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"Left Behind in Near Time: Assisted migration for our most endangered conifer -- now"

by Connie Barlow and Paul S. Martin

We propose assisted migration for Torreya taxifolia, such that this critically endangered conifer endemic to a single riverine corridor of the Florida panhandle is offered a chance to thrive in natural settings further north, and such that the process of assisted migration can be tested as a plant conservation tool. This yew-like tree was "left behind" in its glacial pocket refuge, while other species now native to the southern Appalachians successfully migrated north, and humans are likely the cause, owing to anthropogenic fires and extirpation of seed dispersers. Test plantings could begin immediately, as there is no legal requirement to interact with governmental bodies - so long as plantings occur only on private lands and using private stocks of seed.

Moving Endangered Plants: Easy, Legal, and Cheap

Assisted migration as a conservation tool is both fascinating and frightening for anyone focused on plants. It is fascinating because endangered plants can easily, legally, and at virtually no cost be planted by whoever so chooses, with no governmental oversight or prohibitions -- provided that private seed stock is available and that one or more private landowners volunteer acreage toward this end. This cheap-and-easy route for helping imperiled plants is in stark contrast to the high-profile, high-cost, and governmentally complicated range recovery programs ongoing for highly mobile animals, such as the Gray Wolf, Lynx, and North American Condor, for whom habitat connectivity is a conservation tool of choice.

Assisted migration (a term coined by Brian Keel, in press) frightens for precisely the same reasons as it fascinates: anybody can do it, for good or ill, and with care or abandon. Its promotion could undermine decades of public education about the dangers of exotic plants, as well as more recent efforts to promote the concept of wildlands corridors and connectivity. In an age of global warming, however, assisted migration as a plant conservation tool should not be ignored. This from Peter Wharton, curator of the Asian Garden of the University of British Columbia Botanical Garden: "The Torreya question is a door to immense issues relating to how we facilitate global 'floraforming' of vegetational zones in a warming world. It is another layer of responsibility for those of us who have a passion for forests and wish to promote the ecologically sensitive reforestation of so many degraded forest ecosystems worldwide." (4/2/04 email)

In October 2003 Connie Barlow initiated an email conversation on the merits of assisted migration for an endangered conifer tree, Torreya taxifolia, which was met by early support from Pleistocene ecologist Paul S. Martin and deep curiosity by palynologist Hazel Delcourt. As the months passed, others actively joined the debate (or watched it unfold). The circle widened to include professional horticulturalists, seasoned naturalists, Nature Conservancy staff, and academic and governmental botanists, foresters, ecologists, conservation biologists, and those with an interest in environmental ethics. Torreya expert Mark Schwartz (author of the opposing argument in this Forum) has played an enlivening and educational role in this conversation, as has Peter White, director of the North Carolina Botanical Garden, Chapel Hill. Core components of the discussion will soon be archived on a new website initiated by Barlow: www.torreyaguardians.org.

The World's Most Endangered Conifer

Torreya taxifolia (henceforth, T. tax or Florida torreya) is an evergreen conifer historically found only along a short stretch of the Apalachicola River of northern Florida and the adjacent sliver of southern Georgia. It favors the cool and shady ravines that dissect the high bluffs of the river's east shore. Despite extreme endemism, the species was once a prominent mid- and under-story member of its forest community, which includes an odd mix of north and south: towering beech and hickory next to tall evergreen magnolia, and surrounded by stubby needle palm.

In the 1950s, the species suffered a catastrophic decline, the ultimate cause still unexplained. By the mid 1960s, no large adult specimens -- which once measured more than a meter in circumference and perhaps 20 meters tall -- remained in the wild, felled by what seemed to be a variety of native pathogens. Today, the wild population persists as mere stump sprouts, cyclically dying back at the sapling stage, such that seeds are rarely, if ever, produced. T. tax thus joins American Chestnut in maintaining only a juvenile and diminishing presence in its current range. (Digital photos of Apalachicola specimens in the wild are posted at www.torreyaguardians.org).

The Florida Chapter of the Nature Conservancy, the State of Florida (Torreya State Park), a number of botanical gardens, and dispersed academic researchers are all actively involved in its recovery, guided by a USF&WS recovery plan and pursuant to the Endangered Species Act. "The world's most endangered conifer" is the way a Nature Conservancy pamphlet (1997) introduces Torreya taxifolia.

Mark Schwartz and others maintain hope for recovering T. tax in reproducing, self-maintaining populations in its current range. Since

1997, staff at the Atlanta Botanical Garden have been experimentally taking healthy T. tax grown from seed at the garden and planting these trees at the periphery of the existing range and somewhat further north in Georgia. The efficacy of applying fungicides and supplemental fertilizers to these transplants is now also being tested. The transplants are all progeny of "potted orchards" established from cuttings taken from wild specimens in Florida in November 1989.

Another Torreya expert, Rob Nicholson (conservatory manager at Smith Garden Botanical Garden, at Smith College in Massachusetts) participated in the 1989 salvage of wild genotypes and their propagation as clonal stock. Nicholson presents a less hopeful view of resurrecting a healthy and self-maintaining population of T. tax in its current range. This is drawn from the Torreya conservation page of Nicholson's website:

[blockquote]"Mature trees in cultivation outside of Florida may number less than two dozen. At the beginning of the twentieth century, there were wild populations of Torreya taxifolia estimated at about 300,000 to 600,000. The estimated number of plants in the original habitat is about 500, which means that 99.3 to 99.6% of the population found at the beginning of the 1900s has died. Where 60-foot trees were formerly found, few individuals over 10 feet are now known. Although research into the cause of this decline is ongoing, 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." [insert web page; end blockquote]

Virtually all of us who have been conversing electronically about the pros and cons of assisted migration for T. tax agree that at some point in the future, human-induced global warming will indeed push T. tax (and all too many other plants) to the edge of viability; at that time, assisted migration may become an absolute necessity. For reasons explained below, we believe T. tax is already at that juncture. In a 1990 article, Rob Nicholson speculated, "Is Torreya an early victim of global warming and a precursor of a new wave of inexplicable extinctions?"

We ask: Why wait until a hundred species are on the brink? Rather, let us undertake assisted migration for Torreya taxifolia today, in part, as a trial run for the decades to come. With T. tax we can explore the ecological and emotional hurdles toward such a radical turn in plant conservation.

Rewilding T. tax

We are proposing test plantings of T. tax on forested private lands of the southern Appalachians and Cumberland Plateau. Mark Schwartz and

others who know the tree through years of professional engagement agree that T. tax is very unlikely to become noxious in recipient ecosystems to the north. T. tax might, in fact, serve an ecological function similar to that of Eastern Hemlock: providing evergreen shade along streams and streamlets within deciduous forests. Overall, the ecological interactivity (for good or ill) of T. tax in recipient ecosystems will become apparent only when test plantings in natural forest habitats to the north are carried out and monitored.

In North Carolina there is already evidence of benign thrival of "Florida" torreya. In 1939 Chauncey Beadle collected about a dozen specimens of T. tax from the Apalachicola and planted these along a streamlet as part of a naturalistic grove of open pine forest within the vast holdings of the Biltmore Gardens in Asheville (elevation 2200 feet). Interestingly, today hemlock is prominent on the north-facing slope of this slight ravine, and all the Torreya specimens (including self-propagated saplings, probably planted by squirrels) occur and are thriving on the south-facing slope. As to Torreya's cold-hardiness, Bill Alexander (Biltmore forest historian) reports that in the winter of 1985 all Torreya specimens survived unharmed an episode of unusual cold; temperatures plunged to minus 16 degrees F.

Thus far, the arguments we have made in favor of assisted migration for Torreya taxifolia are grounded entirely in an ethic of biodiversity preservation: T. tax is in deep trouble in its historic native range, so let's give it a chance to establish in cooler realms. Biodiversity preservation is not, however, the only environmental ethic that should guide conservation choices. Increasingly "rewilding" (Soule and Noss 1998; Barlow 1999; Foreman 2004) is a powerful motivator. According to this standard, a network of "potted orchards" of T. tax tended in northern botanical gardens, though a good hedge against outright extinction, falls far short of the mark. "Potted" is the botanical equivalent of "caged."

Might it be possible for T. tax to take its place once again as a thriving member of some subset of Appalachian forest communities? We say "again" because we believe that northern Florida is more properly viewed not as native range for T. tax but as peak-glacial range. Helping T. tax establish in the southern Appalachians is thus not so much relocation for a plant struggling with global warming as repatriation of a once-native. It is thus a form of rewilding that uses a near-time or deep-time baseline for determining appropriate, even "native," range.

Torreya is a member of the ancient gymnosperm family Taxaceae, whose ancestors were evolutionarily distinct from other conifers by the Jurassic. Because Torreya pollen is indistinguishable from the pollen of yews (Taxus) and bald cypress (Taxodium), as well as several other conifers, known fossil occurrences of this genus are limited to macrofossils (seeds, leaves, and secondary wood), and these are

sparse. There are no Cenozoic fossils whatsoever of Torreya in eastern North America. The most recent macrofossils identified as Torreya in eastern North America are upper Cretaceous, and these were unearthed in North Carolina and Georgia - hence, our suggestion that assisting T. tax to rewild in North Carolina would be assisting the return of a deep-time native.

Because worldwide climate during the Cretaceous was much warmer and far less seasonal than that of today, it is not surprising that Torreya macrofossils of Cretaceous age have also turned up along the Yukon River of Alaska. In western North America, there is Cenozoic fossil evidence of Torreya in the John Day region of Oregon (lower Eocene) and variously in California (Oligocene and late Pleistocene). Today, the genus is highly disjunct. Torreya californica survives as a rare tree, locally abundant in a score of isolated populations within the coastal mountains of central and northern California and on the west slope of the Sierras. It favors moist canyons and mid-slope streamside, growing beneath a canopy of taller conifers and deciduous trees. Torreya nucifera is found in Japan and Korea. Four other species inhabit mountainous regions of China. We would not be surprised if one day a remnant grove of Torreya were discovered in the mountains of northeastern Mexico, in patches of mesic forest that still support sweet gum, beech, and yew (Martin 1957).

Torreya taxifolia is the only one of the seven known species that is highly imperiled,
and we believe we know why.

Near-Time Obstacles to Natural Migration

Torreya taxifolia is a glacial relict, left behind in its "pocket reserve" of rich soils and cool, moist microclimates afforded by ravines that dissect bluffs along the east shore of the Apalachicola River. The current richness of North America's deciduous forests is, in large part, thanks to this and other glacial refuges -- including the Tunica Hills of Louisiana and the Altamaha River of southeastern Georgia (Delcourt 2002). For some of the repatriated plants (notably, beech) relict
populations still remain in one or more of these refugia, while the bulk of the range is disjunct much farther north. T. tax was unable to follow the other plant refugees north when the ice retreated, beginning some 15,000 years ago.

Consider: the last interglacial -- 110,000 to 140,000 years ago and preceded by many others of equal magnitude -- peaked at a global temperature not much different from that of today. If Torreya is having trouble surviving in northern Florida now, it should also have had trouble
in multiple interglacials.

So what makes our own interglacial uniquely inhospitable for natural migration? There are only two significant differences between this interglacial and the previous. Either could have posed grave problems for Torreya, and together they would have sealed the fate of the unfortunate refugee.

One difference is that our current interglacial is uniquely understocked in large herbivorous mammals, both in diversity and in numbers. By 10,000 years ago, the mastodons, the mammoths, the giant ground sloths, and other mammals that powerfully affect the vegetation had vanished. Notably, we lost all our big browsers. Small trees would have been untoppled by elephants, saplings and shrubs gone uneaten. Overall, the landscape would have become a lot brushier, and thus more susceptible to fires reaching beyond the fire-adapted pinelands of sandy flats into the moist ravines through which fire-intolerant Torreya would have been edging north (Robinson 2003).

A second difference between this interglacial and the previous is that only in the current interglacial has North America been home to a creature that can make fire on demand. Indeed, the migration of humans into North America is evidently the cause of the coinciding loss of megafauna, by "overkill" (Martin and Klein 1984). Near the onset of the present interglacial, the first paleoindians arrived. Both accidentally and intentionally, and for thousands of years, wildfires were ignited to favor plant species that provided food (the acorns of oaks), to make land easier and safer to cross, to flush out game, and to lure game animals to patches of abundant new growth. This scenario may account not only for the suppression of Torreya but also for the extinction of a recently described new species of spruce, Picea critchfieldii. Late Pleistocene extinctions of plants, to match the devastation suffered by large mammals, are otherwise unknown.

Consider Australia's celebrated native endemic and "living fossil": the Wollemi "pine." Wollemia nobilis is the sole remaining species of a genus that originated in the Cretaceous. Its family, Araucariaceae, includes only two other living genera: monkey puzzle (Araucaria) and Norfolk Island "pine" (Agathis). Wollemia was thought to have long been extinct until 1994, when 24 strange but magnificent trees in a single grove were found hiding out in an all but inaccessible canyon northwest of Sydney. Wollemia's brush with extinction, along with the actual near-time extinctions of several other Australian conifers, have been attributed to anthropogenic fires by early aboriginal peoples (Kershaw 2002).

There is yet a third way in which humans might have stressed local populations of T. tax in near time. The dispersal agents (squirrels, and perhaps also tortoises) upon which T. tax utterly depended for movement of its large, fleshy seed would likely have been severely reduced in numbers, even extirpated, as these creatures are not only attractive foods; they are safely and easily killed -- even by

children (Barlow 2001).

T. tax may thus have been a victim of contact, relegated to a short stretch of moist, riverside ravines by anthropogenic loss of big browsers, anthropogenic fires, and anthropogenic extirpations of seed dispersers. If these are the indeed the causes of T. tax's troubles, then why have the other species of genus Torreya been spared? Our answer is that the other species did not have to move hundreds of kilometers north in order to keep pace with a warming climate. Rather, they shifted their ranges hundreds of meters upslope. Thus we believe that topographical differences are at cause.

T. californica resides in pockets of the Coast Range and the west slope of the Sierras, between 1000 and 2500 meters elevation. In China, Torreya grandis is found in mountain habitats of 7 provinces, often alongside streams, at an elevational range of 200–1400 meters; it is common enough to be used commercially. Torreya fargesii is also found in seven provinces, but its range is higher, 1000–3400 meters. Torreya jackii occurs in three provinces and is listed as a "vulnerable species." Its altitudinal span ranges from 400–1000 meters. For the Florida torreya, in contrast, a journey of 400 kilometers (as the crow flies; far more as the ravine meanders) would have been required before it could take advantage of the quick elevational gain that mountains afford.

One final note in our "Left Behind in Near-Time Story": Because glacial refugees of eastern North America had to make do with mountainless terrain, Torreya was not alone in its troubles. Severe endemism of the Florida yew (Taxus floridiana, also only along the Apalachicola River), historic extirpation in the Altamaha of America's only big-blossomed relative of Asian camellia (Franklinia), and near-time extinction of the once-widespread Critchfield Spruce may all be attributed to the advent of the fire-makers (Martin, in press). Given the sequence of loss in their pocket reserves, it would seem that Critchfield Spruce was the least warm-and drought-tolerant of the bunch, followed by Franklinia, which now thrives in cultivation in the mid-Atlantic states. Next comes T. tax, followed by Florida yew, which is not yet sickly in its Florida refuge but is doing a poor job of reproducing.

"Left behind in near time" may thus be a syndrome that applies to a number of extinct, imperiled, and soon-to-be-imperiled plants, and especially to small isolated populations of species that are not themselves in danger of extinction. For example, how do we understand all the highly endemic populations or species of vascular plants far removed from their peers? Might the "left behind" scenario offer insight? And if so, how does this awareness alter our conservation options as climate shifts? Surely, the stories we tell about how and why these plants came to rest in odd patches will play a big role in the choices we make to preserve them. What stories will we tell?

Perhaps we conservationists will collectively write our own "left behind" series -- compelling stories that move us to reduce the toll amongst innocent green bystanders as we face an Armageddon of our own making.

Torreya Guardians

A self-organizing group, Torreya Guardians, has formed to discuss and act in behalf of Torreya taxifolia. Significant ideas and plans for action initiated by individuals or subsets of this group will be posted at www.torreyaguardians.org. Those who wish to volunteer their time or their students, share insights, offer ground for test plantings, or help with website management (especially threaded discussion) are encouraged to contact the group.

[blockquote]
"I think we ought to purposefully blur the line between scientists and non-scientists. Some scientists might want to be guardians in your sense. Also, the demands of rigorous science are such (and the funding available low enough) that I doubt that science will ever do the job of
large-scale assisted migration. Scientists might inform or inspire it, or do the experimental effort that tests the idea, but I don't think conservation managers should expect scientists to be the most important movers." -- Peter White, director of the North Carolina Botanical Garden, Chapel Hill (7/17/04) [end blockquote]

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