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A Seneca Collapse for the World's Human Population?

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Abstract

Most scenarios for the world's human population predict continued growth into the 22nd century, while some indicate that it could stabilize or begin to fall before 2100. Almost always, decline is seen as not being faster than the preceding growth. Different scenarios are obtained if we consider the human population as a complex system, subject to the general rules that govern complex systems, in particular their tendency to show rapid changes which – in the case of populations – may take the shape of true collapses (defined here as "Seneca Collapses"). The present survey examines a small number of examples of rapid population collapses in the human and in the animal domains. While not pretending to be exhaustive, the data presented here show that biological populations do show rapid "Seneca-style" collapses. So, it is possible that the same phenomenon could occur for the world's human population.

Introduction

> "The Earth provides enough to satisfy every man's need but not for every man's greed." Gandhi (quoted in Pyarelal 1958 p. 552)

While Gandhi's observation about greed remains true even today, his statement regarding the ability of the world to meet needs may not apply to the modern world. In 1947, the world population was under 2.5 billion, about one third of the current figure of 7.5 billion. And it keeps growing. Does the world still have enough for every man's need?

It is a tautology that if there are 7.5 billion people alive on planet earth today there must exist sufficient resources to keep them alive. But the problem is for how long. The concept of "overshoot" was applied by Forrester in 1971 (Bardi 2016) to social systems. The innovative aspect of this concept is that it takes the future into consideration: if there is enough food for 7.5 billion people today, that doesn't mean that will be true in the future. The destruction of fertile soil, the depletion of aquifers, the increased reliance on depletable mineral fertilizers, to say nothing of climate change, are all factors that may make the future much harder than it is nowadays for humankind. The problems will be exacerbated if the population continues to grow.

But will the human population keep growing in the future as it has in the past? Many demographic studies have attempted to answer this question, often arriving at widely differing results. Some studies assume that population will keep growing all the way to the end of the current century, others that it will stabilize at some value higher than the present one, others still that it will start declining. Few, if any, studies have taken into account the phenomenon of rapid decline that I have termed "Seneca Effect" (or "Seneca Collapse") (Bardi 2017), based on the observation of the 1st century Roman philosopher Lucius Annaeus Seneca that "fortune is of sluggish growth, but ruin is rapid".

Seneca Collapse is a phenomenon affecting complex, networked systems where strong feedback relationships link the elements of the system to each other. Biological communities where predators and their prey are linked to each other are a good example of these systems. Such systems normally tend towards "homeostasis," that is they exhibit a tendency to maintain their parameters close to a set called the "attractor." However, they can also jump from one attractor to another in a cascade of phenomena that may strongly affect the structure of the system. The Seneca Effect describes a situation in which the feedbacks of the system act together to generate a rapid decline of some of the stocks

(populations) of the system. It may lead to the extinction of some species or their decline to low levels from which they can gradually recover. The typical "Seneca Curve" is shown in the figure below (ibid).

Seneca Curve

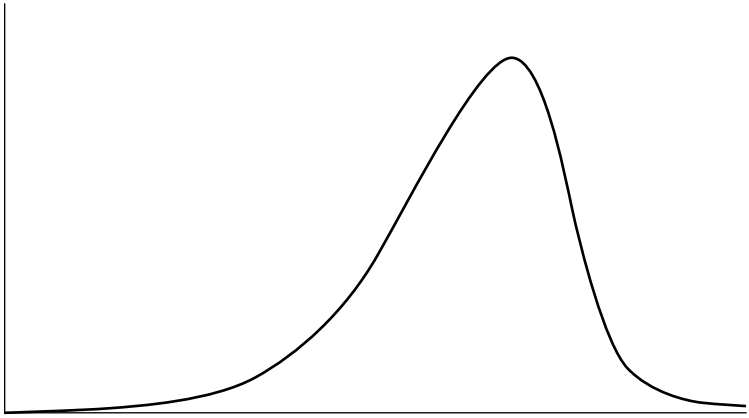

Figure 1. A typical "Seneca Curve" calculated by means of system dynamics. It shows how decline can be faster than growth.

Can the Seneca Collapse affect the human population? As usual, the future is never exactly predictable, but the study of the past tells us what we could expect.

Population collapses in nature

There are many examples of the rapid decline of a biological population. A simple and well-known case is that of the reindeer of St. Matthew Island (Klein 1968).

St. Matthew Island Reindeer Population

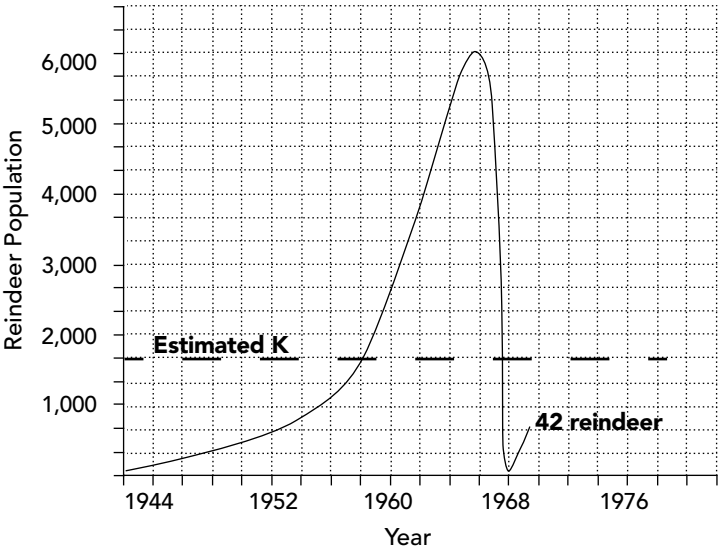

Fig 2. The Reindeer Population of St. Matthew Island. Image created by Saudiberg. https://en.wikipedia.org/wiki/St._Matthew_Island#/media/File:St._Matthew_Island_Reindeer_Population.svg

The curve shown in the figure is heavily interpolated, the actual data are scant. Nevertheless, it does show an extremely rapid crash from a population of thousands of reindeer to a less than fifty in just a few decades. It is a typical example of the "Seneca Curve." The reasons for the collapse are clear: a small number of reindeer introduced on the island grew to numbers that destroyed the grass faster than it could regrow. The result was a classic case of overshoot and collapse.

A different case is that of collapse generated by predation. A visually impressive example is the collapse of the thylacine species (the "Tasmanian Tiger") (McCallum 2012).

Tasmanian Tiger Population

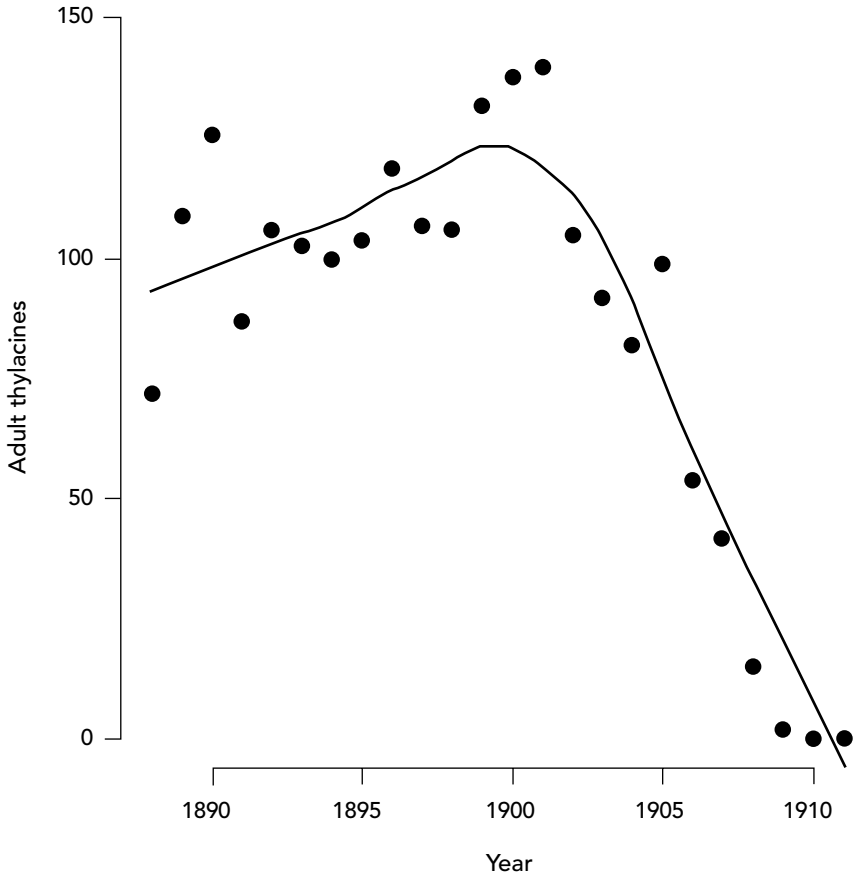

Figure 3. Population of Tasmanian tigers (Thylacines) before their complete extinction in the 1930s (McCallum 2012).

The data shown in figure 3 are not a direct measurement of the population size: they are the number of thylacine pelts produced by Tasmanian hunters as the result of a government scheme that provided a bounty for each animal killed. Nevertheless, they indicate a rapid collapse of the population: it went to nearly zero in just ten years, again a case of Seneca Collapse. The last Tasmanian tigers

were killed in the 1930s. The obvious origin of this collapse is human hunting, although disease has been sometimes blamed. Whether human or microbial pathogens were the predator, the graph shows how rapidly a biological population can collapse – even all the way to extinction – when under stress caused by increasing predation rates.

There is a third possible origin of population collapse, in this case generated by active birthrate control. Although this phenomenon doesn't seem to exist in the wild, we can clearly see it for the horse population in the United States.

Number of Horses in the United States

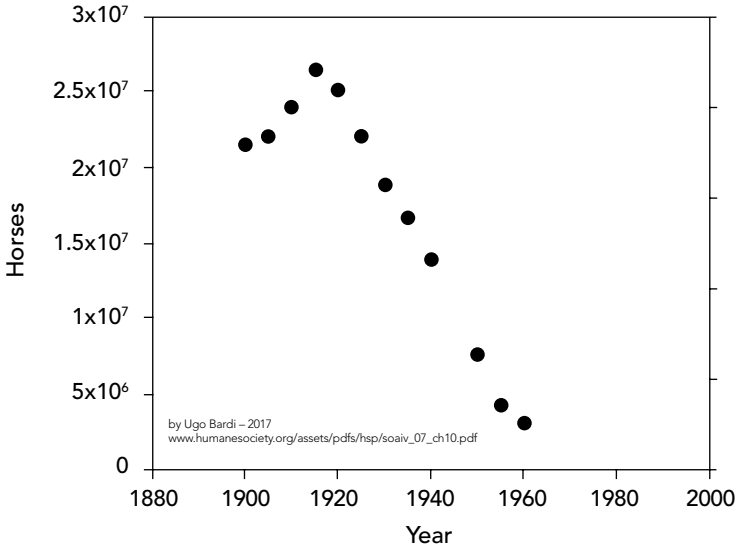

Figure 4. Horse population in the United States (data source: The Humane Society, http://www.humanesociety.org/assets/pdfs/hsp/soaiv_07_ch10.pdf).

We see how the horse population went down rapidly and abruptly, from a maximum of more than 26 million in 1915, to about 3 million in 1960. Today their population has increased again to levels of the order of 10 million, but has not regained the level of the earlier peak.

In this case, clearly, the number of horses didn't decline because lack of food, nor are there reports of fatal diseases affecting horses. Also, horses were not exterminated by humans: there is no evidence of horses being mistreated or killed in this period any more than in earlier periods. Horses were simply no longer competitive in comparison to engine-powered vehicles. They also were at a disadvantage because the pollution they created – dung – was visible and considered a serious nuisance at the time. As a result, horses were not allowed to breed. When old horses died, they were not replaced. Their place was taken by trucks, tractors, and tanks.

Human population collapses

This survey of the collapse of biological populations shows three causes for the "Seneca Collapse" to take place: overshoot, predation, and reproductive control. Do the same phenomena take place with human populations? It seems to be possible and let's see a few historical cases.

Perhaps the best example of the overshoot of a large human population is that of the Irish famine that started around 1845. A graph of the collapse is shown in fig. 5

Ireland Population: the Great Famine

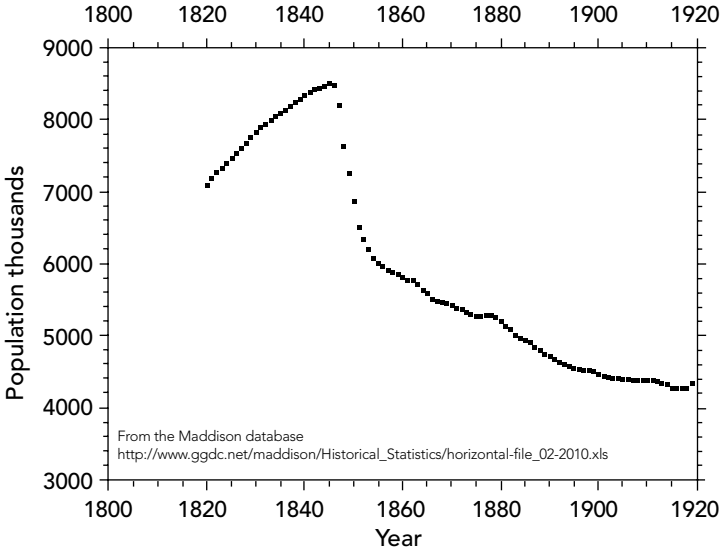

Fig. 5 – Irish population data before and after the great famine of 1845.

Effects of the Plague on Population

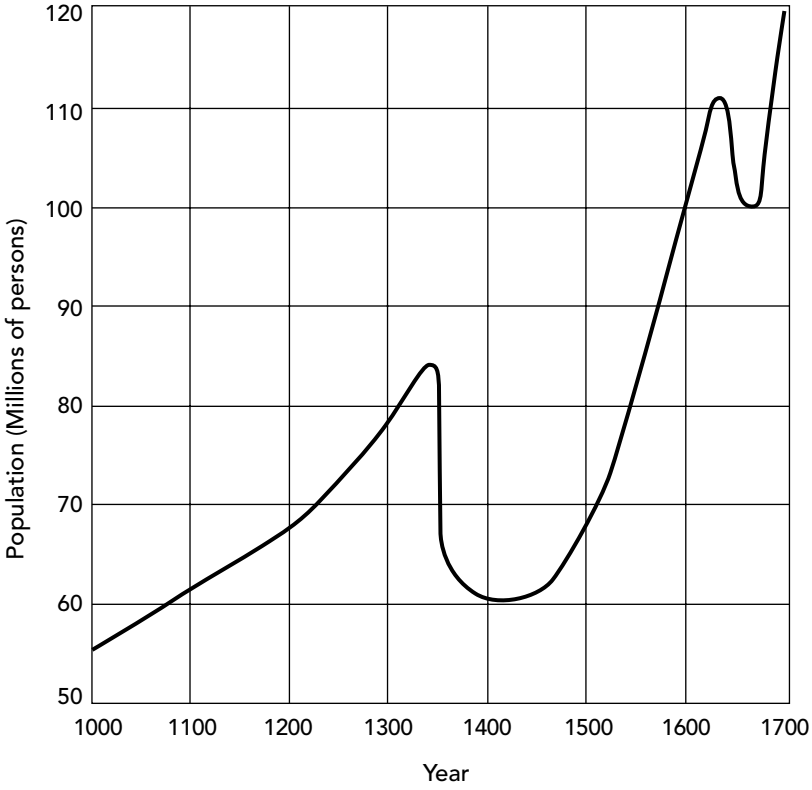

Figure 6 – European Population at the time of the Great Plague (from Langer 1964)

While a complex of economic, social and political factors contributed to the Irish catastrophe, the famine can be seen as a case of overshoot-generated collapse. This doesn't mean that the Irish overexploited their land in a simple way that is analogous to the collapse of reindeer numbers on St. Matthew's Island, but it is clear that the marginal land available to the poorest agricultural labourers couldn't support their population for any extended period. At the time of the famine Ireland was a large exporter of meat and dairy products, but when the potato blight destroyed their source of sustenance, the poorest – like the nearly 1 billion starving in the world today – had no purchasing power in the market for food. Thus, in

the absence of large-scale social and economic changes, the potato parasite that generated the crash was only a trigger for an inevitable population reduction. More than a million people died as a direct result of the famine, but it also precipitated a continuous wave of migration that persisted until the end of the 20th century. The Irish potato famine represents an example of how Seneca collapses can be the result of the complex interaction of ecological and social factors.

How about collapse caused by predation? Humans have no significant metazoan predator, but they are legitimate prey for many kinds of microbial creatures. In history, diseases are known to have caused human population collapses. A good example, here, is the effect of the "black death" in Europe during the Middle Ages.

The data are uncertain, but the "Seneca Shape" of the collapses is clear. In this case, however, the population started to regrow after the collapse. Note the difference with the case of Ireland in mid-19th century: during the Middle Ages, the European food production system was not in overshoot and only the total extermination of the population would have led to irreversible results.

Ukrainian Population

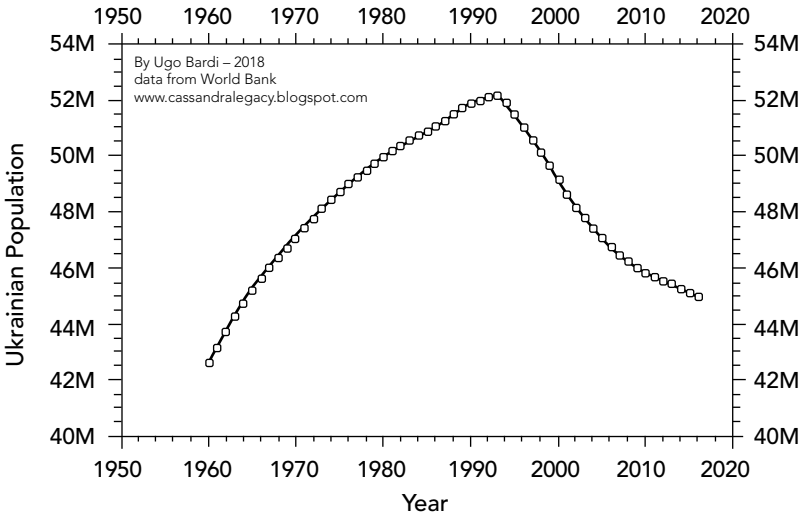

Fig. 7 – Ukrainian population – data from the World Bank

Finally, we can examine cases in which the human population has started to decline mainly as the result of lower birthrates. There are several modern examples, especially in Eastern Europe after the collapse of the Soviet Union in 1991. An especially evident case is that of Ukraine, shown in the figure 7.

There is no evidence of epidemic diseases nor of disastrous famines in Ukraine during the period that covers the recent population collapse. Emigration and increased mortality played a role, but what's impressive is how the Ukrainian population reacted to the economic crisis resulting from the disappearance of the Soviet Union with a decline in birthrates (see figure 8).

Ukraine Birth Rates

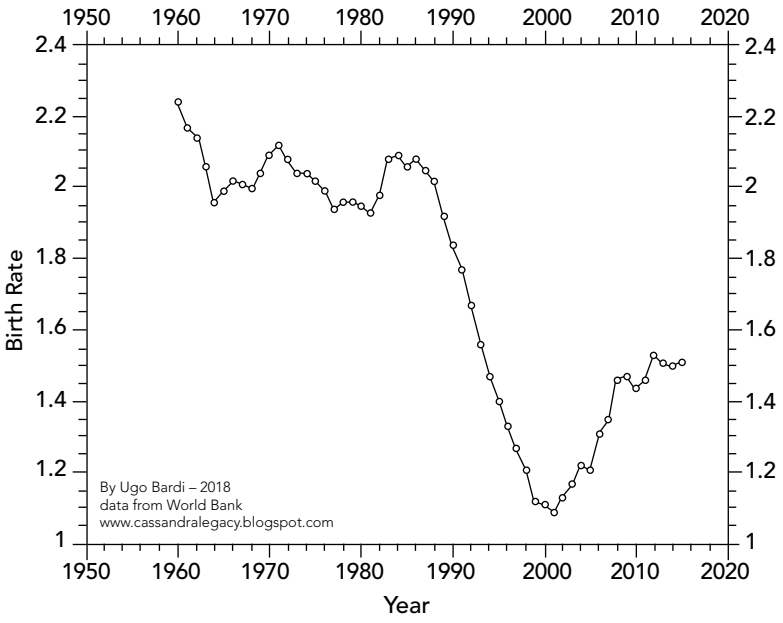

Figure 8 – the crash in birth rates in Ukraine. Data from World Bank.

An explanation of why Ukrainian families and Ukrainian women didn't compensate for the increased mortality and emigration might lie in their perception that there was no benefit in having a larger family given the economic situation. This trend

has been observed in all fomer Soviet Union countries. It may be seen as a typical reaction to an economic decline that in the future might take place worldwide.

Conclusion

The human population is subjected to the same constraints as non-human ones. All populations need food and are affected by predation. Wild populations normally have no internal mechanisms to plan ahead and the result is normally what we call "overshoot," where the population grows over the limits which the resources can sustain over a long time. The result is collapse. Cycles of overshoot and collapse are normally observed for wild populations but have also been observed for human populations in history.

The future of the world's human population may well be that of collapse as the result of one of the three mechanisms identified here: overshoot, predation, and birth control. Of the three, predation could take the form of a microbial infection spreading all over the world and killing a substantial fraction of the human population. It is a common theme of fiction and of conspiracy theories that some evil government or religious sect is engaged in preparing a deadly virus for this purpose and AIDS and the Ebola virus are sometimes described as the results of these efforts. If that is the case, it must be said that the perpetrators of such a monstrous crime don't seem to be as efficient as they are evil, since neither AIDS nor Ebola have led to a significant reduction in the global human population. Yet, it is not impossible that in the future a more deadly microbe will emerge, either by itself or by human manipulation. Even in this case, though, the effect would be short-lived and, if nothing else were to change, the population would soon start regrowing.

A more worrisome phenomenon is that related to overshoot, especially related to the decline of the agricultural capability of producing food or, more simply, to the capability of the globalized economic system to deliver it worldwide. In this case, the effects would be not only tragic, but also long-term. We can't say how long the system would need to recover from overshoot, but it may involve centuries of misery for the surviving population.

Finally, there is the possibility of birth control to reduce the human population before overshoot or diseases intervene. It doesn't necessarily require top-down

government intervention to force people to have fewer children. An economic slowdown or downturn may be sufficient to convince couples and single women that they have no need and no interest in having many children. In particular, the economic value of human beings is constantly eroded by the development of automated systems that replace them in the workplace. So, if women have access to contraception, we may just see a worldwide expansion of what we call the "demographic transition" and which is commonly observed in the so-called "developed countries" where agriculture ceases to be the main source of wealth.

Will the demographic transition be sufficient to reduce the human population before the evil demons of overshoot and plague intervene? This is hard to say, but it cannot be excluded. Humans are, after all, intelligent creatures and they may still be able to take their destiny in their hands.

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