FRED database gathers root traits to advance understanding of below-ground plant ecology

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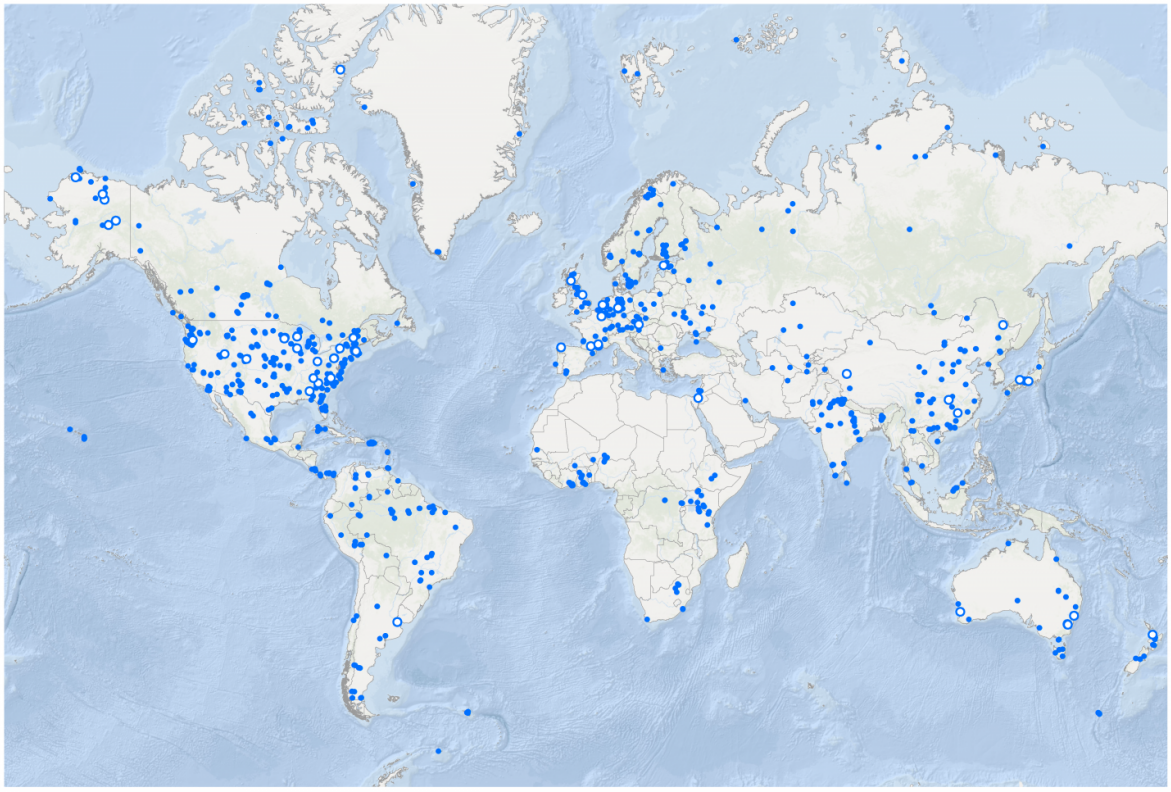

Map of locations associated with FRED observations. Credit: Oak Ridge National Laboratory/Dept. of Energy

Oak Ridge National Laboratory (ORNL) scientists have released a new global, centralized database of plant root traits, or identifying characteristics, that can advance our understanding of how the hidden

structure of plants belowground may interact with and relate to life aboveground.

The Fine-Root Ecology Database (FRED) brings together information from observations and experiments around the world into one accessible online resource, available publicly at no charge.

Version 1 of FRED contains more than 70,000 observations of some 300 different types of root traits as well as associated data such as soil temperature, moisture, and sunlight, from about 800 data sources. The Department of Energy's (DOE) Office of Science funds the work.

"We think a lot about what's happening beneath our feet, how roots are entangled with the surrounding soil environment, and we're trying to predict what might happen to plants and soils in the future as the environment changes," said principal investigator Colleen Iversen, senior scientist in ORNL's Environmental Sciences Division and Climate Change Science Institute (CCSI). "We're interested in root responses to the environment, and in the interactions between roots and the above-ground portion of a plant, but it's been difficult to find the data to inform our thinking or to represent roots in models. FRED helps to solve this problem."

FRED Version 1 is detailed in a newly published article in *New Phytologist*, "A global Fine-Root Ecology Database to address belowground challenges in plant ecology."

Luke McCormack, a plant ecologist at the University of Minnesota who helped design and build FRED, said, "One of our biggest goals is to develop an understanding of how a root trait would change when you go from a cold ecosystem to a hot, tropical one, or from a really fertile soil to a nutrient-poor soil."

Studying the entire matrix of plant ecology can lead to discoveries regarding general plant health, carbon storage, crop survival under drought conditions, and even how best to engineer plants for nutrient or water uptake, Iversen explained.

FRED works to bring that data together and to let researchers see where gaps need to be filled. Although ORNL leads the project, Iversen notes that FRED is the result of collaboration across the United States and internationally. The researchers hope that FRED's release will encourage plant scientists to submit even more data.

"We still have gaps in our understanding of processes happening in our own backyard," McCormack said. "We have measurements of white oaks in Tennessee, for instance, but we don't have the data to know how that particular species may respond in a different environment like Southern Georgia, Minnesota, or Maine."

More data = better predictions

Gathering and disseminating the data is essential to efforts to predict how plants may change under various conditions. Whereas a species likely will not disappear if it is stressed by a couple of seasonal droughts or a change in temperature, it will change and respond to those stresses, McCormack noted. "Without more data we can't make a good prediction as to what those changes might be—for instance, whether roots might change to be slower or faster in nutrient uptake," he said.

Collaboration within ORNL has been essential to FRED, with researchers using the expertise within the Data theme of the CCSI to help assemble the database, including user guidance documents and website presentation. Iversen is lead for the Integrated Ecosystem Sciences theme at CCSI.

The FRED team relied on post-Baccalaureate intern Shafer Powell, who works at the lab through a program sponsored by the Oak Ridge Institute for Science and Education (ORISE), for much of the data input task. Powell recently celebrated filling in the one-millionth data cell in FRED, Iversen said.

FRED was initially named the "Fantastic Root Ecology Database" by an enthusiastic Powell and another researcher helping with the project, Holly Vander Stel. The name was changed to reflect the project's emphasis on narrow-diameter, short-lived "fine" roots that help plants take up needed water and nutrients. But that enthusiasm for the database is contagious and fueled by the collaboration the researchers have appreciated with colleagues around the world.

FRED a 'critical step'

"While fine roots play an important role in ecosystem functions, fine-root traits are underrepresented in global trait databases," the *New Phytologist* article notes. "This has hindered efforts to analyze fine-root trait variation and link it with plant function and environmental conditions at a global scale.

"FRED represents a critical step towards quantifying variation in fine-root traits within the root branching hierarchy, as well as across species, biomes, and environmental gradients while also building a platform for future assessments of trade-offs among root, leaf, and wood traits, and their role in ecosystem functioning," the researchers added in the journal article.

Iversen and her fellow scientists have also submitted the FRED data to the existing TRY global plant trait databasehosted by the Max Planck Institute for Biogeochemistry in Germany, which catalogs mostly aboveground characteristics of plants. "If you can analyze root, wood,

and leaf traits together, you can potentially understand the entire plant or, in a perfect world, could even predict what a root will do based on a leaf or wood characteristic," Iversen said.

The scientists expect to release a second version of FRED in 2018, with additional measurements, traits, and some analysis tools.

More information: Colleen M. Iversen et al, A global Fine-Root Ecology Database to address below-ground challenges in plant ecology, *New Phytologist* (2017). DOI: 10.1111/nph.14486

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