# *What We Are Learning*

## • Torreya's Habitat Preferences
## • Best Practices for Recovery
## • Adaptive Growth Forms

**Ongoing Report by**
**Torreya Guardians founder, Connie Barlow**

https://www.torreyaguardians.org/learnings.html

Visit our **Reports** page for more accomplishments

**Contact: Connie Barlow or Fred Bess**

**Learnings are reverse chronological**



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# 2025 Learnings

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### • May 2025: Cumulative learning of a THREE-FOLD PROOF that ASSISTED MIGRATION is safe and effective for Florida Torreya

The **first oppositional statement against assisted migration of Florida torreya (by Prof. Mark Schwartz in late 2004)** posed two risks that had to be adequately addressed before professional support could be achieved for the then-future actions of Torreya Guardians.

The risks can be expressed in the form of **QUESTIONS, which Torreya Guardians have answered via citizen science and field documentation** (as seen in the summaries of learnings below):

**Q1. Will assisted migration northward fail, and thus be a waste of money and plant material?**

**A1:** Beginning with our first plantings northward in 2008 (North Carolina), we have learned that herbivory and inferior sites (notably, clay soils in flat or bottom lands) can be deadly for this ancient conifer. Nevertheless, we have documented that **latitudinal shifts in climate zones can range as far north as Cleveland, Ohio and still produce mature, reproductive trees**. (See below **November 2023: Cleveland Ohio is a bounteous producer of Torreya seeds**.) Later, we documented that USDA Zone 6 plant hardiness regions were generally safe from excessive winter-kill. (See below **May 2025: Northward limits for assisted migration of Florida torreya**.)

**Q2. How do we know that Florida Torreya will not become invasive in northward ecosystems?**

**A2:** Our onsite inventories of **"Historic Groves"** confirm that Florida torreya is far from invasive. Dependent on squirrels for seed dispersal, less than 100 meters away from the parent tree has been documented in one generation. (See below **2018: Historic Groves of Torreya Trees: Long-Term Experiments in Assisted Migration** and **"April 2015: Visit to century-old Torreya grove confirms ability to naturalize, but very non-invasive"**.)

Beginning in 2018, **fear of spreading a newly named fungal pathogen, *Fusarium torreyae***, severely

constrained official distribution of the seeds of Florida torreya produced at the two ex situ "genetic safeguarding" groves in northern Georgia — more than 200 miles north of its historical range in the panhandle of Florida.

**Q3. How do we know that assisted migration northward won't spread the disease that has nearly extirpated the species in its historical range?**

**A3:** The *Fusarium torreyae* (and presumably cankers caused by this fungus) has been documented at the Florida torreya grove at the **Biltmore Estate near Asheville, North Carolina**. The grove of 13 original seedlings was planted in 1939 and has long produced seeds and established seedlings nearby. But the disease is far from destructive at 300 miles north of its historical range in Florida. (See below **2018: Biltmore health boosts arguments against genetic engineering"**.) Indeed, in December 2023 Connie Barlow posted a lengthy new webpage she created because: **"Botany papers reveal that *Fusarium torreyae* is actually a mutualist, only becoming pathogenic when the host plant is stressed"**.

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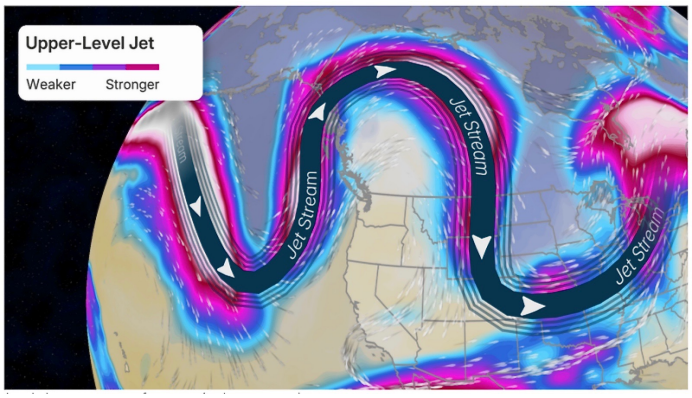
## • May 2025: NORTHWARD LIMITS for assisted migration of Florida torreya determined

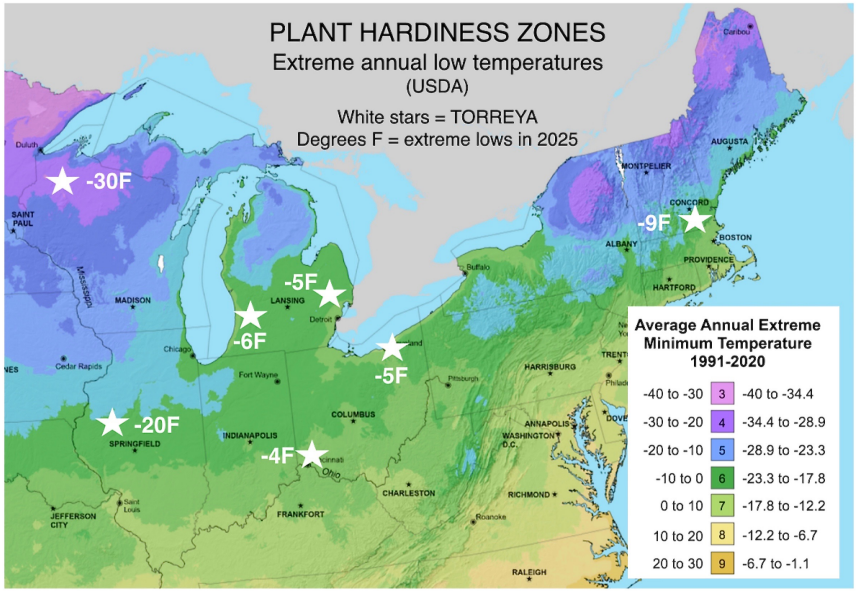
There is no doubt that global heating is underway, although there are some differences of opinion among the populace (less so among scientists) as to the most important causal factors. **Long before any significant change in the *global average* temperature is experienced by individuals, the much larger amplification of *weather extremes* has already become impossible to ignore.**




This includes short bursts of **extremely cold winter temperatures**, when abnormal meanderings of the **JET STREAM** enable polar temperatures to spread unusually far south.

This happened in mid **January 2025 in the northeastern states**, where some Torreya Guardians are experimentally planting the **endangered Florida torreya tree**.

**Extreme windchill** values amplified the dessication and thus winterkill in some regions — especially in habitats devoid of protective topography or tree cover.




LEFT: USDA "**Plant Hardiness Zones**" for the northeastern states. White stars show the coldest winter 2025 temperature extremes at 7 torreya plantings sites.

**• HOW FAR NORTH does it make sense to officially begin "assisted migration" for a critically endangered plant that is already suffering from heat-induced diseases in its small, historical range in Florida?**

**• HOW FAR NORTH is too extreme to begin planting now?**

**A brief look at the MAP ABOVE** suggests that if any of these experiments are too far north, it would be the one in northwestern Wisconsin. And what's going on in Illinois?

THE OVERALL CONCLUSION: **STAY IN THE GREEN ZONES!**

ACCESS THE NEW **NORTHERN LIMITS** **page to see photos and text of all 7 sites.**

EXCERPT OF THE SITE **Northeastern OHIO (-5°F):**

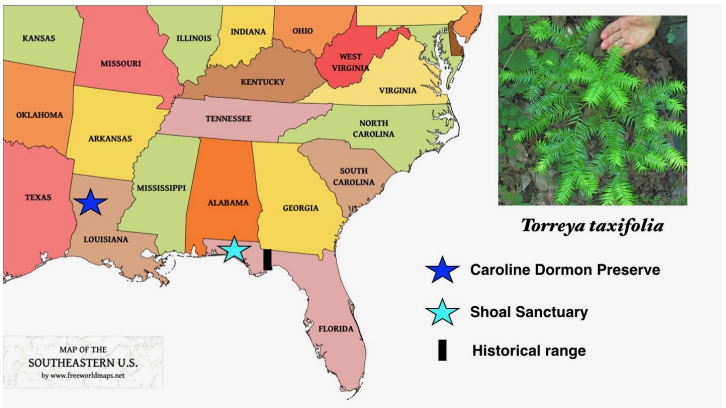
**Fred Bess** has been experimenting with **planting Florida torreya in his front yard in northeastern Ohio since 2011**. The winter of 2025 was not a particularly harsh episode for the torreyas this far north, as the lowest temperature was just **-5F Cleveland, OH** on January 22, 2025. (Fred lives in **Parma**, a suburb to the south of Cleveland.)

**Fred took the PHOTOS BELOW in early May 2025.** He wrote, "The windward southwest (and streetside) had some tip and needle damage. The northeast (leeward) side of the trees sustained no damage at all."

ABOVE: The orchard of Florida torreya trees on its northeastern side. Glimpses of the road are visible behind the torreyas. **The left-most tree is male, the rightmost is female, and the center tree is a two-stemmed hermaphrodite** (the main stem is male and a secondary is female).

ABOVE: This is the **southwestern side of the grove**, which is generally the windward side. Unlike the leeward side, here you can spot some noticeable browning. This side is also **vulnerable to salt spray** from the road during the winter. This kind of branchlet die-off manifests as a kind of pruning. New growth makes the outer form denser, which can protect overwintering reproductive buds from windchill dessication.

# March 2025: Learnings from 2 long-established plantings in SOUTHERN-MOST STATES





LEFT: The two sites. • RIGHT: January 2025 **VIDEO** on these two sites.

**VIDEO Summary:** Photos and videos from 2007 through 2025 are aggregated here tree by tree to offer a **natural history** and **oral history** opportunity to understand several factors that make **flat upland plantings in the southern-most states lethal for torreya, absent irrigation and occasional application of agricultural lime**. This contrasts with the ongoing success of downslope and ravine plantings at the two nature preserves featured here: Shoal Sanctuary in the western Florida panhandle and Caroline Dormon Nature Preserve in northern Louisiana.

## SHOAL SANCTUARY, FLORIDA (25 years old)

**1. UPLAND HABITAT:** Torreyas can be healthy in sandy soils if **IRRIGATION NEVER FAILS**.

**2. UPLAND HABITAT: CLEARING VEGETATION** to ensure full sun will produce dense, tall torreyas.

**3. UPLAND HABITAT: LIMING** (periodically) may be essential in pine-rich landscapes.

**4. GROTTO HABITAT: STEEPHEAD RAVINES** offer ideal moisture, cool, and absence of competition.

**5. RAVINE HABITAT:** Even gentle ravines of creeks may be good if torreyas are **LOW ON THE SLOPE**.

**6. INDICATOR PLANT SPECIES: CHRISTMAS FERN** is the ideal signifier of cool, moist habitat (confirmed at other Torreya Guardians planting sites).

**7. GROWTH FLEXIBILITY:** Torreyas evolved as **UNDERSTORY EVERGREEN TREES** adapted to grow slowly even in deep shade. They trend toward more lateral growth in quest of sunlight. Absent human assistance in clearing overstory vegetation, they would never be able to adopt and maintain a dense, Christmas-tree form. They can, however, **live for a very long time**. (See the **Natural History** page on this website.)

**8. ROLE OF BASAL SPROUTS:** If the apical leader is injured or removed, it will not be replaced. Instead, one or more **BASAL SPROUTS** will rapidly grow upward to take its place. (See the "Burn Tree" example.)

• **MYSTERY QUESTION:** ***Why are all torreyas at Shoal Sanctuary* FREE OF HERBIVORY?** What are the causes? And what does that teach us about finding other IDEAL SITES FOR EXPERIMENTAL POPULATIONS? The HERBIVORY question is explored in the **SHOAL SANCTUARY VIDEO** filmed January 2019 from **timecode 16:13** to 30:48.

## CAROLINE DORMON NATURE PRESERVE, LOUISIANA (75 years old)

**1. IRRIGATION & LIMING IN UPLANDS**: Torreya planted in upland habitats (with no downslope seepage) in the southernmost states apparently require irrigation and probably also liming.

**2. DOWNSLOPE IS BEST**: Of the 3 trees 75 years in age, by far the biggest and healthiest was the single tree downslope. Both of the uplands trees died at age 68 and 72.

**3. COMBINED MALE & FEMALE IN SAME TREE**: The sole remaining tree is also the only one that has periodically produced seeds (but only a small number each time) during at least the past 20 years. Yet pollen production is more abundant on that tree. And at least one of the 2 now-dead upland trees produced abundant pollen. Combining the evidence at SHOAL and DORMON, **it is possible that (a) all torreyas begin as male and then may shift wholly or partly to female, (b) female trees may eventually produce a few male branches, or (c) female trees that experience little or no pollination of their ovules when young, may grow most of their subsquent branches as pollen generators — given the prospect of being able to possibly pollinate a female tree (or their own female branch)**.

**4. DOCUMENTATION OF "FULL NATURALIZATION"**: This is **only the fourth example of full naturalization recorded of a Florida torreya tree in plantings outside of its small historically native range**. Not only have viable seeds been harvested from the downslope tree. For several decades, seedlings appearing beneath or near it have been documented (and transplanted). In 2024 an older seedling was documented about 15 yards distant — signifying **natural dispersal and planting by a squirrel**. *Visit the torreya **Historic Groves** page to learn of the other 3 sites of full naturalization.*

**5. GROUND-LYING LOWEST BRANCHES**:

Torreya has **a remarkable capacity to grow a low branch entirely along the ground**, and with extensive sub-branching, to **obtain sunlight far beyond the tree's own shadow**.

Only 2 other sites have been documented by Torreya Guardians with this adaptation: **Biltmore Gardens** and **Harbison House** — both in western North Carolina.

The Dormon Preserve has **the most magnificent example of a long and reticulating ground branch**. Not only does the branch **reach outwards some 30 feet from the trunk**, but there is extensive sub-branching that entirely fills a vast area with lush torreya leaves. (In some places, the leaves are intermixed with the fronds of **Christmas fern**.)

**6. ABSENCE OF HERBIVORY**: As with two other southern and sparsely populated forested regions (**Shoal Sanctuary in NW Florida** and **Ocoee watershed** east of Chattanooga TN), **the strong presence of predators**, combined with hunting as a valued rural activity, may be the reason for strong seedling survival with no fencing.

● **MYSTERY QUESTION:** ***Why is there no evidence of death by Fusarium cankers — indeed, no evidence of any cankers at all at both the DORMON PRESERVE and SHOAL SANCTUARY?*** Both of the recent tree deaths at Dormon were preceded by droughts. Moreover, death itself was evidenced **not by near-stem leaf-browning but by a fast-paced yellowing of leaves beginning at branch tips.** (Dormon Preserve was unaware of the health benefits of liming the soil when yellowing first appears; so we have no firm documentation as to whether lime could have prevented the upland torreya deaths there.) In contrast; the official proclamations of ongoing weakening and deaths of basal regrowth within the wild historical range is attributed to a novel water mold fungus recently named *Fusarium torreyae*.

## SUMMARY OF HABITAT REQUIREMENTS for wild plantings in the southern-most states (75 years old)

**1. DOWNSLOPES AND RAVINES**: These are the only habitats that have groundwater seepage available during droughts, along with topographical and canopy conditions promoting locally cooler temperatures. NEVER PLANT IN UPLANDS.

**2. NON-ACIDIC SOILS**: Limestone bedrock is ideal. Sandstone may be habitable, too, so long as fallen pine needles are not acidifying the soil and plants also requiring non-acidic soils are growing well in place. A **1994 USDA report** on this species states, "**Florida torreya is restricted to steep, deeply shaded limestone slopes and wooded ravines.** Soils in these areas most likely fall within the orders Alfisols and Mollisols." A **2000 USDA report** states, "**Florida torreya is commonly**

**associated with seepage locations on soils ranging from coarse or fine sand to clay with limestone pebbles** (Kurz 1938; USFWS 1986)."

**3. CHRISTMAS FERN AS INDICATOR SPECIES**:

As already documented by Torreya Guardians, *Polystichum acrostichoides* is a widespread species whose own habitat requirements mimic those of Torreya.

Access **photos of our own torreya plantings doing well amidst the evergreen leaves of Christmas fern**, where you will see how the ferns provide superb camouflage against winter-hungry deer.

See also 2 photos in a **2018 entry below**.

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## • February 2025: Female and Male Reproductive Structures

Below are a compilation of photos taken by Torreya Guardians over the years to show the distinctions between male and female buds. At the bottom of this set is the **crucial 2013 photo** taken by Connie Barlow, where A.J. Bullard in Mt. Olive NC shows her both sexes existing near enough together to pull into a single photograph. This disproved the typical official declaration of Florida torreya as "dioecious" and hencforth "**subdioecious**."

Photos by Joseph Guite, October 2024 at **Tessentee Bottomlands Preserve**.

LEFT: Cluster of 4 squat and lumpy **female buds** next to the ripe seed.
RIGHT: **Male buds** are longer, numerous, and always in linear formation on the undersides of branchlets.


ABOVE: Connie Barlow took these photos while visiting the *Torreya taxifolia* collection at the Atlanta Botanical Garden in December 2007. The bulky, squarish FEMALE CONE buds (LEFT) are always few in number and near the branchlet tip. The MALE CONES (RIGHT) will produce pollen in the spring, and they are always more numerous and stretch a good distance along the underside of a branchlet.


ABOVE LEFT: vegetative buds.

ABOVE RIGHT: male pollen-producing buds. (photos by Fred Bess, spring 2016)

LEFT: The male structures release pollen sequentially over an extended period (photo by **Clint Bancroft**, Tennessee torreya planter).

In 2013 **AJ Bullard** demonstrated on his *Torreya taxifolia* tree in **Mt. Olive, North Carolina** that this species actually **will produce both female and male cones on the same individual**. This condition is termed **subdioecious**, and it is **documented in the Japanese Torreya**.

LEFT: Bullard is showing in the photo, on the same tree:

FEMALE cones on top branchlet.

MALE cones on middle branchlet.

VEGETATIVE BUDS on lowest branchlet.

(Photo by Connie Barlow)

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# 2024 Learnings

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## • November 2024: Conclusive experience that scarification of the seed does NOT speed up germination

November 18, 2024 JOE FACENDOLA of **Wilmington, NC** reported: "Scarification (to the point of total removal of shell) doesn't seem to help or hinder germination. The 2022 seeds with shell removed or kept whole still took until spring 2024 to germinate for me." And LAMAR MARSHALL in **Cowee Valley NC** also reported that his scarification experiment still yielded germination only after 2 winters.

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## • September 2024: Seedlings emerge July through August in northern states

JULY 11 is when the photo far left was taken in **Illinois**. The other photo was SEPTEMBER 5 within the same cage.

In the later photo, the first seedling appears dark green farther back and is fully developed. And now a new young seedling (lighter green and still short) appears in the foreground.

**Volunteer planters in the northern states have noticed that July is the earliest that a seedling will emerge from the ground.** However, when seeds are planted in pots, emergence usually happens earlier because (a) the soil is warmed by the air in a pot and (b) when the taproot hits bottom it likely puts up seedling growth earlier than when a root is unlimited by depth.

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## • March 2024: Confirmed that a significant portion of seeds require 3 winter stratifications before they will germinate.

This learning was pooled from the experiences of three Torreya Guardians:

(1) PHOTO LEFT: Early March 2024, **Connie Barlow in Ypsilanti MI** decided to check on how the NC seeds from the 2021 harvest were doing, after spending a **third winter stratifying**. She was **shocked and delighted that of the 45 seeds that had not germinated after their second winter stratification, 34 had already germinated by early March after their third winter.** Indeed, the roots had already lengthened so much (see photo left above) that they could easily break during shipment or even during careful planting near her home in southern Michigan. Statistics: **45 total seeds**, of which **34 had germinated**, 4 were dark gray (no longer healthy brown) and upon dissection were confirmed dead, 1 had a white wormy insect larva emerging from its round depression near the tip, 2 had the triple crack that precedes germination, and the remaining 4 had the customary thin slit at the tip that precedes the triple crack. (The experiment continued with the remaining 6 brown seeds.)

NUMERICAL SUMMARY:
Of 78 seeds after 2 winters = 29 germinated; 3 gray dead
Of 45 seeds after 3 winters = 34 germinated; 5 more dead; 6 seeds are testing for 4 winters.
Of 78 total seeds, at least 8 were duds (with 6 more still being tested)
Of 63 germinated seeds, **46% germinated after 2 winters and 54% after 3rd winter**

(2) PHOTO RIGHT: Mid December 2023, **Paul Camire of Capac MI** was surprised that he still had a **neglected bag of November 2021 harvested NC seeds** in his refrigerator. So he pulled out the bag and put it in his basement. Connie's early March report that her third-winter stratified seeds had already germinated prompted Paul to check his bag of 2021 seeds. He found that **two had just started to germinate** (photo above right).

(3) End of February 2024, **Mike Heim of Hayward WI** sent me photos of the 5 torreya seedlings that had emerged Summer of 2023 from NC seeds that Mike had planted directly into his deer exclosure right after the Fall harvest, November 2020. Thus, **it took 3 winters in the ground before those seeds produced seedlings**.

Mid-August 2024, Mike Heim took the photo left. This was **the third new seedling to appear this summer** from Torreya seeds directly planted into the deer-exlosure forest patch from **the 100 seeds Mike received November 2020** (half from Clinton NC and half from Mt. Olive NC seed harvests). Two conclusions:

(1) Seedlings emerge as late as mid-August.

(2) The 3 newly emerged seedlings this summer are the **first documentation of seeds taking 4 WINTER STRATIFICATIONS before showing above ground.**

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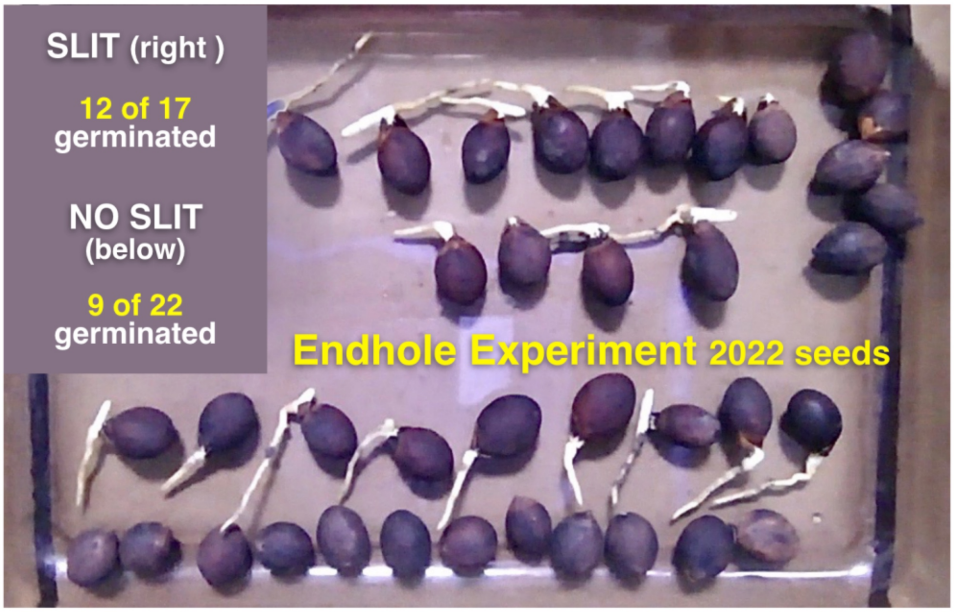
**• March 2024: A second "endhole" experiment, this time using seeds from the 2022 Clinton NC harvest, finds no problem with the trait.**




All 2022 seeds carried through 2 winter stratifications that began with the "end hole" feature are shown in this photo.

The top group entered 2nd winter stratification with slits.

**12 of the slit seeds germinated; 5 did not.**

The bottom set entered the 2nd winter with no slit.

**9 of the unslit seeds germinated; 12 did not.**

(Experiment in **Ypsilanti, MI**)

• **ENDHOLE EXPERIMENT CONCLUSION:** If one discovers a small depression at the round end of the seed (directly opposite of the germinating tip) there is **no reason to doubt the viability of the seed.** About half germinated after their second winter..

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# 2023 Learnings

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## • December 2023: Botany papers reveal that *Fusarium torreyae* is actually a mutualist, only becoming pathogenic when the host plant is stressed.

Summer 2023, the **USF&WS posted a new regulation that finally authorizes the first steps of "assisted migration" for climate-stressed endangered species**. This was accomplished by deleting the "historical range" standard that had previously constrained where "experimental populations" could be planted. This put Connie Barlow on a quest to ensure that Torreya Guardians was up-to-date on any new scholarship that might justify release of wild-genetic seeds to supplement the limited horticultural seeds we (and others) had been accessing for all such plantings. This was because **the two botanical gardens in Georgia** who controlled access to the ex situ wild-stock "safeguarding" orchards in northern Georgia had made **a policy decision that seed production would not be distributed (even though the seeds were too recalcitrant to store)**. Their decision was attributed to a stated risk that **because *Fusarium torreyae* was found "in all seeds"**, it might infect other native trees exposed to it.

Using Google Scholar, and also aided by the PLANT MICROBIOME page on wikipedia, Connie encountered a raft of recent botany papers concluding that **fungal propagules regularly found in seeds entail the SEED MICROBIOME** (a symbiotic subset of the plant microbiome). Such fungal partners, however, **may express pathogenically if a plant host becomes too stressed to produce seeds.**

IMPLICATIONS AND QUESTIONS: **Might this explain why *Fusarium torreyae* had first been detected in stem cankers within the historical range, yet subsequent observations had also detected it in all seeds produced in northern Georgia?** Might the professionals in charge of torreya seed policy not be aware of these recent papers — which entail a marked **paradigm shift**? As well, is there some way that Torreya Guardians could **ensure that these papers would be considered in the next 5-year plan update, due in 2025?**

Toward fostering professional and public awareness of technical papers that brought about this paradigm shift, **Connie posted a lengthy new webpage that links and excerpts the main papers**. She does this within a chronological framework that also lists and excerpts previous scholarship (beginning in 1967) exploring possible causes for the demise of Florida torreya within its historical range. She also produced **video introduction to the paradigm shift** and the history of scholarship pertaining to Florida torreya:

- **Published Documents on Endangerment Causes of *Torreya taxifolia***
  (Table of contents for this lengthy new webpage is below.)

- **VIDEO on the paradigm shift (2023)**
  (Title: "Assisted Migration of Climate-Endangered Plants - Torreya Guardians lead the way")



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## • October 2023: Full-sun growth form deters deer in S. New Hampshire


Photos above were taken by **Daein Ballard in southern New Hampshire** October 2023. Two of the 6 photos Daein Ballard sent us in December are shown here. Significant findings include:

(1) **At least in full-sun sites, torreyas as far north as southern New Hampsire will have 2 growth spurts annually** — just like we have documented in Tennessee. (This torreya is in Daein's backyard, maintained in full sun by lawn-mowing.)

(2) The **growth form in full sun is less yew-like than in shady habitat** (see the lower portion of the photo at right). **Daein reports** **that the full-sun leaf pattern deters deer**. This is likely because the deer cannot avoid getting **poked by the very sharp needle tips** when it tries to bite off the end of a lateral. See how this full-sun growth form is very similar to that already demonstrated by Fred Bess in Ohio. (Go to the **Cleveland-Ohio** page and scroll down to the October 2018 photos.) As yet untested is the possibility that the second growth spurt "hardens" earlier when the torreya is in full sun, thus achieving sharper leaf tips when deer begin to have to find winter food sources.

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## • November 2023: Cleveland Ohio is a bounteous producer of Torreya seeds

**FRED BESS is our Torreya Guardian in Parma, OHIO (a suburb of Cleveland).** He planted his orchard of 3 potted seedlings (obtained legally from Woodlanders Nursery in SC by driving there and back) plus one rooted branchlet (shrub form) in 2006 or 2007.

**First seed production began in 2017 with 5 seeds.** In 2018 there were 22 seeds. By 2022 his orchard produced approx 250 seeds.

PHOTOS LEFT: In **2023** there were too many to count with accuracy, but it may have been twice as many as the previous year.

Fred delivered 1,085 seeds to **Connie Barlow** in Ypsilanti, Michigan.

LEFT: Connie noticed **a clear, thin "cap"** on all seeds — and thus an **experiment**:

For winter stratification outdoors, she put **400 seeds with the cap removed into one pit, and 400 with just the flesh removed** into another pit.

HYPOTHESIS: **Perhaps when this ancient genus was dispersed by large herbivorous reptiles** who swallowed the seeds whole for the food value of just the fleshy aril. Passage through the system may have removed this clear, thin cap that covers just the pointy, germination tip of the seed. Is our own failure to remove this cap the reason why almost no seeds germinate after just one winter? (Most germinate after 2 winter stratifications.) Thus, **will the 400 seeds with caps removed show more first-winter germinations than the 400 seeds with intact caps?** UPDATE 2025: Apparently not.

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## • July 2023: It took 2.5 months for seedlings to emerge after free-planting GERMINATED seeds into a forest site

By Connie Barlow: Having retired to my home state of **southern Michigan**, I have been frustrated by the **overabundance of deer that destroy the understory** in just about every forested site I have explored. Folks who **began planting torreyas in Michigan** a half-dozen or more years ago find that **winter-hungry deer** will sometimes push down even the sturdiest cages.

So in **April 2023** I tried something new. **I selected massively tangled treefall sites** for planting already germinated torreya seeds. These were from the 2021 harvest in Clinton, NC. **None germinated after one winter stratifiction, but 39% germinated after two.**

After planting mid April, **it took 2.5 months for any of the already germinated seeds to show any above-ground growth.** Instead, torreya's big seed invests in a long and well furnished TAPROOT, which is crucial for surviving summer droughts.

At the **3-month point, 5 of the 10 seeds had produced seedlings**, only one of which had been nibbled down to a stub.

ABOVE: Photos show **the first two seedlings** (June 30 and July 5 photos), next to context photos of the **treefall tangles** where I chose to plant seeds in April. (I used round rocks to mark each planting.)

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## • May 2023: Most of the viable seeds will germinate after 2 winter stratifications

In accordance with what Torreya Guardians already knew, none of the 78 seeds remaining from Connie Barlow's share of the November 2021 seed harvest in North Carolina germinated after just one winter. But after a second winter stratification (buried in a small pit under a forest canopy), Connie found that 39% of them germinated between April and the end of May of 2023, and that no more germinated during the summer, while in moist soil at room temperature. She photographed and inventoried the results as follows:



ABOVE LEFT: For seeds harvested in November 2021, **after 1 winter stratification, there were no germinations** in the Spring of 2022. But Connie did notice and document a number of **changes in the seed coat** that some of them displayed, as shown by the labels in the photo left.

ABOVE RIGHT: After **a second winter stratification**, and during 2 months (April and May 2023) in moist, room-temperature soil, **39% germinated** (with no germinations after May).

Other learnings were:

• Whether or not a seed shows a **thin slit** on its germinating point makes no difference in next spring germination.

• Any seed with a **trifold crack** (wider than a slit) at the germinating point will germinate the next spring.

• Any seed with **punky (weak) regions on its seed coat** are just as likely to germinate as seeds with perfect coats.

• None of the 9 seeds (slit or unslit) that evidenced a **dark, circular depression at the opposite (round) end of the seed** germinated after their second winter. UPDATE: But see March 2024 entry above that a different batch (2022 harvest from Clinton NC), which had a lot of seeds with the "endhole" trait did largely germinate after only 2 winters.

More photos and commentary are at the **Ypsilanti, Michigan** Torreya page. Also visit the **"Germinating seeds"** section within our **"Propagation"** page for more photos and guidance from other Torreya Guardians, along with information gathered from scholarly papers.

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# 2022 Learnings

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## • September 2022: Proof that rooted cuttings from apical tips of basal stems will form basal sprouts

Finally, PHOTO LEFT BELOW, we have confirmation that not only will a rooted cutting of the apical tip of a basal stem grow into a tree-like (rather than shrubby) form, PHOTO RIGHT BELOW. **Now we know that it will also grow basals of its own!** This assures us that, as with its wild cousin California Torreya, Florida Torreya grown from apical basal cuttings will indeed be capable of manifesting the tree form again and again — no matter what injury may kill the main stem itself. Nobody has tried to guess whether the rootstock itself may endure for perhaps millennia, because annual growth rings do not form below the soil. (Even the well-studied **Coast Redwood** has not had this mystery answered.)

Both photos were contributed by **CLINT BANCROFT**, our **Torreya planter in Ocoee watershed** of Tennessee.

LEFT: SEPTEMBER 2022 - Basal sprout has formed on the lower stem of a rooted apical cutting of a basal stem harvested from the nearly century-old grove of Florida Torreyas at **Highlands, NC**. Clint harvested the cutting at Highlands in October 2017.

RIGHT: JUNE 2020 - One of the 7 apical cuttings from basal stems harvested at Highlands NC (October 2017) that rooted and is showing leader growth that confirms that basal stem cuttings will indeed produce a tree-like growth forms.

Visit **Clint's Torreya page** to see these photos and many more of his progress reports.

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## • July 4, 2022: Why even professionals mistakenly harvest seeds before ripe

**FRED BESS near CLEVELAND OHIO** is not only one of our **longest-term Florida Torreya planters**. He is the **record-setter for seed production in the northern states** — and he regularly photo-documents his progress. July 4, 2022 Fred reported:

> "My cutting-grown female has outdone herself! I have counted **close to 100 seeds just on 3 branches** (pics of two of them attached). I also find it humorous that **the bulk of the seeds are on the side facing the male** which, as you know, is a fair distance."

Cleveland: July 4, 2022

Cleveland: October 30, 2021

Fred Bess **waits nearly 4 months to ensure that his seemingly full-size torreya seeds are fully ripe**.

More photos and full chronological report:

- **FRED BESS near CLEVELAND OHIO**

LEARNING: Because torreya seeds appear nearly full size (and round shape) in early July, **even professionals may be fooled into harvesting the seeds too early**, in their attempt to prevent squirrels from snatching any. **Fred will be waiting another 3 to 4 months before the JULY 2022 seeds are harvested!** The casing of the seed shell is hidden — and it must fully harden before the seed is removed.


ABOVE: November 2013 Connie Barlow produced the first episode in the now-long series of Torreya Guardians videos. Click on either of the above photos to go directly to the 01:03:55 timecode of the youtube video, where **she dissects and compares (in a total of 7 minutes) a ripe purple "fruit" v. an unripe green one**. She discovered that **the fruit with the green flesh had no solid casing around the seed, whereas the fruit with the purple flesh had a solid (and difficult to saw through) seed casing**. Whether the unripe seed was more vulnerable to drying out or whether, even in a moist setting, might fail to ever fully develop the embryo, remains unknown. But the bottom line is **WAIT FOR SEEDS TO FULLY RIPEN before harvesting** — even if it means losing some to squirrels who may collect and bury them as soon as they fall.

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# 2021 Learnings

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## • November 2021: Three examples of why limiting Torreya plantings to PRIVATE lands is not a long-term solution for recovery

CONNIE BARLOW files this OPINION piece: In the early years of Torreya Guardians I had expectations that the number of landowners seeking to assist the northward migration of this glacial relict, critically endangered tree would be so great that **seed distribution could be limited to those having or agreeing to establish a conservation easement**. Conservation easements legally secure perpetual conservation — at least so long as our civilization continues. Thus far, I am aware of only two conservation easements in process among all the private landowners we have distributed seeds to during the past dozen years.

We have been lucky, thus far. I am aware of only one of our seed destinations (**Dayton, Ohio**) to have changed ownership. But surely there will be more. Meanwhile, over the past two years, we Torreya Guaradians have learned of **landscaping alterations impacting mature torreya trees at 3 private sites in North Carolina where we**

**have traditionally collected seeds** (with landowner permission, of course). Captioned photos of those sites follow.

## 1. HARBISON HOUSE - HIGHLANDS, NC:

October 2021, Clint Bancroft led the effort to harvest seeds at this **century-old horticultural planting**. This year the **owners are new**. What Clint found this year is a mixed blessing:

**Clearcutting of forest** in preparation for the new owner's desired landscaping went up to the north and east sides of the grove. Fortunately, "the new owners are aware of the trees and their rarity," reported Clint.

Thankfully, too, the 3 very tall offspring of the grove (up to 40 yards distant) have not been cut, though **the seedlings in the clearcut regions obviously did not survive**.

Torreya in its subcanopy natural habitat produces few seeds, no matter how big they are. (The team harvested just 64 seeds in 2021.) But **with sunlight now streaming in on two sides, seed production will surely increase** and Torreya Guardians can thereby distribute the unique genetics of this grove to even more places in the future.

PHOTO ABOVE: Preparing a device to reach high for collecting seeds from this closely spaced grove of **six mature torreyas** — now exposed on two sides by removal of neighboring trees.

## 2. MT OLIVE, NC:

A.J. Bullard established **two torreya trees** at his home in the 1990s, from which Connie Barlow initiated seed collection in 2013. A.J. died in 2020, and that fall his widow informed our collector, Joe Facendola, that **he must prune the tree branches encroaching on her driveway**; otherwise she would have her landscaper remove the trees. Joe complied and maintained good relations for collecting seeds again in 2021.

PHOTOS here show **before and after pruning** in 2020.

In 2020, Joe collected 1,060 seeds before pruning.

In 2021, Joe collected 1,480 seeds.

The taller tree is mostly male; the shorter tree is mostly female, from which the bulk of seed collection is taken.

## 3. CLINTON, NC:

In the 1990s, A.J. Bullard "discovered" two mature torreya trees in the front yard of the Kennedy home on College Street in Clinton, NC (likely to have been planted in the late 19th Century). He and his cousin received permission to gather seeds yearly. **In 1998 a hurricane toppled a big pine tree onto the biggest of the pair**, leaving

only the one (with two large basal stems) that is pictured below left. Torreya Guardians began collecting seeds in 2013, and the seeds have proved to be viable. But **could the genetics be dangerously inbred now? And, if not, then where do the seeds get their pollen from?**


ABOVE RIGHT: Clint Bancroft noted **2 short torreya trees in the backyard** of Mrs. Kennedy's home autumn 2020. Joe Facendola photo-documented this pair while seed collecting from the tall female in the front yard in 2021. No seeds were found on these short trees, but they could be producing pollen in the spring.

Joe collected 1,383 seeds in 2020; 670 seeds in 2021. Mrs. Kennedy has also encouraged Torreya Guardians to collect any seedlings we find. In 2020 Clint rescued a 2-foot tall torreya from too-close proximity to a camellia. In 2021, Joe rescued 13 seedlings, none older than about 3 years.

CAUSE FOR CONCERN: Joe reports that **the bases of both of the backyard torreyas showed signs of having been cut once or twice**, with basals re-emerging, just as they appear now. What if that happens again? ***What if the seed-producing elder tree loses a pollen source?***

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## • September 2021: Northern state planters should ensure seeds "epigenetically adapt"

**It makes a difference what climate a Torreya seed experiences during the months (and sometimes years!) while the embryo is slowly maturing**, prior to germination of the rootlike "radicle."

**An adaptive epigenetic memory in conifers with important implications for seed production**

Published online by Cambridge University Press: **24 January 2012**

Igor Yakovlev, Carl Gunnar Fossdal, Tore Skrøppa, Jorunn E. Olsen, Anne Hope Jahren and Øystein Johnsen

ADVICE FOR TORREYA PLANTERS: If you live in **the southern or central Appalachians**, it is surely fine for you to purchase and plant nursery-grown seedlings from more southern states (such as South Carolina and Georgia).

But **if you live in the northern states, it is important to acquire seeds directly and put those seeds into the outdoor ground ("freeplanting") so that they can experience a full winter at their ultimate destination prior to embryo maturation.**

Recent research (as in the **research paper above**) on commercially valuable conifers turned up **surprising abilities of seeds to permanently shift the ultimate budburst timing in the spring and vegetative hardening in the fall**. Because this has nothing to do with changes in the seed's DNA, it is called "epigenetic" adaptation, not genetic.

So, **for northern-state planters**, if you store your seeds in your refrigerator or germinate them in your basement, or if you purchase potted seedlings from a southern state nursery, your torreya trees may permanently be less capable of thriving in your climate than they would have been had you put seeds directly into their ultimate destinations in your forested property. **Genus Torreya** might have even more exceptional epigenetic talents than the younger Pinaceae conifers that have already been tested. Click the image above to read the technical science paper.

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# 2020 Learnings

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## • August 2020: Southern Ohio is excellent Torreya habitat now

Nearing the end of their **4th year after seed-planting in this fully rodent and deer protected garden edge**, these torreyas appear to be happy living in southwestern Ohio.

The learning here is not only that **southwestern Ohio is already a fine climate for Florida torreya**.

The learning is also that **protecting against seed predation by rodents and early browsing by deer and rodents is vital** for maximizing good results.

The PHOTO BELOW was taken by BOB MILLER August 2020. He lives in a rural section of Loveland, Ohio (northeast of Cincinnatti). This is the garden of his neighbor, who volunteered to shallow-plant 29 seeds in November 2015, just a few weeks after the seeds were harvested. Access the photo-rich multi-year webpage of **Torreya in Loveland in Ohio**.

It is a good thing that Bob initiated this planting off his own property, because almost all of the many seeds he planted directly into his forest were either predated by rodents or browsed down to nothing after germination (deer are abundant on his property).

LESSON: **The only reliable way to assess latitudinal and microsite suitability for Florida Torreya in assisted migration experiments requires:**

(1) Harvest seeds properly and get them into soil in ground or pots as quickly as possible (and without letting them dry out after husk removal).

(2) Fully protect against all herbivores until the torreys are tall and shrubby enough to regrow after occasional browsings.

(3) Document and report results.

## • August 2020: Evidence that Torreya is less susceptible to deer browse than Taxus (yew)

Richard Lawson of **Dawes Arboretum** (central Ohio) responded to an email report from Connie Barlow with a piece of relatively good news, given that site experiences of Torreya Guardians with their own young seedlings ranges from intensely destructive deer browsing to no browsing at all. In the latter instances, it is usually confirmed that deer are rarely seen in that locale. But at least it now seems that Torreya is not as attractive to deer as yew is:

> RICHARD LARSON: "Connie - Thanks for the update including the surprising reproductivity of the species in northern Ohio [the Torreya grove planted by Fred Bess near Cleveland]. At The Dawes Arboretum we are encouraged by the performance of *Torreya taxifolia*, although our plants are not yet reproductive. I would now expect that our plants will achieve maturity and cone production. **It appears also that the species is quite resistant to deer browse, and we are not obligated to fence them as with the closely related *Taxus* sp.**"
>
> August 25 addendum by Richard Larson: "I expected deer to browse them [the torreya seedlings] and we do fence young plants in every case even though when they mature, they are resistant or rarely immune. But **a recent planting has not been fenced for 2 years now and so far, no deer browse has been observed**. That is only one example of course and hardly translates into declaring them as resistant as Asimina, Buxus, Berberis, Spiraea, Cryptomeria or Cephalotaxus, but it seems promising."

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## • July 2020: Torreya seeds too big for Gopher Tortoises to swallow (and disperse by defecation) — but a giant AFRICAN SPURRED TORTOISE was successful.

In 2015, Jason Richardson, PhD Student, Department of Integrative Biology, University of South Florida, wrote to Torreya Guardian Lee Barnes to access seeds for a **REPTILIAN SEED DISPERSAL**: Feb 3, 2015, Jason Richardson wrote to Lee Barnes:

"... I would like a pack of seeds. I assume Connie or Jack had me added to this list. If you are unfamiliar, I am a PhD student at the University of South Florida. **For my dissertation, I am examining the effects gopher tortoises have on plant community composition, and also how they affect germination of seeds in their diet.** I am particularly interested in how they may enhance germination of rare and endangered plant seeds, and if they may be used in conservation efforts for such plants, and thus I emailed the Torreya Guardians about obtaining seeds." February 9: "I will be quantitatively testing germination rate and percentage as well as qualitatively examining the seed coat structure via electron microscopy. These two methods will be done both for ingested and non ingested seeds. I had not considered the stratification effects, could I get a pack of 20 of both stratified and non? More is always better for statistical analyses, but I think this will be a good start to see where it leads."

Note by Connie: **Lee sent Jason seeds fr the 2014 harvest, but they were already cleaned of the fleshy covering that would be what tortoises are interested in. JACK SENT 2015 SEEDS with green flesh.**

**2020 REPORT OF RESULTS by Jason Richardson** via July 21 email to Connie Barlow:

July 21, 2020, Jason Richardson wrote to Connie Barlow: "**Seeds were unable to be consumed by gopher tortoises (too large). Any possible chelonian seed disperser is probably extinct. Seeds were fed to a sulcata tortoise at Zoo Tampa. Some were crushed but we did manage to collect a good number of them passed seemingly intact.** I unfortunately had no germination success for these seeds, nor for the unpassed seeds. I have since graduated and am no longer working in science. If you are interested I can give you some other researchers who may be interested in trying to replicate or further this work."

Supplemental information by Connie Barlow: (1) Because Torreya seeds usually require 2 winters of cold stratification before germinating, it is possible that less time and/or insufficient cold were available for study prior to the need to publish results. (2) Richardson's PhD thesis can be found in full **here**; torreya seed experiments are not mentioned in it, however, "Seeds from the two fleshy-fruited species, O. humifosa and P. angustifolia, germinated in significantly greater proportions and faster after gut passage than seeds that did not pass through the gut." (3) **Wikipedia entry on Sulcata Tortoise**: "The African spurred tortoise (Centrochelys sulcata), also called the sulcata tortoise, is a species of tortoise, which inhabits the southern edge of the Sahara desert, in Africa. It is the third-largest species of tortoise in the world, **the largest species of mainland tortoise, and the only extant species in the genus Centrochelys**."

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# 2019 Learnings

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## • December 2019: Seeds stolen by rodent pop up as seedlings 200 feet away

PHOTOS: Left is Oct 12; Middle is Dec 29.

CLINT BANCROFT of southeastern Tennessee received 200 donated seeds from the Fall 2016 seed crop of a pair of 30-year-old Florida Torreyas in Medford, Oregon. Clint put the seeds in soil in a large outdoor pot within his fenced plant propagation area. But something dislodged the wire mesh cover over that pot and stole all but one of the seeds (which later germinated in that pot).

Nearly **3 years later, Clint stumbled upon 2 seedlings** that were a dozen feet from one another, but some **200 feet distant from the pilfered propagation zone**.

**FULL REPORT**

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## • August 2019: Apical cutting of basal clone recovers from herbivory

CLINT BANCROFT of southeastern Tennessee June 2019 report:

"I had an **apical cutting of a basal from Highlands NC, about 6 inches tall**, that had rooted. This year it put up a 6 inch vertical (no lateral growth, and looked beautiful. [SEE PHOTOS APRIL 2019 ENTRY BELOW.] I left it sitting on top of my cage, 4 feet off the ground, and damned if something did not **eat ALL of the new vertical, and also about 2 inches of the original cutting**. I suspect it will survive but I have lost a whole year's growth. It will be interesting to see if a chopped off, rooted, apical cutting will establish a new leader."


**Clint Bancroft** July 2019 update:

"Regarding my accidental experiment in which a **rooted apical cutting** had put up a new 6 inch vertical and then all but a few inches of the whole plant was eaten.

**"In just 2 months or so, the eaten-down stump is putting up what appears to be a new vertical leader.**"

*Note by Connie Barlow, August 2019:*

"I am reading about **Coast Redwood lignotubers and basal growth** and propagation now. Genus *Sequoia* and *Torreya*, ancient members of Cupressaceae Family, have probably survived this long thanks to their ability to produce new stems from basal growth if the original stem fails (or is logged). The term for what we see in the above photo is an **axillary bud** doing what it evolved to do — produce a new vertical leader. Apparently all single leaves produced on the vertical main stem each carry on their upper side a **suppressed axillary bud**. For redwoods, each of those buds can become either a vertical leader or a root, depending on whether it senses air or soil when hormones direct it to wake up. Apparently Torreya can do the same, so **we can actually obtain more than one vertical clone from each basal sprout we cut from.**

"One final note: More recently evolved members of the Cupressaceae Family maintain this ability (Juniperus), but members of the younger Pinaceae Family (pines, spruce, hemlock) have lost this ability to sprout basals and thereby reestablish vertical growth."

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## • July 2019: No leaf damage from -15F multi-day freeze, but severe damage from translocation sudden exposure to full sun

LEFT: **Paul Camire in Capac, Michigan** monitored this seedling as **-15F temperature ramped into -45 windchill**.

Snow was too minimal (below the left-most branch) to offer any wind protection.

The **dark green leaves made it through unharmed**, and the light green new growth indicates that **even the vegetative buds were unharmed**.

BELOW LEFT: In contrast, **even a single day exposure to full sunlight bleached and killed all upper leaves**, sparing a few on the lower branches. Nevertheless, this potted seedling is recovering. It is **producing abundant little green buds along the main stem**.

BELOW RIGHT: This seedling was in perfect condition until **the deciduous canopy overhead suddenly opened to full sunlight**, owing to the fall of a beetle-killed Ash tree. Notice the **bleached tips of leaves** on the middle layer branches, and the **bare branches at the upper level**, where bleached leaves have fallen away. Nonetheless, there is **strong recovery**: light green new growth at branch tips and 3 fresh lateral branches radiating from the leader.

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## • April 2019: California fires show *Torreya californica* resprouting basals after fire kills main stem and all the nearby pines

ZACH ST. GEORGE sent 4 photos of multi-age California Torreyas he saw during a hike in Stevenson State Park (northwest mountains of Napa Valley, north of San Francisco, Coast Range). He wrote:

"We walked through **a large area that had burned recently**, I'm thinking last fall.

It was a crown fire, and all of the mature trees (mostly pine) were dead.

A few oaks / tanoaks survived.

But I noticed a bunch of **torreyas coppicing around some dead trunks**. They were far bigger than the seedling pines that surrounded them, although I suspect the pines will catch up quickly."

*EDITOR'S NOTE:* Notice the yellow color of the Torreya standing trunks, after its bark had burnt and fallen fallen off. **Torreya's remarkable survival capacities** (the genus originated in the Jurassic) owe in part to its ability to prolifically sprout new stems from its root crown after the main stem is injured or killed. Notice how these **basals are already achieving a lot of photosynthesis — which is crucial in order for the individual to keep its roots alive**. Eventually, one or two of the basals will begin to rapidly grow tall, while the remaining basals continue to photosynthesize, so long as sunlight penetrates to their spot near the ground.

In 2005 I got a chance to visit and photograph **California Torreya** in the wild (see the **California Torreya section** of this website). **Viewing this sister torreya species in the wild made a huge difference in how I have scouted for ideal landscapes for planting Florida Torreya seeds and seedlings in the eastern USA.** Now with this post-fire photo, we have a significant new learning. And it means that **Paul Martin's 2004 indigenous fire hypothesis as the cause of Florida Torreya's inability to return northward during the Holocene is conclusively wrong.** Instead, my own favored hypothesis is that while the Chattahoochee River provided swift passage from the Appalachian Mountains southward to the Apalachicola of Florida during glacial cooling, Torreya's seed was unable to tap into river flow in order to return to favorable climates as the Holocene warmed. Learn more about how **my own visit to the Chattahoochee River in 2015** generated my river-flow hypothesis.

## • April 2019: Proof that cutting of basal leader tip yields tree-form Torreya

April 24 email from Clint Bancroft (**Torreya planter in Ocoee watershed** of Tennessee) to Connie Barlow:

> "Look at the new growth on this cutting from Harbison House (Highlands, NC)! The cutting is the **apical tip from a basal** of one of the mature trees."

LEFT: by Clint Bancroft, is April 2019 of **a rooted cutting (collected October 2017) that displays superb vertical growth**.

RIGHT: by Connie Barlow 2006, during a Torreya Guardians site visit to the near-century old **Harbison House Torreya grove**, near Highlands NC. Notice the prolific basal sprouting, of various ages.

LEARNING: The original cuttings of wild specimens in the Florida panhandle (some of which now entail **orchards in the two official ex-situ plantings in northern Georgia**) were collected three decades ago from branches that necessarily assume shrubby growth forms. Wild stock was so weak that cutting of basal terminals would not have been appropriate. However, **when collecting vegetative growth from healthy horticultural plantings in northward states, we now know that apical growth of basals are essential for ultimately producing tree forms**.

MARCH 2020 UPDATE:

PHOTO LEFT shows how the **4 lateral buds** visible in the April 2019 photo above expanded in the growing season of 2019 and then flourished through the winter. Clint Bancroft took this new photo after he slipped the young plant out of its pot for planting into his wild regrowth forest, amidst many other torreyas already thriving there.

Visit Clint's **Ocoee Tennessee Torreya webpage** for more details, and especially for a close look at the superb root development of this specimen.

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## • March 2019: "Endangerment Causes" webpage expanded for scholars

This LEARNINGS webpage features site-specific discoveries and documentation in the field. However, this particular entry is a distillation of the **scholarship and argumentation** pro and con assisted migration of Florida Torreya specifically and the much larger and wider **debate on assisted migration as a climate adaptation tool**, even for common native species, that has been playing out in scientific journals and news media.

The **"Endangered (causes of)" webpage** has been online (and periodically updated) for more than a dozen years. However, in 2019 it seemed time to reconfigure the text for ease of use and to distinguish the background, objective summaries (with key links) from Torreya Guardians advocacy sections.

Two events in 2018 indicated a reconfiguration was in order: In March 2018, **genetic engineering of the Torreya genome was advocated by a University of Florida forest pathologist**. And in August of 2018 the U.S. Fish & Wildlife Service announced that **the 2010 recovery plan would be updated in 2019**.

# At the Brink of Extinction — *Why?*

webpage assembled by Connie Barlow
founder of Torreya Guardians
(updated April 2019)

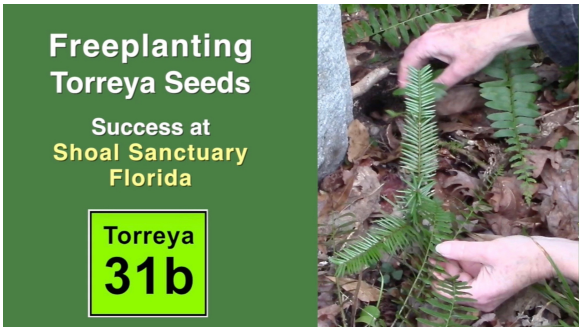


LEFT: Annotated access to key documents is sectioned into six parts.

## • January 2019: First Herbivory-Free Site is Video-Documented

**Shoal Sanctuary, Florida** - 30 January 2019 - **VIDEO 31a** and **VIDEO 31b**

Site visit by Connie Barlow to **Shoal Sanctuary**, due west of Torreya's peak glacial refuge in northern Florida. Documentation of **9 seedlings thriving (and remarkably free of herbivory)** four years after 40 seeds were placed directly into the coolest, moistest habitats. Microsite distinctions portend excellent learnings in the years ahead.




The last part of the video set **summarizes the documentation and offers topics for further study** — notably, **why herbivory was absent at all planting sites**.

Native **Christmas Ferns** are shown as ideal neighbors for:

(1) camouflage

(2) its "endo" mycorrhizal network

(3) as an "indicator species" of best microsites for Torreya.

UPDATE: March 2019, another **herbivory-free** torreya planting was video-documented. This very rural site is in southeastern TN, within the **Ocoee watershed of Tennessee**.

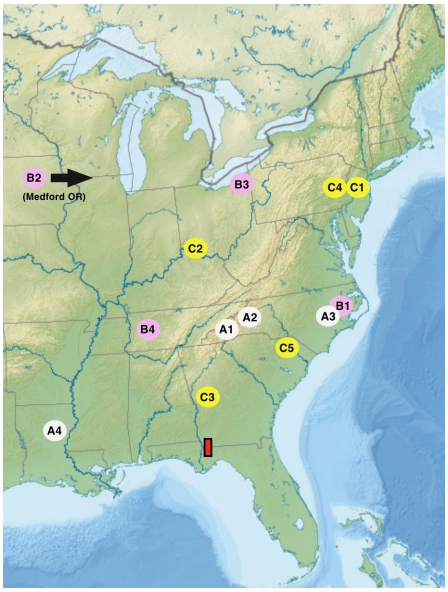
# 2018 Learnings

## 2018 SUMMARIES of Evidence that Clears the Way for Assisted Migration

Throughout the past 14 years, **Torreya Guardians have site-visited and photo-documented horticultural plantings of Florida Torreya in northward states** that are at least 50 years old. **Because the 2010 official recovery plan will be updated in 2020**, Connie Barlow aggregated what these groves teach us onto a new webpage:

### • SUMMARY 1: Historic Groves of Torreya Trees: Long-Term Experiments in Assisted Migration

Lack of documentation establishing the combination of thrival and non-invasiveness were the **key obstacles to adding an assisted migration action to the management plan** for Florida Torreya during the plan update in 2010.




The advisor whose written statement objected to northward experimentation is listed as **Ms. Tova Spector** (Florida Park Service). Her **objection** is quoted on p. 25 of the **2010 Recovery Plan Update**. She stated:

> "The reason for not moving ***Torreya taxifolia*** outside of its range was addressed by **Mark Schwartz, 2005**. Moving Torreya outside of its range would alter the natural community where it is introduced. In addition the species may be susceptible to decline from factors in the introduced location. Instead trees should be safeguarded in botanical collections until the causal agent(s) for its decline can be mitigated in its historical range."
>
> "... If assisted migration is going to be used sparingly, and only in conditions where the need is dire, then **the conservation community should begin now to specify and advertise a consensus view on when this may be appropriate**." As I stated in this document, before an emergency plan is implemented, **guidelines should be developed**."

After the 2010 RECOVERY PLAN UPDATE, Torreya Guardians actively began seeking out and photo-documenting the existing **"HISTORIC GROVES"** of *Torreya taxifolia* planted north of its peak glacial range in Florida. By aggregating our findings into **a single new webpage in 2018**, it became possible for others to easily access the factual documentation and thus **reasonably share our conclusion that:**

(1) Torreya can **thrive and naturalize** in northward states.
(2) It will **not become invasive if assisted to migrate north**.

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## • SUMMARY 2: Academic Papers Trending Toward Assisted Migration

*Much has been learned in the eight years following the 2010 plan update, including:*

(a) ACADEMIC PAPERS ON ASSISTED MIGRATION. **Prof. Mark Schwartz**, whose **2005 paper** was listed in the above quotation as the scientific basis for not authorizing an assisted migration experiment in the 2010 plan update, became **lead author in 2012 of a 31 co-author paper that established guidelines for assessing the risks** (including non-thrival and possible invasiveness) prior to conducting "managed relocation" of a climate-challenged species. And in 2009 he was coauthor of a 22-author paper, **"Multidimensional Evaluation of Managed Relocation"**, the data supplement of which applies an evaluative framework to three case studies, the second of which is **Case 2: "Translocating *Torreya taxifolia* to the Southern Appalachians"**. That 2009 case study, combined with the 2018 compilation of **Historic Groves** documentation by Torreya Guardians, offer a combination of **field evidence and academic evaluation supportive of assisted migration** for this left-behind **glacial relict species**. Heightened scientific projections of the magnitude and rate of **ongoing climate change** (IPCC 2018 report) should also play a role in the 2020 recovery plan update, as should the positive attention afforded assisted migration in parks management reported in the **Jan-Feb 2019 issue of *Sierra Magazine*** and its inclusion in chapters 7 and 28 of our nation's **Fourth National Climate Assessment**, November 2018. As well, a 42-coauthor review paper published in 2018 can help advisors and decision-makers put Florida Torreya considerations within the context of leading-edge academic understandings at the global scale: **"REVIEW PAPER: Managing consequences of climate-driven species redistribution requires integration of ecology, conservation and social science**.

(b) TORREYA SEEDS CANNOT BE STORED. **Torreya's seed is recalcitrant and cannot be stored** except via cryo-preservation following laboratory manipulation of tissue culture via **"somatic embryogenesis"**. The thousands of seeds currently being produced ex situ must therefore be used for plantings or will be lost. They cannot be inexpensively stored. Also in 2018, a paper published in *Nature Plants* confirmed that a large proportion of plants (especially endangered plants and notably trees) have recalcitrant seeds that cannot be stored: **"Seed banking not an option for many threatened plants"**.

(c) ASSISTED MIGRATION AS MODERATE COMPARED TO GENETIC ENGINEERING. **All attempts to ensure Torreya survival in the soil and other conditions within the geographic boundaries of Torreya's native Florida range have failed**. In 2018 **genetic engineering of the genome was offered to infuse disease resistance**. Authorizing assisted migration experiments would be a moderate next step compared to moving forward with genetic manipulation.

(d) **Forestry researchers have charted the way** for assisting the poleward movement of tree species and genetically distinct populations of trees during what is now widely acknowledged as a century of climate change far more rapid than seeds of many species can disperse. Conservation biologists can quickly access the **key forestry research papers on assisted migration** to ensure that their own understandings are congruent with the imperatives of climate change adaptation, as pioneered by forestry researchers who compute **how climate projections will affect range shifts of America's native trees species**.

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## • 2018 Documentation: Free-Planting Torreya Seeds directly into forest habitats

*A NEW WEBPAGE of LEARNINGS by Torreya Guardians (posted December 2018) may assist the recovery of Torreya taxifolia in a very practical way:* ***Assisted migration experiments can be implemented inexpensively****:*

More than a **half-dozen Torreya Guardians** began experimenting (as early as 2011) with **"free-planting" seeds directly into their ultimate within-forest destinations**. This new technique bypasses the labor-intensive, bulky, and potentially costly initial phase of poleward plantings that germinates seeds in pots or wire-protected soil beds prior to final planting (which, again, has often included wire cages for each specimen). **In 2018 results were aggregated into a new photo-rich webpage, which will be updated ongoingly**.


Results are presented in topical sections:

- Risks and Advantages of Free-Planting
- Learnings 1: Seed Harvesting, Storage, Germination
- Learnings 2: Techniques To Deter Seed Predators
- Learnings 3: Torreya Recovers from Herbivory
- Learnings 4: Siting to Minimize Above-Ground Herbivory
- Learnings 5: Siting to Minimize Antler Rubbing
- Learnings 6: Siting for Myccorrhizal Connections
- Learnings 7: Natural Seedlings in Historic Groves

**Photo-rich WEBPAGE**

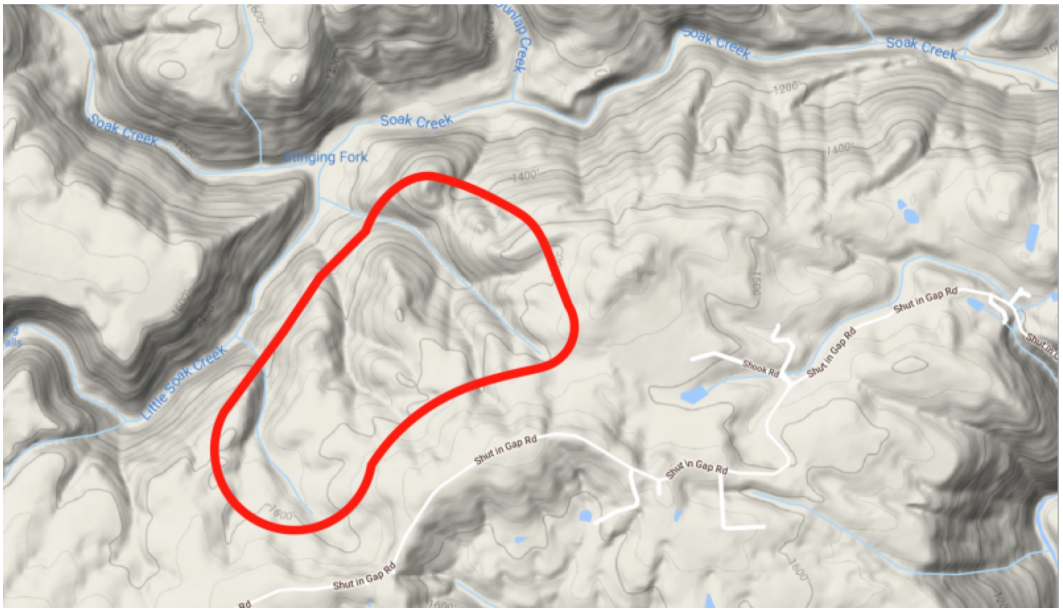

Field documentation of the 6 seedlings that grew and survived with no human help, following **"free-planting" of 15 seeds directly into forest soil** in April 2015. **Russ Regnery** was the planter, within his forest at 3,800 feet elevation on the slope of Black Rock Mountain, near Franklin NC. Video clips of the 2015 planting (Episode 12) are matched with the actual seedlings closely photographed and analyzed Nov 2018. Results: Four summers later, this species exhibits **remarkable capacities to recover from early stem and leaf herbivory**.

**VIDEO 28: Free-Planting Florida Torreya - 2018 Update**

Free-planting experiments have ranged from projects of just 6 seeds to 400 seeds. Our **400-seed planting family, Chris and Christina Anderson (Spring City, TN)** have become our foremost example of how **free-planting can be done quickly, inexpensively, and well documented** (flagged) to facilitate year-by-year appraisals of results:

November 2015 **Chris and Christina Anderson planted 400 seeds over the course of two days** in several sections of their 232 acres on an eastern ridge of the Cumberland Plateau.

All planting sites were **marked with colored flags**, using **best practices**: placing a rock atop each seed or planting 3 inches (or more) deep.




**Most seeds were planted within two ravines** (visible at the SW and NE edges of the bounded red section shown on this map. Some were also planted along the firebreak jeep trail in the uplands, as these sites can regularly be checked without walking off-trail.

Canopy cover where plantings occurred are mostly **deciduous**, with some old **hemlock groves in the deepest ravine**.

**First seedlings** were observed August and September of 2017. Chris Anderson guided Connie Barlow (and her video camera) on a site visit November 2017:


**VIDEO 24: Florida Torreya to Cumberland Plateau - Rewilding an Endangered Tree**

By far **the most expansive and exciting experiment in "rewilding" Torreya taxifolia into northward states** began in November 2015 on the Cumberland Plateau of Tennessee. All **400 seeds were "free-planted"** directly into the ground — either 3 inches deep or under rocks — to protect the seed from rodent predation. Two years later, Connie Barlow video-documented the beginning success of **38 new seedlings**.

**Part 1** (24 minutes) • **Part 2** (23 minutes) *filmed November 2017*

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## • 2018: Free-Planting Learnings used to update instructions to planters

Our **webpage of ADVICE FOR PROPAGATING TORREYA** has been updated to offer clear advice of **Best Practices for Free-Planting Seeds**:

**1. TO DETER SEED PREDATION: Plant seeds at least 3 inches deep (4 to 6 inches may be best).** Flat rocks placed over a seed may also help, but the dangers of rocks are that they attract ants, may prevent the seed from accessing rain, and may force the germinating stem to circle around before finding a way to pop out the side (usually upslope). See PHOTOS of good and bad results at this section of our **detailed free-planting webpage**.

**2. TO DETER ABOVE-GROUND HERBIVORY:** Newly emerged stems and leaves are vulnerable to toothed herbivores upon emergence. Even when the needle-like leaf tips harden, deer and rodents may still nibble and sample. As a subcanopy-adapted tree, Torreya is usually capable of regrowing — again and again, very quickly adding extra vertical stems (as well as regrowing lateral branches) so that the little seedling becomes less and less vulnerable to herbivory as the years pass. (See **photos of herbivory recovery** on our free-planting webpage.) As of 2019, we have several siting recommendations for free-planted seeds that are not given any wire protection upon germination:

**2A. PLANT SEEDS WHERE DEER ARE LEAST LIKELY TO VENTURE:** Possibilities include a deep densely vegetated ravine and the steepest slope you can find. Possibly within the thicket of branches of a recent (but beware that vole tunnels may be abundant there).

**2B. PLANT SEEDS WITHIN THE OUTER REACH OF EVERGREEN FERNS.** Fall of 2018, **three locations documented** that the only free-planted individuals that had escaped above-ground

herbivory after three or more years were **camouflaged during the winter by evergreen fern fronds**. One of the three examples is shown in photos below.

♦ FIND THE TORREYA IN THE PHOTO DIRECTLY BELOW:

The Torreya LEFT has the same camera angle as the photo ABOVE, so you can definitely find it on your own. This perfect little seedling showed **no sign of herbivory**. (December 2018)

This was the only one of 13 emerged seedlings camouflaged by **Christmas fern fronds** — and it was the only one not damaged by herbivory.

This rural area of NE Alabama is a patchwork of cattle grazing and other fields, regrowth forest, and routine logging. **Deer** are not abundant and certainly not overpopulated here. But prints do turn up regularly in muddy sections of this forest.

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## • 2018: The health of torreyas in BILTMORE GARDENS (NC) boosts the argument AGAINST GENETIC ENGINEERING

By the 1950s one or more of a number of documented diseases was consistently resulting in stem dieback of a great proportion of Torreya specimens in their native Florida habitat. **Until 2010, the posited disease agents were multiple (and included below-ground diseases that perhaps weakened the plant enough to undermine its evolved ability to fight off native water molds, including the then-identified stem-canker agent, *Fusarium lateritium*). Beginning in 2010, a single canker disease agent was the focus of Prof. Jason Smith's inquiry.** This led to today's widely reported conclusion that Smith's newly named *Fusarium torreyae* is itself the cause of stem dieback today, and presumably was the cause in the 1950s too. **The crucial observation — that the Fusarium is already present at a northward site** — was reported by Jason Smith (in an email to Torreya Guardian Connie Barlow, 20 February 2018). Smith wrote:

> There is no doubt in my mind that the primary driver in the mortality of the trees is the pathogen. It is reasonable to assume that it is easily moved around. Furthermore, my M.S. Student, **Aaron Trulock, completed a study** that demonstrated that several conifer species native to the southern Appalachians are susceptible, with a couple of species being highly susceptible (Fraser fir, hemlock).... This raise a flag of caution that any planted material there should come from disease-free trees and

> every effort should go into not introducing it. **We did confirm that the trees at Biltmore Estate in Asheville already are infected**, for example… [the end ellipsis was in the original]

**Eight months after receiving Smith's email, Connie Barlow had an opportunity to visit Biltmore Gardens** for about the fifth time since she began work on her 2001 book, ***The Ghosts of Evolution***, during which Torreya's status as a left-behind glacial relict sparked her interest. **October 2018 Barlow visited the Biltmore Torreyas and observed good health**, male and female first-year cone buds, and one (previously unreported sapling; photo below right) with 23 ripening seeds. See photos below:


Several previous text sources also mention stem canker as present at the Biltmore Gardens in North Carolina, so **the pathogen has presumably had more than three decades to manifest serious injuries**. Page 3 of the **1986 original recovery plan** states:

> Mature torreya trees exist in cultivation at the **Biltmore** House and Gardens near Asheville, North Carolina, but even there, **seedlings and young trees show blight symptoms similar to those seen in trees in Florida**. There has been no testing or identification of pathogens from the trees at Biltmore. **The 14 large trees, approximately 40 years old, show occasional lesions but appear to be healthy. They may have escaped more serious symptoms because they suffer little water stress in the cool, moist climate** (Barnes 1983a, Turnage 1985).

Torreya Guardians have repeatedly **documented healthy stems and cone production** on original and naturally recruited specimens at the Biltmore. Photographs and videos posted online enable other parties to view and interpret this conclusion. If our declaration of health is corroborated by Biltmore horticultural staff, and if others so interpret by viewing the photos and videos, **then northward translocation is a well-supported strategy for species recovery**. Moreover, existing and potential translocations comprise a far less controversial approach than does **a University of Florida proposal for genetic manipulation** aimed at inserting disease resistance (from a different plant taxon) so that the peak-glacial refuge might be restocked with engineered embryos that could possibly cope with a too-warm (and still warming) climate zone.

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## • 2018: Documentation of Adaptive Growth Forms (10 YEAR RESULTS)

UPDATED WEBPAGE: The **Lake Junaluska** locale in North Carolina (planted with 10 potted seedlings in 2008) offers insights for helping endangered species recovery ten years later. ADAPTIVE GROWTH FORMS is one of the key insights:

> ADAPTIVE GROWTH FORMS - **If afforded the opportunity to grow in open sunlight, Torreya takes the form of a standard conifer. If the habitat is shaded subcanopy, its form is yew-like and growth is much slower.** Because Torreya genus is not a pioneer-sere taxon, only human intervention in cutting back overgrowth shade can maximize Torreya's growth potential and induce an upright form (and early seed production). As of 2018, no reproductive structures have been observed on even the tallest individuals.

1. HORIZONTAL V. VERTICAL GROWTH FORMS:


**VIDEO 29: Florida Torreya to Lake Junaluska NC - 2018 update**

Ten years after the 2008 planting of ten potted seedlings as a first "assisted migration" project (reported on by ***Audubon Magazine***), Connie Barlow returns to **document ongoing results**. The challenges, the successes, and the learnings are all topics covered here and also on the **Lake Junaluska webpage**.

A key learning is how Torreya is capable of **adapting its growth form** to conditions of shade (horizontal, yew-like form) or abundant sunlight (standard conifer form).

2. LONG, GROUND-LYING BRANCH ADAPTATION:

Autumn 2018 Torreya Guardians Clint Bancroft and Connie Barlow visited 3 mature Florida Torreyas planted 68 years ago at **DORMON NATURE PRESERVE** in north-central Louisiana.

PHOTO LEFT: At Louisiana's Dormon Preserve, Torreya Guardians photo-documented the **third example of the ground-trending, long-branch growth form** that we had documented previously at two North Carolina sites of near-century-old groves.

The photo appears on the new in 2018 **Louisiana Torreya** webpage. Barlow used site visit video to publish a **70-minute VIDEO** in two parts (episodes 30a and 30b) **"Florida Torreya in Louisiana - Mature Grove with Seedlings"**.

One **hypothesis** for the conditions that trigger this growth form is that a torreya tree that begins its life in open sunlight (and thus assumes a vertical-trending, conical conifer form), has **a back-up adaptation if and when fast-growing species of trees close in and begin to overtop it**. That growth form is this:

> GROWTH FORM ADAPTATION TO OVERTOPPING: One (or more) of Torreya's lower branches on the sunniest side, usually south-facing, and which emerge no more than 3 feet above ground on the main stem, will reestablish fast horizontal growth. The branches will be supported by the ground in their quest to reach sunlight. When direct sunlight is accessed, the branch thickly fills out leaves and branchlets to maximize solar collection. Branch lengths easily reach out **20 or 30 feet distance from the main stem**, while the thickness of the branch at trunk emergence remains uncharacteristically thin, thanks to ground-level support.

The photos below show the same ground-lying branch form at two other mature groves:

BELOW LEFT is **BILTMORE (NC)** 2018. Right is **HARBISON HOUSE (NC)** 2015 with Jack Johnston.

NOTE: A USFS webpage has this mention of the LAYERING growth habit: "California nutmeg sprouts from the roots, root crown, and bole following damage to aboveground portions of the tree [3,10,19]. Some nutmegs

**reproduce by layering** [21], but the layering capacity of California nutmeg is unknown." See: **USFS "Fire Effects" species page on Torreya californica**.

3. FULL EXPOSURE PRODUCES DENSE FORM (and COLD CLIMATE HIDDEN SEEDS)

While more photos and comparisons are needed, it is becoming apparent that **in full-exposure sites, Florida Torreya assumes a much denser growth form** than when in shady, inner forest sites. Two photos immediately below show dense growth forms in New York (below left) and also in North Carolina (below right).


ABOVE LEFT (NY): Famed botanist **H.W. Sargent** wrote a supplement to *Treatise on the Theory and Practice of Landscape Gardening*, by A.J. Downing, 6th edition published in 1859. See also his description on **page 49** of the February 1859 issue of *American Agriculturalist*, which includes "**My best specimen is about 10 feet high, very dense, showing nothing but foliage** like a dense arbor vitae and remarkable, particularly in the Winter, for the star like appearance of the extreme tip of its young shoots. I have reports of this tree from Elizabethtown N.J., Dobbs Ferry, Yorkville, Flushing, and Newport, in all of which places it succeeds well; considered hardy except in Newport where it is reported tender."

This *Torreya taxifolia* specimen is attributed to Sargent's own property at his home in **Beacon, NY**. Peter Del Tredici (pers comm. 2019) wrote, "It might be the first image of a cultivated specimen of the tree." Its caption reads: "Torreya taxifolia, at Wodenethe, Age, 6 years. Height, 8 feet. Circumference 20 ft." Note: **Sargent himself clarified the fate of this specimen in the November 1875 issue** of *American Agriculturalist*, **page 428**:

> "I can supply the history: Mr. Downing for many years kept the plant in his greenhouse, and when this was broken up, he gave it to me. I then subjected it to a course of treatment detail on pages 475-76 of my edition of *Downing's Landscape Gardening*, until it became ten feet high and quite as wide. **After several years of apparent hardiness, it suddenly turned brown in the course of one night**, and perished in a few days in the month of April, after going through the winter, and many previous winters without flinching. I always supposed that just as the sap was starting, it suddenly received a coupe de vent, as the French would say, i.e., some peculiar draft of wind, which gave it its death."

ABOVE RIGHT (NC): East of the mountains of North Carolina is Mt. Olive, home of A.J. Bullard, well known botanical naturalist. Here he stands in front of 2 specimens he planted at his home (photo October 2013 by Connie Barlow). See **photo-essay of Mt. Olive torreyas**.

BELOW (OH): The three fully exposed Florida Torreya trees at the home of **Fred Bess near Cleveland OH** exemplify the dense form. Biting winter winds, of course, killed the north windward side leaves when the protected potted seedlings were first planted out. But new growth adapted. **Periodic branchlet diebacks in extreme winter conditions naturally "prune" the trees into even denser forms.**

Most interesting is that the **seeds all seem to be at wind-protected inner locations on the south side of the tree** (see photos immediately below in October 2018 section). Because the female reproductive structures are pollinated during one growth season and must survive a full winter before ripening autumn of the following year, it is possible that the reason for the inner location of seeds is that nascent seeds on the outer branches are generally killed during the winter.

Or, possibly, the tree simply installs its female structures at greater depth than it does in warmer climes. More observations will be helpful.

PHOTOS BELOW show Fred Bess and Connie Barlow search for seeds within the inner depths on the south side of the female tree. (Female tree is far right in the photo above.) All photos taken October 2018.

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## • October 2018: Parma OHIO seed-grown Torreya female produces 19 seeds

**Connie Barlow** and owner-grower **Fred Bess** search for seeds on October 2. **All 19 are on the sunniest side of the tree** (see the tall Blue Spruce at far right). **All seeds are hidden/protected from winter winds by growing on interior branchlets** of the kind of dense, Christmas-tree form that Torreya saplings assume when afforded a lot of sun. (Surroundings must be mowed to make this possible; otherwise, regrowth forest and shrubs shoot up much faster than torreya can grow.)

The seeds will become orange-purple when ripe in late October. **Squirrels will likely be able to steal the seeds** from the lowest branches, but **the needles are so sharp** (notice the gloved hands) and the tree so shrubby that the several that are 2 or 3 feet high may be safe from rodents.

Visit the **Parma Ohio Torreya** webpage, for the full image-rich, year-by-year report of Fred's set of four torreyas (2 females, 2 males), and **WATCH VIDEO** (below):


KEY FINDINGS:

1. These trees have put forth **leaves well acclimated to severe cold spells** in Ohio.

2. **Seeds are produced only on the branches that receive nearly full sun.** (Connie notes from her **2005 site visit to wild California Torreya** habitat that this seems to be a standard of the genus.)

**VIDEO**: 14 minutes, *filmed 2 October 2018*

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## • October 2018: Compilation of 14 years of Biltmore photos document torreya's basal sprout adaptation

**February 2004 was Connie Barlow's first visit to the naturalized grove of Florida Torreya at Biltmore Gardens (Asheville NC).** This was the year that she and Lee Barnes and Paul S. Martin formed Torreya Guardians — and began to take action and advocate for poleward planting of this trapped glacial relict.

Accordingly, she was keen on **photo-documenting the set of original, 75-year-old trees and also their many sapling offspring in the surrounds.** In September of 2004, the gardens were hit by destructive winds of two hurricanes. In 2006, Connie returned and photographed the damages — and what happened to the mature torreys when they were newly exposed to sun, owing to the windthrow loss of their white pine overstory.

PHOTO LEFT: Her next visit was 2015, at which time she videoed the changes, including an **abundance of basal sprouts emanating from the root crown of the top-cut specimens**.

October 2018 marked her most recent visit. Again, she documented the changes.

There is a great deal to learn by viewing this sequence of 14 years of changes at this subsection of our Biltmore Torreya page: **"2004-2018 Hurricane Damage and Basal Growth:" photos by Connie Barlow**

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## • February 2018: Learning Florida Torreya's capabilities by visiting its California cousin

**In 2005, Connie Barlow visited 4 forested regions in California where *Torreya californica* could be found growing in the wild.** Her aim was to experience and photo-record observations of the trees and their surrounds such that volunteer planters of the Torreya species native to the eastern USA (along with professionals in charge of this endangered species' recovery) could **discern habitat preferences of the genus** and thus pinpoint similar environments in eastern states for planting seeds and seedlings.


**Photo-essays of California Torreyas** from her 2005 site visits have long been posted on this website.

In 2018 she edited them into a VIDEOBLOG in two parts:

**Part 1** (25 minutes)

**Part 2** (27 minutes).

Key photos include those that demonstrate the ability of *Torreya californica* (a subcanopy tree) to grow on **exceptionally steep and shady slopes** — even in the company of forest giants such as Coast Redwoods and Douglas-fir.

LEFT: Connie extends measuring tape around one trunk of a double-trunked tree in Kings Canyon Sequoia National Park.

MIDDLE: This genus keeps resprouting new basal stems, even when disease-free, in quest of sunlight. The moss-laden left-leaning stem is still alive and has sprouted a series of vertical branches along its now-horizontal stem (Coast Range near Calistoga).

RIGHT: Another example of a downslope-leaning healthy stem sporting vertical stems reaching for dappled sunlight. (Coast Range near Calistoga).

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# 2017 Learnings

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## • December 2017: Torreya seedlings are HARDY IN NEW HAMPSHIRE

**Daein Ballard in Mason, NH** received seeds from 2013 harvest, germinated them in his greenhouse, then outplanted the seedlings in 2015. Two years later he reports:

> "**This year (2017) no more of the Torreyas from the first planting died.** We had a wetter than usual year and I'm not sure if that was a shocker for them after last year's drought. However, **only a few seeds that I planted out a couple years ago germinated, and all of the new seedlings were eaten by rodents**. I have seedlings from Jeff that are from the same stock/year as those that I will plant out in the spring.
>
> "It seems to me **Torreya can survive in a central New England climate like mine, though the competition from other better-adapted trees may be a bit stiff for them.** **Although the Torreya's endurance (for my climate) as seedlings seems mid-range from the other trees I've dealt with.** They don't sprout nearly as aggressively as Chestnuts or Oaks. They do however seem to be more tolerant of environmental changes after they have sprouted (Chestnut and Oak seedlings died where Torreya survived in last year's drought). **They are much heartier than the Pawpaws I planted (not one seed germinated and the seedlings need to be babied). The healthier Torreya I had that I planted in full sun lost most of their needles pretty quickly last spring due to the drought the previous year. They put on new growth but time will tell if they recover.**

"I've also attached pics [left] of the potted seedling Jeff gave me a few years ago. It's done great where I planted it.

"**We got hit by a snow storm followed by an ice storm and it's still doing good.**

"The female rooted cutting I got from Nearly Native Nursery is also doing well.

"The branch that broke last winter seems to have completely healed and recovered. It also pulled through the ice storm. **It'll be interesting to see how these trees fare when they are larger and get hit by an ice storm.**

"I have a feeling the seed-grown trees will do better due to their Christmas-Tree shape vs. the random bush-like shape of the rooted cuttings."

0CTOBER 2018 UPDATE (**Daein Ballard, Mason NH)**: "It seems that **direct contact with ice on the Torreya needles damages them**. Snow that falls on them doesn't seem to cause damage (in fact, **snow seems to provide protection**), but it's **when it rains on them and then the rain freezes on the needle**. I looked around and I was **surprised no one has seemed to notice this before**, since ice storms are more common in the south than in New England."

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## • November 2017: Superb way to naturally DETER RODENTS

**1. WHEN "FREE-PLANTING" SEEDS:** Although there are no ways to absolutely ensure against losses when "free-planting" Torreya seeds directly into forest soil, we now have enough experimental evidence to suggest some

**best practices** for this form of planting. But first, let's remember the definite **advantages of free-planting**: (1) avoids root trauma as well as water, soil, temperature, and sun "shock" that potted seedlings may experience when out-planted; (2) offers best opportunities for early and long-lasting establishment of mycorrhizal fungal associates; (3) eliminates possibility of taproot repression; (4) offers best opportunity for local climate adaptation during the seed's prolonged embryo development prior to germination.

LEFT: **Diana Spiegel of Dayton, OHIO** takes Connie Barlow on a tour of her free-planted Torreyas on 9 November 2017.

In September she had noticed that **7 of the 12 seeds she planted spring 2016** (from fall 2014 seed harvest) were now 4 to 6 inch tall seedlings.

All were planted on this south-facing forested slope **along a creek south of Dayton OH, deciduous canopy**.

Each seed had been **planted 6 inches deep** and was surrounded by a mesh of chickenwire also buried 6 inches (and staked). Confirming that Torreya seeds easily sprout at that depth is **important news for future free-plantings seeking rodent protection via depth**.


LEFT: **Chris Anderson** points to a newly sprouted Torreya seedling in his **Cumberland Plateau** stewardship forest.

By far **the most expansive experiment in "rewilding" Torreya taxifolia into northward states** began in November 2015 on 232 acres of the Cumberland Plateau of Tennessee. All **400 seeds were "free-planted"** directly into the ground — either **3 inches deep or under rocks** — to protect the seed from rodent predation. Two years later, Connie Barlow video-documented the beginning success of **38 new seedlings**.

WATCH VIDEO: **Part 1** (24 minutes) • **Part 2** (23 minutes)

**2. WHEN OUT-PLANTING POTTED SEEDLINGS:** Over the years, we have learned the hard way that, when out-planting seedlings into their final patch of ground, it is **crucial to shake out any perlite** that might have been in the potting soil. **If the soil around the stem and roots is more attractive than the surrounding soil for small rodents to burrow through, then the Torreya is doomed.** (See examples of rodent damage in the December 2016 entry below.) Now we have learned that it is **easy to make the planting soil even less attractive to rodents** than the natural soil that surrounds the hole. Jack Johnston (GA) and Clint Bancroft (TN) report success with this technique: Simply, **add gravel and/or pieces of shale** to the soil mix you use to fill the hole!

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## • May 2017: History of Columbus GA Torreyas Support Glacial Relict Story



In May 2017 **Clint Bancroft found strong evidence that the original three mature torreyas planted along Front St. (a stone's throw to the Chattahoochee River) in Columbus GA were horticultural plantings** — and thus not evidence of pre-colonial wild population remnants that far northward. For context, the two images above illustrate crucial aspects of the GEOGRAPHY of the southeastern USA — specifically, direction and distance of major river flows and locations of the three most well-studied "peak glacial refuges" along the coasts (each with a famous plant extinction or near-extinction). Long ago, Torreya Guardians became aware of the FLOATING CAPACITY OF THE LARGE SEED, with subsequent experimentation by Clint Bancroft showing that "floaters" have no less capacity than "sinkers" to germinate. These topics are covered in more detail on our webpage that focuses on the **PALEOECOLOGY OF FLORIDA TORREYA**. But here is an excerpt re the now-leading hypothesis:

> EXCERPT: ... 7B. An **alternative hypothesis** is that the large-seed of Torreya (which is sometimes capable of floating for several days) easily caught a **fast and obstacle-free river ride southward** from the Appalachian Mountains by way of the Chattahoochee River at the onset of cooling during the Pliocene or Pleistocene. But **there was no river-flow way to return north during any of the interglacial warmings**. In the first half of the 20th century, the add-on of human-caused warming finally surmounted the physiological threshold of genus Torreya, and it was **no longer able to ward off more than a half-dozen native diseases**. The fact that the **Florida Yew**, *Taxus floridana* is also a subcanopy rare endemic limited to the same relictual range as Florida Torreya suggests that river-flow assistance may truly be limiting. After all, the seed of Florida Yew is bird-dispersed; dispersal by birds offers faster and greater long-distance distribution than can squirrels or tortoises.

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## • March 2017: Learnings from Ex Situ Seed Propagation Sites in Oregon


In February 2017 Connie Barlow visited 2 ex situ *Torreya taxifolia* propagation sites in Medford, Oregon. The four specimens were planted 22+ years ago by Medford resident (and plant expert) **Frank Callahan**, who led Connie on a tour of these sites. He also donated to Connie a bucket of 1,000 seeds harvested from the 2 specimens that, together, produce prolifically. The prolific pair are seed-grown, while the pair rooted from cut branchlets produce mostly small, woody (infertile) seeds. All four specimens were originally sourced from the National Arboretum in Washington, D.C.

ABOVE: Watch the **24-minute VIDEO**: **"Florida Torreya Seed Production in Medford, Oregon (2017)"**

LESSONS & NEW EXPERIMENTS:

**1. CAN WE OBTAIN VERTICAL TREE FORM GROWTH FROM CUTTINGS?** Confirmation that **rooted branchlets will not develop into single-stem trees** (they adopt a shrubby form). This is advantageous for early pollen or seed production, but it is inconsistent with "rewilding" this species into regrowth forests poleward of its Florida range.

Frank Callahan will begin an EXPERIMENT in **clipping the vertical "sports" on the tips of branches** of the two shrubby specimens and attempting to root them in ways that **might yield specimens that ultimately grow in the form of a single trunk** that is indistinguishable from seed-originated trees (except possibly still lacking basal ancillary stems).

DECEMBER 2017 UPDATE: Torreya Guardian **Clint Bancroft** is **experimenting with rooting leaders cut**

**from the basal sprouts** (leaders cut from mature trees in **Madison FL**, **Columbus GA**, and **Highlands NC**). Such leaders already display the vertical growth pattern, and thus our hypothesis is that rooting such will yield specimens with the same vertical aptitude as displayed by specimens grown from seed.

JULY 2018 UPDATE: Connie Barlow just noticed that an online list of actions included in the official recovery plan (USF&WS) confirms that rooting cuttings from vertical "leaders" (such as those found on basal sprouts) is necessary for nurturing a tree-like v. a shrub-like growth form: "**The ABG has switched to propagating cuttings made from 'leaders'** (the rapidly growing apex of a tree). This process forms upright plants of about two-feet tall in about two years." See the 17th column ("Comments") of the 11th row (action #322) at **Recovery Plan ad hoc Report Results**.

**2. SHADE/SUN PREFERENCES & TOLERANCES.** Florida Torreya is **harmed by sudden exposure to direct sunlight**. Ecologically *Torreya taxifolia* is a subcanopy tree species, and further observations of the total plantings by Torreya Guardians will help to answer which shade conditions are ultimately recommended as a balance for encouraging growth, yet keeping specimens safe from summer drought and icy winter winds. (Frank and Connie agreed that **east-facing sun exposure** is the safest.) Note: Watch **16:18** timecode of the Torreya Guardians VIDEO: "Florida Torreya Grove at Biltmore Gardens NC: 75 years old." There you will see that even ten years after a hurricane destroyed a pine overstory, thus exposing the Torreyas to sudden direct sunlight, the trees have not recovered. While there is no visible sun-scald, the only rich vegetative growth is lower down the trunks — including **tall, brushy basal growth** on the full-sun side of two of the trees. As with lush basal growth in **Coast Redwood** trees following topping or loss of the main stem, it is possible that this flush of basal growth may be the fastest way for the tree to regenerate photosynthetic capacity — and thereby keep alive nearly all of its mature extent of root development — before it attends to producing a new leader that can resume upper-level growth. **California Torreya is possibly more sun-tolerant** than Florida Torreya is.

UPDATE ON SHADE V. SUN, APRIL 2017: **Daein Ballard** (see his **New Hampshire Torreya project**) is a molecular biologist, so a query to Torreya Guardians from a USDA soil scientist, Anita Koehn, was forwarded to Daein. **"Diurnal patterns of chlorophyll fluorescence and CO fixation in orchard-grown Torreya taxifolia"**, by Anita C. Koehn and Robert I. Doudrick was published in 1999 in *Journal of the Torrey Botanical Society*. Torreya Guardians has long experience with (a) the importance of leaves supporting photosynthesis for multiple years, yet (b) the detrimental effects of moving potted seedlings with shade-adapted leaves into sunny environments when outplanting. Daein's hypothesis thus far:

> "... I made sure to collect samples of both the needles that grew in the shade and the needles that grew in the sun. Within minutes of collecting the samples, I imaged them alive under a light microscope at 200x with no stain. I imaged them both dry and wet (the needles submersed in water). I've attached some crude images I took with my cell phone through the eyepiece. I'm not an expert in this area but **it seems the stomata on the sun-grown needles are smaller**. Additional to that I noticed that **it seems the stomata on the shade-grown needles stay open even when dry,** while they are mostly closed on the sun-grown needles when dry. When wet, both needle types had open stomata..."

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# 2016 Learnings

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## • December 2016: Preventing Rodent Destruction of Torreya Roots

2018 UPDATE: Jack Johnston (GA) and Clint Bancroft (TN) suggest that, when outplanting potted seedlings, it is a good idea to **add gravel and/or pieces of shale to the soil mix. This makes the soil around the torreya roots and stem even *less attractive* to burrowing rodents than the surrounding forest soil!** In addition, it is crucial to still shake off the perlite! See below for what happens when the perlite is not removed nor gravel added.

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Even 8 or more years after growing in open or forest soil, small Torreya trees are still **vulnerable to ground-burrowing rodents** that kill the trees underground by nipping off small roots and completely gnawing off bark (presumably for food value) of large roots in the upper soil layer. Wire cages protecting lower stems do not protect against below-ground gnawing. **While there is no fail-safe way to guard against burrowing rodents, you can make the soil less attractive to rodents by (a) shaking off the perlite/potting soil mixture when out-planting a potted seedling and (b) having the surrounding "mulch" layer be no different than that found in the immediate surrounds.**

In 2016 Connie Barlow video-recorded the **sudden, over-winter deaths by rodent herbivory of three previously lush-growth Torreyas**. You can watch the video segments at: **2 Torreyas killed at roots in**

**Junaluska NC** and **1 Torreya killed in Brevard NC**. (The previous links will take you to the exact timecodes within the long videos where the dead trees are discovered.) Below are still images drawn from the videos (and also placed on the photo-rich **Brevard, NC torreya** page.

PHOTOS ABOVE were taken from the **Video of 1 Torreya killed in Brevard NC**. See how the roots and the living bark have been entirely gnawed away. Notice the light-colored pellets in the root photo; these are perlite. Perlite and soft soils must be shaken out of roots prior to planting. **Perlite + surrounding packed soils we now know will vastly increase the rodent herbivory** prospects of even carefully tended outplantings.


PHOTO LEFT was taken in **Spring 2016 by Connie Barlow at the Corneille Bryan Native Garden (Junaluska)** site near Waynesville NC.

That was where Torreya Guardians planted 10 potted seedlings in July 2008.

We found the plant (and its above-ground metal cage) laying on their side. The perlite-infused soil was easy digging — and we immediately unearthed a **chipmunk-size rodent tunnel and rodent-gnawed roots**. One more of the 2008 planted Torreyas was also found in the same condition.

Previously at the **Junaluska site**, **3 Torreyas had been killed by rodents their first winter.** All 5 deaths are in the plantings closest to a set of bird feeders at a seasonally occupied home. Equally important is that one can see tiny specks of perlite in the loose soil of the photo left.

In the **2016 Junaluska VIDEO**, at timecode 05:55 you will hear Connie Barlow speculate on her **Seasonal Birdfeeder Hypothesis** for the rodent root damage. At timecode 26:25 she locates a nearby bird-feeder. On reflecting later, however, she regards the **Perlite Hypothesis** as a likely more harmful causative agent. See a 2016 report posted by our NH Torreya Guardian, **Daein Ballard** (posted 22 July 2016), on his **observations of how best to deter chipmunks**.

So we have learned the hard way: **Shake off the perlite before planting out**. Note that this problem of out-planting soils being more attractive than the natural soil can be **alleviated by directly planting seeds** into the outdoor soil ("free planting") exactly where you hope they will keep growing — but **free-planting has its own substantial rodent hazards** that require specific actions to curtail.

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## • 2016: Apical recovery from herbivore nibbling

LESSON: Seedlings do **recover from even severe apical herbivory**, thus resuming a vertical growth form.

The photos below come from the planting site of **Bob Miller in southwestern OHIO**.

FAR LEFT: Mid-June 2016 the right-most seedling in the pot shows **new-growth trending to become the new main stem**, following previous herbivorous destruction of the main stem apical leader.

NEAR LEFT: October 2016 shows the same seedling when it was planted into wild forest. See that the spring new growth has now matured into vertical apical growth. But notice that the nipped-off stem also produced new apical growth from directly beneath the nipped-off top. So **now there are two apical stems**.

**2017 UPDATE ON APICAL RECOVERY:** Photos below by **Nelson Stover** (Torreya planter in Greensboro NC) in sequence Nov 2016, May 2017, and Nov 2017 shows herbivore devastation followed by recovery (both budding from stem and emergence of basal sprout).

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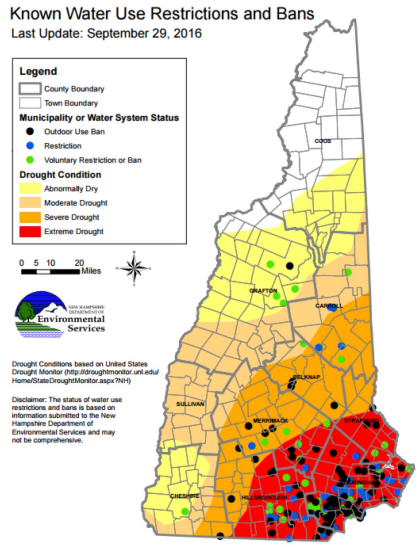
## • 2016: Surviving Extreme Cold and Drought in New Hampshire

**Daein Ballard** is a northern-most Torreya Guardian (s. New Hampshire) for whom 2016 offered supreme tests of Florida Torreya's ability to survive extreme winter cold and extreme summer drought. His reports:




- COLD: February 2016: "Last weekend it got down to **-14F, with a wind chill of -40F**, which is a new low temp since I moved here. I've looked at all the Torreya and in spite of their young age **they all pulled through completely unscathed**. Since then it's gotten over 50F twice to give the seedlings a chance to show signs of damage if there was any. This is with all of the seedlings being at least partially exposed, since the snow was only a few inches deep. **Even the most exposed seedlings in open areas show no ill effects**."

- DROUGHT: August 13, 2016: This summer has been **the driest summer since I moved here**. Although it has caused some yellowing on the more exposed seedling's needles, most seem to be **doing fine**. Other than when I first planted the seedlings, **I haven't provided any supplemental water**."

September 2016: "Just to give you an update on how things are going with my Torreya. Most are doing well, however **this area is experiencing an extreme drought** like nothing I've seen around here in my lifetime. **All but two of the Torreya have made it this far unscathed. Two of them have died back, but put up new basal shoots.** We'll see how all the rest make it through next winter; it's been really stressful for most plants around here."

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## • 2016: Importance of planting where MYCORRHIZAL FUNGI flourish


**VIDEO 13b: Florida Torreya to Ohio's Dawes Arboretum (pt b) 2016**

Documents **superb annual growth on the two Florida Torreya specimens beneath a full deciduous canopy** (and protected from winter winds by a border of evergreen conifers). Confirms 1-month difference in vegetational budburst bt the Florida Torreya (May budburst) and adjacent Chinese Torreya (June budburst). Speculation on the importance of nearby maple helping the Torreyas by **shared fungal root symbionts**.

**17 minutes** - *filmed June 18, 2016*

Full documentation on the **Dawes Arboretum torreya** page.

In 2016 a paper was published in *Science* that requires an immense worldview shift in how we study and interpret forestry results. **"Belowground carbon trade among tall trees in a temperate forest"**, by Tamir Klein et al. (2 pages), is a must-read for all Torreya planters. **Planting Torreya seeds or seedlings beneath a mature deciduous canopy will ensure drought and winter-wind protection, while offering opportunities for the young trees to receive sugars from the canopy via fungal root connections — so long as canopy trees include those using ENDO (not ECTO) mycorrhizal types.** Note: This recommendation is an addition to the **"Encouraging Symbiotic Mycorrhizal Fungi"** section on the Torreya Guardians Propagate webpage.

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## • 2016: New occurrences of FREE-PLANTING success

- **Shoal Sanctuary, Florida**. May 2016 (by Chris Larson): "We searched Grotto Ravine yesterday and are happy to report **five more sprouts. The count is now 11 of the 40**, alive and well. Most are in wetlands but one is ten feet above a creek, fairly dry. I'm documenting every observed detail. June 2016 (by Chris Larson): We're a bit concerned. All 40 of the Shoal Sanctuary seeds were planted at only 1 inch deep. One was dug up within a month. This year we found 11 seedlings in May. Went back to check in June: 2 seedlings have vanished, but 2 others elsewhere have now sprouted. So we are **still at 11 of 40 and counting**.

- **Greensboro, NC**. NOV 2016: Nelson and Elaine Stover revisited all the planting sites. None of the 20 seeds planted from the autumn 2015 seed stock are yet visible above ground. But **10 of the 30 seeds of the 2013 harvest had visible sprouts** (a germination rate of 1 in 3).

- **Southeastern Ohio:** After two winters in the ground, 3 of the initial 18 seeds "free-planted" were visible above ground in June 2016. All 18 seeds had been intentionally **planted on very steep slopes in full-canopy deciduous moist forest** in a ravine. The intent was to ensure that no buck deer would be able to rub against a torreya sapling to dislodge antler velvet. All 18 seeds were planted shallow in the soil, with no rock protection — and **all 3 successes are very near downed logs or large branches**.

**Conclusion:** As of 2016 Connie surmises that **free-planting Torreya taxifolia seeds directly into forests with no rock protection will yield severe losses owing to seed-herbivory**.

TWO POSSIBLE EXCEPTIONS that need further testing:

1. **Perhaps burrowing, seed-predating voles and chipmunks may be rare on very steep, moist slopes indicative of year-round near-surface water seepage.** Such slopes may simply be too moist (or subject to tunnel-collapsing solifluction) for the little rodents to establish below-ground tunnels.

2. **Perhaps planting seeds 4-inches deep into forest soils** will help the seeds evade rodent detection. (One experiment is underway.)

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## • March 2016: Posting of 2015 v. 2006 measurements, BILTMORE GARDENS, NC

In **1939 Chauncey Beadle supplied the Biltmore Estate with a dozen Torreya taxifolia** seeds or specimens collected in Florida — prior to any understanding of climate change and endangered species. Now this **75-year-old grove and its offspring are precious** for securing the wellbeing of the species and for demonstrating that (with little human help) North Carolina is an ideal habitat for escaping the native diseases of a now too-warm Florida.

| | 2006 | 2015 | |
|---|---|---|---|
| Specimen A - ? | 03 inch | 06 inch | |
| Specimen B - ? | 08 inch | ?? inch | |
| Specimen C - F | 07 inch | ?? inch | 1 seed 2006 |
| Specimen D - F | 08 inch | ?? inch | 1 seed 2006 |
| Specimen E - ? | 08 inch | ?? inch | |
| Specimen F - ? | 30 inch | 38 inch | |
| Specimen G - ? | 27 inch | 31 inch | |
| Specimen H - ? | 13 inch | 23 inch | |
| Specimen I - M | 08 inch | 10 inch | |
| Specimen J - ? | 30 inch | 32 inch | |
| Specimen K - ? | 17 inch | 18 inch | |
| Specimen L - ? | 25 inch | 28 inch | "orig #6" tag |
| Specimen M - ? | 28 inch | ?? inch | |
| Specimen N - ? | 22 inch | 23 inch | |
| Specimen O - ? | 24 inch | 25 inch | |
| Specimen P - ? | 29 inch | 30 inch | |
| Specimen Q - ? | 08 inch | 09 inch | |
| Specimen R - ? | 29 inch | 30 inch | |
| Specimen S - F | 08 inch | 12 inch | 21 seeds 2006 |
| Metasequoia A - F | 46" + 40" | ?? + ?? | 32 seeds 2006 |
| Metasequoia B - M | 44" + 39" | 46 + 40 | closest to road |
| Pond Bridge A - ? | unknown | 46 + 40 | 20 ft branches on grd |
| Pond Bridge B - M | unknown | ?? + ?? | 10 foot tall 2015 |
| Taxodium - A | unknown | ?? | 14 foot tall 2015 |
| Woodland Path - A | unknown | ?? | 20 inch tall 2015 |

In Fall of 2015, **Michael Dowd assisted Connie Barlow** in measuring the same set of torreya trees that were measured in 2006.

LEFT: Connie posted onto the **Torreya Guardians Biltmore webpage** a chart that **compares circumferences over the 9 year period**.

**LEARNINGS:** Torreya grows slowly; evidences none of the diseases afflicting the species in Florida; uses basal sprouting and ground-extending low branches to maximize access to sunlight when beneath a closed canopy. April 26 video shows 3 males in different stages of pollen ripening — possibly caused by differential access to direct sunlight.

- Full information at **Torreya Guardians Biltmore webpage** and on our **2016 Biltmore VIDEO**.

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## • January 2016: VIDEO of the Torreya native range in Florida


**VIDEO: Site Visits to Florida's Endangered Torreya and Yew Trees**

Connie Barlow presents **15 years of baseline photos and videos** she recorded of *Torreya taxifolia* and *Taxus floridana* in their **historically native range in Torreya State Park** in northern Florida. This video offers **visual baseline data, including the context and plant associates** that remain in this once **peak glacial refuge** (where the ailing Torreya species was "left behind" and now decimated by a too-warm climate).

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## • 2015 VIDEOS of Rewilding Results and Learnings in North Carolina


**FL Torreya to North Carolina: 2015 progress report (Waynesville, NC)**

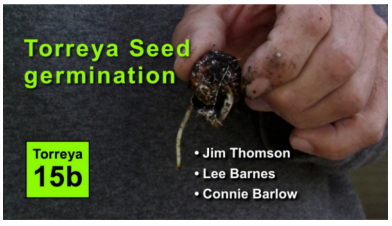
**First video-documentation of fate of historic 2008 rewilding action of the endangered *Torreya taxifolia* from Florida to North Carolina**. Connie Barlow films and narrates a survey of the 21 plants in wild forest on the slope of Eaglenest Mountain, near Waynesville. **Most important results are both positive and negative, which help us ascertain the habitat preferences** of this species (moisture, shade, slope, aspect).


**FL Torreya to North Carolina (pt 2): 2015 progress report (Junaluska, NC)**.

Second half of video progress report on our 2008 rewilding to North Carolina. **Key findings include recommendations for measuring vigor, perils of cohabiting with rhodies, long-term negative consequences of planting root-bound conifers, the stress of seedlings needing to re-orient growth to wild light conditions**. Note: The final 12 minutes of the video include the Waynesville findings in the comparative assessment.


**Free-Planting Torreya Seeds into Wild Forest: 2015 report**. Best practices discovered by Torreya Guardians in attempting to plant seeds directly into the soil of wild forest in the southern Appalachian Mountains. Preliminary results confirm that **planting beneath flat rocks and beneath a thatch of branches were both effective in deterring squirrels**. However, **the results are mixed for voles**. This video chronicles Connie's visit to the Waynesville NC site 17 months after planting seeds.


**FL Torreya to Franklin, North Carolina: 2015 progress report**
Russ Regnery leads Connie Barlow on a tour of his young torreya trees. Topics include (1) the advantage of using a **shading screen** during early years if Torreya is in full-sun, (2) Torreya is vulnerable to **winter sun and wind desiccation** if not protected by a canopy, (3) advantages of planting near **nurse trees** for shading and sharing their **symbiotic root fungi**. "Free-planting" seeds from the 2014 seed harvest directly beneath the forest canopy is final half of video.




**15b: Germinating Torreya Seeds: 2015 report**

Jim Thomson, Lee Barnes, and Connie Barlow discuss what we all have learned thus far about how to germinate Florida Torreya seeds **outdoors, in locales far north of the "historically native range"** of this endangered conifer species. Seeds harvested from the same mother tree in the same year will **span a number of years to germinate**, even when planted under the same conditions.

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# 2015 Learnings

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## • December 2015: First success of "FREE-PLANTING" SEEDS UNDER ROCKS

Connie Barlow reports **5 seedlings newly emerged from beneath large flat rocks 2 years after planting**. The free-planting section of the Propagate page contains the detailed **photo-essay**.

**Results include:** (a) Never plant seeds under or near a log; (b) Rocks distant from vole hiding places work best; (c) Expect the seedling to emerge always on the upslope side of the rock; (d) Success rates for good placement of rocks probably range from 20 to 50% max; (e) Expect seedlings to become visible above ground in about 2 years minimum (after 2 winters).

Barlow recommends these **additional questions for volunteer testing:** (1) Are there any insects (ants?) detrimental to seed germination under a rock? and (2) If a seed is planted very deep (approx 4 inches) out in the open, with no rock protection, will squirrels be unable to smell it?

2018 UPDATE: It is **dangerous** to cover seeds with a big rock on **flat ground** because (1) the underside will stay dry, owing to no down-slope seepage, so ants and even rodents may occupy the area, and (b) if there is no obvious side for the germinating radicle to grow "up" it may grow in ever-widening circles, eventually running out of energy stored in the big seed.

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## • Spring 2015 DATA CHARTS of Waynesville and Junaluska NC 2008 Plantings

**Example from Waynesville, 1 April 2015:**

| NAME in order of relative health | MAIN STEM # Stems # leaf buds | BASAL # stems # leaf buds | INCHES from top of vertical stem down to branch LAYERS 1, 2, 3 | APEX BUDS apical + radial buds (d=dormant) | BRANCHES in each radial layer | BUDS total number |
|---|---|---|---|---|---|---|
| Maxilla 2013 | 1 = 58 | 1 = 1 | 0 + 3.75 | 1A + 0 radial | 6 + 6 + 6 | 59 |
| 2015 | 1a = 43<br>1b = 22 | 0 | 0 + 3.5 + 4.0<br>0 + 3.5 + 4.5 | 0A + 0 radial<br>0A + 5 radial | 4 + 6 + 6<br>0 + 5 + 5 | 65 |
| Celia H 2013 | 1 = 51 | 0 = 0 | 2.5 + 3 | 1A(d) + 5 | 4 + 4 + 4 | 51 |
| 2015 | 1 = 36 | 0 = 0 | 0 + 4.5 + 2.0 + 2.0 | 1A + 0 | 4 + 4 + 4 + 4 | 36 |
| T Berry 2013 | 1 = 40 | 0 = 0 | 1.5 + 3.5 | 1A(d) + 4 | 4 + 3 + 0 | 40 |
| 2015 | 1 = 31 | 0 = 0 | 3.0 + 1.5 + 3.0 | 1A(d) + 4 | 4 + 4 + 3 | 31 |

**Example from Junaluska, 1 April 2015:**

| NAME in order of relative health | MAIN STEM # Stems # leaf buds | BASAL # stems # leaf buds | INCHES from top of MAIN stem(s) down to branch LAYERS 1, 2, 3 (4) | APEX BUDS apical + radial buds (d=dormant) | BRANCHES in each radial layer | Height or total # Buds |
|---|---|---|---|---|---|---|
| Hazel D 2013 | 2 = 195 + 146 | 0 = 0 | 0 + 11.5 + 8.5 (tall) | 1A + 0 radial | 5 • 2 • 5 | unknown |
| 2015 | unknown | 0 = 0 | 6 + 10.5 + 11 + 8 | 1 A + 4 radial | 6 • 4 • 5 • 2 | 66 inches |
| Thoreau 2013 | 1 = 158 | 3 = 63 | 0 + 8.5 + 8.5 | 1A + 0 radial | 4 • 4 • 4 | unknown |
| 2015 | unknown | 1 = 18 | 3.5 + 8 + 8.5 + 9 | 1 A + 3 radial | 4 • 4 • 4 • 4 | 65 inches |
| Aldo L 2013 | 3 = 90 | 0 = 0 | 2.5 + 4.25 + 3.75 | 1A + 4 radial | 3 • 4 • 0<br>3 • 4 • 0 | 90 |
| 2015 | 2 = 56 | 0 = 0 | 0 + 3.5 + 2.5<br>0 + 4.75 + 3.0 | 0A + 4 radial<br>0A + 5 radial | 4 • 4 • 3 • 4<br>5 • 4 • 3 | 56 |

**Data Caveats:** (1) April 1 was too early for the vegetative buds to expand, so some assessments of terminal buds at the Waynesville site (presence or absence) may prove faulty. (2) A few weeks later at the Junaluska site, I noticed for the first time vegetative buds appearing through the bark of older branch segments and even the main stem itself, so bud counts at branchlet ends may under-report tree vigor. (3) Because the potted seedlings we planted in 2008 were all "root bound" (too long in the pot), some had to abort their main stem a few years after planting and put all their energy into growing the basal sprouts.

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## • April 2015: Visit to century-old Torreya grove confirms ability to naturalize, but very non-invasive.


**18 APRIL 2015: Connie Barlow and Jack Johnston** (above) video-documented and measured this precious grove on the historic grounds of **Harbison House**, just south of Highlands NC. The grove is precious because (a) it contains 6 specimens of 90-year-old trees and (b) the property has been left to **grow wild** for decades, and thus it provides an unparalleled opportunity to study the natural growing characteristics of the species beneath a deciduous canopy and to learn its **seed dispersal and establishment** properties.

Watch the **28-minute VIDEO** made by Connie: **"Florida Torreya to Highlands NC**.

The 6 originals have these diameters (DBH inches): 16.5, 14, 14, 10, 7, 5. The biggest sapling (descended from the grove) had DBH of 5.5

ABOVE LEFT: Jack estimates the **ground-laying torreya branch** emerging from a grove tree as being 20-feet in length. We saw one other (8-foot) emerging ground branch and a lot of low, horizontal branches with healthy leaf structure emerging from trunks on all edges of the grove.

ABOVE RIGHT: **Seedlings and saplings ranging to a distance of 40 yards outward** offer evidence of the "seed shadow" dispersal distance achieved by the only operative dispersers here: squirrels.

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## • 2015: Cumulative learnings on PROPAGATION & REWILDING BEST PRACTICES

UPDATE: The below was posted by **Connie Barlow** onto the **Propagate page**, but was later subsumed by page additions over the years.

1. **Beware of planting ROOT-BOUND potted seedlings**. As shown in the Junaluska video above, the Torreya taxifolia seedlings we purchased at a nursery and planted in 2008 were "at least 2 or 3 years too long in the pot." That made them "root-bound", which is especially problematic for a tap-rooted tree (which Torreya is purported to

be). Hence our "rewilding" experiment began with an inherent impediment. By 2015 (or before) **several of the trees had allowed their original main stems to die**, and were putting all effort into converting one or two **basal sprouts** into main stems with a fully vertical central component and apex bud. Nonetheless, **all 7 plants at the Junaluska site are thriving, and all specimens at the Waynesville site planted on the moist, east-facing slope (with creek and waterfall nearby) are healthy**. Only 5 of the 21 potted seedlings planted at the Waynesville site in 2008 were on that favorable slope; thus **17 of the originals are either dead or struggling**.

2. **Selecting among three planting options: (a) potted seedlings, or (2) "free-planting" seeds or (3) sprouted seeds directly into wild forest soils**. Because Torreya has a large seed and because it has delayed germination, planting potted seedlings is the best way to **avoid seed predation by rodents**. Nonetheless, tending pots of seeds and then carefully planting the seedlings is time-consuming and requires some expertise and periodic watering. Also, we have noticed that branch patterns and leaf propensities fine-tune for the sun-shade conditions they grow in; so planting into different conditions will **stress the plants to reorient their growth patterns**. What about "free-planting" seeds directly into forest soils? Experiments are now underway (2013 in NC, 2014 in MI, and 2015 in NC and OH) using different degrees of avoidance of or protection against rodents. See the free-planting section of our **Propagate** page. Several **videos** also portray our **"free-planting" experiments in action**:

> **Ludington Michigan 2014**, **Wolf Creek NC 2015**, **Franklin NC 2015**, and **Waynesville NC 2013 (report of 2015)**. (The only seed-planting video that reports on preliminary results is the Waynesville video.)

As to **free-planting sprouted seeds**, this is a new idea in 2015 by **Torreya Guardian Fred Bess of Cleveland OH**. Fred reports that of 150 seeds harvested autumn 2014 and stratified over the winter in damp peat moss, 27 germinated by May. This is an 18% rate of first-year germination. Connie reports a much smaller germination rate, when 2014 seeds overwintered in peat-moss in a protected container, outdoors in n. Alabama (temperatures as low at 15F); but Janet Manning reported a high proportion of over-winter germination a previous year in her garage. The key **advantage of free-planting sprouted seeds is that, while still somewhat vulnerable to rodents, first-winter predation has been eliminated**.

3. **Deciduous canopy protects young trees during summer heat and drought, while offering full-sun habitats in late fall and early spring.** Consistently, Torreya Guardians report that full-sun sites require partial shade screens at least in the early years. The exception, of course, is if the trees are on an automatic irrigating system. See the **Shoal Sanctuary Video** for an example of full-sun, full-irrigation thrival. UPDATE: BY 2025 it was clear that periodic LIMING of upland soil was crucial, and that any interruption of the electric system running the automatic irrigation could result in torreya death.

4. **Preference moist, east-facing slopes.** Our 2008 rewilding experiment at a mountainous property near Waynesville NC confirms that, at least at that latitude and elevation, east-facing slopes (in which moisture-loving wild plants already are found) are the best habitats. The slopes and **flood-free areas of ravines may also be good choices.**

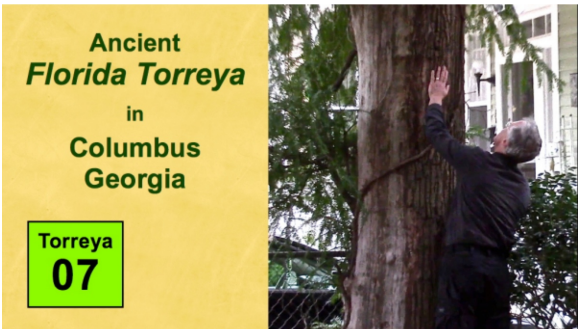
5. **Locate trees where they are protected from winter winds.** While many of our trees are planted beneath wild forest canopy (and some in ravines), others have been planted in areas exposed to winter winds. Northerly exposures are especially disastrous in northward states. The most graphic examples of what happens to Florida Torreya when exposed to temperatures **sub-zero F are in Ohio**. The **Dawes Arboretum 2015 video** (near Columbus OH) begins with a beautiful torreya growing amidst dense shrubbery and beneath a giant white oak. That tree shows no damage from the brutal "polar vortex" the preceding winter. In contrast, near the end of the video you will see a torreya located on a north-facing slope with a half-mile of unimpeded landscape northward; all but the terminal stem and bud suffered complete leaf-kill. In addition, our **Cleveland OH torreya webpage** posts photographs of terrible winter-wind kill of the evergreen leaves in the winter of 2013/14 (although the subsequent video shows full recovery 6 months later); that location is also unprotected by shrubbery or woodland surrounds.

6. **Might southern Ohio be superb habitat?** Southern Ohio is broadly in the same "plant zone" as the mountains of North Carolina — Zone 6. (Recently the USDA has revised the maps owing to climate change; Zone 6 now extends even into southern Michigan.) Thus, while experimental plantings in Cleveland OH and the lower peninsula of Michigan are primarily to **test for Torreya's extreme northern range limits in today's climate**, it is possible that southern Ohio might join western North Carolina as **ideal climate regimes** right now — that is, so long as plantings are protected from summer drought by deciduous canopy or ravine placement and from brutal winter winds.

7. **Supplemental hypothesis on why Florida Torreya was "left behind" in its peak glacial refuge of Florida's Apalachicola River**: While Barlow's 2015 new hypothesis has nothing to do with ascertaining northern range limits and discerning preferred habitats in the southern Appalachian Mountains, it does open a new consideration for understanding the "deep-time" migratory habits of this conifer. The new hypothesis is this: *Might*

*Torreya taxifolia have become stranded in its peak glacial refuge, not so much because of the slow seed-dispersal capacities of squirrels (as hypothesized by Barlow here and here) but because of the* ***absence of northward flowing rivers*** *between Florida and the southern Appalachians?* Barlow arrived at this hypothesis during a field visit to the largest remaining Torreya taxifolia in existence: the one along the Chattahoochee River, in the front yard of a historic-register home at the riverfront. (Click on video below.)

**VIDEO: Ancient Florida Torreya in Columbus Georgia**




While visiting the sole remaining T. taxifolia in Columbus GA, Connie Barlow was struck by its location along a free-flowing section of the Chattahoochee River. The Chattahoochee is the main conduit between the peak-glacial plant refuge in n. Florida and the Appalachian Mountains. **Might Torreya taxifolia have been "left-behind" in its Florida refuge because the Chattahoochee River flows southward?** The tree could have dropped seeds into the river for a speedy journey south, but it would have been utterly dependent on the slower actions of squirrels for the the return trip north.

*Note: In a 2010 email,* ***Lee Barnes*** *made a similar speculation,* "I am curious if the floating seeds might have aided distribution of a species now primarily found growing along a major river?"

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# 2014 and Previous Learnings

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## • May 2014 - Learnings to Pursue

Connie Barlow writes: "**We need to learn more about how to encourage mycorrhizal fungi to attach to the roots of any seeds or seedlings we plant in the future**. **Jeff Morris** reported seeing mycorrhizal fungi on the roots of Torreya seedlings that I collected beneath a mature T. taxifolia tree in **Clinton NC** last fall, and ever since I have been reading about the importance of encouraging such fungi to work with our plantings. (Read about mycorrhizal symbionts and Jeff's ideas on our **Propagation** page.) **Someone should visit the Clinton NC tree, dig up more seedlings, and study the mycelium on their roots** (the seedlings easily gain fungal symbionts because they sprout directly beneath the mother tree). Also, someone should carefully examine a bit of root from samples of our plantings in Waynesville and Junaluska NC.

***Hypothesis to test***: Do the two tallest seedlings from our 2008 plantings in NC (both at Corneille Bryan Native Garden) have the best developed symbiotic fungi on their roots? Both are very near a white pine — so **we need to test whether planting Torreya near a living conifer (and of what species?) is the best way to ensure that seeds and seedlings attract the ideal fungal partners.**

## • March 2015: Now we know that *Glomus* is the fungal symbiont for Torreya — and which trees naturally harbor that genus of mycorrhizae

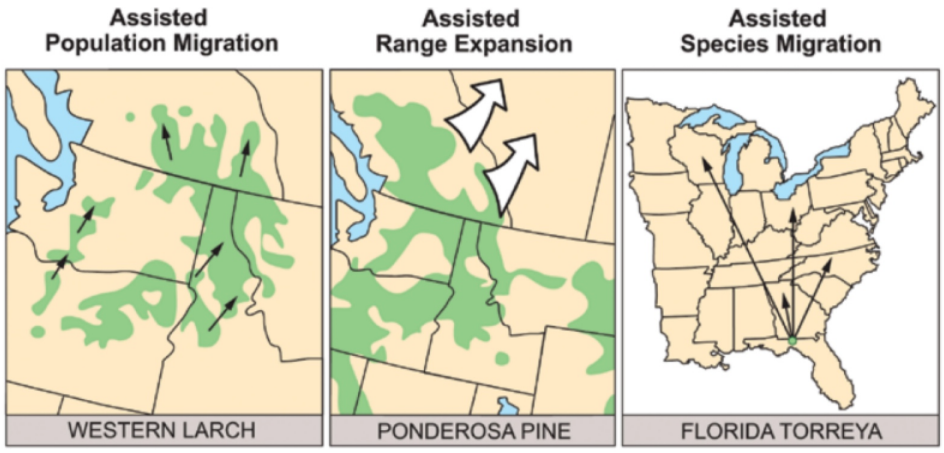
Connie Barlow reports: In early March I had email communications with a **Smithsonian molecular plant ecologist** who did research on *Torreya taxifolia*, but who has not yet published her results in a scholarly paper. We are grateful that **Melissa McCormick** gave us a summary of her findings. She identified ***Glomus*** **as the genus of mycorrhizal fungi that associates with Torreya taxifolia**. I have added her advice and the **list of common trees that do harbor Glomus** and the list of those that do not. Visit this section of the Propagate page: **Encouraging SYMBIOTIC MYCORRHIZAL FUNGI**. Henceforth, we would be wise to mix into pots for seed germination soil from beneath favorable tree species in the locales where ultimately the seedlings will be out-planted.

NOTE: The **Recovery Plan Ad Hoc Report Results** matrix (page 2), documents this work as:

> Dr. Melissa McCormick (Smithsonian Environmental Research Center) proposed to investigate the type of mycorrhizal association formed by T. taxifolia, identify the fungi forming the association, and quantify the degree of colonization. Dr. Melissa McCormick found no evidence that native Torreya habitats were deficient in species of mycorrhizal fungi. She found that Torreya forms associations primarily with fungi in the genus Glomus, which are known to have a role in protecting host trees against root pathogens. Torreya in native habitats had lower mycorrhizal colonization compared to Torreya planted in both forest and garden locations. This might mean that trees in native locations were less well protected against pathogens than in other locations. Alternatively, it might be that the diseased trees in native habitats are less able to pay the carbon cost of supporting mycorrhizal fungi.

## • 2014 - What others are learning from Torreya Guardians:

**"Assisted Migration: What It Means to Nursery Managers and Tree Planters"** is an excellent short introduction intended for full-scale nurseries supplying forestry seedlings, urging that planting for climate change become integral to the profession.




LEFT: The authors (Williams and Dumroese) distinguish **3 types of assisted migration**:

(1) Assisted population migration

(2) Assisted range expansion

(3) Assisted species migration.

**Florida Torreya is the illustrated example of type 3**, which broadly denotes the actions undertaken by Torreya Guardians.

## • NOVEMBER 2013 REPORT

Connie Barlow **gathered seeds from the Clinton and Mt. Olive (North Carolina) Torreya trees** on 31 October 2013. She then **recruited 2 new landowners in North Carolina** — **Cullowhee** and Greensboro — to plant Torreyas on their wild, forested properties.

Along the way, she did a **genetic exchange** with Torreya Guardian Jeff Morris (**Spencer NC**) to increase the diversity within existing and future plantings.

Connie then created a 75-minute **VIDEO** (right), posted on Youtube, to summarize our learnings to date.

As well, a **welcome surprise** came during Connie's October site visit to the Evans property in Waynesville. There, she witnessed **superb new basal growth from 3 of the trees that had been struggling on the dry, east side of the property**: **Johnny Appleseed**, **Charles Darwin**, and Joanna Macy specimens. The new growth surely results from the **very rainy summer** in the Waynesville area.

A.J. Bullard proves a single tree can produce **both male and female cones**.


## • APRIL 2013 STATUS REPORT

The big news in assessing the health of our 2008 seedlings planted at the Evans property near Waynesville NC and the Corneille Bryan Native Garden in Junaluska is three-fold: (1) **Corneille Bryan plants are thriving**. (2) **Mixed results at Evans property**. (3) **New quantitative data format** (example below)

**April 2013 Growth Data** for most vigorous Torreya specimens at
Waynesville 1 (Junaluska Corneille Bryan Garden) and Waynesville 2 (Evans)

| NAME in order of relative health | MAIN STEM # Stems # leaf buds | BASAL # stems # leaf buds | INCHES from top of vertical stem down to branch LAYERS 1, 2, 3 | APEX BUDS apical + radial buds (d=dormant) | # RADIAL BRANCHES in each layer / # triplet (T) bud tips in each layer (Q = quartet or quint) |
|---|---|---|---|---|---|
| 1 - Hazel D | 2 = 195 + 146 | 0 = 0 | 0 + 11.5 + 8.5 (main) | 1 + 0 | 5 + 2 + 5<br>gazillions of T + Q |
| 1 - Henry T | 1 = 158 | 3 = 63 | 0 + 8.5 + 8.5 | 1 + 0 | 4 + 4 + 4<br>8T/Q 3 3 |
| 1 - Aldo L | 3 = 90 | 0 = 0 | 2.5 + 4.25 + 3.75<br>(for 2 of 3 stems) | 1 + 4 | 3 + 4 + 0 (x2)<br>18 15 0 |

The table above is an **excerpt of the data documentation** at end-April. Only the healthiest plants (those that are thriving or at least have a chance to better establish and grow) are included in the graphic, an in order of visual health.

**BRYAN GARDEN**: **Of the 31 potted seedlings planted July 2008, 15 remain in excellent or reasonable health.** Except for the 3 seedlings killed by gnawing voles at Corneille Bryan Garden during the first winter, all 7 remaining there are thriving. (These are marked by a prefix of "1" before the plant's name in chart at left.)

**EVANS PROPERTY**: The **3 plants nearest the waterfall (to the west of the creek) are doing well**. These have the prefix 2W and are named Maxilla, Celia, and T Berry. The 2 plants farther from the falls on the West side are in fair condition: Bob Z and Annie. Only 1 of 4 seedlings that were planted centrally (2C) is in fair condition. And **on the dry east side of the property (2E), only 2 of the initial 12 seedlings planted there are in fair condition**. The other 10 on the east side are either already dead or in a consistently diminishing condition.

These results offer meaningful **opportunities to begin assessing habitat preferences of Torreya taxifolia within the mountainous conditions of North Carolina**. We welcome interpretive suggestions from knowledgable parties. Please continue reading this assessment and then click on the photo + data pages of individual plants (at the bottom of this page). Also, visit our **North Carolina** main page, as there are a half dozen other sites (some much older than ours) where *Torreya taxifolia* has been planted in garden or semi-wild settings in North Carolina.

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## • MAY 2012 STATUS REPORT

Nearly four years have passed since our **July 2008 "rewilding" of *Torreya taxifolia*** (31 nursery-grown, potted seedlings) into the southern Appalachians.

This conifer tree was first visited and described by botanists in the 19th century. Historically, it has been recorded in the wild only in the rich ravine soils bordering a 65-mile stretch of the Appalachicola River in the Florida panhandle and adjacent southern Georgia.

Nonetheless, from **a "deep-time" (Pleistocene and earlier) perspective**, it is reasonable to hypothesize that for millions of years *Torreya taxifolia* lived mostly in the southern Appalachians — and that it migrated into a well documented **"glacial refugium"** when Ice-Age conditions forced it (and other temperate species) far to the south. See the online pdf: **"Paleoecology and the Assisted Migration Debate: Why a Deep-Time Perspective is Vital"**.

Following a **May 2012 onsite assessment by Connie Barlow and Lee Barnes of both the Waynesville NC (Evans property) and Junaluska (Corneille Bryan Native Garden) plantings**, we have begun to discern distinctions in habitat and success rates that will lead toward better management decisions in assisting this **greatly endangered** species within the yew family (Taxaceae) to make its way northward (and upward in elevation) as the climate continues to warm.

Following is **an illustrated essay of what we have learned and what questions remain** for adequately understanding the habitat preferences of eastern North America's species of genus Torreya.

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## • CHARACTERISTICS OF HEALTHY NEW GROWTH

ABOVE LEFT: In studying all 31 specimens, we have learned that the **most robust growth in the upper tier of radiating branches includes new annual growth that is both apical (vertically upward from the center of the main stem) and lateral (radiating outward horizontally)**. In the photo above left of the specimen named Wendell/Thomas Berry, you can see light-green new growth both apically and laterally. Notice ithat the new lateral growth is in the form of **triplet branchlets**, extending outward from the single-branched lateral growth of the apex the previous year.

ABOVE RIGHT: The specimen Julia Butterfly Hill shows a **less healthy singlet growth form** and no new apical growth. Both photos were taken May 2012, when it is still easy to discern the color (as well as texture) distinction of the **new growth, which is a lighter shade of green**.

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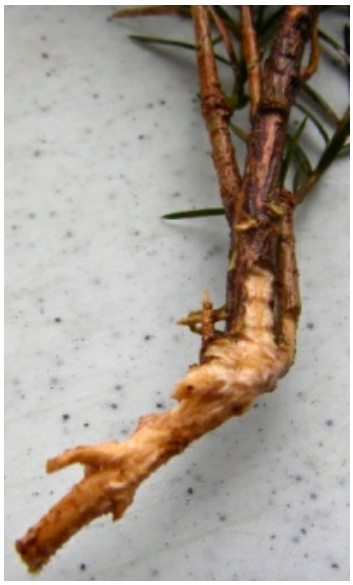
## • DAMAGE BY VOLES



ABOVE: During the first winter (2008/2009) **3 of the 10 seedlings planted at the Junaluska site were killed by herbivory**; Lee Barnes ascertained that voles had nibbled off the bark and cambium of the lower stem and root. The remaining 7 specimens were given wire cages, which remain. *None of the 21 seedlings planted at the Waynesville site received cages, and none have been damaged by voles.*

**Vole-damage hypothesis:** The Corneile Bryan Native Plant Garden at Junaluska is an **isolated forest pocket surrounded by homes**, whose intermittent stocking of **bird feeders might artificially ramp up vole populations**, which then crash when the feeding stops (and some residents depart for the winter). A possibly significant piece of evidence is that the 3 specimens that died were all located nearest to the lower end of the forest patch, not far from a home. More details are provided on the individual webpages for **Chauncey Beadle**, **Hardy Croom**, and **Asa Gray** specimens.

## • DEER SCARCITY IN NC MOUNTAINS

Left is a **photo of a deer-damaged Torreya in its "historically native" habitat (Appalachicola State Park, FL)**. Deer damage of sapling Torreyas is so severe in the park that USF&WS-sanctioned restoration efforts in the Florida preserves regularly install cages to preclude deer.

The migrated Torreyas in Junaluska and Waynesville NC are still too small to attract the attention of **buck deer scraping off antler velvet**. Even so, the owners of the Waynesville property on which 21 seedlings were planted in 2008 tell us they have witnessed **no evidence of deer on their property**. It is possible that the Junaluska site has some deer, owing to its expanses of mowed lawn, and thus abundant forest-edge habitat.

## • MIGHT DECIDUOUS CANOPY BE PREFERRED BY TORREYA?

ABOVE: **Compare the two seasonally distinct photos** above, taken at the **Evans property site in Waynesville NC**. At left, Russell Regnery stands by the just-planted specimen we named Thomas (or Wendell) Berry; photo taken **July 31, 2008**. At right, Chuck Dayton stands in exactly the same spot (compare the tree trunk at left in both photos) **November 13, 2008**. Although there are some clusters of rhododendron and mountain laurel on this property, it is otherwise deciduous at all levels: canopy, subcanopy, and ground. The (evergreen) hemlock trees that had been present on this property are all dead, and **there are no pines and thus no evergreen trees in the canopy.** Note: Connie Barlow's recollection of the Appalachicola site is that the Torreya specimens there are in some locations shaded by pine and/or the evergreen American Holly.

An important question is **whether the evergreen Torreya accomplishes much of its photosynthesis in early spring and late fall** when the upper and lower canopies are bare of leaves. Perhaps shade is important in times of summer heat and drought. (This is a question worth considering.)

## • CALIFORNIA TORREYA FOR COMPARISON


4 PHOTOS ABOVE AND BELOW: All of these photos were taken by Connie Barlow in 2005, during **site visits** to native habitat of **the California species of Torreya** (*Torreya californica*). The purpose of showing these California photos here is to suggest that **it is ill-advised to attempt to ascertain the habitat preferences of the EASTERN North American species of this ancient genus without also becoming familiar with the range of habitats which currently support North Amercia's WESTERN species of genus Torreya.**

ABOVE LEFT: **A typical yewlike (planar) form of leaf growth on branches manifests when Torreya grows beneath a largely evergreen canopy of California Live Oak and California Bay Laurel.** This photo was taken May 5, 2005 (by Connie Barlow) in Sequoia National Park, on a western slope at 4,100 foot elevation. More photos **here**.

ABOVE RIGHT: **Once a Torreya breaks through into the canopy, it may take an astonishingly more luxurient growth form**, as does this specimen just downhill of a road on a steep south-facing slope in Yosemite National Park, elevation 5,000 feet (photo taken May 19, 2005). Connie initially **mistook this specimen for a Douglas Fir!** More photos **here**. Note: The huge single seed encased within the fleshy sarcotesta of a Torreya provides a huge initial energy increment, which allows this species to grow even within a tumble of tall boulders that challenge it with shade during its first several years of growth. The multi-trunked specimen in this photo arises from such a bed, which you can see in **photo 9 on the Sierras page**.

LOWER PHOTOS: **In the coast range of California, Torreyas typically are found in association with redwoods.** When challenged by shade, they assume a yewlike growth form, as in the photo left below (with giant redwood right behind it; flash on camera automatically triggered because of the intense shade). The photo to the lower right shows, nonetheless, what a Torreya is capable of achieving even in a redwood forest. Connie is shown standing alongside the **champion Torreya californica tree**, which occurs on an elevated terrace of a creekbed that is only several hundred feet above sea-level, just five miles inland of the ocean north of Santa Cruz. The frequent fogs during the winter dry season likely have played an important role in producing a large number of very large (and canopy-tall) Torreyas within and on the slopes of this particular valley. See more photos **here**.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## • THE IMPORTANCE OF SITE VISITS

PHOTOS ABOVE: Connie Barlow strongly recommends that **all persons in official decision-making roles with respect to ESA management of the endangered EASTERN species of genus Torreya make site visits to at least the Santa Cruz, Napa, Sequoia Park, and Yosemite Park native expressions of the western**

**species.** At minimum, the **photo-essays of California habitats** posted online by Connie should be studied and discussed.

As well, this photo-essay with links to more detailed photo pages is intended to acquaint all those with an interest in the future thrival of the eastern species of genus Torreya with the **ongoing learning experiences** that accrue via the volunteer work of Torreya Guardians in **actual field tests of assisted migration into Appalachian habitats of various types**.

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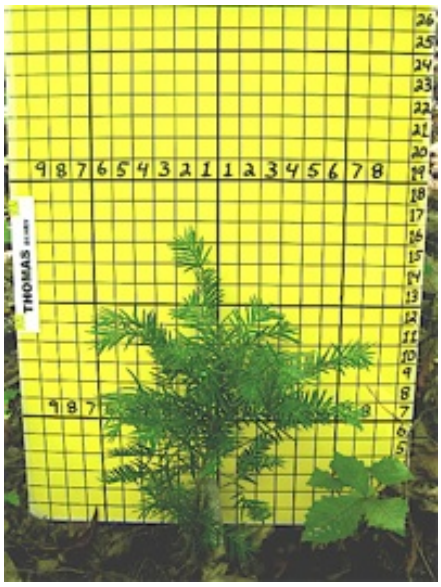
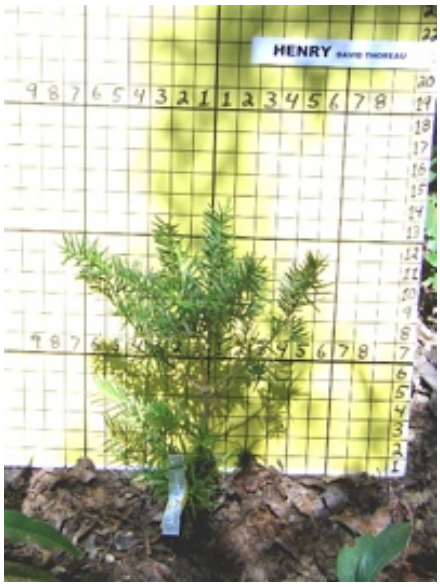
## • GROWTH DIFFERENCES BETWEEN WAYNESVILLE AND JUNALUSKA


Above photos **compare the most vigorous individuals** between the two different properties into which potted seedlings were planted in July 2008. Left is at Waynesville of the "Thomas/Wendell Berry" tree. **Right is at Junaluska** of the "Henry David Thoreau" specimen. Both photos were taken in late May 2012.

The photos below show **how similar in size the two specimens were when initially planted** in July 2008, with Berry on left and Thoreau on right. The fact that the Berry specimen is not a great deal taller in 2012 than it was at planting is not a disappointment, as examination of the seedlings during planting revealed that they had stayed in their pots for a year or two or three too long — and thus **we expected some initial dieback and the likelihood of a long period of root establishment** before a main stem would evidence obvious and sustainable growth.

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## • SUCCESS RATE DIFFERENCES BETWEEN WAYNESVILLE AND JUNALUSKA

Connie Barlow created the matrix below (includes both **Waynesville** and **Junaluska** NC plantings) to help assess why some individuals are thriving, some are failing, and several died. Note that **all the Junaluska trees show more luxurient growth than any of the Waynesville trees**, on a "rate" system spanning 0 (dead) to 16. Although Junaluska initially lost 3 of its 10 initial plantings to voles, once short wire cages were added to prevent future losses, *not a single specimen has died*. More, **every specimen in Junaluska is thriving**.

In contrast, the matrix below shows **a wildly varying success rate at the Waynesville site**, with declines and deaths having nothing to do with voles. This high variability in success is welcome, as it offers the **opportunity to begin discerning distinctions between favorable and unfavorable habitats** and plant associations for this Torreya species.

2012 Assessment of 31 Torreyas planted July 2008: Waynesville and Junaluska, North Carolina

| NAME | site | Elev. ft. | Rate* | Aspect | Canopy | Sub-can | S? | Moist v. Dry indicator species (May 2012) |
|---|---|---|---|---|---|---|---|---|
| C Beadle | Juna | 2,600 | **0** | East | full decid | ? | Y | ? [killed by voles eating cambium] |
| H Croom | Juna | 2,600 | **0** | East | full decid | ? | Y | ? [killed by voles eating cambium] |
| A Gray | Juna | 2,600 | **0** | East | full decid | ? | Y | ? [killed by voles eating cambium] |
| L Braun | Juna | 2,600 | 11 | East | full decid | medium | Y | jewelweed trillium witch-hzl p-ivy v-creep |
| R Carson | Juna | 2,600 | 12 | East | full decid | medium | Y | ? |
| Bartram | Juna | 2,600 | 12 | East | full decid | medium | Y | jewelweed hydrangia |
| W Mathai | Juna | 2,600 | 11 | East | full decid | dense+ | Y | jewelweed f-sol-seal violets v-creeper |
| A Leopold | Juna | 2,600 | 10.5 | East | full decid | medium | Y | hydrangia, trillium, jack-pulpit, v-creeper |
| Delcourt | Juna | 2,600 | 14 | South | open | dense+ | Y | jewelweed, nettle, violets, calycanthus |
| Thoreau | Juna | 2,600 | 16 | South | open | dense+ | Y | jewelweed, witch-hazel, p-ivy white-pine |
| J Applese | Wayn | 3,400 | 9 | South | full decid | lo-med | Y | sassafras |
| J Muir | Wayn | 3,400 | 1 | South | full decid | very low | Y | ? |
| Jefferson | Wayn | 3,400 | **0** | South | full decid | very low | Y | ? |
| P Martin | Wayn | 3,400 | **0** | South | full decid | very low | | ? |
| M Murie | Wayn | 3,400 | 3 | South | full decid | low | | sourwood pine-seedling ferns p-ivy |
| E Abbey | Wayn | 3,400 | 3 | South | full decid | very low | | f-azalea (in bloom!) |
| S Udall | Wayn | 3,400 | 1 | South | full decid | very low | | sourwood sassafras vaccinium |
| Mollison | Wayn | 3,400 | 1 | South | full decid | very low | | sourwood sassafras vaccinum f-azalea |
| J Butterfl | Wayn | 3,400 | 4 | South | full decid | very low | | Indian cuke (no ferns) |
| Audubon | Wayn | 3,400 | 3 | South | full decid | low | | f-sol-seal sourwood f-azalea vaccinium |
| C Darwin | Wayn | 3,400 | 8 | West | full decid | lo-med | | sourwood sassafras red-maple |
| J Macy | Wayn | 3,400 | 2 | South | full decid | low | | sourwood sassafras f-azalea vaccinium |
| L Eiseley | Wayn | 3,400 | 4 | South | full decid | low | Y | beech-sapling ferns f-azalea |
| J Huxley | Wayn | 3,400 | 5 | South | full decid | low | | ferns sourwood f-azalea crossvine |
| Kokopelli | Wayn | 3,400 | 7 | South | full decid | lo-med | Y | ferns sourwood |
| D Brower | Wayn | 3,400 | 5 | South | full decid | lo-med | | ferns Indian-cucumber |
| A Dillard | Wayn | 3,400 | 7 | South | full decid | lo-med | | ? |
| B Zahner | Wayn | 3,400 | 7 | SE | full decid | medium | | ivy v-creeper f-azaela sassafras |
| Berry | Wayn | 3,400 | 10 | East | full decid | medium | | hydrangia ferns f-sol-seal pipevine |
| M Evans | Wayn | 3,400 | 9 | East | full decid | dense | Y | hydrangia umbr-magnolia ferns |
| C Hunter | Wayn | 3,400 | 10 | South | full decid | dense | | hydrangia kohosh ferns sol-seal ivy |

All 31 individuals were planted beneath a full-deciduous canopy, except Delcourt & Thoreau.

Sub-can is the density of ground-level greenery in immediate surroundings.

S? refers to whether any "soil amendments" were added during the 2008 planting. Y = yes

* **"Rate"** column is a health-rating system, from "0" (dead) to "16" superb growth.

**Aspect** is the micro-habitat, as both sites are south-facing as a whole.

The **MATRIX** above includes a first attempt to catalog and compare possible indicator plant species.

- **BLUE font indicates moisture-loving plants**
- **RED font indicates plants that are typically found in drier conditions**

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## • ELIMINATING POSSIBLE CAUSES OF SUCCESS DIFFERENCES

- **Not SOIL SUPPLEMENTS**: The column titled "S?" in the matrix above denotes whether or not soil amendments were mixed into the specimen at the time it was planted in July 2008. While all the Junaluska specimens were given soil supplements (marked by "Y"), less than a third of the Waynesville plantings received such supplements. Note that the two most successful trees at Waynesville (those rated a "10") received no supplements, and one of the two trees that died had received supplements. Overall, **by analyzing the success rates *within* the Waynesville site, we see we can eliminate soil supplements as a causal factor.**

- **Not SUPPLEMENTAL WATERING**: For several months directly following the July 2008 planting, all specimens at both Junaluska and Waynesville were given supplemental water by hand. But after that, ***no supplemental watering*** was given. Indeed, with the exception of the basal stem cages at Junaluska and a bit of greenbriar pruning and hardwood-seedling pulling when photographs were taken, **all individuals were left entirely alone** — thus with the freedom to live or die as "rewilded" individuals (that is, seedlings that had germinated in a nursery and which spent the first 4 or 5 years of their life in pots at a nursery).

- **Not GENETICS**: Thirty of the 31 seedlings planted in total at the Waynesville and Junaluska NC properties in July 2008 are **very genetically similar**. Those 30 were **purchased from Woodlanders Nursery in Aiken, South Carolina**. The nursery owners wrote, "I believe all of the Torreya we have propagated and distributed in recent years (including the ones you refer to) were seedlings from plants here in Aiken. Years ago on a nearby estate we planted two female trees and a male. **The females were cutting-grown from the famous old Torreya in Norlina, NC** and the male was cutting grown from a specimen at the **Henry Foundation in Gladwynne, PA**.

  **Seedling No. 31, "Celia Hunter", was donated by Atlanta Botanical Garden.** It grew from one of many seeds produced by the Garden's "potted orchard," which was cloned from branchlets harvested in 1991 from living original, wild trees in the Apalachicola pocket reserve. So this particular seedling has a pedigree directly related to the wild genotypes. (At the time of donation, the ABG had no idea that the donated seedling might be used in an assisted migration project.)

  NOTE: Torreya Guardians are aware that **the genetics of these plantings are dangerously inbred**. We look forward to the time when the officials in charge of the Endangered Species Management Plan for *Torreya taxifolia* will conclude (with us) that **the benefits (in both knowledge acquisition and species longevity) of assisting the northward migration of this highly endangered conifer far outweigh the possible risks of invasion and disease** that some parties put forth as reasons to preclude experimentation with assisted migration as part of ESA plant management. At such time, the property owners at both sites would likely be very receptive to (a) additional plantings to increase the genetic diversity, and (b) ESA-sanctioned visits to monitor site progress. For more on this topic, see the online essay by Torreya Guardian Connie Barlow, **"Paleoecology and the Assisted Migration Debate: Why a Deep-Time Perspective Is Vital**." For access to the ESA management plan and other pro-assisted-migration comments that were filed, click **here**.

Lee Barnes returns to Evans Property site November 2008. Here, by seedling "Loren Eiseley," he displays a photo he took 20 years earlier of the **biggest Torreya taxifolia tree: a female in Norlina, NC. She is "Grandma" to all but one** (all but "Celia") of the 31 seedlings that were planted in NC July 2008. Note: Lee Barnes studied Florida Torreya for his PhD dissertation at the University of Florida (1985), available online: **"Clonal Propagation of Endangered Plants: Rhododendron chapmanii, Taxus floridana, and Torreya taxifolia"**.

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## • POSSIBLE CAUSES OF SUCCESS DIFFERENCES (for further testing)

- **Elevation Difference**: **The Junaluska site is 800 feet lower in elevation than the Waynesville site (2,600 feet compared to 3,400 feet).** Lee Barnes, who lives in Waynesville, observes that during the winter there will often be moist snow falling up at the Waynesville Torreya site when there is only rain down in Junaluska. So this difference could be significant and calls for further investigation.

PHOTO LEFT: The specimen **"Celia Hunter" torreya** after a moist snow at the Waynesville site in December 2008.

- **Amount and Timing of Direct Sunlight**: In the matrix above, note the "Aspect" column. At a **macro scale**, all specimens at the Junaluska and Waynesville sites were planted on **south-facing mountain slopes**. But there were big **differences in the micro-scale aspect**, which is what is depicted in the matrix. Much more investigation needs to be conducted on the matter of sunlight (but, as noted below, "indicator species" may be a more practical site characteristic to assess).

It is important to know that by far **the most successful individuals were the only two planted in pretty much full sun: "Hazel Delcourt" torreya** and **"Henry David Thoreau" torreya**. The photo below left shows the context of "Hazel Delcourt" immediately after planting in July 2008 (photographer is facing north, and Hazel is directly under the crouched man's left hand). At right is "Hazel Delcourt" in May 2012, which now just overtops the poster grid Lee Barnes is using to measure growth (photographer is also facing north). Note how lush all the new growth is in this untended part of the garden.

- **Hydrology**: It is reasonable to surmise that, with the exception of perhaps the first year of site acclimation, specimens that grow in the most sunlight generally do best. Indeed, one of Connie's observations of naturally occurring California Torreya is that **seeds are only produced on trees/branches that receive a good deal of direct sunlight**. (See, for example, the captioned photos at the bottom of **this page** documenting a California site visit on the slopes west of Napa Valley.) However, **too much sunlight can be problematic in seasonal drought times**. Hence, the importance of hydrology. But, here again, a survey of naturally growing herbs and shrubs (and to a lesser extent, canopy trees) that are neighbors to a Torreya individual may provide the most direct and easy to acquire information about soil moisture levels. Hence, the importance of undertaking inventories of plant associations, as detailed below — and, from those, working to determine "indicator species."

- **Soil Chemistry**: Torreya Guardian Russ Regnery (and steward of **out-planted seedlings near Franklin NC**) supplements this field report with a suggestion that **soil pH** would be important to test as a possible causal factor in the growth differences apparent between and within the Waynesville and Junaluska sites. Direct testing along these lines would be useful. Nonetheless, as with the other possible causes, differences in associated plant species may also indicate soil chemistry differences.

- **Importance of "Indicator Plant Species"**: It is reasonable to conclude that **hydrangia and trillium** are indicators of plentiful soil moisture, and thus are likely good locales for planting Torreya. It is also reasonable to conclude that it is unwise to plant a Torreya seedling near **sassafras, vaccinium, and flame azalea**.

A classic **OAK-HICKORY CANOPY is thus to be avoided** — which is precisely where we planted the cluster of 12 specimens shown on the matrix headed by the specimen named "Johnny Appleseed." The question, then, is **Why (among those 12) are Johnny Appleseed and Charles Darwin doing so well?** Careful site inspection, followed by group dialogue, would surely reveal important considerations.

WHAT ABOUT JEWELWEED IN JUNALUSKA? ***Impatiens capensis*, jewelweed, is the only moisture-indicating species that was found (often in abundance) around all but one individual at the Junaluska site** — but at none of the Waynesville locales. A quick internet search reveals this:

> *Impatiens capensis* is an annual plant native to North America. It is common in bottomland soils, ditches, and along creeks. The preference is light shade to partial sun, wet to moist conditions, and a fertile soil with an abundance of organic material. Submergence of the roots by flood water is tolerated for up to 2 weeks without apparent ill-effects.

Overall, now that the 2008 specimens have established (or died or severely declined), we have **a terrific opportunity to make qualitative and quantitative observations that might lead to real breakthroughs in understanding the habitat preferences** of America's eastern species of genus Torreya.

**Experienced ecologists are encouraged** to survey the matrix above and to click on the photo-essays for each individual specimen planted in Junaluska and Waynesville (the links to each specimen are listed at bottom). Please email your conclusions and speculations (and any advice for future on-site observations) to Connie Barlow: conniebarlow52 at gmail.com

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## • "REWILDING" AS THE ULTIMATE GOAL

Ideally, habitats will be found not only where *Torreya taxifolia* may survive with continuing human-assistance, but also **habitats where the species can sustain and propagate independently** — as it seems to have done in recent years, thanks to **squirrels dispersing seeds** at three verified locations: **Biltmore Gardens near Asheville NC** and on other private lands in **Clinton, NC** and **Highlands, NC**.

Ideally, humans will be able to help this conifer genus return to the rich deciduous montane forests of eastern North America as a **self-perpetuating contributor to natural plant ecologies** within the "discordant harmonies" and "ever-shifting" dynamics wrought by climate change and phylogenetic flows over the course of geological time. As some have speculated, perhaps *Torreya taxifolia*, over the course of millennia, might be able to fill in for the ecological devastation wrought by the invasive disease (woolly adelgid) that has virtually eliminated the only other canopy evergreen in moist low-mountain forests of the southern Appalachians: **hemlock**, genus Tsuga.

PHOTO LEFT: A naturally dispersed seedling on private lands in **Highlands, NC**.

The photo was taken with a flash camera during a site visit in August 2006.

The site visitors entailed Lee Barnes, Connie Barlow, Jeff Zahner, and two others. (Jeff is the son of famed forester of North Carolina Bob Zahner, for whom one of the Torreya seedlings planted in 2008 on the Waynesville property was named.)

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## • A DEEP-TIME PERSPECTIVE ON WHAT IS "NATIVE"

From the very beginning, **a symbiotic working relationship between Torreya Guardian activists and the professionals who are bound to abide by the specifications of the Endangered Species Management Plan for *Torreya taxifolia* has been thwarted, largely because of a disagreement about what constitutes "native" range and "native" habitat.**

So long as the professional botanists and ecologists in charge of endangered species continue to assume that "native range" is limited to where these species were living when Europeans first arrived on this continent, mutually beneficial coordination of activities will be difficult to achieve.

**In this time of rapid climate change, we simply must acquire a deep-time perspective.** We've got to look at the migratory patterns of species and habitats with eyes that honor the flow of biological history — not just human history. It is time to begin thinking about "native range" over the genus and species' entire biological lifespan. That means in thousands and millions of years, not just a few centuries.

To move weedy plants from one continent to another is, unquestionably, ill-advised. But moving a native and highly endangered conifer tree a few hundred miles northward on its home continent should be even less controversial than helping the California Condor re-establish nest-holds on the Colorado Plateau — where it lived only in prehistory. (See the 2008 paper by Jillian Mueller and Jessica Hellmann, "**An Assessment of Invasion Risk from Assisted Migration**".)

See also the comments filed by Connie Barlow in 2010 re the USF&WS request for comments on the proposed update of the ESA Management Plan for *Torreya Taxifolia*. She subtitled her comments, "**An Opportunity to Shift to a Deep-Time Perspective of Native Habitat**." See also this short-version, illustrated webpage: "**Paleoecology and the Assisted Migration Debate: Why a Deep-Time Perspective Is Vital**."

Finally, although portions are now outdated, see the original paper that launched the debate in 2004, co-authored by Connie Barlow and (the late) Paul S. Martin: **Bring Torreya taxifolia North — Now**."

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## • THE APPALACHICOLA HABITAT AS GLACIAL REFUGIUM

**Palynologist Hazel Delcourt**, in her 2002 book, ***Forests in Peril: Tracking Deciduous Trees from Ice-Age Refuges into the Greenhouse World***, has well established that the Apalachicola region of the Florida panhandle is one of a handful of primary "pocket refuges" along the Gulf Coast and the southern Atlantic to which the rich flora of the central and southern Appalachians retreated during the peaks of glacial episodes. Indeed, it can be reasonably inferred that **had this continent lacked such large riverine environments with banks of rich soil (contrasting to the predominant sandy soils of the region), North America would have lost to extinction genus Liriodendron** (tuliptree) — as did Europe.

The MAP (left) shows **the primary watercourse routes that rich-soil and moisture-loving species of America's eastern deciduous forests would have taken to find refuge during peak glacial times**. The "Alatamaha" refugium would have extended out onto the continental shelf of the Atlantic side of Georgia, when ocean level was at a low because of all the water bound up as glacial ice. It was along the lower Alatamaha that the only specimens of the nearly extinct ***Franklinia*** shrub species were ever found.

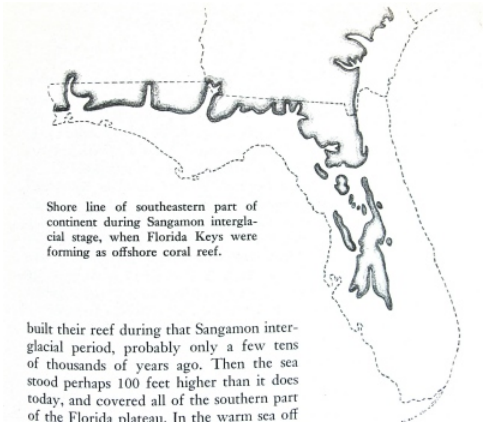
It is plausible that *Torreya taxifolia* once took refuge along the lower Alatamaha, but it has never been seen there in historic times. Its **only "historic" sightings have been at or near the Appalachicola River** (marked in orange on the map) — which served as another key glacial refugium for temperate species of eastern North America.

**CONCLUSION:** The best explanation for why *Torreya taxifolia* is now endangered is not that it is poorly adapted for continued existence in eastern North America after a legacy of millions of years. Rather, the eastern species of this Northern Hemisphere genus is a **glacial relict** in its current location. It was "left behind in near time," in its ice-age refugium, according to the late Pleistocene ecologist **Paul S. Martin**.

Observe (left) that **the large seed would have required squirrels** (who extract and bury the seed) to help this species **move in tandem with climate change**.

Paul Martin and Connie Barlow surmised that, because the Apalachicola refuge habitat was so limited, and because the riverine habitat would have been so attractive to the first peoples 13,000 years ago, **the local squirrel population may have been extirpated**, thus depriving this species of an animal disperser.

Hence, the call today for **"assisted migration"** to help this conifer quickly sync with a warm, interglacial climate.




Map of how **rising sea-level at the peak previous interglacial period** (Sangamon Interglacial, 125,000 to 75,000 years ago) would have forced the coastline of Florida to recede. Where would have been "native range" for *Torreya taxifolia* during that time — and where should it be today?

Source: **Rachel Carson**, *The Edge of the Sea*, 1956 (p. 195). On the facing page to this map, Carson wrote, "To understand the living present, and the promise of the future, it is necessary to remember the past."

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**A. J. Bullard** with his Torreya taxifolia in Mt. Olive NC, which he planted from a seedling from the mother Torreya in Clinton NC.

**Squirrels are repulsed from stealing unripe seeds still hanging on the tree**; the branches are too long, the leaves too prickly, and the seeds borne too far out on slim branches for any squirrel to access. Rather, squirrels have to wait for seeds to fall to the ground when ripe.

This contrasts with seeds produced at the **Atlanta Botanical Garden** from specimens that began as rooted cuttings from wild Apalachicola genotypes. Those branches retain a "memory" of being on a much older tree: even though they were rooted as the new main stem of a growing individual, they retain a shrubby stature and produce seeds more than a decade earlier than a Torreya tree germinated from seed.

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## • CALLING FOR PROFESSIONAL AND ACTIVIST COLLABORATION

**Overall, the pattern of success and failure resulting from even these first 4 years of fieldwork by Torreya Guardians offers important guidance for homing in on preferred habitat specifications for North America's eastern species of Torreya under the climate conditions that prevail today (and as projected into the future).**

**Site visits, consultation, and further experimentation northward of the species' glacial refugium are highly recommended** toward coming to understand the preferred habitat and the survival/thrival boundary conditions of North America's eastern species of genus Torreya — the only endangered species of genus Torreya in the world. Thus far, it is the activists within the Torreya Guardians collective, and the private landowners they work with, who are in the lead for doing the actual fieldwork by which to best discern the species' habitat preferences under today's climate conditions (and with an eye to how plants zones may continue to shift over the course of even a single generation of trees assisted in migrating). See how much the zones have already shifted, as

indicated in the **February 2012 release of a new plant zone map for the USA by the US Department of Agriculture**.

**Observational work and conjectures in the tradition of "natural history" will continue to be highly useful.** Professionals and avocational volunteers with broad experience are both needed for formulating hypotheses for rigorous testing, while field testing and assisted migration continue.

**Qualitative assessments and tentative conclusions will also continue to be necessary**, especially in assisting private landowners who wish to abide by current best practices in how best to aid this species in migrating to habitats that today (and in the future) will offer its best prospects.

**By discerning Torreya's preferred habitat conditions and doing our best to plant seeds and seedlings in such habitats, we will be giving the tree a chance to use its natural defenses to thwart Phytophthora water molds** (and other plant diseases) that have already destroyed its reproductive capabilities in its historically native habitat (northern Florida).

It thus will be humans who help the species to **"migrate"** northward, but it will be up to the species itself as to whether **"colonization"** is the long-term result. This is a hugely important distinction. By experimenting with possible habitats well northward and altitudinally higher of its "historically native range," we Torreya Guardians are aiming for results that will enable species preservation without the need for continuing taxpayer support. In contrast, so long as the ESA management plan limits Torreya restoration to the region best understood as its peak-glacial refugium, there is little realistic hope that the species will ever be restored to independent viability. See the online post: **advocating the term "assisted migration"** and the **communications with scholars** upon which it is based.

"My personal and professional odyssey as a historian of deciduous trees
has brought me to the realization that the future of the eastern deciduous forest is now at risk.
We can provide corridors to allow for species to migrate successfully
in the face of climate change. We may also need to be prepared to transplant
endangered species to new locations where climate will be favorable."

— Hazel Delcourt, ***Forests in Peril*** (2002, pp 97, 207)

Hazel Delcourt Torreya tree with Sara Evans (left). Henry Thoreau with Janet Manning (right).

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**Contact Connie Barlow** **OR** **Return to HOME PAGE**