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Forests and floods

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One strategy for reducing catastrophic floods invokes protecting or regenerating forests that lie upstream of the threatened region. Support for this approach comes from a global-scale analysis of flood risk.

Floods can be devastating, especially in developing countries, which are already struggling to improve the welfare of their people. Floods in such countries during the 1990s took almost 100,000 lives, displaced more than 300 million people and caused more than US$1 trillion in damage to properties[1,2]. To mitigate flooding, several nations are investing in projects to restrict the loss of forests or to reforest cleared lands that lie upstream of the potential flood region. But these strategies are controversial. Some argue that the link between forests and flooding is too weak to justify the often large outlays needed to retain or recover forests[2,3]. In the journal *Global Change Biology*[1], however, Bradshaw *et al.* provide strong correlative evidence that native forests do reduce the frequency and severity of floods in developing nations.

Forests are thought to reduce flooding[4] by acting as sponges — that is, they trap water during heavy rainfall, then release it slowly into streams, which lessens the severity of floods and maintains stream flows during dry periods. Forests also increase the permeability of the soil and emit water vapour into the atmosphere through evaporation and transpiration, further reducing the run-off of rainwater[5]. For these reasons, a nation such as Costa Rica, which places high value on natural-ecosystem services, and those such as China, India, Nepal and Bangladesh, which have been plagued by devastating floods (Fig. 1), have invested heavily in forest protection or reforestation.

Yet this approach is contentious. Most notably, a serious counterargument came from an influential report[2] published in 2005 by the Food and Agricultural Organization of the United Nations (FAO) and the Center for International Forestry Research (CIFOR) in Bogor, Indonesia. The analysis concluded that the evidence that forests reduce flooding is weak, especially for the largest and most devastating floods. The report suggested that retaining or regenerating large forest areas was an economically dubious strategy for developing nations, at least from a flood-reduction perspective.

Bradshaw *et al.*[1] step into the fray with a global-scale empirical analysis of the association between forests and flooding; earlier efforts had invariably examined much smaller catchment areas or regional scales. The authors evaluated flood frequency, duration and damage (the number of people killed and displaced, and estimated economic losses) from 1990 to 2000 in 56 developing countries in Africa, Asia and Latin America. Using a battery of statistical models, they first controlled for confounding factors such as country size, rainfall, topography, degraded land and soil-moisture regime, then evaluated the residual associations between native-forest cover and flooding.

Their simplest and most realistic models account for more than 65% of the variability in flood frequency and duration, an impressive figure for such a vast, heterogeneous cross-section of Earth. Native-forest cover and the rate of forest loss account for 14% of this variation, on average. Associations between forest cover and the damage caused by floods were weaker but still evident. Statistical simulations suggested that arbitrarily removing a tenth of the remaining native forest would increase the frequency of floods by 4–28%, and lengthen their duration by 4–8%. The authors emphasize that assessment of flood risk is complex and fraught with confounding factors. But they say that their study shows the need for large-scale forest protection and more reforestation to help reduce the frequency and severity of floods.

In my view, Bradshaw and colleagues' paper[1] will turn out to be a landmark study. But at least one point will provoke debate — their decision to exclude floods driven by extreme events, such as cyclones and typhoons, which they suggest can cause flooding "independently of landscape characteristics" such as forest cover. Their rationale is that massive storms can dump vast amounts of rainfall in just a few days. Even if upstream forests were intact, almost nothing could prevent downstream lowland areas from flooding.

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Figure 1 | Jiujiang, China, 12 August 1998. Local dyke defences in the Jiujiang region were overcome during a series of floods caused by relentless rain in the upper catchment of the Yangtze river.

The apparent inability of forests to buffer against extreme floods is one of the main arguments of the FAO–CIFOR team[2], who assert that expensive efforts to reforest steep catchments in densely populated, monsoonal countries such as Nepal, India and Bangladesh have been largely ineffective. Rather, they argue, investments would be better aimed at other measures, such as discouraging human settlement in flood plains, which can be devastated by flooding during monsoons. Bradshaw *et al.* side-step the issue of extreme flood events. But if nations are to be convinced that forests are valuable for reducing flooding, it will be necessary to show that they are of at least some benefit during the most catastrophic floods. In addition, the broad-brush approach of Bradshaw *et al.* cannot encompass all situations. Because local conditions vary greatly, forests will surely be better at reducing floods in some areas than others.

Nonetheless, the study's ambitious geographical scope and statistical rigour make it persuasive. The findings add to other evidence that large expanses of native forest can have major benefits not only for reducing floods, but also for limiting wild fires, conserving biodiversity, and slowing regional and global climate change[4–6]. Tropical forests, in particular, are crucial for combating global warming, because of their high capacity to store carbon and their ability to promote sunlight-reflecting clouds via large-scale evapotranspiration[7]. Such features are key reasons why preserving and restoring tropical forests could be a better strategy for mitigating the effects of carbon dioxide than dramatically expanding global biofuel production would be[8].

Flood reduction is one area of environmental science in which the latest research is quickly invoked to justify land-management strategies, with all the pungent realities and controversies this implies. In a world facing potentially serious shifts in rainfall, water run-off[9] and storm regimes[10] from climate change, and where burgeoning populations are increasingly forced to live in flood-prone areas, the stakes could not be higher. ■

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