Carrying capacity

The maximum number of individuals that can be supported sustainably by a given environment is known as its 'carrying capacity'.

For most non-human species, the concept is quite simple. If carrying capacity is exceeded, the population declines, because its environment can no longer support the excess numbers. In many situations this can happen very rapidly, because excessive demand degrades or even devastates the environment and there is a sudden and catastrophic feedback effect. Such a feedback effect can not only eradicate those numbers of population in excess of the carrying capacity of an environment but, under certain circumstances, it can also cause the near-extinction of an entire species.[1, 2]

Carrying capacity

A population can exceed the carrying capacity of its environment for a short while by using up the stored resources (i.e. natural capital) of its environment, but sooner or later the 'overshoot' will catch up. Once the capital is exhausted, population numbers inevitably fall because there are no longer enough resources available to support the number of individuals.

In the case of human populations, there is a large variation in per capita consumption levels between poor and affluent communities, so the basic definition of carrying capacity needs to be qualified and the given level of per capita consumption and waste generation needs to be taken into consideration.

The carrying capacity of a given environment is much greater for people living at a subsistence level than it is for people with a typical Western European or North American lifestyle.

Too much of a good thing?

In 1944, on St Matthew Island in the Bering Sea, the US Coastguard shipped in 29 reindeer as food for the navigation station personnel, but none were ever shot, and all 29 reindeer were left behind on the island at the end of the war.

By 1957 the herd had swelled in size to more than a thousand individuals, thriving on the abundant moss and lichen. Although the animals were healthy, observers noted small patches of overgrazing. The island had reached its carrying capacity. Six thousand were counted in 1963. The reindeer were thin and showing signs of stress.

When observers returned in 1966, the island was littered with skeletons. The herd had been reduced to just 42 reindeer with no active males; it faced extinction in the next generation, and the island environment had become devastated by the herd.

It is also important to note that different geographic regions have a greater or smaller carrying capacity. Climate and local geography both play a crucial part. In some parts of the world, endemic species recover swiftly following a drop in population, whereas in other areas of the world recovery is measured in tens or hundreds of years.

Polynesian settlers who crossed the Pacific left behind a landscape that responded well to burning (they used fire to clear land and refresh forest growth), but the lands they settled did not. The dramatic decline in tree cover on Easter Island, Hawaii and New Zealand is attributed to a fundamental misunderstanding of the localised conditions by the newly-arriving people.[3, 4]

Similarly, the Viking community that settled in Greenland experienced a parallel collapse when they attempted to farm the marginal lands in the same manner they had done with other lands where they had settled, but without taking account of local conditions.[5]

The lesson is that we cannot assume that any particular agricultural method is sustainable in all circumstances.

The Mayans' population growth exceeded the carrying capacity of their ecosystem

Another case where a human community is believed to have exceeded its carrying capacity is that of the Mayans. It appears that population pressure forced them to cultivate more and more marginal land, leading to a reduction of carrying capacity in their ecosystem. The forest land was not amenable to long-term intense cultivation, leading to topsoil erosion on a large scale. This, in turn, led to competition between Mayan cities for land which inevitably could not support their rising populations; conflict and gradual collapse of their society ensued.[6]

In a number of other instances where entire peoples have disappeared, this has been at least in part attributed to their populations exceeding the carrying capacity of their local ecosystems. However, where the evidence is archaeological rather than historically documented, it is often difficult to determine with any certainty the extent to which overpopulation — rather than other factors, such as climate change, conflict, social unrest, etc. — was the principal cause of the collapse.

The fact that declining welfare of communities can be the result of a combination of factors also means that the symptoms of a population being near to exceeding its carrying capacity are often misread. For example, starvation following a poor harvest may be attributed only to the poor harvest, rather than the population size.

Read about biocapacity and ecological footprint.

References

Internet references accessed April 2016

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[3] Jared Diamond, Collapse: How Societies Choose to Fail or Survive, Allen Lane 2005. See review by J Porritt: http://www.guardian.co.uk/books/2005/jan/15/society

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[5] http://archive.archaeology.org/online/features/greenland/

[6] http://science.nasa.gov/science-news/science-at-nasa/2009/06oct_maya/

