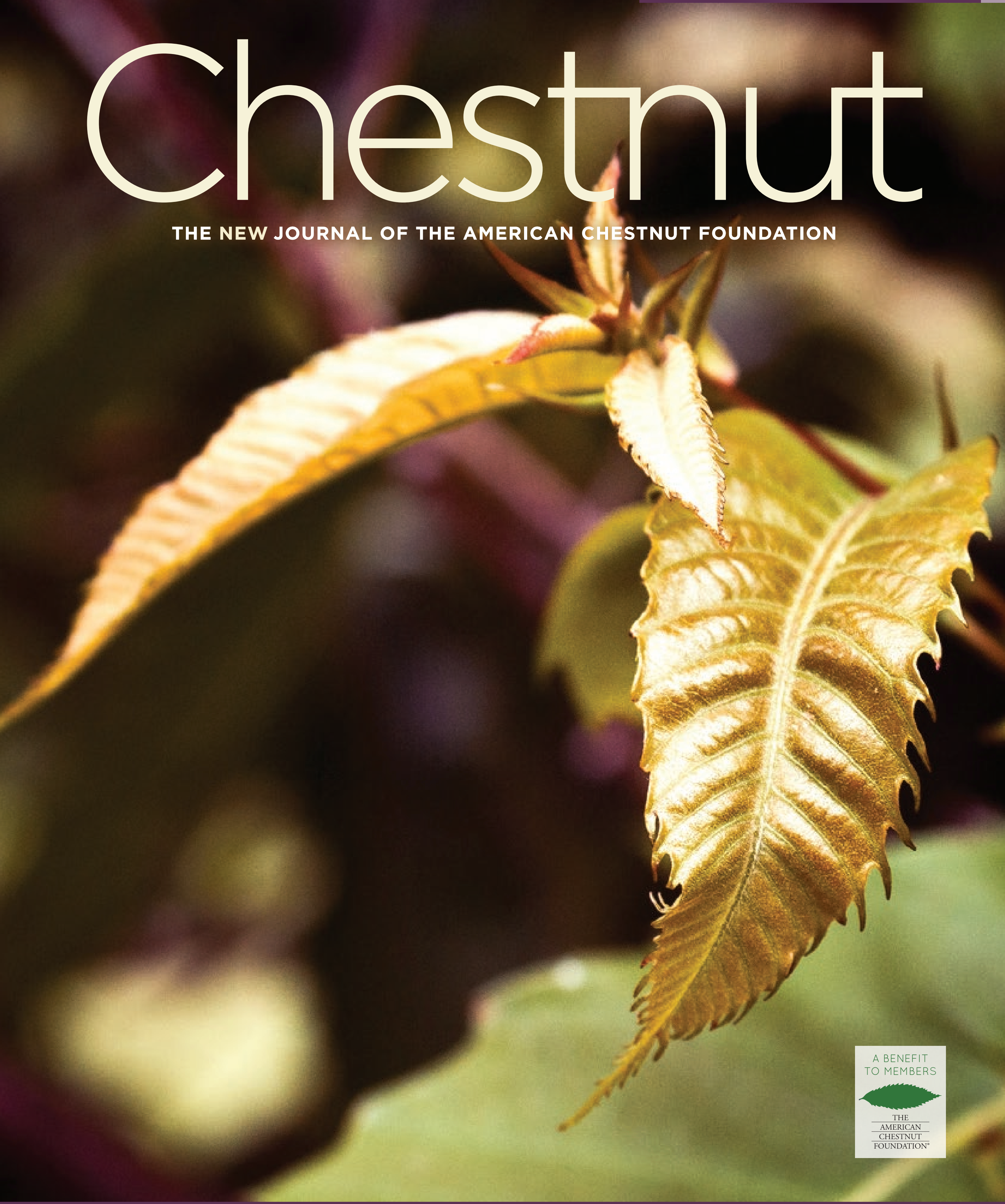
FALL 2015 ~ ISSUE 3 VOL. 29

Chestnut

THE NEW JOURNAL OF THE AMERICAN CHESTNUT FOUNDATION



A BENEFIT TO MEMBERS
THE AMERICAN CHESTNUT FOUNDATION®

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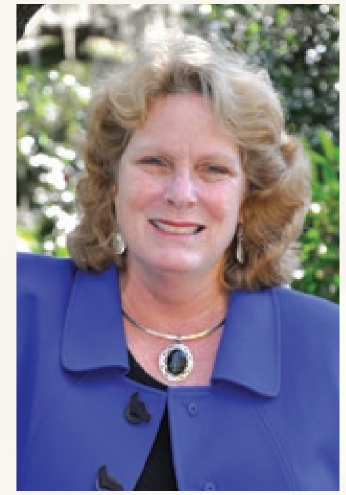


Lisa Thomson

President and CEO

DEAR CHESTNUT ENTHUSIASTS,

Fall is quickly approaching and like many of you, the rest of the year will fly by with meetings, conferences and of course, the holidays. It is harvest time in our field work, with seed gathering the main activity. We look forward to updating you on our seed production this year, combined with stories about the hard work of the dedicated staff at Meadowview and our regional science coordinators.

Speaking of staff, you will read about two new additions to the TACF family, housed in the Asheville office: Heather Nelson and Wendy Wilson. Heather is our Accounting Manager and brings a wealth of financial and bookkeeping experience from a non-profit background. Wendy came from Vanderbilt University and is helping coordinate all administrative functions of the office. Although not profiled in this issue, Vic Hutchinson recently joined our team as development director so expect to read a full profile of him in the next issue. Vic is also located in the Asheville office, and he looks forward to hitting the road and meeting many of you. Finally, I hope you enjoy the tribute on page 40 for Chief Scientist Emeritus Fred Hebard who retired in June after dedicating 26 years to restoring the American chestnut. His profile is featured in our new Founder's Tribute, to pay homage to those early pioneers in TACF history.

Our board of directors, staff and chapter leadership are busy looking to the future. Where is TACF poised to go and how do we grow the organization in a thoughtful, strategic way? What kind of new audiences should be reached, and how do we better tell our compelling story? How do we translate our science and restoration work into a forest of self-sustaining chestnut trees? These and other questions will be addressed, as a strategic planning process has commenced. Starting with the compilation of survey results conducted this summer, we have already received critical feedback to learn about trends and new ideas from our most important ambassadors: board of director members, chapter leadership, current staff and long-term members of our community. Thanks to all of you who took the time to respond to our survey and stay tuned for updates.

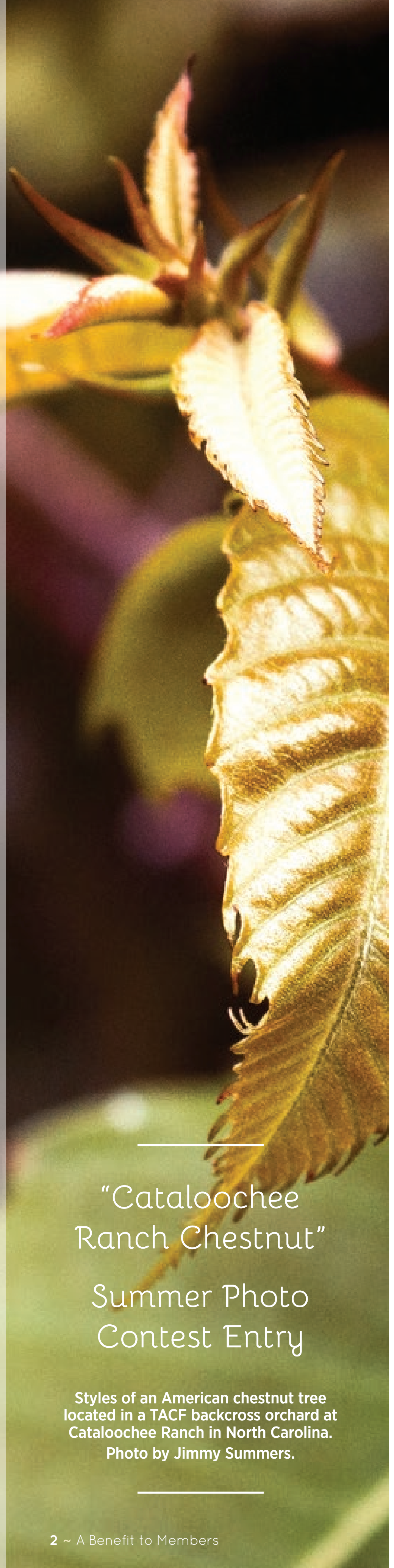
None of these goals and dreams would be possible without the steadfast financial support from you, our members and generous donors. In this issue please find the center page launching our fall annual fund campaign, with a goal of $250,000, our most ambitious ever. This goal was derived from critical capital needs at our Meadowview Research Farm to organizational enhancements such as a new, integrated website, launch date to be in January 2016. I hope you consider TACF as generously as your circumstances allow in your year-end charitable giving decisions. Rest assured we will use your contribution wisely; any amount is gratefully received.

With best wishes for a happy and healthy rest of 2015,

Lisa Thomson

Lisa Thomson
President and CEO
The American Chestnut Foundation

Follow me on Twitter (@MadameChestnut).



"Cataloochee Ranch Chestnut"

Summer Photo Contest Entry

Styles of an American chestnut tree located in a TACF backcross orchard at Cataloochee Ranch in North Carolina. Photo by Jimmy Summers.

THE AMERICAN CHESTNUT FOUNDATION®

WHAT WE DO

The mission of The American Chestnut Foundation is to restore the American chestnut tree to our eastern woodlands to benefit our environment, our wildlife, and our society.

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TACF Wraps Up

MULTI-YEAR CONSERVATION INNOVATION GRANT

By Michael French, TACF Forester

Professional tree planters planting ripped ground at the CIG project in Clinton County, PA (2014). Photo by Michael French.

In 2011, The American Chestnut Foundation (TACF) was awarded a national Conservation Innovation Grant (CIG) by the USDA – Natural Resources Conservation Service (NRCS). This was an exciting opportunity as the grant had multiple objectives to help TACF forward our mission of restoring American chestnuts to eastern forests, while also working toward NRCS's mission of putting private lands into permanent conservation.

Project objectives included: 1) the establishment of diverse, mixed hardwood/American chestnut forests on reclaimed mine lands in Kentucky, Ohio, Pennsylvania, Virginia, and West Virginia; 2) the creation of workshops, models, and a manual to aid landowners who wish to reforest mined lands or establish chestnut plantings; and 3) support for TACF's online trees database. TACF worked closely with the Appalachian Regional Reforestation Initiative (ARRI) and Green Forests Work (GFW) to implement this grant and we have successfully completed all of the project objectives.

Mined land plantings

A major objective of the CIG was to demonstrate large-scale reforestation of reclaimed surface mined lands using ARRI's most recent reclamation recommendations, known as the Forestry Reclamation Approach (FRA), while also demonstrating the blight-resistance and the competitive ability of TACF's most advanced generation of chestnuts. A total of 12 plantings were established on coal surface mines in Kentucky (2), Ohio (2), Pennsylvania (4), Virginia (2), and West Virginia (2).

Each of the 12 plantings included a 1-acre progeny test for TACF's Restoration Chestnuts 1.0, which will help TACF determine and demonstrate which families carry higher levels of blight resistance. Progeny test trees were direct-seeded (i.e. planted as seed), sheltered with 2' tree shelters to protect the seeds and young seedlings from rodents, and locations of the individual trees were mapped at the time of planting. A randomized complete block design was used for the progeny tests to allow for later analysis of differences in blight resistance, growth, and other characteristics between the families.

The progeny tests are surrounded by larger reforestation areas, approximately 30 acres in size, and planted to create a mixed hardwood/chestnut forest type, which has been virtually absent from Appalachian forests for more than 60 years. For the mixed hardwood reforestation area, 1-year-old bareroot seedlings were used, as this is the most common planting stock used for mined land plantings. The mixed hardwood reforestation areas will demonstrate how chestnuts compete against other species in a mixed hardwood setting.

Although the CIG called for approximately 360 acres to be reforested for the 12 projects, TACF and many partnering organizations and individuals managed to apply the FRA to slightly more than 425 acres, resulting in the planting of 294,588 trees. Several of the CIG projects included working with active mining operations to implement the FRA for the first time, and some of those companies were so happy with the projects that they intend to implement the FRA on future reclamation projects. Unfortunately, we cannot describe all 12 plantings in this article, so we have selected four to highlight.

Bill Reichert of Schuylkill Headwaters Association discusses how the FRA benefits trees, water, and soil at the first CIG workshop in 2012. Photo by Michael French.

Schuylkill County, Pennsylvania (2012)

This 22-acre site was established on an active coal mine within the Chesapeake Bay Watershed. Residents downstream from the site were attributing flash flooding and sedimentation issues to the mining operation, which had been reclaiming the land by compacting it, seeding it with grasses, and planting trees. TACF and ARRI worked with Bill Reichert and Schuylkill Headwaters Association, PA-DEP, NRCS, the local Soil and Water Conservation District, Schuylkill County Municipal Authority, and the mine operator to implement the Forestry Reclamation Approach. To do so, the mine operator must cross-rip the ground, which loosens the ground and allows rainfall to better infiltrate the soil and to release water more slowly, rather than quickly running off the compacted surface. The loose ground also fosters higher survival and faster growth of planted trees by allowing roots to extend more quickly and into the soil. Cross-ripping also disturbs and exposes soil, providing native seeds with a place to germinate and take root as they land on the site from surrounding areas. A mix of trees including white oak, chestnut oak, black cherry, sugar maple, Restoration Chestnuts 1.0, hazelnut, eastern redbud, and others were then re-planted. Survival of planted seedlings across the site has been very good and native species such as aspen and birch have been colonizing the site.

Dickenson County, Virginia (2013)

This 22.5-acre site in southwestern Virginia had been compacted and seeded with grasses and legumes as called for in the mining permit as part of the hay/pastureland revegetation plan. The site was quickly being overrun with autumn olive (*Elaeagnus umbellata*) and other exotic, invasive species. TACF, ARRI, and GFW worked with the Virginia Department of Forestry (VDOF) and the landowners to implement the FRA on the site. During the summer of 2012, the exotic shrubs and trees were cut down, and the cut stumps were treated with herbicide to prevent re-sprouting. After two growing seasons, survival in the progeny test planting was 72% and seedlings averaged 30 inches tall. Survival in the mixed hardwood area was estimated to be around 92% after two growing seasons.

From 2012 through 2015 (when the CIG was being implemented), this NRCS grant allowed TACF to assist in the planting of more than a million trees across 1,692 acres in eight states (AL, TN, KY, VA, WV, OH, PA, and MD).

Bill Miller of VDOF cuts autumn olive at the site in Dickenson County, VA. Photo by Michael French.

VDOF staff pushes brush into piles for wildlife. Photo by Michael French.

Elk County, Pennsylvania (2013)

This 30-acre project in central Pennsylvania also lies within the Chesapeake Bay Watershed. It had been compacted and seeded in grasses during reclamation in the early 1990s and very little natural regeneration of tree seedlings was occurring. The Western Pennsylvania Conservancy (WPC) owns the property and desired to have this parcel reforested as a part of their overall management plan for improving water quality in the watershed. The reforestation site was cross-ripped and TACF, ARRI, and GFW worked with WPC, Pennsylvania Wildlife Habitat Unlimited, and volunteers to plant 11 of the 30 acres. The remainder was planted by professionals and more than 20,000 seedlings consisting of 14 different species were planted. Survival in the progeny test was nearly 75% after two growing seasons.

Coshocton County, Ohio (2014)

This 30-acre reforestation project occurred on a surface mine reclaimed as hay/pastureland on a property owned by Tom Brannon, a long-time TACF volunteer who contacted TACF when the CIG was announced. Tom had been reforesting the reclaimed areas with the help of his family and they thought that the property might be ideally suited to the CIG. TACF, ARRI, GFW, and the Brannons worked with NRCS and local volunteers to plant the progeny test. After one growing season, survival in the progeny test was 86%. The 30-acre reforestation area was planted with more than 21,000 trees from 20 different species. Tom is currently pursuing another NRCS contract to reforest the remaining reclaimed areas of the property.

These reforestation projects will result in cleaner air and water, increased carbon sequestration, future timber production, and better wildlife habitat for numerous species. However, many exhibit additional benefits for pollinators immediately after ripping. Following the herbicide application and ripping, or ripping alone, several sites showed a noticeable increase in native wildflowers, both in terms of diversity and in the percentage of total groundcover.

Tools for landowners and cooperators

CIG, TACF, ARRI, and GFW developed two state-and-transition models to help natural resources professionals understand and describe the existing conditions of mined lands, and to recommend methods to help them achieve success in reforesting mined lands. We also developed a technical manual that gives general guidelines for helping landowners establish and maintain different types of chestnut plantings. Although only 12 workshops were required, the partners hosted 25 training workshops held throughout the Appalachian region. Each of these was designed to educate landowners, mining regulators, and the public about mined land reforestation using the Forestry Reclamation Approach and chestnut restoration efforts.

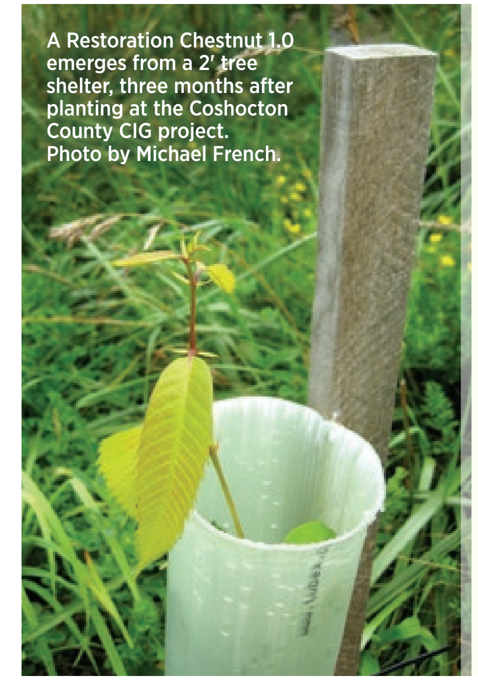
Online Trees Database

As TACF's restoration effort grows and the number of plantings increases, the creation of a universal tracking database will be essential to monitor and record chestnut plantings. The CIG provided funding to develop an online database to help TACF staff, members, landowners, and natural resource professionals to store, share, and track data on American chestnut plantings. Many orchards, progeny tests, and trees have been entered into the database.

Two chestnuts in the progeny test emerge from the native wildflowers that returned after conservation practices were applied. Photo by Michael French.

Pennsylvania Wildlife Habitat Unlimited and volunteers help plant seedlings on the ripped slope at the CIG project in Elk County. Photo by Michael French.

Author's note: I would like to personally thank all of The American Chestnut Foundation's valued members, donors, and partners. This work would not have been possible without the continued support of USDA-Natural Resources Conservation Service, the US Forest Service, the Appalachian Regional Reforestation Initiative, Green Forests Work, the Arbor Day Foundation, the Norfolk Southern Foundation, the Richard King Mellon Foundation, numerous state and federal agencies, universities and colleges, and the countless volunteers who worked tirelessly to make these plantings a success. Thank you!



A Restoration Chestnut 1.0 emerges from a 2' tree shelter, three months after planting at the Coshocton County CIG project. Photo by Michael French.

Next steps

Recently, the Appalachian Mountains Joint Venture (AMJV) was awarded a 5-year, Regional Conservation Partnership Program (RCPP) grant by NRCS to improve forest habitat for cerulean warblers. Although the focus of this award is to improve 12,500 acres of forested habitat, TACF and Green Forests Work are proudly partnering with AMJV on this grant, which will lead to the creation of 1,000 acres of forestland on reclaimed surface mines in KY, MD, OH, PA, and WV. If you know of a landowner who wishes to have forestland on reclaimed surface mined land, please contact Michael French by email at: michael@acf.org or by phone at: (812) 447-3285.

MASSACHUSETTS/RHODE ISLAND CHAPTER ESTABLISHES

Large-scale Seed Orchard

at the Massachusetts Division of Fisheries & Wildlife Headquarters

By Denis Melican, MA/RI Chapter Member

The Wayne F. MacCallum Wildlife Management Area in Westborough is also the location of Massachusetts' newest seed orchard. Photo by Kathy Desjardin.

Massachusetts is one of the most urbanized, suburbanized, and densely populated states in the Northeast. It is also one of the smallest states in size. Despite all of this, Massachusetts holds one million acres of conservation lands extending from the spruce trees on the summit of Mount Greylock State Reservation to the sand dunes of the Cape Cod National Seashore. Nearly 200,000 of these acres are under the stewardship of the Massachusetts Division of Fisheries & Wildlife (DFW), a state agency with deep roots throughout the state's long history of conservation.

MassWildlife was founded in 1866 as a state fisheries commission and branch of the Massachusetts Division of Fisheries & Wildlife (DFW) that strives to reflect the will of its citizens to protect the state's natural resources. Specifically, *MassWildlife*'s charge is the stewardship of all wild amphibians, reptiles, birds, mammals, and freshwater and diadromous fishes in the state, as well as endangered, threatened, and special concern species, including native wild plants and invertebrates. Because of its statutory responsibilities, the mission of The American Chestnut Foundation (TACF) struck a sympathetic chord with *MassWildlife* officials when they first learned about the Foundation's efforts.

Rufin Van Bossuyt, founding member of the MA/RI chapter and TACF Board of Directors, initiated what has become a flourishing relationship between TACF and *MassWildlife*. In 2011 Van Bossuyt was working as a forester for the New England Electric Company and became involved with *MassWildlife*'s legendary efforts to restore the bald eagle at the Quabbin Reservoir. This experience created a mutual respect and strong friendship between Van Bossuyt and *MassWildlife* officials.

One of the first projects between the two organizations was the planting of a BC_3F_2 research orchard along the entrance road at the Central Division of the West Boylston facility. *MassWildlife* District Manager Bill Davis worked closely with Van Bossuyt during this initiative, and Davis saw an opportunity to further the collaboration.

One of the first five chestnut seedlings planted at the Westborough Seed Orchard. Photo by Kathy Desjardin.

Left-right: District Supervisor Bill Davis, Director of the Division of Massachusetts Fisheries and Wildlife Wayne F. MacCallum, and TACF Board Member Rufin Van Bossuyt attend a demo planting ceremony at the Field Headquarters in Westborough. Van Bossuyt started the B_3F_3 seedlings in 2010 with nuts grown/harvested in Meadowview. The walking sticks they are holding were made by Bill Davis from American chestnut sprouts. Photo by Kathy Desjarden.

When *MassWildlife* was in need of a planting at its brand-new state DFW headquarters in Westborough, the Wayne F. McCallum Wildlife Management Area, TACF and its Restoration Chestnuts 1.0 were at the top of the list.

The MA/RI chapter is very excited about furthering its partnership with *MassWildlife* and the feeling is reciprocal. This organization shares the same attributes and virtues of the MA/RI chapter including a time-tested commitment to conservation, concern for future generations, science and fact-based decision making, as well as a dedication to public outreach and education. In terms of a partner, *MassWildlife* has been nothing short of 'perfect'.

Brian Clark serves as the MA/RI chapter's vice president of orchard management, and he has played a major role in bringing the DFW project to life. Clark and Van Bossuyt have been responsible for the entire orchard planning process. This tremendous role involves organizing work parties, installing fence posts, removing rocks and stumps, laying out the rows, and installing the plantings, among many other tasks.

In terms of progress, 1,250 seeds have been planted at the DFW headquarters to date. But as all TACF members know, seed orchards are an ongoing effort with regular maintenance requirements including weeding, mowing, irrigation, fertilizing, and additional plantings. The MA/RI chapter is also fortunate to have the leadership of orchard managers Jamie Donalds and Brad Smith. Thanks to their organization, the expected completion date of this seed orchard is approximately one year away. At that time, there will be a total of 3,200 trees planted at this very high-profile location.

The MA/RI chapter is very excited about the opportunity for additional projects with *MassWildlife*. This relationship makes discussions possible about more chestnut plantings within the 200,000 acres of DFW's Wildlife Management Areas located throughout the state. It also clearly illustrates how forest diversity and wildlife sustenance can be greatly improved by the reintroduction of healthy, blight-resistant chestnuts.

When it comes to conservation in Massachusetts, no organization does a more thorough job than *MassWildlife*. The establishment of the Westborough seed orchard is a major step in TACF's partnership with *MassWildlife* and towards the organizations' shared goal of reestablishing the American chestnut as a keystone species in Massachusetts.

NEWS FROM TACF

FALL 2015

CHESTNUT FESTIVALS

8th Annual West Virginia Chestnut Festival in Rowlesburg

Sunday, October 11, 2015
10:30 AM – 7:30 PM
Rowlesburg Park & Szilagyi Creative Arts Center

Meet TACF President & CEO Lisa Thomson, sample chestnuts roasted on an open fire and other savory chestnut dishes, visit chestnut vendors selling crafts and wares, purchase American chestnut saplings, watch a chestnut demonstration planting by Mid-Atlanta Regional Science Coordinator Matt Brinkman, attend the Gala Chestnut Dinner Banquet with keynote speaker Kathy Marmet, and witness the 8th Annual Crowning of Chestnut Royalty: Mr. and Mrs. Chestnut, Robert and Carolyn Sypolt.

6th Annual Chestnut Restoration Celebration in Meadowview, Virginia

Saturday, October 17, 2015
2:00 – 6:00 PM
Glenn C. Price Research Laboratory
Meadowview Research Farms

Catch seedlings during the chestnut drop, relax on a hayride tour of Meadowview Research Farms, win raffle and door prizes, taste chestnut dishes, roasted chestnuts and chestnut flavored beer, and listen to music by local acoustic trio The Pointer Brothers.

For more information about these upcoming events, please visit: acf.org/calendar.php.

Ceremonial Trees

DATABASE IN VIRGINIA

By Jacob Winn, Virginia Chapter Intern

Ceremonial tree plantings are an important component of The American Chestnut Foundation's mission to restore this iconic species to the eastern forests of the U.S. These plantings generate new interest in chestnut restoration.

High-profile planting sites such as the Fairfax County Government Center in Fairfax, James Madison's Montpelier in Orange, and Thomas Jefferson's Monticello in Charlottesville provide a great opportunity to direct attention toward The American Chestnut Foundation's restoration efforts and to teach the general public about this tree's important story.

There are currently TACF ceremonial trees planted at more than 30 locations throughout the state of Virginia so fellow intern Sarah Hagan and I spent the summer creating an online database to document them. The exciting part is that the database can be easily accessed by the general public using Plantsmap.com. This website hosts plant collections free of charge so Sarah and I added all of the state's ceremonial trees including photos, location information, and other pertinent details. The overall process will also make identification, tracking, and on-going maintenance very user-friendly.

Most ceremonial plantings consist of Restoration Chestnuts 1.0, a potentially blight-resistant hybrid that is the latest product of TACF's backcross breeding program. However, some of the planting sites also contain pure American and pure Chinese chestnut trees, which provide a valuable learning tool about genetics and the important role it plays in chestnut survivability and restoration.

The Virginia chapter hopes this initiative will serve as an example of how to document TACF ceremonial plantings, not only in Virginia, but throughout the Appalachian range. Ceremonial plantings typically occur in high-profile locations and our goal is make them easy for the public to access and admire. We invite all TACF members to see what we have accomplished. **The Virginia chapter ceremonial tree database can be accessed here: http://plantsmap.com/organizations/virginia-chapter-of-the-american-chestnut-foundation.**

Restoration Chestnut 1.0 planted at the Fairfax County Government Center. Photo by Charles Layton.

Annual Relay for Life

EVENT GIFTS CANCER SURVIVORS WITH AMERICAN CHESTNUTS

For the second year in a row, registered cancer survivors each took home a pure American chestnut seedling from the 11th Annual Relay for Life of Madison County in Oneida, New York on May 30, 2015.

"The symbolism of survivors, cancer survivors, and the American chestnut revival inspired strong, emotional moments and everyone was able to learn a little bit more about the research and progress of this important work," said Kristen Russell-Stewart, Relay for Life of Madison County PR Coordinator and State University of New York College of Environmental Science and Forestry (SUNY-ESF) graduate.

With each new chestnut seedling, participants also received The American Chestnut Foundation (TACF) membership brochure and a pamphlet on The American Chestnut Research and Restoration Project at SUNY-ESF. This year's Relay for Life of Madison County event raised more than $100,000 with approximately 650 participants and 140 registered survivors.

More than 140 seedlings were given out that day. Chestnuts had been collected from all over New York and then grown into seedlings in Russell-Stewart's living room. According to Russell-Stewart, several survivors were thrilled to receive a second American chestnut and had stories to share about the first gifted American chestnut: some were still proudly flourishing in pots or deer had stealthily snacked on others during the night.

Russell-Stewart is a two time cancer survivor herself. Two years ago, she introduced the idea of intertwining these two survival stories to Dr. William Powell, Professor and Director of the Counsel on Biotechnology in Forestry at SUNY-ESF. He was instantly on board. Powell is also a member of TACF's New York chapter.

"When Kristen first approached me with this, it seemed like a natural fit. The American chestnut is a survivor, so the gift is very symbolic. We wanted to recognize the physical and emotional trials of cancer and celebrate survival," Powell expressed.

Russell-Stewart worked with Andy Newhouse, biotechnologist at SUNY-ESF, to get the wild American chestnut seedlings in 2014. These small, symbolic gifts were so popular that they decided to make the seedlings a permanent addition to the annual Relay for Life of Madison County program.

For us, the biggest accomplishments were recognizing the American Cancer Society's powerful research efforts, honoring the memory of those we have lost, and celebrating the survivors," Russell-Stewart explained. "The story of the American chestnut celebrates a similar theme."

TACF's New York chapter, in collaboration with The American Chestnut Research and Restoration Project at SUNY-ESF, was delighted to support the American Cancer Society for this event. The American Cancer Society Relay for Life is the organization's largest annual fundraising event for research.

All photos by Kristen Russell-Stewart.

Pure American chestnut seedlings were given to every registered cancer survivor at the 11th Annual Madison County Relay for Life event, and each seedling featured a proverb on its tag.

MASSACHUSETTS/RHODE ISLAND CHAPTER

BRIAN CLARK

Brian Clark has worked around trees his entire life. He was born and raised as a fourth generation apple and dairy farmer in the Apple Valley region of Ashfield, Massachusetts.

"As an undergraduate at Clark University, I was in a bookstore and found a publication about the geological and natural history of New England, and I bought it. One chapter detailed the American chestnut history, which I had never heard anything about before. I was very impressed by the story and later talked to my father about it, who remembered collecting nuts as a child on a hillside near our farm," Clark recounts. The story has remained with him throughout his adult life.

Clark earned a B.S. in psychology in 1974, and then pursued a master's degree in computer science at New Mexico State University. Soon after, he relocated to Rochester, Minnesota to begin what turned into a 30-year career with IBM. In 1996, he was awarded an IBM fellowship, a distinction that only 267 IBM employees worldwide can claim. Clark also lived in Germany from 1999 until 2001, where he headed an international project assignment with SAP, a German multinational software corporation.

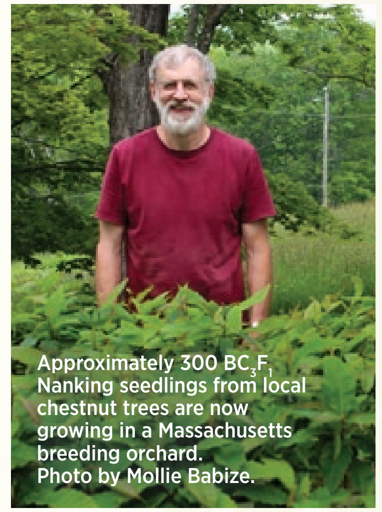
Clark's first hands-on experience with chestnut trees was in 1987 when he learned about the Wexford Soil Conservation District and its sale of chestnut seedlings in Cadillac, Michigan. He was excited about the opportunity to cultivate the tree whose story had such an impact on him as a young man. He bought ten chestnuts and planted them on his property in Minnesota.

"But it wasn't until 2002 that I discovered The American Chestnut Foundation. The local NPR station ran a story on their research and work, and I immediately joined as a member. I also attended the Foundation's next annual meeting in La Crosse, Wisconsin. I told them I had been growing American chestnuts since 1988 in Rochester and was very eager and excited to become part of TACF's program," he continued.

Clark retired from IBM in 2007 and returned to his family's apple farming business, Clark Brothers Orchards. He currently manages one of his chapter's primary breeding orchards on his land in Hawley, Massachusetts. This orchard contains more than 1,400 chestnut trees from six different plantings, and his official position within the MA/RI chapter is vice president of orchard management. In this role, he helps establish and manage the breeding orchards across Massachusetts and Rhode Island. His recent work has focused on the establishment of three additional seed orchards and he has also adopted an "orphaned" breeding orchard in a neighboring town.

New England Regional Science Coordinator Kendra Gurney boasts of Clark: "Brian is a quiet, but vital force behind much of the work conducted by the MA/RI chapter. His passion and willingness to go above and beyond, combined with his technical skills, knowledge, and resources have made him a natural leader for the seed orchards and other breeding program efforts. On top of that, he's one heck of a nice guy. I always very much enjoy my visits to his orchards - both chestnut and apple!"

A conservationist in all facets of his life, Clark has been driving pure electric cars for more than two years, in an effort to truly produce zero pollution. He also currently serves on energy, conservation, and technology committees and boards involved in renewable energy projects for farms and the surrounding regions of western Massachusetts.



Approximately 300 BC_3F_1 Nanking seedlings from local chestnut trees are now growing in a Massachusetts breeding orchard. Photo by Mollie Babize.

> "Brian is a quiet, but vital force... His passion and willingness to go above and beyond, combined with his technical skills, knowledge, and resources have made him a natural leader..."
>
> KENDRA GURNEY, NEW ENGLAND REGIONAL SCIENCE COORDINATOR

TACF Welcomes

Heather Nelson, Accounting Manager

"I have a passion for non-profit work. When I first discovered TACF, the mission, work, and longevity of the organization were definitely appealing. I have enjoyed getting to know the staff and learning how the organization works. I am driven to make things better and more efficient. I strive to 'find a need – fill a need' in every aspect of my life," Heather Nelson explains.

As accounting manager, her major responsibility will be ensuring the foundation's finances are in order from day-to-day and year by year. She is also charged with monitoring human resources duties and looks forward to helping TACF create and implement processes that will support TACF's long-term growth and sustainability.

An "almost native," Nelson moved to Asheville on her first birthday and has enjoyed watching the city grow and change very quickly. Her early adult years were spent working, putting herself through college at the University of North Carolina at Asheville and raising her daughter.

"While being a good mother has always been my most important priority, my second 'baby' has been my non-profit work, both as an employee and as a volunteer. I have dedicated the last fourteen years of my life to running Pack Place Education Arts & Science Center, a non-profit cultural center and arguably one of downtown Asheville's crown jewels," said Nelson. She also holds a certificate in non-profit management from Duke University.

Nelson explains that she is excited for what is to come: "I am a sucker for potential and I look forward to helping elevate TACF and building something sustainable. It seems like TACF is poised for growth, as is this next generation of American chestnuts! The people at the Asheville office have been great to work with and are dedicated to the mission."

Over the last few years, Nelson feels that she has grown to learn the importance of a healthy work-life balance, which has given her the opportunity to travel more. She says her travel has "mostly centered on sampling different cuisines, with my partner and fiancé, and our combined families. I try to enjoy the little things in life and I especially enjoy cooking, spending time outdoors, learning to garden and helping others."

Wendy Wilson, Administrative Manager

Wendy Wilson brought a proven background in administration and program management to TACF's team in April of 2015 as Administrative Manager. Most recently, she served as Administrative Manager for the Vanderbilt University Medical Center in its Office of Graduate Medical Education.

Wilson says that "the idea of working with an organization that exists solely to save a great American tree," was what initially attracted her to TACF. Within her role at the Asheville office, she works closely with President & CEO Lisa Thomson and VP of Operations Betsy Gamber, assisting them with day-to-day operations and development activities. She also serves as a liaison to the Board of Directors.

Wilson welcomes the opportunity to learn and grow within a new field as she takes on this role with TACF. She is also excited to have the ability to roam the beautiful Appalachian Mountains with her camera.

WHO WILL CARRY THE TORCH...

Tomorrow?

By Jim Peters, Supervisor of Science, CCPS; and Brad Yohe, Educational Consultant, STEM & NGSS

Since the beginning of the space age in the late 1950's, American education began to reform its educational practices. These reforms have evolved over fifty years to the present day initiatives in Science, Technology, Engineering and Mathematics (STEM) education and the Next Generation Science Standards (NGSS). STEM is the 'call to action' to improve instruction in these disciplines. NGSS provides a framework for what to teach and how to teach it through science disciplinary core ideas, engineering practices and cross-cutting concepts. Educators continue to be challenged to navigate the tenets of these reform initiatives which were designed to produce changes to the way science is taught in our schools.

Photo by Mary Yohe.

EDUCATION PARTNERS POWER THE FUTURE OF AMERICAN CHESTNUT SCIENCE

For more than fifteen years, professional educators in Carroll County, Maryland have partnered with TACF's Maryland Chapter to incorporate the story of the American chestnut and the science of chestnut restoration into the science curriculum for grades 6 -12. This effort has required ongoing training of teachers, many hours devoted to writing lesson plans, as well as planting and maintenance of chestnut orchards at several school sites.

The American chestnut curriculum has allowed students to authentically engage in the hands-on practice of conservation skills. And thanks to students' high test scores, Carroll County has been able to obtain funding to plant chestnut orchards, write curriculums, and purchase equipment.

TACF owes a debt of gratitude to former Science Coordinator Brad Yohe and his successor Jim Peters for their outstanding leadership in this initiative. To their credit, at least 25,000 Carroll County students have actively engaged with the American chestnut at several points in their educational career.

But now, the next step is to share the benefits of this valuable work with other educators. Read the success story of Carroll County's chestnut curriculum.

An interesting reform story began in 2002 in the Carroll County, Maryland Public Schools (CCPS), a system that includes 27,000 students. The central goal of the program involves students in hands-on scientific chestnut tree explorations, civic tree plantings, project-based learning, and environmental activities. The result of this STEM curriculum is that more than 9,000 students per year have been engaged in lessons containing project-based learning frameworks since its inception.

The chestnut theme begins in grade 6 as students begin studying environmental issues. They learn the story of American chestnut, specifically its importance in terms of food, habitat, and lumber. Next, they learn about the fungal blight which nearly destroyed the tree over the last century. Students explore chestnuts in the wild at the outdoor school and help to maintain the 400 chestnut trees in the school's on-site orchard. The complexity of studies grows with each successive grade to include lessons in genetics, soil studies and climate science. High school students begin to study advanced science in biology classrooms such as DNA gel electrophoresis of the species as well as in depth genetics studies that enable students to explore the complexity of The American Chestnut Foundation's (TACF) backcross breeding program. The CCPS Science Research course is a one of a kind environmental curriculum that partners with TACF, Maryland Department of Natural Resources (DNR), and Maryland Sea Grant (MDSG). School orchards provide the research opportunities and data analysis experiences that students need to meet the call of STEM and NGSS.

The use of the American chestnut story as an environmental theme is an effective example of authentic curriculum development and lesson design thus shifting instructional strategies and applying real world examples of STEM and environmental science. The reform parameters defined so carefully in the NGSS extend the boundaries of authentic lesson design to motivate students to process a reduced amount of content while increasing their know-how as it relates to the day-to-day

The Gettysburg Heritage Center will sponsor the STEM/NGSS Educational Summit with individuals sessions scheduled for Fall 2015 and Summer 2016. Photo by Daryl Wheeler.


Winters Mill High School seniors Zachary Peters and Ryan Cunningham work in their schools newly remediated orchard during the summer of 2015. Photo by Jim Peters.

Please share this article with your local school administrators and encourage them to consider attending the following Grant Funded Activities in Gettysburg, PA.

STEM/NGSS EDUCATIONAL SUMMIT

sponsored by the Gettysburg Heritage Center

October 15, 2015—School Leaders (4:30 - 7:30 pm)

November 12, 2015—STEM Teachers (4:30 - 7:30 pm)

June, 2016—Teacher Training

Please contact Brad Yohe for any questions about this initiative: brad.yohe@gmail.com.


Left-right: Cathy Scaramastra, Dave Armstrong, and Ava Grill. Photo by Mary Yohe.


West Middle School's orchard is located right off the main parking lot and includes trees visible from classroom windows. Photo by Jim Peters.

work of a scientist or engineer as they solve problems. Students are encouraged to use science and engineering practices: ask questions, build models, interpret data, design solutions, engage in discussions and communicate information.

As the chestnut curriculum has evolved the project has gained grant support from the Chesapeake Bay Trust, the USFS, and the Maryland Forest Service. The concept has also spread to other counties in Maryland, and there is a broad interest in expanding it to the neighboring states of Pennsylvania, Virginia and West Virginia. In January 2015 CCPS initiated its partnership with MDSG and the University of Maryland Extension (UME) program to further revise the piloted chestnut curriculum and to replicate it, complete with school orchards, in Allegany County Public Schools in Western Maryland. These exciting, newly revised lessons will be posted on the Maryland Sea Grant's public web site (mdsg.umd.edu/) and will reflect the NGSS framework. Thanks to the diligent work of CCPS, finding the means to apply these exciting tenets of STEM and NGSS initiatives to school classrooms may not be as daunting as it seems.

Do you ever wonder if the story of the American chestnut tree will have a happy ending? Who will plant trees and conduct research in the future? With reform initiatives such as the ones described above, perhaps a happy ending is not all that far away. Our children must carry the torch not only for the American chestnut, but for clean air, water, and so much more. **The question is: will they be ready?**

OLYMPIC HIGH SCHOOL'S B3 PROGRAM INCORPORATES GENETICS INSTRUCTION USING

American Chestnut

By Steve Barilovits and Doug Gillis, TACF Board Members and Carolinas Chapter Members


Students investigate a TACF Learning Box.

"Our goal was to empower students to then go out and pursue an experiment of their own," Weller expressed.


Students collecting chestnut leaf samples at Crowders Mountain.

Photos by Jennifer Weller.

The Olympic High School B3 Program is a unique summer camp and Saturday science enrichment program designed for high school students enrolled in one of Charlotte, North Carolina's Olympic Community of Schools. Funded by a multi-year grant from Burroughs Wellcome, B3 stands for biotechnology, biodiversity, and bioinformatics – three quickly expanding areas of scientific education. For the past six years, the B3 Program has incorporated American chestnut and its genetics into the curriculum, teaching students about genetic research and exposing them to both field work and laboratory research activities.

Fifteen students from Olympic High School participated in the 2015 summer camp, held June 12-26. Instructors included Jeanne Smith and Erica Putnam, teachers of Biothechnology at Olympic High, Charlotte-Mecklenburg Schools; Dr. Jennifer Weller of the Department of Bioinformatics and Genomics, UNC-Charlotte; Kelly Cooke, NC State Park Ranger, Crowders Mountain State Park; and TACF leaders Steve Barilovits and Dr. Paul Sisco.

On the opening day, Barilovits lectured students on the theory of genetic inheritance developed by Gregor Mendel. He provided a short overview of the former place of the American chestnut in eastern North America, and explained the backcross breeding program of TACF. Cooke presented detailed information about the chestnut blight, specifically its effect on local ecology in the Carolinas due to the loss of so many trees. Contents of a TACF Chestnut Learning Box were spread among six lab stations, and teams of students moved from one station to the next to view all the materials and learn from its contents. Students also inspected fresh samples of pure Chinese chestnut trees and hybrid American chestnut trees that Barilovits provided. The fresh samples were then compared to the Learning Box samples.

Students and instructors met the following day at Crowders Mountain State Park. Students were given GPS coordinates for three American chestnut trees located along a path 1.5 miles from the parking lot. They collected leaf samples from each of the three trees. Back in the classroom at Olympic High School, students received instruction on molecular laboratory techniques and theory. After their lesson, they practiced the lab techniques using the leaf samples they collected.

Another exciting field trip for the students and instructors included a trip to the Carolinas chapter seed orchard near Edneyville, North Carolina. Sisco explained the process of inoculating American chestnut trees with the chestnut blight fungus and why it is necessary to test each tree's level of resistance. Students then performed an inoculation of a tree. They also helped with orchard maintenance and learned a lot about the importance of weeding. "By maintaining a clearing around the trees, you reduce the competition for nutrients. Weeding also helps to reduce the stress on inoculated trees," said Sisco. Finally that evening, the students presented their various projects and were evaluated by the judges, Barilovits and Jens Erichsen of Kapa Biosystems.

On the final day of camp, students toured Dr. Jennifer Weller's lab at UNC-Charlotte where they were exposed to state-of-the-art gene sequencing instruments. "This camp provided hands-on experience in collecting samples and

Students extract chestnut DNA.

On a field trip to a Hendersonville orchard, students inoculated trees.

then using wet-lab and computational methods that are currently being used in biological research. Our goal was to empower students to then go out and pursue an experiment of their own," Weller expressed.

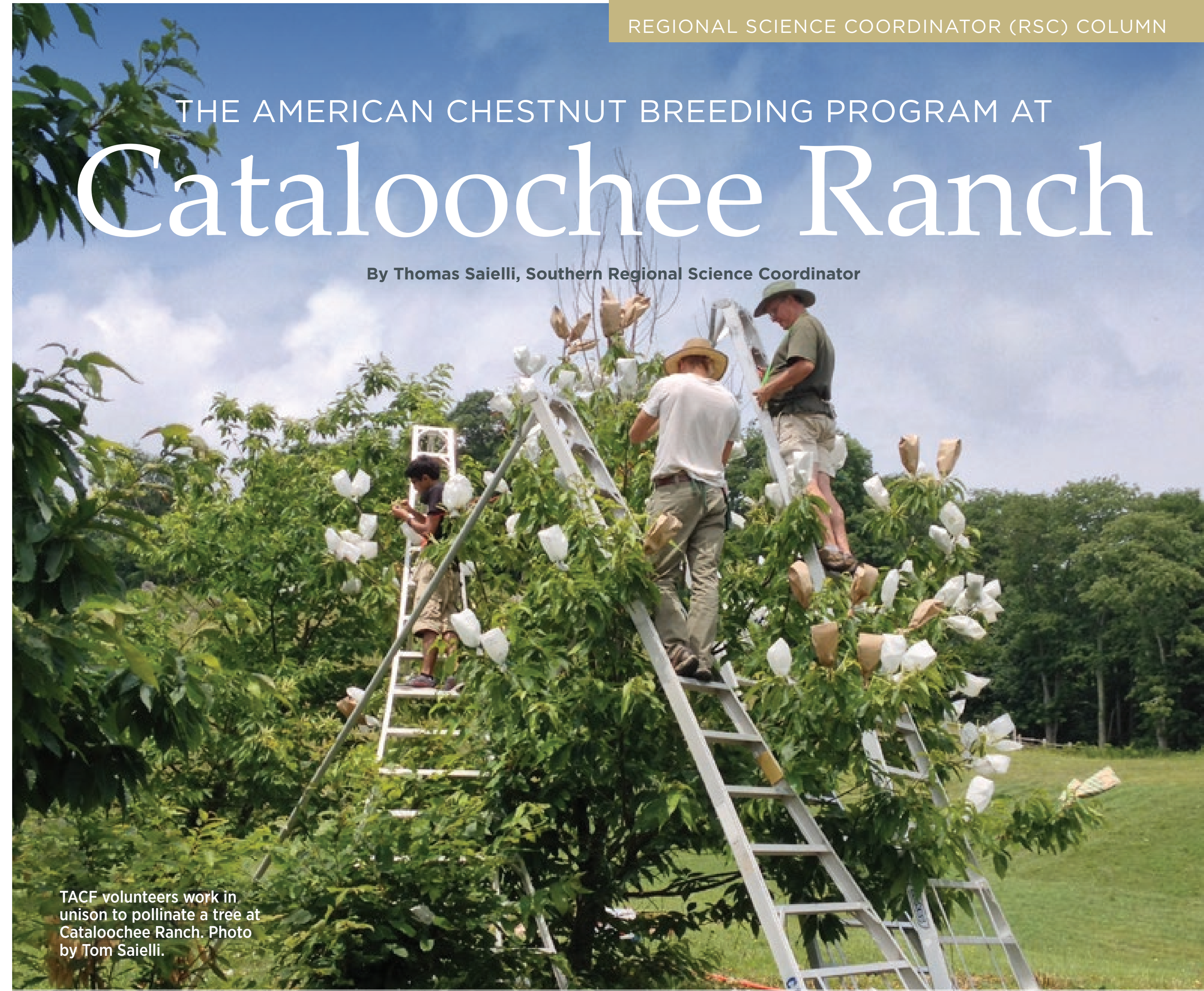
Barilovits has been quite involved with the B3 Program over the years. He has helped revised laboratory protocols to help students apply the basic knowledge they have gained using the instrumentation they have available to analyze data. In addition, he has written hundreds of lines of code, making it available to the students to use in analyzing and organizing data so it is understandable.

For additional information about Dr. Jennifer Weller and her research, please visit: http://nanoscalescience.uncc.edu/jennifer-weller-phd.

Students present their posters on the final night of the program.

THE AMERICAN CHESTNUT BREEDING PROGRAM AT Cataloochee Ranch

By Thomas Saielli, Southern Regional Science Coordinator



TACF volunteers work in unison to pollinate a tree at Cataloochee Ranch. Photo by Tom Saielli.

At a 4800-foot elevation, Cataloochee Ranch is nestled high up in the beautiful Appalachian Mountains of Maggie Valley, North Carolina. The facility originally opened 1938 as a mountain camp, but it has transitioned into a magnificent vacation retreat, offering hiking, skiing, horseback riding, and delicious meals combined with a view that simply cannot be beat.

More importantly, Cataloochee Ranch is also home to one of the finest American chestnut breeding orchards of the Carolinas chapter of TACF. These spectacular orchards serve as a venue for both outreach and education, but recently, they have also become the site of cutting-edge research and advanced regional breeding.

REGIONAL SCIENCE COORDINATOR (RSC) COLUMN

Cataloochee Ranch has a history with American chestnut

Judy Coker is the owner of Cataloochee Ranch. She is also the daughter of the ranch's founders, Tom and Judy Alexander. Coker remembers a time when American chestnut trees grew wild on the property, inundating the surrounding forests. In fact, there are still hundreds of American chestnut sprouts to be found there. Years ago, Coker transplanted three chestnut sprouts to a hill that overlooks the main ranch. Two of these sprouts have grown into large trees and are being used to help advance the southern region's breeding program. In addition, the field where these trees are located is now site of one of the Carolinas chapter's most successful breeding orchards.

Coker first contacted The American Chestnut Foundation in 2006 after realizing American chestnut was surviving in the woods near the ranch. Paul Sisco was president of the Carolinas chapter at that time, and under his direction in 2007, the Carolinas chapter established a 284-tree backcross breeding orchard and transplanted 77 more seedlings in 2008. With a survival rate of nearly 95% and an amazingly uniform growth, this orchard stood out as "exceptional" from its very first year. The Cataloochee Ranch crew took great care to fertilize and weed the trees, and the topsoil at that high elevation was remarkably deep, most likely because it was never row-cropped like lower elevation soils.


Judy Coker stands in front of the Cataloochee Ranch Trophy Tree #180. Photo Paul Sisco.

In the spring of 2012, a group of students from Brevard High School inoculated the trees in the lower orchard. The following year a team comprised of Carolinas chapter members Paul Sisco, Judy Sutton, Don Surrette, and Steve Barilovits inoculated the trees in the upper orchard, selected the trees with the greatest blight resistance, and cut back the weaker trees to stump sprouts. The weaker trees were retained for genetic analysis at a later date.

To date, the remaining trees in both orchards are growing and spreading, and the flowers are increasing in number each year. Sisco returns on an annual basis to pre-bag the trees for controlled pollinations. Each of the selected backcross trees is now being used to make intercrosses destined for the Carolinas chapter seed orchards.

As for the pure American chestnuts that Coker planted years ago, these trees are being used to make new F_1s and B_1s, along with several other sources of pure Americans growing on the property. These F_1s and B_1s will provide new sources of resistance in the southern chapters.

Current Breeding and Research at Cataloochee Ranch

Members of the southern chapters are completing their Clapper and Graves sources of resistance from Meadowview and will focus their breeding efforts on seed orchards. During this period, we will begin to create new sources of resistance using southern Chinese and Japanese germplasm crossed with southern sources of American germplasm. In many cases, the southern states are also developing new lines of resistance designed to capture unique genetic haplotypes (non-D cytoplasm types – American chestnuts that have unique mitochondrial DNA). These new sources are often screened for resistance to *Phytophthora cinnamomi* root rot (PRR) in an effort to develop trees resistant to both pathogens. The combination of non-D cytoplasm, PRR resistance, and all germplasm coming from the south, makes these new sources of resistance unique hybrids of the south.

This work has been taking place for about a decade thanks to the leadership of Sisco and Hill Craddock of the Tennessee Chapter. Through their efforts, all of the southern states are now pitching in - making new F_1s with southern sources of American x Asian crosses. The southern states have also been making B_1s by crossing new sources of American germplasm with the F_1s selected for resistance to both pathogens.

Volunteer efforts at Cataloochee Ranch have proven extremely productive over the past several years. Individuals come to work with a dozen pure American and F_1 trees, creating unique F_1 and B_1 crosses for regional efforts. Regular participants include: DJ McMillin, Hill Craddock and interns from the University of Tennessee at Chattanooga; Michael and Matt Egan and Marty Cipollini (GA); David Morris and Edwin Camp (AL); and Scott Freidhof (KY). In addition, a group of students and teachers from the Iliff School of Theology in Denver, Colorado participated in 2015 as part of an environmental education program with the state of North Carolina. This year, my 6-year old son Owen Thomas McNeill Saielli, assisted with pre-bagging, pollinations and harvests.

Finally, Cataloochee Ranch is also the site of a very interesting research project involving genetic analysis. Jennifer Weller of UNC-Charlotte leads the project in conjunction with Barilovits and Jared Westbrook. The work has involved analysis of certain Clapper lines growing there. Weller and Matt Egan sampled leaves from two Clapper BC_4 families, including both susceptible and resistant types. "That's why we did NOT rogue the trees at this orchard," says Sisco; "we just cut them back to stump sprouts to save the susceptible genotypes for current and future analysis."

Outreach & Education at Cataloochee Ranch

Outreach and education efforts at Cataloochee Ranch are certainly are not limited to school groups. Other activities have included:

- Wednesday Tours of the Chestnut Orchards, hosted by Judy Sutton (Judy Coker's daughter), is another great way to create public awareness about TACF's breeding program. These tours are a tremendous example of how Cataloochee Ranch uses the lure of an idyllic retreat to educate folks about the significance of American chestnut. Orchard tours are open to the public and take place throughout the summer months on Wednesdays at 11 a.m. Guided tours are available for $15 and include lunch. Self-guided tours are available at any time.
- Chestnut Saturday Events in 2010 and 2011: These fun chestnut-themed events featured live music, horseback rides, clogging demonstrations, crafts, great food, and of course, chestnut talks combined with a tour of the chestnut orchards.
- The NE-1033 meeting in 2010: Dozens of researchers and TACF staff converged on Cataloochee Ranch for a two-day conference to discuss genetics, breeding work, and chestnut science.


Students from the Iliff School of Theology help pollinate chestnut trees at Cataloochee Ranch. Photo by Tom Saielli.

THE AMERICAN CHESTNUT FOUNDATION®

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TO HELP SUPPORT OUR PILLARS OF EXCELLENCE – RESEARCH, RESTORATION AND EDUCATION.

Research. Restoration. Education.

TACF has exciting future goals to further our mission, including:

Genome mapping of our hybrid trees to better pinpoint the exact locations of the genes responsible for blight resistance;

Construction of a greenhouse at Meadowview Research Farm to serve as a propagation facility and speed up our breeding methods;

Support the hard work and travel costs of our science staff who help plant your chapter volunteer-run orchards; and

Rebuild TACF's website for increased capability and mobile-interface among our members.

However, these strategic initiatives and capital projects come at a cost. Please help us meet our year-end fundraising challenge of $250,000 – our most ambitious goal yet. Your support is critical in helping us restore this American icon. Please give generously by returning the attached Fall Appeal envelope or visiting: acf.org.

(828) 281-0047 ~ chestnut@acf.org

AN EXCITING COLLABORATION

On December 1st, TACF will announce an exciting collaboration with Chuck Leavell, tree farmer and keyboardist for the Rolling Stones. This innovative project will be released via the TACF website, and social media platforms. Stay tuned!

MEADOWVIEW RESEARCH FARM COLUMN

Partners in Restoration:

The American Chestnut Foundation and the Virginia Department of Forestry

By Jeff Donahue, Director of Operations, and Matthew Brinckman, Mid-Atlantic Regional Science Coordinator

Meadowview Research Farms serve as the Foundation's principal research and development center. This facility began functioning in 1989 and currently consists of four individual farm properties, all of which are located in Washington County in Southwest Virginia. The Glenn C. Price Research Farm houses the laboratory, administrative offices, seed storage, and the breeding orchards that provide genetic material for restoration programs in southwest Virginia, northeast Tennessee, and western North Carolina. It also houses a containerized seedling nursery that produces seedlings for research field trials.

The Wagner and Duncan Farms contain TACF's most advanced generation seed orchards. Established purely as seedling seed orchards, they are still in a development stage that requires substantial testing to determine which trees are most resistant. This is done through a process called progeny testing. Seedlings derived from individual orchard trees are exposed to the chestnut blight pathogen either naturally or artificially and the results are then used identify superior family lines and trees.

Progeny testing requires a wide variety of planting sites, and these tests are typically achieved through the assistance of numerous public and private sector collaborators, state and federal forestry agencies, and universities. One of the most steadfast supporters of Meadowview's breeding and testing program is the Virginia Department of Forestry (VDOF).

The VDOF supports TACF in many areas of its operations: from growing bare root chestnut seedlings to providing land for orchards and progeny tests, as well as seedling storage facilities. The Department has provided people and equipment to plant field trials, and it trained Meadowview staff in lift equipment operation. In addition, the VDOF has grown TACF chestnut seedlings for several years at the Augusta Forestry Center in Crimora and provided seedling storage in both Augusta and another VDOF facility in Abingdon. In 2008, they also supplied the resources to establish a chestnut orchard on the Matthews State Forest. This fall, more than 2,000 seeds will be growing at this site. Finally, the VDOF generously provides office space for the regional science staff in its State Headquarters in Charlottesville, Virginia.

In 2012, American chestnut "mother" trees began producing more seeds and as a result, progeny testing of Meadowview's seed orchards became more of a priority. To date, 31 field trials have been established on varying site types in ten states (GA, IN, KY, OH, PA, NC, NJ, TN, VA, WV). The Conservation Innovation Grant provided funding for 12 progeny tests planted on old mine land sites in Kentucky, Ohio, Pennsylvania, Virginia, and West Virginia and the VDOF helped provide the manpower and equipment for site prep and test establishment activities for all Virginia sites.

This past February at the Augusta Forestry Center, the tedious task of sowing, growing, and lifting seedlings for research projects began.

Meadowview staff gather and pack chestnut seedlings from the mechanical lifter as they are harvested.

VDOF Senior Area Forester Bill Miller and Technician Michael Slayer help establish a CIG progeny test in Wise County, Virginia.

TACF Technical Coordinator Eric Jenkins next to containerized seedling nursery that produces seedlings for research field trials. This nursery has the capacity for 10,000 seedlings.

Forest Management and Education Specialist Zak Olinger (left, center) and Western Region Forester Ed Shoots (right, center) speak to a group of VDOF employees about chestnut restoration efforts at TACF's Nanking orchard on the Matthews State Forest in Galax, Virginia. The ten acre project is surrounded by a ten foot tall fence for deer protection.

Photos by Jeff Donahue.

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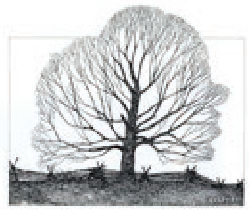
THE SCIENCE



The Evolution of Forest Genetics

AND TREE IMPROVEMENT RESEARCH IN THE UNITED STATES

Nicholas C. Wheeler, Kim C. Steiner, Scott E. Schlarbaum, and David B. Neale

Forest genetics (FG) research in the United States began more than 100 years ago with racial (seed source) trials of ponderosa pine (*Pinus ponderosa* Douglas ex C. Lawson) and Douglas-fir (*Pseudotsuga menziesii* [Mirb.] Franco) and over the ensuing four decades gradually emerged as a distinct and important discipline of study within the forestry research community. Coupled with the allied field of tree improvement (TI), the discipline enjoyed rapid and expansive growth for more than 30 years beginning in the early 1950s. The subsequent 30 years witnessed an equally dramatic contraction and transformation of the FG/TI community. We review the economic, social, and policy factors that contributed to the decline of FG/TI and the transformation to a discipline that now includes a strong ecosystem management component. Cautionary lessons are coupled with a call for enhanced funding of traditional and genomic FG/TI efforts in the face of growing forest health and climate change threats that are having profound effects in the nation's forests.

Forest genetics research in the United States began just more than 100 years ago, shortly after the rediscovery of Mendel's studies, with racial trials of ponderosa pine (*Pinus ponderosa* Douglas ex C. Lawson) and Douglas-fir (*Pseudotsuga menziesii* [Mirb.] Franco) conducted by the US Department of Agriculture (USDA) Forest Service scientists. Since then, experts have regularly promoted the beneficial application of genetics to forestry practice, and forest genetics gradually emerged during the early decades of the 20th century as a distinct and important field within the forestry research community. Although in a strict sense forest genetics is simply the study of heritable variation in forest trees, the dominant and almost exclusive focus of forest genetics until recent decades was tree improvement: the application of genetics to improve the productivity and health of commercially important tree species. Even research that was not explicitly in the service of tree improvement was usually published in journals and conference proceedings read by practicing foresters and forestry scientists working for university forestry schools, state divisions of forestry, the USDA Forest Service, and forest industry. The tacit assumption was that the information was useful to the practice of forestry, which throughout most of the century was largely focused on growing trees for their wood.

Forest genetics and tree improvement became shorthand terms, abbreviated here as FG/TI, for an amalgam of research methodologies, subjects, and objectives, all more or less pursued for the broad purpose of improving timber management. From scattered and sporadic activities through the first half of the century, FG/TI exploded as a major research focus in the years after World War II. It is difficult to overstate the importance that FG/TI had within forestry during the 1950s1970s, or the rapidity with which that importance faded beginning in the 1980s. With the exception of continued support of tree improvement cooperatives for a few tree species of major economic importance and modest disease resistance breeding efforts for ecologically and economically relevant species such as American chestnut (*Castanea dentata* [Marsh.] Borkh.) and Port-Orford-cedar (*Chamaecyparis lawsoniana* [A. Murray] Parl.), the collapse of traditional FG/TI was remarkable in scope, considering the magnitude of the investments made in the three decades after the war.

Beginning in about 1980, there emerged a new set of methodologies in forest genetics that enables, for example, descriptions of individuals and populations based on information encoded in DNA sequences. A largely new community of scientists has developed around this work, a community rooted in basic plant biology and ecology, whose connections with forestry practice are often remote. The new methodologies have proven useful in FG/TI, but they also have application to ecosystem management (EM) for which the goal is not "improvement" but rather preservation, conservation, or restoration of genetic diversity and adapted populations. Thus, we argue in this article that FG/TI has become transformed during the last three decades into FG/TI/EM and that this transformation is a result of the changing consensus of the purpose, scope, and economic structure of forestry.

Our purpose here is to first chronicle the growth and decline of the traditional FG/TI enterprise during periods we have defined as the Pioneering, Rapid Expansion, Transitional, and Genomic Eras (**Figure 1**) and the evolution of FG/TI to FG/TI/EM during the latter two eras. We then attempt The Pioneering Era: Scientific to describe a vision for going forward that Forestry Embraces Genetics integrates traditional and modern technologies toward a sustainable approach to managing forests using genetic information.

AFFILIATIONS: Nicholas C. Wheeler (nickwheeler@scattercreek.com), Department of Forestry and Environmental Resources, North Carolina State University, Raleigh, NC. Kim C. Steiner (kcs@psu.edu), Pennsylvania State University. Scott E. Schlarbaum (tenntip@tennessee.edu), Department of Forestry, Wildlife and Fisheries, University of Tennessee. David B. Neale (dbneale@ucdavis.edu), Department of Plant Sciences, University of California, Davis.

THE PIONEERING ERA: Scientific Forestry Embraces Genetics

The early 20th century was marked by rapid advances in the science of genetics and 2015 the breeding of crop and horticultural plants. In the excitement that accompanied these advances – especially the remarkable gains in maize (*Zea mays* L.) productivity – it was natural that foresters and others would contemplate the application of this technology to trees. As part of a conservation movement that valued productivity, efficiency, and sustainability, the American incarnation of scientific forestry, borrowed in large part from Europe, emphasized reforestation and good management in the service of timber production (Hays 1959, Perry 1998). Those with an interest in forestry were quick to grasp the contribution that genetics could make toward the goal of increasing forest productivity (Clements 1911, Austin 1927, Conville 1928, Leopold 1929, Schreiner 1937, Minckler 1939).

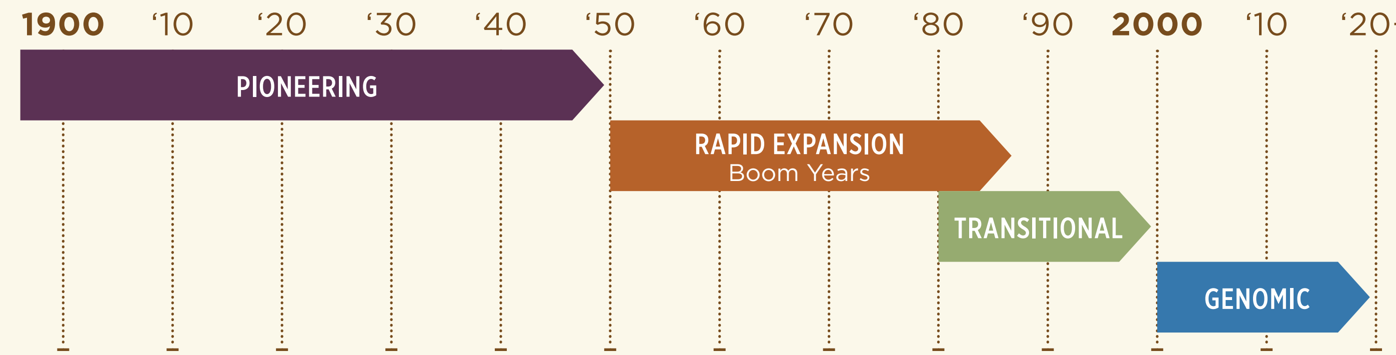
Aside from early breeding work with American chestnut pursued out of horticultural interest (Van Fleet 1914), the earliest FG/TI studies were trials of racial variation within species, the forerunners of replicated provenance tests. Modeled after earlier work in Europe, the first trials were performed by the USDA Forest Service beginning early in the 1910s (Munger and Morris 1936, Weidman 1939). Provenance studies of forest trees were applied science at its best because they anticipated basic research that eventually rendered the phenomenon of provenance differences “understandable” in theoretical terms (e.g., Turesson 1922, Huxley 1938, Clausen et al. 1940). Indeed, then and now, much of our knowledge and understanding of intraspecific variation in wild plants has come from FG/TI studies that were motivated by the desire and need to improve or at least manage wild populations of species that dominate the landscape.

Similar trials were slow to follow the earliest Forest Service tests, but it was generally understood by the 1930s and 1940s that forest trees possessed a great deal of heritable variation, much of which was distributed on the landscape in nonrandom, if not necessarily predictable patterns and that there were sometimes useful levels of genetic variation among the offspring of different trees (Bates 1930, Meuli and Shirley 1937, Schreiner 1939, Wright 1944, 1953a). These trials showed that reforestation efforts were most likely to succeed if locally adapted seed sources were used, but source movement was feasible and even sometimes desirable from the standpoint of growth and productivity. Furthermore, by the 1930s and 1940s, methods were being developed for conducting controlled crosses within species (Snow and Duffield 1940, Wright 1953b), and a number of projects had been undertaken to explore the potentialities of inter-specific hybridization (Ness 1927, Stout and Schreiner 1933, Graves 1939).

The USDA Forest Service’s initial steps in FG/TI were taken up by others beginning in the 1920s and 1930s. In the West, Seattle lumberman James G. Eddy established the privately owned Eddy Tree Breeding Station and Arboretum in Placerville, California, in 1925. This property was deeded to the USDA Forest Service in 1935 and renamed the Institute of Forest Genetics (USDA Forest Service 2001). Early work at the Institute focused on interspecific pine hybrids and later, provenance and progeny trials. In the East, the Oxford Paper Company and the New York Botanical Garden began cooperating in 1924 in the breeding of fast-growing poplar hybrids for the production of pulpwood (Stout and Schreiner 1933, Schreiner 1935). This project was turned over to the USDA Forest Service in 1936 and became the nucleus of a long-running genetics project within the Northeastern Forest Experiment Station. In the southern states, efforts to increase yields of naval stores (oleoresins or terpenes) in southern pines began in the early 1930s and continued for several decades at the Southeastern Forest Experiment Station (Squillace 1965, 1971). At midcentury, FG/TI work in the United States was dominated by the USDA Forest Service, with involvement also from some universities and state governments and, to a lesser extent, private industry (Righter et al. 1954).

The emphasis in early FG/TI research was productivity (wood and oleoresins), and indeed it appears in retrospect that productivity along with modest efforts to improve wood quality and protect yields from insect and disease pests constituted virtually the only reasons for interest in the genetics of forest trees until recent decades. It is worth emphasizing that there is little in the literature from the early decades that suggests sensitivity to ecological health other than a nascent appreciation for the limits of seed movement from its native origin. Even with that, the concern seems to have been more about loss of productivity than about maladaptation. Productivity and yield were paramount considerations, and it was natural and uncontroversial to contemplate replacing natural eastern woodlands with commercial plantations of Norway maple (*Acer platanoides* L.), dawn redwood (*Metasequoia glyptostroboides* Miki), Scots pine (*Pinus sylvestris* L.), and Japanese larch (*Larix kaempferi* [Lamb.] Carr.) or reforesting the Sierras with fast-growing or disease-resistant pine hybrids (Wright 1953a). Indeed, an enthusiasm for the potential of exotic species in forestry, present by our observations up until the 1980s, was a natural extension of seed source studies and another manifestation of an attitude that valued forests more as crops than as ecosystems.

Figure 1 Major eras in the evolution of forest genetic and tree improvement research in the United States, as defined by the authors, including seminal decadal activities, discoveries, and new technologies.



1900s
Mendelian genetics rediscovered

1910s
Within-species racial trials

1920s
Hybridization trials for poplar/pine (ongoing in poplar)

1930s
Provenance trials (core period, after that much more modest, to present)

1940s
Controlled cross method development in conifers

1950s
Universities begin hiring dedicated forest geneticists

University/industrial cooperative tree improvement

Regional tree improvement conferences form

1960s
McIntire-Stennis Act, Hatch Fund supported cooperative regional projects

1970s
New technologies emerge: electrophoresis (allozymes), recombinant DNA, genetic transformation, tissue culture

1980s
National recession and reduced federal budgets for research

TVA discontinues most FG/TI in hardwoods

Forest industrial landscape altered by mergers and acquisitions

Wave of university faculty retirements, new hires

Polymerase chain reaction technology discovered

Competitive grant programs emerge for forest genetic research

1990s
USFS transitions from tree improvement to regional genetic resource programs, budget reduction

Industrial forest land holdings shift toward REITs and TIMOs

Sanger DNA sequencing methods

2000s
Competitive grants programs shift toward large, multi-institutional projects

Genomic selection and association genetics methods demonstrated in forest trees

First tree genome sequenced (poplar)

2010s
Next generation high through-put sequencing methods

First conifer genomes sequenced

Management and Policy Implications

We propose that a balanced and broad-based model should be used to fund and support future FG/TI/EM research in the United States. Three essential elements should be included in the model: long- and short-term funding, a coordinating board to guide funding, and education. A balance of long-term support for applied tree improvement research in support of forest and ecosystem health and short-term support for biotechnology, genomic, and ecosystem management research is needed for maximum benefits. We advocate formation of a national coordinating board, akin to the National Plant Board, which would work in a strategic manner with stakeholders, Congress, and grant funding programs at the National Science Foundation, US Department of Agriculture, and Department of Energy so that the investments made by long-term and short-term funders are made in a balanced and coordinated manner, addressing key forest health threats. There is precedent for the policy role of such interagency or interinstitutional committees in many areas of science that have not been applied to forestry and specifically forest genetics research. Emphasis on education of the American public, specifically grades K through 12, is key to alerting the nation to the importance of ecosystem health challenges and natural resources management issues. More tree geneticists with breeding experience are required to meet the long-term needs.

THE RAPID EXPANSION ERA: A High Tide of Interest and Activity

By the early 1950s, activity in FG/TI work was such that Righter et al. (1954, p. 690) termed it a "boom" and observed that "almost everyone wants to climb onto the bandwagon." In reality, the boom was just beginning, and the ensuing 30 years witnessed continued growth in funding, hiring, and infrastructure building in FG/TI research in the United States and around the world. A wave of research activity swept from coast to coast, supported by infusions of cash and in-kind contributions from federal and state governments, private industry, and universities.

An important agent of this research boom at universities was new research funding within forestry schools as a result of the McIntire-Stennis Act of 1962 (Bullard et al. 2011). McIntire-Stennis funding significantly transformed forestry schools and departments: schools hired more faculty, and the faculty hired with those funds had budgetary responsibility to conduct research as well as to teach. McIntire-Stennis funds helped support a growing population of graduate students and provided the crucial assurance that long-term research in FG/TI would have continued support. The first university course in forest genetics was taught at Yale University in 1955 (H.D. Gerhold, Pennsylvania State University, pers. comm., Feb. 12, 2007), and within 5 years a half-dozen more universities had hired forest genetics specialists. By 1980, virtually every forestry school at a research university had at least one geneticist on its faculty.

In addition to McIntire-Stennis funds, many forestry faculties had access to federal funding under the Hatch Act of 1887. Hatch provided USDA funding for a number of cooperative regional projects, in association with state agricultural experiment stations, which sought to bring scientists from all sectors – private, academic, and government – together to work on projects with a common theme. For example, the NE-27 project, which began in 1956, grew to include the active participation of scientists from 15 universities, 4 state agencies, 18 lumber and paper companies, the USDA Forest Service, 9 commercial and state nurseries, and at least a half-dozen additional agencies, offices, associations, and nonprofit entities (K. Steiner, Pennsylvania State University, file information, Aug. 15, 2014). NE-27 developed, among other things, a series of provenance trials throughout the Northeast. The financial support that came with participation in Hatch projects was sometimes rather substantial, but it was only available to forestry scientists at State Agricultural Experiment Stations. Other participants collaborated with their own resources with the expectation of mutual benefit.

Industry-Focused Programs

In many ways, the most enduring and consequential FG/TI work during this period proved to be narrowly targeted, applied tree improvement, most notably the work of university/state/industry cooperative tree improvement programs. These first appeared in the early to mid-1950s and were primarily focused on major timber species such as loblolly (*Pinus taeda* L.) and slash (*Pinus elliottii* Engelm.) pines and Douglas-fir. Their work typically took the form of plus-tree selection in wild stands, grafting scions from those trees into production seed orchards or breeding orchards and evaluating the genetic quality of their progenies in large, replicated field trials. Data from field trials were used to estimate heritabilities for traits of interest such as growth rate, form, wood specific gravity, fiber length, and resistance to specific diseases. Estimates of genetic correlations among traits were used to guide selection schemes, and heritabilities were used to estimate genetic gains. Selections made as a result of progeny testing were used to provide materials for advanced generation breeding. Orchard design was studied to reduce the frequency of crossing between close relatives and maximize effective population size. Progress was variable among programs and generally a function of commitment by the parent institutions and funding and of whether the program was part of an industrial cooperative or not.

The Texas Forest Service Tree Improvement Cooperative was the first of several such organizations established in the 1950s. This cooperative began in 1951 under the guidance of Dr. Bruce Zobel and the support of 14 industrial partners. Its name became the Western Gulf Forest Tree Improvement Program (WGFTIP) in 1969. Formation of other cooperatives soon followed at the University of Florida (1953) and North Carolina State University (1956). All three of these focused on southern pine species, especially loblolly and slash pines. In the Pacific Northwest cooperative programs began in 1955 with Douglas-fir (now housed at Oregon State University) and in 1968 at the University of Idaho to address a handful of local species. All five of these cooperatives exist today. Smaller cooperatives proliferated at additional universities such as the University of Tennessee, Michigan State University, University of Minnesota, and Pennsylvania State University, although most have since discontinued operations.

The general working model for the university/state/industry cooperatives was that tree breeding strategy, analytical expertise, graduate student training, and guidance were provided by the host institution while the industrial cooperators conducted in-kind activities such as plus-tree selection, breeding, field testing, and establishment of production seed orchards. Although cooperators typically were (and are) timber-based corporations, state and federal forestry agencies also sometimes participated. As the cooperatives evolved, cooperators often employed their own genetically trained staff to work with scientists at the host

Figure 2

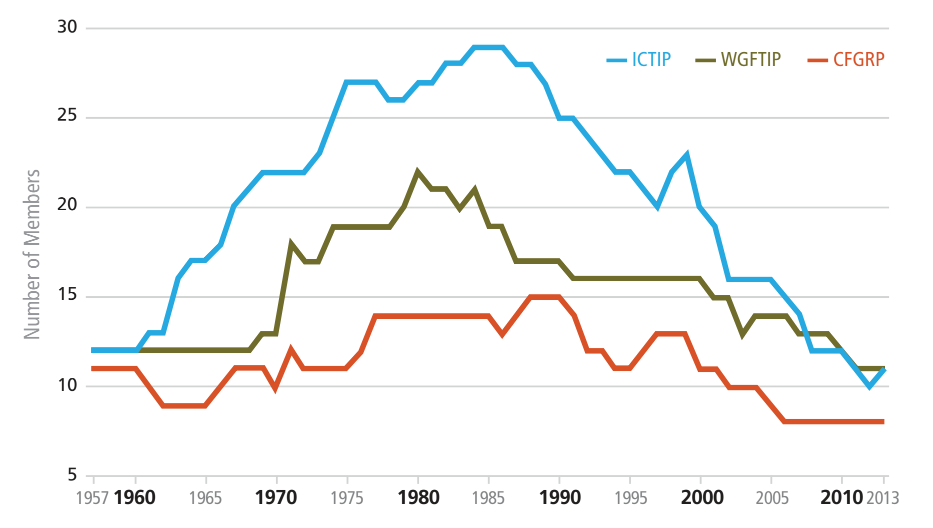


Figure 2. The number of "full" members to the three southern pine tree improvement cooperatives since their creation in the early 1950s (CTIP, North Carolina State University Cooperative Tree Improvement Program; CFGRP, University of Florida Cooperative Forest Genetics Research Program; WGFTIP, Texas Forest Service Western Gulf Forest Tree Improvement Program). "Contributing Members," a recently created level of membership for ICTIP, are not shown here but numbered 16 in 2014.

university. Cooperative memberships grew gradually throughout this period (**Figure 2**), as test results began to reflect genetic gains in traits, principally growth rate and form. In time, several of the large forest products companies established their own FG/TI research programs, some of which became quite large. One company, Weyerhaeuser, employed as many as 14 scientists in the mid1970s, half with PhDs, in its FG/TI programs on Douglas-fir, loblolly pine, and other species.

Nonindustrial Programs

The USDA Forest Service greatly expanded its involvement with forest genetics research and development during this period. Most, if not all, of the regional forest experiment stations hired or added genetics staff through at least the 1970s. The Southern and North Central Institutes of Forest Genetics were created to complement the original institute in Placerville, California. Over time, most of the National Forest System regions developed regional FG/TI programs, hiring regional and zone geneticists for the purpose of implementing tree improvement on federal lands. By 1968, research and development in FG/TI in the USDA Forest Service involved 87 employees. At a more regional level, nonaffiliated organizations such as the Tennessee Valley Authority (TVA) began an extensive softwood and hardwood tree improvement program involving seed source studies, phenotypic selections, grafting, and testing of many species, including exotics. The TVA program also included a unique objective of improving hard and soft mast production for the benefit of wildlife.

Whereas industry and cooperatives focused mostly on a few valued softwood species with plus-tree selection followed by breeding, the genetics projects that emerged during this period at federal, state, and academic institutions worked with a great many tree species and addressed widely divergent research questions with a variety of methodologies. The establishment of provenance trials was a central interest in many programs beginning (in this period) in 1951 with the Southwide Pine Seed Source Study (Dorman 1976) and extending into the 1980s. Literally dozens of such trials were established across the country. At the vanguard of this effort, Michigan State University's research station, Kellogg Forest, established plantations of more than 50 tree species in 106 field trials (provenance, progeny, species, and spacing) during this period. As earlier, virtually all of the practitioners came from forestry backgrounds, although their level of formal training in genetics and plant breeding was significantly greater than during the first half of the century. It was an exciting time to be working in FG/TI.

Regional Tree Improvement Conferences

The desire to interact and share results, methods, and approaches in this new and exciting field was compelling, and it led quickly to the creation of regional forest genetic conferences (**Table 1**). All of these groups met annually or biennially and started with virtually 100% participation from the forest genetics community. These were important forums for presenting and discussing research, organizing collaborative efforts, and publishing results in the proceedings that most of the conferences issued. Attendance at one or more of these conferences every year or two was simply a matter of course for scientists, graduate students, and technicians engaged in FG/TI.

New Technologies Change the Face of FG/TI

During the latter years of this Era, the emergence of an array of research tools and methods, collectively termed biotechnology, brought a significant infusion of funding and novel research goals to FG/TI. The most influential of these was the use of electrophoresis to identify allozyme genetic markers, which provided the ability to study Mendelian genetics (single genes) based on protein polymorphisms. Allozymes provided, for the first time ever, the ability for plant and animal geneticists to study allelic variation in a large number (20–70) of genes that coded for known proteins, in a rapid and relatively inexpensive manner.

THE SCIENCE

THE TRANSITIONAL ERA: Ecosystem Management Becomes a Higher Priority than Tree Improvement

The technology was wholeheartedly adopted by both the forest genetics and tree improvement communities. For the former, allozymes were used to describe the amount and distribution of genetic variation in natural and domesticated populations of dozens of forest tree species (population genetics), study gene flow among populations, and quantify the level of inbreeding in mating systems. For improvement programs, the tool was used extensively in seed orchard management to quantify pollen contamination levels and success of treatments such as controlled mass pollination and to simply provide the ability to accurately identify the genetic origin of plant materials in the program. A large part of a full generation of students based their graduate studies on the use of allozymes.

By the early 1980s, Krugman (1987) was able to count 65 private companies, 22 state agencies, and all Forest Service regions as engaged in forest genetics research, and their work involved to some degree research on as many as 122 tree species! By 1980, there was hardly a Research 1 institution forestry school or modest-size forest products company without someone on the staff engaged in FG/TI. The number and quality of both domestic and foreign applications for graduate study in forest genetics were strong, especially in the better-known programs, and MS and PhD level students were graduating in record numbers and generally finding employment. The largest forest industry companies were investing millions of dollars a year to grow their forest genetics programs. All university-industry cooperatives were still active and adding members (Figure 2), and at least two new cooperatives were formed in the early to mid-1980s: the Minnesota Tree Improvement Cooperative (1981) and the North Central Fine Hardwoods Tree Improvement Cooperative (1986).

Even as interest and engagement in FG/TI was flourishing in the early 1980s, social and economic forces were emerging that would soon cause a reversal of fortune in FG/TI research and a transition to FG/TI/EM research. The 1980s witnessed the retirement of the first large cohort of geneticists on forestry faculties, most of whom were not replaced in kind. In 1987, the director of timber management research for the USDA Forest Service observed that many timber companies were reducing their investments in forest genetics and the Forest Service had closed or severely cut back on five of its FG/TI projects (Krugman 1987). By the late 1980s, declining interest in purely FG/TI focused research led to dramatic contractions in tree improvement conferences (**Table 1**). The large, regional cooperative tree improvement projects that were initiated by the US Forest Service in the 1950s and 1960s in the Northeast, Midwest, and South were largely abandoned by the early 1990s. Most of the smaller university-industry cooperatives gradually disappeared, and participation in the major southern university/state/industry tree improvement cooperatives began declining in the mid-1980s and continued to do so until 2012 (**Figure 2**), although very recent changes in membership status and new recruitments have provided a boost to two programs (the North Carolina State University Cooperative Tree Improvement Program [CTIP] and the WGFTIP; numbers not shown in this figure). The number of FG/TI programs at universities that were not affiliated with an industrial cooperative declined until only very few currently exist. Independent corporate TI programs, at one time numerous and highly competitive, have mostly disappeared. Today, only Weyerhaeuser, Plum Creek, Rayonier, and ArborGen retain notable internal tree improvement programs.

As a result of these trends, the thriving field of FG/TI has become radically downsized and, to some degree, transformed in the past 30 years. The decline has been particularly notable in the East, Midwest, California, and Rocky Mountain regions and less so in the South and Pacific Northwest where economic interests in timber productivity are strong.

How could there have been such a rapid decline in support of FG/TI research? The proximal causes, of course, were simple: a collective (if uncoordinated) realignment in research priorities, implemented through personnel decisions and funding choices within the federal and state governments, universities, and industry. The reasons for the realignment are more complex, however. None by itself was dispositive, but their cumulative effect proved to be profound and rather rapid.

Table 1: Regional conferences catering to forest genetics and tree improvement in the United States.

Conference affiliation	Years of operation
Southern Forest Tree Improvement Conference	1951–present
Northeastern Forest Tree Improvement Conference	1953–1980s
Lake States Forest Tree Improvement Conference	1953–1980s
Central States Forest Tree Improvement Conference	1959–1980s
Western Forest Genetics Association	1955–present

The Southern and Western conferences continue to meet on a biennial basis. The Northeastern, Lake States, and Central States conferences eventually merged and have met only four times since 1991.

Irrational Exuberance

One of the main drivers behind the development of a large FG/TI research enterprise was the belief that the biggest challenge facing forestry was improving forest productivity, conveniently coupled with a conviction that science and technology could provide satisfactory solutions to this challenge. The unpleasant truth is that much of the work was probably unnecessary as applied science and redundant as basic science, although the FG/TI community certainly did not think so at the time. The rationale for applied tree improvement is not relevant if trees are not planted. For many of the 100+ species that came under study in applied research projects, including most of the hardwood species and minor conifers, the level of operational planting activity was never large enough for genetic gains in productivity or quality to have a meaningful economic impact. For hardwood species, particularly fine (=valuable) hardwoods, applied tree improvement proved to be much more difficult and expensive than with commercial conifers, and rapid gains from tree improvement were not forthcoming in these species to the degree necessary to alter planting practices, e.g., establishment of veneer-quality plantations. The justification to continue such purely applied tree improvement programs thus became weak, as federal and state funding tightened, stagnated, or was redirected (see below).

Coupled with this was excessive optimism about the ease with which tree improvement could be universally accomplished across species. Successful application of tree improvement technologies has consistently required sustained investments over decades, selection and breeding work that is clearly integrated with an actual planting program, and improvement goals that are silviculturally and economically meaningful. These attributes were missing in whole or in part from most of the programs that were initiated during the boom years, and most have disappeared. Unreasonable optimism, divorced from practical reality, about the power of science and the efficacy of scientists is not unusual, but it had a particularly strong effect on FG/TI.

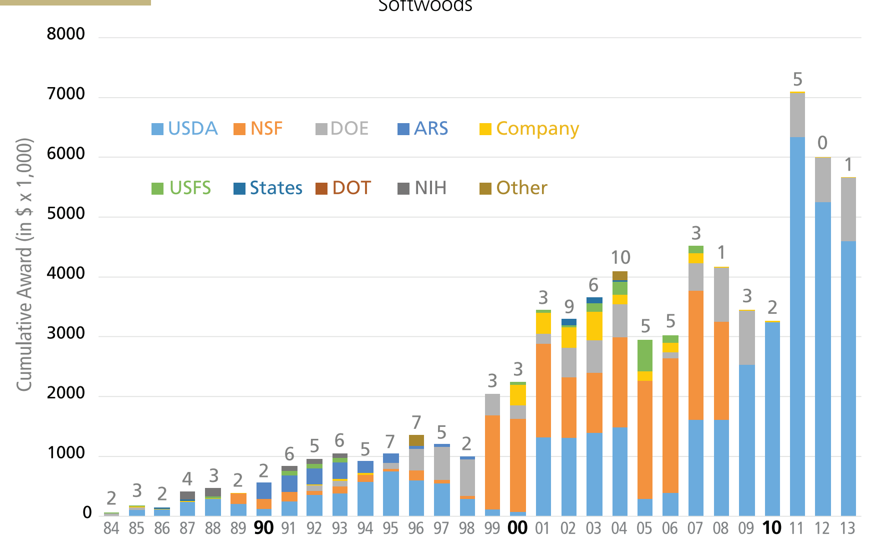
Budgetary Constraints

In the early 1980s the nation experienced a strong recession. Federal and state agency budgets were significantly reduced and FG/TI programs, with inherent longterm costs associated with establishment and maintenance of field trials and orchards, were easily targeted for reduction. The number of Forest Service research projects devoted to FG/TI began to decline in the mid1980s. In the early 1990s, the National Forest System tree improvement programs were renamed "Regional Genetic Resources Programs" (RGRPs), and their mission was broadened to include gene conservation of woody and nonwoody species. This began the transition to FG/EM research. Despite additional responsibilities, the budgets for RGRPs continued to dramatically decline. From a high of more than 90 scientists engaged in forest genetics in the 1970s, the number in Forest Service Experiment Stations and the National Forest System totaled only 23 in 2013 (Monty Maldonado, USDA Forest Service, pers. comm., Nov. 29, 2013). Currently, three Forest Service regions (2, 3, and 4) have no resident genetics staff.

The TVA, which had been very active in hardwood tree improvement, discontinued virtually all FG/TI activities in 1982. State programs were also affected by the declining economy and began to shrink and have continued to be affected by budget constraints unrelated to the general health of the economy. Many states have ceased or severely cut back on tree seedling production through state nurseries. In Wisconsin, for instance, nursery production has dropped from more than 25 million seedlings a year in the 1970s to less than 6 million a year currently (Ray Guries, University of Wisconsin, pers. comm., Jan. 18, 2015). The situation is not entirely bleak, however. Although institutionally and economically challenged, a number of state forestry programs (>10) in southern and western states remain full and important partners in the university/state/industrial tree improvement programs today.

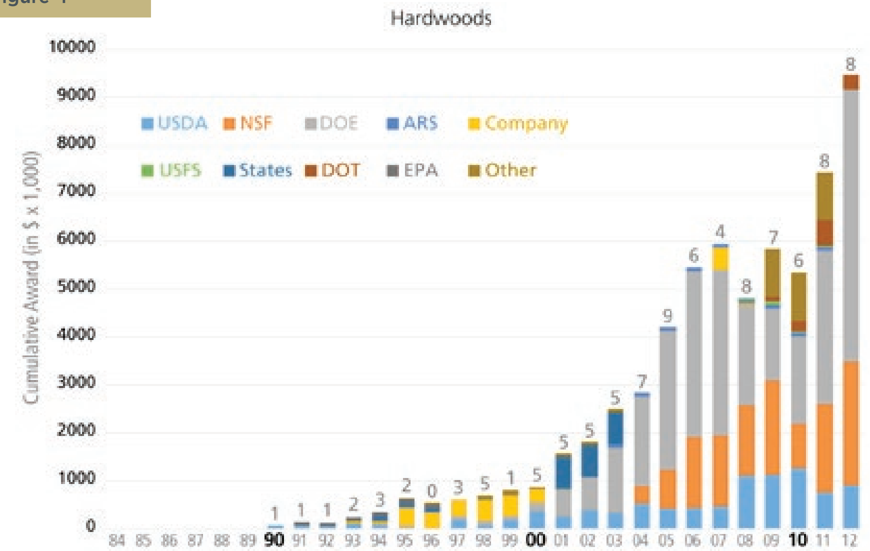
University programs have also undergone significant fiscal challenges. Since the 1980s, both the federal appropriations for forestry and agriculture research (McIntire-Stennis and Hatch funding) and the support of state governments for higher education have failed to keep pace with inflation (Bullard et al. 2011, Fischer and Stripling 2014). One outcome of these trends has been a shift of McIntire-Stennis funding away from direct project support to support of faculty salaries and departmental operations, and forestry research has become more dependent on relatively short-term grants and contracts (**Figures 3 and 4**). As explained below, research investments in molecular genetics work remain strong, but most of those grants go to a small number of institutions (**Table 2**). Considering all areas of forest genetics research, the number of practitioners is much diminished from the 1980s. In a survey of programs accredited by the Society of American Foresters and institutional members of the National Association of University Forest Resources Programs (NAUFRPs), we could identify only about 60 faculty members at 25 universities involved in some aspect of forest genetics work, and only one program, at North Carolina State University (NCSU), still offering an undergraduate course in forest genetics. Including USDA Forest Service and private industry, the total number of forest geneticists practicing applied research in the United States appears to be considerably less than 100 and the total number of scientists working in applied tree improvement is probably less than

Figure 3



The cumulative annual awards for extramural grants distributed, by funding agency/institution, for softwood (conifer) species. Multiyear awards are distributed equally over the life of the grant. Numbers above columns refer to the number of grants awarded in that year. Agencies are as follows: USDA, US Department of Agriculture; NSF, National Science Foundation; DOE, Department of Energy; ARS, Agricultural Research Service; USFS, USDA Forest Service; DOT, Department of Transportation; NIH, National Institutes of Health.

Figure 4



The cumulative annual awards for extramural grants distributed, by funding agency/ institution, for hardwood (deciduous) species. Multiyear awards are distributed equally over the life of the grant. Numbers above columns refer to the number of grants awarded in that year. Agencies are as follows: USDA, US Department of Agriculture; NSF, National Science Foundation; DOE, Department of Energy; ARS, Agricultural Research Service; USFS, USDA Forest Service; DOT, Department of Transportation; EPA, Environmental Protection.

25. This decline is somewhat offset by an emergence during the past two or three decades of a cohort of university scientists on nonforestry faculties engaged in basic research on the molecular genetics of forest trees.

Industry Mergers and Acquisitions

Beginning in about the 1980s, the forest products industry underwent an unusually active period of corporate mergers and acquisitions and, later, large-scale divestitures of lands to real estate investment trusts (REITs) and timber investment management organizations (TIMOs). These changes have had a profound effect on FG/TI research programs, most of which were discontinued or severely cut back. Partly as a result of these changes in the structure of forest industry, membership in the southern tree improvement cooperatives reached all-time lows (**Figure 2**), and fulltime dues revenues have fallen by 20% and more over the past two decades. The cooperative's struggles were detailed in an article on the future of tree improvement in the southeastern United States (Byram et al. 2005).

Elevated Priority for Ecosystem Management

Budget reductions and a growing public awareness of environmental concerns engendered significant changes in the philosophical and strategic approaches to research in the USDA Forest Service and other government agencies. In the West, a strong push to limit or stop altogether the harvesting of old-growth timber was underway, bolstered by concerns over habitat loss for endangered species. This was coupled with two significant USDA Forest Service administrative changes: USDA Forest Service Research was directed to move support from long-term to short-term projects, and an "ecosystem management," multiple-use approach to management of National Forests was adopted (Schlarbaum 1998). The results were dramatic. Annual timber harvests in National Forests of the West declined by as much as 80% during this period. Timber approaching maturity in eastern National Forests, interpreted as "old" growth, was subjected to similar pressures against harvesting from environmental groups. Many of the long-term tree improvement objectives in the National Forest System's Regional Tree Improvement Programs (now RGRPs), across the United States, were de-emphasized or consolidated, in favor of ecosystem conservation and restoration studies.

This attitude shift worked against traditional FG/TI research in two ways. First, it tended to destroy the original rationale that timber productivity was an unqualified goal of forestry that could be furthered through the application of genetics. If nature cannot be improved on, then there is little that genetics can do but assist in the understanding of it (and, indeed, that has been an important objective of forest genetics research in recent decades). Second, with reduced harvests on much of the public land, the opportunities for deploying genetically improved stock by planting have diminished. If trees are not being harvested, then they cannot be replaced. So, not only did the desirability of faster growing forests decline in the minds of managers and the general public, but also the mere ability to create such forests diminished.

Table 2: Number of grants awarded to principal investigator scientists at academic and research institutions in the United States between 1984 and 2013.

	Institution Receiving Funding								
Taxa	**OSU**	**NCSU**	**MTU**	**USFS**	**UCD**	**UF**	**PSU**	**VT**	**UGA**
SOFTWOODS	11	41	9	27*	4	10			3
HARDWOODS	34	10	23	2	3	2	6	6	5

Many of these grants supported coinvestigators and staff at multiple institutions but have been assigned here based on the home institutions of the principal investigator only. Consequently, many institutions, including some not shown, have benefitted from and played critical roles in the grants enumerated here but are not fully recognized by this summary. OSU, Oregon State University; NCSU, North Carolina State University; MTU, Michigan Technology University; USFS, US Department of Agriculture Forest Service; UCD, University of California at Davis; UF, University of Florida; PSU, Penn State University; VT, Virginia Polytechnic Institute and State University; UGA, University of Georgia, Athens.

*Includes principal investigators from multiple regional research experiment stations, although the large majority originated at the Pacific Southwest Forest Experiment Station.

Advent of Biotechnology

As noted above, the emergence of new technologies in the 1980s had a profound effect on the funding and direction of both forest genetic and tree improvement research across the United States and much of the world. The principal technologies of note were electrophoresis, genetic engineering (GE), and tissue culture. Electrophoretic technology that enabled the study of allozyme variations in populations of virtually dozens of forest tree species had two opposing effects on FG/TI. The first was to attract a large new cadre of students to forestry graduate schools, at first blush a positive effect. The result of this "conversion," however, was to detract from the production of more traditional FG/TI graduates. Although these new graduates replaced many of the retiring traditional geneticists around the country, their tenure in university, government, and corporate settings seemed short-lived, the result being an overall loss of staffing with genetics backgrounds.

GE, or transformation, technology was a vibrant research field in agronomic crops at this time, and the first tree to be transformed, a poplar, was produced in 1987 (Fillatti et al. 1987). Although a few companies adopted research programs of their own in this area, the majority of the forest industry demonstrated interest in GE by joining newly emerging research cooperatives such as the Forest Biotechnology Research Consortium at NCSU (1988–2013) and the Genetic Engineering Research Cooperative at Oregon State University (1994–2009; later named the Tree Biosafety and Genomic Research Cooperative, 2010–2015). To date, genetically modified trees using GE technology have yet to receive regulatory approval for commercial purposes, and the steep costs of gaining public and regulatory approval have imposed high hurdles to overcome. As a consequence, research in this field has diminished significantly.

Tissue culture was viewed as the means for producing genetically outstanding planting stock in the form of clones. In addition to streamlining field and mill operations, clonal forestry was viewed as a necessary technology for propagating GE trees and was a driving vision for managers of conifer tree improvement programs during this period. Literally millions of dollars were invested annually by a handful of forest product and technology companies to study cloning technologies. Work in this area has also retracted dramatically as technological hurdles and lack of acceptance of GE trees have proven challenging.

THE SCIENCE

THE GENOMICS ERA: New Directions in Forest Genetics Research

Genomics is a discipline of genetics that seeks to sequence, assemble, and analyze the function and structure of genomes and, coupled with transcriptomics, to identify all the genes in an organism. Its development has changed how genetics is applied in plant and animal breeding. Until the 1980s, our understanding of the genetics of forest trees depended primarily on statistical, "quantitative genetic" inferences about the genome structure of populations and species based on large and long-term, replicated field tests. These methods were perfectly suited to the identification, recombination, and assortment of desirable genetic traits through conventional breeding. However, by 1980, recombinant DNA, the polymerase chain reaction (PCR), and Sanger DNA sequencing technologies together provided the tools to study the structure, expression, and variation in individual genes. For many years, these laboratory methods remained tedious and time-consuming so only one or a small number of genes could be studied at one time. Although useful for simply inherited traits such as some human diseases, they did not allow for the study of large numbers of genes controlling complex traits (quantitatively inherited traits) such as those typically of interest to forestry. This situation changed dramatically beginning around 2000 with the introduction of genomic and other "omics" technologies.

Big Science Comes to Forest Genetics

The landmark event that ushered in the Genomics Era in all disciplines, including forestry, was the sequencing of the human genome in 2001. This feat was a direct result of the development of high-throughput DNA sequencing, gene expression, and genotyping technologies that have now been commercialized and are being used in agriculture and forestry.

Another important development, beginning around 1998, was a general shift in funding research from individual investigator awards averaging a few hundred thousand dollars to large multi-investigator, multi-institutional awards of several million dollars. This change was initiated by the National Science Foundation's Plant Genome Research Program, a series of programs offered by USDA's National Research Initiative and Agriculture and Food Research Initiative programs, and several Department of Energy projects (**Table 3; Figures 3 and 4**). Forest geneticists and scientists from other fields learned to form large collaborative projects to succeed in obtaining funding from these national competitive grant programs. An early result of this shift was that funding went to a smaller number of researchers working in the most highly advanced genetic systems such as loblolly pine and poplar (**Table 2**).

Tree Genomes Sequenced

A "reference" genome sequence is the necessary prerequisite for application of genomic and other related technologies. A reference genome sequence is generally defined as the first and most complete genome sequence for an organism and is most often obtained from a single individual. Reference genome sequences for black cottonwood (*Poplar trichocarpa* Torr. & A. Gray) (Tuskan et al. 2006), Norway spruce (*Picea abies* [L.] H. Karst.) (Nystedt et al. 2013), white spruce (*Picea glauca* [Moench] Voss) (Birol et al. 2013), and loblolly pine (Neale et al. 2014) have now been completed, and several more conifer genome sequences are under construction (Wheeler and Neale, 2013a). Forest trees are now positioned to take full advantage of these technologies and resources that have made significant impacts in human medicine and agriculture.

Table 3: Total funding for genetics/genomics competitive grants between 1984 and 2013 by agency or institution for conifer (softwood) and hardwood taxa.

	USDA NRI/ AFRI	USDA ARS	USDA USFS	NSF	DOE	DOT	EPA	NIH	PR*	ST	OT
SOFTWOODS	44.3	1.6	1.6	17.4	9.8			0.5	2.4	0.3	0.3
HARDWOODS	9.1	0.7	0.2	13.0	29.2†	1.2	0.4		2.8	2.3	3.5

Figures are in millions of dollars and are considered underestimates of actual support provided in most cases. USDA, US Department of Agriculture; NRI, National Research Initiative; AFRI, Agriculture and Food Research Initiative; ARS, Agricultural Research Service; USFS, USDA Forest Service; NSF, National Science Foundation; DOE, Department of Energy; DOT, Department of Transportation; EPA, Environmental Protection Agency; NIH, National Institutes of Health; PR, Private; ST, States; OT, Other.

*Numbers here refer only to grants awarded. Many of the large, multi-institutional grants have benefited from members of the tree improvement cooperatives via contributions of data, plant materials, and in-kind support.

†Value reflects funding for competitive grants only. DOE has provided substantial funding for noncompetitive research in both hardwood and softwood genomics through national laboratories such as the Joint Genome Institute. Total contributions from DOE may approach $60 million (G. Tuskan, DOE, Oak Ridge National Laboratory, pers. comm., Dec. 15, 2013).

Marker-Based Breeding

Forest tree breeders have long sought ways to increase breeding efficiency and decrease breeding costs. Along with fellow plant and animal breeders, forest geneticists enthusiastically developed means of using genetic markers to facilitate these goals. The study of marker assisted selection progressed through a series of marker types, from allozymes in the 1970s and various DNA fragment technologies in the 1980s and 1990s, to the abundant single nucleotide polymorphism (SNP) markers revealed by sequencing. Early studies were largely unsuccessful because markers to provide meaningful and practical associations with phenotypic traits were not sufficiently plentiful and inexpensive. It was not until gene sequencing technology could be applied in large genetic association studies that genetic markers (SNPs) could be found at very close linkage to the genetic traits of interest (Neale and Savolainen 2004). Consequently, the past 15 years have been a very active period in establishing the feasibility of using marker technology in tree breeding. Today, applications such as association genetics and genomic selection are being evaluated in a number of the larger tree breeding programs (Gonzalez-Martinez et al. 2007, Resende et al. 2012).

Landscape Genomics

As noted, genomic technologies have been used to better understand the relationships between tree genotypes and phenotypes in domesticated populations of forest trees. More recently, these same general approaches have been used in natural and domesticated populations to better understand relationships between tree genotypes and the environments in which they grow (Eckert et al. 2010, Mosca et al. 2012, Sork et al. 2013, Wheeler and Neale 2013b). Landscape genomics approaches combine genomic and geographic information system (GIS) technologies to discover the patterns of genetic variation at individual genetic loci across heterogeneous environments. This information can be used to deploy adapted material in reforestation and restoration efforts, in some cases without having to establish long-term common garden tests. There is optimism that landscape genomics technologies can be used to help mitigate the impacts of changing climate and help to sustain healthy and adapted forest populations.

CONCLUSIONS

Forest genetics and tree improvement have unquestionably made significant contributions to forestry practice and the timber economy of the United States. Although forest plantations comprise only about 15% of commercial forestland in the United States, they produce more than half of the nation's annual harvest of timber. To reforest these lands today, over a billion seedlings are planted annually, the great majority of which are genetically improved conifers (Steve McKeand, NCSU, pers. comm., Sept. 2014). Many of today's plantations produce 30–50% more wood per acre than they did 40 years ago (McKeand et al. 2010), thanks in large part to FG/TI research and development. Indeed, conventional breeding, along with newly developing applications of genomic technologies and genetic resources derived therefrom, will almost certainly continue to be used effectively and to great advantage with our primary commercial species.

Economic imperatives aside, the dual threats of climate change and introduced forest pests and diseases are already changing the structure and function of the American forest landscape and, correspondingly, the commercial and noncommercial values that we derive from these forests. In 2006, almost 8% percent of US forests – approximately 58 million acres – were at significant risk from insect and disease mortality (Alvarez 2007). This situation is expected to become much worse with the continued introduction of exotic forest pests and their progressive spread throughout American forests (Campbell and Schlarbaum 1994, 2002, 2014). Research efforts must be started now for a wide range of tree taxa not currently supported by commercial tree improvement programs if pending and existing threats are to be ameliorated. Within the last 100 years the United States has witnessed widespread mortality in many important tree species including American chestnut, American beech (*Fagus grandifolia* Ehrh.), Fraser fir (*Abies fraseri* [Pursh] Poir.), white pine species (*Pinus* L. subgen. *Strobus* Lemm.), and butternut (*Juglans cinerea* L.). Currently ash species are being lost to the emerald ash borer (*Agrilus planipennis* Fairmaire), eastern hemlock (*Tsuga canadensis* [L.] Carriere) and Carolina hemlock (*Tsuga caroliniana* Engl.) to the hemlock wooly adelgid (*Adelges tsugae* [Annand]), and whitebark pine (*Pinus albicaulis* Engelm.) and other western five-needled pines to white pine blister rust (*Cronartium ribicola* Frish). Oaks are threatened by sudden oak death (SOD) (*Phytophthora ramorum* Werres et al.) and black walnut (*Juglans nigra* L.) by thousand cankers disease (TCD) (*Geosmithia morbida* Kolarik), both of which are largely sequestered west of the Rockies. However, outbreaks of TCD and trapping of SOD spores in eastern forests have occurred, and these diseases could have devastating effects on forest biodiversity. Cumulatively, exotic forest pests are rapidly transforming forest structure and function (Campbell and Schlarbaum 1994, 2002, 2014). Compounding this transformation are the potential effects of climate change on all flora and fauna. Shifting species ranges, less thrifty stands, forcing migration through evolutionary bottlenecks, and potential increased susceptibility

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to native and exotic pests call for improved understanding of the genetics of adaptation. We believe FG/TI/EM are key and indispensable elements of any integrated plan to manage forest health and/or enhance forest productivity and deserve renewed support from state and federal governments, private companies, and REITs and TIMOs.

The obvious question is how such services should be constructed and supported and to what extent they should be developed. As chronicled in this article, the unbridled enthusiasm for FG/TI that reigned in the United States for more than 30 years (1950s-1980s) deflated rapidly thereafter owing to many factors, all of which played important roles. Clearly, history has provided lessons about the wisdom of science policy for our discipline as well as for forest sciences in general. Perhaps most critical to FG/TI is the inevitable shifting of research priorities and policy that occurs over time, sometimes over very short periods. Almost without exception, successful FG/TI endeavors have depended on uninterrupted, long-term fiscal and policy support, coupled with a market for the fruits of the research. By its very nature, tree breeding and forest genetics research is conducted over extended periods of time. The loss of established FG/TI programs in the USDA Forest Service, state forestry programs, private industry, and many universities has essentially reduced the discipline to reliance on university/state/industrial cooperative programs and relatively short-term grants, both of which favor a very select group of species and scientists. Although grants have been enormously beneficial in advancing basic research objectives, particularly in genomics, their relatively short funding cycles are not well designed for dealing with sustained development and application of genetic resources for the multitude of species that make up the bulk of our natural forest ecosystems.

Beginning in the 1980s, it became clear that the "improvement" focus of most FG/TI work was becoming unfashionable as broader societal and policy trends began to strongly favor ecosystem values over forest commodities. Although this shift disfavored tree improvement, it did not render obsolete the need for forest genetics research. Challenged by biotic and abiotic agents and pervasive human influences, our forests must still be managed if species and populations are to be retained as ecosystem components. Resource management, even of natural forests, requires an understanding of their genetic structure and, sometimes, how to manipulate it in the face of threats. For this purpose, genomics and related technologies are very well suited and, indeed, indispensable. This application of genetics was hardly contemplated 40 years ago. In parallel with the earlier usage (FG/TI), we could call it forest genetics in the service of ecosystem management (FG/EM).

Although we are reluctant to offer a list of specific research priorities that "must" be pursued, we emphatically underline the need for long-term research that is focused on forest and ecosystem health and adaptation in the face of threats that appear likely to be with us for decades, even centuries. Given the potential threat of extirpation of many of our native tree species as a result of native and introduced pests and diseases and climate change, we support policy and research priorities that favor the establishment of long-term integrated programs, with significant FG/TI/EM components, in federal and state agencies, with partnerships forged with other public and private institutions. Such programs would probably include, in most cases, both traditional and genomic elements, incorporating support of longterm field trials and bioinformatic database development, maintenance, and data retrieval. Perhaps most importantly, we encourage development of education and outreach resources to inform the general public of forest health issues, their relevance to the national economy and ecosystem health, and the importance of research to ameliorating the outcomes of these biotic and abiotic challenges.

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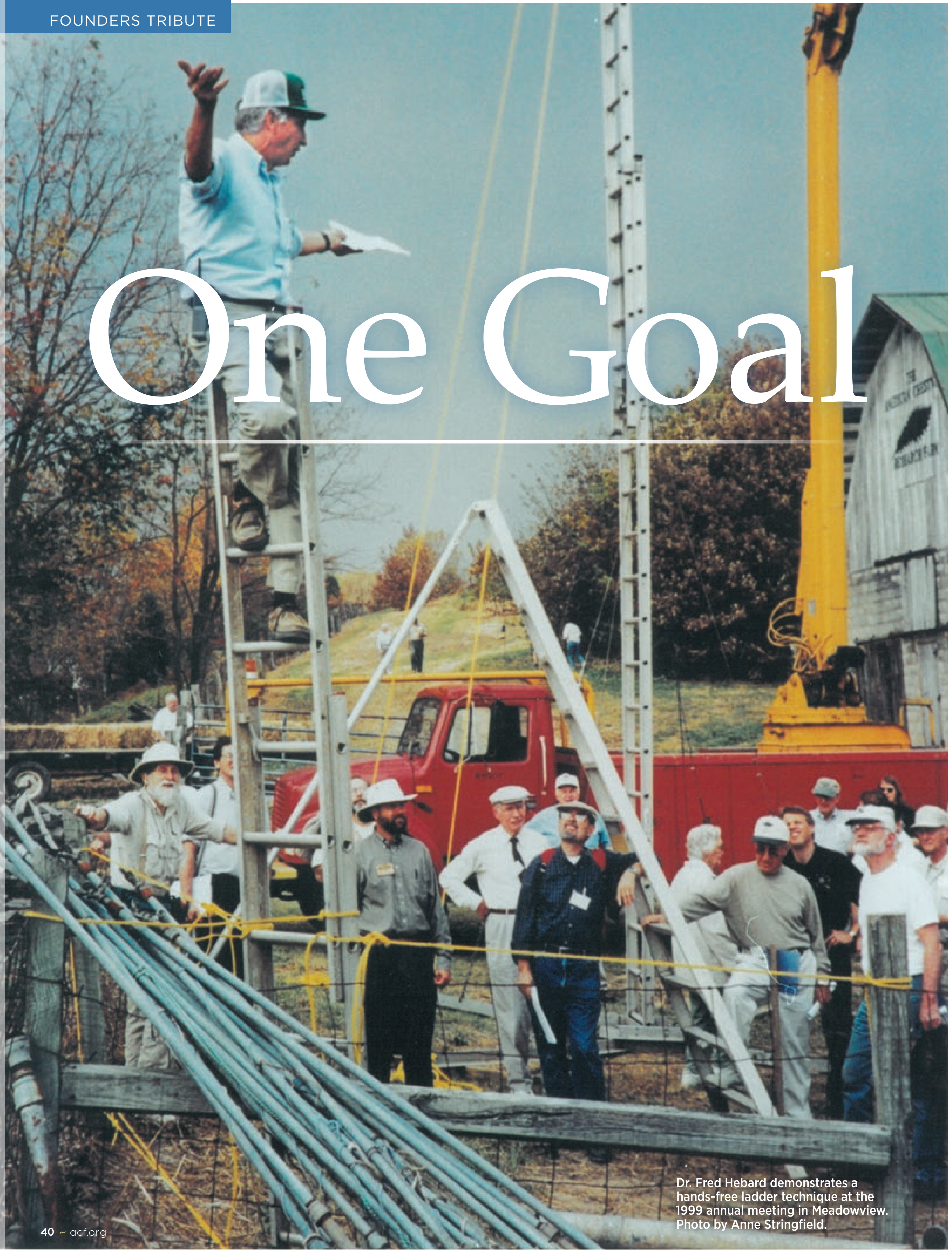
FOUNDERS TRIBUTE

One Goal



Dr. Fred Hebard demonstrates a hands-free ladder technique at the 1999 annual meeting in Meadowview. Photo by Anne Stringfield.

Fred Hebard was chasing heifers through the Connecticut countryside the first time an American chestnut tree caught his attention. He was taking a semester off from college, working on a dairy farm. When some of the cattle broke out of a pasture, he and the farmer went looking for them and they came across a chestnut sprout. The farmer told Hebard what had happened to all the chestnuts: once giants of the forest, they had been wiped out by blight. Before this sprout could grow tall, it would die like the rest.

"I thought, wouldn't it be great to go back to school, study biology, and save the American chestnut?" Hebard says.

"I thought, wouldn't it be great to go back to school, study biology, and save the American chestnut?" Hebard says.

For the next 45 years, he pursued that goal with single-minded focus. "I didn't realize it was a lifetime proposition back then," he says with a chuckle. He changed his major, went on to grad school, earned a doctorate in plant pathology from Virginia Tech, and researched ways to combat chestnut blight — even though most people saw the American chestnut as a lost cause.

Although they once made up a quarter of all hardwood trees in Appalachian forests, hardly any American chestnuts were left standing after the blight swept through in the 1920s and 30s. New sprouts sprang from old roots and young trees could live long enough to produce seeds — but they were doomed by the blight. As Hebard pursued his education and research in the 1970s and 80s, he says, the consensus was that restoration was not an achievable goal.

Still, a few scientists kept working on chestnut blight. They took two main approaches. Some studied hypovirulence, in which blight grows weaker. Others, including Hebard, researched the potential to breed a blight-resistant tree.

In 1989, as he was finishing a post-doc, the fledgling American Chestnut Foundation scraped together funding for a research farm in Meadowview, Virginia and they needed someone to run it. "I'd been wanting to breed chestnut trees on such a farm since the early 1980s," Hebard says. "It was my dream job. So, I jumped at it."

The job required serious sacrifice. Hebard's wife, Dayle Zanzinger, was also a plant pathologist, but there weren't exactly abundant opportunities for her in Meadowview. She gave up that career and started over as a nurse practitioner. The budget for the research farm was all of $30,000 – if the foundation could raise it – including Hebard's salary, which didn't come to much. He took the job anyway, with the vision that, as the work advanced, the foundation would grow.

Their goal was to back-cross the blight resistance of the Chinese chestnut into the American chestnut — preserving other qualities of the native tree, which was adapted to thrive in American forests. At first, it wasn't clear whether they even had a shot. If the genes that conveyed resistance were fairly simple — then, yes. If they were complex — then, no. It took four years just to establish that their goal was not impossible. Even then, Hebard says, "There were never any eureka moments." When they reached that milestone, it took weeks to collect the evidence and weeks to calculate the results.

Hebard directed the Meadowview Research Farms for 26 years, eventually serving as TACF's chief scientist. It was slow, steady work — crossing trees, testing offspring, selecting the best. Then again. Then again. But, by the time Hebard retired this year, his work — in collaboration with numerous volunteers and scientists in an effort that grew to span sixteen states — had produced a population of trees that averages 15/16 American chestnut and has resistance to blight: the Restoration Chestnut 1.0.

Hebard's favorite pursuit in retirement is breeding chestnut trees. "I'm kind of monochromatic," he says. His lifelong goal "gave me a mission," he says. "I was lucky to be able to pursue it for as long as I did."

In another 5-10 years, he thinks, scientists may track down the exact genes that control blight resistance. That knowledge could help breeders, cutting down on the time-consuming process of trial-and-error. It could also open up possibilities for genetic engineering. But, Hebard points out, the Restoration Chestnut 1.0 is not a product of genetic engineering. And unlike genetically engineered trees, there's already a sizeable population of Restoration Chestnuts, from diverse ancestors, growing in numerous locations across the eastern U.S. Hebard says, "We know we've got partial blight resistance in the Restoration Chestnut 1.0 and we know they grow as well as American chestnut trees in the forest. We've also captured a tremendous fraction of the genetic diversity of the American chestnut."

Left to Right: Founding TACF members Phil Rutter, Fred Hebard and Bill Raoul deliberate over a chestnut tree in Meadowview, Virginia, c. 1990. Photo courtesy of John Herrington.

Hebard inspects the catkin of an American chestnut. Photo courtesy of TACF.

Hebard examines a chestnut leaf in the Glenn C. Price Research Laboratory. Photo courtesy of TACF.

Chestnut Foodways

By David S. Shields, Ph.D.

David S. Shields, Ph.D. is the Carolina Distinguished Professor and the McClintock Professor of Southern Letters at the University of South Carolina. He also serves as chairman of the Carolina Gold Rice Foundation. Shields has published several monographs in the fields of early American literature and culture, the history of photography, and food studies. This year, the University of Chicago Press issued *Southern Provisions: the Creation and Revival of a Cuisine*. In 2016 the University of Chicago Press will publish his collection of 200 biographies, *Culinarians: American Chefs, Caterers, and Restaurateurs 1794-1919*. Besides his scholarly work in food studies, Shields is responsible for the repatriation of a dozen classic ingredients to the Southern region's fields and gardens, most recently the Carolina African Runner Peanut and Purple Ribbon Sugar Cane. He also heads Slow Food's Ark of Taste Biodiversity Committee for the Southern Region.

At the Carolina Gold Rice Foundation, we are working to restore and raise awareness about a once lost keystone mast, the Carolina gold rice. This historic, long grain rice was once a commercial staple in the coastal lands of the Carolina Territory in 1685. The Carolina Gold Rice Foundation's key interests lie in preserving or restoring the most significant ingredients of traditional Southern cuisine. As a result, we have followed the work of The American Chestnut Foundation with an acute interest, aware that inhabitants of the Southern uplands made the American chestnut a central component of diet from prehistoric times. In fact, we began researching the 19th century foodways associated with American chestnut, eyeing the crop's reactivation.

We can think of chestnut foodways in two ways: (1) those that arise from wildlife fed on the nutfall of American chestnuts and (2) those that arise from the human processing and preparation of the nuts themselves. In this article, I will focus on human preparation and consumption.

The edible portion of the American chestnut is piquantly sweet, smallish, rather toothy in texture, and when dried makes admirable meal and flour (recipe for "Chestnut Bread" on next page). The Sicilian chestnut, the most reputable of European strains, is larger, more meaty in texture, pleasantly sweet, but not so distinctive in taste as the American. Both Chinese and Japanese chestnuts are significantly less sweet, and sometimes tend to chalkiness of texture.

The American chestnut became a central component of people's foodways for not only its wonderful flavor but for its nutritional value. It was used to produce flours, porridge, pickled chestnuts, roasted chestnuts, dressing, desserts, and more. And recipes varied by region. Georgia, South Carolina, Tennessee, Kentucky, North Carolina, and Virginia had two distinctive versions of chestnut bread. One used chestnut meal in a cornbread recipe to create a soft, crumbed bread. The other rested in a chestnut dough to form flat griddle cakes.

In the late 1810s, the production of sugar in Sapelo Island, Georgia drove prices of loaf sugar to an all-time low. During this time, sugar became a common article of grocery consumption, and its broad availability wrought a revolution in household food processing throughout the southern and eastern United States. Jams and preserves exploded, but chestnuts did too. "Preserved Chestnuts" (recipe on p. 44) were crisp and piquant, and when preserved in simply syrup, they became doubly sweet. America may not have cottoned to marron glacé, but it loved sugar preserved chestnuts.

The sweetness of chestnuts inspired a plethora of desserts: chestnut caramels, chestnut cakes, chestnut cream, and chestnut pie. A more everyday dessert preparation used pureed chestnuts to create pudding. Some of the pudding recipes can be identified as Appalachian descendants of the old English nesselrode pudding. In all of these puddings, the chestnuts were boiled, mashed, and strained through a sieve to achieve a creamy consistency. This was bound into an egg custard, with a fair amount of sugar. In the nesselrode version, dried currants or golden raisins were incorporated into the pudding and the preparation set in a freezer. However, only those places that boasted refrigeration could enjoy this refined treat.

Chestnut ice cream was another take on the custard recipes of this time. Using a pureed chestnut formula, this dessert appeared on the menus of Delmonico's Restaurant in New York. Chef Charles Ranhofer, reputed to be the greatest chef in the history of the 19th century, had a particular weakness for chestnut ice cream.

In terms of savory chestnut dishes, vegetarians in the 1890s devised a delectable version of chestnut pie based on the model of mashed potato pies, which were quite popular at the time. One of the savory dishes I encountered that has most fascinated me during my survey of culinary employments is "Deviled Chestnuts" (recipe on p. 44). I have made it, served it with pleasure, and I may be facing borderline addiction issues to it.

Here, I've tried to suggest the range, depth, splendor, and interest of the southern tradition of chestnut cookery. If you are interested in southern food, please read my newly released book about the history of the agriculture, marketing, and culinary preparation of the greatest tradition ingredients in *Southern Provisions: the Creation and Revival of a Cuisine*. The Carolina Gold Rice Foundation has primed the pump for American chestnut restoration, stimulating demand and interest wherever and whenever it can. We are anxiously awaiting the first crops of American chestnuts, and I am ready to write a coda – a new chapter about the revival of chestnut cookery.

Chestnut Recipes Before The Blight 1910

CHESTNUT BREAD

[Mrs. N. K. M. Lee, Eliza Leslie, The Cook's Own Book, p. 25, **1840**]

Roast a hundred fine chestnuts, being careful not to burn them; peel them well, and pound them with butter and double cream; pass them through a sieve; add two eggs, and then strain them again. Weigh your paste, and for a pound, allow half a pound of powder, a little vanilla in powder, and two ounces of flour; mix these together, and form of the preparation as many chestnuts as it will make; lay them on a sheet of wafer paper, butter, and dorez them several times, and then bake them in a hot oven.

CHESTNUT SKILLET BREAD

[Mrs. H. D. Cullum, Letter-recipe October 16, **1875**]

Measure out 2 ½ cups of chestnut meal, and mix in 1 ½ tablespoons of salaeratus [baking power], and salt to taste. Beat an egg, mix in 1 ¼ cups of warm milk, and melt ½ pound of butter—not too hot, add the melted butter to the milk. Pour these into the meal and stir until the batter is free of lumps. Pour into a smoking hot skillet greased with lard. Cook in a hot oven 40 minutes or until browned.

CHESTNUT PUDDING

[Charles Elme Francatelli, The Modern Cook, p. 487, **1877**]

Bake or boil fifty fine chestnuts, rub their pulp through a sieve, and place this in a stewpan with a pint of cream, four ounces of butter, six ounces of sugar, a pounded stick of vanilla, and a very little salt; stir these ingredients over a stove-fire until the preparation thickens, and then quicken the motion of the spoon, so as to prevent the paste from adhering to the bottom of the stewpan. As soon as it leaves the sides of the stewpan, remove it from the fire, add eight yolks, and the whites of six eggs whipped firm; pour the pudding mixture into a plain mould, previously spread with butter, and then steam it for about an hour and a half. When the pudding is done, turn it carefully out of the mould on its dish, pour some warm diluted apricot-jam over it, and serve.

CHESTNUT CAKE

[Almeda Lambert, Guide to Nut Cookery, p. 373, **1899**]

Take 2 cups of chestnut flour, 5 eggs, 1 scant cup of sugar, 2 tablespoonfuls of water, and a pinch of salt. To make the chestnut flour, first dry the nuts before shelling, or toast them slightly with the shells on. By doing this the skins will be loosened and easily rubbed off without blanching; then grind them in a family grist-mill or a coffee-mill to a fine flour, or they may be ground through the nut-butter mill. When all material and cake tin is ready and the oven hot, separate the eggs, and beat the yolks to a thick cream with the sugar. Then beat the whites until they are stiff and crumbly, adding the water and salt after it begins to get foamy, but before it is stiff. Then pour in the yolk mixture, and fold it carefully in, and lastly fold in the 2 cups of chestnut flour. Bake like other cakes.

CHESTNUT CARAMELS

[Mary J. Lincoln, Philadelphia Inquirer, p. 11, **1899**]

Put one-half cup of granulated sugar in a smooth omelet pan, place the pan over the fire, or over the chafing dish lamp, and stir until the sugar melts and becomes quite brown, then remove from the fire. Put the boiled chestnuts in another pan, with a little butter, and toss them about until the butter is absorbed, then dip them in the hot caramel and lay them on buttered paper. When cool, serve with ginger wafers and cheese.

CHESTNUT STUFFING

["Household Recipes," Biloxi Herald, p. 3, **1889**]

Shell and blanch thirty-four chestnuts, and boil until tender. Drain off the water and pound ten to a paste, add one cracker rolled fine, quarter pound chopped raw meat, one teaspoonful chopped parsley, one teaspoonful salt, one teaspoonful of pepper, on teaspoonful thyme and two tablespoonfuls butter and twenty-four whole chestnuts. Mix well.

DEVILED CHESTNUTS

[Mary J. Lincoln, Philadelphia Inquirer, p. 11, **1899**]

Cut a slit in the shell of each chestnut, put them in a popcorn popper over an open fire and shake them frequently. When they burst open they are done. Remove the shells and skin and then toss them about in hot water in the chafing dish. Sprinkle with salt and paprika, and add sufficient Worcestershire sauce to moisten them. Stir them till all have received a portion of the pungent dressing, and serve them hot.

PRESERVED CHESTNUTS

["What to do with Nuts," Charleston Evening Post, p. 3, **1899**]

Select the largest of the chestnuts and boil them for five minutes. Drain them and remove the shell and skin. Make a rich syrup of one pound of sugar and one pint of water. Boil it until it spins a thread, then put into it one pound of the chestnuts. Boil them until tender and put into air-tight jars as you would preserved fruit. When you wish to serve them as a dessert put a teaspoonful of the chestnuts and the syrup into a broad, shallow glass, and add a tablespoonful of vanilla ice cream and a tablespoonful of whipped cream. Serve at once. This is a delicious dessert.

CHESTNUT SOUP

["Chestnuts for Thanksgiving," Seattle Daily Times, p. 18, **1901**]

Remove the outside shell from a pin of chestnuts and let them stand in boiling water until the inner skin will peel off. Then cover them with water, to which a pinch of salt has been added, and boil until quite tender, with a leek and a sprig of parsley. A slice of bacon may be added if desired. Press through a colander, add a lump of butter, a dash of black pepper, a quart of milk and spoonful of finely minced parsley, and let all come to a boiling point.

CHESTNUT CUSTARD

["The Luxurious Chestnut," Bay City Times, p. 10, **1903**]

Boil a quart of large chestnuts, peel, skin and mash to a smooth pulp; add the grated yellow rind of a lemon, a tablespoonful of lemon juice, a grating of nutmeg, and a custard made as follows: Beat three eggs with a third of a cup of granulated sugar, a pinch of salt and a grating of nutmeg. Pour a pint of scalded milk over the mixture, blend and return to the boiler and stir and cook until it is a thick, smooth cream. Take from the fire and stir in the whites of the eggs beaten to a stiff froth. Turn the custard into stemmed glasses, set on ice and when cold and ready to serve, heap whipped cream on top.

Many of these classical recipes do not reflect a 21st century style of cooking or baking. For a modern 'best practices' recipe on Chestnut Caramels, use the following:

1. Get a heavy skillet or sauce pan—one that will distribute heat evenly. Coat the bottom evenly with the half cup of granulated sugar.
2. Cooking at a moderate setting, use a wooden spoon or heatproof spatula and push the liquefying sugar to the center of the pan.
3. If lumps form, turn the heat down, continue stirring; they should melt and brown.
4. It is important to not let sugar scorch by being kept stationary on one heated section of the pan. Keep it moving.
5. When you reach an even rich amber color, turn heat to low. You can swirl the buttered whole boiled chestnuts in the caramel and let them cool on a silpad or wax paper.
6. Modern taste suggests a robust salting of the buttered nuts will make the caramel taste even more pointed.
7. Let the caramel coated nuts cool completely before serving.

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