Assisted Diversification for an Era of Habitat Extinction[1]

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Abstract

How do we conserve tree diversity in a rapidly changing world, dominated by intensive human impact on the landscape? The Anthropocene is a useful term to describe a new era in Earth's history, where we dominate the globe's resources so completely that our activities alter basic nutrient, water, climate, and energy cycles. These rapid environmental changes and the substantial decline in available and appropriate habitat for many organisms has led to predictions of a sixth global extinction event, where a large fraction of the world's species are lost. These mass extinctions clearly impacted animal species more than they did plant species. Recent studies suggest that plant speciation may have actually increased at the end of the Cretaceous Period when the dinosaurs largely vanished. Plants must have life histories and reproductive strategies that allow them to persist through times of rapid environmental change.

In addition to being autotrophic and capable of remaining dormant as seed for many years, most plants in diverse genera remain inter-fertile among closely related species. Early evolutionary botanists described these suites of inter-fertile species that retain the ability to exchange genes at a diminished rate as a syngameon. Numerous examples have been identified and documented in the scientific literature and this reproductive strategy has also been termed "diversification with gene flow". Oaks (*Quercus* spp.) are famous for being promiscuous across species boundaries and numerous examples of hybrid offspring, genetic introgression, and cytoplasmic organelle capture exist. I would argue that oaks are not at all unusual among trees, but instead are representative of diverse tree genera, particularly in the tropics. The oaks are one of the few examples of a temperate tree group that has diversified in the same way that many tropical genera have. I would further suggest that participation in a syngameon is a critical aspect for trees to adapt to environmental change and novel environments.

The most troubling part of the Anthropocene is that habitats themselves will become extinct. How does one conserve a species for which the natural and preferred habitat no longer exists? The Anthropocene presents an essentially unpredictable and unprecedented challenge to trees over the last 5 million years. We cannot accurately predict what climate and land-use will exist in any one location over the next century. So, as tree breeders, geneticists, and land managers, how do we choose a 'winner' in this situation? Do we invest in a particular breeding program or germplasm stock? Can we be assured that these narrowly-related trees will thrive in the Anthropocene? Environmental change has always happened in Earth's history. The major difference now is the pace of change, which has accelerated substantially. How do we assist trees to accelerate their ability to adapt? We should exploit the strategies they employ naturally. One of these strategies is the participation in a syngameon and the exchange and capture of advantageous genetic material from closely related species.

A carefully designed program of assisted diversification should be explored and the living collection of an arboretum is the perfect setting to conduct this work. Trees of the same type, often in the same genus, are brought together from around the world. These interactions allow cross-pollination and hybridization across considerable phenotypic and biogeographic difference. Seedlings from these crosses could be screened and selected, both by phenotype and genotype, to represent the broadest possible diversity of variation and combinations. These diverse set of hybrids could then be grown in a common-garden experiment and their growth and performance followed. The production of novel phenotypes which combine the best of both progenitors is standard practice among plant breeders, often to overcome invasive disease or pests. This 'diversity grove' could act as a fail-safe resource of genetic and trait variation for future use and allow 'winners' to naturally emerge from the stock.

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