Written in the Rings

Arboretum study aims to improve predictions of climate change impacts to trees

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Our world is getting warmer. In New England, temperatures have already increased by 1–2°F degrees in the past 100 years and are expected to rise by an additional 3–5 degrees by the end of the twenty-first century. This shift could mean that the summer heat index in our region would closely resemble current conditions in Virginia or North Carolina. Not surprisingly, such dramatic shifts in climate will cause large-scale changes to New England's flora and forests.

Exactly how trees will be affected by climate change remains uncertain, however. Studies to date suggest that temperate and boreal tree responses will vary significantly across species—some will grow faster, others slower, and some will remain unchanged. This great ambiguity in predictions is largely because previous research findings have varied across species, populations, and regions. Predictions are further complicated because previous studies almost always examine trees growing in their native geographic ranges. However, climate change will alter climates beyond historic variation, with much of the world experiencing novel climates by 2100. In addition, most studies focus on a single species, which hinders the ability to make generalizations and forecast responses across multiple species.

Jon Hetman

Ailene Ettinger has collected core samples from a broad range of species in the Arnold Arboretum collections as part of her research into how trees respond to variation in climate. Her research is funded by the Katharine H. Putnam Fellowships in Plant Science with additional support from the DaRin Butz Foundation.

The Arnold Arboretum provides unique opportunities to address the limitations that characterize previous studies of plants and climate. Its renowned collection of woody species growing together enables climate responses to be studied across diverse species. Furthermore, many species in the Arboretum's collections are nonnative and have been exposed to a "novel" climate for their entire lifespans—often growing in an environment that may resemble future conditions in their native distributions. In my research as a Katharine H. Putnam Research Fellow at the Arboretum, I study the extent to which variation in responses to climate change may be controlled by particular traits, such as wood density, leaf characteristics, and the timing of leaf-out and flowering (or phenology). For example, previous studies suggest that earlier spring phenology may be associated with greater temperature sensitivity, whereas greater wood density may be associated with reduced sensitivity. Functional trait analysis is a valuable approach for understanding past inconsistencies in climate change responses because comparisons can be made across species, ecosystems, and timescales.

In temperate climates like Boston, where trees produce annual rings due to seasonal variation in their growth, increment cores can be used to age trees and measure annual growth going back in time. Using a boring tool to remove a straw-sized wood sample from trees without harming them, I have collected increment cores from 470 individual trees across 65 species growing at the Arboretum to assess variation in climate sensitivity. First, I will analyze the cores and compare their annual growth to climate data—including temperature and precipitation—recorded over the past century to quantify the climate sensitivity (the degree to which growth is affected by climate) of each cored tree. Given the great variation observed in other studies, I also expect to find that tree growth will be positively correlated with temperature for some trees (suggesting that their growth will benefit from global warming), and negatively correlated for others.

Next, by comparing each tree's climate sensitivity to the traits I measured, I hope to be able to explain some of this variation. For example, the timing of a tree's first spring flush of leaves may be a good predictor of climate sensitivity. I expect that species that leaf out early in [*Continued on page 9*]

After collecting for the Arboretum, William Purdom teamed up with plantsman Reginald Farrer to continue explorations in the Tibetan border region during 1914–1916. Their collaboration was notable for their collections of many new alpine plants, such as *Viburnam farreri*, and *Buddleia farreri* (now *B. crispa*). At the conclusion of their expedition, Purdom remained in China and took a position as division chief in the recently formed Chinese Forest Service. As part of his work, he established tree nurseries to aid in reforestation of the Chinese countryside. Sadly, his life was cut short on November 7, 1921, when he succumbed to complications following a minor operation.

All: Arnold Arboretum Photographic Archives

Above, two of William Purdom's ethnographic photographs from his travels in China include a young peasant girl on the left, and a Kansu Drokwa tribesman on the right, both photographed in Gansu Province in summer 1911.

Purdom's legacy lives on in the plants he collected and shared with the West as well as the extraordinary photographs that document both his journeys and the characteristics of a bygone era in Chinese history. These collections have been carefully preserved in our archives, and digitized to aid the work of scholars and delight the imaginations of the public. Our William Purdom photographs may be viewed at http://via.harvard.edu.

The British Library collection of Purdom photographs may be viewed as part of the International Dunhuang Project, an educational collaboration which is making historical photographs, manuscripts, paintings, textiles and artifacts from Dunhuang and the Eastern Silk Road available on the Internet. They may be viewed at http://idp.bl.uk by entering "Purdom" in the search box.

VIBURNUMS ALL AROUND *(continued from page 4)*

A recent and potentially devastating scourge is viburnum leaf beetle, a non-native invasive that has been spreading in eastern North America. Both the adults and larvae of this small beetle feed on viburnum foliage and can completely defoliate plants, especially favored species such as arrowwood (*V. dentatum*) and cranberrybush (*V. opulus* and its varieties). And several viburnums themselves can be pests, notably Siebold (*V. sieboldii*) and linden viburnums (*V. dilatatum*), which have become invasive in native woodlands in some regions.

The Arboretum holds a robust collection of viburnums: 273 plants from 160 accessions, representing 78 different taxa. Many were collected in the wild, adding to their research and conservation value. In fact, having so many viburnum species growing on one site has made the Arboretum a destination for a number of scientists. Current research includes Yale graduate student Miranda Sinnott-Armstrong's study of the evolution of fruit color in viburnums and honeysuckles (*Lonicera* spp.) (see back page). Whether you visit the Arboretum for science or a Sunday stroll, be sure to see the viburnum collection this fall.

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the spring will be more sensitive to temperature than those that leaf out later, and that their annual growth will be positively correlated with temperature, since long, cold winters are likely to limit the growing season here in New England. If this is true, it suggests that these "early species" will show increased growth with climate change, at least initially.

My research aims to identify predictors for climate sensitivity that may be relevant worldwide, providing a leg up to future studies of mechanisms behind climate responses and improving forecasts of future biological impacts. Since tree growth is correlated with other aspects of performance—such as reproductive success and mortality—my results may identify climate change "winners" and "losers" at the Arboretum and elsewhere. Understanding how climate affects tree growth is an essential step in preparing for larger changes to come, since trees are a vital component of ecosystems and play a prominent role in the global carbon cycle. Knowing how they might respond will be particularly critical to shaping the adaptation and mitigation efforts that will be necessary in the near future.