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Where the Wild Things were is Where Humans are Now: an Overview

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Abstract
Humanity is undergoing an unprecedented demographic transformation in that global population is rising from 2 billion in the 1920s to an expected 8 billion in the 2020s, an annual increase of roughly 80 million. The requirements of this expanding human population are strongly linked to depletion of wildlife and increasing difficulties facing both wildlife and environmental conservation efforts. I assess current and potential risks stemming from the environmental changes due to unchecked human population growth.

Keywords Overpopulation · Population growth · Habitat and wildlife conservation · Biodiversity · Environmental degradation

Introduction

The global human population has more than quadrupled since the beginning of the twentieth century and overall growth is expected to rise in future (Population Reference Bureau 2018; UNDESA 2017a). Official forecasts (Population Reference Bureau 2018) predict that growth will be unevenly distributed around the world: of the 2.3 billion additional individuals anticipated between 2019 and 2050, roughly 1.3 billion will be born in Africa, 0.7 in Asia and 0.3 in the rest of the world. Even though there are global achievements in reducing fertility rates, notably in developed nations (Pison 2017; Frejka 2017; UNDESA 2017b), population growth remains a legitimate concern, primarily in developing nations. However, countries that have attained below replacement fertility (BRF) of 2.1 births per woman have not fully recognized the inherent social and environmental benefits (Götmark *et al.* 2018) and are faced with decelerating economic growth and an ageing population of dependent individuals. Consequently, 62% have enacted pro-natal policies (Wong and Yeoh 2003; UNDESA 2017b), and others have turned to immigration to fuel population growth (Cafaro 2018).

The promotion of further population growth in countries with some of the highest carbon and the most significant ecological footprints (Global Footprint Network 2018; World Bank 2019)) is not just environmentally detrimental but morally questionable (Rieder 2017; Conly 2016). Human collective responsibility to the environment, in preserving wildlife, and to alleviate human suffering due to the effects of climate change that are predominantly attributable to affluence or wealth, creating extreme carbon inequality, has been widely recognized (Oxfam International 2015; Rieder 2016; Hubacek *et al.* 2017; Population Media Center 2018; Randers *et al.* 2018; UN Environment 2019; Vidal 2019). Ignoring the moral dimensions of migration and efforts to increase fertility, the environmental impacts of mass movement of peoples from low-income countries to higher-income countries are ultimately detrimental to global environmental sustainability (Cafaro and Staples 2012; Hickey *et al.* 2016; Kopnina and Washington 2016; Phillips *et al.* 2018; Frum 2019).

Population Growth as a Threat Multiplier to the Natural World

Although the size of the global human population has often been characterized as unsustainable in terms of its current and future ecological impacts, there are those who claim that human population growth will translate into benefits, such as higher educational levels, contributing to more solutions for the problems created by an otherwise unsustainable global population (e.g., Ord 2014; Itkowitz 2019). However, overall, the scientific consensus is that the current rate of human population growth is not sustainable (Daily and Ehrlich 1992; Union of Concerned Scientists 1992; Pimentel *et al.* 1994; Murtaugh and Schlax 2009; LeDoux 2009; Cafaro 2012; Ehrlich *et al.* 2012; Ripple *et al.* 2017; Bongaarts and O'Neill 2018; Kuhlemann 2018a, b) and is a root cause and a multiplicative agent in the ongoing global mass extinctions

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of species (Stallings 2002; Ceballos *et al.* 2015, 2017). Population growth and economic development continue to be described as the primary causes for wildlife and land use loss (Zhou *et al.* 2018; Marques *et al.* 2019). The recent *Global Environment Outlook* from the United Nations reports:

"Human population dynamics or trends, particularly population pressure, and economic development have been acknowledged for many decades as the primary drivers of environmental change" (2019:6).

Human activities directly impacting 84% of Earth's surface are rendering a quarter of the world's vertebrate species vulnerable to extinction (Allan *et al.* 2019). Growing human populations contribute to a reduction in the biodiversity essential to food production as well as adversely impact ecosystem services provided by habitats (Song *et al.* 2018 ; FAO 2019). The need to satisfy human dietary requirements has already led to the decline or extinction of many animal and plant populations, precipitated ecosystem disruption, and promoted biohomogeneity (Burkle *et al.* 2013; Machovina *et al.* 2015; Ceballos *et al.* 2017; Crist *et al.* 2017; Bar-On *et al.* 2018; Watson *et al.* 2018; WWF 2018).

Currently, roughly 40% of the planet's ice-free land is used for agriculture and livestock, which has led to the global decline of wild animal populations (Cardillo *et al.* 2004; Foley *et al.* 2005; Machovina and Feeley 2014; Ripple *et al.* 2015; Ogutu *et al.* 2016; Roser and Ritchie 2019). Overfishing, along with global warming, has led to the serious depletion of marine resources worldwide (FAO 2018; Kroodsma *et al.* 2018), and growing demand for cash and subsistence crops, such as soybeans or palm oil, is contributing to current deforestation in the tropics (Gibbs *et al.* 2010; Maverick 2014; Vijay *et al.* 2016).

Given the evidence of extensive damage already incurred from anthropogenic climate change and pollution, it is possible to anticipate future impacts as global human population continues to grow to a projected over two billion by 2050 (Song *et al.* 2018). Such rapid population growth, in conjunction with rising affluence, translates into roughly 70% greater global demand for food by 2050 and double or triple that by 2100 (Clay 2011; Maddocks *et al.* 2016;). Global requirements for animal-based foods, such as meat and dairy products is expected to soar by 70% (Population Matters 2018; Searchinger *et al.* 2018). At the same time, animal production in wealthy nations will need to be reduced in the order of 90% for beef and 60% for milk in order to avoid the dangerous tipping point of 2 °C rise in global temperature (Springmann *et al.* 2018). The foreseen extension of cultivated landmass in addition to the expected 55% increase in demand for freshwater by 2050 and the concurrent rise of water-stressed areas due to this surge in demand, suggest that, globally, effective functioning of local ecosystems, not to mention worldwide conservation efforts, would be severely undermined by continuous population growth (Tilman *et al.* 2001; Leflaive 2012; Crist *et al.* 2017; WWAP 2019).

Not only is there growing demand from more consumers, but these consumers are becoming wealthier and consequently eating higher in the food chain, requiring more goods to be extracted, manufactured, transported, and stored (Rees 2006; Gerbens-Leenes *et al.* 2010; Bonhommeau *et al.* 2013; Weinzettel *et al.* 2013; Sun *et al.* 2018). Regrettably, the biosphere is also threatened by a more globalized and interconnected world (Wiedmann and Lenzen 2018; Watson *et al.* 2018; Tucker *et al.* 2018; Newbold 2019), with expanding infrastructure fragmenting wildlife refuges and disrupting the life support systems of wildlife (Ascensão *et al.* 2018; Laurance 2018; Sloan *et al.* 2019). Similarly, the increased ubiquity and mobility of human populations facilitates the introduction and establishment of invasive species (Owens and Bennett 2000; McKee 2005; Vilà *et al.* 2011).

Sanctuary

At the turn of the millennium, researchers began to focus on the importance of biodiversity hotspots and the mounting pressure from population growth (Myers 1988; Cincotta *et al.* 2000; Myers *et al.* 2000). Cincotta *et al.* (2000) report that as of 1995, the then 25 designated hotspots were home to 1.1 billion people, roughly 19% of the global population. As of 2018, 36 hotspots have been identified (Conservation International 2018), collectively comprising a tiny fraction of the planet – 4.6% of the Earth's total surface area (15.4% of the land area) – but crucial to biodiversity as they contain 50% of vascular plants and 42% of terrestrial vertebrates as endemic species (Myers *et al.* 2000; Mittermeier *et al.* 2011; Cunningham and Beazley 2018).

Rates of population growth are particularly relevant. Cincotta *et al.* (2000) assess the global growth rate from 1995 to 2000 was 1.3%, but it was 1.6% in the hotspots (Williams 2011). Human populations in the hotspots have continued to grow at a faster rate than the global average (Williams 2011), with more recent research reported by Cunningham and Beazley (2018) concentrating on the changes of population density through the 20-year period of 1995–2015. Since focusing solely on rates of population growth can be misleading (Cincotta *et al.* 2000), Riggio *et al.* (2019) point to the rapidly growing economies as well as the population growth rate of 2.71% (versus the global average of 1.09%) in Protected Areas (PAs)[1] of East Africa. These growing economies will pose critical challenges to the conservation of wildlife, even though much progress has been made in the establishment of the PA network in the region.

Although there is some disagreement about the mechanisms, there is little doubt that increasing human population density (HPD) in biodiversity hotspots directly jeopardizes

[1] Areas in which human activities such as livestock grazing, hunting, logging, or cultivation are restricted (Watson *et al.* 2014).

wildlife; the general consensus is that human presence is a crucial element contributing to the decline of native species and a hazard to conservation and re-wilding (McKee *et al.* 2004; Dietz *et al.* 2007; Luck 2007; McKee 2012; McKee *et al.* 2013 https://www.sciencedirect.com/science/article/pii/S0006320703000995; Cunningham and Beazley 2018; Kunzmann 2018). In the period 1995–2015, average population density across all biodiversity hotspots expanded by 36%, from 76 people per square kilometre (ppl/km^2) to 103 ppl/km^2. While having a lower increase in HPD when compared to the global changes for the same period (47% increase, from 38 to 56 ppl/km^2), 11 hotspots exhibited average HPD increases higher than the global average. In comparison, in 2015 21 of the 35 biodiversity hotspots showed average HPDs above the global average, with the predicted increase between 2015 and 2020 of 8.93%.

In spite of apparent differences between growth rates and population densities among the hotspots, it is possible to generalize that human population growth has been faster and will continue to be so, in sub-Saharan Africa, followed by south-central Asia, south-eastern Asia and Oceania, with Latin America and the Caribbean also showing considerable increases in population (Williams 2011). As a result, it is predicted that population growth will continue to be a significant threat for priority conservation areas, since PAs are themselves the focus of migration (Wittemyer *et al.* 2008; Naughton-Treves *et al.* 2011; Estes *et al.* 2012). For this reason, despite some evidence to the contrary (Joppa *et al.* 2009), accelerated ecological and wildlife degradation at the boundaries of PAs due to animal husbandry, crop cultivation, and extraction of natural resources are to be expected. At present, more than one-fifth of the world's population inhabits areas of high biodiversity (Diamond 2012), while it is anticipated that 50% of global population will inhabit the tropics by 2050, up from the current approximately 40% (Wilkinson 2014; State of the Tropics 2017). These increases in HPD, accompanied by commensurate increases in environmental pressures, have unfolded in areas that Jones *et al.* (2018) describe as "Protected yet Pressured," and they report that only 10% of the PAs in their study do not show "intense human pressure" as roads, ranches, mines, and building construction encroach onto lands designated as national or regional parks, reserves, and wilderness sanctuaries (Cannon 2018).

Sri Lanka and the Indian Western Ghats (also known as the Sahyadri Mountain Range) constitute one of the 36 current biodiversity hotspots. Besides being one of the eight "hottest hotspots" owing to its substantial plant and animal endemism (Myers *et al.* 2000), until recently the region had the highest human population density among all biodiversity hotspots (average 335 ppl/km^2).[2] Historically, between 1920 and 1990 40% of this region's natural vegetation was converted into coffee and tea plantations and at present only approximately 6.3% of the original vegetation remains (Sloan *et al.* 2014). Even though the rates of deforestation are at their lowest in the last 100 years, and are even below the average of other forested pars of India (Reddy *et al.* 2016), the Western Ghats lost more than 750 km^2 of forest between 2000 and 2016, to the point that there are evident adverse repercussions to biodiversity due to this erratic small-scale deforestation (Dérer 2018).

Krishnadas *et al.* (2018) correlate the forest deficit in the Western Ghats with the economic expansion of the population. They report that the deforestation was mostly outside PA's and that forest protection initiatives in the form of wildlife sanctuaries and designated national parks effectively reduced forest loss by 30%. Moreover, they found that for every 22 km increase in mean distance to human settlements, forest loss decreased by 16%, with even less impact for PAs, which are 36% less likely to lose forest than non-protected forests when contiguous to human habitations. Equally, with every 4 km in increased distance from roads in non-protected areas and PAs, forest loss abated by 21% and 33% respectively. However, the benefits of formal protection weakened by 32% with every increase of 24,000 people above mean local population densities. In fact, where local human populations were higher in the Western Ghats, PAs were 70% more susceptible to forest cover loss than non-PAs, indicating that the difference in rates of forest loss between PAs and non-PAs is highly correlated with local population densities (Dérer 2018; Krishnadas *et al.* 2018). Similarly, Madagascar's diverse and unique forests, among the earliest designated 25 hotspots, are sustaining immense losses due to population growth of more than five-fold since 1960 from around 5 million to 26.3 million in 2018, and meeting the concomitant food requirements is resulting in a prioritization of agricultural production over environmental protection (Myers *et al.* 2000; Clark 2012; PopulationPyramid.net 2017).

Estrada *et al.* (2018) address the equally important issue of the apparent overlap between protected areas, primate distribution, human population density, and the upsurge in human activities with disruptive repercussions for the primates' habitats. By modelling the distribution of protected areas and primate presence in Brazil, Democratic Republic of Congo, Madagascar, and Indonesia, they found that on average, primates had only 38%, 14%, 38%, and 17%, respectively, of their ranges included within the borders of the PAs, leaving the majority of non-human primate populations in unprotected areas.

When considering that subpopulations of the same species are already frequently separated from each other due to human activities and infrastructure (Mascia *et al.* 2014; Spracklen *et al.* 2015; Waeber *et al.* 2016), it is unsurprising that an increase in human population density within 50 km of a PA significantly impacts levels of illegal activities and biodiversity loss (Rovero *et al.* 2015; Estrada *et al.* 2018).

[2] At this writing it has been supplanted by a hotspot in the Philippines with an average 345 ppl/km^2 (Cincotta *et al.* 2000; Cunningham and Beazley 2018).

The Ecological Impact of Poverty

Much attention has been paid to climate change (e.g., Watts (2018) reports that one news story about UN biodiversity appears for every 20 about UN climate conferences) and the fact that the role of wealthy nations in exacerbating climate change (Dong *et al.* 2018; Chancel *et al.* 2015) overshadows their impacts on biodiversity conservation (Bellard *et al.* 2012; Pecl *et al.* 2017). Continued population growth in wealthy countries is crucially relevant to the degree of effectiveness achieved by biodiversity and wildlife conservation initiatives and yet concern with increasing population levels as been diminishing since the late 1970s (Foreman and Carroll 2015). Nevertheless, the majority of predicted global population growth is due to occur in less prosperous nations.

More research is required on the nexus between human poverty, habitat destruction, and wildlife depletion, although the link has been reasonably well established (Hassan *et al.* 2015; Watmough *et al.* 2016; Cheng *et al.* 2018). Communities and individuals living in impoverished conditions frequently rely on accessible natural resources and ecosystem services for their subsistence (Sen 2003). Such local impacts on the environment can have alarming ecological repercussions: Subsistence river or coastal fishing can ultimately deplete fish stocks; and subsistence swidden cultivation, nomadic pastoralism and livestock grazing, illegal forest harvesting for building materials and fuel, and overhunting and poaching for household consumption and trade can all lead to serious habitat loss (Donald 2004; Naughton-Treves *et al.* 2007; NASA 2009; Western *et al.* 2009; Klanderud *et al.* 2010; Harrison 2011; Kolankiewicz 2012; Duffy and St John 2013; Serra 2015; Eldridge and Delgado-Baquerizo 2017; Keskar *et al.* 2017; Lin 2017; Jones 2018). In addition, subsistence households seeking employment for their livelihoods are often limited to extractive industries with poor environmental records, such as mining or logging, or industrial cash crop production, e.g., palm oil plantations (Gamu *et al.* 2015).

The hunting of wildlife as a direct meat source is often considered to be a more significant menace to the conservation of biological diversity in tropical forests than deforestation (Dreifus 2006; Fa *et al.* 2002; Gray 2017; Fa *et al.* 2003; Ripple *et al.* 2019; Wilkie *et al.* 2005). The multibillion-dollar trade in bushmeat, especially critical in Africa and south-eastern Asia, is among the most immediate threats to tropical vertebrates (Brashares *et al.* 2004), provoking many cascading trophic effects magnified by expanding human populations (Dirzo 2013; Ripple *et al.* 2014; Ripple *et al.* 2016), increasing commercial trade in wild meat (Robinson and Bennett 2004), and the enhanced efficiency of transport and firearms (Levi *et al.* 2011). With wildlife numbers dwindling outside of protected areas, hunters are turning their attention to parks and reserves and their frontiers (Geldmann *et al.* 2014), and as a result, many wildlife refuges are becoming 'empty landscapes' (Nasi *et al.* 2011; Ripple *et al.* 2015). For instance, Brashares *et al.* (2001) found a marked positive relationship between the size of a given human population and the rate of local extinction of mammals, with the highest incidence of hunting being identified at reserve edges.

Researchers point out the substantial role of bushmeat in the economy of several countries, with around 150 million households in the Global South acquiring meat through bushmeat hunting (*Nielsen et al.* 2017; Nielsen *et al.* 2018). Contrary to the assumption that most hunting activities are for commercial purposes, Nielsen *et al.* (2017, 2018) found that from their sample of 8000 randomly selected households in 24 tropical and sub-tropical countries, 39% hunted bushmeat and 89% of the resulting income is dedicated to household dietary needs. Further, the researchers (Nielsen *et al.* 2017) found a higher than expected reliance on bushmeat, with Nasi *et al.* (2011) reportint the extraction of 6 million tonnes of bushmeat each year from the Congo and Amazon Basins alone. In many cases it is the absence of alternative sources of protein that motivates villagers to become illegal hunters (Loibooki *et al.* 2002; Holmern *et al.* 2007; Knapp 2012), although others deliberately hunt protected animals to sell their body parts for medicinal uses (Lemieux and Clarke 2009; Douglas and Alie 2014).

According to Robinson and Bennett (2000), the carrying capacity of tropical ecosystems, such as the Congo Basin[3] and the Amazon for hunting activities translates into one subsistence hunter per square kilometre, even though continuous population growth is a reality in these regions. Since the dependence on bushmeat is a matter of survival with few if any alternatives for many communities, the impacts of hunting on wildlife population are becoming increasingly apparent (Nasi *et al.* 2011). Consequently, reconciling the conservation of species with a regulated and sustainable harvest of bushmeat is indicated. The first steps could be through the implementation of a suitable legal framework, the participation of the public health, private and development sectors, and emphasizing communal involvement to ensure successful development and implementation of conservation approaches. On the other hand, Bennett *et al.* (2007) argue that until we effectively deal with the multiplicative effects of rapid human population growth such as resource depletion, habitat fragmentation and loss, pollution, and the spread of diseases, wildlife populations will continue to decline, thus making successful conservation strategies an unattainable aspiration.

[3] In much of the Congo Basin bushmeat is the primary source of protein (Wilkie and Carpenter 1999), especially where livestock husbandry is not a practical option and wild fish not available.

Conclusion

Ultimately, global goals of protected-area coverage and the conservation of wildlife, in general, are unlikely to be met unless PAs are well managed, appropriately located (Butchart *et al.* 2015), better-funded (Cunningham and Beazley 2018), and conservation targets are scientifically and not politically driven.[4] However, as Cafaro *et al.* (2017) note, achieving these goals will require curbing further population growth as well as decreasing our current global population to an optimum size of 1.5 to 2 billion individuals (Daily *et al.* 1994; Foreman and Carroll 2015).

We have to realize that a world with ever more human beings is also a world with more human encroachment, habitat loss, deforestation, depletion of ecosystems, and climate breakdown, all leading to the inevitable outcome of wildlife depletion. Therefore, it is imperative to facilitate the clarification and public awareness of the link between the growth of global human population and the rise in per capita affluence, and how, in conjunction, these trajectories potentially lead to possibly irreversible negative impacts on our climate and environment. Harding (2018) argues that it is paramount that the goals of global human population stabilization and eventual reduction are included in this agenda. In order to achieve that scenario, we should humanely curb population growth by choosing to act on its deliberate reduction. Paul. R. Ehrlich (2013) has proposed that:

> "… the best way to accelerate the move toward such population shrinkage is to give full rights, education, and job opportunities to women everywhere, and provide all sexually active human beings with modern contraception and backup abortion."

The best strategies to secure a reversal of population growth are currently the advancement of women's rights for equality, political voice, economic independence, as well as the dissolution of patriarchal norms such as child marriage (Engelman 2016). Further, the removal of barriers to contraception and safe and legal abortion (Population Matters 2019), as well as removal any cultural stigma associated with the choice of smaller family sizes or no children are equally important. 'Educating girls' and 'family planning' are together demonstrably the best methods for the reduction of atmospheric CO_2 and amelioration of consequences of global warming (Project Drawdown 2019). Resources and support from the developed world will play a decisive role in the success of these approaches (Guttmacher Institute 2019; The Overpopulation Project 2019).

[4] Studies point to a 25–75% area of protection, or even the widely discussed 'Half-Earth' with its goal of 50% protection, instead of the current aim of 17% for terrestrial areas and inland water and 10% for marine and coastal areas (Noss *et al.* 2012; Convention on Biological Diversity 2013 https://www.cbd.int/doc/strategic-plan/targets/compilation-quick-guide-en.pdf; Büscher *et al.* 2017https://www.cambridge.org/core/journals/oryx/article/halfearth-or-whole-earth-radical-ideas-for-conservation-and-their-implications/C62CCE8DA34480A048468EE39DF2BD05; Baillie and Zhang 2018))

Compliance with Ethical Standards

Conflict of Interest The author declares he has no conflict of interest.

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