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Was Malthus right, but early?

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<https://www.soa.org/research/opportunities/environmental-essays.pdf>

Thomas Malthus wrote *An Essay on the Principle of Population* (1798), where he claimed that population would grow faster than food production. This was not long after Adam Smith's *Wealth of Nations*, American independence, and the French revolution. Malthusian theory has been discussed ever since. While some belittle the arguments, theories aren't actively debated for over 200 years unless there are valid arguments that need to be addressed.

Malthus argued that population grows exponentially, food production linearly, and that "poor laws" designed to aid those in poverty create poor incentives. Population can self-correct, with overcrowding increasing the likelihood and impact of natural occurrences like floods and earthquakes. Human populations can also be inundated by famines and viruses that create mass kill-offs. Family planning techniques that reduce the number of babies will also ease the pressure on population growth through later marriages, self-restraint, and various methods that reduce reproduction. Offsetting factors that expand population are increasing life expectancies through improved health care and sanitation. More drastic voluntary measures enter the realm of science fiction, with humans being killed at a certain age a la *Logan's Run*, using religion or cult status to gain acceptance. Malthus has not been proven correct, so naysayers say he was wrong. A closer look argues that he did not anticipate a number of positive scientific achievements that accelerated food production, nor improvements in management of human fertility. Have these factors only delayed the inevitable? Will his arguments eventually be proven right? Scenario planning can help us to answer these questions.

Historical Review

Malthus could have written his paper today, with the argument generalized away from exponential and linear to focus on faster growth of population relative to food production and impacted by climate change. Much has happened in the meantime that Malthus did not anticipate. What have we learned, and how might his theory be updated?

Ecosystem

Historically, humans discover something that works and exploit it to the extent possible. The Earth is an ecosystem, with humans the dominant species. While it is possible that a virus or bacteria could serve to maintain a balance between human population and living space, no animal has evolved to challenge humans.

When I attended Michigan Technological University, our statistics class was visited by Dr. Rolf Peterson. He led a study of the ecosystem between wolves and moose on Isle Royale, a National Park located in Lake Superior. Mammals arrive as new entrants to the island only when the lake freezes over, which happens rarely. This gives scientists a chance to study the cycle of predator and prey; some years the wolf population expands and kills more moose, followed by periods when the lack of food causes the wolf population to shrink.

As food supply decreases, predators limit reproduction and die of starvation. When it increases, the opposite occurs. In the long run, every species must play by these rules. Humans have no such balancing factor in the short term. We do what we want until resources are depleted. In the movie *Downsizing* by Alexander Payne, a technique is developed to shrink humans to limit resource use. When they determine that not enough of the population is following through the developers become survivalists, entering a cave where they will live underground for a millennium until the Earth has had time to cleanse itself. An organism with no limits imposed on it has the ability to destroy itself.

Ratchets and Pivots – it works until it doesn't

In her book, *The Big Ratchet: How Humanity Thrives in the Face of Natural Crisis – a biography of an ingenious species*,¹ author Ruth DeFries presents a history of food production. The human species finds something that works, expands it until it becomes destructive, and then pivots to a new method. Then the cycle repeats. This is how humans have avoided a Malthusian trap. We rely on science developing radical solutions to problems. One misstep or slow pivot may be all it takes to trigger catastrophe. Considering scenarios, especially qualitatively, builds resiliency and encourages adaptability.

Much of the food we consume comes either directly or indirectly from plants. We eat plants, and eat things that eat plants, as part of a complex food chain. As energy is extracted by plants from the soil there is a need to replace those nutrients for future generations. Each ratchet the author describes is an updated version of this process, increasing yields and supporting further population growth. Humanity extends a cycle by settling new areas and increasing population until, just before the hatchet falls, there is a new pivot to a method that works better and avoids the pitfalls of the prior method. We saw this strategy play out in the past when Europeans came to the New World, and again now as futurists like Elon Musk talk of inhabiting Mars. These are not efforts to make current practices sustainable, but efforts to find new places to live where we can continue as before. While not as glamorous, funding basic science designed to capture carbon from the atmosphere and oceans may be a scenario that better increases long-term survivability.

As humans evolved our brains grew in size, we developed opposable thumbs, and we figured out how to control fire. We developed tools and language. We built on this

¹ http://www.amazon.com/Big-Ratchet-Humanity-Thrives-Natural/dp/0465044972/ref=sr_1_1?s=books&ie=UTF8&qid=1444158074&sr=1-1

knowledge (despite periods where past learnings were repressed), learning to grow more food with fewer farmers. Much of this improvement is based on experimentation. Often breakthroughs come from accidental occurrences, but they would not be possible if experiments weren't being done.

The Earth has a built-in recycling process. For example, water and carbon circulates between land, ocean, deep beneath the surface, and in the atmosphere. It is a self-correcting cycle that regulates the climate over long periods of time. DeFries calls it the "foundation for human civilization." The planet can temporarily be moved out of balance, but not permanently. Human impact that defines the Anthropocene epoch has taken the Earth's ecosystem out of balance. Scenarios, both positive and negative, can help explore future paths.

The oil, natural gas, and coal that exists deep in the ground started mostly as leafy plants grown while converting the sun's energy. Many millions of years of life, death, and erosion resulted in carbon being taken out of the air and captured underground. As we extract and burn fossil fuels, imbalances create toxins in the atmosphere and oceans, impacting weather and climate. These rapid changes create a lack of harmony in the ecosystem, with species becoming extinct and reducing biodiversity. A new pivot is needed.

Early pivots -3.5 billion years ago

Single celled organisms appeared, followed 2 billion years later by those utilizing photosynthesis. This built up oxygen in the atmosphere, created the ozone layer, and replaced early bacteria with air breathing animal forms.

Next pivot – 1.5 billion years ago

Sexual reproduction allowed quicker evolution and easier adaptation. Several hatchets fell as the environment rapidly changed, for various reasons. There have been at least five occurrences where 96% of species went extinct.

Farming pivot

Humans, like other living things, pass on their genes to the next generation. We teach succeeding generations what we have learned. Man started out as a forager, but the rich abundance of the Fertile Crescent region led to farming and cities. Scientists now study how man's influence has taken the "garden of Eden" to a desert state as a possible precursor for the planet.

Settled life pivot

Over 6,000 years ago animal power was added to supplement human labor, and 3,000 years ago crop rotation was developed in China. Human waste was collected from city dwellers to use as fertilizer, returning nutrients to the soil.

14th century pivot

Changing climate and wars led to famines and plague in Europe. During the agricultural revolution (followed by the industrial revolution) crop rotation, enhanced tools, better seeds and livestock improvements led to a food surplus.

Columbus pivot

Using the trade winds to cross the Atlantic, a general homogenization between species began. Ships traveling west carried animals and seeds, and those on the return trip carried crops and gold. Diseases mostly traveled west, as the domestication of animals that led to jumps between species and built-up immunity was much further along in the Old World. Native American populations were decimated by diseases such as smallpox. Africans had greater resistance to these diseases, encouraging the slave trade.

Late 18th century pivot

Drought, war and inflation led to Malthus' warning that "the power of population is indefinitely greater than the power in the Earth to produce subsistence for man." Cities had built up, with flush toilets and sewers improving sanitation, yet the phosphorus and nitrogen cycles were breaking down and soils were degrading. The next hatchet was getting ready to fall.

Guano pivot

Bird droppings in South America provided rich nitrogen and phosphorus to the Incas, and by the mid-1800s mining techniques were shipping guano to North America and Europe.

Chemical pivot

The next pivot extracted nitrogen from the air as ammonia using heat derived from coal. The Germans improved the process during WWI as part of the war effort to make explosives. Sources of phosphorus were also developed during this period. Over time, runoff into lakes created algal blooms that destroyed everything else as they blocked sunlight and sucked up oxygen. It was during this period that the great dust bowls of America, when a severe drought followed a period of perfect climate for growing crops, led to improvements in crop rotation and other techniques that increased stability of agricultural production.

Monoculture pivot

Hybrid seeds, using the double-cross method, increased yields while decreasing the diversity of crops. This led to the next hatchet, where unintended consequences allowed pests to defeat the defenses of a focused species. Failed solutions like DDT pesticides followed.

Green Revolution pivot

Led by Norman Borlaug (Nobel Peace Prize 1970), breeders devised ways to defeat pests and bacteria using increasingly complex techniques that manipulated genes. First wheat rust was (temporarily) defeated, and then other crops were modified. Large scale

monoculture farming using aquifers in unsustainable ways became widespread. This left regional crops to die out, with their broad defense structures eradicated and the ecosystem's resiliency reduced. Eventually a seed bank was implemented, but much had already been lost. This is important to understand, because pests and bacteria continue to evolve. All solutions are short-term. Efforts are underway to cross breed back in some of the traits lost from these efforts. DNA driven techniques allow pesticides to go after bugs or bacteria while having no impact on the crops themselves.

Genetic engineering and biotechnology have pros and cons, with concerns about incentives for the private sector offset by populations that need to eat. Each pivot has unintended consequences that must be identified and addressed in future (temporary) solutions.

Urbanite pivot

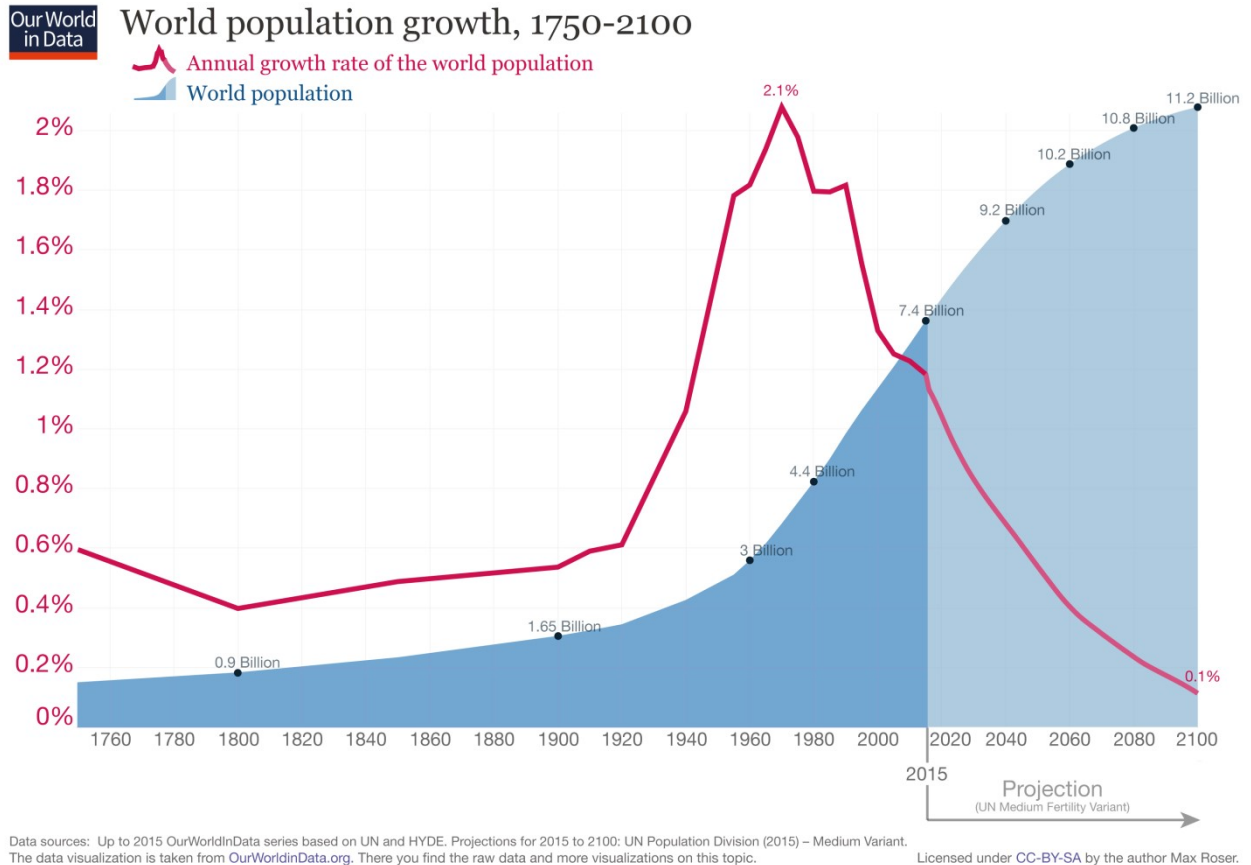
More than half the world's population now lives in cities, with many facets of life now manipulated that previously evolved naturally. There are three things needed for the planet to remain habitable: a stable climate, a recycling apparatus, and diversity of life. Each is threatened today. In addition to burning of fossil fuels by industry and individuals, greenhouse gases from agriculture come from fertilizer production, manure, and the stomachs of cows. Forest clearing wildfires release carbon that has recently been removed from the atmosphere, and volcanos periodically release both carbon and sulfur. The process to extract nitrogen from the air currently has no counter that returns it. Sewage systems do not return phosphorus to the soil. Resiliency has been lost and the ecosystem is more fragile. In the best of times it will be difficult for governments to agree on a solution. War-time conditions may compound and accelerate many of the issues discussed here, potentially leading to an unsustainable spiral.

Going forward

The DeFries book guesses at some future pivots. In the past the sole problem was deemed to be a shortage of food. Now many diets are unhealthy, and obesity threatens to unwind the mortality improvements made as sanitation improved and cigarette smoking decreased during the last century (disruptions could also occur as cures for cancer or cell regeneration techniques move forward). Some city dwellers are participating in the solution, with rooftop gardens and human waste recovery efforts. Farmers are using technology to manage water use and fertilizer. Less wasteful habits in the developed world and improving storage in the developing world would help. We currently grow enough food to feed the Earth's population, but recent growth is problematic if extrapolated. Since the beginning of the Industrial Revolution human population has grown quickly, from about 1 billion by 1850 to over 7.5 billion today.²³

² <https://www.zmescience.com/science/unsustainable-human-population-growth-0534/>

³ The chart was created by Our World in Data under a CC BY-SA license. <https://ourworldindata.org/wp-content/uploads/2013/05/updated-World-Population-Growth-1750-2100.png>



Much of this growth has been in developing countries where there is less management of population, food supply, and economies. Food that costs more than a family can pay is useless, as is food that sits in ports and feeds rodents rather than being distributed. The good news is that, across the last two generations, agricultural production growth has outpaced population growth.⁴ Malthus' arguments should be adjusted to show a reversal of his exponential population and linear food production growth. But this does not mean there are not risks moving forward, mostly driven by climate change. Considering scenarios that are not a continuation of the recent past will build resiliency and reduce fragility of the ecosystem.

New agricultural options will be created as extreme northern and southern latitudes warm, providing opportunities to introduce better methods. But there will also be surprises, some of which can be anticipated and some which cannot. Already we see glaciers melting. As regions thaw not only will frozen tundra disappear, but the winds that drive our weather systems will likely weaken. We already see storms that sit over one area (e.g., hurricane Harvey in Houston in 2017) for longer periods, and multiple storms follow the same path while moisture is lacking nearby.

Oceans are increasingly acidic, hurricanes stronger, and tornados more prevalent and further north. Higher ocean levels will doom those living in low lying areas including

⁴ http://cowlingallotmentgroup.blogspot.co.uk/2011_11_01_archive.html

population hubs like Miami and Jakarta, or much of the country of Bangladesh. Fracking near coastlines will accelerate the problem as these areas sink in response.

Recent actions by US government agencies under the Trump administration not only do not address the issue but might accelerate the end result.⁵ A widespread war would be fought using fossil fuels. Little effort will be made to worry about the environment during a conflict. In a way this would be similar to the extreme toll taken on the world's youth during the influenza pandemic that coincided with World War I. Such an event may be what Neil Howe describes in *The Fourth Turning*,⁶ finally convincing everyone that something needs to be done. Hopefully it will not already be too late. This is why I prefer to look at carbon capture ideas rather than dwell on a carbon tax. Unfortunately, I believe it is already too late for a financial solution alone to solve climate change.

Scenarios that include the impacts of higher sea levels on investment returns and other assumptions should be included in any new product developed. This doesn't mean everything has to be quantified, but will lead to a greater ability to identify marginal impacts from an event.

Other Factors

With each surge in population a new hatchet has led to a pivot allowing population to continue its growth. If a new pivot does not become available this leaves us to ponder the alternatives to controlling population – natural disasters, war and disease. Let's hope the scientists can keep up.

Drought

Warmer temperatures and drought lead directly to food shortages. In the US, the current drought monitor shows much of the country in at least a short-term drought.⁷

⁵ Vanity Fair magazine has published a number of Michael Lewis articles that reflect lessened attention provided to the Department of Energy and USDA <https://www.vanityfair.com/contributor/michael-lewis>

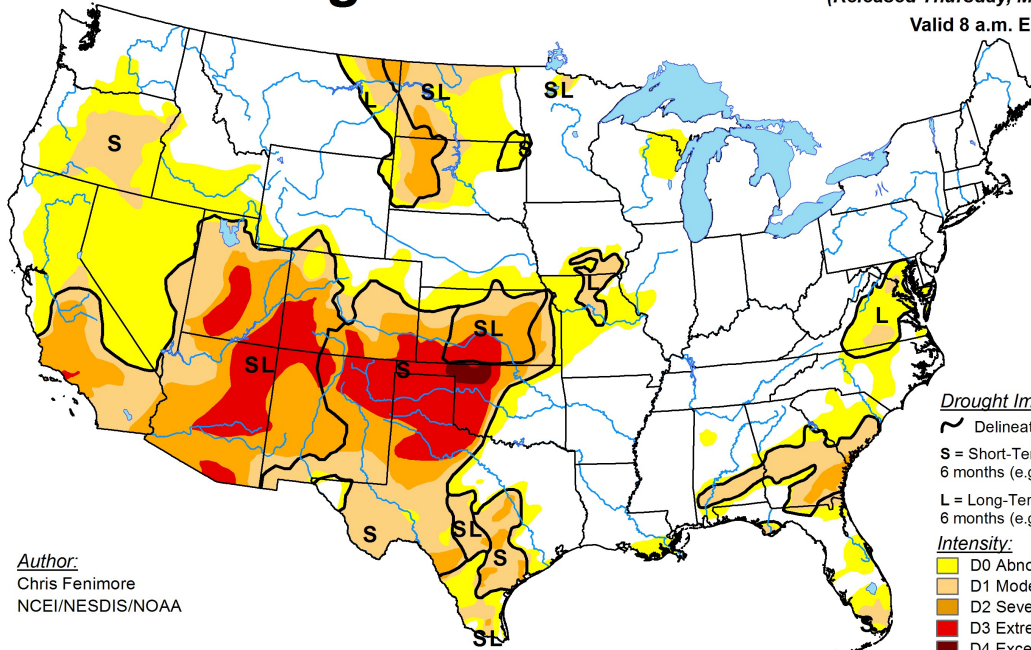
⁶ Strauss, William and Howe, Neil. *The Fourth Turning: An American Prophecy*. 1997. Broadway Books.

⁷ National Drought Mitigation Center at the University of Nebraska-Lincoln. March 20, 2018. <http://droughtmonitor.unl.edu/>

U.S. Drought Monitor

March 20, 2018
 (Released Thursday, Mar. 22, 2018)

Valid 8 a.m. EDT



Author:
 Chris Fenimore
 NCEI/NESDIS/NOAA

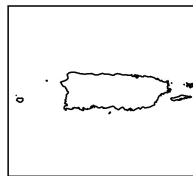
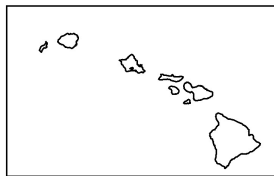
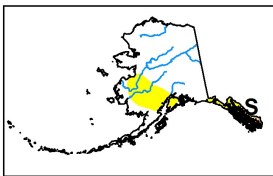
Drought Impact Types:

- ~ Delineates dominant impacts
- S = Short-Term, typically less than 6 months (e.g. agriculture, grasslands)
- L = Long-Term, typically greater than 6 months (e.g. hydrology, ecology)

Intensity:

- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.



<http://droughtmonitor.unl.edu/>

Dry conditions have also contributed to an increased number of wildfires in California, Montana and the southeast US as the fire season becomes both longer and more intense. Underground aquifers can provide water for crops and human use, but may not be sustainable over the long run as they become depleted.

The opposite is also true – weather extremes are tied to climate change as the actuarial index shows.⁸ Extremes of temperature, rainfall, consecutive dry days, wind, and sea level all contribute to stresses for both humans and our food sources.

Acidic oceans

It appears that oceans have acted as a sink to delay carbon buildup in the atmosphere, but this causes problems for shellfish and coral reefs. It also stresses other sea life, impacting biodiversity. This provides arguments for those choosing to “lie with statistics,” misleading the public about climate change by focusing solely on the carbon buildup in the atmosphere, and delaying solutions.

⁸ <http://actuariessclimateindex.org/home/>

Economic challenges

Volatile growth patterns, high inflation, deflation, and other economic variables cause stresses that make it hard for businesses to prosper. Whether prices are too high for consumers to pay or changes to climate eliminate jobs, a strong and stable economy is important for a sustainable future.

Disease

Historically, disease has been a limiting factor for human population. Illnesses like plague and influenza strike periodically, and some groups deal with endemic diseases like malaria on a regular basis. Health care has made great advances in the past century, but it remains to be seen if these changes are permanent. For example, resistance to antibiotic treatments have increased as bacteria have evolved stronger than ever. If these lifesaving drugs are no longer effective, who will be willing to risk injury that potentially results in death? Viruses that today seem like no big deal will once again become life threatening, and elective surgeries like knee replacement become less prevalent. Long frozen bacteria are being released in the Arctic that humans may have no resistance against. Spillover effects, where humans encroach on previously unexplored areas, allow diseases to jump species as has occurred with HIV (chimpanzees), novel influenza (birds) and Ebola (bats).

Previous Extinctions

In *The Sixth Extinction: An Unnatural History*⁹, a Pulitzer Prize winner written by New Yorker staff writer Elizabeth Kolbert, five historical mass extinctions are described. Many occurred because the rate of change was too fast for the ecosystem to evolve. We appear to have entered a sixth during what is now called the Anthropocene Period, an epoch defined by human impact on the Earth. This extinction is caused mainly by our unsustainable release of carbon through the use of fossil fuels.

Agriculture

Food production has changed over the years. Humans were once nomads, living off what they could find in an area before moving on. Initially evolving from Africa, we gradually filled the Earth in a zone surrounding the equator before spreading to the open areas north and south. When Europeans “discovered” America this provided more space to spread into, with spillover diseases that previously jumped from livestock to farmers (e.g., smallpox) being carried to the new world.

Population Growth

Attempts at world-wide coordination of anything, whether it be carbon emissions or population, is hard with incentives varying across the planet. Developed economies point to the growth in developing economies and say they need to slow down; developing economies point to current levels and wonder why they can’t participate? Developing

⁹ Kolbert, Elizabeth. *The Sixth Extinction*. 2014. Henry Holt and Co.

economies typically lack a broad-based insurance industry, losing out on an economic incentive to manage risk. When natural disasters occur the human cost is high but the insured cost is often low.

Malthus may yet have his day

No question on my annual emerging risk survey has created so much consternation from respondents as the one about limited resources and the likelihood that we could face choices in the future. Many of the risk managers seem to feel that science will always keep ahead of these issues. Many doctors argued that pandemics were a thing of the past when I wrote about pandemic influenza 15 years ago.

A book by David Quammen, *Spillover*,¹⁰ details the increased likelihood that benign infections in host animals will jump to humans (called zoonosis) given our encroachment on their natural ranges and evolving ecosystems. *Guns, Germs, and Steel*,¹¹ the Pulitzer Prize winner written by Jared Diamond, showed how access to weapons and metals, along with close contact with domesticated animals (building up immunity to disease) gave the Europeans great advantages, especially against those in the Americas. Humility about our knowledge is a requirement for sustainability.

There are other changes coming, and some are already here. Fresh water shortages challenge population growth and drive regional conflicts. Climate change has led to increased volatility of harvests and weather patterns.

Omaha, Nebraska, where I live, over a two year period experienced both flooding (due to heavy precipitation upstream on the Missouri River) and drought. The warm winter of 2011-12 generated little snowfall and led to an early growing season. The corn crop was knee high by Memorial Day, but limited moisture after that destroyed the expected bounty. Various crops are becoming susceptible again to bugs and disease for the first time in decades. Antibiotics are moving closer to the end of their ability to evade the constant evolution of many bacteria. At some point the most dangerous place in your community will become your local hospital. The use of vaccines has created unintended consequences as disease reenters a region with no immunity to it or with a few who refused to take the vaccine allowing the disease to reestablish a stronghold. Resources are not unlimited and science is neither infallible nor quick.

Evolution can also generate solutions. The lodgepole pine, decimated by the bark beetle and fuel for wildfires in the American west, has recently evolved to create a sap that traps the beetle.¹²

Resource Depletion

Many emerging risks interact with population growth. Fresh water, energy, and minerals are important to growing economies, yet many countries do not control their own

¹⁰ Quammen, David. *Spillover: Animal Infections and the next human pandemic*. 2012. WW Norton & Company.

¹¹ Diamond, Jared. *Guns, Germs, and Steel: The Fates of Human Societies*. 1997. WW Norton & Company.

¹² Smithsonian magazine. April 2018. Page 9.

supplies of everything they need. This traditionally has led to regional conflict and could easily do so again.

Poor Laws

Malthus argued that the poor laws, designed to help those living in poverty, created perverse incentives that actually made the situation worse. Charles Dickens appears to refer to this in *A Christmas Carol* (1843) when Scrooge says that he does not intend to donate funds for idle people. When the solicitor argues that many would rather die, he replies that “they had better do it, and decrease the surplus population.” The Malthusian argument is that providing food to those who cannot otherwise afford it only encourages them to have families and add more people that must also be fed by others, creating a population spiral. It is a form of moral hazard.

War

During war time, everything else becomes unimportant. A large enough conflict could make climate change irreversible as fossil fuels are used without limit to power the war machines. Population growth could be reduced significantly, either through direct casualties or through a simultaneous pandemic.

One of the goals of German leaders during World War II, in concert with their Aryan supremacy ideology and discussed at length in *Black Earth*¹³ (by Timothy Snyder), was to gain access to Ukrainian farmland. Psychology was used by both invading armies, German and Russian, to turn the people against each other and eradicate certain groups, primarily intellectuals, leaders, Jews, and certain other minorities. Through eugenics using characteristics chosen by the victors, breeding would be limited to the smart and/or rich. This was all part of a multi-stage German model to avoid Malthusian overpopulation.

Why Might Malthus be Proven Wrong?

Demographics

Since Malthus' time, demographics have integrated with sanitation and health care to create a much older population. A newborn can now expect to live over 80 years in many parts of the world. While methods to control unwanted reproduction have slowed population growth, the primary driver seems to be economic growth and reduced infant mortality. Parents have more children when many are expected to die before they can work. As more live there is less need for so many.

Movement between countries, whether voluntary or forced, also impacts population. This can be direct, as when one group attempts genocide on another, or indirect as when an aging country with low fertility needs service workers. Japan has chosen to develop robots for this need rather than allow immigration from other areas, with long-term repercussions.

¹³ Snyder, Timothy. *Black Earth: The Holocaust as History and Warning*. 2015. Tim Duggan Books (a division of Penguin Random House LLC).

When supply and demand are allowed to incent movement this reduces the downside of immigration, but more effort needs to be taken to mesh new cultures into a region. There will be bumps in the road but efforts taken will help groups assimilate.

Missed by Malthus

Malthus looked at the world as he knew it. He did not anticipate changes that have led to advances in agricultural output. He also did not think through the higher order impacts of his what-if analysis. He tended to focus on exponential growth of population versus linear growth of food production. Creating multiple scenarios would have helped him.

Agribusiness has used improvements in fertilizer and genetic developments, leading to fewer farmers feeding more people while using less land.

Larger populations historically have meant that more land was utilized for people to live on. Areas have been cleared and wild areas encroached on. Continents have been “discovered” and filled. Spillover diseases occur when species are closely mixed. Prior pandemics formed in this way include smallpox, Ebola, and plague. Influenza continues to evolve through its reservoir and host species, creating periodic pandemics and annual outbreaks that mainly impact the young and old. Current travel practices increase the likelihood of new pandemics rapidly spreading throughout the world, with growing concerns about bioterrorism. Social Security may be underfunded, but is only a severe pandemic away from health. It is not a business plan that should be relied on.

How do you tell if a certain resource, like the sun, is cycling normally or if something new has occurred? This is a great challenge for scientists, not only to separate the signal from the noise, but to communicate the differences clearly to the general population.

Lack of data is used against scientists because they do a poor job communicating the message. Science deniers tend to assign little value to future events, so argue that it doesn't matter what they do today. They believe that it will all work out.

Those who discount the future are really relying on those they ridicule, who continue to look for pivots they can implement before the hatchet strikes.

Regulations

One way a dominant species can remain sustainable is through self-regulation. By devising an accounting system that creates a fee/tax for things like resource depletion and pollution, humans could attempt to stabilize today's imbalances. This is much easier where one party rules, like in China, than in a democracy. It is difficult to change a ship's course quickly when culture requires debate and consensus. Unfortunately, in the US, the government is currently moving in the opposite direction and dismantling environmental safeguards.

The Earth is a complex adaptive system. As population grows humans need more food, but land becomes scarce. Clear cutting of trees reduces the planet's ability to stabilize carbon, increasing spillover risk and other secondary climate impacts. There are no easy solutions.

The Role of Actuaries

The actuarial profession is defined by its ability to discount contingent events and place a value on the financial results. We are rare in that we have studied a wide range of topics, including finance, investments, life expectancy, health care, and demographics. This makes actuaries well placed to straddle the fence between theoretical and practical solutions in a field like climate change. This is especially true when insurance risk mechanisms are considered.¹⁴ Climate survival requires long time horizons to increase resiliency.

While population growth could accelerate relative to food supply, the greater challenge is for the human impact on Earth to be sustainable. Oceans are rising, with two billion at risk in their coastal homes. Ocean stocks are being depleted, with dead zones and dying coral reefs found around the world. Fresh water shortages are causing regional conflicts at a time when displaced immigrants are not welcome elsewhere due to perceived economic hardship. Trends toward inequality have ushered in a new gilded age, where lobbyists seem to have more sway than voters.

We must first qualitatively assess the impact of scenarios before quantifying them. The future is uncertain. Techniques that we try may not work. We continue to learn about the ecosystem. We waste a third of the food we grow, yet many remain hungry. We build McMansions despite techniques being available that make urban planning more sustainable. We need a sustainability pivot soon, or we will be challenged with both a food and population hatchet. This could result from reaching a carbon tipping point with rising temperatures and acidity, a virulent pandemic, or a regional conflict over resources that expands into a broader war.

The debate continues, but it reminds me of Pascal's Wager (Is there a God? If there isn't a God, it is not a big deal to believe. But if there is a God, the downside to not believing is big.). There is no downside to preparation for climate change using scenario planning. If it does not occur then everyone is better off. But if climate change is real, preparation for a pivot can defeat Malthus once again.

Warning: The information provided in this newsletter is the opinion of Max Rudolph and is provided for general information only. It should not be considered investment advice. Information from a variety of sources should be reviewed and considered before decisions are made by the individual investor. My opinions may have already changed, so you don't want to rely on them. Good luck!

¹⁴ <http://waterforfood.nebraska.edu/wp-content/uploads/2016/06/Holley.pdf>