Massive effort to document the genetics of European forests bears fruit

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Faced with deforestation, climate change, invasive pests, and new diseases, many trees are in trouble. Foresters and conservationists are scrambling to save them, but can't protect every stand of woods. And prioritizing which places—and even which individual trees—warrant preservation has been a challenge. For example, "You want a lot of genetic diversity in a conservation area. … The higher the diversity, the more the chances that the population will survive," says F. A. (Phil) Aravanopoulos, a forest geneticist at Aristotle University of Thessaloniki. But robust data on the genetic diversity of trees can be scarce.

Now, a 4-year, $7.7 million effort to document the genetic diversity of forests in Europe is helping fill that gap. In a project dubbed GenTree, researchers from 14 countries measured, cored, and took DNA samples from 12 important tree species across Europe. No other continent's forests have been documented so broadly and so comprehensively, says Nathalie Isabel, a forest geneticist and forester with Natural Resources Canada. "The sampling is amazing."

The results, reported at a forest genetics conference this week in Avignon, France, could help conservationists, tree breeders, forest managers, and researchers trying to understand how forests will cope with climate change. The data trove will "provide a solid base for a better understanding of the links between genetic diversity and increased adaptation and resilience of the European forests," says forest researcher Hernán Serrano-León, who worked at the recently disbanded European Forest Institute Planted Forests Facility.

More than 42% of the European Union's land area is covered by forests and other wooded land. These areas provide wood, food, energy, and ecosystem services such as clean water and flood control, and are enjoyed by hunters, hikers, and birdwatchers. In a bid to improve forest management, in 2016 the European Union's Horizons 2020 program funded GenTree to document tree species of both economic and ecological importance. It is the first project "to consider genetic diversity not only from the breeding side, but also from the

conservation side," says project leader Bruno Fady, a forest geneticist at the French National Institute for Agricultural Research.

A core that GenTree researchers extracted from a black poplar in the Drôme region of France in 2017 MARC VILLAR/INRA, FRANCE

To assemble the data set, research teams looked at about 20 trees from each of the dozen tree species, which included maritime pine, Norway spruce, sessile oak, stone pine, and European beech. They took samples from 10 to 25 populations of each species, working to include individuals from across the tree's range, and that survived in places with extreme environmental conditions, such as drought or late frosts. The researchers then sequenced active genes, as well as other DNA from across the genomes, to determine the range of genetic variation both within and between tree populations. The researchers also measured key traits such as annual growth, leaf surface area, seed germination rate, and resistance to disease, and analyzed the degree to which these traits were linked to specific gene variants.

Such data helped reveal how trees coped with their local environments; for example, identifying populations and individuals that were better adapted to drought or frost than others. A key revelation was just how much genetic variation exists in some populations. "There's a huge within-species diversity, which is rarely acknowledged in forestry and rarely used in management," Fady says. A single population of beech, for example, might contain high- and low-elevation trees that are as different genetically as trees living in forests that are hundreds of kilometers apart.

Such genetic insights can be very helpful in planning conservation programs, Isabel says. "I wish we could have a North American project like that," she says.

The data might also come in handy for researchers thinking about how to help forests survive climate change. One possible strategy is to transplant trees from warmer climates into cooler areas undergoing warming, a process called assisted migration. In some cases, the genetic data could be key in deciding which seeds to plant in new areas, or how to breed hardier trees. But in others, the genetic data might indicate "don't bother with assisted migration," Fady explains. "You have enough seeds [with enough variation], and natural selection will play the role of the breeder," so the trees will be able to adapt to warming on their own.

The work also drives home the need for tree breeders to focus more on genetics, says David Neale, a forest geneticist at the University of California, Davis. “They need to understand the genetic composition of the individual [tree],” he says. “It’s not enough to say [the tree] came from this place in the world. … That’s the level the foresters are working with right now.”

Other results at the meeting suggest better genetic data can benefit commercial foresters. In one modeling study, researchers found that pine forests grown from relatively expensive “improved” seed developed by breeders are likely to be worth the added cost, because the bred trees mature quickly and produce more wood. “It’s a negligible extra seedling cost,” says Serrano-Leon, who predicts that “tree breeding programs all over Europe will benefit from the [GenTree] data. … It is an extraordinary resource.”

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