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ORIGINAL PAPER

Role of genomics in the potential restoration of the American chestnut

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Abstract The development of genomic tools will enhance traditional tree breeding technologies leading to more certain and timely recovery of the American chestnut, a keystone heritage tree of the eastern United States. Major efforts are being made in gene discovery, genetic marker development, construction of a BAC-based physical map, and DNA transformation technology. A strategy of map-based cloning, association genetics, and genetic engineering, combined with traditional and marker-assisted backcross breeding is proposed for the long-term genetic restoration of this iconic tree species.

Keywords Genomics · Chestnut · Restoration

Introduction and historical context

The American chestnut (*Castanea dentata* [Marsh.] Borkh.) was once one of the most important tree species in America (U.S. Census Bureau 1908; Davis 2006) but virtually ceased to exist as an economically and ecologically relevant forest tree by the mid 1900s, having fallen victim to the chestnut blight, (*Cryphonectria parasitica* [Murr.] Barr), an introduced fungal pathogen. The blight killed some four billion trees, one of the greatest ecological disasters in American history. Decades of tree breeding efforts and research on chestnut and the fungal pathogen engender hope that the tree species will be restored. Breeding is now at the third generation of backcrossing, with genotypes expected to be 15 out of 16 American germplasm. This paper briefly reviews the status of the American chestnut and discusses how genomic science may complement ongoing efforts and accelerate the reintroduction of the species in American forests. Chestnut may become a model for application of genomic technology to other threatened tree species, particularly as increased stresses come to our forests through climate change and introduced pests/diseases.

The role of chestnut in America's forest ecosystems has been shaped by glaciation and settlement. Chestnut probably survived the Wisconsin glaciation in small Southern Appalachian refugia and migrated north along the mountain chain as the climate started warming about 10,000 years ago, reaching the current northern limit of its natural range (Fig. 1), within the last few thousand years (Russell 1987; Russell and Davis 2001; Anagnostakis 2001). Likely uncommon in precolonial times, the American chestnut expanded rapidly following disturbance caused by settlers, no doubt a result of the species ability to sprout prolifically from cut or burned stumps, quickly establishing dominance on cleared sites (Paillet 2000). Today, chestnut survives as rare, large "escapes" or as numerous small understory sprouts in the heart of its range (Stephenson et al. 1991).

The American chestnut possessed a remarkable array of desirable traits. It grew very rapidly, often to a great size, with outstanding form and wood quality. The wood was very resistant to rot and therefore was used extensively in construction as lumber and roofing, poles, masts, and railroad ties. Tannins were extracted from bark and wood chips, and the chips were subsequently pulped for the production of paper. The tree grew well on dry uplands, a trait that today would make it a valuable biofuel species in

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