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We must get a grip on forest science — before it's too late

Trees are one of our biggest carbon hopes. Supporting the scientists who study them should be a high priority.

Humanity's understanding of how forests are responding to climate change is disconcertingly fragile. Researchers don't fully understand how climate change interacts with a multitude of forest processes. Complex, unsolved questions include how climate warming affects forest health; how it affects the performance of forests as a carbon sink; and whether it alters the ecosystem services that forests provide. Forests are our life-support system, and we should be more serious about taking their pulse.

Six papers in this week's *Nature* provide important insights into those questions. They also underline some of the challenges to fully understanding forests' potential in the fight against climate change. These challenges are not only in the science itself, but also relate to how forest scientists collaborate, how they are funded (especially where data collection is concerned) and how they are trained.

Many disciplines are involved in forest science and contribute to dynamic global vegetation models (DGVMs). These simulate how carbon and water cycles change with climate and, in turn, inform broader Earth-system and climate models of the type that feed into policymaking. Different DGVMs make different predictions about how long forests will continue to absorb anthropogenic carbon dioxide for. One reason for these differences is that models are sensitive to assumptions made about the processes in forests. There are many influences — including temperature, moisture, fire and nutrients — that are generally studied in isolation. Yet they interact with each other.

For example, not all DGVMs account for the dampening effect that a lack of soil phosphorus can have on carbon fertilization — the phenomenon by which plants absorb more CO_2 as its concentration in the atmosphere increases. Parts of Amazonia are poor in phosphorus, and research has shown that introducing phosphorus limitation into DGVMs can cut the carbon-fertilization effect[1]. Hellen Fernanda Viana Cunha at the National Institute for Amazonian Research in Manaus, Brazil, and her colleagues report[2] a powerful experimental demonstration of how the soil's poor phosphorus content limits carbon absorption in an old-growth Amazonian forest (see page 558).

Models simulating the northward spread of boreal forest as temperatures rise are also missing key drivers[3], according to Roman Dial at Alaska Pacific University in Anchorage and his colleagues. They report that a white-spruce population has migrated surprisingly far north into the Arctic tundra (see page 546). To explain this, it is necessary to take into account winter winds (which facilitate long-distance dispersal) along with the availability of deep snow and soil nutrients (which promote plant growth).

Models are often based on a small number of 'functional tree types' — for example, 'evergreen broadleaf' or 'evergreen needle leaf'. These are chosen as a proxy for the behaviour of the planet's more than 60,000 known tree species. But the biology of individual species matters when it comes to a tree's response to climate change.

David Bauman at the Environmental Change Institute at the University of Oxford, UK, and his co-workers reported in May that tree mortality on 24 moist tropical plots in northern Australia has doubled in the past 35 years (and life expectancy has halved)[4], apparently owing to the increasing dryness of the air (see page 528). But that was an average of the 81 dominant tree species: mortality rates varied substantially between species, a variation that seemed to be related to the density of their wood. Peter Reich at the Institute for Global Change Biology at the University of Michigan in Ann Arbor and his colleagues now report that modest alterations in temperature and rainfall led to varying rates of growth and survival[5] for different species in southern boreal-forest trees (see page 540).

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Failure to examine multiple factors at once means that scientists are making findings that challenge the assumptions in models. Spring is coming earlier for temperate forests and most models assume that, by prolonging the growing season, this increases woody-stem biomass. However, a study[6] carried out in temperate deciduous forests by Kristina Anderson-Teixeira at the Smithsonian Conservation Biology Institute in Front Royal, Virginia, and her colleagues found no sign of this happening (see page 552).

To obtain comprehensive data for the models, continuous, long-term observations need to be made, and that depends on the availability of long-term funding. Achieving such continuity is a problem for both remote-sensing and ground-based operations. The former can cost hundreds of millions of dollars, but the value of its long-term data sets is immense, as is demonstrated[7] by a team led by Giovanni Forzieri at the University of Florence in Italy. The authors used 20 years of satellite data to show that nearly one-quarter of the world's intact forests have already reached their critical threshold for abrupt decline (see page 534). But even field-based data collection, which costs a pittance by comparison, struggles to achieve financial security.

Forest science relies on the long-term data that scientists wring from forests over decades. Our chances of overcoming climate change are small, but they will diminish further if we forget the basics of monitoring our home planet.

1. Goll, D. S. *et al. Biogeosciences* **9**, 3547–3569 (2012).
2. Cunha, H. F. V. *et al. Nature* **608**, 558–562 (2022).
3. Dial, R. J., Maher, C. T., Hewitt, R. E. & Sullivan, P. F. *Nature* **608**, 546–551 (2022).
4. Bauman, D. *et al. Nature* **608**, 528–533 (2022).
5. Reich, P. B. *et al. Nature* **608**, 540–545 (2022).
6. Dow, C. *et al. Nature* **608**, 552–557 (2022).
7. Forzieri, G., Dakos, V., McDowell, N. G., Ramdane, A. & Cescatti, A. *Nature* **608**, 534–539 (2022).