Research into oaks helps us understand climate change

July 24 2012, By Gene Stowe

Research into the evolution of oak trees in North America will help us understand how the trees adapted to changes in climate.

Jeanne Romero-Severson, associate professor of biological sciences at the University of Notre Dame, and her collaborators, are tracking the evolution of the live oaks of eastern North America, seeking to understand how the trees adapted to climate change during glacial periods.

When the ice advanced, the oaks retreated. When the ice retreated the oaks advanced, spreading from tropical to temperate zones, up from Central America and Mexico into the Piedmont Carolinas. The researchers expect the study of live oak migrations and phylogeny will provide clues to the success of the oaks that range up into northern Ontario in Canada.

Oaks originated in southeast Asia before the continents split and migrated both east and west, but North America has far more species than other regions. Researchers have long suspected that repeated climate challenges might have led to this diversity. Previous studies have shown that the live oaks that live in Mexico cannot survive the Carolina winters. This shows that there are genetic differences between the southern live oaks and their northern descendants.

“In Mexico, live oaks do not experience repeated cycles of freezing and thawing,” Romero-Severson says. “Are the live oak species that now live further north different species because of this cold tolerance? What about the live oak species that span the tropical-temperate divide? It is logical to assume there is a genetic basis for the ability to survive in those cold temperatures. With four groups of researchers working together, we can tease out how it was that oaks were able to adapt to the climate as they moved north. What were the genetic changes they underwent?”

Romero-Severson focuses on genetics and genomics of the oaks. Andrew Hipp of the Morton Arboretum in Lisle, Ill., is studying their morphological differences; Paul Manos of Duke University is studying their systematics (family trees based on DNA markers); and Jeannine Cavender-Bares of the University of Minnesota is studying their ecophysiology, including the survival of seedlings in cold temperatures. A National Science Foundation grant supports the research.

The team hypothesizes that trees in contact with relatives who could just manage to survive in the cold were able to “capture” from these relatives a few genes favorable for survival in colder climates, without retaining extensive genetic changes that would alter their morphology. Different animal species rarely hybridize in nature and when they do, the offspring are often sterile, like mules. Different forest tree species often make fertile interspecific hybrids, but the parent species remain morphologically distinct.

“It’s a mystery to us how oak species can have rampant interspecies hybridization and yet maintain species distinction, but they do,” Romero-Severson says. “Favorable gene combinations from one live oak species can be captured by any other live oak species.” There might be an “interspecific hybrid screen,” a process that retains a relatively small number of good genes that equip the species for successful northward migration, while maintaining all the other genes that determine species identity.

Identification of the genetic changes in the relatively small number of live oak species in the southeastern United States and Mexico can provide clues for study of the more extensive deciduous red and white oaks, which reach from the Caribbean into California to the west and up into Canada from the east. Eastern North America alone has more than two dozen red oak species and close to two dozen white oak species. Some regions in the southeastern United States have the highest concentration of oak species in the world.

“Our hypothesis is that the same set of genes is involved in cold tolerance in all of these species,” Romero-Severson says. “We feel that we have defined the problem so carefully that what we learn from these live oaks will help us understand how evolution works, and how natural adaptation arises. Our goal is to understand the role of hybridization in the evolution of forest trees and how forest trees actually respond to rapid climate change.”

Romero-Severson, who came to Notre Dame in 2003, is also part of a team of researchers from seven universities with an NSF grant to develop genomics tools for finding the genetic basis for tolerance to the introduced insects and diseases that threaten the nation’s hardwood trees

Provided by University of Notre Dame