American Chestnut: The Past 100 Years

Pre-blight uses, Blight introduction and Spread, Species Restoration work

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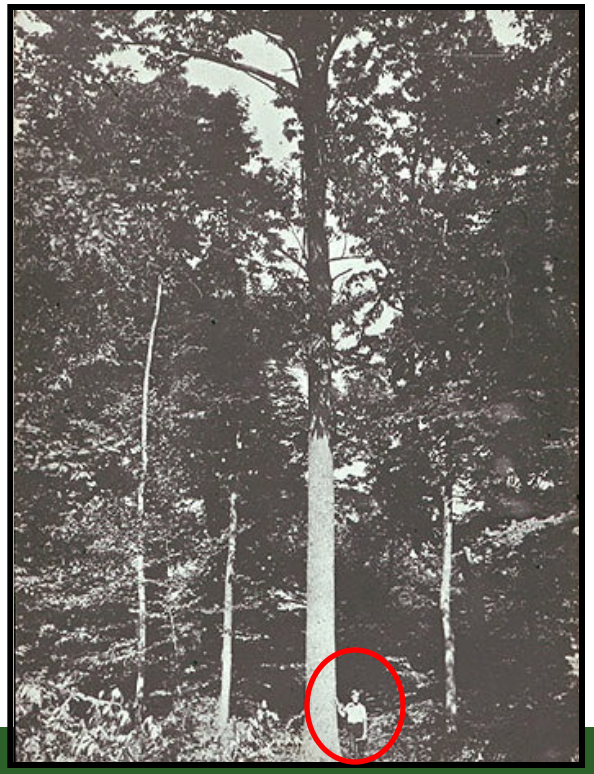
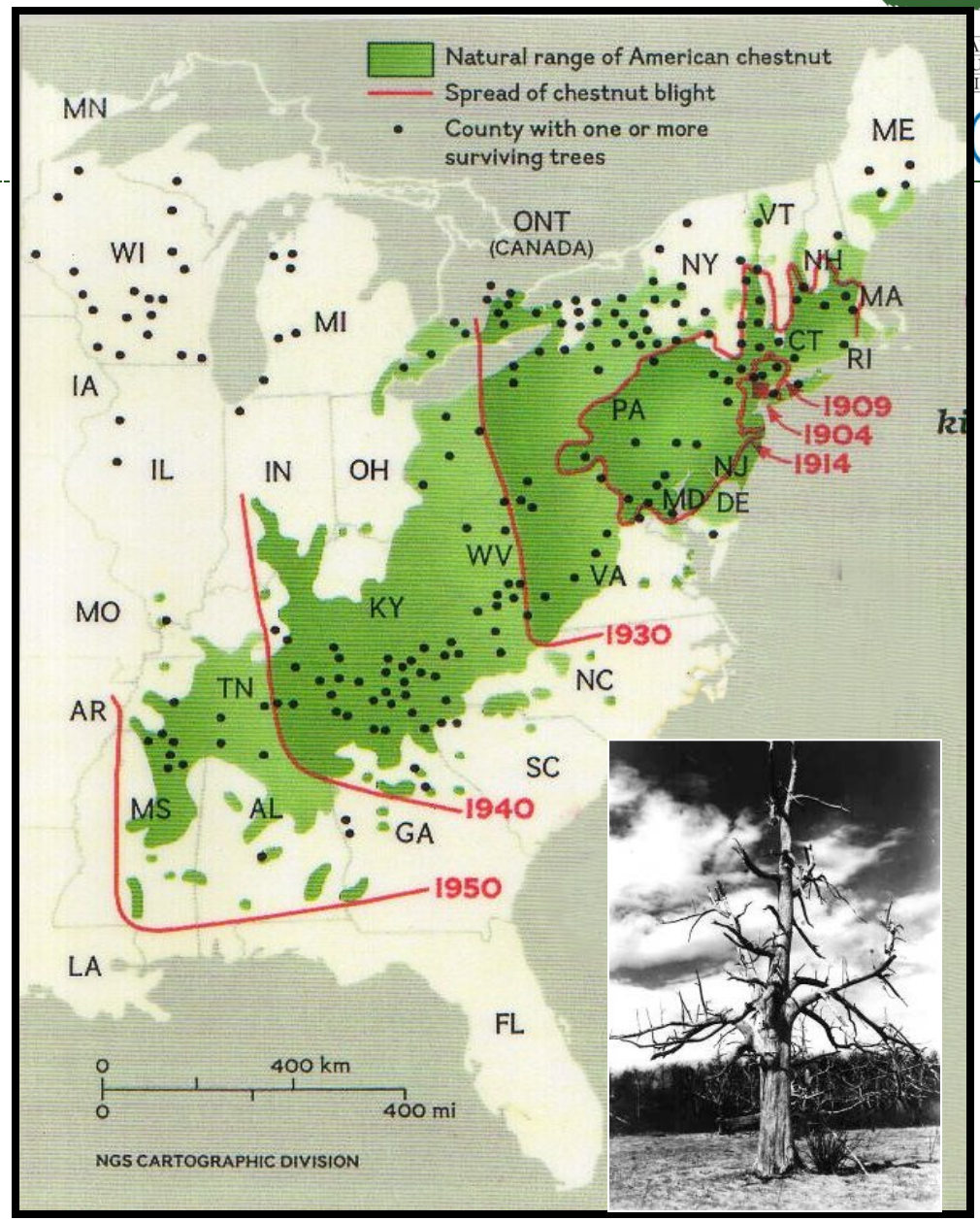
American Chestnut: The Tree

- Major component of eastern forests
- Fast growth, large, extremely rot resistant
- High-value timber species
- Nuts valuable to wildlife
- Tannins used in tanning leather
- Nuts valuable to people and livestock
- Culturally significant



Spread of the Chestnut Blight…

Approximate movement of 20 to 50 miles per year because of American chestnut's density and almost complete susceptibility to the blight.

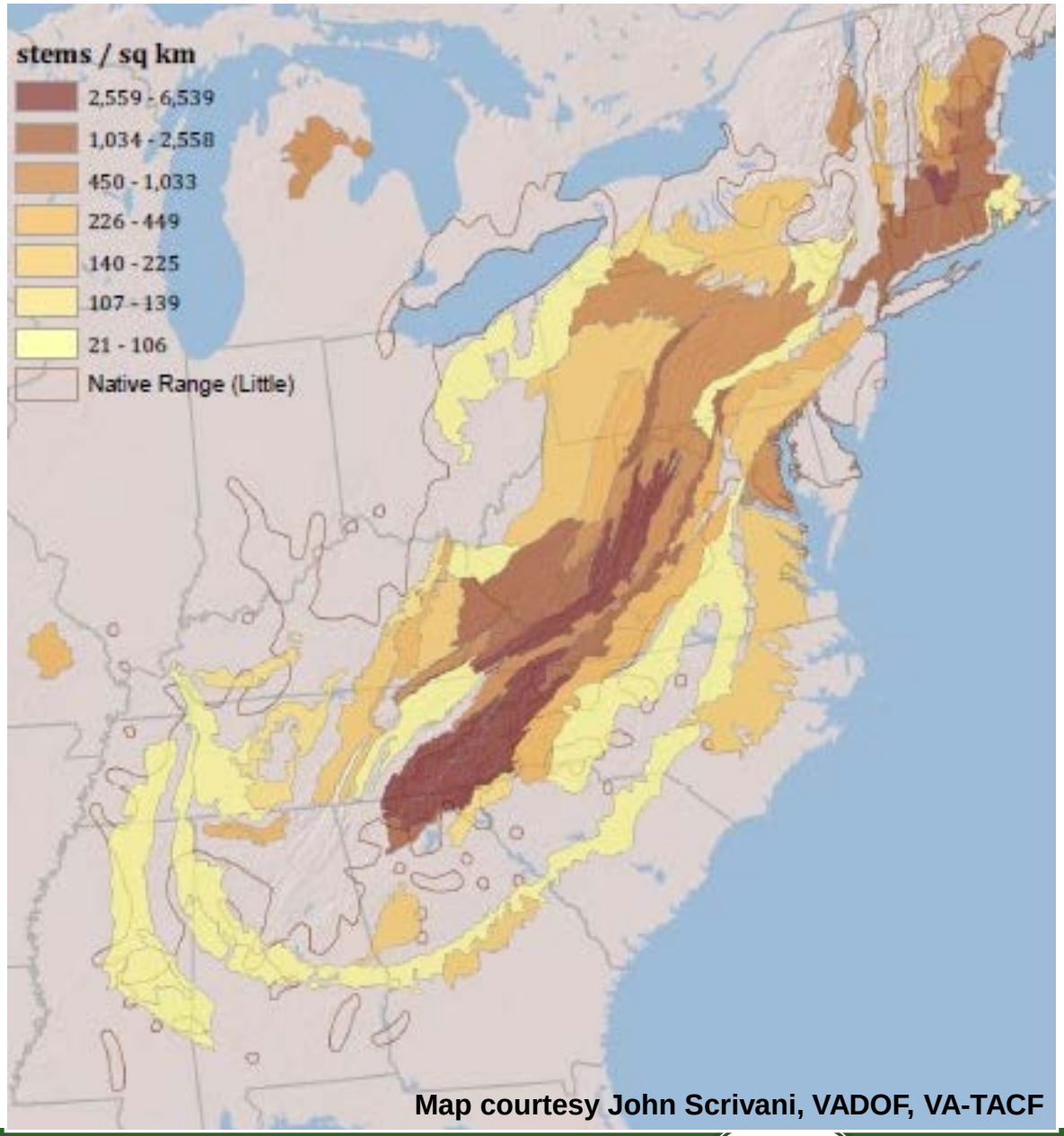


What is the blight?

A fungal disease caused by *Cryphonectria parasitica*, introduced from Asia.

Photo courtesy of Dr. Tom Volk, UW

- The blight fungus enters the tree though the cracks typical of chestnut bark and through wounds.
- It forms a canker and quickly girdles the tree.
- Affects cambium, not roots.



Map courtesy John Scrivani, VADOF, VA-TACF

Chestnut Survival Data

FIA 2010 data

Founded in 1983, the goal of TACF is to restore the American chestnut tree to its native range within the woodlands of the eastern United States, using scientific research and a backcross breeding program developed by its founders.

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TACF's Breeding program

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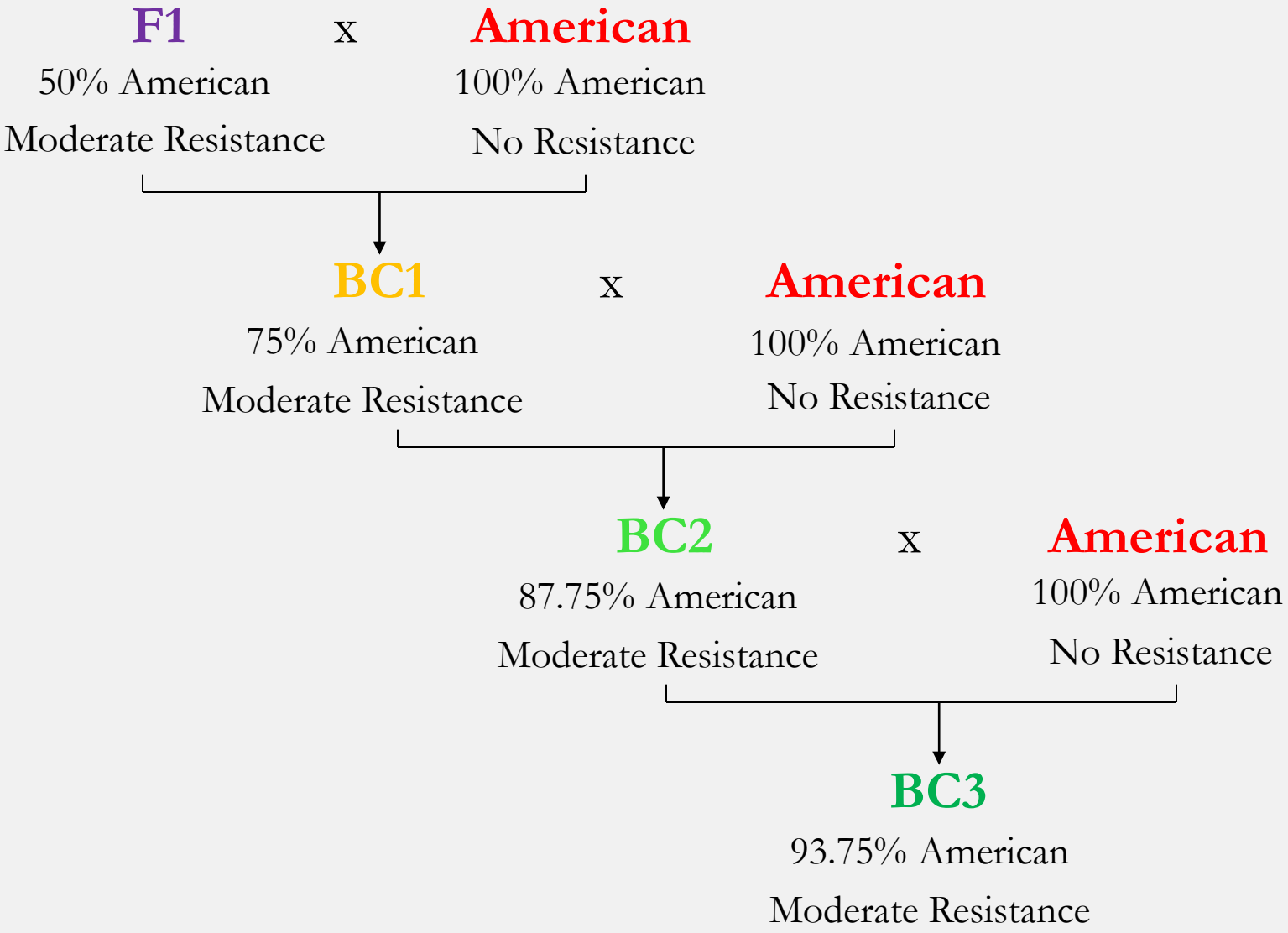
Characteristics of Chestnut Species

American chestnut (*Castanea dentata*)	Chinese/Japanese chestnut (*Castanea mollissima/crenata*)
Not resistant to blight	Resistant to blight ★
Height: 80 – 100 feet ★	Height: 40 – 60 feet
Form: Dominant canopy tree straight trunk ★ few lower branches	Form: Orchard tree many branches

Backcrossing



Final Stages

At every stage, screened for blight resistance. Only those with acceptable resistance continue in the breeding program.

BC3 x **BC3**

93.75% American Moderate Resistance

93.75% American Moderate Resistance

BC3F2 x **BC3F2**

93.75% American Fully Resistant

93.75% American Fully Resistant

BC3F3

93.75% American **Hypothetically** Highly Blight-Resistant

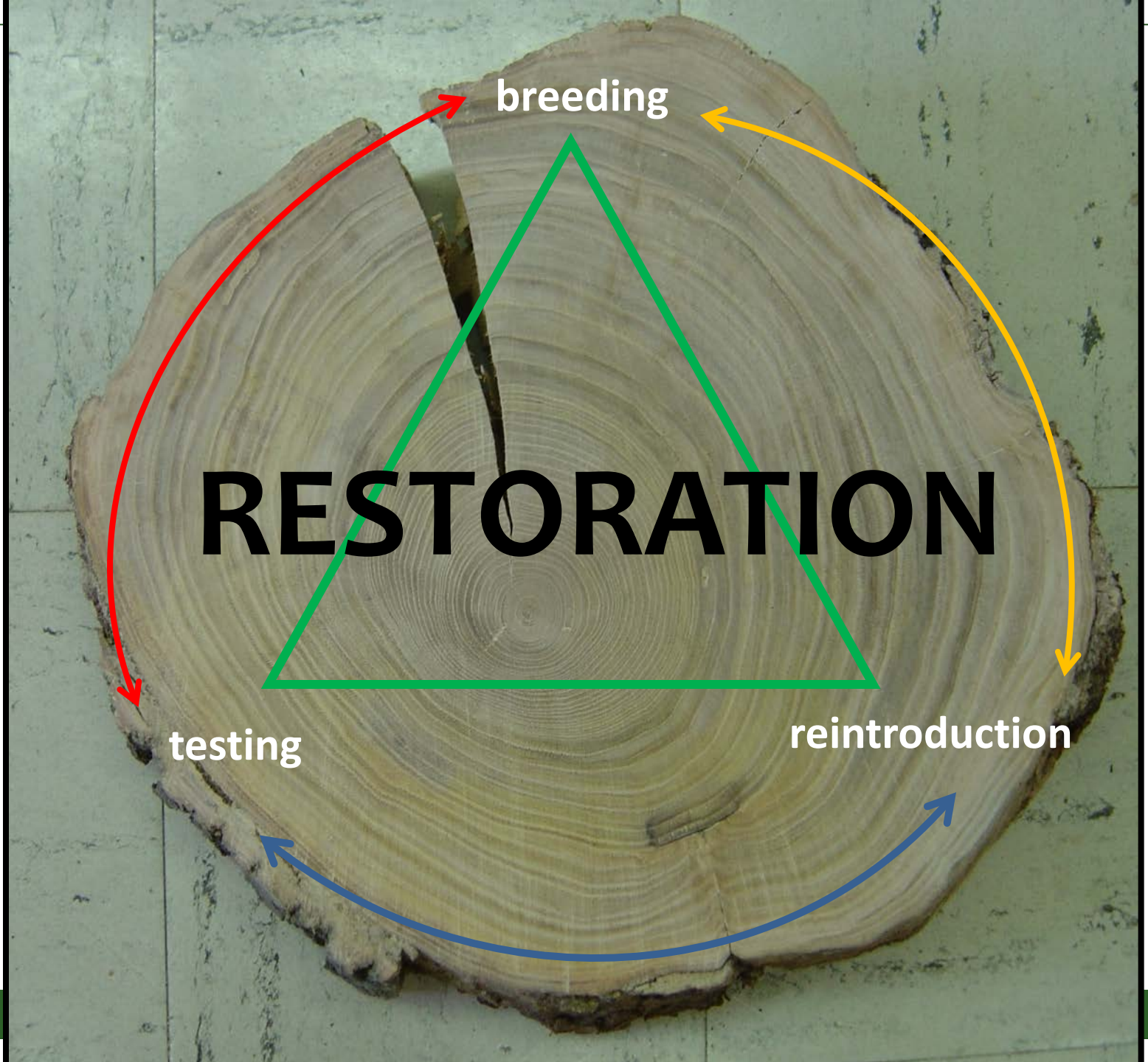
Seed for Reforestation and Distribution

We Are Not Done!

- Have been doing restoration since 1983
- Restoration is a feedback loop of breeding, testing, and reintroduction.
  - Starting testing
  - Should move seamlessly into reintroduction
- But breeding will always continue to improve product!

TACF's Restoration Practices

- **Establishment of TACF**
  - Structured organization created a network of state Chapters and volunteer-run breeding orchards to develop blight-resistant trees
- **Breeding**
  - Developing a tree with adequate levels of blight-resistance and American growth characteristics
- **Testing**
  - Evaluating the effectiveness of our breeding program through progeny tests and silvicultural testing in the "real world"
- **Reintroduction**
  - Returning the chestnut to our eastern forests
- **Breeding – Testing – Reintroduction** represent TACF's practices in our overall process of restoration


breeding
RESTORATION
testing
reintroduction

TACF Backcross Breeding Program

Meadowview

- Started with 'Graves' and 'Clapper' sources of resistance
- Produced 4 generations of breeding stock since 1986
- Provides backcross pollen to state chapters
- Working to develop additional sources of resistance
  - More time-consuming, need to start at F1 cross

State Chapters

- Identify local mother trees
- Use pollen from Meadowview to complete final backcross generation locally
- Breed final two intercross generations locally
- Allows state chapters to complete breeding work more quickly, while still incorporating local genetics and adaptations

American Chestnut: Where we are now

State Chapters

Meadowview and testing progeny

Research into gene sequencing

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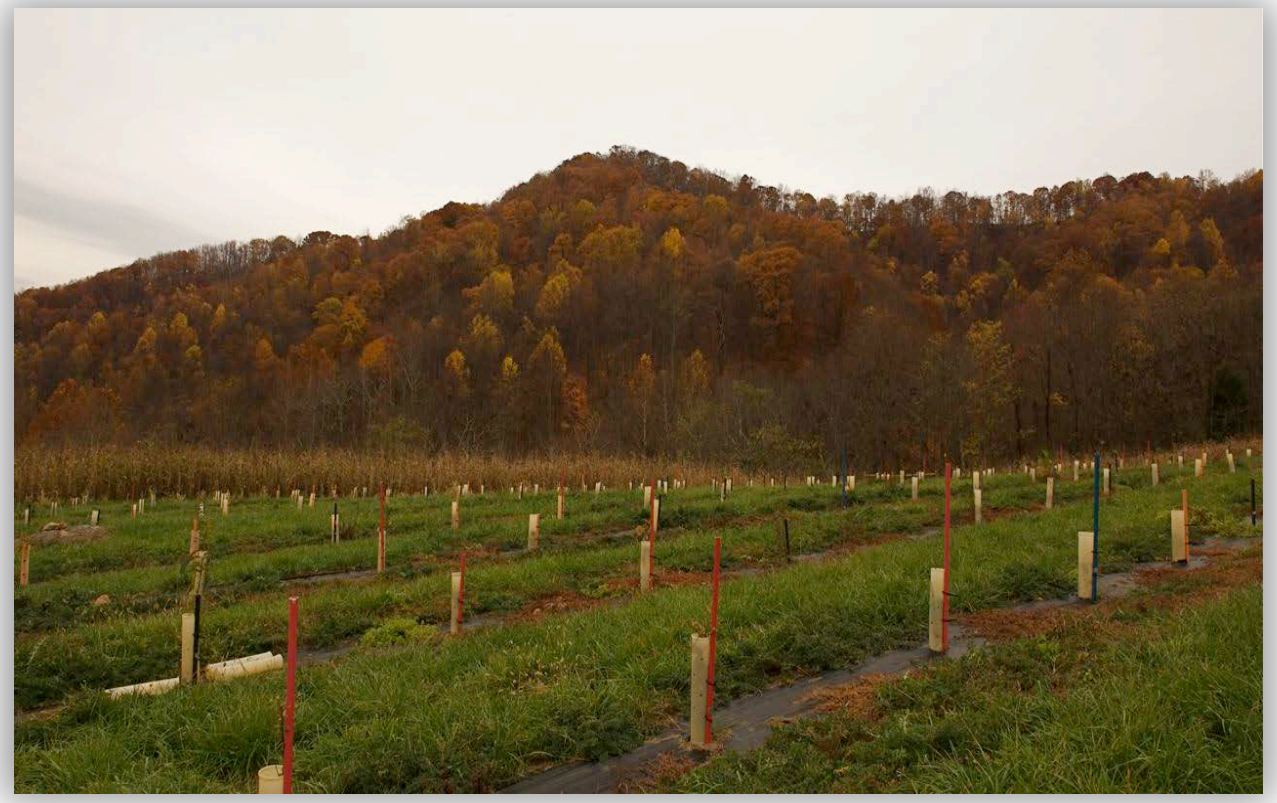
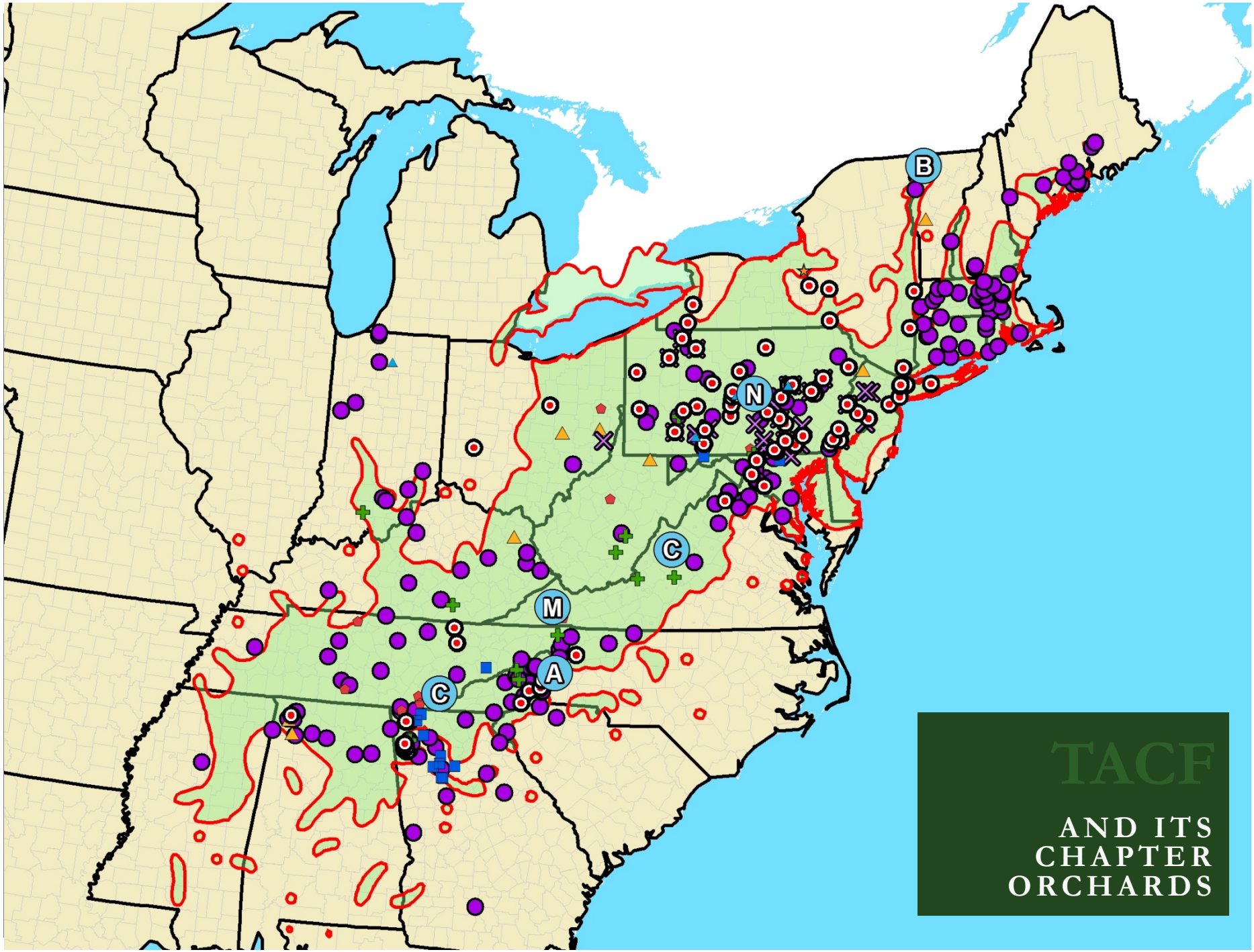
Today, most chapter states have established orchards, and many are one to two generations away from producing regionally-adapted Restoration chestnuts




B
N
C
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A
C
TACF
AND ITS
CHAPTER
ORCHARDS

Meadowview Research Farms have over 34,000 trees at various stages of breeding, planted on more than 150 acres of land.

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Restoration chestnuts

are beginning to be produced at Meadowview on a scale that is expected to increase over the next few years.

Currently, these seedlings are being grown at the Virginia Department of Forestry's Augusta County nursery.

Progeny Testing Protocol

Testing of the Restoration chestnut seedlings has begun on a variety of sites along the Appalachian Mountain range, using current testing site protocols designed by the TACF.

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Planted:

- Cherokee N.F., NC
- Daniel Boone N.F., KY
- Jefferson N.F., VA
- Wayne N.F., OH
- Hoosier N.F., IN
- Monongahela N.F., WV

Planned for 2011:

- Asheville, NC
- Bolivar, PA
- Rupert, WV
- Big Island, VA

TACF/GP Big Island 2011 Test

8 ft x 8 ft spacing

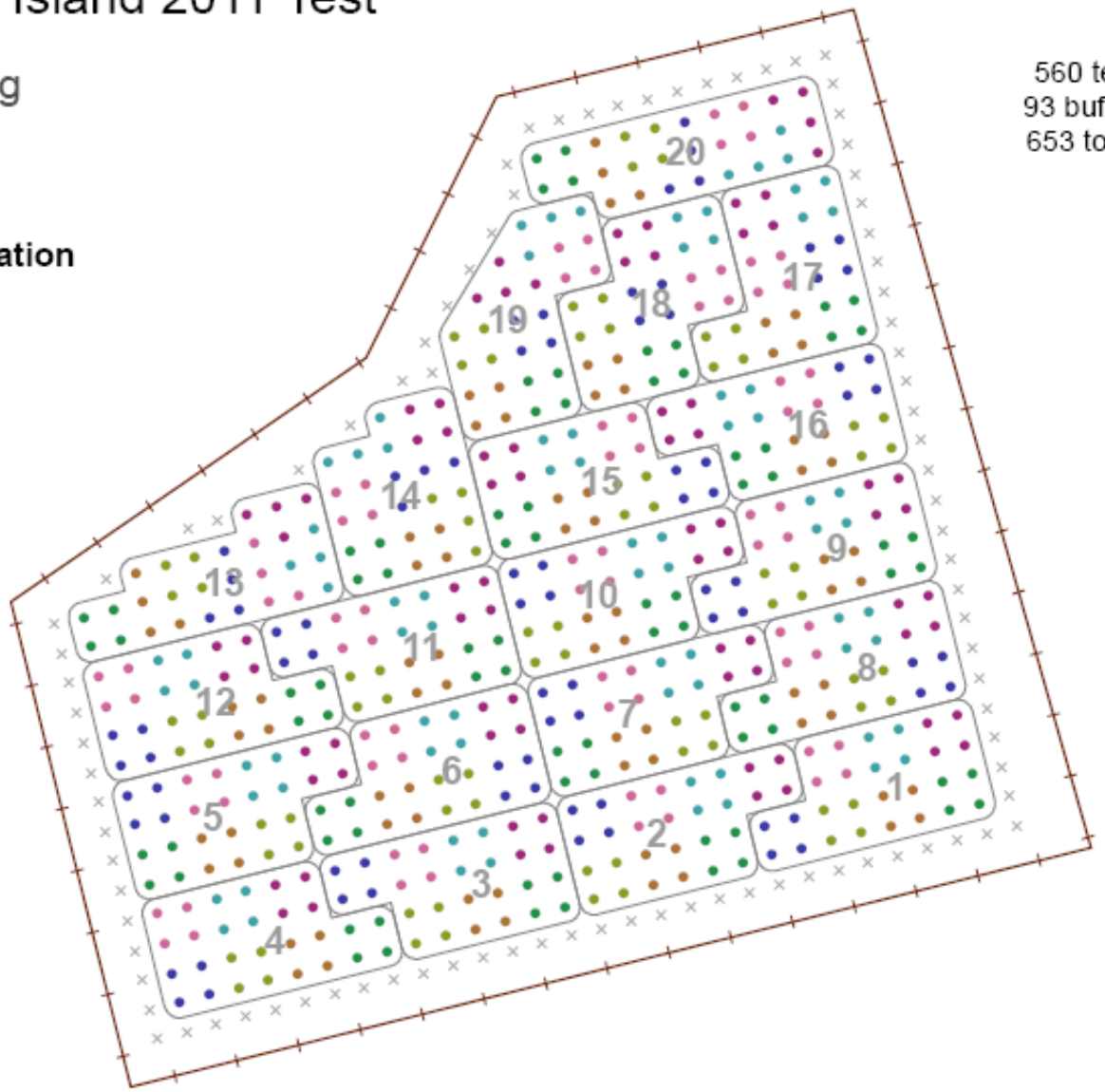
Replications

buffer tree

block within replication

- 1
- 2
- 3
- 4
- 5
- 6
- 7

560 test trees
93 buffer trees
653 total trees

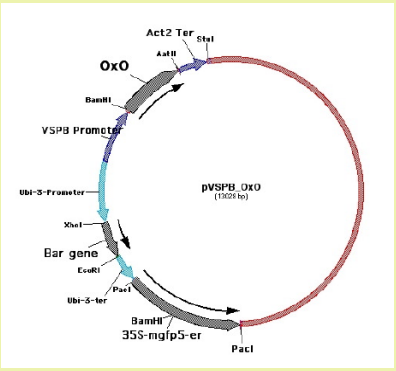


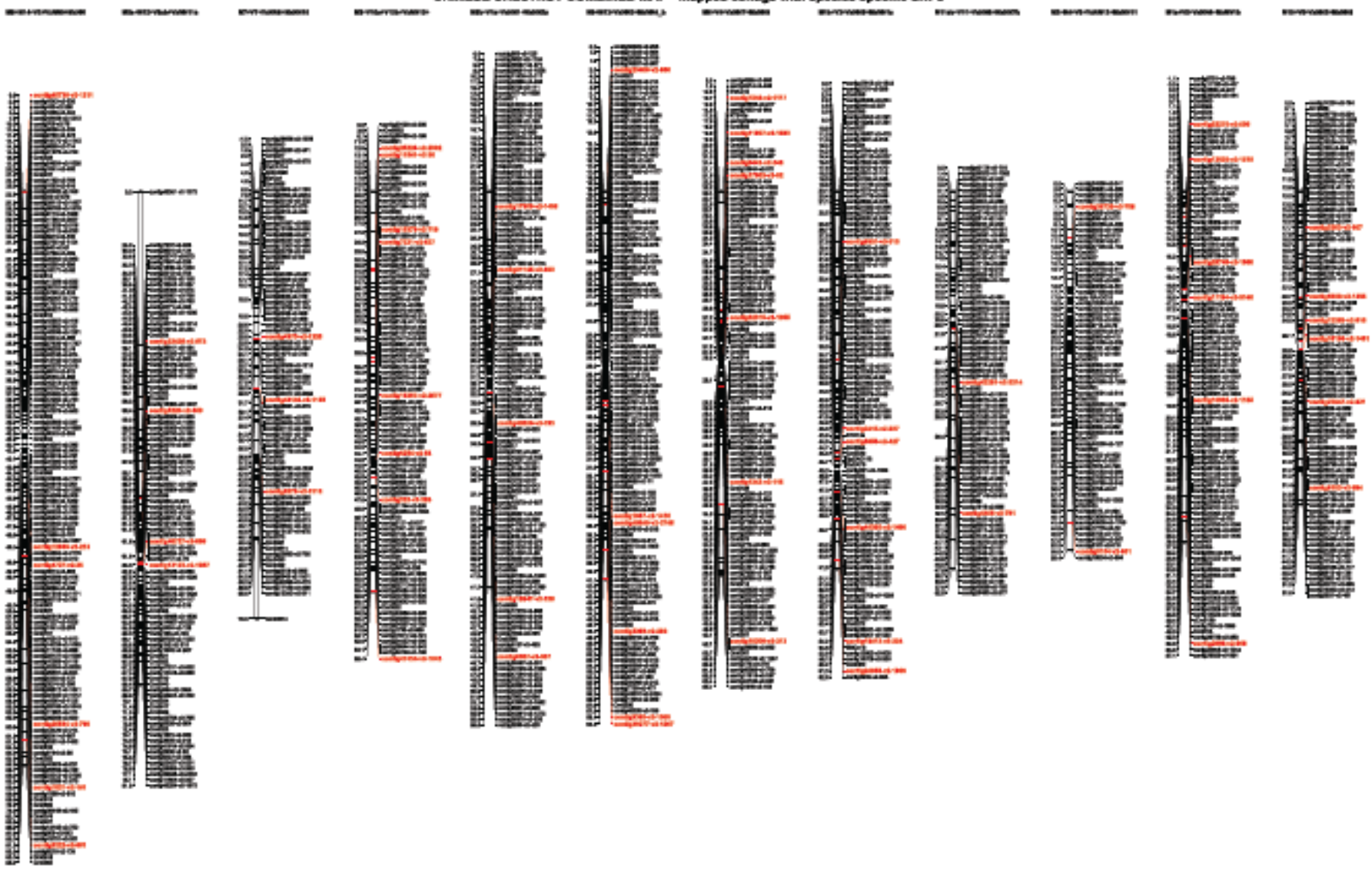
20 replications
28 treatments
4 tree small blocks

John Scrivani
February 10, 2011

Genetic Engineering

- First planted seedlings in 2006
- 25+ transgenic events ready to go
- First large-scale plantings – 2010:
  - Syracuse
  - Zoar Valley - near Buffalo, NY
  - Lasdon Arboretum – Somers, NY




CHINESE CHESTNUT COMBINED MAP - mapped contigs with species specific SNPs

All the Other Things We Do

- Mineland Restoration / Reclamation
  - ARRI
- Outreach and Education
  - Chestnut Learning Box
- Hypovirulence Research
- Native Chestnut Conservation
- Other Pests and Diseases
  - Ambrosia beetle, Phytophthora cinnammomi, gall wasp, etc., etc.

What Can I Do?

- Outreach
  - Give a presentation to an interested group in your area
- Make items for auctions
- Start a Restoration Branch
- Plant something
  - Americans
  - Backcross material
  - MSR material
- Help someone at their orchard
- Find Trees – especially new Americans

American Chestnut: Pending Hurdles

Ecology and silvics

Reality of reintroduction

Strategies

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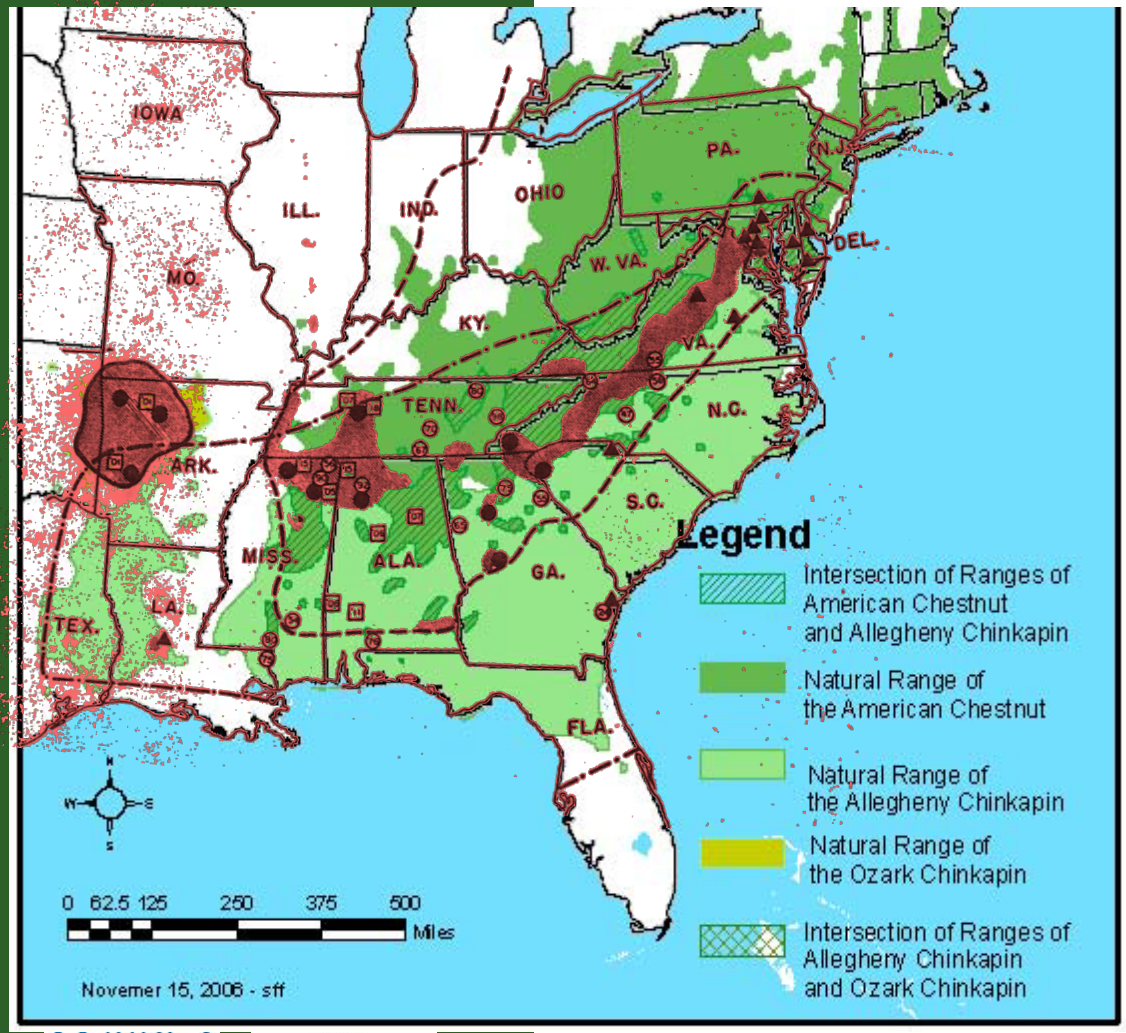
Ecological Challenges

- Critters
  - Explosive deer populations, among other things
- Invasive competitors
  - Stiltgrass, multiflora rose, bittersweet, honeysuckle, mile-a-minute, kudzu
- Variety of pests
  - Asiatic gall wasp, Japanese beetles, Cicadas, Aphids, Tent capterpillars, Ambrosia beetles, just to name a few
- This disease is still there, as well as others
  - Potential for disease mutation
  - *Phytophthora cinnamomi*
- Limitations in genetic fitness
- Natural range = 200 million acres!
  - Regional adaptability and logistics

Phytophthora cinnamomi

(ink disease/root rot)



- Introduced to US about 200 years ago
- Wiped out chestnut from many low-lying areas in the South
- Most likely eradicated chestnut from piedmont of South prior to introduction of chestnut blight fungus.

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Crandall, Gravatt, and Ryan. Phytopathology 35: 162-180, 1945

Logistical Challenges

How do we physically and fiscally prepare for this task?

- Alabama
- Carolinas
- Connecticut
- Georgia
- Indiana
- Kentucky
- Maine
- Maryland
- Massachusetts
- New York
- Ohio
- Pennsylvania
- Tennessee
- Vermont/New Hampshire
- Virginia
- West Virginia

Logistical Challenges

VOLUNTEERS. TACF depends primarily upon its members to support research to develop a blight-resistant American chestnut tree. Currently, over 5,600 members are helping to bring this important tree back to its native range.

Locate flowering American Chestnut trees for pollination and nuts.

Identify prospective "mother trees" for American characteristics.

Pollinate native American chestnut trees using hybrid TACF pollen.

Harvest open pollinated American and hand pollinated hybrids.

Seed storage and winter stratification.

Planning orchard locations and selecting prospective growers.

Spring Planting American, hybrid, and experimental orchards.

Orchard Maintenance fertilizing, weeding, watering, inoculation and selecting.

Documentation "We always finish the paperwork!"

All Done by Volunteers

Restoration Branches

Ways to create a nucleus of

- Put together a committee
- Decide on a project on which to focus
  - Education and Outreach
  - American chestnuts
    - Germplasm conservation
    - Wildlife enhancement program
  - PA-TACF MSR/CMS program
  - Regional Breeding
  - Other research

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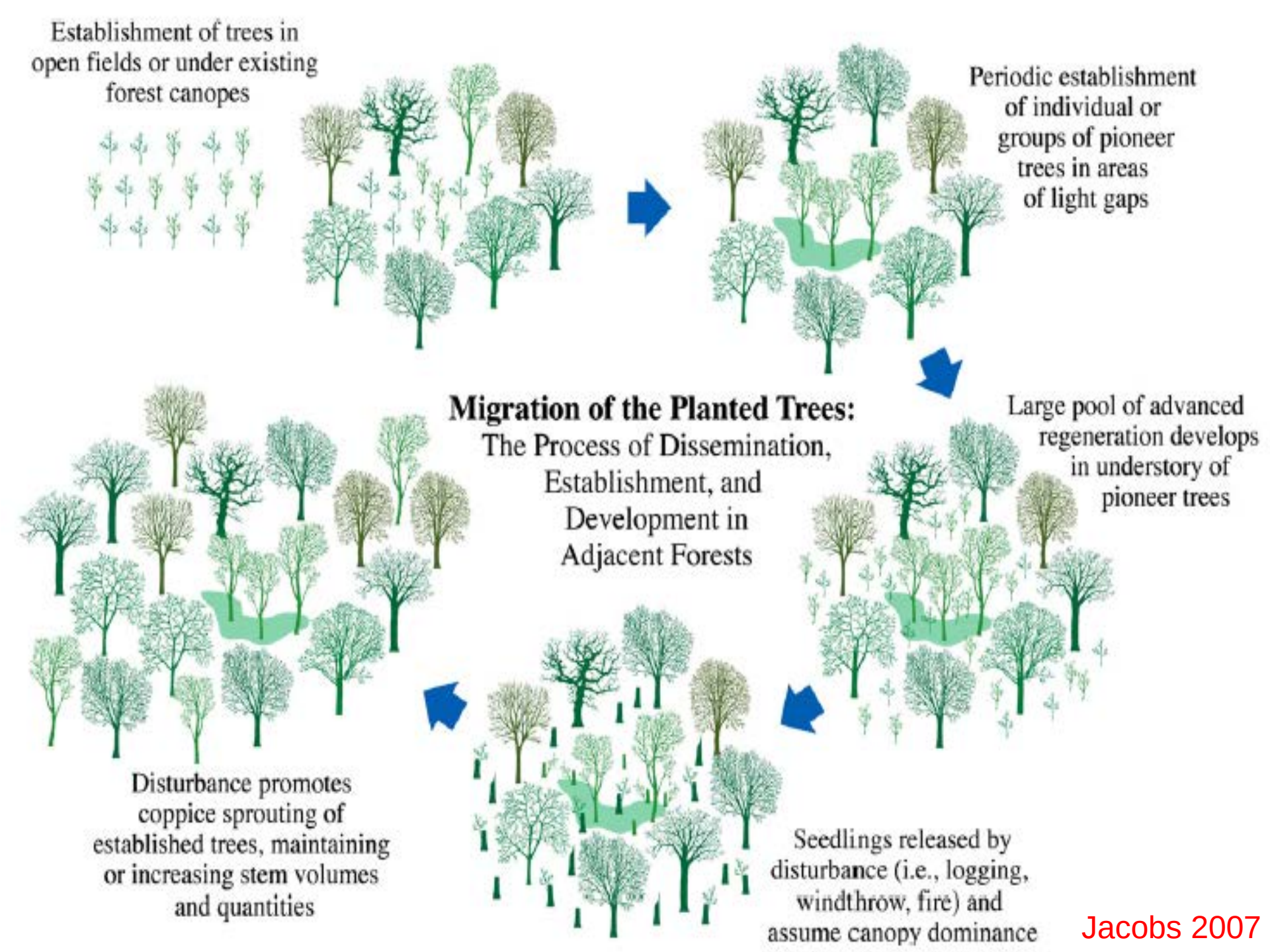
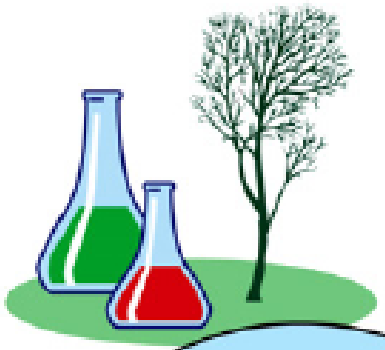
Chestnut characteristics

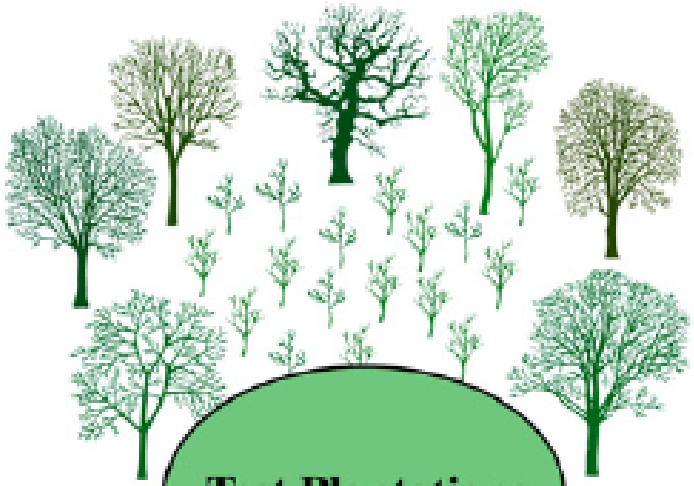
- **What do we think we know?**
  - Adapted to a wide variety of sites
  - Seedlings & sprouts able to survive long periods under forest canopies
  - Able to respond rapidly to disturbances
  - Capable of rapid growth and competes well

- **What do we think we don't know?**
  - How much resistance is necessary
  - How much "American character" is necessary?
  - How to fit in other technologies?
    - Genetic modification
    - Hypovirulence
    - Etc.


Establishment of trees in open fields or under existing forest canopes
Periodic establishment of individual or groups of pioneer trees in areas of light gaps
Large pool of advanced regeneration develops in understory of pioneer trees
Migration of the Planted Trees:
The Process of Dissemination, Establishment, and Development in Adjacent Forests
Disturbance promotes coppice sprouting of established trees, maintaining or increasing stem volumes and quantities
Seedlings released by disturbance (i.e., logging, windthrow, fire) and assume canopy dominance

Jacobs 2007





Blight-Resistant Breeding Program

- Resistance to exotic insects and pathogens
- Enhancing genetic diversity
- Ensuring seed supply for deployment
- Increasing sources of resistance

Test Plantations

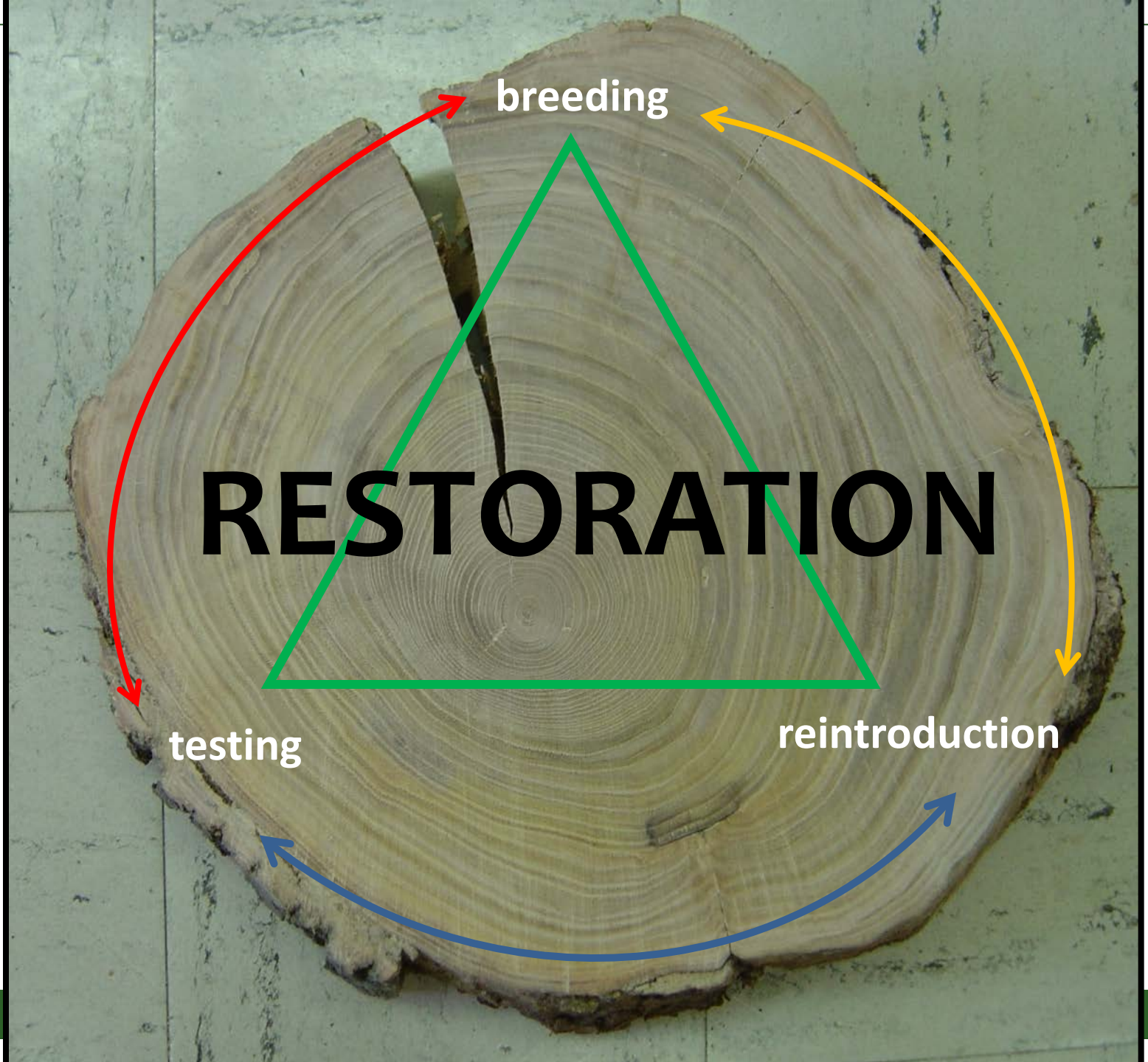
- Avoidance of exotic insects and pathogens
- Long-term adaptability
- Genetic fitness
- Impact on ecosystems

Development and Education

- Public acceptance of hybrid chestnut
- Governmental policies for reintroduction
- Chestnut introductions outside range
- Germplasm release and marketing

How Do We Do This?

- Habitat Suitability?
- Public vs. Private Lands?
- Put out Many? Put out Few?
- A Mixture of All of the Above
- How do we know we have succeeded?
- How to integrate biotechnology?
- How to integrate hypovirulence?
- Should we save/protect native chestnut populations?
- Who is going to do all of this work?
- Where are we going to get the resources?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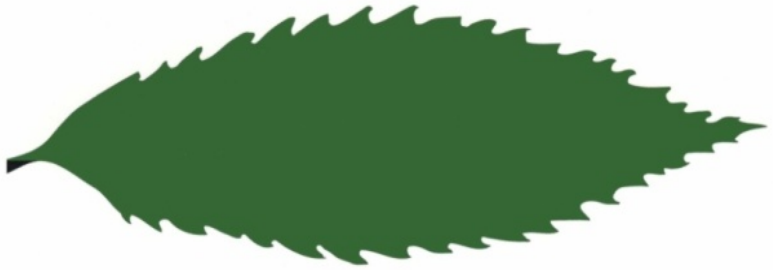

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