Editorial

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Connecting geology to ecology

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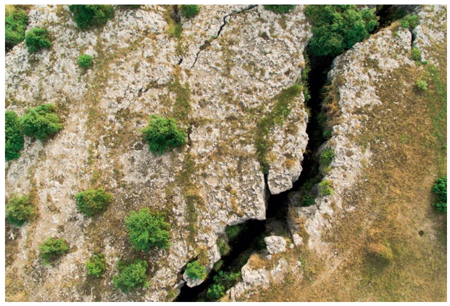
Understanding the ecosystem response to global environmental change requires consideration of geological processes, highlighting the interconnected nature of our Earth system.

The world boasts a remarkable diversity of ecosystems that provide wide-ranging societal benefits and sustain biodiversity. Forest ecosystems are particularly prevalent, covering 30% of the world's land surface and playing a key role in the global carbon cycle. Resilient forests that can withstand disturbances are crucial for delivering effective long-term carbon storage to help mitigate climate warming. The health and longevity of a forest is dependent on the complex interplay between long-term drivers such as climate change, and transient disturbances like wildfire and drought. While the importance of climatological and hydrological conditions in governing forest functioning is well-established, the influence of geological hazards has received far less attention. In an Article in this month's issue of *Nature Geoscience*, Eryuan Liang and colleagues show that earthquakes can cause changes in forest resilience that can last for decades after the seismic event, demonstrating the influential role that geological processes can have in shaping ecosystems around the world.

Forests are increasingly threatened by both anthropogenic pressures and a range of natural disturbances. In February this year wildfires broke out in central Chile which spread rapidly leaving over 29,000 hectares burned[1]. Meanwhile, the Amazon River basin has been in a state of exceptional drought since mid-2023 (ref. 2), putting acute stress on the rainforest and local communities. Highly resilient forests can recover from such disturbances, but forests that are more sensitive to external pressures are at risk of irreversible regime shifts.



Unfortunately, there are signs that climate change is driving a reduction in forest resilience globally[3].

Seismic activity can also disturb the landscapes upon which forests grow. Liang and colleagues show that earthquakes can both positively and negatively affect forest resilience through altering local hydrology. In dry temperate regions, earthquake-induced cracks in the soil can improve infiltration of rainfall to deeper layers, enhancing the ability of trees to extract water and nutrients. The increase in forest resilience can last for decades after the seismic activity. In contrast, in regions with abundant rainfall these earthquake-induced cracks increase soil erosion and nutrient leaching, leading to reduced forest resilience.

Other geological hazards, such as rockfall in mountainous regions, can also influence the local environment. Rockfall is likely to become an increasingly important disturbance in alpine regions due to the degradation of permafrost as the climate continues to warm. In an Article in this issue, Markus Stoffel and colleagues show that ongoing warming has enhanced rockfall from an unstable mountain slope in the Swiss Alps over the last century. Their valuable long-term record was obtained by examining the growth-rings from trees in downslope forests damaged in the rockfall events.

Beyond local damage, escalating rockfall may have much broader environmental impacts via their consequences for glaciers. Glaciers in high mountain regions play a key role in the hydrological cycle and can be a valuable water resource for downstream ecosystems and communities. For example, the glaciers of the Himalaya are the headwaters for some of the world's largest river systems, including the Ganges-Brahmaputra, Indus and Yangtze rivers. Glaciers around the world are shrinking with ongoing climate warming[4], but it is unclear how increasingly unstable mountain slopes may affect their evolution. Glaciers covered in rock debris can behave quite differently and may be more climatically resilient thanks to the insulating layer of debris cover[5]. Therefore, the evolution of unstable mountain slopes could have an important influence on future glacial water resources and the downstream ecosystems they supply.

The two articles we have highlighted from this month's issue both demonstrate the ongoing dynamic interplay between geological processes, climate, and the biosphere. Observing these intricate interactions is fundamental to understanding the resilience of vital ecosystems under global environmental change. Here at *Nature Geoscience*, we appreciate that there is a need for research that bridges hard rock geology and environmental science; traditionally two distant fields of study. We welcome research uncovering the connections between the geological workings of our planet and the surface environment we depend on.

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