NPG Negative Population Growth, Inc.

FOOD SECURITY IN THE 21ST CENTURY

An NPG Forum Paper

by David R. Montgomery

I am not Catholic, but I find many things to like about Pope Francis. The most recent was his disarmingly blunt delivery of the opinion that people have a responsibility to care for creation and not "breed like rabbits." This refreshingly impolitic papal admonition shines a bright light on the long-neglected issue of human population growth.

Few facts stand as starkly obvious and routinely ignored – we are at the point where we don't really need a lot more people on the planet. In a world stretched to its ecological limits, having seven or eight children can no longer be considered virtuous. We've been quite fruitful and multiplied quite enough. Sorry folks, even the Pope apparently thinks the planet's full.

This is not to be construed as saying that people are bad, or to be in any way seen as advocating coercive population control. For I reject both views, as I suspect does Francis. What it is intended to say is that if even the spiritual head of one of the world's longest running anti-birth-control lobbies is talking about the wisdom of voluntary population control, then maybe it's high time for society at large to re-engage on the question of how to reduce global population growth in the coming decades. Doing so sure would make it a lot easier to feed the world a century from now, which to a geologist like myself sounds a lot like tomorrow morning.

It should sound obvious that negative population growth would be a positive influence on all of the major environmental challenges humanity faces in the 21st century. From climate change, to biodiversity loss, the growing scarcity of fresh water, and the ongoing degradation of the world's agricultural soils, a smaller human population would help keep regional crises from blossoming into global disasters.

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A decade ago another luminary, Harvard biologist E. O. Wilson, called for humanity to domesticate no more than half the world.[1] He thought we should leave the other half for nature to ensure both the biotic integrity of the world's ecosystems and the quality of life for future generations of people. This is an eminently sensible proposition that would require constraining, and eventually reversing, population growth. We have been remodeling the planet faster than we have learned how its ecosystems work, or understood the intimate connections between the essential components of Earth's life-support systems. Keeping self-sustaining natural systems intact may well prove essential to sustaining our own health and prosperity in ways we have yet to realize. Consider how scientists just recently discovered that previously-unknown soil bacteria produce an antibiotic remarkably effective against the growing scourge of antibiotic-resistant superbugs. What other surprises await discovery in nature's pharmacy?

Probably more than we can imagine. For we are only now discovering that how we farm and what we eat produces a ripple effect in the soil, the beneficial microbial inhabitants of our agricultural soils, and our own guts in ways that impact the health of plants and people. Such connections have long been suspected, but technological advances in imaging, isotopic studies, and genetic sequencing have been revealing the underlying mechanisms. It's looking like maintaining both our health and our ability to feed ourselves over the long haul depend on microbial communities that we are still trying to identify – and are only beginning to understand as we come to see how we are losing them to the long march of "progress."

For we are also starting to realize that the ongoing loss of species in the visible world of nature above ground is mirrored in the loss of species in the hidden worlds of microbial life below ground, and in our own internal microbial ecosystems. Changes in our gut microbiota increasingly appear to be a key factor behind the rise of chronic diseases since the Second World War. This puts a rather personal spin on the reality that the scope of the extinction event going on at present in the Anthropocene – our namesake era of geologic time – is on track to rival the great die-offs that reshaped the tapestry of life at key points in Earth's geologic past. Through the weight of our numbers, we are acting like a slow-motion version of the comet or asteroid impact that did in the dinosaurs.

Of course, the question is not whether our global numbers will be limited, but how that limit will come about and what the world – the rest of nature – will be like when it does. If we do nothing and let our demographics collide with depletion of our planet's finite resources and degradation of its renewable ones, we can anticipate a very rocky ride as our numbers overshoot Earth's capacity to support us. Naturally, techno-optimists will predict that we can keep changing the game, innovating new ways to wring more from less. But another, less risky, approach would be to limit our numbers through rational choices and democratic means.

Far too often the issue of population reduction is framed as a coercive issue of social control, like China's one-child policy that limits personal choice on one of the most personal choices of all. But turn the focus around, and a way to achieving reduced population growth – or reducing the human population – can become a liberating exercise in unleashing human potential. Regional experiences over the past several centuries point to economic development, alleviation of poverty, and the education and economic empowerment of women as effective mechanisms for fostering a demographic transition that can stabilize or reverse population growth. One of the things that Malthus failed to realize in formulating his dour prognostications was that the flip side to how poverty breeds fertility is how prosperity reduces – and can reverse – population growth.

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In other words, there is a voluntary path to negative population growth rooted in bettering the human condition – a path through which individual choices can balance out across the populace. The global fertility rate peaked in the 1950s at 5 children per couple. Today the global fertility rate stands near 2.3 and about 40% of the world's population lives in countries with fertility rates below 2 children per couple (that is, they are already at negative population growth). Were it not for immigration the population of the United States would have been declining for decades, as the fertility rate has been at or below the replacement rate of 2.1 births per couple since the mid-1960s. In all, our collective experience over the past several centuries shows that when people become more prosperous, and women have access to educational and economic opportunities, enough people choose to have fewer children that others could have more without resulting in net expansion of the population.

The lesson here seems pretty clear. If we in the developed world are truly concerned about the potential for the world's growing population to impact key natural resources on which we all depend (as we indeed should be), then we should be doing everything we can to reduce both our own per capita resource use and the rate at which the human population is growing. And a proven way to do the latter is to promote the empowerment of women and economic development that creates jobs and self-sufficiency in the developing world. All too often, however, international aid and assistance programs are tailored more to sell products and enhance returns for corporate interests than to address the root causes of poverty and hunger. Yet it is not hard to see the benefit to humanity of a robust global plan for getting the world's population through the demographic transition, and then ramped down through economic development. Though it may be politically naïve to imagine such a global plan, this does not change the bottom line that human population growth lies at the root of all the major threats to humanity's future on this rock hurtling through space. Our descendants cannot afford for us to neglect the issue any longer.

While any discussion around limiting human population growth runs into thorny issues concerning cultural and religious practices and beliefs, wrestling with such questions would be infinitely preferable to other ways that may ultimately limit the human population. We could not expect to have any real control over things like the repeatedly Hollywoodized scenario of a major asteroid impact. And pandemics have resulted in serious negative population growth in the past, such as in Europe during the Black Plague and in the post-European-contact smallpox epidemics that decimated the Americas. It is not hard to imagine a new global pandemic emerging from the confluence of human encroachment on tropical forests and the ultra-mobility of a globally connected, jet-set world. All it would take is for something like Ebola with a significant incubation period to become highly contagious via airborne transmission. Such scenarios provide regular fodder for science fiction, and even the pop-culture fantasy of a zombie apocalypse may be seen as rooted in fear of deadly pandemics.

But there is another potential limit to human population growth that we can see coming at us over the course of the 21st century, albeit slowly enough that few truly perceive its catastrophic potential. That problem is how the erosion of fertile topsoil is undermining humanity's agricultural enterprise. Fortunately, we know how to prevent the worst-case scenario from playing out. Unfortunately, we are not doing what it would take to ensure it won't.

If we look back through history, we can see the all-too-often overlooked effects of human population growth overshooting the supply and productive capacity of fertile agricultural land. This has happened before in regions around the world and it could happen again, only this time with global rather than regional effects. As we grapple with the question of reducing human population growth, the ongoing degradation of agricultural land is the other side of the coin – the other half of the equation. For if the world's agricultural capacity defines an upper limit to the global population, as it must for the simple reason that we all need to eat, then each hectare of productive land that is degraded today lowers the population ceiling for future generations.

At its simplest level, the essential history of the past half billion years can be boiled down to the observations that soil supports life and life helps make soil. The development of soil on Earth's terrestrial surface promoted the colonization, expansion, and growth of plants (and thereby animals). And the roots of plants helped mechanically break up rocks and exuded organic acids that break down rock minerals, bringing more nutrients into biological circulation.

After the evolution of land plants more than four hundred million years ago, the long-term pace of global soil production matched or exceeded the pace of soil erosion by enough to build up a surficial layer of rotten rock and organic matter that covers most of our world. And outside of alpine and arid regions, there are few natural environments where one walks on bare earth – nature clothes the soil in plants. And plants, in turn, help to break down rocks and supply organic matter that makes soil a fertile borderland between the dead realm of geology and the living world of biology.

Since the dawn of agriculture, humanity has managed to reverse one of the most basic trends of earth history, as global rates of soil erosion from conventionally farmed soils exceed rates of soil production by at least an order of magnitude.[2] The root of the problem lies in the development of agricultural methods that leave the soil bare and vulnerable to erosion by wind and rain – like the plow. With the pace of natural soil formation measured in fractions of a millimeter a year, it can take centuries to millennia for nature to make an inch of fertile soil. Yet a single serious storm on a bare, plowed field can strip off decades' to centuries' worth of soil production overnight. This simple erosional math explains how the agriculture we depend on for our food gradually reverses nature's long-running trend of soil creation. It also means that conventional practices do not bode well for agricultural sustainability.

History is replete with examples of societies that failed to care for their soil over the long haul, and the geographic legacy of impoverishment that comes with degraded land.[3] The classical Greek philosopher Plato commented on the eroded state of his homeland's soil – and bemoaned how it limited the ability of the land to support a population large enough to marshal an adequate defensive army. Today, as Greece teeters on the edge of bankruptcy, one can still find Bronze Age agricultural implements on abandoned slopes eroded down to bare rock. The barren slopes of Roman outposts around the Mediterranean that today stand stripped of soil offer a sharp counterpoint to ancient tax records that show these regions once produced abundant crops and exported grain back to feed Rome. The ruins of the great Roman city of Timgad in Libya stand surrounded by rocky hills, as do Roman ruins in Syria where foundations now standing well above the ground surface offer compelling testimony to loss of the soil that once covered a prosperous region that can now barely support itself and has descended into seemingly perpetual civil war.

Many regions around the world followed the pattern of an initially growing agricultural population expanding from lowland river valleys into upland areas where erosion of plowed fields outpaced soil production. Eventually, soil loss limited the ability of the land to support the population, undermining societal resilience and stability. And while other factors – like climate shifts, natural disasters, and war – all played decisive roles in the demise of particular civilizations, a common theme in their rise and fall is that those that failed to care for their land did not endure.

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When I was researching my book in which I explored this theme (*Dirt: The Erosion of Civilizations*), I wanted to evaluate whether rates of erosion of conventionally farmed fields occurred at a pace fast enough to potentially influence the lifespan of civilizations. Although ancient ports now stranded well inland testify to substantial sediment delivery from eroding uplands in classical times, there were no scientists measuring rates of soil loss from Greek or Roman fields. So I decided to compile modern estimates of erosion of conventionally plowed fields, and compare them against long-term background geological rates of erosion. What I found was that the average rate of agricultural soil loss (from a global compilation of data covering a wide variety of settings and practices) was more than a millimeter per year, whereas the average rate of soil production was several hundredths of a millimeter a year. Conservatively estimating a net loss of a millimeter per year, six inches of topsoil could be eroded in a couple of centuries. On upland slopes with 1 to 3 feet of soil it would take less than a thousand years to completely erode hillslope soils. This crude estimate of the time it would take to agriculturally erode through a region's natural endowment of topsoil approximates the lifespan of major civilizations – with a few illuminating exceptions.

The ancient practice of terracing hillsides can dramatically reduce soil erosion. Some Asian and Incan terraced fields have been farmed for millennia in conjunction with the practice of returning organic matter to the land. Yet China's original agricultural heartland on the edge of the Tibetan Plateau bears the scars of ancient soil erosion. And after Chinese agriculture moved down into the fertile alluvial lowlands, the eroding uplands still supplied enough sediment that efforts to prevent flooding by building levees to line the rivers resulted in sediment piling up in river beds as fast as the levees could be built up. This led to a perpetual race between raising the levees and rising river bottoms – a competition that gradually elevated river channels well above their floodplains, creating the potential for catastrophic flooding should a river overtop its levees – as all rivers eventually do if it rains enough. The levee-busting flood along the Huang He (Yellow River) in 1887 inundated an estimated 50,000 square miles and killed between 1 million and 2 million people. Another flood in 1931 killed perhaps as many as 4 million people. Deadly as they became, the floods still delivered fresh silt that replenished soil fertility.

Major hydraulic civilizations on river floodplains and deltas offer other examples of long-lived agricultural societies.* For millennia, fields along the Tigris and Euphrates rivers in Mesopotamia and along the Nile in Egypt were fertilized by floods that delivered silt and clay derived from erosion of distant uplands. But on these arid-zone floodplains, salinization was the threat – not soil erosion. Egypt may be the gift of the Nile, as the Greek geographer Herodotus famously wrote, but this gift was purchased with erosion of upland soils in Ethiopia and Sudan – regions that remain impoverished centers of modern conflict. Construction of the Aswan High Dam in the 1950s changed the game for Egyptian agriculture, preventing the annual high flow from delivering its endowment of fresh mineral soil eroded off of distant uplands. Today, the fertility that the Nile formerly replenished is sustained by fertilizers manufactured using power produced by the dam that holds back the river's life-giving silt.

Even in the history of the United States, soil erosion and the state of the land played a far larger role than is typically acknowledged. The erosive effects of colonial agricultural practices were widely recognized by astute plantation owners. So bad was the problem of colonial soil erosion that Thomas Jefferson designed a plow to reduce erosion by following topographic contours rather than running straight up and down hill.

And in a revealing letter to Alexander Hamilton written in 1796, George Washington complained about the sorry state of American agriculture:

> *It must be obvious to every man, who considers the agriculture of this country… how miserably defective we are in the management of [our land]. …A few years more of increased sterility will drive the Inhabitants of the Atlantic States westward for support; whereas if they were taught how to improve the old, instead of going in pursuit of new and productive soils, they would make these acres which now scarcely yield them any thing, turn out beneficial to themselves.*[4]

Long before the great American push westward, our first President was deeply concerned that the degradation of farmland would force a nation of farmers to migrate inland.

But few adopted progressive practices like those advocated by Washington and Jefferson. Tenant farmers had no long-term interest in soil conservation and prioritized short-term returns. Plantation agriculture generally favored methods that left the soil vulnerable to erosion. And losses to soil erosion built up at a pace that did not threaten the annual bottom line.

Centuries later the root cause of Washington's concern can still be read, written on the land. The original American agricultural powerhouse of the Piedmont region of the Southeast – the rolling hill country from Virginia to South Carolina – no longer has all the rich black topsoil that caused European colonists to marvel over how the land could be so productive. Driving through the region today you see subsoil exposed in the fields. Most of the rich, black topsoil eroded away as plantation agriculture treated soil as a disposable input and new land was cleared when the fields could no longer produce bumper crops of tobacco.

The problem of soil degradation is not restricted to the South. A recent study from New England

* For more information on urban floodplains, see the NPG Forum paper *Should New Orleans be Rebuilt?*, available online at **www.NPG.org**.

documents how colonial soil erosion was 100 times faster than the pace of soil production.[5] Iowa has lost roughly half its topsoil in the past century and a half. So too did the loess-covered Palouse region of Washington state, over the course of the 20th century. The great clouds of earth in the Dust Bowl era vividly illustrated the problem of soil erosion, but the ongoing problem is that most of the time soil erosion steals land below society's radar at a pace few notice – and fewer act upon.

Since the Dust Bowl era, the Soil Conservation Service (now the Natural Resource Conservation Service) has worked to greatly reduce the pace of soil loss from American farms. They have been quite successful at reducing soil loss, by some estimates by a factor of 3 or more. However, their success invites complacency from others even though soil loss still proceeds at a faster clip than soil production. In the past, the availability of new land with productive soil has allowed agricultural production to keep up with population growth, even as land was exhausted and abandoned. That strategy is no longer viable now that there is little land with fresh soil to farm.

But we have also had dramatic technological improvements and innovations in agricultural practices. While our population has been growing, the amount of cropland needed to support a person has been reduced greatly in the post-glacial world. The amount of land that it takes to support a person declined from about 100 hectares per person in hunting and gathering days to a global average of about 0.2 hectares per person today – and 0.1 hectares per person in the most intensively farmed regions of the world. The projected rise in human population means that globally, the amount of land available to feed a person will drop to 0.1 hectares per person by 2050. This means that somehow we need to roughly double agricultural production, something that will be all the more difficult if we continue to lose productive ground to degradation and topsoil erosion.

What does this all mean for agriculture in the coming century? It means that if we want to avoid the potential for a global population overshoot scenario, we either have to pull another technological rabbit out of the hat or restore a lot of now marginal or degraded agricultural land to greater productive capacity. Soil degradation has been estimated to have taken about a third of the world's cropland out of production since the Second World War. However you look at it, we simply cannot afford to continue degrading the productive capacity of the world's agricultural land.

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There is a very real possibility that regional food security issues could become global stability issues over the course of the present century. In this context, it is interesting to contrast the strategic situation of the United States and China. The United States has a large supply of agricultural land relative to its population and actively promotes food exports, shipping soil fertility overseas in the form of crops. And by some estimates, the average American farm loses a ton of soil in producing a ton of grain. This means that for every ton of grain we export we reduce our future capacity to feed not just the world, but ourselves. In contrast, China is largely self-sufficient in food production at present, but has little capacity to expand its agricultural land base. Although its food imports are projected to rise dramatically in the next several decades, China is rapidly degrading farmland and losing soil. What might happen if the most populous country on Earth became critically dependent on – and then lost access to – substantial food imports? It would certainly have impacts beyond its borders and reverberate around the world.

We can look north to Canada for the reason that the United States is in such an envious strategic position in regard to long-term agricultural outlook. The great agricultural soils of the American Midwest, the fertile silt-rich deposits known as loess that blanket much of the American heartland, are derived from the soil and weathered rock that ice-age glaciers scraped off of Canada and bulldozed along as the ice marched south into what is now the United States. There strong winds blowing down from the north off the mountain of ice picked up and reworked the pulverized rock and blew it around the region, depositing the fertile blanket Americans now farm. This is why the soils of this region were so vulnerable to the blowing winds of the Dust Bowl era after the prairie sod was plowed up in the early 20th century. Once roots no longer anchored the loess in place, the wind that delivered the soil could pick it up and blow it around again.

Why do we still need to pay attention to the state of our agricultural lands, and take steps to restore as many degraded hectares as possible to a more productive state? At any one time we have less than a year's supply of food on the planet. In a way, humanity is living from harvest to harvest. We don't have much in the way of a buffer against unforeseen factors that could seriously disrupt regional harvests – like a run of anomalously cold winters, extreme droughts, large volcanic eruptions, or the human folly of wars. What would happen if something seriously disrupted global food production for a few years?

A tragic aspect of the historical legacy of degraded land is that it is not an inevitable outcome of agriculture. Practices that can help conserve soil – like no-till and conservation agriculture – can build fertile soil under even intensive agricultural use. This is not a radical new idea. Centuries ago, the Dutch reclaimed land from the sea and built up some of the best agricultural soils in Europe by returning urban organic wastes to their fields. And long before them, indigenous Amazonians built fertile soil from scratch – resulting in the surprising fact that at the time of European contact the most fertile soil in the Amazon was found in association with the greatest human population densities.

Getting back to America today, negative population growth could help remove marginal lands out of cultivation and promote recovery of soil fertility lost over the past century. So too would changes in agricultural practices. A number of farmers I have met over the past several years have volunteered how, after four abnormally dry summers in a row, they were not convinced that climate change was real – but they were quite interested in adopting no-till methods that could keep water in their soil, summers being dryer now than they used to be.

We all know that we depend on agriculture for our food supply. It may seem hard to find reasons to worry about the connection between population and food security in the United States, since our nation produces an exportable surplus of food (and feeds livestock enough grain to solve the problem of world hunger if used for that purpose). But if you look ahead to later in the 21st century, the two primary dimensions to the food security problem are on track for collision – more people and less productive land. Since we are already farming most of the land that could be productively farmed over the long run, we need to begin restoring our marginal and worn out agricultural lands. Getting more people back onto smaller farms would help increase agricultural output, build soil, and reduce soil erosion.

Still, we continue losing ground and soil fertility even as we need to dramatically increase agricultural production to support the projected rise in global population. Given the reality of global demographics, we need a new agricultural revolution – one that ushers in an era of regenerative agriculture. Toward this end, we should be promoting practices that retain and return organic matter to agricultural land – and advocating policies that work to reduce and ultimately reverse population growth until we reach a truly sustainable level.

Unfortunately, in some ways we are moving backwards. The recent push to promote using crop stubble as feedstock for biofuel production reduces the potential to return organic matter to the land, undercutting the most accessible way to build and retain soil fertility. And the low-till and no-till farming methods that can cut erosion down to close to background soil production rates remain alternative practices.

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But here, in the end, let me turn back for a moment to the question of an ideal population size – which is very difficult to answer. Many assumptions about lifestyle and environmental quality are embedded in any such opinion. So while I will not offer a specific number, I do know that the world cannot support 10 billion people with a North American resource use – at least not for more than a geological instant. And regardless of the level of other resource use, evaluating the "carrying capacity" of our country (or of the whole planet) is contingent on whether and how well we take care of the soil – for we could well yet prove Malthus right if we don't.

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NOTE: The views expressed in this article are those of the author and do not necessarily represent the views of NPG, Inc.

NPG, Inc. is a national 501(c)(3) nonprofit membership organization. Since 1972, our primary purpose has been to educate the American public and policy makers regarding the damaging effects of U.S. population growth on our environment, natural resources, and quality of life. We advocate national policies which work to slow, halt, and eventually reverse population growth — until we reach a much smaller, truly sustainable size. For more information on NPG, visit our website at **www.NPG.org**.

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