

# Behind the Scenes on Naming a New Hemlock Species

*Peter Del Tredici*

In my thirty-five years working at the Arnold Arboretum, I have only once been involved in naming a new species—a hemlock tree (*Tsuga ulleungensis*) native to the volcanic island of Ulleungdo in the Sea of Japan. This South Korean island lies 80 miles east of the mainland and 176 miles from the west coast of Japan. It's a small island—twenty-eight square miles—and rises to an elevation of thirty-two hundred feet. Geological records indicate that Ulleungdo emerged from the ocean floor some 2.7 million years ago and that it has been vegetated for the past 1.7 million years. The story of how I got involved with naming this new hemlock tree is complicated, but it bears telling for what it reveals about the process of doing basic botanical research and about how well-documented collections of plants—leavened with a bit of serendipity—can contribute to research on evolution and biogeography.

Although I was not aware of it at the time, my involvement with the plant actually began with the arrival of hemlock woolly adelgid (*Adelges tsugae*) at the Arboretum in 1997. This invasive sucking insect is native to Japan and was discovered in the eastern United States in the 1950s. It took about forty years for the bug to spread from the site of its original introduction in Richmond, Virginia, to the Arboretum—its relentless northward spread driven by warmer winters induced by climate change. When it finally arrived in 1997, it struck with a vengeance, attacking over a thousand trees located on the twenty-two acres of Hemlock Hill and scattered throughout the rest of the grounds. While the insect certainly presented serious problems for the Arboretum, it posed a far bigger threat to the wild-growing hemlocks of southern New England.

In response to the arrival of hemlock woolly adelgid in the Northeast, biologists adopted a multipronged approach to try controlling the pest: Plant physiologists evaluated various chemical controls. Entomologists began

searching for Asian insects that might be used as potential biocontrol. And horticulturists began evaluating other hemlock species for resistance to the bug. Given the Arboretum's extensive collection of hemlock species, which is nationally accredited through the American Public Gardens Association's Plant Collections Network, a number of researchers began coming here in hopes of finding something—anything—that might shed light on the problem and contribute to a solution. Among these researchers was a young graduate student in entomology at Yale University, Nathan Havill, who was also working at the United States Forest Service's Northern Research Station in Hamden, Connecticut, trying to unravel the insect's complex life cycle and assess its genetic diversity across the region.

As luck would have it, Michael Donoghue, a graduate and former professor at Harvard, was on Nathan's dissertation committee at Yale and suggested that just studying the insect was not enough and that Nathan should also do genetic work on hemlock trees. Now anyone who has been a graduate student knows how annoying it can be when a committee member adds more work to a thesis project, but Nathan recognized a good idea when he saw one and agreed to investigate the genetics of the Arboretum's hemlocks in order to create a phylogenetic tree describing their relatedness. For help, he recruited Chris Campbell, a professor at the University of Maine and another Harvard alum, to help with the project because one of Chris's former students, Tom Vining, had produced DNA sequence data on *Tsuga* and developed a rough phylogeny of the genus in 1999.

I first met Nathan in the spring of 2003, when he came to collect hemlock samples at the Arboretum. He was also looking for adelgid galls on the bug's alternate host, the Japanese tiger-tail spruce (*Picea torano*). It wasn't until the following year, having completed his genetic analysis, that Nathan shared the preliminary

results of his research with me and casually mentioned that one of our accessions—labelled as southern Japanese hemlock (*Tsuga sieboldii*), from Ulleungdo, South Korea—did not line up with the Arboretum’s other specimens under the same name, which was weird. Our two plants from Ulleungdo (accession 1251-83\*A and B) had arrived in 1983 as wild-collected seed obtained by the Chollipo Arboretum, an institution located outside of Seoul, and no one prior to Nathan had questioned their identity.

Despite its small size, Ulleungdo is famous in botanical circles for harboring over thirty species found nowhere else in the world. Ernest Henry Wilson visited the island in the late spring of 1917, guided by the botanist Takenoshin Nakai who was describing the island’s plants on behalf of the Japanese government, which had taken over the kingdom of Korea in 1910. Wilson collected herbarium specimens of the hemlocks that he found there and, following Nakai’s lead, referred to them as

*Tsuga sieboldii*. This was a logical decision on his part given close morphological similarities with the southern Japanese hemlock and the fact that there were no hemlocks on the Korean peninsula or adjacent parts of China. Nakai’s classification held up until 2008 when Nathan published his finding that the Ulleungdo hemlock was genetically distinct from the southern Japanese hemlock. Although Nathan indicated that more detailed analysis was required, his results suggested the taxon was more closely allied with the northern Japanese hemlock (*T. diversifolia*).

A few months before this paper was published, I met up with Nathan at the Fourth Symposium on the Hemlock Woolly Adelgid, held in Hartford, Connecticut, in February 2008. I asked him about the Ulleungdo hemlock, and he told me that his research was inconclusive as to whether or not it was a new species. I was surprised to hear this and immediately asked him if he would have a problem



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Two anomalous hemlocks on Bussey Hill became the catalyst for naming a new hemlock species (*Tsuga ulleungensis*), which is endemic to Ulleungdo, South Korea. Accession 1251-83\*B is shown here, overlooking the oak collection.



Ulleungdo is a small volcanic island, ecologically isolated within the Sea of Japan. Botanists have discovered more than thirty endemic plant species or subspecies on the island. Collecting locations by Peter Del Tredici and his colleagues are marked.

with me continuing his work on the taxonomic status of Ulleungdo hemlock. That would be fine, he said, because he was now working full time for the Forest Service on the genetics of the hemlock woolly adelgid and had no time for continued research on the trees. He also suggested that I collaborate with Ashley Lamb, an entomologist at Virginia Tech, who was going to southern Japan in the spring to study a potential hemlock woolly adelgid biocontrol insect, a small beetle known as *Laracobius osakensis*. I located Ashley at the conference later that day, and in no time flat, we agreed to collaborate on an Arboretum-funded trip to Ulleungdo. We would collect hemlock leaf samples and look for adelgids that Nathan could sequence for his research.

Not even three months later, on May 9, Ashley and I met in Osaka, Japan, and immediately caught a flight to Seoul. There, we made contact with Nam Sook Lee, a professor at Ehwa Womans University, and her colleague Sung Hee Yeau. I had met Nam Sook several years earlier when she was visiting herbaria in the eastern United States—including Harvard—and we had kept in touch. When I began developing my plans to go to Ulleungdo, Nam Sook generously agreed to host the expedition, which meant making all of the travel arrangements and procuring the permits needed to collect research samples on the island. The four of us left early the next morning on the three-hour drive from Seoul to Donghae, the point of departure for the

ferry to Ulleungdo. It was a clear day, but the seas were rough. Despite my scopolamine patch, I suffered mightily from sea sickness during the seemingly endless journey, as did most of the other passengers on the ship. As far as I could tell, only Ashley, sleeping with her head down on a table the whole time, emerged unscathed.

Needless to say, I was relieved when our ship finally landed at Jeodong, one of the island's two main cities, where we were met by Suk Su Lee, who worked for the local forestry department.

(Later, from 2011 to 2015, he served as chief of forestry for Ulleung County, which also includes forty-three smaller islands). Suk Su quickly found a taxi and took us to our hotel, where I promptly passed out for two hours. He met us later for lunch (which I skipped, still feeling queasy), and then he drove us up into the hills north of Jeodong, nearly one thousand feet in elevation, where I got my first look at the native forest with *Camellia japonica* in bloom in the understory, along with the Ulleungdo beech (*Fagus crenata* var. *multinervis*), which many taxonomists treat as a separate species (*F. multinervis*). We also observed two varieties of maple endemic to Ulleungdo (*Acer mono* ssp. *okamotoanum* and *A. pseudosieboldianum* ssp. *takesimense*), the Japanese white pine (*Pinus parviflora*), and most importantly, the Ulleungdo hemlock, the target of our expedition.

On the second hemlock tree we examined, Ashley found evidence of the adelgid and immediately collected samples for Nathan. We stayed in the area for a couple of hours, collecting more samples of the adelgid as well as herbarium specimens and leaf samples of the hemlocks. On the way down, the sun was setting, and we stopped at the elementary school in Jeodong, where Suk Su proudly showed us three hem-



**Dodong, the primary port city for Ulleungdo, is located south of Jeodong. In the foreground, *Sorbus ulleungensis*, an endemic mountain ash, can be seen flowering.**

lock trees that he had collected from the forest and planted at the entrance. They were growing extremely well—about twenty-five feet tall and very full—and all three were loaded with developing cones.

We were up early the next day and took a taxi across the island to Taeha Ryeong, a special reserve established in 1962 to protect some of the largest hemlocks, beeches, and Japanese white pines on the island. The slopes were steep, and the hemlocks were especially large in trunk diameter—up to 25.5 inches (65 centimeters). I managed to collect leaf samples from about twenty trees that had branches low enough to reach; all were growing around fifteen hundred feet in elevation. From there, we hiked down the mountain through a patch of woods that harbored an unbelievably rich herbaceous understory. We ended up at a clearing where our taxi driver was supposed to meet us, but since he wasn't there, we took the opportunity to do more collecting. Suk Su, at some risk to life and limb, climbed a tall hemlock and managed to collect a branch with both male and female cones on it, which we had been unable to obtain at our earlier location because the trees were too tall. He climbed down from the tree with the precious specimen just as our cab showed up.



Collaborator Suk Su Lee collected *Tsuga ulleungensis* from the wild and planted three specimens near the elementary school in Jeodong. After Peter Del Tredici visited in the spring of 2008, Suk Su sent seed from these plants to the Arboretum, where they were propagated and planted in the landscape.

From Taeha Ryeong, we drove halfway around the island to the Nari Basin, a volcanic caldera left after an eruption that occurred about ten thousand years ago. This is now the only place on the island with relatively flat ground, so the locals have taken advantage of this fact by establishing agricultural fields devoted to the cultivation of local medicinal plants, such as *Codonopsis lanceolata*, a vining member of the bellflower family (Campanulaceae). The landscape was beautiful, ringed by mountains, with specimens of the Ulleungdo hemlock in the surrounding forest and *Sorbus ulleungensis*, an endemic mountain ash, growing at the edges of the fields. (Incidentally, the mountain ash was then considered to be *S. commixta*—a species that ranges through northern Japan and the islands of eastern Russia—illustrating another case where speciation on Ulleungdo was long unrecognized.) We had lunch at a vegetarian restaurant that served the traditional *bibimbap* dish filled with medicinal plants

cultivated in the caldera and wild plants from the surrounding mountains—super healthy we were told—which was unlike anything I’ve tasted before or since.

The caldera was a jumping-off point for hiking to the highest peak on the island, but it was too late in the day for us to make the trek, so we headed back down the mountain to our hotel. We were greeted with bad news that a storm was moving in and that we would have to leave the island a day earlier than planned or risk getting stuck and missing two lectures I had scheduled in Seoul. The *coup de grace* was that there were no seats left on the boat leaving at five o’clock the following afternoon, so our only choice was to take a ferry at five the next morning. In the absence of any alternative, I packed up the specimens and set my alarm clock. It was frustrating to have come this far only to have the trip cut short before I could finish exploring the island. The good news was that I had collected leaf samples from



Ernest Henry Wilson photographed a stand of hemlocks—now *Tsuga ulleungensis*—on Ulleungdo in 1917, estimating heights ranging to 75 feet (23 meters). Peter Del Tredici observed similarly impressive specimens at the Taeha Ryeong Reserve in 2008, including this tree, which measured 98 feet (30 meters) tall.

thirty-one plants in five different locations, which was enough for a thorough genetic analysis of the Ulleungdo hemlock population.

After returning to the Arboretum from Korea, I continued making observations on the leaf and cone morphology of our two specimens of the Ulleungdo hemlock, but I failed to make progress on the genetic analysis of the leaf samples. The breakthrough finally came two years later, in August 2010, at the Botanical Society of America meetings in Providence, Rhode Island. I met with Chris Campbell, the professor from the University of Maine who had collaborated with Nathan on hemlock phylogeny, and his graduate student Garth Holman. After a brief discussion, we all agreed that Garth should include a chapter on the Ulleungdo hemlock in his dissertation on conifer genetics. His research would be based on the Arboretum's trees and on the DNA samples I had collected from Ulleungdo. It was with great joy and relief

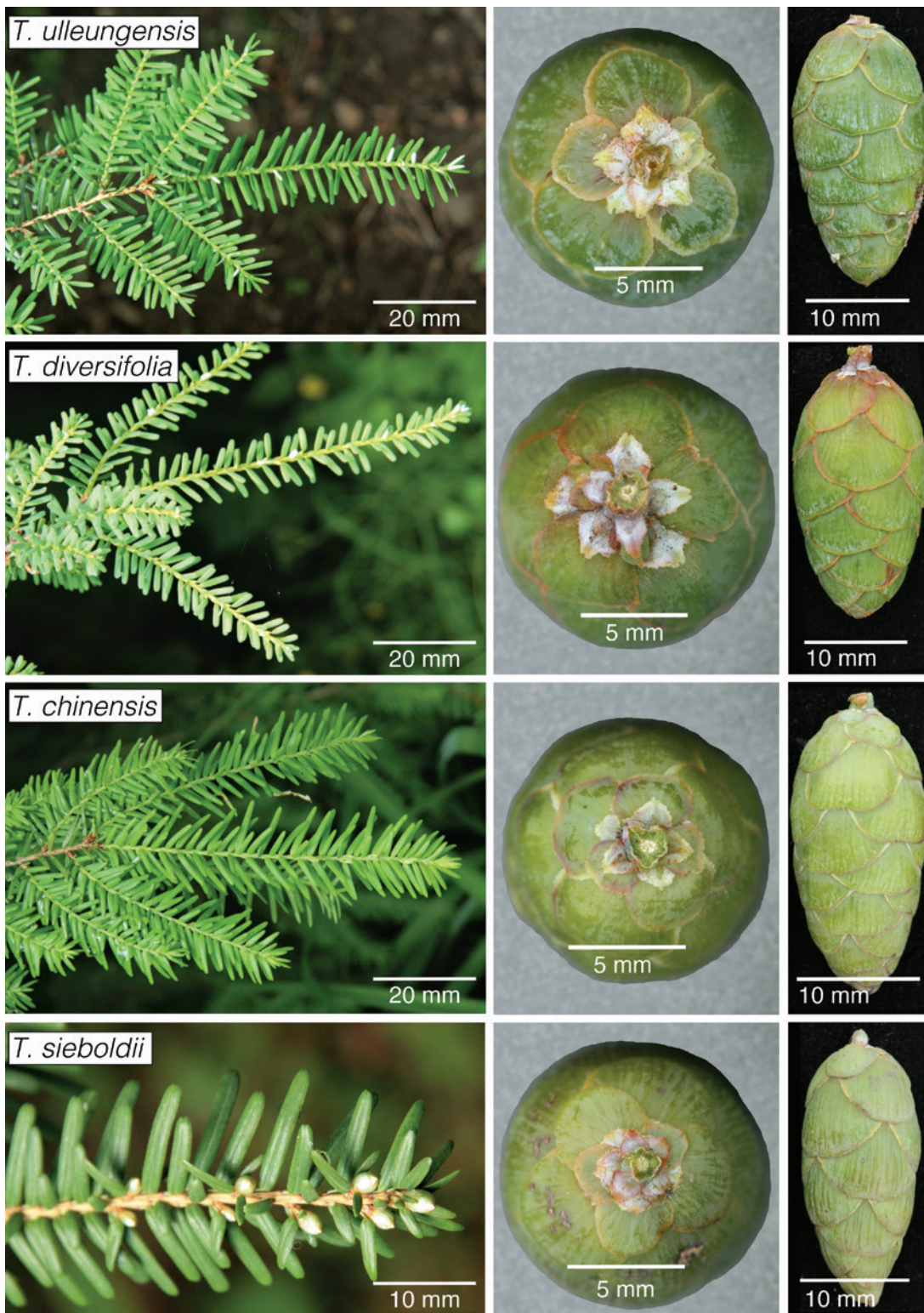


that I turned my samples and herbarium specimens over to Garth later that fall—at last they were going to someone who would put them to good use.

For the next four years, Garth labored in the lab on the genetic analysis of various hemlock species, while also assessing their morphological variation. At the same time, I continued with my phenological studies at the Arboretum, which showed that the Ulleungdo hemlock consistently leafed out a few days before *Tsuga diversifolia* and more than a month before *T. sieboldii*. With the help of Arboretum staff member Kevin Block, I also determined that the Ulleungdo hemlock was tolerant but not immune to damage by the hemlock woolly adelgid.

Garth completed his dissertation in September 2014 with a preliminary description of the Ulleungdo hemlock as a new species: *Tsuga ulleungensis*. Going from a dissertation to an actual publication in a scientific journal, however, is not always a quick process. In this case,

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Comparison of four Asian hemlocks growing at the Arnold Arboretum. On the left, the branches show simultaneous phenological conditions on May 23, 2012. The central images show the attachment point for the seed cones, where differences in the shape of cone-scale bracts are most evident—providing a subtle but important diagnostic characteristic for the species.

it took Garth another two years to expand and improve the research he had done for his degree, before submitting for publication to *Systematic Botany* in 2017. The final results, which were published in December of that year, painted a complicated picture of the Ulleungdo hemlock's ancestry: its chloroplast DNA indicated a closer relationship to *T. diversifolia* than to *T. sieboldii*, while the nuclear DNA was equivocal about the relationships among the three species. The morphological data—its cone and leaf structure—indicated that the Ulleungdo hemlock was more similar to *T. sieboldii* than *T. diversifolia*. Taken together, this evidence indicates that *T. ulleungensis* is distantly related to both Japanese hemlocks but is probably closer to *T. diversifolia* than to *T. sieboldii*.

The Ulleungdo hemlock is most likely a remnant of a species that was once widespread on the Korean peninsula but disappeared from the mainland as a result of multiple glaciations that took place during the Pleistocene, over the past million or so years. Because of its mild, oceanic climate, Ulleungdo is the only place in Asia where *Tsuga ulleungensis* survived. The existence of some thirty-three other endemic species or subspecies of plants on Ulleungdo provides further evidence that this isolated landmass has long served as a glacial refugium.

To me, the most interesting thing about the *Tsuga ulleungensis* story is how it illuminates the role that well-documented living collections can play in supporting basic scientific research and conservation. We start with a graduate student sampling the collections and finding a genetic anomaly. Next, we check the records to see where the plant originated, and then, in collaboration with scientists from the host country, we go back to the original location to recollect the plant for more in-depth analysis. Without the Arboretum's well-managed curatorial system, it would be impossible to make any of these connections. In the case of the Ulleungdo hemlock, a plant growing inconspicuously on the grounds of the Arboretum for twenty years unexpectedly provided a key to understanding the complex evolutionary history of a species restricted to a tiny

island off the coast of Korea—half a world away. From a research perspective, the Arboretum's collections are a means to an end rather than an end in themselves: they provide easy access to a significant percentage of the world's temperate trees and shrubs and are the perfect jumping-off point for any number of studies that can open the doors to basic evolutionary questions.

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