Got nitrogen? On the links between nitrogen pollution and overpopulation

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All the articles in this issue on overpopulation touch upon the contentious nature of the population question. Controversy surrounding population issues has underwritten decades of silence and neglect, since many analysts understandably do not want to be stigmatized by the slur of 'neo-Malthusian,' branded an 'eco-fascist' or shamed for allegedly blaming the world's poor for our woes.

Suspecting population analysts of harbouring ethically dubious motives could not be more amiss or more ironic. Environmental writers and activists who highlight the calamities connected with overpopulation are motivated by deep concern for the well-being of all life; they also emphasize that a smaller global population can be achieved by policies and actions that promote fundamental human rights. To achieve a sustainable human population, they urge the global community to pursue full gender equity; ensure education for girls (and all children) through secondary schooling and beyond; make high-quality family planning universally available; include comprehensive sexuality education in school curricula; and aggressively oppose the abusive cultural practice of child marriage. With these human rights ambitiously pursued and universally attained, population growth can end sooner (than via 'the invisible hand' of globalization) and a smaller global population gradually attained.

These human rights will markedly improve the quality of life of individuals, while in their aggregate demographic outcome they will markedly support a higher quality of life for all beings on Earth. As I discuss in this essay, a smaller human population can be supported with agroecological (organic, diversified, no- or low-tillage) food production. Such regenerative agriculture systems will provide nutritious food for all people; practice an ethical rapport with nonhuman life, both domestic and wild; and mitigate the climate crisis by

absorbing anthropogenic carbon from the atmosphere and keeping soil carbon safely sequestered. Superseding chemical (industrial) agriculture will terminate its nonstop polluting and killing operations that afflict planetary and human health and threaten to unalterably impoverish Earth's remaining biodiversity. Fighting for a food system that is just and healthy for all, as well as modestly scaled within the Earth system, necessitates a global human population far lower than it is today – let alone than where it is going if silence and neglect around the population factor continue.

Actively decelerating, ending and reversing population growth, as all authors in this issue urge, is a critical action that humanity must take if our goal is the preservation of a biodiverse planet, averting unnecessary suffering and death, and bequeathing a high quality of life to posterity.

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Half the world's population of nearly 8 billion people is supported with food grown with synthetic fertilizer (Ritchie and Roser, 2020). Herein lies a crucial indicator (if not definition) of overpopulation. What enabled the population explosion, in connection to the food system, has been the industrial production of fertilizer utilizing the Haber-Bosch process, which of all innovations of the Green Revolution is the single most decisive factor in boosting crop yields (Erisman *et al.*, 2008; Ritchie and Roser, 2020).

Synthetic fertilizer has bankrolled population growth and synthetic fertilizer is a pollution disaster. The disaster of nitrogen pollution has remained somewhat under wraps. Röckstrom and co-workers' (2009) analysis of planetary-boundaries showed that the nitrogen cycle and biodiversity loss were the most exceeded Earth-system boundaries, followed by climate change. However, it is climate change that has commanded the most attention – nitrogen pollution far less so (Pearce, 2018). Generally overlooked as well is that nitrogen pollution and biodiversity loss are not coincidentally in the red zone of breached planetary boundaries: anthropogenic nitrogen is one of the drivers of biodiversity destruction (Campbell *et al.*, 2017). What's more, human population growth – especially via the expansion of the food factor – has been a cornerstone of both.

Anthropogenic nitrogen has not received anything close to the attention it deserves for three reasons. First, it is a complicated matter given that nitrogen pollution bears on soil, groundwater, streams, rivers, lakes, estuaries, coastal seas, atmosphere, climate and stratosphere (Erisman *et al.*, 2013). Grasping the big picture of disrupting the nitrogen cycle – over half of the nitrogen in the Earth system is anthropogenic – is thus not a straightforward exercise (and one I barely scratch the surface of in this essay). Second, nitrogen pollution is obscured by the vocabulary used to describe it. A sampling from the scientific and popular literature includes terminology such as *excess nutrients*, *nutrient overload*, *algal blooms* and *eutrophication* (from the Greek for 'well-nourished'). Such seemingly 'life-friendly' descriptors make it easier to gloss over anthropogenic nitrogen, which menaces life beginning with its adverse impact

on soil biodiversity. That impact is all the more deleterious because fertilizers are typically accompanied by other Green Revolution poisons – fungicides, herbicides, and insecticides. A third reason that the dangers of nitrogen pollution remain relatively overlooked is the connection between synthetic fertilizer use and human population size and growth. Since many analysts and lay people prefer not to broach the politically sensitive 'population question,' discussion of nitrogen pollution is also muffled.

Fertility: Real and fake

The problem of anthropogenic nitrogen looms. It is not so much the elephant in the room as the multi-headed Hydra in the room. Nitrogen pollution fans out into all Earth systems, and it stems mostly from one thing: synthetic fertilizer, or NPK (nitrogen-phosphorus-potassium fertilizer ingredients), or *anthropogenic nitrogen* as I refer to it here for simplicity's sake.

Perhaps the most obfuscating vocabulary associated with synthetic *fertilizer* is the word fertilizer itself – a word in which the idea of 'fertility' features centrally. Yet synthetic fertilizers do not have much to do with fertility. To be sure, they make crops grow faster and bigger; but so would giving your child growth hormone. Biological fertility, by contrast, is neither a hurried nor lopsided affair, but ensues from life's diversity and relationships, wherein living processes build and decompose organic matter in soil structures. Agronomist Richard Haney states that organic matter on farmland is a critical indicator of fertility. After decades of chemical farming, levels of organic matter are way down, in some fields lower than one per cent; where synthetic fertilizer is applied both microbe activity and organic matter are low (Haney quoted in Schiffman, 2017). In brief, synthetic fertilizers actually diminish fertility while appearing to augment it. Along with other chemical inputs, fertilizers degrade the soil and simultaneously mask that degradation.

The high yields of Green Revolution agriculture come at the unsustainable price of ruining the health of the soil. "Healthy soil," organic farmer Jason McKenney writes, "is an inherently biological medium" (McKenney, 2002: 122). With natural fertility, plants absorb a diversity of nutrients from life-made and life-cycled organic matter; those nutrients are gradually released into the soil and slowly absorbed by plants in the course of their natural growth (Jackson, 2002). The profusion of foods that surround citizens (especially) of the developed world – a profusion that much of humanity aspires to – comes at the Faustian trade-off of Earth's fertility. Over time, Green Revolution agriculture extinguishes fertility by bombarding (soil and above-soil) biodiversity with chemicals. Haney succinctly summarizes the mind-set of chemical agriculture: "Let's kill everything and grow what we want" (quoted in Schiffman, 2017).

The impact of fertilizer on soil is only the beginning. Actually, there's a beginning before the soil, when fertilizer is produced via the Haber-Bosch method. That process is so energy intensive that manufacturing fertilizers yearly emits as many greenhouse gases as all United States households (Johnson, 2018). More greenhouse pollution comes after fertilizer application,

when the heat-trapping gas nitrous oxide (N_2O) is released into the atmosphere. Global emissions of nitrous oxide have increased 30 per cent in the last four decades. "The recent growth of N_2O emissions," write Hanqin Tian and colleagues, "exceeds some of the highest projected emissions scenarios, underscoring the urgency to mitigate N_2O emissions" (Tian *et al.*, 2020: 248). Underscoring that urgency further, nitrous oxide emissions are emerging as this century's lead threat to stratospheric ozone, just when we thought we had effectively addressed that problem (Campbell *et al.*, 2017; Tian *et al.*, 2020).

Anthropogenic nitrogen seeps into ground and surface waters, poisoning the drinking supplies of humans and other animals. Nitrogen pollution is deadly to freshwater and marine organisms by triggering algal growth, which rapidly exhausts water-dissolved oxygen and asphyxiates living beings. Through this mechanism, chemical agriculture has, for example, divested North American waterways of their once bounteous life. "Nationwide," writes environmental author Richard Manning, "any river or stream that wends through farm country suffers pollution to the point of death... In the upper Midwest the plague is near total" (Manning, 2016). The plague is also near total in many of China's rivers, lakes and estuaries (Pearce, 2018).

Dead zones in estuaries and coasts have multiplied ten-fold since 1950 (Minogue, 2018). The dead zone in the Gulf of Mexico, caused by the Mississippi River washing America's Corn Belt nitrogen (mostly from fertilizer but also from manure) into the estuary, typically extends 5,300 square miles; in 2017, it reached a record area of 8,800 square miles (Pearce, 2018). This surge may be signalling what lies ahead, as scientists warn that mounting deluges and floods, in a rapidly warming world, will magnify nitrogen pollution of Earth's waters (Sinha *et al.*, 2017; Conniff, 2017). And it is not only coastal seas suffering from human-driven anoxia – the ocean's open waters are also seeing substantial oxygen drops due to global heating. "To halt the [marine oxygen] decline," reports Kristen Minogue, "the world needs to rein in both climate change and nutrient pollution" (Minogue, 2018). What we are seeing instead is these life-devastating crises intensifying and fueling each other.

Synthetic fertilizer as a detonator

When nitrogen pollution spills into waters, its action resembles dynamiting: it can cause mass die-offs of fish and other creatures. Speaking more metaphorically, synthetic fertilizer has also been – in the words of Vaclav Smil (1999) – the detonator of the human population explosion. They have also been a detonator of the farmed animal population: the industrial production of synthetic fertilizer, post mid-20th century, facilitated the explosive growth of livestock numbers by allowing more crop allocation for animal feed (Ritchie and Roser, 2020). Indeed, according to a recent report, no less than three quarters of nitrogen fertilizer worldwide is used to make livestock feed (Wise, 2021). Growing numbers of livestock, especially in factory farms, have compounded and further toxified nitrogen contamination. The manure streaming from those operations is a noxious nitrogen-loaded sludge of

pathogens, antibiotics, growth hormones, animal body parts, cleaning compounds and other chemicals. That sludge is stored in underground pits or open-air 'lagoons' – or sprayed on fields as *fertilizer* (Weis, 2013).

The chemical agriculture that exacts such ecological costs and demands human acquiescence to using a detonator in lieu of biological fertility is worth opposing with determination. Chemical agriculture also exacts a steep social cost. Synthetic fertilizer and the entire Green-Revolution-inputs package make Big Ag and Big Pharma exceedingly wealthy and politically powerful. Agrochemical giants profit from ecological devastation, while pharmaceutical companies profit from mounting chronic diseases fuelled by industrial food and a polluted planet. Rising human and livestock numbers – entangled in mutually-reinforcing feedback loops with chemical agriculture – are thus heightening both the ecological catastrophes and corporate malignancies associated with that agriculture. Indeed, we are heading – nonchalantly, as far as the political-economic establishment is concerned – toward a nitrogen-drenched, not to say glyphosate-drenched, planet. Is it not time to rethink fundamentally the question of 'feeding the world'?

Environmental analysts insist on the imperative of increasing the efficiency of synthetic fertilizer application (Foley *et al.*, 2011; Mueller *et al.*, 2012; Willett *et al.*, 2019). No doubt, this is extremely urgent. Yet all the talk of 'precision agriculture' in order to mitigate nitrogen pollution (and other challenges) threatens to vanish into thin air by precipitation torrents, as well as by sheer growth overwhelming efficiency gains: growth of the food system in the wake of increasing human and livestock numbers, standards of living and global trade. A 2019 *Lancet* article drily summarizes the dire forecast: "For the business-as-usual scenario, we project that food production could increase greenhouse-gas emissions, cropland use, freshwater use, and nitrogen and phosphorus application *by 50–90%* from 2010 to 2050 in absence of dedicated mitigation measures" (Willett *et al.*, 2019: 471; emphasis added). We are already dangerously breaching boundaries on all those fronts. What does the world look like even in a single generation?

While we pressingly need "dedicated mitigation measures" in conventional food production in the short term, even more pressingly we need to phase out chemical agriculture. The reason goes beyond the massive problems outlined above. More fundamentally, it is about refusing the killing mind-set and fake fertility of chemical agriculture. Earth creates an abundance of diverse life and Earth knows fertility. By revering nature's life-affirming ways and emulating them, we can design food production systems that will allow us to thrive along with all Earth's beings.

Staying within limits

To nourish ourselves we should not exceed the constraints that Earth's fertility offers humanity as one among countless life-forms. By staying within the limits that sustain all biodiversity, humans can receive the gift of an indefinite sojourn on a fecund planet. It is odd, and sadly telling, that the idea of limits rings negative to so many a modern ear. Yet a high-quality human life

nourished by Earth's plenitude can *only* transpire within limits. Breaking limits is rarely good; after all, it's the very meaning of gluttony. By exceeding the constraints of our fair share of the biosphere's fecundity, we have impoverished the whole planet, present and future humans included. On the other hand, honouring limits circumscribed by Earth's inherent fertility has unavoidable implications for sustainable human numbers.

The recognition that we have overpopulated the planet does not amount to wishing away half the human population. That is a foolish inference and a groundless suspicion. In my view, it is naysayers of overpopulation who unwittingly fail the test of compassion for both nonhumans and human beings given the tough times here and ahead. To mention only one gruelling challenge, estimated projections of 21st century environmental refugees number in the hundreds of millions. Climate change alone is expected to displace 200 million people by 2050 (Merone and Tait, 2018). By mindfully choosing today to bring fewer children into the world, we increase the odds of shepherding human and nonhuman beings through a less chaotic future. The compassionate call we might all rally around – regardless of our perspective on the population question – is broadcasting the option of adoption. Instead of bringing more children into existence at this historical juncture (especially more than one), prospective parents can choose to adopt children who are already here and need a home.

Addressing overpopulation will be an intergenerational achievement. Advocating for a global shift toward plant-based eating is also critical, for even partial success in this endeavour will yield benefits more swiftly. Without a dietary revolution, the momentum of population growth in the pipeline, alongside expected rising consumption of calories and animal products, will dangerously swell food demands even by mid-century (Mueller *et al.*, 2012; Willett *et al.*, 2019). By contrast, were people to shift to a plant-based diet, humanity would need only one-fourth of current agricultural land for sustenance; seventy-five per cent of cultivated lands and pasture could thus be reverted to wild ecosystems (Richie, 2021). Marine life would also rebound if humanity chose a plant-based diet. Such restitution of terrestrial and marine biodiversity would be beautiful and hope-filled, and it would contribute significantly to absorbing and retaining anthropogenic carbon (Griscom *et al.*, 2017; Roberts *et al.*, 2017).

We could say, enlarging on George Monbiot's point, that we have *two* population crises (see Monbiot, 2015). One of humans, especially considering that the entire population will not convert to plant-based eating in the foreseeable future and that food is only one of the human systems that takes a heavy ecological toll. The second population crisis is of livestock, which can be met by people choosing to become more, hopefully *mostly*, plant-based eaters. Global human transformation into a smaller sized, mainly plant-based species may not be as farfetched as it sounds: that choice will support Earth's well-being and human health in tandem.

Addressing two overpopulation challenges is hardly the sole task before us. The global economic machine – like its chemical-agriculture and industrial-

food industry subsidiaries – is all about the insane pursuit of High Yields: over-extractionist, over-producing and overly wasteful. With the use of its financial arm, the global economic machine also orchestrates over-consumption chiefly through the fabricated ploy of shelling out credit and producing debt (Lazzarato, 2012). Human beings are becoming 'richer' (some obscenely so) by devastating the planet and selling out the future.

There remains a beautiful possibility that may still lie within reach. Earth is the creative source of life's resplendent diversity, abundance, complexity and unfolding. To preserve that fecund, life-nurturing planet we have to defer to its aboriginal ways, cease domineering and downscale the human enterprise on all fronts. The only thing that can inspire such a swerve from 'business as usual' is recognizing our love for planet Earth. It's the only chance we've got.

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