Ecosystems need maths not random nature to survive

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Credit: Wikipedia.

A previously unknown mathematical property has been found to be behind one of nature's greatest mysteries – how ecosystems survive.

Found in nature and common to all ecosystems the property, Trophic Coherence, is a measure of how plant and animal life interact within the food web of each ecosystem – providing scientists with the first ever

mathematical understanding of their architecture and how food webs are able to grow larger while also becoming more stable.

Identified by researchers led by the University of Warwick, Trophic Coherence's identifiers argue that it demonstrates that ecosystems are less random and more structured than had previously been thought. Trophic Coherence was found to be a universal, mathematical property found in each and every ecosystem.

Dr Samuel Johnson, from Warwick's Mathematics Institute, explains:

"Buildings require structural supports, such as the metal or timber frames around which they are then built. For the building to remain standing though these supports need to comply with the laws of mathematics and physics; if the roof is too heavy for the frame, the building collapses. The frames also need flexibility to adapt to conditions, if they are too rigid they become fragile and, for instance, unable to cope with difficult weather.

"The same is true of natural ecosystems; they need support and structure. Trophic Coherence seems to play a similar role in ecosystems as supporting frames of buildings - it is a structural property that helps ecosystems survive, and is common to all the ones we have analysed. It provides them with essential support and structure".

Although coherence appears to be crucial to ecosystem survival, the researchers argue that this does not imply it was selected by the forces of nature for this purpose. "Most animals will eat whatever they can, whether or not this is good for their ecosystem. But, luckily, coherence emerges from the fact that species tend to consume others which have certain things in common, such as their diet."

"Observed in nature these interactions, which comprise an ecosystem's

food web, can look totally random, but if they were truly so then they would collapse. In reality, beneath this random façade lays a fundamental mathematical property that helps the ecosystem to survive – this is Trophic Coherence", says Dr Johnson.

"As mathematicians we aim to uncover the underlying patterns in the natural world and ecosystems had been puzzling mathematicians for decades – how can something, which appears to be random and should not be able to survive, actually do so? Trophic Coherence allows food webs to become larger while maintaining stability, a bit like flying buttresses were the element needed for cathedrals to do likewise".

Knowing whether a given ecosystem is likely to become more or less stable if it lost certain species is, the researchers argue, important for conservation efforts. The results may also find potential application in fields such as finance and engineering, where understanding the relation between size and stability in interconnected systems is often paramount.

The research, titled Trophic coherence determines food-web stability, is published by the *Proceedings of the National Academy of Sciences* (*PNAS*).

More information: *PNAS*, www.pnas.org/content/111/50/17923.abstract

Provided by University of Warwick