly. A new drive for a zoological species inventory, that also conserves biodiversity and secures options for the future, is essential in the context of massive species loss. For conservation in the here and now, new and direct emergency action is needed to protect natural habitats. One overriding need is for a simple and straightforward mechanism for providing significant funding for poor but biodiversity rich countries to protect natural habitats. Used for the benefit of their human populations, this is possibly the only way to arrest immediate biodiversity loss where it is driven by poverty. This is happening in a small way but it needs to be on a huge scale, something appropriate for private agencies and governments to engage with through the United Nations.

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INVITED ARTICLE

Bioproportionality: a necessary norm for conservation?[1]

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Abstract

In the early stages of the environment movement, one of the principal objects of conservation was wilderness. In the 1980s, the category of wilderness gave way to that of biodiversity: conservation was reconceived as biodiversity conservation. With this change of categories, the focus of conservation shifted from the saving of vast and abundant terrains of life to the saving of types of living thing, particularly species. A little-noted consequence of this reframing was a reduction in scale: ***minimum viable populations*** *of species, which set targets under the new biodiversity-based conception of conservation, were often orders of magnitude lower than the populations that might have occurred in wilderness areas. Exclusive focus on the value of diversity thus tended to lead conservationists to lose sight of the value of abundance. To correct this disastrous miscarriage of environmental intentions, a new*

1 This essay is adapted from a much longer paper, "From biodiversity-based conservation to an ethic of bio-proportionality" (Mathews 2016). Please refer to that paper for full bibliography and further details.

complementary category is here proposed: ***bioproportionality****. It is not enough to conserve minimum viable populations of all species. The aim should be to optimize such populations. Optimized targets will be estimated by reference to the principle of bioproportionality: the population of each species should be as abundant as is consistent with an ecologically proportionate abundance of adjoining populations of other species. Applied to the human population, this principle will require a dramatic reduction.*

Keywords: Anthropocentrism; biodiversity; bioproportionality; environmental ethics; optimal population; wilderness.

In our current era of ecological emergency, in which more than a million species have recently been deemed to be at imminent risk of extinction (IPBES 2019), how should we value the living matrix of our planet? How should we share the resources of this planet with our fellow creatures? How much do we owe them? What, if any, are the limits on the uses we may make of them and of the living systems in which they are embedded?

This has been the great ethical blind-spot of the Western tradition, and it is the blind-spot around which modernity - now exported, in the form of science-based industrial development, to most corners of the globe – has organized itself. From the perspective of modernity, 'nature' is a moral nullity, there for the taking. Of no ethical significance in itself, it merely sets the stage for ethics, which begins with the entrance of *el supremo*, the mighty human – the protagonist relative to whom the rest of reality acquires meaning.

The story of this blind-spot – which is known as anthropocentrism – has become familiar in recent decades thanks to environmental philosophy and cognate discourses. But in practice anthropocentrism has continued to define the project of modernization and industrial development throughout the world. This has led, as we all know, to a human population that is now splitting its ecological seams and progressively and inexorably annexing the habitats of all wild species.

To the limited extent that there has been moral pushback against this human annexation of the planet, it has been via the environment movement and its correlative ethos of conservation. In the early stages of this movement, one of the principal intended objects of conservation was wilderness. Environmentalists campaigned in the 1970s and 1980s to save forests and other extensive tracts of relatively ecologically intact land, wherever these still remained. For conservation purposes, wildernesses were generally defined as large areas in which ecological and evolutionary processes were free to continue unfolding without undue human disturbance. (Devall and Sessions, 1984, 126-129; Rolston, 1988)[2] Implicit in the defence of wilderness was an anti-anthropocentric acknowledgment that wild communities were morally entitled to their own existence - that other beings and life forms were created not merely for the (human) taking but existed in a kind of parallel moral universe which it was not always our prerogative to appropriate or disturb.

The notion of wilderness was a legacy of 18th-19th century Romanticism, where Romanticism had been the first major episode of reaction against the regime of modernity instituted in Europe by the Scientific Revolution of the 17th century, followed by the triumphal 18th century Age of Reason. With its implied threat to anthropocentrism – and hence to the project of industrial development – Romanticism was historically short-lived, and, not surprisingly, so was the 20th century wilderness movement. The very category of wilderness, with its aesthetic and spiritual overtones, seemed out of place in the otherwise thoroughly modernist – scientistic and instrumentalist - discourses of governments and policy makers in the 1970s – 1980s. So, mid-1980s, a new, more congenial category came to the fore as a basis for conservation: *biodiversity*. (Mathews, 2016)

The category of biodiversity was scientifically respectable. It had a veneer of objective descriptiveness that 'wilderness', with its perceived, culturally idiosyncratic (and very Eurocentric) loadings – aesthetic, spiritual or otherwise subjective – patently lacked. The fact that when biodiversity was cast as a goal for conservation it too became subtly normatively loaded – incorporating an 'ought' as well as an 'is' – was often overlooked. Nonetheless, it seemed to be a norm to which scientists and policy makers could comfortably assent, and soon it became the avowed object of conservation: conservation came to be understood almost universally as biodiversity conservation.

2 See, for example, the landmark US Wilderness Act of 1964, Section 2.C. https://winapps.umt.edu/winapps/media2/wilderness/NWPS/documents/publiclaws/PDF/16_USC_1131-1136.pdf

With historical hindsight it is possible to see in this shift from wilderness preservation to biodiversity conservation a logical though unintended contraction in the scope of the conservation project. Where wilderness preservation had mandated the setting aside of vast and often abundant realms of earth-life for their own sake, biodiversity as a norm referenced only the *diversity* of the *bios* and not the size of its populations. In other words, when the object of conservation was defined exclusively in terms of *diversity*, its implied purpose was merely the saving of *types* rather than *instances*: if one hundred instances of type A and one hundred instances of type B exist, and fifty of A and fifty of B are lost, there has been no net loss of diversity. But if a hundred instances of A exist and a hundred of B, and a hundred instances of A are lost, then a net loss of diversity has indeed occurred. The same number of instances is lost in each case, but only in the latter case does a loss of diversity occur. In a conservation context, this means that huge reductions in the population of a given species may occur without this registering as a loss of biodiversity. Conservation focussed exclusively on the loss of biodiversity will accordingly serve to mask major absolute losses of earth-life.

In line with this reading, biodiversity conservation did become popularly understood as a project dedicated to the prevention of *extinctions*: the principal trigger for the activation of conservation measures was species endangerment. A social consensus seemed to obtain that extinctions ought to be averted. The implied locus of value, and hence moral considerability, in this new conservation scheme of things was thus not the individual organism, which could be dispatched at will, nor vast wildlands, which could properly be opened up for economic development, but the type or species, which alone warranted protection.[3]

Conservation biologists proceeded to estimate *minimum viable populations* for different species – the minimal population of a particular species required to avert local extinction. Official Minimum Viable Population figures of course varied from species to species, but were generally in the order of only hundreds or a few thousand: one meta-study of different estimates in the literature put the average

3 The diversity implied by the term 'biodiversity' is generally taken to include not only species diversity but genetic diversity within species and diversity of ecosystem types. (United Nations Convention on Biological Diversity, 1992, Article 2) But, for the purposes of this paper, I shall focus mainly on species, since it is species which figure most prominently in the rhetoric of conservation. Conservation campaigns are often headlined by a requirement to save particular threatened species.

figure at 4169 individuals (Traill et al., 2007). Such figures generally of course fell orders of magnitude below pre-disturbance populations or populations that might be present in large wilderness areas. Using such figures as targets thus drastically curtailed the potential scope of conservation.

Resort to estimates of minimum viability also made little ecological sense: ecology is generally premised on abundance. Tens of thousands of seeds are produced to replace a single organism; huge populations are required as buffers against environmental set-backs and unforeseeable contingencies. At the individual level, organisms may indeed compete for scarce resources, but at the population level, plenitude is the rule: nature operates with large numbers. If nothing is protected until it becomes endangered, and if it is then afforded no more than a minimal level of protection, consistent merely with its non-extinction, eventually only remnants will remain. Viable ecologies cannot, as studies in island biogeography have consistently shown, be constituted indefinitely out of such remnants: *attrition* will inevitably occur. (Quammen, 1997; Whittaker and Fernandez-Palacios, 2007)

A simple change of framing categories thus in effect historically transformed the arithmetic of conservation, putting the movement on the back foot, ultimately dooming its small victories to attrition in the face of inexorable human encroachment.[4]

At the same time as the transition from the category of wilderness to that of biodiversity was taking place, the category of *development*, in the sense of large-scale modernization and industrialization, was undergoing revision. Wherever development could be pursued consistently with the maintenance of minimum viable populations of species, it was now legitimated as 'sustainable'. Indeed the two terms, *biodiversity* and *sustainability*, became inter-defining, as evidenced first in the Brundtland Report of the World Commission on Environment and Development of 1987 and then in the United Nations Convention on Biological Diversity of 1992, in which biodiversity replaced wilderness, or earth-life under any of its other sovereign aspects, as the variable to be sustained. The category of

4 Note that a limited amount of wilderness legislation continued to be passed; in Australia, for example, the NSW and SA Wilderness Acts appeared in 1987 and 1992 respectively, while the Wild Rivers Act appeared in Queensland in 2005 – and was repealed in 2014. Conservation in general however became overwhelmingly defined in terms of biodiversity.

biodiversity was well adapted to the project of development not only on account of the minimalist population targets it set for developers, but also because, as a scientistic category amenable to reductive quantification, it precisely purged earth-life of the sovereign aspects that concepts such as that of wilderness had captured. Biodiversity as a category was consistent with images of earth-life subjugated and consigned to the fragmented interstices of human installations, subject to surveillance and control via scientific methods such as counting, culling and tagging, forced sterilization or test-tube reproduction. The conservation of biodiversity could arguably even be represented in terms of storage of DNA in laboratory freezers. Well might industry welcome conservation under a conception of earth-life so deeply attuned to instrumentalism and well might it endorse the injunction to 'sustain' such life reduced in this manner to a valuable resource. In the guise of 'sustainable development', as articulated in the United Nations Convention on Biological Diversity (1992), society was offered a moral inducement to co-opt the biosphere for its own use, subject only to the condition that other-than-human species, however reductively articulated, not be entirely extirpated.

It might have appeared to conservationists that they had little choice but to embrace the mutually defining categories of biodiversity-based conservation and sustainable development. Capitulation to the sustainability rhetoric served to bring conservation back into line with the anthropocentric outlook which held, and continues to hold, almost exclusive sway in the developed world and from which the wilderness movement had marked a temporary deviation. The claims of conservation, from the viewpoint of a biodiversity-based ethic, make minimal inroads into the entitlements of a privileged species, *homo sapiens*, which considers all living things, as individuals, subject to its will, and all the resources of the biosphere as properly its own, provided only that other species qua species are not by human appropriation entirely eliminated. Even this latter condition was arguably a precautionary one traceable to our uncertainty as to which species were dispensable, from the viewpoint of overall ecological functionality, and which were not. To assure overall ecological functionality for the sake of human amenity and survival, it might once have seemed prudent to place a general ban on extinctions. It is worth noting however that today this precaution no longer seems necessary: as we stare into the abyss of a million imminent extinctions (IPBES 2019), with biosphere functionality evidently still relatively intact, it no longer seems arguable that the entire net of the biosphere will unravel if individual species are removed. It may be for this reason that new trends in policy are now retreating even from the bottom line of conservation, established in the 1980s: that extinctions must be prevented.[5]

Be that as it may, the historic shift from wilderness preservation to biodiversity-based norms of sustainability in practice validated populations in the billions for humans while mandating 'minimal' populations in the low hundreds or thousands for most wild species. Such a version of conservation was well placed to appease moral qualms about the destruction of the natural world while subtly reinforcing the human development imperative and the anthropocentric presumption on which it rests. This perhaps explains the routine if nominal incorporation of conservation into government policy since the 1980s – and the simultaneous collapse of biospheric systems since that time.

If a conservation ethic based solely on the category of biodiversity, with its implied exclusive valorization of types or species, is then ultimately self-defeating, what might a sounder basis for conservation look like? What further categories could be invoked to protect earth-life not merely as a vehicle for civilization – a vehicle that might become increasingly superfluous as geo-technologies and bio-technologies progressively mimic and replace ecological processes – but as a realm entitled to its own existence?

Arguably any such – bio-inclusive as opposed to merely anthropocentric - version of conservation must rest on a generalized respect and appreciation for all living things and for the naturally evolved relationships that knit them into the ecological systems that co-constitute them.6 Such respect and appreciation cannot readily translate into the kinds of ethical categories that as humans we apply to one another. It cannot, for example, translate as the *right to life* of every organism,

5 See, for example, the influential Ecomodernist Manifesto of 2015 that advocates, on both ethical and pragmatic grounds, the rooting out of bio-inclusive tendencies within conservation discourse in favour of an exclusively anthropocentric orientation. From this latter perspective, the independent moral considerability of earth-life, whether in the guise of individual organisms, ecosystems or species, will no longer be countenanced; only its value for human communities will be taken into account (Asafu-Adjaye 2015).

6 Of all the versions of environmental ethics developed in earlier decades, such "generalized respect and appreciation for all living things" perhaps equates most closely to that of Paul Taylor (Taylor 1986). For a convenient survey of the various versions, see Andrew Brennan 2008.

because all organisms live off the lives of other organisms, and hence are often entitled to take the lives of others in the interests of sustaining their own. But it does mean that no living thing is, ethically speaking, merely subject to our will, let alone to our whim. We, like all species, are entitled to make use of our fellow beings in order to preserve our existence, but we must devise moral categories that allow for this without cancelling a generalized respect and appreciation for life at large and recognition of the conditional entitlement of all living things to their own lifeways and existence.

If a generalized respect and appreciation for all life is taken not merely as *a* norm but as *the* ethical foundation for human life, as an alternative to anthropocentrism, then two complementary categories may be proposed which together would help to give ethical structure to this foundation. The first category is indeed that of biodiversity. Ecological diversity is, as is already so well recognized, a necessary condition for the adaptability, resilience and robustness of biotic communities and for their capacity to colonize new environments and recover from all manner of adversities. However, as we have seen, though biodiversity is a necessary condition for the flourishing of earth-life, it is not a sufficient condition, since taken as a stand-alone norm it exerts a downward pressure on conservation. A generalized respect for life must also acknowledge the tendency of life to proliferate, to make itself abundant, continually adapting itself to fill available niches and make the most of every opportunity (Crist, 2019). Since this expansiveness of the life process – upward, downward, sideways, along both quantitative and qualitative axes – is its very telos or intrinsic tendency, respect for life must honour this tendency, allowing the biosphere to continue its work of not only diversifying but also optimizing – optimizing the populations of all its constituent species. Such a process of optimization will be limited only by the internal constraints imposed by the (trophic and other) checks and balances inherent in ecosystems: the population of each species will be as abundant as is consistent with an ecologically proportionate abundance of adjoining populations of other species. (An optimal population of predators, for example, will be smaller than the correspondingly optimal population of the herbivores on which those predators prey.) Optimization is achieved, consistently with the maintenance of biodiversity, when ecological proportionality of populations – let us term it *bio-proportionality* – obtains across all species.

To acknowledge a generalized respect and appreciation for earth-life as a normative foundation for civilization then is not to insist on the sanctity of individual life, after the manner of human ethics. Rather, such an underlying commitment may be articulated via the two normative categories of biodiversity and bioproportionality. In line with the requirement of biodiversity, we must not eliminate individual organisms if doing so would place the future of a particular species at risk. But further to this – very minimal – requirement, the principle of bioproportionality enjoins us to allow populations of all species to optimize themselves in accordance with inherent ecological dynamics. These dynamics include, amongst other more overtly positive forms of collaboration and initiative, the strategies of predation and competition. To follow an ethos of respect and appreciation for earth-life then is not to rule out the mutual utilization of individual organisms as necessary but to accept that such utilization is only justified when it contributes to an overall pattern of population optimization.

Optimization of the populations of all species is an aspirational state that could be achieved only in the context of the like optimization of the human population. In order to optimize the human population we would need to bring human numbers into ecological proportion with those of other species. Such optimization of the human population would of course entail dramatic reduction, since the size of our present population has been achieved at massive cost to other populations. Such reduction would not be a matter merely of actual numbers however, but of offsetting the ecological costs of human activity against any positive ecological contributions that a prospective environmentally reformed civilization might make to the biosphere[7]. In the absence of any environmentally reformed civilization on the planet today however, the principle of bioproportionality does call for major reductions in the human population, by whatever consensual or incentive-driven methods might be available.

Since no methods commensurate with this task have as yet materialized, this might seem an unsatisfactory point at which to conclude the essay. But in fact my aim has been less a practical one than a conceptual or philosophical one. I have sought to show that organizing conservation exclusively around the

7 Architect William McDonough points out that the combined biomass of ants on earth is greater than the combined biomass of humanity. But the ant population is still optimal because ant activity contributes more to ecosystems than it costs them. (McDonough and Braungart 2002).

category of biodiversity has sold conservation disastrously short. When we look at conservation exclusively through the lens of biodiversity, the only evident constraint on the population of *homo sapiens* is that it should not be so large as to leave no room on earth for (minimum populations of) other species. Otherwise biodiversity specifies no limit. Bioproportionality as a norm, by contrast, sets a very definite limit: it specifies (in the sense of rendering calculable in principle) optimal population sizes for all species, including ours. To entertain a population in the billions for us, while countenancing populations in the hundreds and low thousands for most other species, flagrantly violates bioproportionality as a precept. This precept thus helps to show up a critical normative blind spot at the core of our conservation thinking.

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OPINION

Could humanity's hoofprint overwhelm nature?[1]

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Abstract

Humanity's global footprint is greatly affected by food and the way it is produced. Agriculture already occupies nearly half the useable land surface of the planet – 80% of which is devoted to meat and dairy. As an equation, humanity's footprint has three components: the number of consumers multiplied by the amount consumed multiplied by the way those resources were produced. Future sustainability relies on addressing all three components of humanity's footprint: population, consumption and method of production. Global action is therefore needed to alleviate poverty, address overconsumption of livestock products and move food systems to regenerative forms of conservation agriculture.

Keywords: Agriculture; Anthropocene; biodiversity; climate change; factory farming; food system; mass extinction(s).

1 This article is based on extracts from *Dead Zone: Where The Wild Things Were* by Philip Lymbery, published by Bloomsbury (2017) and a speech given to the Population Matters conference, *The Last Elephant in the Room*, held in London on 27th April 2019.

Why our children's future relies on what we eat

Imagine opening your morning newspaper to read the headline, 'Government agrees to building a hundred new cities the size of London'. Well that, plus 30 more cities the size of Los Angeles, is what one billion extra people looks like. From three billion of us in 1960, there are 7.5 billion today. By the middle of this century, we are set to add another two billion people to the planet. And like a fried egg with a small yolk within a sprawling area of white, each of those cities requires much more land elsewhere to grow food. We know in Britain that about a tenth of our land surface is urban, (ONS, 2014) whilst 70% is devoted to agriculture (World Bank, 2019a). Yet, as a nation, we're still only about half self-sufficient in feeding ourselves (Defra, 2017).

Then there's the second population explosion: of livestock. As it stands, a billion extra people means 10 billion extra farm animals produced every year, together with all that means for land, water and soil. Once we realise that agriculture already occupies nearly half the useable land surface of the planet – 80% of which is devoted to meat and dairy – we can quickly see that our planet is under great strain.

Environmental footprint

Within the last half-century, humans have changed the face of the Earth to such an extent that the traditional scientific way of classifying its main habitats (into forest, grassland, desert and tundra) looks hopelessly outdated (WorldBiomes, 2009). Genuine wildland now makes up just a fraction of the Earth's land surface. With most of 'nature' engulfed within human land use, some scientists believe there needs to be a new land-classification system. Ellis and Ramankutty (2008) have suggested terms such as 'dense settlement', 'villages', 'croplands' or 'wildlands'.

The biggest single driver of this dramatic change is farming. Accounting for 47% or more of useable land globally, an area the size of South America is devoted to growing crops, and an area bigger still to raising livestock (Owen, 2005; Searchinger et al. 2013).

As the population rises, so does the quest intensify for more land to cultivate. Right now, we are in no danger of running out of food (distributional problems notwithstanding), but the environmental damage attached to the way we are choosing to produce it may be irreversible. Flora and fauna are falling extinct one thousand times faster than the rate viewed by scientists as the expected 'background' rate (Gavrilles, 2014). Food production is the biggest driver of this biodiversity overkill.

The last half-billion years have seen five mass extinctions: episodes of sudden dramatic loss of biodiversity. Dinosaurs developed after one of the biggest mass-extinction events at the end of the Permian period some 250 million years ago. They disappeared, or underwent vast changes, about 66 million years ago, over a brief span of geological time. Although the exact causes of past mass extinctions remain a mystery, volcanic eruptions and large asteroid strikes are two prime suspects. The resulting dust clouds probably blocked out sunlight for months if not years, causing plants and plant-eating creatures to die. Heat-trapping gases would also have triggered runaway global warming.

Of course, planet Earth is tough. Ecosystems bounce back eventually. After one of the most devastating extinction events of all time, things did recover, but it took a long time: some 30 million years. Some scientists believe we are now on the cusp of the sixth mass extinction. It is expected to be the most devastating since the asteroid impact thought to have wiped out the dinosaurs. This time, the cause is much closer to home: us. It appears that we have moved into our own geological era, one like none before, the ultimate expression of humanity's growing footprint; the combined effect of our population and our impact through consumption, production and destruction.

Welcome to the Anthropocene.

Humanity's footprint

Humanity's footprint has been calculated as our human population multiplied by what we consume. Using this calculation, some have suggested that action on consumption alone will be enough to save the planet. However, there is growing recognition of the need by policymakers to address all parts of the equation. Take consumption of meat and dairy in Britain as an example. In the ten years from 2006, the number of vegans in the country rose from 150,000 to more than half a million (Vegan Society, 2016) – impressive growth of over 300%, until one realises that in the same ten-year period, the number of people in the country grew by five million (World Bank, 2019b). By implication, the impact on meat consumption by an increased number of vegans was far outweighed by an increase in people choosing to eat meat.

From my own research, I conclude that humanity's footprint equation, particularly around food, has a third component: method of production. The way that food is produced; whether it be intensively on farms factory, or extensively on free ranging or organic systems, can have a dramatic impact on the resources needed to produce a unit of food. Similarly, the production method can have a profound effect on wildlife and the environment.

Since the dawn of agriculture, 10,000 years ago, farming has pretty much worked in harmony with nature. However, the middle of the last century saw the rise of a particularly resource-intensive and damaging form of food production – factory farming – which saw farm animals disappear from the fields into windowless sheds crammed with cages and crates. Age-old crop rotations that utilised nature's ways of fertilising soil and controlling pests and disease gave way to monocultures doused in chemical fertilisers and pesticides. The age of industrial agriculture was born.

Two sides

Yet, it wasn't only farm animals that started to disappear from the countryside. Wildlife too suffered steep declines that continue to this day, Barn owls and hedgehogs close to home, jaguars and elephants on continents far away. In the last 40 years, since the widespread adoption of factory farming, the total number of wild mammals, birds, reptiles, amphibians and fish worldwide has more than halved. That's a shocking statistic.

And much of this decline is down to the two sides of factory farming, the first side being where the animals are kept. Chickens taken from bushes and rangelands to be kept in cages. Mother pigs who prefer to raise their piglets in woodland edges, kept in crates so narrow they can't turn around. Cattle taken from pastures to be confined in mega-dairies or feedlots where they are fed grain instead of grass. What looks like a space-saving idea actually isn't. By keeping them caged, crammed and confined, we then have to grow their feed elsewhere, on scarce arable land, using chemical pesticides and fertilisers – factory farming's second side.

As crop fields expand in the wake of industrialisation, so the trees, the bushes and the hedges disappear, along with wildflowers. And when they disappear, so too do the insects, and the seeds; and the birds, the bats, the bees that depend on them. Even worms disappear, along with other soil-living biodiversity and soil fertility, leaving little else but the crop.

Then we take this crop and feed it to factory farmed animals, losing most of the food value of that crop, in terms of calories *and* protein, in conversion to meat, milk and eggs. In this way, we waste enough food to feed an extra four billion people on the planet. That's not to say an extra four billion people all at once would be a good idea. It wouldn't; it would be an environmental disaster. It is to say that without industrial agriculture, we could feed everyone on less farmland, not more.

Yet, instead of switching to more sustainable regenerative farming and reining in meat consumption, vested interests use growing population pressure to encourage more industrial agriculture, regardless of the fact that more than half our food is lost or wasted; with the biggest single portion of food waste on the planet being the feeding of human-edible crops to factory farmed animals. To keep pace with this short-sighted vision, by 2050, we will need an area of extra cereal cropland the size of France and Italy combined. Up to a fifth of the world's remaining forests are likely to be lost, including an area of tropical forest equivalent to much of Argentina.

Overwhelming nature

As humanity's footprint grows, agricultural encroachment, together with the further industrialisation of farming, causes irreversible damage to biodiversity, forests, soil and water. More wildlife extinctions follow. Nature is overwhelmed.

The alternative to bulldozing forests for more arable land to feed a burgeoning intensive livestock population is to keep farm animals on pasture – in other words, land that is unsuitable for crops. Indeed, a quarter or more of the world's land surface is covered in grassland pastures, (Searchinger et al., 2013). Farm animals have also long been kept on permanent pastures, or as part of a rotational farming system where grass is interspersed with crops to build soil fertility naturally.

Some pasture, particularly in temperate lowlands as in Britain, is there by choice: we choose to graze cattle rather than grow crops. Yet much of the world's pasture or 'rangelands' is in places too steep, too dry or on too poor a soil to be much use for arable land without copious chemicals and irrigation (FAO, 2011). The steep slopes of the chalk downlands where I live are a prime example. They are largely covered in grass, as crop farming would be difficult and precarious. Other examples of grasslands in areas unsuitable for major crop farming include the drylands of Africa, the steppes of Central Asia and the highlands of Latin America. Places like these are prone to drought and desertification if the land is worked too hard. Nevertheless, they remain productive as grazing land for animals (FAO, 2011).

The best way to produce healthy meat with the fewest resources is to use permanent pasture or keep animals on the grassland rotation of a mixed farm. In this latter routine, soils are rested from the relentless demands of arable cropping for a few years by turning them for a while into grazing land. By transforming grass into meat, milk and eggs, we convert something we can't eat – grass – into something we can. Instead, by taking animals off grass and feeding them grain, we have created a rivalry between people and animals for food. That makes it harder, not easier, to feed a growing world population. Yet there is no sign of a change of approach. Policymakers and the food and farming industry continue to argue for more industrial meat production to meet what is predicted to be a near-doubling of demand for food by the middle of the century.

This notion is totally misconceived. Globally, we already produce enough food calories for around 16 billion people, way more than enough even for the huge projected population rise[2]. The trouble is we waste so much of it, not least by shovelling food enough for billions of people into the grain-troughs of factory farmed animals. So, who benefits from this 'produce more' narrative? Those industries set to benefit from yet more factory farming – of both crops and animals. Chemical fertiliser and pesticide companies, pharmaceutical companies (half the world's antibiotics are fed to farm animals); equipment manufacturers;

2 For crop and animal production see FAOSTAT Production databases, production data for crops primary, crops processed, livestock primary. Production data from 2012–2014 period is available on database. For calorific values see FAOSTAT Food supply database, food balance and food supply. People fed calculated as 2250 kcal per person per day for one year (FAOSTAT, ND).

and grain companies who, of course, have worked out you can sell far more grain to a given population by selling it to feed farm animals rather than simply using it to make bread.

Unless there is a major global policy shift, the majority of additional farm animals will be raised on grain-guzzling factory farms, and pressure for additional land will be so intense that farming is likely to replace forests as well as spread further into marginal lands, heaping yet more pressure on wildlife already on the edge. An area of extra cereal cropland the size of France and Italy combined will be needed by 2050 to keep pace. Up to a fifth of the world's remaining forests are likely to be lost over the next three decades, including an area of tropical forest equivalent to much of Argentina (OECD, 2012; Keenan et al., 2015). Great swathes of extra croplands look set to join the chemical-soaked arable monocultures of East Anglia in England. There'll be more fields of maize to grow animal feed when it could be feeding people. And more virgin forest will be converted to palm plantations; yes, palm products are also used as animal feed.

The encroachment of agriculture into remaining wildlands, together with the onward march of industrial farming, will almost certainly cause irreversible damage to biodiversity, forests, soil and water. Wildlife extinctions will follow. Conservationist and explorer, Dereck Joubert interviewed by *National Geographic* (Langin, 2014) noted that fifty years ago there were nearly half a million lions left in the world, and that every time the human population rises by one billion, the population of lions' falls by half. "*Today we're at 20,000 to 30,000 lions and the same is true for leopards, for cheetahs, for snow leopards*," he said. As nature retreats, she stops providing essential services like pollination, soil replenishment and carbon sequestration too.

Throughout human history, for better or for worse, *Homo sapiens* has outdone all-comers, from magnificent mammals like the bison that roamed the American plains in vast numbers, to birds like the passenger pigeons that once flocked like great rivers in the sky. Whatever has stood in our way, and sometimes just within reach, has been seen off. With scientists now suggesting that we have moved into our own geological era, the Anthropocene, the major force shaping the planet is us. What is now starting to be recognised is that one of the biggest victims of the Anthropocene could be… us.

It was legendary conservationist, Sir David Attenborough, who said there are few environmental problems that "*wouldn't be easier to solve with fewer people, or harder, and ultimately impossible, with more.*" (BBC, 2009).

Humanity currently faces major problems. Talk grows of an existential threat. Scientists warn that we have 12 years to solve climate change. Pollinators essential for the very existence of a third of our food are in steep decline. Antibiotics, half of which we feed to farm animals to prop-up factory farming, could soon stop working. Wild fish stocks are set to be depleted within 30 years. And the UN itself warns that if we carry on as we are, we could have just 60 years of harvests left in the world's soils before they are depleted too (UNEP). At the heart of all these declines is the expansion of industrial agriculture.

Global warming is the wild card, the game-changer that threatens to throw a world already stretching planetary limits into chaos. Sea-level rises could see land disappear just when more is needed. It could disrupt the water cycle, just when freshwater is at a premium. And if there's still enough soil for planting, it could reduce crop yields across the globe by as much as a fifth (Leclère, 2014).

The world's governments gathered in Paris in December 2015 to strike an historic deal to limit global warming to within 2 degrees Centigrade; a temperature rise deemed by scientists to be the 'safe' maximum level. Even at this level, scientists believe a third or more of all land-based species of plants and animals are doomed to extinction (Thomas et al., 2004). A third or more! The figure bears repeating. Think about what that actually means: so many mammals, birds and plants gone for ever: a massacre of life's variety. Millions of years of evolution wiped away in a geological heartbeat.

One thing is for sure – business as usual is not an option; not if we want our children and grandchildren to know a world anything like as beautiful and plentiful as the one we inherited.

Fuelled by runaway meat production, the climate impact of the way we produce food alone could take us to the brink of catastrophic global heating. That's without adding in the negative role of other industries, like energy and transport. As the temperature creeps up, the world as we know it starts to change. Drastic changes are likely this century to water cycles, ecosystems and forests, which could mean whole forests disappearing and the Amazon turning to savannah or even desert. The world could be lashed by greater and more severe storms, drought, floods and crop failures. This may sound apocalyptic; but it is only what leading climate authorities like the Intergovernmental Panel on Climate Change (IPCC) are warning (Field et al., 2014).

People are going to be deeply affected. Low-lying cities and regions could disappear underwater, including hundreds in America (Le Page, 2015a; 2015b; Strauss et al., 2015). Bangladesh faces the threat of disappearance. Millions of 'climate migrants' are likely to be forced from their homelands by extremes of weather, crop failures, or conflicts over increasingly scarce resources. If we don't do something and fast, these changes will be irreversible. They're already happening. Yet it doesn't have to be like this; there is another way.

Key to the future

The key to that better way lies in addressing all three components of humanity's footprint: population, consumption and method of production. A decent future for our children tomorrow relies on us starting a big conversation today about longstanding taboos, those elephants in the room around population pressure and the need to eat less meat. It relies on embracing positive, life-affirming ethical solutions, like alleviating poverty and empowering women and girls worldwide: both seen as effective at addressing population pressure (Population Matters, ND) and are things that we should be doing anyway, regardless. Gender equality, female empowerment and making poverty history are surely the cornerstones of an ethical and decent society.

The future for our children also relies on more balanced consumption; diets that don't overdo livestock products, not least for the climate. As already mentioned, scientists tell us that if we carry on eating meat and dairy in the way we are, then our food alone could trigger catastrophic climate change. To stabilise the climate and save the natural world on which we all depend, there is a pressing need to reduce meat and dairy production by at least half. High-consuming regions like Europe and North America need to take the lead, with governments introducing policies to encourage greater consumption of alternative foods to livestock products. Companies too need to do their bit; setting measurable targets for reductions in the amount of meat and dairy they use or sell in their businesses, be they retailers, fast food restaurants or ready-made meal manufacturers. Everyone can play their part.

On production, the key to better food lies with the world's pastures; on moving away from factory farming; instead, rearing animals like cattle and sheep by grazing them for life on pastures instead of feeding them grain. By keeping animals on the land, in mixed rotational systems, we have a much more efficient way of producing food that genuinely adds to our global food basket, rather than factory farming, which takes away from it. In this way, we have a recipe for better, more nutritious food for all, not just for today, but for future generations.

Clearly, this isn't about people versus animals – far from it. I am not arguing for draconian population control. What I am saying is we need an urgent conversation about how to address all three parts of humanity's growing footprint; population pressure, consumption and production. And the time for that conversation is now. With our children's future at stake, it is so important that we look for win-wins; for people, animals and the environment. Moving to genuinely regenerative ways of producing food – that put back natural capital and save our ability to produce food for the future – has to be one of the most glorious opportunities available to us.

When we restore animals to the land in the right way – in well-managed, mixed rotational farms – amazing things can happen. There can be a cascade of positive benefits for farmers, consumers, the local environment, forests both near and far, and for animal welfare too. Landscapes start coming back to life. Free-ranging animals on pasture can run and jump and stretch their legs and wings. They can scratch and graze and peck and root. They can feel fresh air and sunshine, roll in grass, bathe in dust or wallow in cooling wet mud. They can express their nature, enjoy that freedom to behave normally something viewed as so important by the internationally recognised guidelines known as the 'Five Freedoms' (Farm Animal Welfare Council, 2009). And this gift of freedom matters so much to them.

Is it really too much to ask? After all, animals just want the space and scope to be themselves. And allowing them to do so brings more contented animals with better immunity and less disease. Returning animals to the farm can help soils regenerate too. The age-old nitrogen cycle comes back into play: sunlight, soil, plants and the droppings of farm animals work together to return fertility to the soil. Cowpats from naturally healthy animals (without chemical treatments) become hives of life – harbouring numerous insects, like the dung beetles that thrive on taking parcels of poo underground to further enrich the soil. Healthier soils encourage all sorts of creatures in a magical circle of life, from earthworms and oribatid mites to springtails and a whole host of tiny microscopic creatures. Small they may be, but their contribution to our survival can be huge. They play key roles in maintaining fertility, structure, drainage and aerated soils, breaking down plant and animal tissues, releasing stored nutrients and converting them into forms that plants can use. Earthworms, perhaps the most important topsoil creatures, can multiply; mixing soil and nutrients together, stirring up essential ingredients for healthy plant growth.

Restoring animals to the land in mixed, rotational systems – breathing new life into tired soils – brings benefits to crop yields and the overall sustainability of the system. It can reduce reliance on chemical pesticides and fertilisers, encourage more plants, insects and other farmland wildlife. The landscape can then grow more varied, bursting with plants and flowers, luring back indispensable pollinating insects like bumblebees, along with hoverflies, butterflies, beetles and moths. This revitalised landscape provides patches of cover, homes for voles and other small creatures that also offer a living to barn owls and other predatory birds. Seeds and insects provide food for farmland birds to thrive once again, sustaining them through the harshness of winter and feeding hungry chicks during the summer.

Grasses with their mass of deep roots and perennial growth help stop precious soil and its nutrients being washed away by the rain, encouraging the soil's sponge-like quality in holding water too. Their deeper roots enable them to tap into water sources shorter-rooted plants can't reach, so that landscapes grow resistant to drought as well as to flood. Without soil erosion and nutrient pollution, rivers become cleaner and less likely to silt up. Natural communities of flora and fauna have a chance to revive, like water crowfoot, starwort and water celery on chalk streams, providing home to all manner of aquatic creatures as well as cover, shade and refuge for fish. These, together with insects like the mayfly, encourage fish like the native brown trout in a web of life graced by the scurry of the water vole.

Rearing animals on pastures rather than grain crops takes less water from rivers and aquifers for irrigation. Switching from grain-feeding, which is forty times more water-intensive than grass, helps relieve some of the relentless demand on hard-pressed water courses. Reducing the clamour for more farmland by cutting down on grain-fed farm animals, plus easing-off on resource-intensive meat, can cut the risk of the axe to remaining forests. Trees that might otherwise go the way of the chainsaw are free to carry on removing carbon from the atmosphere and returning oxygen for us to breathe. And at the same time, we gain healthier, more nutritious food. Animals fed on grass – the fruit of a timeless interaction between sun, rain and soil – provide meat lower in saturated fats and higher in health-giving nutrients like omega-3s. Remarkably, wherever I have gone in the world – Africa, America, China or Europe – the one thing people consistently say about food from the land is that it tastes so much better, has so much more flavour.

Crossing continents in recent years, I've discovered that when animals are returned to the land in the right way, in well-managed mixed and rotational farms, whole landscapes spring to life. Helping to revive a living countryside can be as easy as choosing to eat less and better meat, milk and eggs from pasture-fed, free-range and organic animals. With care, the food on our plate really can support the best animal welfare, bring landscapes to life and safeguard the future for our children.

Global Agreement

Whilst as consumers, we have great power to help rebalance the food system, the scale of the task now facing humanity requires nothing short of decisive action by the world's leaders: governments, business and the UN, working with civil society. That is why, to save a world worth having for future generations, I call on the United Nations to forge a global agreement to create a regenerative food system without factory farming and excessive meat production. To set a course where the world moves beyond destructive, climate-destabilising, wasteful and cruel methods of food production. Instead, replacing them with the kind of food systems that support life on Earth tomorrow and that preserve our legacy of a decent future for our children.

We have nothing to fear from addressing these issues in a way that empowers people to create a better future. In fact, given the crisis facing food and the natural world, there is everything to fear from simply carrying on as we are. For our way of life to stay anything like the same, a great deal has to change. As teenage climate activist, Greta Thunberg, says, "*…the rules have to change, everything has to change, and it has to start today.*" (Thunberg, 2018). We are, after all, the last generation who can hand over a planet worth having to our children. Let's create that better future so that, whatever form newspapers take in the years to come, headlines talk of a positive future for people, animals and the planet - for our children, forever.

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PEER REVIEWED ARTICLE

The potential environmental impacts of EU immigration policy: future population numbers, greenhouse gas emissions and biodiversity preservation

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Abstract

This article clarifies the potential environmental impacts of more or less expansive EU immigration policies. First, we project the demographic impacts of different immigration policy scenarios on future population numbers, finding that relatively small annual differences in immigration *levels lead to large differences in future population numbers, both nationally and region-wide. Second, we analyze the potential impacts of future population numbers on two key environmental goals: reducing the EU's greenhouse gas emissions and preserving its biodiversity. We find that in both cases, smaller populations make success in these endeavors more likely – though only in conjunction with comprehensive policy changes which lock in the environmental benefits of smaller populations. Reducing immigration in order to stabilize or reduce populations thus can help EU nations create ecologically sustainable societies, while increasing immigration will tend to move them further away from this goal.*

Keywords: Immigration; Population; European Union; Carbon emissions; Biodiversity protection.

1. Introduction: an implicit assumption

According to recent demographic projections (Lutz et al., 2019; United Nations, 2019), immigration levels will make a substantial difference in the size of future EU populations. Since population size is one of the fundamental parameters determining the human impact on the environment (Millennium Ecosystem Assessment, 2005; IPCC, 2014), this would appear to raise the question of how EU immigration policy choices could impact future environmental protection efforts. Yet surprisingly, this question rarely gets asked by environmentalists, or influences EU policy-makers. The following evidence illustrates the typical failure to consider this issue.

In the run up to elections to the European Parliament in May, 2019, the coalition of European Green parties put forth a statement of principles and political goals, "Priorities for 2019" (European Greens, 2019a). It was organized around twelve key goals, starting with fighting climate change – "the defining challenge of our times" – by phasing out all coal use by 2030, promoting energy efficiency, and moving quickly to 100% renewable energy sources. It continues with commitments to boost trains at the expense of (more polluting) air travel, reducing air and water pollution within the EU, and eliminating non-recyclable plastics. "To preserve our valuable nature," Greens advocate that nations "expand protected natural areas

The authors thank the Department of Philosophy, Colorado State University, the Department of Biological and Environmental Sciences, Göteborg University, and the Global Challenges Foundation, Stockholm, for their generous support.

significantly so that they cover key ecosystems." They also seek to reorient EU agricultural policy, by "producing good local, GMO and pesticide-free food" and "farming without cruelty to animals."

Curbing population growth, however, was not one of these twelve key environmental goals, or even a subsidiary goal. Neither in "Priorities for 2019," nor in the related "Manifesto 2019," nor in a more elaborate list of policy positions on its website, did the EU Green coalition affirm the need to limit, end, or reverse population growth – either as a stand-alone policy goal, or as necessary to any of the environmental goals it did endorse (European Greens, 2019a, 2019b). In discussing the means to decrease carbon emissions, increase protected areas, or achieve any other environmental goals, limiting population was not mentioned.

Immigration policy was discussed in these documents, not for any potential role in impacting future population numbers, but as part of affirming immigrants' rights and combatting xenophobia and racism. A core Green goal in "Priorities for 2019" was to "defend the right to asylum and establish legal and safe channels for migration," expressed in language implying that attempts to limit immigration are immoral (European Greens, 2019a). A related statement on "Human Rights and Migration" advocated "a more ambitious resettlement and relocation scheme," with the clear goal of increasing immigrant numbers and no indication that this potential increase demands demographic or environmental analysis (European Greens, 2019c).

Based on a review of recent policy manifestos from several national Green parties, these coalition statements appear to accurately represent the national parties' own positions on population matters (see, for example, statements from the UK's Green Party (2003, 2017) on population and migration). Based on these documents, the EU's Green parties appear to make the following implicit assumption: *Population size and immigration rates have no important roles to play in the efforts of EU nations to meet their environmental challenges and create ecologically sustainable societies.*

To be clear, neither EU Green parties nor the coalition affirm such a position explicitly. However, they act as if this assumption is true by proposing immigration policies that could greatly increase future EU population sizes, while simultaneously endorsing a number of very ambitious environmental goals. We could find no evidence that any of these parties praise Europe's sustained low fertility trends, which suggests that they see no environmental value in the smaller populations to which they could lead. Some, such as Austria's Green party, argue for more immigration for conventional economic reasons (Die Grünen, 2017), which implies that they see little environmental disvalue in higher populations or increased economic activity. All this indicates that European Greens assume that the implicit assumption is correct.

In a similar manner, the chief European Commission documents setting out current EU policy goals for greenhouse gas emission reductions (European Commission, 2018), biodiversity preservation (European Commission, 2011a, 2015), and general environmental sustainability (European Commission, 2011b; European Parliament, 2013) are all equally silent regarding any connection between future population numbers and achieving ambitious environmental goals. Like the EU's Green parties, the EU itself has not formulated a population policy. It does have an immigration policy, or rather a complex suite of policies, which are contentious and in flux (European Commission, 2011c, 2019). But these policies make little reference to immigration's potential impact on population numbers, beyond recurring statements that immigration will help support workers' pensions in the future (European Commission, 2011c, 2014). This suggests that belief in "the implicit assumption" extends more widely to agencies and policy-makers across the political spectrum.

In response, this paper makes the implicit assumption explicit and attempts to test it against reality. Section two explores the potential demographic impacts of immigration on future EU population numbers. Sections three and four consider the potential impacts of human numbers on EU greenhouse gas emissions and on possibilities for biodiversity conservation in Europe. Section five concludes that the implicit assumption is false and that immigration policy should be made in recognition of its environmental effects.

2. Impacts of immigration on future population numbers

Europe is the first continent to end the population explosion that has characterized humanity's recent demographic trajectory. This is largely a function of sustained below-replacement fertility levels over the past two generations, with strong indications that they are likely to continue (Balbo et al., 2013). Recent projections out to 2100 predict relatively slow population growth across much of western and northern Europe and more or less sharply decreasing populations among eastern and southern European nations (Lutz et al., 2019; United Nations, 2019). However, such baseline projections mask wide uncertainty and future numbers will vary depending on actual fertility, mortality, immigration, and emigration rates. Demographers tend to agree that immigration trends have the greatest potential to influence future EU population numbers (Azose et al., 2016). This is because increases in longevity will remain popular and uncontroversial goals for future political leaders; because immigration numbers can be raised or lowered much more quickly than fertility rates through direct policy choices; and because there is growing pressure for increased immigration coming from rapidly growing countries in Africa and the Middle East (United Nations, 2019).

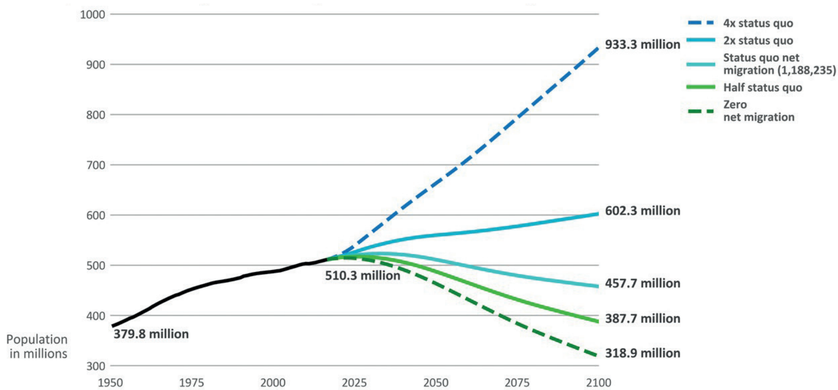
In an effort to understand the potential impact of immigration, family support and economic safety net policies on future population numbers, the authors and colleagues recently developed new policy-based EU population projections out to 2100 (Cafaro and Dérer, 2019). The sheer range of immigration policies advocated by European political parties is impressive and we sought to capture this range in our projections. For western European nations and the EU as a whole, five different immigration scenarios were considered, built around multiples of the average annual net immigration for the past twenty years, which we labelled “status quo.” These scenarios were zero net migration, ½ status quo annual net migration, status quo net migration, 2X status quo net migration, and 4X status quo net migration. This last scenario represents a rough proxy for an “open borders” policy, which is difficult to model. These broad migration scenarios capture the range of policy choices advocated across the EU today, from drastically curtailing immigration to greatly expanding it, with the three middle alternatives (*½ to 2X* the status quo) covering the most likely range of alternatives (see Cafaro and Dérer, 2019, for methodological details). For a full range of population projections for all EU nations and the EU as a whole, please see the website of The Overpopulation Project.

Consider first our projections for the European Union as a whole. The current 28 countries in the EU had a combined population in 1950 of 379.8 million and their combined population in 2016 was 510.3 million.[1] The region’s current total fertility

1 Note that past, present and future numbers for “the EU” include all the EU’s current members, including the UK.

rate (TFR) is 1.60 and its average annual net migration level over the past 20 years (1998-2017) was about 1.2 million. Figure 1 graphs population projections for the EU under our five migration policy scenarios.

Figure 1: European Union Projections Under Five Migration Scenarios



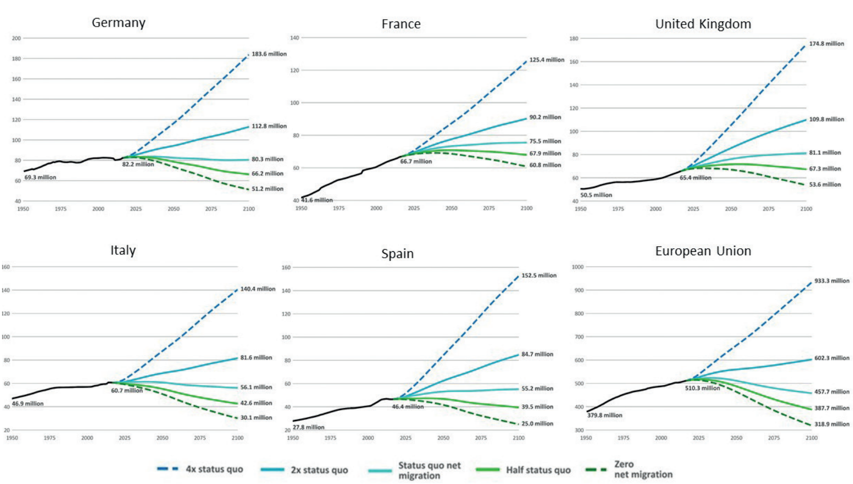
Status quo migration is the continuation of the past 20 years average annual net migration level (1,188,235). Migration scenarios use total fertility rates varying between 1.65 and 1.90, with higher immigration levels projected to drive higher TFRs.

Source: Cafaro and Dérer, 2019.

How might immigration influence future EU population numbers? Continuing the status quo of about 1.2 million annual net positive migration (along with status quo family support policies and economic safety net policies, which influence fertility rates) would lead to a 10% population decrease, or 52.6 million fewer people in 2100. Cutting net average migration in half would reduce the EU population by an additional 70 million people, or an extra 14% compared to the population loss under the status quo scenario, for a total drop of 122.6 million people by 2100 (24%) compared to the current (2016) population. Doubling net migration, conversely, would switch the EU's population from declining by 52.6 million (-10%) under the status quo to growing by 92.0 million (+18%). That's a difference of 214.6 million people across the most likely range of immigration policy changes (cutting in half or doubling current migration rates). The spread across all five policy choices is much greater: over 600 million people, from swelling to 933.3 million in 2100 (an 83% increase) in the case of quadrupling status quo net migration numbers, to contracting to only 318.9 million in 2100 (a 38% decline) by reducing net migration to zero.

Clearly, immigration policy changes have the potential to increase or decrease the EU population by hundreds of millions of people by 2100 (Lutz et al., 2019; Cafaro and Dérer, 2019). A key take-away is that relatively small *annual* changes have the potential to cumulate into large *overall* changes in the not-too-distant future. And what is true for the EU as a whole, holds true for its individual nations. Figure 2 graphs population changes for the five most populous EU nations under our five immigration scenarios. It shows that by 2100, just three generations from now, different immigration policies could generate widely different national population numbers.

Figure 2



Population projections for the five most populous EU countries and the EU as a whole under five migration scenarios: zero net migration, ½ status quo migration, status quo migration, 2X status quo migration, and 4X status quo migration. Total fertility rates vary, with higher immigration levels projected to drive higher TFRs.

Source: Cafaro and Dérer, 2019.

For example, annual net migration levels into Germany have averaged a little less than 260,000 over the past twenty years. Continuing at this level for the rest of the century would lead to a stable German population, according to our calculations, while increasing or decreasing annual immigration levels would lead to populations that were tens of millions higher or lower. Such variations are possible. Net immigration into Germany has varied widely in recent years, from – 56,000 in 2008 to 1.2 million in 2015 (Eurostat, 2019), and there is widespread support both for greatly increasing immigration (Social Democrats and especially *Die Grünen*) and greatly decreasing it (Christian Democratic Union and especially *Alternative für Deutschland*). The three most likely immigration policy scenarios generate a population range in 2100 of 46.6 million people, while considering the full range of migration scenarios increases the 2100 population variability to 132.4 million: between 62% and 123% of the current population.

France, with higher native fertility rates and lower net migration levels, exhibits a less dramatic demographic range than Germany, while Spain, Italy and the UK exhibit greater potential demographic volatility. But in every case, immigration's potential impacts on future populations are substantial (see table 1).

Table 1

	Annual status quo net migration	Zero net migration	½ status quo	Status quo migration	2X status quo	4X status quo
European Union	1,188,235	-38%	-14%	-10%	+10%	+83%
Germany	259,316	-38%	-19%	-2%	+37%	+123%
France	100,525	-9%	+2%	+13%	+35%	+88%
United Kingdom	230,107	-18%	+3%	+24%	+68%	+167%
Italy	229,093	-50%	-30%	-8%	+34%	+131%
Spain	270,112	-46%	-15%	+19%	+82%	+228%

Status quo annual net migration numbers (average from 1998-2017) and percentage change from current population by 2100 under different migration scenarios.

Source: Eurostat, 2019; Cafaro and Dérer, 2019.

The key point is that population decrease is not a given for the EU during the coming century, despite much attention in the media and among economists to "aging and shrinking populations." EU fertility rates may remain low compared to other regions of the world. But immigration policies clearly have the power to cancel the population decreases to which low fertility rates otherwise would lead: indirectly, by increasing European fertility rates (Sobotka, 2008; Kulu et al., 2017; Pailhé, 2017), and more directly, by adding tens of millions more people and their descendants (Pew Research Center, 2017). However, in most cases, EU nations appear well placed to stabilize or slowly reduce their populations, should they choose to do so. But should they? That depends, at least in part, on whether the implicit assumption is correct, that population sizes are irrelevant to achieving environmental goals. We turn now to this question.

3. Impacts of human numbers on EU greenhouse gas emissions

To their credit, the EU and its member states have set some of the most ambitious climate goals in the world. The EU enacted legislation to reduce greenhouse gas emissions 20% by 2020 compared to 1990 levels, a goal it achieved several years early. It set a 40% reduction target for 2030 as the union's "nationally determined contribution" under the Paris Agreement (European Council, 2014), subsequently developing a "low-carbon economy roadmap" aiming for 80% to 95% reductions by 2050. The European Commission recently strengthened these goals, committing to 55% reductions by 2030 and "zero net emissions" by 2050 (European Commission, 2018).

In the past, population growth has been identified along with increased economic activity as one of two main drivers of increased global CO2 emissions (IPCC, 2007, 2014) and reducing population growth has been identified as an important potential mitigation response (O'Neill et al., 2012; Casey and Galor, 2017; Bongaarts and O'Neill, 2018). A recent study found that regional population growth has contributed considerably to recent CO2 emissions in Western Europe (Weber and Sciubba, 2018). In contrast, looking forward, the implicit assumption implies that population size has no important role to play in the efforts of EU nations or the EU as a whole to meet their carbon emissions reduction goals. Is this assumption plausible?

We do not know how successful the nations of the EU will be in decreasing their per capita carbon emissions by 2050. We analyze the potential impact of population on this effort by considering three possible per capita emission paths to determine how different population sizes could impact reduction targets. The first, pessimistic scenario is a continuation of current (2016) emissions levels of 8.7 tonnes CO_2e (CO_2 equivalent). The second is the "reference scenario" where existing national commitments reduce annual GHG emissions 48% by 2050 relative to 1990 levels, with per capita emissions declining to an average of 5.7 tonnes CO_2e (Capros et al., 2016). In the most optimistic scenario, we imagine increased national commitments reducing the average EU citizen's per capita emissions to 2.2 tonnes CO_2e; 18% of 1990 levels, equivalent to the GHG emissions of the average UK citizen in 1800.

As the annual GHG emissions of a nation or region equal its total population multiplied by their per capita emissions, a simple equation can show how our five immigration scenarios could intersect with these three per capita emissions scenarios to determine future emissions. Table 2 shows the different annual emissions outcomes in 2050. In every case, increased immigration leads to larger populations, which in turn lead to smaller decreases in total greenhouse gas emissions, in individual countries and in the EU as a whole. For example, under the reference scenario, Germany achieves a decrease to 56% of current emissions levels at zero net migration, but only a decrease to 88% of current levels when net immigration increases to 4X recent levels. The greater the decrease in per capita emissions, the smaller the increase in 2050 emissions caused by increased immigration. However, for all per capita emissions rates, total emissions in 2050 are significantly higher at higher immigration levels. Thus, at least for this medium-range time frame, the implicit assumption appears provisionally falsified.

Table 2

	Zero net migration	½ status quo	Status quo	2X status quo	4Xstatus quo
	Per capita emissions remain at current levels (2016)				
European Union	90.8%	95.5%	100.1%	109.7%	129.9%
Germany	89.5%	95.7%	100.5%	114.8%	141.7%
France	102.5%	105.8%	109.4%	115.8%	130.4%
United Kingdom	102.4%	109.4%	116.3%	130.8%	161.0%
Italy	83.5%	90.8%	99.8%	112.9%	144.0%
	Per capita emissions decrease as in the reference scenario				
Germany	55.6%	59.5%	62.4%	71.3%	88.0%
France	73.6%	76.0%	78.6%	83.2%	93.7%
United Kingdom	59.6%	63.7%	67.7%	76.2%	93.8%
Italy	56.8%	61.8%	67.9%	76.8%	98.0%
Spain	66.2%	74.4%	84.6%	99.4%	134.4%
	Per capita emissions decrease to 2.2 tonnes CO2e				
European Union	**23.0%**	**24.1%**	**25.3%**	27.7%	32.8%
Germany	**17.3%**	**18.5%**	**19.4%**	**22.2%**	27.4%
France	31.7%	32.8%	33.9%	35.9%	40.4%
United Kingdom	**28.5%**	**30.5%**	32.4%	36.4%	44.8%
Italy	25.5%	27.7%	30.5%	34.5%	44.0%
Spain	26.9%	30.2%	34.3%	40.3%	54.5%

Percentage of annual greenhouse gas emissions in 2050 expressed as a percentage of GHG emissions in 2016, for five EU countries and the EU as a whole. The boldfaced scenarios achieve the minimum decreases needed to stay on track for the "low carbon economy" target (80% reductions from 1990 levels).

Source: own calculations.

Notably, the scenarios that achieve the emissions decreases needed to stay on track for the "low carbon economy roadmap" (boldfaced areas in table 2) combine low average per capita emissions with relatively low immigration levels. This suggests that human numbers, average consumption levels, and the technologies used to accommodate them, all make a substantial difference to total emissions. By itself, curbing population is not enough to achieve ambitious EU emissions reduction goals, but clearly it would help. Table 3 illustrates the same point, calculating what percentage of per capita emissions reductions would be necessary for the EU's most populous countries to achieve the minimum target for the low carbon economy roadmap under different immigration scenarios. As immigration and thus total population increases, so does the need to decrease average per capita emissions, leading to the common phenomenon of having to "run faster just to stand still" and safeguard environmental achievements (Palmer, 2012).

Table 3

	Zero net migration	½ status quo	Status quo	2X status quo	4Xstatus quo
European Union	71.6%	73.0%	74.3%	76.5%	80.2%
Germany	69.8%	71.8%	73.1%	76.5%	80.9%
France	77.2%	77.9%	78.7%	79.8%	82.1%
United Kingdom	66.3%	68.5%	70.4%	73.6%	78.6%
Italy	69.8%	72.2%	74.7%	77.7%	82.5%
Spain	80.7%	82.9%	84.9%	87.2%	90.5%

Per capita emissions reductions required to meet the 2050 minimum goal for the low carbon economy roadmap, expressed as a percentage reduction compared to per capita emissions in 2016.

Source: own calculations.

Readers may wonder why we do not analyze a 100% emissions reduction alternative, which, after all, is now an official EU policy goal for 2050 (although not an official policy goal for most EU nations). We do not do so because the goal of "zero net emissions" is not really the same as reducing average per capita or personal emissions to zero, which is impossible, at least by 2050. Zero net emissions, if it is achieved, will instead combine low per capita emissions (generated by continued food consumption, transport, etc.) with so-called "negative emissions," in which as yet untested and unscaled technologies would remove carbon from the air, water, or soil (European Commission, 2018).[2] Achieving these negative emissions at the necessary scale is likely to be very expensive, if it is possible at all, and some of the technologies being considered may be more dangerous than climate disruption itself (Lenzi et al., 2018). For these reasons, climate experts agree that it would be best to decrease actual "positive emissions" quickly and to the greatest extent possible (Van Vuuren et al., 2018). EU citizens deserve a realistic picture about the contributions reducing their consumption or population numbers could make in helping them do their part to limit global climate change.

To get a fuller picture, let us look further out in time and consider not just potential GHG emissions at some discrete point in the future, but the *cumulative* impacts of immigration policies on *total* emissions during the rest of the century. After all, many GHG emissions will remain in the atmosphere for a long time, warming the Earth for the entire time and contributing to ocean acidification when they eventually cycle back down (IPCC, 2013). The challenge is to transform our societies as quickly as possible so as to minimize their GHG emissions over the course of this century.

Consider how our five immigration scenarios would influence the total reductions achieved under three plausible emissions reduction scenarios: 50%, 70% and 90% per capita GHG reductions, each phased in linearly between now and 2100. Taking 80 years to reduce per capita emissions 50% would represent a waning EU commitment to deal with climate change, with slow renewable electrification and lifestyle changes, etc.; it is a pessimistic yet possible scenario. 70% per capita reductions represent a stable to modest increase in current national commitments, especially taking into account that per capita emissions have not improved since 2014 for the EU-28 population. 90% per capita reductions can stand in for an optimistic "total decarbonization" scenario, since as we have seen, "zero net emissions" is shorthand for low per capita emissions combined with high-tech efforts to suck carbon out of the environment and safely sequester it.

2 While allowing former farmlands to regrow forests can provide significant carbon removal from the atmosphere, scaling up such negative emissions will demand more energy- and technology-intensive methods as well.

Table 4

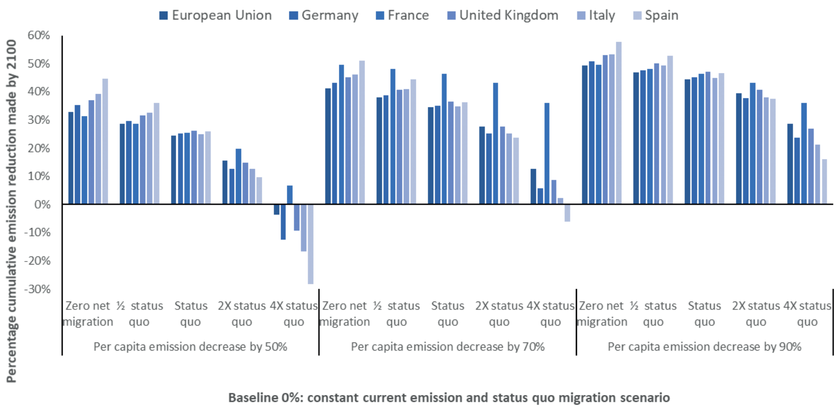
	Zero net migration	½ status quo	Status quo	2X status quo	4Xstatus quo
	Per capita emissions decrease 50% by 2100				
European Union	243.2	258.7	274.2	306.1	376.0
Germany	50.7	55.1	58.7	68.5	88.1
France	29.9	31.1	32.5	34.9	40.6
United Kingdom	31.9	34.6	37.4	43.0	55.3
Italy	21.8	24.1	26.9	31.4	41.8
Spain	17.8	20.6	23.9	29.1	41.4
	Per capita emissions decrease 70% by 2100				
European Union	213.0	225.2	237.3	262.3	316.8
Germany	44.6	48.1	50.8	58.6	73.9
France	21.9	22.6	23.4	24.7	27.9
United Kingdom	27.8	29.9	32.1	36.5	46.1
Italy	19.3	21.1	23.4	26.8	35.0
Spain	15.7	17.9	20.5	24.6	34.2
	Per capita emissions decrease 90% by 2100				
European Union	183.9	192.7	201.5	219.7	259.0
Germany	38.5	41.0	43.0	48.7	59.7
France	21.9	22.6	23.4	24.7	27.9
United Kingdom	23.7	25.3	26.8	30.0	36.9
Italy	16.8	18.1	19.8	22.3	28.2
Spain	13.7	15.3	17.2	20.1	27.1

Cumulative GHG emissions in gigatons, 2016–2100, for the five most populous EU countries and the EU as a whole, under three per capita emissions reduction scenarios and five net migration scenarios. Immigration changes are phased in over 10 years, per capita emissions reductions are phased in linearly over the course of the century.

Source: own calculations.

Table 4 shows that for every country, higher immigration leads to higher population numbers, which in turn lead to substantially greater cumulative GHG emissions. Under the 70% per capita emissions reduction scenario, for example, cumulative emissions would be 18% less for Germany if they halved net migration compared to doubling it, and 14% less for the EU as a whole. The impact of immigration numbers on cumulative emissions decreases with faster per capita emissions reductions. But even under the optimistic 90% per capita emissions reduction scenario, the impact of changing immigration levels remains substantial. Figure 3 compares cumulative GHG emissions under various scenario combinations to the cumulative emissions that would be generated if per capita emissions and net migration levels remained at current (2016) levels.

Figure 3



Percentage emission reductions by 2100, compared with emissions that would be generated if per capita emissions and net migration levels remained at current levels. Calculated for the five most populous EU countries and the EU as a whole, under three per capita emissions reduction scenarios and five net migration scenarios. Negative percentages indicate cumulative emissions would be worse than a continuation of current per capita emission and net migration levels.

Source: own calculations

One important result is that changes in immigration levels appear to have about as powerful an impact on cumulative GHG emissions as changes in per capita emissions. For example, decreasing Germany's per capita emissions 90% rather than 50% while keeping immigration at current levels leads to 15.7 gigatons fewer emissions by 2100, while the difference between reducing German net migration to ½ current levels and increasing it to 2X current levels spans 13.5 gigatons at 50% per capita reductions. For the EU as a whole, cumulative emissions under a 4X status quo migration/90% per capita emissions reduction scenario would be more than cumulative emissions under a zero net migration/50% per capita emissions reduction scenario: 259 vs. 243 gigatonnes CO_2e.

These results show that the implicit assumption is mistaken, at least regarding climate change. Population size will play an important role in the efforts of individual EU nations and the EU as a whole to meet their GHG emissions reduction goals, and immigration policy could play an important role in facilitating or undermining such efforts.[3]

4 Impacts of human numbers on EU biodiversity conservation

Biodiversity loss is as serious a global environmental problem as climate disruption and the EU and its member states have set ambitious goals for preserving and, where possible, restoring Europe's biodiversity. Legal mandates include the Directive on the Conservation of Wild Birds (European Commission, 2009) and the more encompassing Directive on the Conservation of Natural Habitats and of Wild Fauna and Flora (European Commission, 1992): the former decreed "the conservation of all species of naturally occurring birds in the wild state" within Europe, by "preserving, maintaining and re-establishing" sufficient habitat for them; the latter set in motion the creation of a pan-European network of conservation areas, Natura 2000, to preserve sufficient habitat for all native plant and animal species (Campagnaro et al., 2019). A review in 2010 showed that despite some progress, "up to 25% of European animal species were facing extinction, and 65% of habitats of EU importance were in an unfavourable

3 One might object that any increase in EU countries' GHG emissions from immigration would be offset by emissions reductions in the EU's sender countries. But this is unlikely; since immigration into the EU tends to move people from countries with lower per capita emissions to ones with higher per capita emissions, overall emissions are likely to increase, as has been the case with immigration into the US (Kolankiewicz and Camarota, 2008).

conservation status, mainly due to human activities" (European Commission, 2015). In response, the EU strengthened its biodiversity protection strategy, aiming to "halt the loss of biodiversity and ecosystem services by 2020" and "to restore ecosystems in so far as is feasible" (European Commission, 2011a).

As with climate change, population growth has been identified as a key factor driving biodiversity losses around the world (Millennium Ecosystem Assessment, 2005; Driscoll et al., 2018). McKee et al. (2003) found that two factors, population density and species richness, accounted for 88% of the variation in countries' numbers of threatened and endangered species in 2000. Conservation biologists agree that habitat loss and degradation are by far the leading causes of biodiversity loss (Maxwell et al., 2016) and a recent study found that population increases contributed significantly to urbanization and habitat loss in western Europe between 1990 and 2006 (Weber and Sciubba, 2018). Increased human numbers have also been shown to multiply other important factors driving biodiversity loss, including habitat fragmentation (Krishnadas et al., 2018) and agricultural expansion (Crist et al., 2017). In the UK, increased human population density has been linked to the extirpation of rare local plant species (Thompson and Jones, 1999).

Unfortunately, quantifying biodiversity loss and species extinction in relation to human population density cannot be done as easily as for GHG emissions and population size, in part because conservation biologists have failed to give the relationship between human and wildlife numbers the attention it deserves (Rust and Kehoe, 2017; Driscoll et al., 2018). Thus, we cannot calculate figures for likely habitat availability or species extinctions under our five different immigration scenarios, as we could for future greenhouse gas emissions. Still, these scenarios lead to great variation in future population densities in Europe (table 5) and the evidence suggests that future EU population numbers could greatly influence the success of efforts to preserve biodiversity in the EU.

Table 5

	Current inhabitants per km2	Density				
		Zero net migration	½ status quo	Status quo	2X status quo	4X status quo
European Union	117.7	73.0 (-38%)	101.2 (-14%)	105.9 (-10%)	129.5 (+10%)	215.4 (+83)
Germany	233.1	144.5 (-38%)	188.8 (-19%)	228.4 (-2%)	319.3 (+37%)	519.8 (+123%)
France	105.3	95.8 (-9%)	107.4 (+2%)	119.0 (+13%)	142.2 (+35%)	198.0 (+88%)
United Kingdom	270.6	221.9 (-18%)	278.7 (+3%)	335.5 (+24%)	454.6 (+68%)	722.5 (+167%)
Italy	205.4	102.7 (-50%)	143.8 (-30%)	189.0 (-8%)	275.2 (+34%)	474.5 (+131%)
Spain	92.5	50.0 (-46%)	78.6 (-15%)	110.1 (+19%)	168.4 (+82%)	303.4 (+228%)

Population density (inhabitants per km2) and percentage change in density: current (2016) and in 2100 under five migration scenarios. Source: Eurostat 2017 and own calculations.

Consider the main targets pursued under the EU's current biodiversity strategy (European Commission, 2011a). Target 1 focuses on protecting habitats needed by nonhuman species, in part by completing the Natura 2000 system of protected areas and improving their management. Target 2 involves creating "green infrastructure" that is less environmentally harmful to other species and restoring 15% of currently degraded ecosystems, improving them as wildlife habitat. Target 3 focuses on making agriculture and forestry less destructive of biodiversity, either by making production less harmful to other species, or by shifting agricultural or forestry lands out of production altogether (e.g., by increasing designated wilderness acreage on public forest lands). Target 4 makes similar efforts to improve fisheries management and increase the number of marine protected areas. We can sum up these efforts by saying that the EU biodiversity strategy seeks to increase the amount of habitat available to other species and improve its quality and effectiveness, both within protected areas and outside them.

All these efforts to preserve effective wildlife habitat will be facilitated by having fewer people and undermined by having more, since they all depend on reducing human impacts on the habitat that we are trying to protect. We summarize some of the scientific evidence for this in table 6 below.

Table 6

Driver of biodiversity decrease (in one case, increase)	Scientific study affirming increased population density as a key driver of factor in question
Habitat availability	
Protected areas "downgraded, downsized, or degazetted" due to development/settlement pressure	Radeloff et al., 2010; Watson et al., 2014; Symes et al., 2016; Qiu et al., 2018; Krishnadas et al., 2018
Natural areas lost to agriculture or industrial forestry	Scharlemann et al., 2005; Estrada et al., 2017; Marques et al., 2019
Natural areas lost to urbanization, sprawl	Scharlemann et al., 2005; Seto et al., 2011; Colsaet et al., 2018; Driscoll et al., 2018; Qiu et al., 2018; Weber and Sciubba, 2018
Increased protected area acreage facilitated by rural depopulation	Navarro and Pereira, 2015a; Corlett, 2016; DeSilvey and Bartolini, 2018
Habitat quality or effectiveness	
Increased habitat fragmentation by human settlements, transportation corridors, other factors	Radeloff et al., 2010; Estrada et al., 2017; Driscoll et al., 2018; Krishnadas et al., 2018; Qiu et al., 2018; Tucker et al., 2018
Increased pollution, both ecotoxicity and eutrophication	Turvey, 2008; Driscoll et al., 2018
Increased hunting pressure	Stanford, 2012; Boitani and Linnell, 2015
Increased spread of invasive species	Driscoll et al., 2018
Increased climate disruption	IPCC, 2007; IPCC, 2014; Marques et al., 2019

Summary of recent scientific evidence that increased human population density drives biodiversity loss. Also included are studies showing that rural population decrease facilitates increased protected area acreage. Note: a similar table would be possible, collecting evidence for how economic sectors that are most harmful to biodiversity are made more damaging by increased human numbers.

While the complexity of the phenomenon prevents us from affirming a strict 1:1 inverse relationship, the overall trend is clear: greater human numbers reduce biodiversity. Knowing that changes in human population density correlate well with changes in habitat availability and quality, both generally (Seto et al., 2011; Symes et al., 2016; Khrishnadas et al., 2018) and specifically in Europe (Thompson and Jones, 1999; Navarro and Pereira, 2015a; Lehsten et al., 2015; Weber and Sciubba, 2018), we sketch broadly the impacts of changing population densities on biodiversity preservation in the EU in table 7.

Table 7

	Habitat trends under five migration scenarios				
	Zero net migration scenario	½ status quo migration scenario	Status quo migration scenario	2X status quo migration scenario	4X status quo migration scenario
European Union	▲ ▲ ▲	▲ ▲	▲	▼	▼ ▼
Germany	▲ ▲ ▲	▲ ▲	▲	▼	▼ ▼
France	▲	▼	▼	▼	▼ ▼
United Kingdom	▲ ▲	▼	▼	▼ ▼	▼ ▼ ▼
Italy	▲ ▲ ▲	▲ ▲	▲	▼ ▼	▼ ▼
Spain	▲ ▲ ▲	▲ ▲	▼	▼	▼ ▼ ▼

Expected population-driven changes in habitat availability and quality by 2100 in the EU under five migration scenarios. Small, medium and large habitat improvements correspond with the following changes in human population density: ▲ = 1-10% decreased density, ▲ ▲ = 11-30% decreased density, ▲ ▲ ▲ = 31-50% decreased density. Small, medium and large habitat declines correspond with the following changes in population density: ▼ = 1-50% increased density, ▼ ▼ = 51-150% increased density, ▼ ▼ ▼ = 151-250 % increased density.

Source: own calculations.

Just as every extra individual, now and in the future, will generate some GHGs and thus help heat Earth's climate, with more individuals generating greater climate change, so every extra individual, now and in the future, will take some habitat and resources away from other species, with more individuals generating greater biodiversity losses. Habitat losses or degradation caused by population increases could be mitigated by other factors, such as more efficient use of resources and better management of protected areas. But habitat increases or improvements caused by population decreases could be boosted by those same factors. Under all possible environmental futures, lower human population densities clearly will be better for other species.

As further evidence, consider the impact of recent EU population decreases in furthering ecological restoration, a cornerstone of the EU's biodiversity preservation strategy. Since 1960, Europe's rural population has declined by 20% (United Nations, 2014), contributing to extensive farmland "abandonment." Within the past two decades, up to 7.6 million hectares of agricultural land have gone out of production in Eastern Europe, southern Scandinavia and Europe's mountainous regions, as have 10-20% of the agricultural lands in the Baltic states (Leal Filho et al., 2017). Overall, these trends have been valuable for wildlife, particularly for larger herbivores and carnivores (Deinet et al., 2013; Boitani and Linnell, 2015). One promising European organization working for restoration of large natural areas, Rewilding Europe, acknowledges the positive role of rural population decreases, and most of their projects include ecological restoration of abandoned agricultural lands (Rewilding Europe, 2019). In turn, nature-based tourism can create jobs that benefit younger residents (Navarro and Pereira, 2015b).

Continued population reductions and release of land from agriculture could contribute even more to such successes in the future, helping European nations to meet and hopefully exceed their targets for restoring degraded ecosystems and increasing protected area acreage. The population of predominantly rural regions is projected to fall by another 7.9 million people by 2050 (ESPON, 2017). According to the Institute for European Environmental Policy, an additional 3–4% of total EU land will go out of production by 2030, with 126,000–168,000 km^2 potentially available for nature restoration (Keenleyside and Tucker, 2010). Other estimates range from 5 to 15% of agricultural areas (arable land and pasture), or 10 to 29 million hectares of land released between 2000 and 2030 (Verburg and Overmars, 2009). Many factors influence land abandonment, such as urbanisation and the profitability of various farming practices. But if population declines accelerate, more agricultural land within the EU could be released from intensive human use over the course of this century, while if population declines are reversed, less land is likely to be available for ecological restoration or biodiversity-sensitive agriculture or forestry. Since resource demands cross national boundaries, lower populations would also help EU nations reduce their negative impacts on biodiversity elsewhere, another key target of the EU biodiversity strategy (European Commission, 2011a).

Of course, realizing the benefits of population decreases for wildlife depends on putting in place the right policies and management (Cerqueira et al., 2015; Navarro and Pereira, 2015b) – just as in the case of greenhouse gas emissions. Unfortunately, the potential benefits of smaller populations have largely been ignored by European policy makers, who tend to view decreased agricultural activity as a problem, rather than an opportunity (Queiroz et al., 2014). Under the European Common Agriculture Policy (CAP) "less favored areas" (i.e., areas where agricultural use is less profitable) have been designated mainly to maintain agricultural production, regardless of its appropriateness. The largest amounts of funding for biodiversity conservation are available through EU and national agro-environmental schemes aimed at preserving traditional farming systems and reversing abandonment trends (Navarro and Pereira, 2015b). These support biodiversity preservation efforts in many rural areas (Zingg et al. 2019), but simultaneously CAP encourages large-scale intensive agriculture which displaces biodiversity on many other lands (Pe'er et al., 2014). Conservation policies should include keeping extensive acreages of traditional farmlands, while also recognizing that some former agricultural lands can be given back to nature through rewilding (Corlett 2016). Both kinds of efforts are needed and both would be furthered by smaller populations.

Once again, then, the evidence seems clear that "the implicit assumption" is mistaken. Population size will play an important role in EU efforts to preserve biodiversity, and immigration policy could play an important role in facilitating or undermining such efforts.

5 Conclusion

In the absence of convincing evidence to the contrary, what holds true for climate change and biodiversity loss can be presumed to hold true more generally. The implicit assumption under which most EU environmental advocates and policymakers have labored in recent decades appears mistaken. Population size will play an important role in the efforts of EU nations to meet their future environmental challenges. Reducing immigration can help create ecologically sustainable societies that share the landscape generously with other species, while increasing immigration will tend to move EU nations further away from these goals.[4]

One straightforward policy implication, based on the EU's strong environmental commitments, might be that European nations with high immigration levels, like Germany, Spain and the United Kingdom, should reduce them. Countries with stable or declining populations, like Italy, Poland, Hungary and the Netherlands, could embrace rather than fight these demographic trends (Götmark et al., 2018). Alternately, EU nations could reduce their current environmental commitments, increase immigration and embrace even denser human populations. Sustainability is not the only proper goal of policy-making. Arguably however, it is a fundamental goal, necessary to long-term societal flourishing (Millennium Ecosystem Assessment, 2005; European Commission, 2011b; Foreman and Carroll, 2014).

At a minimum, EU citizens deserve an honest discussion of how immigration policies will impact their environmental goals going forward, since demographic trends are not set in stone but strongly depend on public policies (Lutz et al., 2019; Cafaro and Dérer, 2019). Whatever immigration policies are decided on should respect the claims of justice, including the rights of refugees and would-be immigrants to fair treatment (Miller, 2016), the rights of EU citizens to democratically choose policies that will affect their societies in fundamental ways (Phillips, 2018) and the rights of other species not to be extinguished by human beings (Staples and Cafaro, 2012). But they also must respect the reality of ecological limits to safe human resource use, which humanity is already seriously transgressing (Ripple et al., 2017; O'Neill et al., 2018). Partha Dasgupta (2019) recently wrote, "to me it remains a puzzle that population [ethicists] haven't subjected their reasoning to a world facing socio-ecological constraints of the kind we have now come to know." As we have shown, policy-makers also tend to avoid subjecting their reasoning to such constraints. We believe the time for such avoidance is over.

4 Similar arguments hold for Australia (Smith, 2011) and the United States (Cafaro, 2015).

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BOOK REVIEW

Falter: has the human game begun to play itself out?
Bill McKibben
New York: Henry Holt 2019. $28.00 (USD). 304pp. ISBN: 9781250178268

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Thanks to Bill McKibben not just for his new book, but for 30 years of honest, eloquent, and insightful environmental writing and activism.

He begins *Falter* by pointing out that "the human game we've been playing has no rules and no end, but it does come with two logical imperatives. The first is to keep it going, and the second is to keep it human" (p.17).

What McKibben calls "the game" that we must keep going and keep human, is similar to what C. S. Lewis called the "Tao" (in his 1944 classic *The Abolition of Man*), by which he meant our common morality informed by natural law and spiritual insight, the historical and evolving traditional conscience and wisdom of mankind. The Tao develops and evolves out of its own past. It is our best understanding of objective value. We have no freedom to depart from it in any fundamental way – it transcends both subjectivism and naturalism. In McKibben's version, the "human game" has to both continue and remain human. It is the second part that gets close to Lewis, who wrote long before the age of genetic engineering and CRISPR. His "Conditioners" were only educators and psychologists. But for purposes of argument, Lewis granted them the complete power to mold their subjects, the same power that seems to be possessed by the modern genetic Conditioners of today, so his argument remains relevant, indeed becomes more so.

1 Overlapping commentaries and discussions drawn upon here have appeared in the blogs *Great Transitions Initiative*, and *The Steady State Herald*.

His argument is simple: the Conditioners want to create in their subjects a new artificial Tao, a "better" one. They have the power to do so. They may appeal to the traditional Tao for guidance on how to make the artificial Tao better. But then they are really still servants of the Tao and not creators of a new Tao. They are developing the Tao, not replacing it. To replace the Tao, they must step outside of it to find their criteria for how to remake it. But in stepping outside, they step into an ethical void. "I should" or "I ought" comes from the historical Tao and disappears with its absence. What remains to motivate the Conditioners is "I want". The personal desires of the Conditioners, uninstructed by the Tao from which they have emancipated themselves, become the motives directing the "I can" of these all-powerful Conditioners. What appeared to be the collective power of mankind over the Tao as a presumed part of nature has turned out in the end to be the arbitrary power of some over many, with knowledge of nature as the instrument of domination. The future subjects are no longer men, but creatures of the Conditioners' wants, whims, desires and fantasies – hence the title *The Abolition of Man*.

Lewis is not arguing against knowledge or technology. For each step in controlling nature, it may (or may not) be that the benefits outweigh the costs. He is insisting, however, that the last step, treating the Tao as if it were just another part of nature to be remade according to human desire, is fundamentally different, like dividing by zero instead of by a smaller and smaller number. At this last step, the process does not continue, it blows up in your face.

McKibben's argument, as I understand it, is similar in form, but different in its terms. The Tao is "the human game" that we must keep both going and human. The continuation of the game is threatened by the fact that we are destroying the physical board (or sphere) on which the game is played. Much of McKibben's writing and activism has been motivated by saving the biophysical board necessary to keep playing the game, in particular saving a climate conducive to life. What is new in this book (at least it seems so to me) is the emphasis on keeping the game human, or "within the Tao" in Lewis' terms.

McKibben says:"I am not great with eschatology; I don't know the final destination. While I don't know how to change the "system," the urgent nature of the climate crisis doesn't let us simply put off action. The biophysics doesn't allow it. " (2019)

One understands his reluctance to "go eschatological", and to stick with the biophysical. Yet McKibben is already neck deep in eschatology, and necessarily so. Emphasizing the apocalyptic consequences of the climate crisis is already a big step in that direction, but where it really happens is in his reflections on the full-blown and frank eschatology of the Silicon Valley billionaire self-creationists.

As McKibben reports, a number of these folks are planning to live forever, not in the New Jerusalem, or in a Platonic spirit world, but here on unredeemed earth. Either survive whole or freeze your severed head until the Singularity (Second Coming?), when science will resurrect you, or at least your consciousness, by uploading it into silicon memory chips. Where, oh Death, is now thy sting? What they ridicule as naive religious belief, a remnant of the old Tao, they recreate as a new technological religion, an eternal digital heaven on earth (or maybe Mars), populated (indeed overpopulated in the absence of death), not by mortal men, but by---what? Marxists did something similar (but less extreme) with their eschatology of the new socialist man and classless society.

McKibben is politely disrespectful of the eschatology of these self-rapturing techies, noting their extreme individualism (stemming from their common hero, Ayn Rand) that leads them to appropriate forever a place on earth for themselves. McKibben reminds us, however, that these are the richest people in the world, and what they believe is influential. Modern theologians have prematurely "closed the office of eschatology". Now it has been re-opened, under new management. G. K. Chesterton famously said that when people stop believing in God, the problem is not that they then believe nothing, but that they are likely to believe anything. Could be.

Keeping the present creation going as long as possible is an ethical judgment in favor of longevity, not a logical imperative. Nothing in logic prevents extinction or death; indeed, evolution requires it for individuals and species. For creation as a whole, whether the ultimate future will be entropic physical dissipation or theological new creation, is the eschatological question. It is a question of reasoned expectation and hope rather than demonstrated knowledge. We tend to dismiss eschatology on the grounds that the sun will last for some billions of years, and thoughts about the final end will distract attention from the immediate crisis. Fair enough, but the scientific materialism underlying

Salvation-by-Singularity has given us the power to destroy creation without providing, indeed by undercutting, any reason to keep it going – other than chanting the colorless abstract noun "sustainability". Meanwhile the Silicon Valley eschatologists are working out their personal salvation independently. Probably, they already have started marketing it to those who can afford it.

McKibben has demonstrated that "The climate threat is so pressing and so intermingled with current economic arrangements, that it provides the best possible lever for making profound change in other aspects of the economy..." (2019). I suspect that a serious effort to solve the climate crisis, or the biodiversity crisis, or water crisis, or political crisis for that matter, will soon lead to the recognition of their underlying common cause, namely the continuous physical growth of the human economy and its consequent displacement and degradation of the rest of our world.

Nevertheless, most discussions of climate change usually fail to make the connection to growth. The focus is on how to *accommodate* growth within the structure of complex climate models and their predictions. The main accommodation is to advocate a switch from nonrenewable to renewable energy resources, but without recognizing that renewables effectively become nonrenewable, once growth leads to exploitation levels beyond sustainable yield.

Maybe, after repeated failures, a steady state economy will begin to seem like a reasonable policy – to save whatever is left for however long it can last. That falls far short of a real eschatological vision, but it is better than the cryogenic rapture of the Singularity preached by the technical Gnostics. McKibben does not pursue his initial critique of Silicon Valley eschatology, and one cannot blame him because the topic is daunting. But the eschatological question of ultimate purpose and final end keeps breaking through into policy discussions, however unwelcome to present attitudes. In *Falter*, McKibben at least identifies this usually repressed issue.

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ISSN 2398-5496