Developing Clones of *Eucalyptus cloeziana* Resistant to Rust (*Puccinia psidii*)

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Besides its high resistance to *Chrysoporthe cubensis* canker, *Eucalyptus cloeziana* is a highly valuable tree species for wood production. It can be used for furniture, electric poles, fence posts, and charcoal. Nevertheless, it is highly susceptible to the rust caused by *Puccinia psidii*, which limits its growth in areas favorable to infection. Since *E. cloeziana* does not interbreed naturally with other *Eucalyptus* species, its seedling plantations in Brazil are relatively uniform. Thus, the selection and multiplication of rust-resistant genotypes could constitute the best strategy for rust control. However, it is recalcitrant to rooting, which limits its large-scale clonal multiplication of resistant genotypes for planting, as has been done with *E. grandis*, *E. urophylla*, and their hybrids. Aiming to obtain the greatest possible number of rust-resistant genotypes for cloning, about 3,500 seedlings of several seed lots of different origins were spray inoculated with an inoculum suspension of $2x10^4$ urediniospores/mL of the single pustule isolate (EUBA-1, race 4) of *P. psidii* according to the standard procedures used in our laboratory. The assessment of disease severity on each seedling was performed at 12 and 20 days after inoculation using the rust severity scale of Junghans et al. (2003, Fitpatologia Brasileira 28:261-265). *Eucalyptus grandis* x *E. urophylla* hybrid clones C1179 (resistant) and C1183 (susceptible) were used as controls. Only about 2% of the inoculated seedlings were resistant and clonable. Attempts to multiply all 69 resistant clones are being made in order to have enough plants for clonal trials to evaluate their silvicultural performance and wood properties.

Testing Resistance to Chestnut Blight of Hybrid Chestnuts

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Castanea sativa is an ecologically and economically important species in Europe, not only as a forest tree, but also as a fruit tree**.** It is dramatically threatened by ink disease caused by *Phytophthora* spp., introduced during the XIXth century (Robin *et al*. 2006, Vettraino et al. 2005). To limit its impact, *C. mollissima* and *C. crenata*, which proved to be tolerant species, were imported from China and Japan in Europe at the beginning of the XXth century, together with the agent of chestnut blight (*Cryphonectria parasitica*) which is now spreading all over Europe (Robin & Heiniger 2001). A clonal selection has resulted in the use of a few inter-specific hybrids, as rootstocks tolerant to ink disease and onto which fruit cultivars are grafted, as fruit cultivars for the fruit quality and as forest clones selected for growth characteristics. New chestnut forest plantations are clonal in Spain (Pereira-Lorenzo and Fernández-López 1997), but not yet in France. However, with the threat of increasing loss due to ink disease and chestnut blight, hybrid clones are seen as a promise by some foresters. Our aim was to test the resistance to chestnut blight of hybrid chestnuts which are used as rootstocks or grafted varieties for fruit production, or inter-specific full sib families used for building chestnut maps. Field testing revealed significant differences among genotypes: some fruit cultivars being less susceptible than the large majority, in agreement with field observations. With excised stem assays, a large phenotypic variation within the F1 progeny was observed.

Cold as a Possible Limitation for the Restoration of American Chestnut

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Approximately 100 years ago, American chestnut (*Castanea dentata* (Marsh.) Borkh.) was rapidly removed as an overstory tree by the fungal pathogen *Cryphonectria parasitica* (chestnut blight). Over the years multiple efforts of restoration have been attempted. Currently, the most effective method involves the hybridization of American chestnut with the highly blight resistant Chinese chestnut (*Castanea mollissima* Blume). However, preliminary evidence suggests that backcross material may not have the cold hardiness needed for restoration in the north. Two factors that can significantly influence cold tolerance are genetics and the environment (e.g., cold exposure of plant tissues). Also, the cold tolerance of nuts is of concern because reproductive tissues are particularly sensitive to freezing damage. Thus, in an effort to contribute to the successful restoration of American chestnut in the north, the focus of this research was to analyze the cold tolerance of American chestnut through: 1) the comprehensive evaluation of nut cold tolerance for a range of American and Chinese chestnut nuts and red oak (*Quercus rubra* L.) acorns for comparison, and 2) studying the first-year growth and shoot winter injury of a range of American and Chinese chestnut and red oak seedlings under three silvicultural treatments (open, partial-, and closed canopies) in the Green Mountain National Forest (GMNF). Differences in canopy cover among silvicultural treatments were measured using hemispherical photography. Differences in winter air temperature lows associated with silvicultural treatments were also assessed. We examined American chestnut sources by region - north, central, and southern portions of the species' range (nut cold tolerance experiments only) and by temperature zone (warm, moderate, or cold) that differentiated sources based on winter low temperatures in the areas where they originated (both experiments).

Nuts of Chinese chestnut were significantly less cold-tolerant than either American chestnut nuts or red oak acorns, which were indistinguishable. Among American chestnut sources, nuts from the southern region were significantly less cold-tolerant than nuts from the northern region, with nuts from the central region being intermediate. Significant differences among sources were also identified within each region. Nuts from warm and moderate temperature zones exhibited similar levels of cold tolerance, but were significantly less cold-tolerant than nuts from the cold temperature zone. There were significant differences among sources within the warm and moderate temperature zones, but not within the cold temperature zone. The seedlings at GMNF grown under open canopies exhibited greater growth than seedlings grown under partial and closed canopies (which were indistinguishable), but also experienced increased shoot winter injury. Chinese chestnut seedlings had significantly greater growth, but also experienced greater winter injury than American chestnut and red oak seedlings. Among American chestnut sources, seedlings from sources from warmer low-elevation, southern and central locations grew more, but experienced greater winter injury than seedlings from sources from the colder north. We believe that the temperature zone index may provide a reliable guide for assessing the tradeoffs between growth and vulnerability to winter shoot injury, as well as nut cold tolerance, and could help to identify

those sources that best bridge tradeoffs in cold tolerance and growth. Our results also suggest that both silvicultural treatment and genetic selection can greatly influence growth and winter injury of American chestnut at the northern limit of its range.

Breeding for Resistance to Adelgids in *Abies fraseri, Tsuga canadensis,* and *T. caroliniana*

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The balsam woolly adelgid (BWA; *Adelges piceae*) and hemlock woolly adelgid (HWA; *Adelges tsugae*) have had a tremendous impact on native ecosystems with Fraser fir (*Abies fraseri*), eastern hemlock (*Tsuga canadensis*), and Carolina hemlock (*T. caroliniana*) in the eastern United States since their introduction from Asia. They have also caused serious economic damage in Christmas tree plantations and nurseries. The Alliance for Saving Threatened Forests is engaged in research to complement other methods of adelgid control through the development of genetically resistant Fraser fir and hemlocks. The approach focuses on the identification, testing, and breeding of resistance or tolerance found within natural populations. In addition, development of interspecific hybrids is underway, incorporating both traditional breeding techniques and somatic embryogenesis.