Blight Resistance/Control Research With Large, Surviving American Chestnut Trees, And Chinese Chestnut Trees Over 30 Years

The American Chestnut Cooperators' Foundation and Virginia Tech

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Sept., 2010

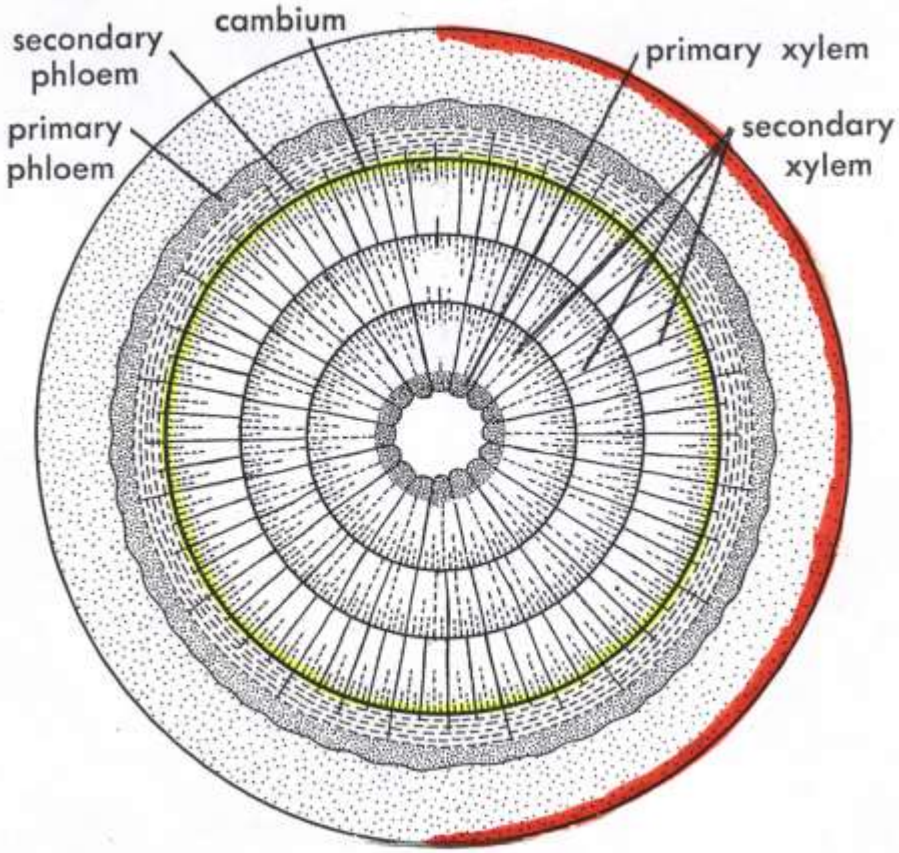
Previous ACCF officers and workers:

- Al Dietz, founding Vice President, ACCF, and pioneer in radiation breeding for blight resistance in American chestnut and locator of large, surviving American chestnut trees
- Dave McCurdy, West Virginia Division of Forestry, previous Vice President, ACCF, and nursery propagator of ACCF seedlings
- Bruce Given, West Virginia Department of Agriculture, early chestnut grafter for ACCF and locator of large, surviving American chestnuts

Early blight resistance screening by inoculation of chestnut seedlings with a virulent strain of *Cryphonectria parasitica*

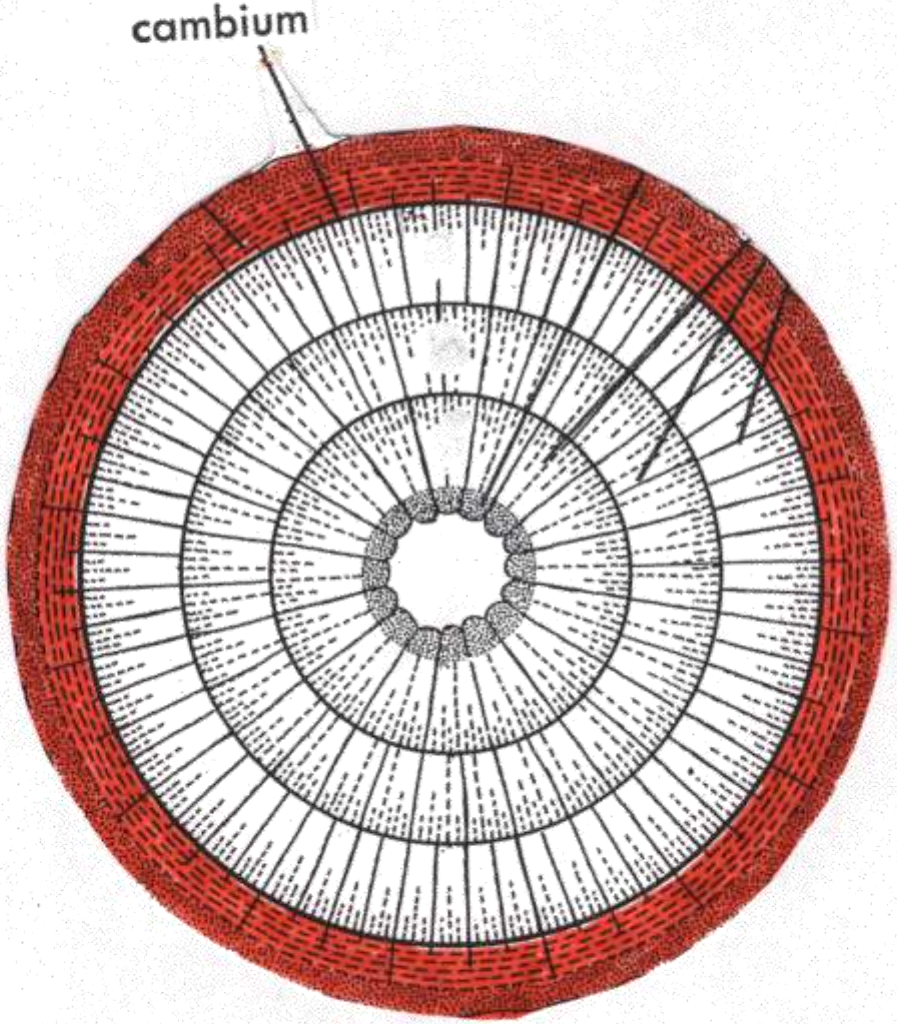
Early blight resistance screening is usually done with **seedlings**, but grafts also can give useful results for early blight resistance screening. Canker length, width, and depth may be evaluated at a specified period of time after inoculation of stems, of a given age or size, with a virulent strain representative of the *C. parasitica* population. Very small stem size may not give meaningful data.

Griffin, Hebard, Wendt, and Elkins. 1983. Phytopathology 73:1084-1092



Canker depth

Resistant chestnuts have **small**, **superficial** cankers; cambium is not killed.



Canker depth

Susceptible American chestnuts have **large**, **non-superficial** cankers; cambium and bark tissues are killed.

Non-superficial canker on blight-susceptible American chestnut stem

Blight resistance values for American chestnut seedlings may or may not be associated with durable blight control ratings, especially at very high altitude (>3,000 ft.) stressful sites.

Resistance trials on seedling progeny of large, surviving (LS) American chestnut trees vs. durable blight control

Canker length (**resistance indicator**) after inoculation of seedlings from LS trees with a virulent *C. parasitica* strain and subsequent rating of LS trees as parents for durable blight control at 10-20 years (based on field evaluations of LS seedlings and later F1 progeny).

Source of tree seedlings	**Canker length** (at 46 days) mm	**Durable blight control rating** (stem survival at 10-20 years)**
W (susceptible reference)	64.2a*	None
LS-20	59.4ab	Fair-poor
LS-9	49.8bc	Good-poor
LS-23	48.7bc	Fair-poor
LS-18	47.7c	Good-fair
LS-24	25.7d	Fair-poor (high alt. only)

*Means followed by the same letters are not significantly different ($P < 0.05$) by Duncan's multiple range test. Seedlings from LS tree nuts were 12-25 mm in diameter and 3-4 years old. Ten cankers were evaluated for each source. Altitude of test site: 2,100 ft.

For individual progeny trees growing at 2,100-3,200 ft. altitude and exhibiting **partial blight resistance (e.g. from LS-9, LS-23,LS-18, and LS-24 trees) during resistance trials.

*Data from Griffin, Hebard, Wendt, and Elkins. 1983. Phytopathology 73:1084-1092.

Present evaluation of partial blight resistance in American chestnut

Preferred methods now used by the **ACCF** to evaluate **partial** blight resistance found in large survivors and their progeny:

Stem size: Because small diameter stems have only a relatively thin layer of phloem tissue, which may be colonized to the vascular cambium by a virulent strain of the blight fungus, a larger stem diameter is used for our blight resistance trials with about a 4-cm stem diameter or larger preferred.

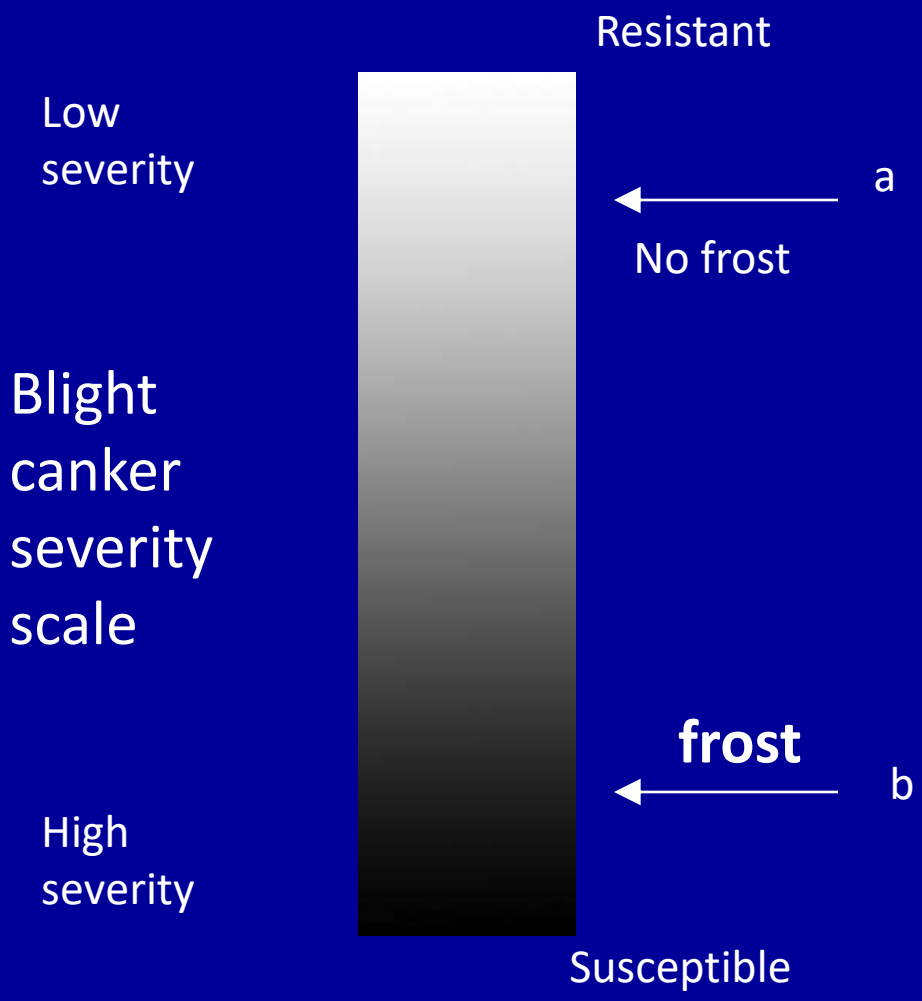
Period of testing: The test period is usually from early May to early May the next year. Using this stem size, we measure **canker length at 5 months** after inoculation with a virulent strain**. After 12 months,** we measure (a) **canker length** and (b) core the canker tissue,

examining the cores to determine if the **canker is superficial (very important for partial blight resistance)** and necrosis does not extend to the vascular cambium. Blight-susceptible American chestnut is used as a reference.

Canker "breakouts": Canker expansions in length, width, or depth during the winter are commonly observed on artificially established cankers and also on natural cankers (evaluated for "field blight resistance") each year. This can affect durable blight control.

Griffin, Elkins, McCurdy, and Griffin. 2006. Rest. Amer. Chest. For. Lands Conf. Proc. NPS/NCR/CUE/NRR pp. 97-107.

High blight canker severity **ratings** in the field have been associated with **environmental stress**



R

- drought/shallow soil
- **low winter temperature at high altitude**
- **frost injury**
- hardwood competition / low light

- **favorable rainfall pattern**
- deep fertile soil
- high light intensity
- low altitude, warm winter

Frost injury (and other stress factors) have been associated with increased blight severity ratings for normally blight-resistant Chinese chestnut

Early **fall frosts, frost pocket sites, and winter injury** have been associated with increased blight canker severity or “breakdown” of blight resistance in Chinese chestnut.

Canker severity rating is very high, and canker was lethal to side branch of this Chinese chestnut in
a frost pocket in VA ----->
Altitude: 2,180 ft.

Berry. Plant Dis. Reptr. 35:504-505 ;
Jones, Griffin, and Elkins. Plant Disease 64:1001-1004.

Blight canker incidence and severity on Chinese chestnut can be high in the field at higher altitudes (> 2,000 ft.)

Severe blight development on Chinese chestnut trees at high altitudes*

Low altitude (505-1,437 ft.)	Mean canker severity** (area, cm^2)	Canker incidence (% of trees)	Topography
GA 1	400	13.3	Piedmont
GA 2	432	1.5	Piedmont
NC 1	969	9.3	Piedmont
NC 2	555	12.5	Piedmont
High altitude (2,181-3,352 ft.)			
VA 2	3,066	25.0	High ridge
VA3	3,672	93.3	Flat mountain
WV2	1,104	top	
NC3-TN1	1,485	50.0	High plateau
		28.6	Mountain slopes

*Data from Jones, Griffin, and Elkins. Plant Disease 64:1001-1004. Trees were growing in open landscapes.

**Based on the largest canker on each tree. At low and high altitudes, 246 and 259 trees were evaluated, respectively. Mean stem diam.= 28.1 cm.

Low temperature injury on Chinese and American chestnut tree tissue

Vascular cambium tissue of Chinese chestnut exhibited browning injury at – 20 C (- 4.0 F)

Jones, Griffin, and Elkins. Plant Disease. 64:1001-1004.

Low temperature stress on American chestnut occurred at very high altitude (3,900 ft.) in VA during winter, indicated by increased electrolyte leakage from bark tissues.

Griffin. Journal of Forestry. 98:22-27.

Canker “breakouts”, or canker expansion, during winter and early spring may affect durable blight control

Canker “breakouts” (flat, red-brown or orange discolored areas) observed in early spring for a natural, healing, superficial canker (tan, slightly swollen) on stem of progeny tree from a large, surviving American chestnut. Altitude: 2,500 ft.

“Breakouts” in canker length, width, or depth in winter have been associated with physiological stress and/or secondary infection by a more pathogenic strain of the blight fungus.

Griffin, Khan, and Griffin. Can. J. Plant Path. 15:159-167. Griffin and Griffin. Eur. J. For. Path. 25:351-355. Griffin. J. For. 98:22-27.

Blight control on American chestnut growing at very high altitude (3,200 ft.)

Durable blight control on a 14-year-old ACCF American chestnut at a stressful high altitude site in 2007.

The tree (arrow) is a second-generation progeny tree from large, surviving American chestnut parents . However, at 15 years old, this tree had a blight canker that killed the leader near the top. A lateral shoot has now taken over at 17 years.

J.R.Elkins

Low altitude (less than 2,000 ft.) has been associated with durable blight control on large, surviving American chestnut trees in or near the Virginia Piedmont*

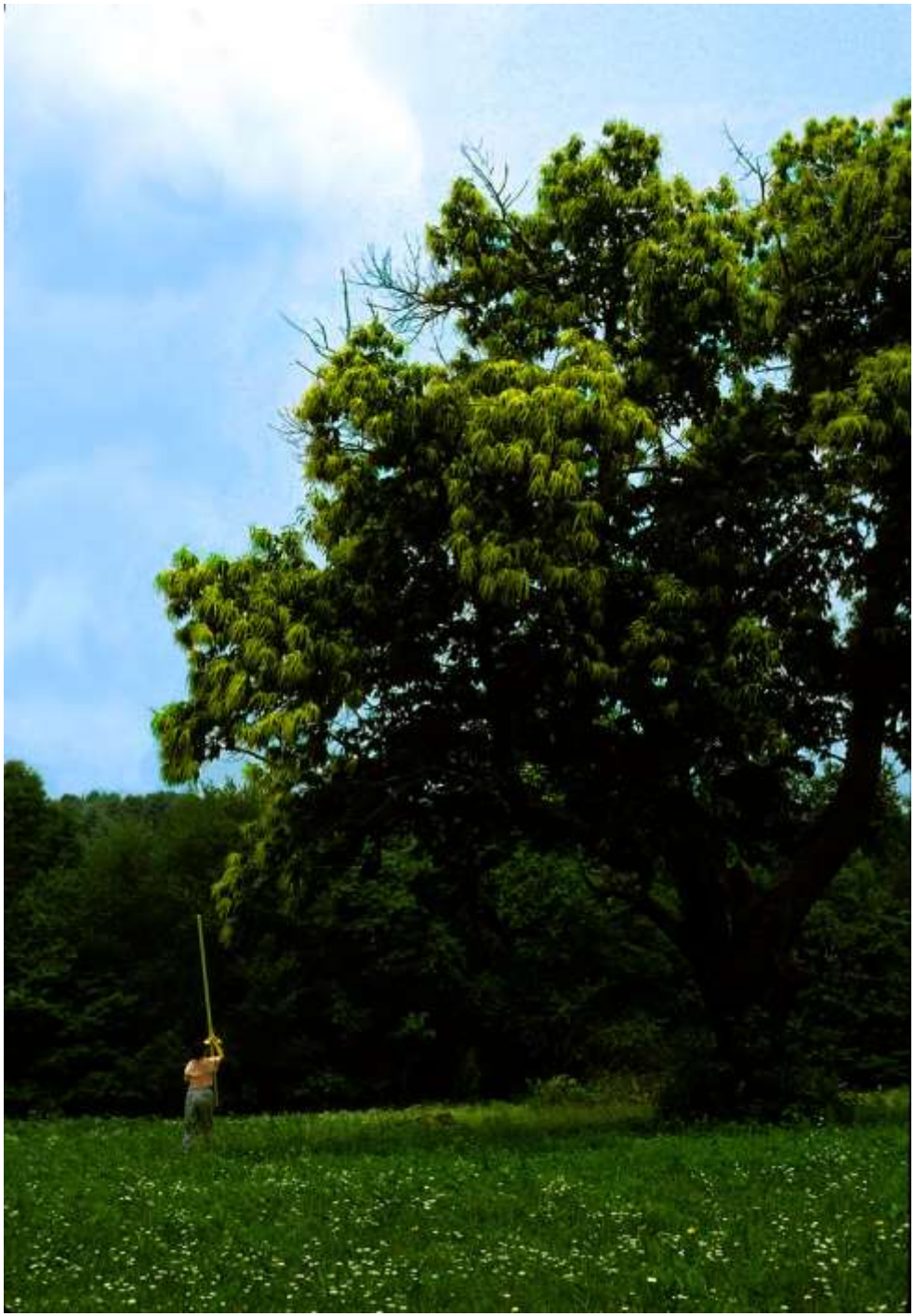
*Some of the trees yielded evidence of partial blight resistance in standard resistance tests. In this region, most American chestnuts have died from chestnut blight or from Phytophthora root rot.

Griffin, Hebard, Wendt, and Elkins. Phytopathology 73:1084-1092.
Griffin, Khan, and Griffin. Can. J. Plant Path. 15:159-167.
Robbins and Griffin. Eur. J. For. Path. 29:51-64.

The Amherst American chestnut tree is largest to survive blight of 3.5
billion original canopy AC trees in the natural range of A. chestnut

Factors associated:
1.Favorable Virginia environment of low altitude (750 ft.), fertile soil, and full sun
2. Partial blight resistance
3. Reduced virulence strains of blight fungus in cankers (based on field tests on AC trees)

Griffin, Hebard, Wendt, and Elkins. Phytopathology 73:1084-1092



L. Griffin collecting pollen

Durable blight control (10-50 or more years)

Factors that have affected, or have been associated with, **durable blight control**:

1. Degree of **blight resistance**-**full or partial** exhibited in resistance trials.
2**. Environment**- **nonstressful** or **stress** factors of frost, low winter temperatures at high altitudes or latitudes, reduced sun light ,associated with hardwood competition, and poor soils due to low fertility, heavy texture, inadequate depth, or drought. These stress factors have been associated with **increased blight severity ratings** in the field and may indicate a **"breakdown" of blight resistance .**
3. **Virulence** of *Cryphonectria parasitica* in cankers, low to high, including hypovirulence associated with hypovirus infection of *C. parasitica.*
4**. Ontogenic** factors-**small stem diameters** (easier to kill) and tree age.

Integration of a) partial blight resistance, b) favorable environment, and c) hypovirulence has resulted in excellent and durable blight control on American chestnut in some instances.

Griffin. J. of Forestry 98: 22-27.

Grafted TH (left) and RM (right) large, surviving American chestnut trees exhibiting excellent and durable blight control at 27 years old in VA (2007 photo)

Factors associated:

1.Favorable environment of low altitude (1,400 ft.), deep loam soil, and full sun.

2. Partial blight resistance

3. Italian hypovirulence spread in *C. parasitica* following artificial inoculation.

Robbins and Griffin. Eur. J. For. Path. 29:51-64.
Hogan and Griffin. For. Path. 38:302-313.
Griffin et al. For. Path. 34:33-46.

Note blight-killed, small American chestnuts to left, behind pink ribbon

American chestnut restoration efforts by ACCF

National Forest, State Forest, and National Park Lands: 1980-present
ACCF locations:
Jefferson National Forest, VA
Lesesne State Forest, VA
Mammoth Cave National Park, KY

Private and state lands: 1976-present
ACCF research locations having mostly controlled pollination progeny of F1, F2, and/or F3 generations: Giles Co., VA, Montgomery Co., VA, Raleigh Co., WV, Nelson Co., VA, Humphreys Co., TN

ACCF Cooperators (citizens, federal and state foresters, university researchers, scout troops, 4-H clubs) Locations are in natural range of American chestnut, having mostly open but some controlled pollination progeny from ACCF: Plantings are located in almost all eastern states of the U.S.A. **Somatic seedlings** have been produced and planted in 2010 in cooperation with Scott Merkle (UGA). S. Anagnostakis (CAES) and S. Schlarbaum (UT) have field tests of ACCF progeny.

Number of American chestnuts planted by ACCF cooperators: >**160, 000 seedlings or nuts as of 2010**

Selected research references, ACCF/VT:

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Hogan, E.P. and G.J. Griffin. 2002. Spread of *Cryphonectria hypovirus 1* into 45 vegetative compatibility types of *Cryphonectra parasitica* on grafted American chestnut trees. For. Path. 32:73-85.

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