

GENETICS AND CONSERVATION OF HEMLOCK SPECIES THREATENED BY THE HEMLOCK WOOLLY ADELGID

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ABSTRACT

Camcore is a forestry research cooperative program housed in the Department of Forestry and Environmental Resources at North Carolina State University, specializing in the applied conservation and domestication of forest genetic resources utilizing an *ex situ* approach. We make genetically representative seed collections from populations of threatened and endangered tree species that cannot be reliably conserved in their natural environment and send those seeds to regions of the world with suitable climates where trees are grown in protected plantations. Once threats in the area of origin are mitigated, seeds or other propagules are collected from these conservation plantings and utilized to restore the species to its native environment. In our 29-year history, Camcore and its member organizations have utilized this approach to help conserve more than 40 tree species worldwide, working in the United States, Central and South American, South Africa, Kenya, Tanzania, Uganda, and Indonesia with numerous genera including *Pinus*, *Eucalyptus*, *Gmelina*, *Tectona*, and *Tsuga*.

The USDA Forest Service Forest Health Protection, in 2003, entered into a three-phase cooperative agreement with Camcore to preserve seeds of eastern (*Tsuga canadensis* Carr.) and Carolina (*T. caroliniana* Engelm.) hemlocks threatened by the hemlock woolly adelgid (*Adelges tsugae* Annand) in the eastern United States. The objectives of the agreement are to: 1) develop a framework plan for hemlock gene conservation; 2) describe patterns of hemlock genetic diversity across the geographic range of both species; 3) collect seeds from hemlock populations distributed across the geographic range of both species; 4) place hemlock seeds into long-term cold storage at Camcore facilities and those maintained by the National Germplasm Repository; and 5) establish national and international conservation seed orchards for both hemlock

species. The first phase of this effort began in 2003 with seed collections from populations of Carolina hemlock across its Southern Appalachian range. The second phase began in 2005 and is focused on seed collections from eastern hemlock populations distributed throughout the southeastern U.S. portion of the species' geographic range. The third and final phase will follow in late 2009 with a 4-year effort to make seed collections from portions of the eastern hemlock range in the northeastern and Midwestern regions of the United States. The overall goal of this cooperative program between Camcore and the U.S. Forest Service is to secure genetically diverse seed reserves and maintain viable populations of eastern and Carolina hemlock in perpetuity so that genetic material will be available for restoration efforts in areas where the hemlock woolly adelgid eliminates hemlock from the forest. The following is a brief synopsis of project accomplishments to date.

Hemlock Genetic Diversity: Genetic diversity studies with amplified fragment length polymorphisms (AFLPs) indicated that Carolina hemlock has moderate levels of diversity compared with other conifer species, and that there is a general trend of decreasing diversity moving from south to north across the species geographic range (Jetton et al. 2008). Eastern hemlock was found to have overall low diversity in the southeastern U.S. portion of its range in a study using isozyme markers, with diversity decreasing from east to west (Potter et al. 2008). Currently, Camcore and the U.S. Forest Service are cooperating on a microsatellite (SSR) marker study to describe patterns of genetic diversity within and among populations of eastern hemlock throughout its entire geographic range in the United States and final results are expected in late 2009.

Hemlock Seed Collection: The genetic studies serve as important guidelines for the conservation effort, allowing targeted seed collections in portions of the geographic range that will result in capture of maximum levels of diversity for both species. Using this data, steady progress has been made from 2003-2009 with seed collections from surviving hemlock stands in the southeastern U.S. Seeds have been acquired from a total of 97 mother trees in 13 populations of Carolina hemlock in Georgia, Tennessee, Virginia, and North and South Carolina. Eastern hemlock collections represent 195 mother trees from 26 populations in Georgia, Kentucky, Tennessee, Virginia and North and South Carolina. In 2010, we hope to reach our seed conservation goals for eastern and Carolina hemlock in the southeast and plan to initiate eastern hemlock collections in the northeast and Midwest.

Our seed collections to date are in support of the *ex situ* conservation effort, and the Camcore seed bank in Raleigh, NC, serves as the primary repository. Utilizing recommendations from the Woody Plant Seed Manual (Bonner and Karrfelt 2008) and results of ongoing studies at Camcore, we are currently developing optimal seed storage protocols for both species. Small amounts of Carolina hemlock seed have also been submitted to the U.S. Forest Service National Tree Seed Lab for accession in the National Germplasm Repository, and we will do the same with eastern hemlock in the future.

Hemlock Conservation Seed Orchards: Camcore members Arauco-Bioforest and Forestal Mininco in Chile and Rigesa-MeadWestvaco and Klabin SA in Brazil are working with Camcore and the U.S. Forest Service to establish hemlock *ex situ* conservation plantings in South America. In the United States, the University of Arkansas and the U.S. Forest Service are working together to establish similar plantings in the Ozark Mountains. Currently, one operational Carolina hemlock conservation bank, containing approximately 1,400 seedlings representing 64 mother trees and nine populations has been planted by Arauco-Bioforest in Chile. Additional conservation plantings are planned for 2010 establishment utilizing eastern and Carolina hemlock seedlings under cultivation at forest nurseries in Brazil and Carolina hemlock seedlings being grown at the University of Arkansas. In 2009, all cooperators in Chile, Brazil, and the U.S. will receive additional seeds of both species for future conservation bank expansion.

In addition to these plantings outside of the hemlock range, Camcore is also working to establish small hemlock seed orchards within the species' native ranges. In 2007, the first of these, containing 400 seedlings, was established for Carolina hemlock in Ashe County, NC and we plan to expand this to include eastern hemlock in the near future. Although such plantings will eventually require insecticide protection from the hemlock woolly adelgid, they are important tools for research on hemlock establishment requirements in seed orchard settings and breeding strategies that will be needed for restoration efforts.

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