Extinctions of large animals sever the Earth's 'nutrient arteries' (Update)

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Credit: AI-generated image (disclaimer)

(Phys.org) —A new study has demonstrated that large animals have acted as carriers of key nutrients to plants and animals over thousands of years and on continental scales.

The paper in the advance online publication of the journal *Nature*

Geoscience explains that vital nutrients are contained in the dung and bodies of big animals. As they eat and move more than small animals, they have a particularly important role in transporting nutrients into areas where the soil is otherwise infertile.

In the study, the researchers use a new mathematical model to calculate the effect of mass extinctions of big animals around 12,000 years ago, focusing on a case study of the Amazon forest. They estimate that extinctions back then reduced the dispersal of phosphorus in the Amazon by 98%, with far-reaching environmental consequences that remain to this day. The model also enables them to forecast the likely environmental effects of the extinction of large animals currently under threat in Africa and Asian forests.

Up until 12,000 years ago, much of the world looked like an African savannah. For instance, South America was teeming with large animals, described by scientists as 'megafauna' – a term for animals with a body mass of more than 44kg (the size of a large dog). These megafauna in South America, which overlapped with the earliest humans, included several species of elephant-like creatures, giant ground sloths, and armadillo-like creatures the size of a small car. In South America, most nutrients originate in the Andes mountain range and are washed into the forests through the river system. However, on dry land, these nutrients are in short supply unless they are transported through animal dung and bodies. While small animals distribute nutrients over small distances, large animals have a much greater range. According to the study, the extinctions of large animals 12,000 years ago wiped out one of the main means of transporting nutrients far from the rivers creating a nutrient deficiency which continues to affect plant and animal life in parts of the region today.

The researchers have developed a mathematical model, similar to one used by physicists to calculate the diffusion of heat, to estimate the

ability of animals to distribute nutrients. The model is based on the body size of the animal, drawing on existing data of their fossilized remains. From this, the researchers have been able to estimate how much the animal ate, defecated, and the range and distance they travelled, which was then combined into one simple term. This model allows them to calculate the ability of animals to distribute nutrients anywhere on the planet at any time, if the animal's average size and distribution is known. It can estimate the effects of past extinctions, such as those in the Amazon. It can also forecast the effects of potential events thousands of years in the future, such as calculating how much the fertility levels of the soil would fall following elephant extinction in Africa.

The study finds that the effect of the mass extinction of megafauna 12,000 years ago was to switch off a nutrient pump – vital nutrients, such as phosphorus, were no longer spread around the region but became concentrated in those areas bordering the floodplains and other fertile areas. It concludes that even thousands of years after the extinctions, the Amazon basin has not yet recovered from this step change. Nutrients may continue to decline in the Amazon and other global regions for thousands of years to come, says the paper.

Lead author Dr Christopher Doughty from the Environmental Change Institute at the School of Geography and the Environment, University of Oxford, said: 'We have developed a model, based on the size of the animal, that enables us to calculate how extinctions affect the fertility of the landscape that species once inhabited. While 12,000 years may be a timescale that is beyond most people's understanding, through this model we show that extinctions back then still affect the health of the planet to this day. Put simply, the bigger the animal, the bigger its role in distributing nutrients that enrich the environment. Most of the planet's large animals have already gone extinct, thereby severing the arteries that carried nutrients far beyond the rivers into infertile areas. We can also predict the effects of further extinctions – a fate fast approaching many

of the large animals that remain – and examine the likely impact thousands of years into the future.'

Co-author Dr Adam Wolf from the Department of Ecology and Evolutionary Biology at Princeton University said: 'On today's planet, the supply of nutrients in the soil is determined by river deposits or nutrients that are airborne. Yet this analysis suggests that we may be experiencing a peculiar post-extinction phase in Amazonia, and probably many other parts of the world. We believe that large animals once played a vital role in fertilising their landscape, so that the naturally occurring deposits in rocks were less important. If humans contributed to the mass extinction of big animals 12,000 years ago, this suggests that humans started to affect the environment at global scales well before the dawn of agriculture.'

More information: Repeated Pleistocene glaciation of the East Siberian continental margin, DOI: 10.1038/ngeo1904

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