

The first research plantings of blight-resistant American chestnut (*Castanea dentata*) in the southeastern United States
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LEGEND
Natural Range of the American Chestnut

Is Restoration Possible?



Chestnut blight (*Cryphonectria parasitica*)

Lack of biological and silvicultural knowledge

Root rot (*Phytophthora cinnamomi*)

Gypsy moth (*Lymantria dispar*)

Asiatic Oak Weevil (*Cyrtopistomus castaneus*)

Animal damage to seedlings and nuts

Oriental Gall Wasp (*Dryocosmus kuriphilus*)

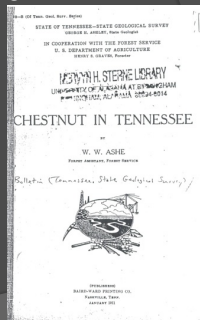
Chestnut Demise and Restoration

- Occupied up to 50% of basal area in eastern hardwood forest; used for wood, food, tannin, cattle fodder, and important for wildlife



Chestnut Demise and Restoration

- Ashe reports "Chestnut is one of the most widely distributed trees of Tennessee and the most important tree in the mountains of the eastern portion of the state... chestnut is one of the most promising trees for forest management"



USDA Forest Service: Chestnut Restoration

- USDA Forest Service is "most favored recipient" according to 2004 MOU with The American Chestnut Foundation
- MOU renewed in 2010
- Forest Service charged with implementing test and reforestation plantings and providing land
 - No clear agency goal for this testing
 - No clear agency goal for reforestation



SOUTHERN RESEARCH STATION

Upland Hardwood Ecology and Management
Research Work Unit 4157
Bent Creek Experimental Forest

Stationed at the University of Tennessee Knoxville, TN

Partnerships: The Forest Service, The Foundation, and The University of Tennessee

TACF Meadowview Orchard (Fred Hebard)

National Forest System, Southern Region (Bob Makowski, Barbara Crane)

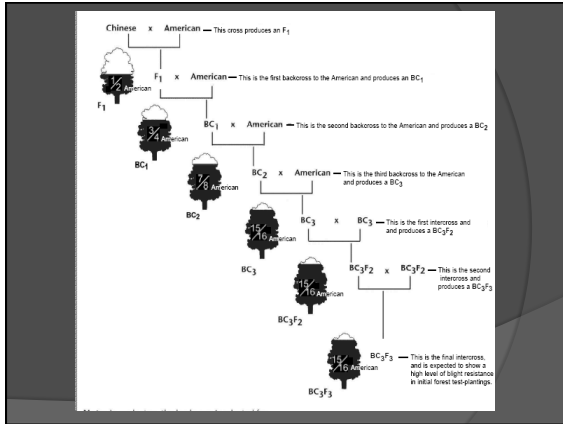
Southern Research Station
SRS-Stacy Clark

UT-Tree Improvement Program (Scott Schlarbaum)

Background

- Research and resources of Forest Service has focused on production of blight-resistant American chestnut
 - Forest Health Initiative
 - The American Chestnut Foundation
- Testing hybrids has been limited
 - Past work by Griffin and Anagnostakis indicates interaction between site and blight resistance
 - Potential 'break-down' of blight resistance over time
 - What is relationship between blight-resistance and other phenotypic characteristics?

Meadowview TACF research farm





Th... t end

Planting of hybrid chestnuts on clearcut/prescribed burn site on Cherokee National Forest, TN

Important research questions for the next phase of restoration

- How can we produce a tree that will be successful after planting in forests of the species range?
- How will this tree compete against native tree species?
- What are the tree's silvicultural requirements?
- What pests (native and non-native) will affect the success of this tree?
- Will blight-resistance hold?
- How is blight-resistance/hypovirulence affected by site conditions (elevation, topography, etc.)?

Native sawfly defoliating planted chestnut

Required resource requirements for forest experiments

- Land base that has long-term ownership
- Facilities and infrastructure
 - Nursery
 - Trained personnel
 - Vehicles and trailers
 - Coolers
- Expertise in establishment techniques using state of the art experimental designs
- Ability to maintain site
 - Competition control
 - Animal damage protection (fox, deer)
- Protection of site from theft/vandalism
- Ability to monitor plantings closely and to collect data that can be empirically analyzed

The First Test Plantings by the USDA Forest Service (Southern Research Station and the Southern Region), The University of Tennessee, and the American Chestnut Foundation

3 year old Chestnut tree

- Goal
 - To test TACF American chestnuts that have been **traditionally bred** for blight-resistance for the ability to **survive, compete, and remain blight-resistant** in forest within the species native range





Measure trees

Sow nuts by genetic family

Establish Planting

Nursery production

- 1-0 bare-root nursery
- Seedling size maximized (Paul Kormanik's work)
 - 3.1 to 4.4 ft average height (0.3' to 8.5')
 - KBC bar or Auger planted (8" bit)
- Split seedlings into two size classes¹
 - Does not reduce variation but improves seedling quality



¹ Clark et al. in press. Nursery performance of American and Chinese chestnuts and backcross generations in commercial tree nurseries. *Forestry*.

Field Plantings

- Seedlings planted on newly harvested sites [shelterwood with reserves, 10-20 ft² acre⁻¹ basal area (2-5 m² ha⁻¹ basal area)]
- Stump sprouts chemically treated



Field Plantings

- It will be just as important to determine if these trees can grow and survive in this highly competitive environment as it will be to determine blight-resistance.



Study design and experimental material

- Established 11 plantings in 2009, 2010, and 2011 on National Forests in TN, VA, NC
- Planted 4596 trees: mixture of American (837), Chinese (535), BC_1F_3 (470), BC_2F_3 (455), BC_3F_2 (277), and BC_3F_3 (2022)
- Incomplete block design, single tree family plots
 - Family nested within generation/species, family whole plot factor, seedling size split-plot factor



2009 Plantings: 3rd year growth

- Total height=71" (sd=28") across all sites
- American (75", se=2") and BC_3F_3 (68", se=2") were taller than Chinese (54", se=3")
- Large size class trees were 13" (33 cm) taller than small size class trees



2009 Plantings: 3rd year survival and bud break phenology

- 80% (sd=40%) across all 2009 sites
- Large seedlings had lower survival (77%, se=2%) than small seedlings (85%, se=2%)
- Chinese had lower survival (70%, se=3%) compared to rest of generations and American (~84%, se=3%)
- Generations/parental species differ in bud break timing
 - Chinese > BC_1F_3 > BC_2F_3 > BC_3F_3 > American
- Blight on less than 5% of trees
 - Too early to test resistance



Deer browse in 2009 plantings

- 80% (sd=40%) browse at TN, 46% (sd=50%) at VA, and 13% (sd=33%) at NC
 - We sheltered trees at TN and VA in year 2
- 7% of trees were above browse line at planting
- A 20" tree at planting was 5 times more likely to be browsed than a 60" tree (logistic regression)
- 58% of trees above browse line by 3rd year
- Trees browsed in year 1 were 9" (se=2") shorter in year 3



2010 Plantings: Growth and Survival

- One planting was decimated by root rot (*Phytophthora cinnamomi*)
 - Planting was not well-drained
- The other planting has 70% (sd=46%) survival and trees are averaging 79" (sd=27") in height after 2 growing seasons
 - Range from 6" to 154"



2010 Plantings: deer browse

- 50% of trees above deer browse at time of planting
- Sheltered one site at planting



2011 Plantings: Growth and Survival

- These plantings are compromised by root rot caused by *Phytophthora cinnamomi*
- Overall survival ranged from 51 to 83% after one year and is dropping fast
- Growth was negative due to dieback



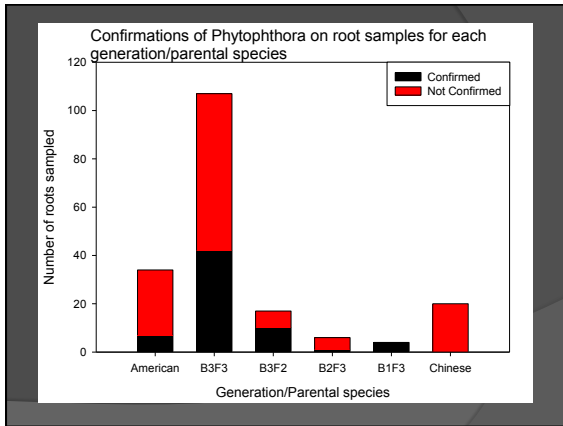
Phytophthora cinnamomi: What is it?

- Exotic fungal pathogen that came into US in 1870s
- Attacks American chestnut, shortleaf pine, and Fraser fir
- Is most virulent in clayey, compacted, or poorly drained soils
- Chestnuts show little resistance
- No chemical treatment is effective
- Comes from commercial nursery soils and is transplanted through bare-root nursery seedlings
- Does not grow in northern latitudes (above ~40°)

Root rot caused by *Phytophthora*

- Confirmations were made at all 11 sites by pathology experts (Steve Jeffers, Clemson; Gary Griffin, VA Tech and ACCF, Sandra Anagnostakis, CAES)
 - under estimating disease
 - Anagnostakis also found *Phymatotrichum omnivorum* on 2011 trees





Other pests we have seen

- Non-native:
 - Asiatic oak weevil (*Cyrtopistomus castaneus*)
 - Identified at 4 plantings (Bud Mayfield, SRS)
 - Asian chestnut gall wasp (*Dryocosmus kuriphilus*)
 - Identified at 5 plantings



Other pests we have seen:

- Native:
 - Chestnut sawfly (*Craesus castaneae*)
 - Identified at 2 plantings
 - Periodical cicadas (*Magicada* spp.)
 - Severe damage at one planting



Post-hoc data collections

- *Phytophthora* damage at all plantings
- Insect defoliation study:
 - Monitoring Asiatic oak weevil abundance at one planting
 - Insect defoliator collections at two plantings
- Gall wasp data collection
 - Counting galls by tree at four plantings
- Cicada damage on all trees at one planting
- Late-season frost damage at three plantings



Other data we are collecting:

- Bud-break phenology at four plantings
- Photosynthesis and water-use efficiency at one planting
- Deer browse and dieback to main stem
- Distance to nearest overstory tree
- Midstory and understory competition
- Photosynthetically active radiation in years 1-3
- Blight




Preliminary Conclusions

- Restoration success will depend on how well these trees adapt and resist exotic pests
- 2009 plantings are doing well because minimal *Phytophthora* and we protected from deer
- Seedling quality at planting does make a difference in growth
- Chestnut grows fast! > 1 foot/year
- BC₂F₂ not behaving exactly like Americans in height or in budbreak phenology
- *Phytophthora* will be major obstacle in restoration
- Blight-resistance will be tested this coming year



Biological Challenges: *Phytophthora?*


- Use containerized seedlings
 - Increased costs (5-10x of bare-root)
 - RPM® (Root Pruning Method) is most advanced technology (Forrest Keeling nursery)
 - Need to develop quality seedling balanced with logistical constraints
- Will begin experiment in fall 2012 to test container size and grading on seedling quality and development



RPM seedling on left; bare-root seedling on right

Biological Challenges: Deer

- Use deer repellants or shelters
 - very expensive and labor intensive
 - \$0.10 per tree per application for repellant
 - \$3-6 per tree for shelters
- Plant large seedlings
 - May be more difficult with containerized stock



Research Challenges

- Everything loves chestnut!
 - Gall wasp, oak weevil, ambrosia beetles, soil diseases, gypsy moth, deer, bears, etc.
- Need multi-dimensional research approach
 - Silviculture/silvics
 - Pathology
 - Entomology
 - Wildlife ecology
 - Genetics
 - Soils
 - Physiology



American chestnut: Charismatic Megafloora

- February 12, 2009
 - WUOT, Knoxville, on-air interview
- February 23 2009
 - Knoxville News Sentinel
- February 27, 2009
 - Birmingham News
- March 17, 2009
 - Chicago Sun Times
- March 18, 2009
 - News Chief, Winter Haven, FL
- April 2009
 - The Forestry Source
- September 23, 2009
 - EurekAlert (genengnews.com; physorg.com, sciencedaily.com)
 - Citizen Times, Asheville, NC
 - WBIR.com (NBC affiliate), Knoxville, TN

American chestnut: Charismatic Megafloora

- September 24, 2009
 - Knoxville News Sentinel
 - Maryville Daily Times
- September 28, 2009
 - The New York Times
- October 20, 2009
 - USA Today
- October 22, 2009
 - Talk Radio, Roanoke, VA On-air interview
- November, 2009
 - Land and Life Science, UT Institute of Agriculture Publication
 - Tennessee Farm Bureau News
- January 2011
 - The Times Daily



American chestnut: Charismatic Megafloora

- July 2011
 - Under secretary of Agriculture mentions chestnut work in NPR interview
- August 2, 2011
 - Aljazeera English reports on chestnut work
- August 8, 2011
 - Knoxville News Sentinel
- September 2011
 - The Charlotte Observer
- February 2012
 - Smoky Mountain Living
- August 21, 2012
 - Wall Street Journal
- 17 Magazine or Newspaper stories
- 5 TV stories

Upcoming events

- Webinar October 17, 2012
 - <http://www.forestrywebinars.net/webinars/the-restoration-of-the-american-chestnut>
- Chestnut Symposium October 19-21, 2012
 - Asheville, NC
 - <http://www.acf.org/summit/index.php>



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- Forest Service, State and Private Forestry, Forest Health Protection
- SRS Communication Staff, Region 8 Communication Staff, TACF Communication Staff

Websites

- Stacy Clark's research page:
 - <http://www.srs.fs.usda.gov/uplandhardwood/americanchestnut.html>
- TACF:
 - www.acf.org
- MOU between USDA Forest Service and TACF:
 - http://fsweb.wo.fs.fed.us/aqm/grants/static/servicewide_agreements/american_chestnut_foundation/10-MU-11132425-123.pdf
