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PERSPECTIVES

TROPICAL FORESTS

Tree diversity reduced to the bare essentials

Tropical forest dynamics can be explained by merely two functional trait axes

By Harald Bugmann

orests are a key component of the global climate system, particularly regarding the fluxes of carbon and water (1). Tropical forests are hotspots in this context, and thus their future fate could have strong implications for livelihoods and feedbacks to the climate. These forests are also key targets for biodiversity conservation (2). Their species richness applies to multiple organism groups, including trees, often featuring several hundred tree species per hectare compared to perhaps a dozen or just a few for temperate and boreal forests, respectively. This high tree species diversity hinders attempts to project future forest properties in the tropics. On page 165 of this issue, Rüger *et al.* (*3*) present an innovative approach for handling this vast biodiversity by simply considering two trait axes and five tree functional types. Reducing species diversity with these parameters may allow reliable projections of future tropic forest responses to climate change.

Ongoing and expected anthropogenic changes of the climate, such as heat and drought, will trigger strong, albeit considerably lagged, responses of forests (4). Assessing these responses is important from both a global climate and a local livelihood perspective, as most human societies depend in multiple ways on ecosystem services provided by forests (5). They include goods (such as timber and fuel), ecological functions (such as carbon storage and providing habitat for wildlife), and social benefits (such as recreation). However, such assessments cannot be done for forest vegetation as an entity, because the tree species making up a forest will react individually (6). Hence, forests will not change as monolithic units, but climate change will induce nonlinear trajectories that begin with current complex forest stand (i.e., tree community) structures to unknown, sometimes new future stand structures that may feature a very different species composition (7).

Projecting these future trajectories of forest structure and function is thus an important task that is greatly complicated by the vast number of tree species in tropical forests. The concept of plant functional types (PFTs) is typically used to collapse the large set of species to a few manageable units. Yet, defining PFTs is typically done in a pragmatic manner, lacking a systematic approach (8). Rüger *et al.* used trait data for 282 tree species of the tropical moist forest at Barro Colorado Island (Panama) to demonstrate that forest dynamics can be

PICTURES

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captured with a strongly reduced set of rigorously defined PFTs. The classical view of the traits that underlie forest successionand thus changes in species compositionrelates to the trade-off between growth and survival (i.e., at the extremes, the organisms either grow fast and die young, or they grow slowly and reach high longevity) (9). Rüger et al. complement this one-dimensional view with a second axis representing the stature-recruitment trade-off, which allows them to explain the existence (and often dominance) of long-lived pioneers that grow tall but do not invest much into recruitment, whereas at the other end of the gradient there are short-stature pioneers that invest heavily into recruitment and do not grow old.

In a carefully designed simulation experiment with an individual-based model of forest dynamics, Rüger *et al.* demonstrate that five functional groups of trees based on these two trade-off axes are sufficient to capture forest dynamics as well as when the entire set of 282 species is used. Their demonstration challenges earlier research on tropical forest tree diversity that has relied on the assumption that the fast-slow continuum alone governs most of tropical forest dynamics.

The finding of Rüger et al. is notable for several reasons. The approach allows for the prediction of key functional aspects of forests (including biomass and composition) on the basis of a small set of attributes of functional diversity, which is in stark contrast to the large taxonomic diversity. This does not mean that most tree species in tropical forests would be redundant and thus not important, because they have multiple other roles beyond carbon and water cycling, of course. Yet, the rigorous definition and testing of PFTs provide the basis for representing tropical forest dynamics much more accurately in dynamic global vegetation models (10) that are often integrated in Earth system models (11).

Also, previous approaches to using PFTs in climate impact research were often marred by the problem that PFT-based approaches worked well for the current climate but not under scenarios of climate change, thus greatly limiting the applied value of these concepts (*12*). It is quite pleasing to see that with the approach by Rüger *et al.*, this problem appears to be solved.

Ecology is getting closer to a theorydriven understanding of long-term forest dynamics ("succession"), an issue that has kept ecologists busy for more than a century (13). It is certainly true that the results of Rüger *et al.* for Barro Colorado Island need evaluation and corroboration in other tropical forests, but they are sound enough to serve at least as a general hypothesis for forests on other continents, and most likely beyond the tropical zone.

Rüger *et al.* also show that there is huge potential in combining the ever-larger data sets on species and ecological processes that are becoming available increasingly online (*14*), with rigorous statistical analyses and dynamic forest models. This could allow for robust projections of ecosystem dynamics at temporal and spatial scales that are accessible neither to experimentation nor direct observation.

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IMMUNOLOGY

The "iron will" of the gut

A gut-derived hormone controls iron concentrations, microbiota composition, and mucosal healing

By Maria Rescigno

he importance of trace elements in the mammalian diet, such as minerals, cannot be underestimated. For example, deficiency of iron results in anemia, accompanied by tiredness and fatigue due to the inability to carry oxygen to tissues. Conversely, iron excess is also dangerous, leading to liver disease, heart problems, and diabetes related to iron-mediated oxidative stress. Hence, iron metabolism is tightly controlled at both cellular and systemic levels (1). On page 186 of this issue, Bessman et al. (2) demonstrate an additional level of iron metabolism control that occurs in the gut and is mediated by the interplay between dendritic cells (antigen-presenting cells linking innate with adaptive immunity) and the microbiota through the hormone hepcidin in mice. This cross-talk is essential to allow recovery from intestinal inflammation.

Mammalian cells and most of the bacteria in the gut microbiota rely on iron for many cellular processes (3). Hence, they compete with each other for iron procurement. Under homeostatic conditions and with adequate intake of dietary iron, this is not harmful because iron is not generally excreted from the body, and only small amounts that are lost through bleeding, sweating, or urinary excretion have to be replaced through dietary sources (1). However, during intestinal inflammation and associated bleeding, the massive amount of iron that is lost in the intestinal lumen can have two major consequences: It can foster the growth of iron-dependent bacteria such as potentially pathogenic enterobacteria (4), and it deprives the host of this essential nutrient, which has to be reabsorbed from the intestinal lumen.

Iron metabolism is controlled within the cell by iron regulatory proteins that

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