Max Planck Institute
for Biogeochemistry

Max Planck Fellowship Group

Functional Biogeography

The Funtional Diversity of Plants





We study the role of biodiversity in the Earth system. In this context our Fellowship Group contributes to quantify and understand global plant trait diversity. We investigate the relationships between plant traits, ecosystem function, and biogeochemical cycles — and how these are affected by and feed back to ongoing global environmental changes.

Species Loss

During the last few centuries humans have increasingly modified the environment worldwide, with large consequences for biodiversity, ecosystem function, and global climate. Global extinction rates of plants and animals are 100 times higher than in the past. Humans contribute to these losses by intensifying land-use and gradually changing the global climate system. Human activity also promotes the spread of alien species across the globe. How are ecosystems influenced by the loss or addition of plant species? How will distinct plant species and vegetation as a whole respond to climate change? And how will this impact the climate system via changes in ecosystem fluxes of carbon, water, and energy?

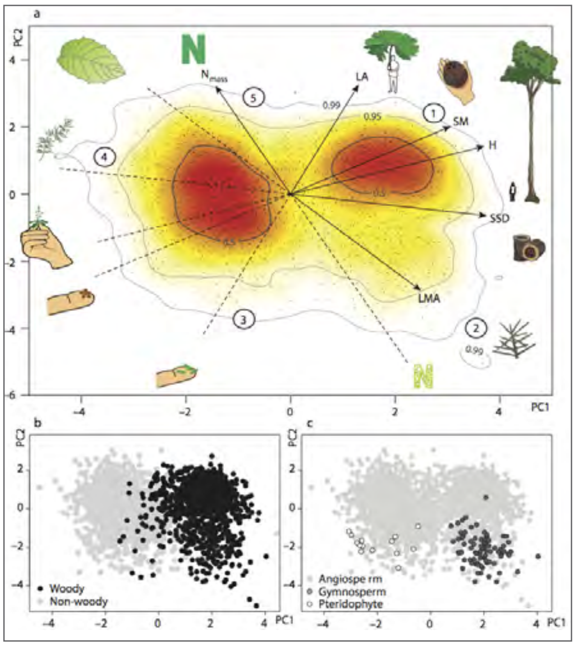
To address these questions, we have to translate biodiversity dynamics into ecosystem-level impacts. Here, plant traits – the morphological and physiological properties of plants, such as their size, lifespan, the speed at which they grow, and the size and number of their seeds – provide key information. These traits determine how plants as ‘primary producers’ of (chemical) energy and biomass drive ecosystem fluxes and how plants respond to environmental changes. Because plant traits are measurable on individual plants but also visible from Earth observation platforms, they are ideal tools to investigate environmental change from the local to the global scale.

Consolidating plant trait data

Plant traits have been meticulously collected in data bases for several decades. However, they were dispersed over numerous datasets, many of them inaccessible to the scientific community. In 2007 our group initiated the TRY project to consolidate plant trait data at a global scale and make them available to all researchers. By now, the TRY initiative (www.try-db.org) has become an international network of vegetation scientists from more than 200 institutions, providing 6.9 million trait records from 329 plant trait data sets for around 150,000 of the world’s 400,000 plant species. The TRY database is hosted at the MPI for Biogeochemistry and covers more than 1,800 different plant traits. As of April 2017, TRY has served 3,100 data requests contributing to more than 120 scientific publications.

The global spectrum of plant form and function

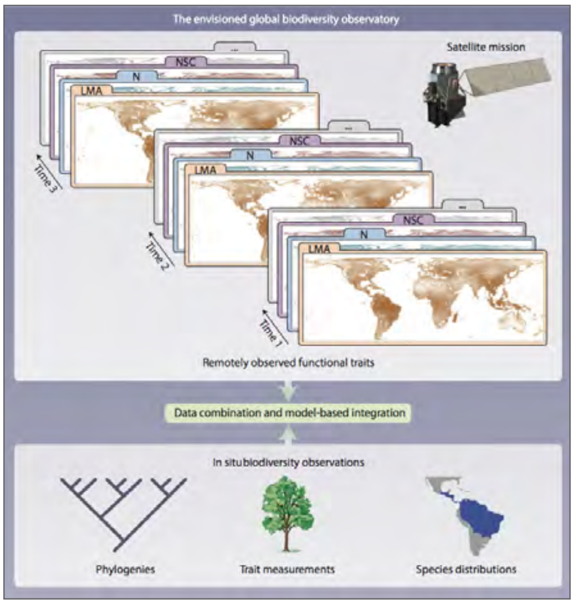
Earth is home to a remarkable diversity of plant forms and life histories, yet comparatively few trait combinations seem to be evolutionary successful in the plants of today‘s terrestrial biosphere. For example, leaves, stems, or seeds of plants generally have only a few combinations of forms. But how tightly different traits are interconnected across plant organs remains unresolved. We addressed this question by using the TRY database to analyze worldwide variation in six major traits critical to growth, survival, and reproduction: plant height, seed mass, leaf area, leaf nitrogen concentration, stem specific density, and leaf mass per area. We found that most plants fall into two major groups. One group includes trees and other tall plants with woody stems, large seeds and leaves, and high-density stems that are expensive to produce, last a long time, resist damage and pathogens, and contain a lot of carbon. The other group includes herbaceous plants that are short, lack woody stems, have small seeds and leaves, and produce low-density stems that grow quickly, contain a lot of water, and don't contain as much carbon. Within each group, the next most important difference was between plants that have broad, flat leaves with high nitrogen concentration and plants with leaves that are not flat (such as pine needles or the feather-like leaves of some aquatic plants) and with relatively low nitrogen concentration. These results provide a backdrop for elucidating constraints on evolution, for functionally qualifying species and ecosystems, and for improving models that predict future vegetation based on variation in plant form and function.



The global spectrum of plant form and function. Top: Projection of global vascular plant species (dots) on the plane defined by the two major principal component axes. Solid arrows indicate direction and weighing of vectors representing the six traits considered: plant height (H), seed mass (SM), leaf area (LA), leaf nitrogen concentration (N_{mass}), stem specific density (SSD) and leaf mass per area (LMA). The color gradient indicates regions of many (red) and few (white) plant species. Bottom: The location of different plant functional types and taxonomic groups on the projection (Diaz et al. 2016, Nature).

Monitoring plant functional diversity

Many aspects of vegetation, such as biomass or leaf area index, are relatively well characterized at the global scale via satellite remote sensing. However, surprisingly little is known about global patterns of plant traits, because most of these cannot yet be monitored from satellites. Although the next generation of space-based imaging spectrometers is expected to be able to provide information on some traits at global scale, several traits will remain invisible from space. We use the TRY database to contribute to the design of a global biodiversity observatory, which will integrate remote sensing information of different vegetation characteristics - including plant traits - and in situ observations of plant traits with species distributions and phylogeny to monitor global change in plant functional diversity. These integrated data products will deepen our understanding of the pace and consequences of biodiversity change, and how to manage it. They will provide essential background and input information for models of biogeochemical cycles in the Earth system.



The envisioned global biodiversity observatory. Space-based imaging spectrometer sensors and other sensors (such as LiDAR) capture global spatial data on key functional attributes over time, including leaf mass per area (LMA), nitrogen concentration (N) and non-structural carbohydrates (NSC). An informatics infrastructure and appropriate modelling techniques connect this information with the TRY plant trait database and with evolutionary and spatial biodiversity information collected worldwide (Jetz et al. 2016, Nature Plants).

Portrait Christian Wirth

Max Planck Fellow Christian Wirth heads the group. He is a Professor at the University of Leipzig and Director of the German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig. His research focuses on biodiversity and ecosystem function with emphasis on trees and temperate and boreal forest ecosystems.

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Portrait Jens Kattge

Jens Kattge who leads the group, studied biology and chemistry with emphases in plant ecology and soil sciences at the University of Gießen, where he also received his PhD. In 2002 he joined the institute working as a postdoc on terrestrial biosphere modeling and data assimilation.

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