Changes big and small

Population growth

What are the implications of an ever-growing population?

In 2011, the human population reached 7 billion. By 2050, the human population is predicted to have swollen to almost 10 billion, despite the slowdown of population growth. These statistics might have surprised the economist Thomas Malthus, who at the turn of the 19th century made some gloomy predictions about population growth.

He believed that overpopulation would soon lead to war and famine, as demand for food outstripped supply. In ecological terms, we would have exceeded our carrying capacity – the maximum population that our environment and all of its resources can support.

Malthus was writing from the perspective of a man living in a world of 1 billion and didn't foresee the advances in farming technology that would enable the planet to support many more people. However, by no means are all 7 billion (now nearly 8 billion) well fed. Around one in nine people suffer from chronic hunger, mostly in low- and middle-income countries, which are also predicted to see some of the biggest population increases over the coming decades.

The enduring growth of the human population is often referred to as the 'population explosion'. But other species undergo booms too. In Florida, the population of green iguanas has been exploding for the last decade. By 2019, it reached the point where the state conservation agency started asking residents to kill the burrowing reptiles, which can destroy pavements and crops, and carry disease. Consistently warm weather is blamed for the explosion in their numbers.

Other animal populations experience shorter-lived booms. The numbers of Monarch butterflies rise and fall dramatically depending on everything from the weather to the availability of the flowers that they use for food. Some scientists consider them a "boom and bust" species. However, it's important not to let such natural variability mask longer-term declines. Charting monarch numbers in the US from the mid-1990s to 2018 shows a downwards trend overall.

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Malthus vs Boserup: two theories of population growth

Humans, like members of all populations of plants and animals, are in competition with one another for the Earth's resources. The global human population is growing by over 80 million people a year, a growth rate of around 1.1 per cent per year, and as it does the competition for resources increases.

One of those resources is food. In high-income countries food supply is relatively secure; Britain has not experienced a widespread food shortage since the Second World War. But as demand for food increases, supplies come under greater pressure. In 2017, a drought in the Amazon caused the region's Brazil nut pods to drop too early, resulting in a poor harvest and price hikes of over 60% across Europe. There was also a 50% increase in the price of avocados that year, due to floods in Peru, late harvesting in Mexico and droughts in the US. These shortages didn't last long, but in the future will we be able to produce enough food to support the ever-increasing human population?

While this seems like a 21st-century problem, it is actually a question that has concerned economists for hundreds of years (and farmers since the first days of agriculture).

Malthus's theory

In the 18th century an economist called Thomas Robert Malthus wrote an essay outlining his response to the problem. The work, entitled 'An Essay on the Principle of Population' (1798), set out Malthus's theory of population growth: a theory of how and why the size of the population would change.

Malthus thought that if the human population continued to grow, food production would not be able to keep up with demand and there would not be enough food to go around. The result, he warned, would be a terrible famine that would kill many people.

In ecological terms, Malthus was arguing that the human population was at risk of outgrowing its carrying capacity (the number of individuals that can be supported by a specific habitat). There are examples of this happening to particular populations of animals, such as the reindeer on St Matthew Island near Alaska. In 1963, visiting scientists counted 6,000 reindeer on the remote island, yet when they returned just three years later there were just 42 - and masses of reindeer skeletons. Climatologists put the population bust down to an extremely harsh winter of 1963-1964, which covered much of the reindeers food supply (lichen) in snow.

Malthus reasoned that this disastrous outcome could only be avoided if the population stopped growing. He described two types of 'checks' that could stop population growth: a negative check that would cause a drop in the birth rate (e.g., increased use of contraceptives) and a positive check that would increase the death rate (e.g., disease or war). These checks, he argued, were more likely to take effect as the population got closer to its carrying capacity, either because governments would take steps to stop the population getting any bigger or because of increased competition and hardship within the population. This, Malthus thought, was what would save us from large-scale starvation.

But the population has not stopped growing. Since Malthus's lifetime the number of humans on the planet has continued to increase, and in 2011 the population reached 7 billion. According to Malthus's theory, this should not have been possible. Where did he go wrong?

Malthus's theory was based on the assumption that the population would grow exponentially (1, 2, 4, 8, 16, 32) whereas food production would grow linearly (1, 2, 3, 4, 5), much more slowly. At the time when he was writing the Industrial Revolution had not yet arrived, and without developments such as pesticides and fertilisers the amount of food that could be produced per acre of land was much smaller than it is today.

Over the 250 years since Malthus published his essay, advances in technology and innovations in farming methods have allowed food production to grow quickly enough that we can now, in theory at least, provide sufficient food for the world's nearly 8 billion inhabitants. Malthus did not account for these advances in his population theory, but another economist, Ester Boserup, did.

Boserup's theory

Ester Boserup (1910–1999) was a Danish economist who specialised in the economics and development of agriculture. She worked for the United Nations and her experience working in low- and middle-income countries such as India helped to shape her theory of the relationship between human population growth and food production.

In her work 'The Conditions of Agricultural Growth: The economics of agrarian change under population pressure' (1965), Boserup challenged Malthus's conclusion that the size of the human population is limited by the amount of food it can produce. She suggested that food production can, and will, increase to match the needs of the population.

Drawing on her knowledge of farming in the developing world, where populations were growing quickly, Boserup argued that the threat of starvation and the challenge of feeding more mouths motivates people to improve their farming methods and invent new technologies in order to produce more food.

Boserup described this change as 'agricultural intensification'. For example, a farmer who has four fields to produce food for his family might grow crops in three of the fields, but leave the fourth field empty as the ground is dry and his crop will not grow there. However if the farmer has two more children, the pressure to produce more food might drive him to build irrigation canals to bring water to the fourth field or to buy a different type of seed that will grow in drier ground. He would change the way he farms to make sure that he has enough food to support a larger family.

Is there a limit?

Boserup's theory seems to provide a model for continuous population growth, but there are those who argue that Malthus was right and that there is a limit to the number of humans the planet can support.

As modern environmentalists, scientists and politicians debate the future of the world's climate and resources, we must hope that Boserup was right to believe that human beings are capable of remarkable ingenuity in the face of a problem.

QUESTIONS FOR DISCUSSION

- Can you find an example of an individual or a group that thinks Malthus was right? What are their arguments?
- Food is not the only resource that we need to survive. Can you think of other resources that humans compete for? What would happen if they ran out?

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Factors influencing population change

The influence of biotic and abiotic factors

Ecologists often divide the factors influencing ecosystem and population change into two types. Biotic or intrinsic factors relate to living organisms, and include predators and competition between organisms for food, while abiotic or extrinsic factors relate to non-living aspects of the environment, such as water or places to live.

Biotic and abiotic factors interact. For example, in the 1970s a drought (an abiotic factor) caused a crash in the population of medium ground finches living on one of the Galapágos Islands. The birds were pushed to the brink of extinction as the drought wiped out their food supply, seeds (a biotic factor).

Biotic and abiotic factors typically influence population size in different ways. Abiotic factors (like temperature) may affect individuals whatever the size of the population: they are density-independent.

On the other hand, biotic factors may have different effects depending on the population size: a single predator may have a much bigger impact on a small population than a large one; and competition for territory may force some animals out of prime mating areas when populations are large. Such effects are density-dependent. However, weather alters habitat quality, so these factors almost always interact.

Migration and travel

The animal world provides some stunning examples of mass migrations, such as the millions of North American monarch butterflies that migrate over 4,800 km each year to spend the winter in fir groves in central Mexico. But animal migrations may also be the result of human interventions – accidental or intentional – with sometimes unwanted knock-on effects for other populations.

In the 1980s, Harlequin ladybirds were imported from Asia into France and Belgium to help keep aphids from damaging crops. They crossed the Channel into the UK in 2004 by flight and on fruit, vegetables and flowers from mainland Europe. The ladybirds are cannibalistic and thought to be responsible for the decline of several native species, including the smaller Two-spot ladybird.

Migration in human populations has changed the course of our evolution. Until around 70,000 years ago, all humans lived in Africa. By around 14,000 years ago, we had colonised almost every corner of the planet. The isolation of different populations within differing environments led to evolutionary changes that gave us a rich and varied genetic history.

In modern times, the forced migrations of millions of Africans to Europe and America as part of the slave trade have shaped the ethnic backgrounds of those populations. Now, in the 21st century, international travel is easier than it ever has been, so people from different ethnic backgrounds are more likely to mix up their genes by having babies together. This should mean that human populations become increasingly less isolated and less marked in their differences. The hyper-connectedness of our world also has implications for the transmission of disease. The strain of H1N1 swine flu that emerged in La Gloria, Mexico in 2009 spread across 23 countries in a month, even reaching New Zealand, 15,000 km away.

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Populations and disease are intertwined

The spread of disease affects a population in the short term through ill health and death, but also in the long term by influencing the overall genetic structure of the population.

The ravages of HIV/AIDS may affect the genetic make-up of populations. One genetic mutation, CCR5-delta 32, protects against HIV, helping people survive. Research carried out in 2005 suggests it has become more common in Europe during the last 2,000 years, though not because of HIV. Some scientists think that CCR5-delta 32 spread because it offered protection from other diseases such as bubonic plague. However, the mutation could also become more common in modern, HIV-affected populations. HIV/AIDS is estimated to have killed a total of 32 million people as of 2019 and so has had and continues to have an important influence on populations.

The behaviour of some diseases depends on population size. Measles statistics show that before a vaccine became available, larger cities were associated with an increased frequency of epidemics. This is probably because in smaller cities there were not enough susceptible people to allow the measles virus to circulate – people had already been infected and become immune.

Plants get sick too, of course. A fungal disease called ash dieback, which has been spreading through Europe since the 1990s, has affected 90 per cent of Denmark's ash trees. However, starting in 2012, scientists have identified a small population of 200 resistant trees and have been using grafts from these trees to establish seed orchards. The genetics of these trees will have an important influence on the future of the Danish ash population. Ash trees are important in woodlands because their canopies allow light to filter through to support life on the ground.

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