Past and Future Pests

Digging into genetics and population dynamics to fight tomorrow's plant foes

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The history of North American forests is dynamic. Alternating glacial and interglacial periods have reshaped forest communities over the past million years, causing species to migrate south during cooling periods and north during warming periods. Evidence of these migrations can be found in fossil pollen deposits, which provide a snapshot of the plant communities present in an area at a particular time. In Massachusetts, for instance, glaciers covered much of the land area twenty thousand years ago. As the climate warmed and the glaciers receded, boreal species arrived from the south and were eventually replaced by today's deciduous forest.

Many of the North American tree species that comprise these forests span large geographic areas. Red maple (Acer rubrum) is common in Massachusetts, Minnesota, Florida, and even Texas. Other species with widespread distributions include white oak (Quercus alba), tulip tree (Liriodendron tulipifera), pignut hickory (Carya glabra), basswood (Tilia americana), black cherry (Prunus serotina), and flowering dogwood (Cornus florida). Within these species, there is often significant variation in traits like flowering time, leaf shape, or disease resistance. And often, this variation within species is underpinned by genetic variation.

As a Katharine H. Putnam Research Fellow at the Arboretum, I am studying genetic variation in blue ash (Fraxinus quadrangulata) and the North American Castanea, chestnuts and chinquapins. These are widespread, ecologically important tree species under attack from pests or pathogens brought to North America by human activities. Once a common tree in eastern North America, the American chestnut (Castanea dentata) was famously decimated by the chestnut blight (Cryphonectria parasitica)—first identified in 1904, the blight spread rapidly and by 1950 had killed nearly every adult tree across its range. The collapse of the beloved American chestnut is infamous as an ecological disaster that permanently transformed North American forests.

Meanwhile, the story of North American ash trees is still unfolding. In 2002, a metallic green beetle from eastern Asia called the emerald ash borer (Agrilus planipennis) was found in Michigan, and has since been observed throughout the eastern United States, including eastern Massachusetts (it was first detected at the Arboretum in 2014). Its larvae feed on the phloem and outer cambium of ashes, eventually girdling and killing them. Given the advance of these lethal invaders, it is increasingly urgent to learn everything we can about Fraxinus and Castanea.

My research at the Arboretum focuses on two types of genetic variation: genetic structure and genetic diversity. Genetic structure describes how populations are similar or different from one another and is often correlated with
Looking for Trouble: Preparing for Tomorrow's Pests

According to a 2016 study, nearly sixty non-native forest pests are imported into the Commonwealth each year. While most of these pests won’t necessarily become a major problem for forests and woody plants here, we never know what might become the next emerald ash borer or chestnut blight—or worse.

Fortunately, the Arnold Arboretum has a long history of finding innovative ways of dealing with a wide range of exotic and local pests and diseases. Rather than wait for a new pest to show up and scramble to find a solution, the staff at the Arboretum devote significant time and effort investigating which emerging pests and diseases may be headed for the Arboretum in the future.

As part of my work as the Living Collection Fellow, I am tasked with getting the Arboretum ready for these threats before they are able to cause considerable harm to landscapes like ours. This past year, I’ve kept an eye on a few potential pests. The first of these is the spotted lanternfly (Lycorma delicatula), a Chinese leaf hopper first observed in Pennsylvania in 2014, which appears to be spreading east. We’re also watching for thousand cankers disease, which results from the combined activity of the walnut twig beetle (Pityophthorus juglandis) and a canker producing fungus, Geosmithia morbida, and jumped from the Southwest to the East Coast in 2010. Finally, southern pine beetle (Dendroctonus frontalis), found in Cape Cod in 2015, is a beetle from the Southeast that attacks almost every species of pine (Pinus).

To prepare for the worst, we have been developing partnerships with other public gardens and organizations like the Massachusetts Department of Conservation and Recreation (DCR), the American Public Garden Association’s Plant Sentinel Network, and the US Forest Service’s Cryptic Borer Program, as well as researchers and universities around the country. A great example is a collaboration with our colleagues at DCR to deploy specialized traps that will show us exactly when southern pine beetle arrives in our landscape. We’ve also worked with entomologists at Colorado State University to see which species of walnut (Juglans) are most susceptible to thousand cankers disease, and our colleagues at Longwood Gardens and the Morris Arboretum have helped us prepare the most efficient integrated pest management strategies for confronting spotted lanternfly.

The research, resources, and recommendations shared through these alliances are key to helping us protect our immensely valuable living collections at the Arnold Arboretum. In turn, sharing what we learn can help build public awareness and help others in our region prepare for these and other environmental challenges.

At the upcoming Arnold Arboretum’s Annual Garden Party on August 18, we’ll celebrate the many strategies we’ve been implementing to protect and preserve these collections. Join us to learn more about the work we are doing to protect our living collections.

—Jared Rubinstein, Living Collections Fellow
infrastructure with an eye toward prioritizing future needs for repairs and upgrades. Two projects came immediately to the foreground: new traffic infrastructure to improve safety and pedestrian access at intersections on Bussey Street (South Street and Walter Street), and major repairs to historic stone walls along the western edge of Bussey Brook Meadow.

In the first project—driven largely by studies illustrating the severity of the circulation problems at these intersections—the City installed new traffic lights, improved sidewalks and crosswalks, and made safe pedestrian access into the Arboretum a priority. The changes also allowed staff to reconsider the quality of the landscape around the Walter Street Gate, and the appearance of our perimeter along our border with Roslindale. The crumbling puddingstone walls along South Street bordering the urban meadow had long been an aspirational focus for renovation, and on this point the Arboretum already had a number of friends in its corner. One was Paul Sutton, program manager of the Urban Wilds Initiative of the Boston Parks and Recreation Department, who for years had utilized part of his modest annual repair budget to help fund restoration of sections of the South Street wall. Though his contributions were timely and meaningful, more help was needed to complete a full renovation of all Arboretum walls.

To move the project ahead, the City of Boston, as landowner with responsibility for the integrity of the Arboretum perimeter, would need to be fully engaged and persuaded. In addition to Paul Sutton, the Arboretum turned for help to Boston Parks Commissioner Christopher Cook (now Chief of Environment, Energy, and Open Space) and City Councilor Matthew O’Malley. The Arboretum had worked closely with both on a number of issues, and had received their encouragement regarding the aims of an infrastructure-needs assessment the Arboretum submitted to the City. Councilor O’Malley led efforts to recognize some of these needs in the City’s operational budget, and Commissioner Cook assisted the Arboretum in calling attention to some of the Arboretum’s critical needs with his colleagues at City Hall. Last year, Boston received a windfall settlement as part of a development deal in the Back Bay, and—with the extraordinary advocacy of Manager Sutton, Commissioner Cook, and Councilor O’Malley—a sum of $100,000 was allocated to fund a major survey and design plan for restoring all of the Arboretum’s puddingstone walls. Substantial funding from Boston—up to $1 million—has been reserved to complete the renovation.

Although the Arboretum is both a unit of Harvard University and a part of the Boston park system, nearly everything the Arboretum does to expand and preserve its collections, to advance scientific study, and to educate and engage the public is funded by past and present philanthropy. There will always be a need for the Arboretum to rely on the generosity of its friends to achieve its vision, and for 137 years the City of Boston has played a defining role in shaping how the public connects with this landscape. With at least 863 years left to go on the first 1,000 years of our lease, there is much to look forward to as this most unique of relationships continues to blossom.

The research projects began in the Arboretum’s living collections. I visited the Arboretum’s chestnut and ash trees last spring, checking the winter buds and waiting for leaves to emerge. Most of the chestnuts and ashes at the Arboretum have been collected from wild populations. Some were collected close by, like an American chestnut from Petersham, Massachusetts (24-80*A); others originated on the distant edges of the species’ ranges, like a chinquapin (Castanea pumila) collected in Arkansas (21486*A). I sampled young leaves (often the best for DNA extraction) from all of these trees in early spring. To draw a broader picture for each species, I made several field excursions to collect leaves from populations throughout each species’ range, visiting sites in Arkansas, Mississippi, Florida, South Carolina, Georgia, North Carolina, and Virginia. After extracting DNA from all of the leaves I amassed, I should obtain the first genetic sequences within the next few months.

Essentially, I’m looking for insights into both the past and future of these species. Genetic variation in a species carries clues of past events that can be disentangled to reconstruct aspects of its history. In this way, genes can show us how natural forces have caused adaptation, changes in population size, migration, or even hybridization. This project will also provide important information for future conservation efforts by identifying populations that are particularly distinctive or genetically diverse. Often, conservation strategies that protect the broadest range of genetic variation within a species will give that species the best chance to adapt to current threats and future climatic changes. This kind of genetic information can also be useful for horticultural breeding programs that aim to produce individuals adapted to a specific environment or with particular characteristics, like disease resistance.