“The Ex Situ Conservation of Stinking Cedar”

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The propagation of plants for food, timber, medicines and aesthetics has been a principal activity of man for millennia. However, the systematic propagation of plant material for the purposes of conservation has a recent history, probably dating back only a few decades. The propagation and distribution of *Torreya taxifolia* from wild collected, documented material is one of the largest projects of its kind ever attempted, and many positives and negatives will be learned from the ultimate review of this project.

Background: *Torreya taxifolia*

Torreya is a primitive member of the Taxaceae, the yew family. Seven species are known worldwide: four species in China, one species in Japan and Korea, one species in California, and one species in Florida and Georgia. *Torreya taxifolia* is a rare and endangered species known only from a restricted area of the Florida panhandle and adjacent Georgia in the unique ecosystem known as the Appalachicola Ravines.

The cultivation of *Torreya taxifolia* began not long after its discovery in 1835 by Hardy Bryant Croom. By 1859, A.J. Downing reported on the success of the plant growing in cultivation: "Our best specimen is about eight feet high, very dense, showing nothing but foliage, like a thrifty arbor vitae, and remarkable, particularly in winter, for the star-like appearance of the extreme tips of its young shoots. We have returns of this tree from Elizabethtown, N.J., Dobbs' Ferry, Yorkville, Flushing and Newport, in all of which places it succeeds well, and is considered hardy, except at the last place where it is reported tender." Sargent in 1905 wrote that *Torreya* was "now often planted in the public grounds and gardens of Tallahassee, Florida."

At present, no trees of any size are known in the northeastern United States and the successful long-term cultivation of *Torreya taxifolia* north of Virginia remains unknown. The number of mature trees in cultivation outside of Florida may number less than two dozen. In contrast, old and large trees of *Torreya nucifera* are found in Boston, Massachusetts, and Swarthmore, Pennsylvania.

Beginning in the late 1950s a sharp decline in the health and reproductive capacity of the native stands was noticed. Since then, all full-sized mature individuals have perished and seed production is extremely rare in the wild (E.O. Wilson, pers. comm.). Where trees of 60 feet were found, few individuals over 10 feet are now known. Research into the cause of the decline is ongoing, but *in situ* preservation appears problematic and management efforts now include the propagation of rooted cuttings from documented wild stands to be grown in *ex situ* populations. Because set seed is so rare in the wild, vegetative propagation is the only means left to secure documented wild germplasm for study, possible distribution, and possible reintroduction.

The Study

For this study, 2,622 cuttings were collected from 166 trees at 14 individual sites from throughout the native range of the species (20 miles north to south, 14 miles east to west). The vigor of individual trees varied greatly and the majority of those sampled were under six feet tall. The number of cuttings harvested varied with each tree depending on the overall health of the specimen. As few as one and as many as 82 cuttings were taken per plant with the average being 15.79. Each collection from each genotype was given an accession number at the time of collection and this number followed the plant through the propagation cycle. A metal label bearing this number was affixed to the parent tree. Cuttings were taken in November 1989 and were transported to greenhouses in Massachusetts, where they were given a fungicide soak (Zyban) and subsequently propagated.

Previous trials with *Torreya* cuttings (Nicholson, 1987) had experimented with various rooting hormones and hormone strengths and had produced a topmost rooting percentage of 65%. In an attempt to increase this percentage, different rooting media were compared and the hormone strength was doubled from 5000 ppm Indolebutyric Acid (IBA) to 10,000 ppm IBA in 50% EtOH. A total of 666 cuttings from 45 different genotypes had the bottom 4 cm of needles removed from the stems, were given a fresh cut, and the basal portions were immersed in the 10,000 ppm IBA solution for five seconds. These were then stuck under a poly tent in a medium of coarse builder's sand and medium grade perlite (1:1 by volume) with a bottom heat of 75 degrees F. One thousand eight hundred and forty-eight cuttings from 121 different genotypes were treated in the same manner, but a rooting medium of #10 grade crushed pumice, shredded peat moss, and medium grade perlite (6:2:1 by volume) was used. Cuttings were evaluated after six months and potted on. Rooting percentage of those cuttings stuck in the sand/perlite medium was 79.2 percent while those cuttings stuck in the pumice/peat/perlite mix rooted at a percentage of 90.8 percent.

Roots were measured and counted for all cuttings stuck in the sand/perlite mix and for an equivalent number of randomly selected cuttings from the pumice mix.

A total of 1332 cuttings were analyzed. Recorded were:

- number of primary roots (roots originating from the stem)
- longest root length
- total number of root tips (primary and branch roots)
- cumulative length of roots

The cuttings rooted in the sand/perlite mix produced an average of 2.90 main roots and 3.44 total root tips. The longest root length averaged 6.37 cm with an aggregate root length averaging 12.98 cm. Highest values recorded for each category were 13 primary roots, 13 total root tips, 14 cm greatest length, and 42 cm aggregate length.

The cuttings rooted in the pumice mix produced an average of 2.40 primary roots per cutting and 5.09 total root tips. The longest root averaged 10.26 cm with an aggregate length averaging 16.92 cm.

Highest values recorded for each category were 10 primary roots, 18 total root tips, 22 cm greatest length, and 49 cm. aggregate length.

A comparison of these two media showed that the pumice mix yielded a higher percentage of rooted cuttings, and a more highly branched root system of greater total length.

Cuttings were potted and grown for two years and then shipped to botanic gardens and biological institutions worldwide for observation and research. Institutions receiving plants were the Arnold Arboretum of Harvard University; Bok Tower Gardens; Royal Botanic Garden, Edinburgh; Illinois Natural History Survey; Mercer Arboretum; North Carolina Botanic Garden; Tall Timbers Research Station; USDA Forest Service, Berkeley; and USDA Forest Service, Gulfport.

Of particular note is the collaboration between The Botanic Garden of Smith College and the Atlanta Botanical Garden. Cuttings sent to the Atlanta Botanical Garden were raised in containers and by 1997 some had grown to five feet and had begun to set seed. A nursery mix of 15 parts composted pine bark mulch, one part granitic sand, and amendments of lime, bone meal, and cow manure proved to be an excellent growing medium, and the plants were grown outside under 50 percent shade.

Fertilization was provided by high nitrogen 17-6-12 Osmocote, applied at half strength twice a year. If the plants looked peaked, additional fertilization was by 20-10-20 liquid feed.

All plants were labeled as to original locale. In 1997 these plants were the source of additional cutting material. More than 4,000 cuttings representing 150 genotypes were installed at The Botanic Garden of Smith College. Once rooted, these will be transported to the Atlanta Botanical Garden where a distribution to other botanic gardens, agricultural stations, colleges, nature reserves, and state parks in Georgia is envisioned.

The partnership between our two gardens, both with a strong emphasis on conifers, has proven to be a great success, and plans are being formulated to further develop this collaboration.

Discussion

Reintroduction of documented *Torreya taxifolia* germplasm into the original collection areas within the native range is the most logical goal of the ex situ program, and a multidecade or multigenerational approach probably is needed. The microclimate or ecosystem of the ravines may have been irrevocably altered and *Torreya taxifolia* may no longer be able to survive within this new environment. The success of an *ex situ* program is, in itself, no guarantee that successful reintroduction can occur. However, it is a necessary approach given the ongoing decline of wild stands.

Thought also must be given to the best type of propagules with which to attempt reintroduction of the species. Dr. Mark Schwartz produced an estimate of population levels prior to the species' collapse based on population density data from 1914 that showed 30 *Torreya* per acre. Given the size of the potential habitat, he extrapolated a maximum population of between 300,000 to 600,000 plants, meaning, sadly, that 99.3 to 99.9 percent of the earlier population is dead. This means that the scope of any reintroduction is of a scale that will require collaborative efforts. To build up numbers of plants approaching these levels from the current estimates of 500 individuals is daunting to a botanist, horticulturist, or ecologist, but would probably be considered a manageable project to forestry professionals. The ravines inhabited by *Torreya* are unique ecosystems and contain many endemic species. The ravine slopes are often steep- sided, and large armies of volunteers planting *Torreya* could possibly destroy much of the understory layer if planting is not correctly planned.

Thought has to be given to the eventual product of an *ex situ* program with an eye toward re-introduction. Germplasm is always the product but in what package? Will it be large b&b plants, one-gallon size, racks of seedlings or rooted cuttings in tube pots, or seed? This is tied to many factors: cost of production, space and labor limitations, cost of transport to the ravines, impact of transport into the ravines and survivability once planted. We do not know if 10 large plants or 1,000 seeds offer a better chance of success in terms of long-term survival and regeneration.

Germination of *Torreya* seed, like many primitive gymnosperms such as *Taxus* and *Podocarpus*, can involve a long after-ripening of the embryo once the fruit senesces from the tree. If seed were used it would have to be preconditioned and planted at the cusp of germination, thus avoiding a long period of dormancy in the ground when it would be subject to predation. Seed pretreated and ready to sprout would be the most cost-effective to produce, the easiest to transport and plant, and least environmentally damaging method of restocking the native range of *Torreya taxifolia*. New data by Chien, Kuo-Huang and Lin offer some crucial clues for successful pretreatmant of *Torreya* seed, and this line of research needs further exploration with *Torreya species*.

Given the scale and scope of this project, it boggles the mind to assume that mankind is capable of repeating this process with every endangered species of plant. *Ex situ* conservation projects, such as the work with *Torreya*, may in fact become the best kind of advocacy for *in situ* conservation and the maintenance of where the wild things are.

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