4.4 Know your classics: the limits to growth

We can’t go any further without talking about a classic archetype, called “limits to growth”.

If this archetype sounds familiar it is most probably because it was named after a report of the same name on the limits to population growth published by the Club of Rome’s in the 1970s. The Club of Rome is a private think-tank that was founded in 1968 to raise awareness amongst politicians and decision-makers of the delicate interaction between economic development and the environment. It commissioned a team of systems scientists at MIT to investigate the interactions of population, food production, industrial production, pollution, and the consumption of non-renewable natural resources. The team built and ran a system dynamics computer model between the years 1900 and 2100 that showed how population growth, food production and industrial production are limited by the availability of natural resources and pollution. In 1972 the Club of Rome published the results in a report entitled “The Limits to Growth”. Over 10 million copies of the report were sold and it was translated into 30 languages.

The results of the report were thought provoking, and made headlines at the time. Let’s have a look at what they said.

Growth that slows, stops and even collapses is caused by a simple systemic structure. Let’s walk through a catastrophic “limits to growth” scenario where a limit is overshot and leads to the collapse of the resource and the stock that depends on that same resource.

Imagine a situation where there is a growing stock. It could be a population of fish, bacteria, reindeer, trees or people. Let’s say it’s a population of people. The population grows through births and falls through deaths. There is positive feedback between the number of births and the population and negative feedback between the population and the number of deaths. Both increase according to their corresponding compounding fractions: the birth rate and the death rate.

People in the population use a resource to survive, such as a food resource or reserves of drinking water. The consumption of the resource depends on the number of people in the population and the consumption per person. The amount of the resource that each person consumes depends on the level of the resource. For example, as the amount of resource available to the population decreases a rationing policy may be put into place and consumption per person will fall. As less resource is available to the population the death rate of the stock begins to increase which, if the level of the resource continues falling eventually leads to the collapse of the population.

Let’s have a look at how this situation evolves over time. We’ll use a computer simulation to watch things unfold. The link to this online model is in the additional materials below.

Firstly, the positive feedback loop composed of “births” and the “population” drives the exponential growth of the “population.” So long as the birth rate is greater than the death rate, the reinforcing loop of births will dominate the balancing loop of deaths and the population will continue to increase. This is the case until the end of year 15.

As the population increases, so too does the consumption of the resource. After all, every person in the population consumes a little of the resource each year.

The exponential increase in the “stock” causes the “consumption” of the resource to also increase dramatically.

When the consumption outflow is greater than the regeneration inflow, the net flow becomes negative and the resource level begins to fall. As there is less of this vital resource available to the population, the death rate increases. We unfortunately see this happen in some areas of the world whenever there is a famine or a drought.

As the death rate increases, the net flow of people joining the population begins to decrease to zero. As the net flow into the stock decreases the stock stops growing exponentially and its growth becomes asymptotic. As the population is still increasing in size, albeit at a slower rate the "resource" continues being depleted through "consumption," and the death rate continues to grow due to the lack of resource needed for survival. The stock peaks at year 16 when the net flow is equal to zero.

As soon as the net flow becomes negative, the population starts decreasing. The "outflow" continues to increase because of the growing death rate while the "inflow", the number of births has started to decrease as a result of the decrease in the size of the population.

As the population starts decreasing, consumption falls and the decrease in the level of the resource is no longer exponential, but asymptotic. The number of deaths per year starts decreasing because of the decrease in the population and the net flow becomes less and less negative. But it is too late. The resource so critical to survival has been depleted leading to the extinction or migration of the population.

There are of course many other factors that can influence the availability of a resource, such as weather conditions or technology that can be used to preserve or increase the level of the resource. For example, when much of southern Australia experienced severe drought from late 1996 to mid-2010 state governments invested in desalinations plants to make seawater drinkable. Nonetheless, technology and weather do not modify the underlying structure. Reinforcing feedback pushes strong growth in a stock which slows and may even collapse as a limit is reached and overshot.

Therein lays the problem of many complex problems. We don't see disaster coming until it is too late. This happened to the fishery in chapter 3. If you were a fisherman, your indicator for the health of the industry would be the industry's yearly catch. This increased continuously for 15 years until it unexpectedly fell and then collapsed from year 16 onwards. If we had had information about the stock of fish, we could have anticipated the collapse of the industry. Instead, as the industry grew it attracted more and more fishing boats which accelerated the decline of the stock.

A number of scholars have used the "limits to growth" structure to explain the rise and fall of ancient societies such as the Mayan civilization in Central and South America and Easter Island in the Pacific Ocean. Overexpansion and the exhaustion of available natural resources have played key roles in the collapse of great cultures in human history. You can simulate the rise and fall of the population on Easter Islander using the walkthrough exercise in the additional materials below.

So, how can knowledge of this archetype help? Well, it reminds us that nothing can grow infinitely in a finite world. Once we recognize the limits then we can anticipate their slowing or limiting actions and address them early, before they gain momentum.