A new window into plants of the past

September 28 2022

Herbarium book from the Siebold Collection at Naturalis Biodiversity Center. Credit: Naturalis Biodiversity Center

Within the cabinets and drawers of the world's herbaria are nearly 400 million dried plant specimens. These collections have long served as a

vital record of what plant species exist on Earth and where they grow. But hidden within the desiccated leaves, stems, flowers and roots is far more information on how the plants interacted with their environment while they were alive. Knowing about these "functional traits"—aspects like leaf structure, chemical composition and water content—could help researchers understand how plant communities change over time, and ultimately how we can help ecosystems thrive in the future.

Until now the only way to learn about these traits from herbarium collections has required destroying bits of the precious specimens. But recently researchers from the University of Minnesota and Université de Montréal in Quebec, developed a fast, nondestructive way of estimating the functional traits of herbarium specimens.

The researchers used a technique called reflectance spectroscopy, which measures how much light a material reflects at different wavelengths to obtain leaves' spectroscopic "fingerprints," or spectra. On more than 600 plant samples from northern temperate and boreal forest biomes of North America, they measured the spectra of fresh, living leaves; leaves that had been pressed like herbarium specimens; and ground-up leaves. They also measured the leaves' chemical and structural traits using conventional means. They then used the data to develop models that use spectra to estimate functional traits and evaluated how well the models performed on new plant samples from the same biomes at Cedar Creek Ecosystem Science Reserve. Finally, they tested how well the spectra could be used to tell species apart.

Their findings:

- Fresh-leaf spectra yielded the best predictions for traits relating to leaf structure and water content, while ground-leaf spectra worked best for traits relating to leaf chemistry.
- Pressed-leaf spectra yielded very good predictions—usually in

between fresh-leaf and ground-leaf spectra. For example, they predicted more than 75% of the variation in leaf nitrogen content and more than 90% of the variation in leaf mass per area.
- Both pressed-leaf and ground-leaf spectra yielded nearly perfect predictions of species identity.

The research, published this month in *Methods in Ecology and Evolution,* offers ecologists a powerful new tool for using biological collections to understand how plant communities change over time, providing insights into how we might best keep ecosystems healthy in the future.

"This study opens the door to using the world's herbarium specimens to study the evolution of functional traits across the plant tree of life," said co-author and University of Minnesota professor Jeannine Cavender-Bares. "It's a very exciting advance for the integration of ecology and phylogenetics."

"Far from just being dead plants in musty drawers, herbaria are some of the most important tools we have to understand the stunning diversity of plant life," added co-author and former University of Minnesota graduate student Shan Kothari, now a postdoctoral researcher at Université de Montréal. "We hope this method can take its place among the many clever and innovative ways ecologists have repurposed herbarium collections to new ends."

More information: Shan Kothari et al, Reflectance spectroscopy allows rapid, accurate and non-destructive estimates of functional traits from pressed leaves, *Methods in Ecology and Evolution* (2022). DOI: 10.1111/2041-210X.13958 , besjournals.onlinelibrary.wile … 1111/2041-210X.13958

Provided by University of Minnesota