The JOURNAL OF THE AMERICAN CHESTNUT FOUNDATION

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Summer/Fall 1996

"Toward the Restoration of an American Classic"

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NOTES

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EDITOR'S NOTES

Summer/Fall 1996

I the spirit of the harvest season we'vegathered in for you a number of sheaves of several different color sand textures. Stored here for the cold months ahead are hundred-year old photographs of a lumberjack skidding chestnut logs. (ACF member NelsonCalkins, Jr., grandson of the lumberjack, thinks they're chestnut logs. Can any one make a positive identification?)

You'll find a posthumous recollection of chestnut trees from the southside of Long Island Sound, and from my interview with a resident of the north side of the Sound, memories of chestnuts collected in a New England city park. There are stories of chestnuts in the Appalachians and a poem from a wilderness ranger in Maine. There is a description of unusual trees in northwestern Pennsylvania, and an exploration of thehistory of the relationship between hemlock, chestnut and theactivities of people at the Harvard Forest in Massachusetts.

The annual update on activities at theFoundation's research farms in Meadowview, Virginia is here, and for context a short discussion of our breeding strategies has been included too. (New members particularly — and welcome to you! —might find it useful.) And you might just as well be breeding your own trees, for which purpose you'll need the short article on harvesting and storing chestnut burs and nuts.

As you' ll note, this autumnal abundance of science and story has been given us by our members. (Every contributor belongs to ACF.) And just as this is their —your —Journal, The American Chestnut Foundation is your organization. Who does all the work around here? You do, of course! Thank you all for the most plentiful harvest.

Shelly Stiles
Editor

LETTERS

Dear ACF,

I have always wondered if the logs shown in the photos I've enclosed are chestnut logs. (These pictures show my grandfather at a farm here in Rutland, Massachusetts and were taken just about one hundred years ago.) When I was reading the Summer 1995 Bark I noticed the picture of Phil Rutter and the West Salem giant chestnut. I think your West Salem picture makes a good comparison and tends to confirm my opinion that grandad's logs are chestnut. Maybe other readers would comment.

I still own about one hundred acres of grandfather's land and chestnut shoots still come up and grow to bur-making size but dieback about then, before making viable nuts.

When I was growing up during the 1930 's therewerestill many dead chestnuts. My gr andfather , who by then had a stationary water-powered sawmill, was still sawing and made lumber out of the better dead trees. We used most of the rest for firewood and fenceposts.

Nelson Calkins, Jr.

Henry W. Calkins delivers what might be chestnut logs to a sawmill near Rutland, Massachusetts circa 1895.

▲ Henry W. Calkins and two hard-working oxen skid what might be chestnut logs.

NOTES FROM MEADOWVIEW

Spring 1995 - Spring 1996

F. V. Hebard, Superintendent
Wagner and Price Research Farms

1995 GROWING CONDITIONS

IN 1995, the Meadowview area suffered a severe summer drought _ with essentially no rain between July 4 and August 20, and then no more until Sept 20. June on the other hand was cool and damp. The June weather turned out to be good for pollinating, or at least not bad. The summer drought didn't affect tree growth too much, but it may have been related to some winter die back over 19951996 . We had already fertilized by the time the drought became evident, so the plants may have failed to harden off properly because they carried excess nitrogen into the fall that was not taken up during the summer. The winter die back due to cold injury was fairly mild and only affected 25% of the trees.

1995 POLLINATION AND HARVEST

Although we placed more bags in 1995 than in any single previous year, this was not our largest harvest ever. But compared to past years, we produced many more nuts for breeding purposes, as opposed to research purposes. This higher yield of nuts for breeding occurred because we had more American chestnut mother trees to work with than in years past. In 1995, we also had very little pollen contamination; it was confined to six mother trees. So overall, we harvested an excellent crop.

I attribute the low rates of pollen contamination to our practice in 1995 of attempting to bag female flowers as soon as styles were exerted from the burs. There is still some question, however, as to whether this practice will lead to premature abscission of burs. We had very low rates of premature abscission in 1995, possibly because the weather was extremely cool and wet during pollination season. In hotter years, we may see unacceptably high rates of premature bur abscission associated with fairly early placement of bag.

The poor nut yield was directly attributable to the pollen used for particular crosses. Some sources of pollen gave high yields while others gave low yields. We will have to examine this more carefully in subseq uent years. For most crosses, pollinations were made using fresh catkins that had been covered with brown paper grocery bags the night before, then left on the father tree until morning.

Several volunteers helped out with pollinating in 1995. Once again, Chandis Klinger came down from Pennsylvania and was the great help he has always been. Barbara and Alan Cox came up from Chattanooga to provide critical quality control during inoculation. Charlie Allen gave two weeks of excellent help inoculating, bagging and pollinating. California ACF member Bernie Monahan helped me replace the water pump in the tractor, and he temporarily overcame his fear of heights while pollinating. Lou Silveri came in from Memphis and spent several days clearing around sprouts in the mountains, as did Welles Thurber from Maine. Christine Bock missed seeing a bear in the mountains, but she did see and bag some pretty big chestnut trees. Bill Lord and Bob & Ann Leffel organized a crew from Pennsylvania that included Tom Pugel, Rosina Coltellaro and Bill Peifer.

Again, Peter Devin was a great help, sending pollen so that 1 did not have to travel to Connecticut. However, 1 am pleased to say that we have moved beyond needing pollen from Connecticut! The breeding of the Graves, Clapper and their associated trees is complete and we are now breeding their progeny.

In 1995 we produced 806 third backcross nuts from offspring of the Clapper tree that had been bred in Connecticut in 1989. We also harvested 2962 openpollinated, BC_2F_2 nuts from those trees. If you compare our holdings this year (Table 2) to those of last year, you will see that the number of second backcrosses has decreased! We ripped out most of the Clapper second backcrosses bred in 1989, leaving only the most blightresistant trees. So a fair proportion (about onesixteenth) of their BC_2F_2 nuts should grow into highly blight-resistant trees.

We will repeat this process in 2001 with the trees grown from those third backcross nuts, harvesting BC3F2 nuts. We expect to be harvesting BC_3F_3 nuts from those BC3F2s in 2006. We hope also to harvest BC3F3 nuts in 2004 and 2005 from earlier plantings. This will complete the breeding process as envisioned by Dr. Burnham!

The breeding of the Graves, Clapper and their associated trees is complete and we are now breeding their progeny.

TABLE 1.

American Chestnut Foundation 1995 Nut Harvest
from Controlled Pollinations and Selected Open Pollinations.

			Pollinated			Unpollinated Checks			Number of American Chestnut Lines
Nut Type	**Female Parent**	**Pollen Parent**	**nuts**	**bags**	**burs**	**nuts**	**bags**	**burs**	
BC1	American	Nanking FI	443	512	1341	11	52	121	6
BC1	Nanking FI	American	39	69	89	0	5	9	1
BC2	American	Douglas BC1	16	75	130	0	7	14	1
BC2	American	Graves BC_1							3
BC2	Douglas BC1	American	5	17	71	0	2	0	1
B2F2	Clapper BC_2								
BC3	American	Clapper BC2	786	1052	1908	109	225		5
BC3	Clapper BC2	American							
F1	Miller 654	American	19	18	59	0	4	18	6
F1	American	Nanking	77	65	221	0	7	23	3
F1	Meiling	American	22	16	90	0	2	7	1
F1	Nanking	American							1
F1	Orrin	American							2
F_3	Mahogany F_2	Mahogany F_2							1
LS I_1 *	Lrg Surv Amer	open pollinated							1
LS F_1	American	Ort	148	107	205	0	11	22	1
F1	Seguinii	American	50	10	30	1	1	2	1
Total Controlled Pollinations			1945	2182	4770	19	230	501	

*an intraspecific F1 parent

Type and Number of Chestnut Trees or Planted Nuts at the ACF Meadowview Research Farms in May, 1996, with the Number of Sources of Resistance and the Number of American Chestnut Lines in the Breeding Stock.

	Number of		
Type of Tree	Nuts or Trees	Sources of Resistance	American Lines*
American	738		21
Chinese	359	28	
Chinese x American: F_1	184	7	26
American x (Chinese x American) BC_1	628	9	26
American x [American x (Chinese x American)]: BC_2	2293	3	36
American x {American x [American x (Chinese x American)]}: BC_3	910	2	19
(Chinese x American) x (Chinese x American): F_2	275	3	4
[Ch x Am) x (Ch x Am)] x [Ch x Am) x (Ch x Am)]: F_3	18	1	1
[Amer x (Chin x Amer)] x [Amer x (Chin x Amer)]: BC_1F_2	422	2	1
{Am x [Am x (Ch x Am)]} x {Am x [Am x (Ch x Am)]}: BC_2F_2	590	1	6
Chinese x (Chinese x American): Chinese BC_1	145		
Chinese x [American x (Chinese x American)]	43		
Japanese	4	3	
American x Japanese: F_1	1	1	1
(American x Japanese) x American: BC_1	5	1	1
Castanea seguinii	48	3	
Chinese x Castanea pumila: F_1	2		
Large, Surviving American	5	4	4
Large, Surviving American X American: BC_1	259	8	9
Large, Surviving American x Large, Surviving American: 1_1**	48	3	3
Irradiated American	48	3	3
Other	22		
Total	7062		

* The number of lines varied depending on the source of resistance. We will have to make additional crosses in some lines to achieve the desired number of 75 progeny per generation within a line. In keeping with past practice, the num. ber of lines for each source of resistance are added separately; thus, progeny from two sources of resistance with the same American parents would be counted as two lines rather than one line.
**an intra specific Fl parent

1996 PLANTINGS

The new Price farm is starting to look like a chestnut research farm! We planted 2,341 nuts and trees there on about 6 acres. Much of the farm is visible from the road, so those six acres look like a lot, even though they are scattered from one end of the 93 acre farm to the other.

The plantings included most of the nuts detailed in Table 1, including our first large orchard of third backcross nuts. Those nuts were planted at one end of the farm to ensure their isolation from pollen of less advanced crosses, planted towards the other end of the farm.

The spring of 1996 has been very moist, so we have had excellent emergence, approaching 90%.

We now have 7,062 trees growing at the Price and Wagner farms.

These include a complete set of around 20 lines each from the Graves and Clapper trees, some second backcrosses from the Douglas trees, and close to 10 lines of first backcrosses from Nanking, which is a Chinese chestnut tree.

If you would like to help at our Meadowview farms, please write me at 14005 Glenbrook Avenue, Meadowview, VA 24361 or call (540) 9444631. We expect our peak times next year will be the weeks of June 17 and 24. However, this can vary a fair amount due to the weather, which is why I request that you call after June 5, 1997 when the timing for the year will be more apparent.

Controlled pollination at our Meadowview research farms is a painstaking process that would never get done without the help of many committed volunteers.

GET YOUR .REPRINT NOW

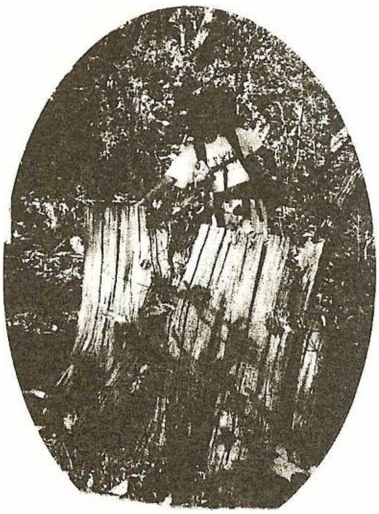
A limited number of reprints are still available of ACF Farm Superintendent Fred Hebard's technical article in the November/ December 1994 *issue of* The Journal of Heredity, in *which Hebard examines various characteristics that might affect the success of the ACF's backcross breeding program. (Call us for a copy.) The Following abstract is from that article.*

"Inheritance of Juvenile Leaf and Stem Morphological Traits in Crosses of Chinese and American Chestnut" by F. V. Hebard

Progeny from crosses of American and Chinese chestnut were examined for the following traits: occurrence of simple hairs on interveinal areas of abaxial leaf surfaces (interveinal hairs); density of simple hairs on twigs (twig hairs) and on abaxial leaf midribs and secondary veins (vein hairs); stipule size; stipule dehiscence; green or red stem color; and bud shape. The inheritance of bud shape could not be ascribed to a simple Mendelian model. All other traits appear to be controlled by two genes, with two exceptions: high density of vein hairs on Chinese chestnut is probably controlled by three dominant genes, and occurrence of interveinal hairs in Chinese chestnut may be controlled by a single gene with additional modifiers. High density of twig hairs on Chinese chestnut is probably controlled by two incompletely dominant genes. Red stem color on American chestnut may be controlled by two incompletely dominant genes. Large stipules on Chinese chestnut take much longer to senesce and dehisce than small stipules on American chestnut. This appears to be strictly related to stipule size and controlled by the same gene(s). The three hair traits and stem color were linked to each other. Stem color also was linked to stipule size. The stem color determinations were the most interesting from a pathological perspective. Data on bud break at one date prior to the first frostfree date in spring are also presented.

THE SENTINEL

(Dedicated to my leafy friend, the mighty bearer of the bur, whose fragile existence has so enriched my own.)



Krista Butterfield searched for and found remnants of an Appalachian chestnut forest on a recent trip to North Carolina.

It came on the wind, a silent foe
So very many years ago
From many miles across the sea
Where it had spent eternity
In new and better places, where,
On freely taking to the air
I t made itself a fine abode,
It radiated from the node
Without conflict, spreading near
A score of miles with every year.

It prospered well, and held its ground
But no control was ever found
And no solution. One that might
Eradicate this parasite
Before its wrath was fully wrought
Before its lethal blow was brought,

I t set its roots, and set them firm
On hillside, valley, col and berm,
In parks, on homesteads, and in woods,
And one of our most valued goods,
The timber, strong and handsomegrained,
So cherished, and so long retained
From one great hardwood, now assumed
A finite resource, truly doomed,
And what of creatures, what of these
Who made their homes among the trees
Where lofty branches held the fruits
Of their survival, and the roots
Bore forth the mighty boles to wield
A bumper crop for every yield?

Alas! What losses did incur
The mighty bearer of the bur!

Yet some poor souls, by fate or chance,
Stand frozen in their battle stance,
Now stark with pallor, stripped of limbs,
They loft and sway on weather's whims,
Until one day, the winds will blow,
And clinging ice, and drifting snow
Shall cleave the snags from off their roots
And maybe someday, little shoots
Will sprout from those old roots and then
Will die and sprout and die again,

Beneath each page of "past" upturned,
There lies a moral to be learned,
That moral being, simply put,
A certain order is afoot
That Nature clearly must obey,
The past cannot be cast away,
But somewhere in some cyclic stage,
The answer lies, however vague,
As to the cure so badly sought.
We must all bear in mind this thought:
That whether soon, with human help,
Or later on, by time itself,
The latent cure indeed exists,
And will be found, if we persist.

I'll proudly join the great crusade
To hasten to the Chestnut's aid,
And seek the cure that will alone
Restore it to its rightful throne!

KRISTA JACKSON BUTTERFIELD

(Krista Butterfield, formerly an electrical engineer and a member of the Connecticut chapter of The ACF, now lives in western Maine and works as a wilderness ranger for the US Forest Service, She and her husband grow 45 *American chestnut seedlings on their* 94 *acres, and search fm' chestnuts wherever they travel.)*

HARVESTING
AND STORING CHESTNUTS

It's that time of year again! The following harvest checklist is adapted in part from our "Pollination" and "Harvesting Chestnuts" fact sheets. These fact sheets and others including "Mudpacking," "Planting," and "Quick Guidelines," are produced by The American Chestnut Foundation and are available at no cost from ACF, P.O. Box 4044, Bennington, VT 05201.

What do I harvest?

Chestnut seeds or nuts are carried inside spiny shells called burs, one to three nuts per bur. Whether you intend to eat or plant the nuts, harvest or collect the burs themselves.

When do Iharvest the burs?

Harvest burs when they begin to split open, a sign that the nuts inside are ripe. Nuts begin to ripen as early as midAugust in the southern part of the chestnut's range and as late as early October in its northernmost or highest locations.

How do I harvest the burs?

Some burs will fall to the ground at the ripe stage and can be easily collected. To avoid animal predation, however, try to schedule the harvest when the burs still remain on the branches. They can usually be removed with a slight tug or can be knocked loose by shaking or swatting the branches with a pole pruner or plastic or aluminum tubes. Wear heavy leather gloves or a pair of rubber gloves inside leather gloves. (The spines on the burs are very sharp.) Collectors at the Meadowview research farms gather their harvest in 3mil plastic bags hung from their belts. Plastic or heavy paper feed and seed sacks or leaf bags might work too.

How do I remove the nuts?

Place burs in brown paper bags in a cool, dry place protected from animal intruders. Every two to three days, check the bags and remove those nuts that have fallen free of their burs. At the end of ten days, remove all remaining nuts from their burs even if the burs haven't fully opened.

How do I store the nuts?

Nuts to be planted should be stored in moist (not wet) peat moss inside plastic bags: Generously puncture the bags using a toothpick or similar device. Make sure each nut is surrounded by peat moss and doesn't touch other nuts or the sides of the bag. Store at 34 degrees F until planting time.

Nuts for eating can be stored in breathable plastic bags in a refrigerator for several weeks. They will keep up to a year boiled or steamed and then frozen.

I want to plant my nuts for use in breeding. What about recordkeeping?

When harvesting, keep burs from different trees separate in different bags. Label each bag carefully with information on the date collected and on the parent tree's location and appearance. (Is it well formed? Healthy? Badly blighted?) Keep a record of the number of nuts collected from each tree.

Continue to segregate the burs and nuts by parent throughout the harvesting and storage process, keeping each bag carefully labeled inside and out using a waterproof marker.

memories

MEMORIES

OF THE RURAL APPALACHIANS . . .

I was born in Virginia and lived there until I was eight year s old, when we moved to North Carolina. [In Virginia,] we lived on Chestnut Ridge, just up from [what are now the] Meadowview [research farms] . The Crenshaw's lived on the west side and we lived on the east.

There was a large chestnut tree close to our home. Mother took us up there every day to pick up the chestnuts before the squirrels and the neighbor s got them. She stored [the nuts] in the cellar . She gave some for Christmas to relatives who lived in North Carolina and we had plenty for ourselves. I've eaten chestnuts raw, boiled, and roasted by an open fire. Great every way!

There were a few chestnuts trees in David County, North Carolina [to which we moved] , but they didn't produce many chestnuts. ([The trees] were probably too scattered.) My husband William [a David County native] got his first taste of chestnuts at an annual Masonic picnic here. We still go. Its the only time we get to ride the ferris wheel and the merry- go- round!

If I were younger and in better health I'd love to participate in raising trees. Sometime I might get to Meadowview to see the far ms and also to visit relatives near there. We are a big and very close family — the Keesees [my mother's family] and the McAlisters —we still visit when we can.

Myra McAllister Anderson
Mocksville, North Carolina
(Myra McAllister Anderson is 77 years old and has ten grandchildren

OF SUBURBAN LONG ISLAND, NEW YORK . . .

Born in 1916, I do not remember any live chestnut trees, but I , well remember a few dead ones. There were live chestnuts on Long Island, but we moved there from New York only in 1926, when the blight had already started. And it wasn't that at ten years I was unaware of trees. I had gone to camp in Maine and was well aware of pines, spruce, hemlocks and cedar, as well as oaks and maple which covered Rockville Center [the Long Island community to which we moved].

Chestnut trees entered my life the next year, when I took wood shop in the seventh grade. Chestnut was the ideal wood for a shop where only hand tools were used. It was clear, straight-grained, not too hard, and did not easily split. And although an open-grained wood, it would take a good finish. I made a table lamp and a tabouret a small, octagonal decorative table.

My second contact with chestnuts came in 1929 when I became a Scout. The handbook told us that chestnut was the ideal wood for a campfire. Pine was good for a quick fire to boil water. Oak gave good coals for roasting. Chestnut served well for both purposes, but I never had any to burn for some time, [until] in 1931, then an Eagle Scout, I attended a statewide Jamboree on the Whitney Estate near Oyster Bay. They gave our troop 18inch split logs to chop up for our fire-wood. They turned out' to be from chestnut trees killed by the blight.

Edward G. Lowell
Tarzana, California

(Edward Lowell died in October 1995. This letter is printed with the permission of his widow, Ruth Lowell.)

OF URBAN NEW HAVEN, CONNECTICUT . . .

When Richmond and Sally Curtis of Guilford, Connecticut sent in their membership application earlier this year, they mentioned having fond memories of the American chestnut. When we called them to find out more, this is what Richmond had to say .

I was born in New Haven (and so was my wife we're both 89 years old) and I remember collecting chestnuts in New Haven city parks when I was a kid. (The ground beneath the trees would be covered with burs, and a kid had to be careful about where in the grass he sat down, particularly when lightly dressed.) "You must always eat chestnuts in the dark," my mother used to say. "That way you won't see the worms."

Later I remember noticing trees dying the bark just hanging on trees ten and 20 inches wide on Livingston Street opposite East Rock Park. By the time I became assistant superintendent for the New Haven Parks Department in the midthirties, all the city's chestnuts were gone.

When I was in 7th grade we used chestnut in shop class to make furniture. It was nice to plane, and it split nicely. I also believe the posts used for the netting of shadegrown tobacco in the Tobacco Valley along the Connecticut River were made of chestnut.

In 1909 my mother and fatherinlaw occupied their new summer cottage at Leete's Island in Guildford, Connecticut on Long Island Sound. In 19lO a telephone line was installed from Leete's Island Road to the cottage 7/10 ths of a mile, all on chestnut poles.
In 1937 the cottage burned to the ground but the pole nearest the house wasn't damaged. When the Southern New England Telephone crew came in 1939 to replace the line, the foreman looked at the pole and said "this is still good. We'll use it again for another short line!"

I belong to an old man's Wednesday walking club, and we are still on the lookout for chestnuts on our travels.

(Richmond isn't the only one who walks. He and Sally together have walked from Long Island Sound to Canada in various trips beginning in 1974.)

science and natural history

SURVIVING TREES IN ERIE COUNTY, PENNSYLVANIA

Pat Chamberlain

Most of us by now are painfully aware of the utterly destructive role the chestnut blight played in the elimination of the American chestnut tree as a producer of quality timber. And many of us have seen first hand how quickly a favorite tree or sapling can be destroyed once infected.

Until recently, we considered all the trees in our area of northwestern Pennsylvania to be as susceptible as any other American chestnut. But in 1992 a rather remarkable discovery was made just fourteen miles northwest of our farm. Thanks to an initial tip from state forester Tom Erdman, a small population of trees and sprouts has been identified which is surviving despite being infected.

The first and largest found so far is growing in the back yard of Mr. and Mrs. Richard Walbridge in Erie County near East Springfied. The tree, which was confirmed to be American by ACF farm superintendent Fred Hebard, was measured by Tom Erdman and was found to be 39 feet tall with a spread of 44 feet and a DBH of25 inches. From one thick horizontal limb, an old-fashioned swing hung by twin metal chains, apparently with no adverse effect.

The Walbridge tree is obviously stressed and in a state of decline. Both killing and healing cankers are present in the crown, with mostly the healing types winning out on the lower limbs. Fred Hebard's research indicates that a tree which' has both healing and killing cankers in a partially live but declining crown most likely survives due to hypovirulence. Although little evidence of hypovirulence was detected in a test of bark samples taken from the Walbridge tree, the tree's condition suggests that a larger, more varied bark sample should be sent off for additional study.

Four other survivors have been found less than a mile from the Walbridge residence. While not nearly as old as the large tree, all exhibit the same hypovirulenttype appearance and look as though they have been infected for some time. And in the town of Girard, about six miles from East Springfield, a multistemmed chestnut with

European characteristics and a swollen hypovirulent type appearance also survives, The main trunk has a 21inch DBH but only reaches a height of 15 feet. (The top has been sawn off.) Twin llinch DBH trunks shoot past the main trunk to about 35 feet. Five smaller stems at up to 7 inches DBH guard the perimeter.

It is interesting to speculate as to why hypovirulence might persist in this area and yet isn't in evidence a mere 14 miles further south, Lake Erie, which is generally less than a mile away from the Walbridge and Girard trees, may contribute toward producing subtle climatic and environmental conditions uniquely favorable for the proliferation of the hypovirulent virus. Tom Erdman wonders whether a symbiotic relationship exists between mycorrhizae on the trees' feeder roots and the hypovirulent blight fungus on the stems.

Perhaps the soil itself plays a role, it being a well drained, friable sandy type unlike that of any other chestnut site we have seen in northwestern Pennsylvania. At our farm the soil is a fertile clay type. Further southeast in the mountains the topsoil becomes thinner, sometimes barely covering a seemingly compacted subsoil.

Given the observable survivability of the trees in this area, it may be possible to establish plantings of their seedlings and eventually have orchards of blight-scarred trees which could be counted on to produce seed in a fairly reliable fashion. Perhaps someone should give it a try.

(Pat Chamberlain, who was profiled in the Spring 1992 *ACF newsletter, breeds chestnut on his Erie County farm. For more information on the Walbridge and Girard trees, write Pat at* RD 2, *Edinboro, PA 16412.)*

THE ARCHAEOLOGY OF CHESTNUT: INVESTIGATING THE HISTORY OF AMERICAN CHESTNUT ON A NEW ENGLAND WOODLOT

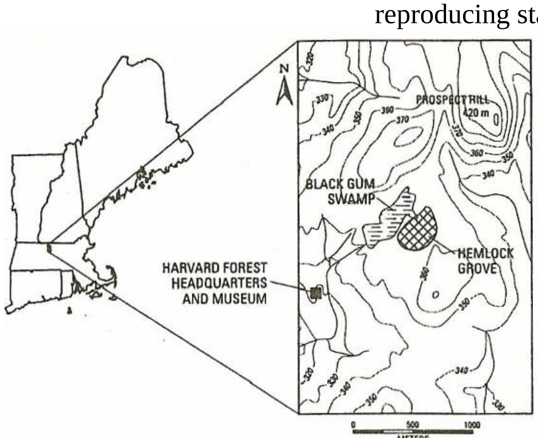
By Fred Paillet

Fred Pail/et is a research geologist with the US Department of the Interior's Geological Survey office in Denver. His interest in chestnut dates back to 1980, when he began to study pollen and macrofossil records of the genus for what they reveal about climate change. His research has since taken him in search of chestnut records throughout North America and Asia.)

My original motive for studying the subject of land use and chestnut was related to my interest in understanding how European settlement caused a dramatic increase in chestnut pollen in the lakes and ponds of Connecticut (Brugham, 1978). Ecologists cannot relate local chestnut abundance (as indicated by the proportion of chestnut pollen in sediments) to site conditions and climate because there are no naturally reproducing stands of American chestnut trees with which to calibrate ecological models. Therefore, it seemed useful to see what documented historic conditions might be used to explain an increase in chestnut pollen identified in the geologic record. Also, an understanding of how human activity increased chestnut might tell us how to reestablish blight resistant chestnut in the future.

But along the way, my New England chestnut studies disclosed a real mystery: remains of old chestnut trees seemed to be consistently most common in what are now dense hemlock groves. This seemed

Figure I. Location of Black Gum Swamp at Harvard Forest In north-central Massachusetts.



strange because hemlock is a shadeloving tree known to prefer moist locations, while chestnut is thought to have avoided shade and to have prospered on dry ridges.

The presence of chestnut and the long history of forest research at Harvard Forest in Petersham, Massachusetts suggested that the forests of north central Massachusetts might be a likely place to study chestnut ecology. Here was a place where a great deal was known about past land use history.

My studies were directed to the woodlots at Harvard Forest and especially the old hemlock grove on the side of Black Gum Swamp, only a few hundred yards /Tom

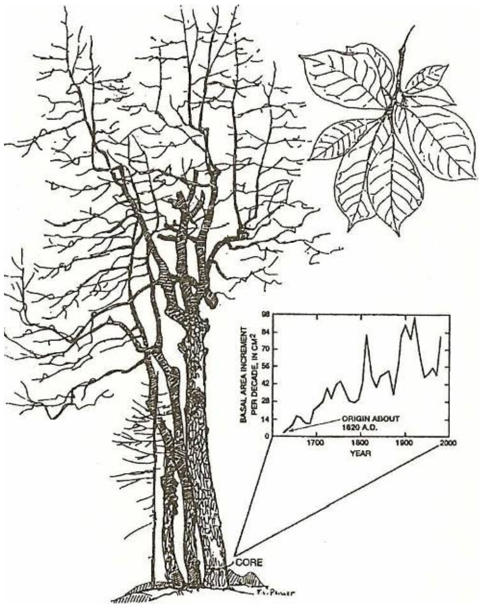
Forest headquarters (figure 1). This hemlock grove disclosed the familiar attributes of my established research sites in Connecticut: chestnut stumps and logs strewn throughout the understory of the hemlock grove, another example of a former chestnut stand replaced by hemlock.

Like many other hemlock groves in New England, the hemlock stand adjacent to Black Gum Swamp appears wild and pristine (figure 2). The interior of the grove is dominated by massive hemlock trees with trunks up to a meter in diameter. The dense shade of the hem¬locks results in a barelooking forest floor, covered with a thin brown carpet of hemlock needles. A few sparse mountain laurel shrubs, ferns and moss are mixed with stunted hemlock and spruce seedlings all indications of the severe shade conditions imposed by the hemlock canopy. (The thick hemlock overstory makes it difficult for even the most shadetolerant seedlings to survive for very long.) The hemlocks dominating the forest canopy are mixed with a few other trees such as spruce, beech, and yellow birch, but the numbers and size of the giant hemlocks completely dominate the character of the grove.

The remains of chestnut are found' almost everywhere under the hem locks, indicating that chestnut was once one of the most common trees in this particular woodlot. Largediameter sawn chestnut stumps are scattered throughout. There were also a number of chestnut logs .

Figure 2. Interior view of the hemlock grove adjacent to Black Gum Swamp at Harvard Forest:

A. The large, canopy-dominant hemlock trees In the hemlock grove at Harvard Forest.
B. Chestnut poles leaning into the branches of the big hemlocks.
C. The flat•topped saw-cut stumps of what were once big chestnut trees.
D. Partially decayed chestnut logs lying on the ground under the big hemlocks.
E. The sparse undergrowth under the hem locks consists of spindly or recently killed tree seedlings and mountain laurel.
F. The forest floor is covered by a thin brown layer of hemlock nee• dies and a few light brown beech leaves.
G. A very few thinner red spruce, beech, and yellow birch trees are mixed with the large hem locks



lying on the ground. There were even a number of chestnut "poles" up to about six inches in diameter sti1l standing, supported by branches of the large hemlocks.

An obvious starting point in investigat ing the background of this woodlot was to relate the known history of the site to that of surrounding areas. Land use records showed the familiar pattern of intense agricultural activity around Black Gum Swamp. The hemlock grove was the only area in addition to the swamp itself that had been continuously forested. Most of the surrounding land had once been pasture or plowed field. These former fields are now covered with stands of birch, white pine, oak and red maple, or with coniferous plantations established in forestry studies. A1l of the general historical data further suggested that the hemlock grove had been selectively cut and probably grazed over various periods since European settlement around 1700. So the hand of man had been applied to even the few continuously forested parts of the landscape. In spite of appearances, this hemlock woodlot is neither wild nor pristine.

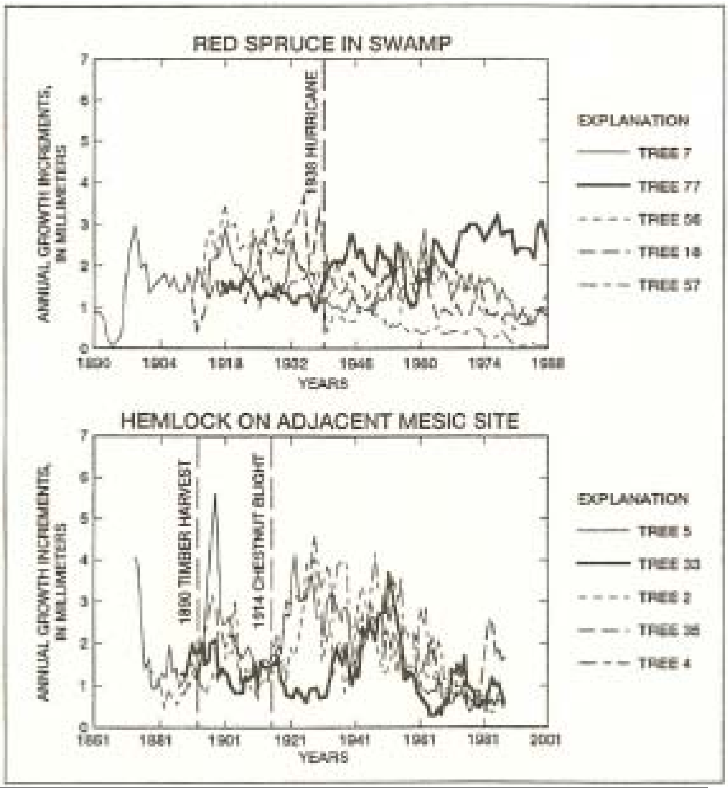
Figure 3. Ancient black gum tree and decade-smoothed growth history reconstructed from tree ring analysis.

One direct approach to reconstruction of forest history on this site was to develop a tree ring chronology by coring the large trees in the hemlock grove (hemlock and two white pines) and in the adjacent swamp (red spruce, hemlock, and black gum). The largest hemlocks had ages in the range of 120140 years. The sma1lerdiameter, slower growing spruce trees in the swamp were almost as old. A major surprise was the age of the black gum trees, several of which exceed 300 years even though they were smaller than the great hemlocks. One of the oldest black gum trees cored by Harvard graduate student Tad Zebryk and processed by the US Geological Survey Tree Ring Laboratory indicates the history of the forest in Black Gum Swamp

(figure 3). This tree started growing just about the time the Pilgrims landed at Plymouth in 1620. The tree continued to grow in diameter with four periods of major interruption. The last of these is clearly the 1938 hurricane. The effects of that hurricane are still visible in the broken crown of the tree today. We assume that each of the earlier periods of interrupted growth represent earlier episodes of wind dam¬age and recovery. In contrast, the shorter records from spruce in the swamp (figure 4) show a mixture of decreased growth caused by canopy damage and increased growth from the destruction of compet¬ing trees after the 1938 hurricane. Thus, the story of the forest in Black Gum Swamp seems to be one of catastrophic wind damage about once a century.

The hemlock cores from the nearby hemlock grove tell a very different story (figure 4). Most of the hemlock trees originated after 1870, and show spurts of growth in 1890, 1915, and 1938. The forest distur¬bances in 1915 and 1938 suggested by the increases in hemlock growth can be firmly tied to the recorded appearance of chestnut blight in Petersham in 1914 and the 1938 hurricane. However, there is no obvious regional forest disturbance known to have occurred in 1890. Harvard Forest records show that the 1890 event was the logging of a chestnut stand at this location. This logging and not the salvage of standing dead timber produced the

Figure 4. Tree ring width series for typical overstory hemlock trees in the hemlock grove and red spruce trees from the adjacent swamp forest.

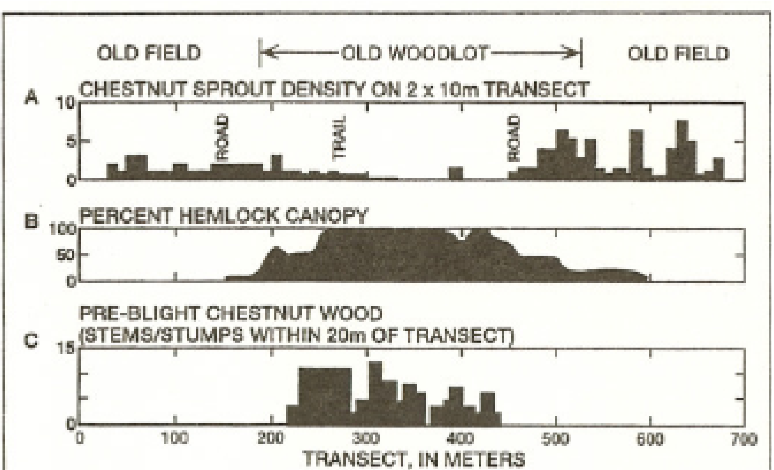


many large chestnut stumps found in the forest today. The stumps show that those trees were from 12 to 24 inches in diameter, and mostly consisted of multiplestemmed trees. Such trees arose as cop¬pice sprouts after the cutting of earlier stems.

We surmise that this former chestnut stand had arisen through the same disturbance regimen responsible for the general rise in propor¬tion of chestnut in New England forests following settlement. Although the exact details are still unclear, the woodlots interspersed between the many subsistence farms in Massachusetts and Connecticut in the years before the Civil War were relatively enriched in chestnut. We suspect that the cycle of fuel wood cutting and other land use practices were favorable to such "sprout hardwoods" as chestnut and red oak. Therefore, ecologists have a strong clue that the nature and frequency of disturbances introduced as part of early settlement were favorable to chestnut establishment and reproduction.

Figure 5. Distribution of A) livIng chestnut sprouts, B) hemlock shade. and C) old chestnut logs and stumps along a transect through the hemlock grove.

The story told by the hemlock ring chronologies is thus, first, one of chestnut tree harvest where hemlocks were already established in the understory. A nearby hemlock seed source was present in the adja¬cent swamp, and the decline in agricultural activities would have allowed young hemlock saplings to escape periodic grazing and dam¬age from intentionally set fires. The 1890 cutting of chestnut allowed the slowgrowing hemlocks to profit for a short time, but faster growing chest¬nut sprouts soon overtopped the young hemlocks. The lack of larger stump sprouts from the older chestnut stumps and the many long dead chestnut poles still propped up by the 700 I hemlocks show that many of the chestnut



stems generated after the 1890 cutting arose as sprouts from "old seedlings" and not the bigger trees. The number of chestnut poles present in the hemlock grove suggests that this stand was well on its way towards becoming another chestnut grove by 1910.

The second part of the story told by both the hemlock tree cores and Harvard Forest records is of the rapid development of the young chestnut stand until the chestnut blight arrived in 1914 and the stage was set for a transition to hemlock. Young hemlocks liberated by the abrupt death of chestnut have since expanded to the great size we see today, with only a slight depression of growth rate from the 1938 hurricane.

The distribution of chestnut reproduction around Black Gum Swamp is just as interesting as the history of the large chestnut trees that once grew on the site of the hemlock grove. The distribution of the former chestnut trees and the seedlings being established from the nuts those trees produced can still be studied today (Paillet, 1984). We can do this because decayresistant chestnut wood persists so long on the forest floor that we can recognize the stumps and logs from older trees. We also recognize that chestnut seed has not been pro¬duced on this site since 1914, and that the many chestnut sprouts we see in the forest today represent nuts that germinated before that time. (We can be certain of this because chestnut only sprouts from the root collar and not from roots like beech or aspen. All small chest¬nut stems in the woods today therefore must be old seedlings if they are not located right next to the stump of a former chestnut tree.)

The distribution of chestnut sprouts in and around the hemlock grove at Harvard Forest tells its own story (figure 5). In 1910 the future hemlock grove was surrounded by young trees of such species as white and gray birch, white pine, red cedar, and aspen. The distrib¬ution of old chestnut seedlings today clearly shows that the former woodlot was surrounded by a "halo" of chestnut reproduction under¬neath this young forest (Paillet, 1988). We cannot tell whether it was difficult for chestnut seedlings to get established directly beneath mature chestnut trees, or whether the dense hemlock shade has since caused the death of some of the chestnut seedlings that were once established there. Whatever the cause, at present the density of old chestnut seedlings in the young forest around the old woodlot is more

"The second part of the story told by both the hemlock tree cores and Harvard Forest records is of the rapid develop-ment of the young chestnut stand until the chestnut blight arrived in 1914 and the stage was set for a transition to hemlock."

than ten times the density of chestnut within the boundaries of the old woodlot.

The hemlock grove at Harvard Forest is only one of many sites where forest stand reconstructions suggest that chestnut had difficulty reproducing under itself, as well as in mature hemlock forests. For example, Thoreau cites an almost complete absence of chestnut seedlings under established chestnut groves, whereas he found many chestnut seedlings in pine and birch forests growing on former pas¬tures (Paillet, 1988; Whitney and Davis, 1986).

The complex relationship between chestnut reproduction and for¬est conditions in the vicinity of Black Gum Swamp is indicated in a series of investigations by David Foster, Peter Schoonmaker, and Tad Zebryk (Foster et al, 1993, Foster and Zebryk, 1993). These studies examine the distribution of chestnut pollen in sediment cores recov¬ered from the swamp, from a small forest hollow adjacent to the swamp, and from forest soil layers. (Such studies allow the comparison of chestnut populations on different scales, because the swamp surface traps pollen from a wide area while the forest hollow and soil humus collect pollen mostly from the immediate vicinity of the sampling sites.) They support the thesis that chestnut does not reproduce well under itself or in the mature forest. The pollen samples show that chestnut pollen proportions in Black Gum Swamp sediments have been relatively constant over the past 2000 years, but that there have been tremendous fluctuations in the number of chestnut trees on a given site such as the area immediately adjacent to the nearby forest hollow.

Further insight into chestnut reproduction in natural forests has recently been presented by information on natural oldgrowth chest¬nut forests in the western Caucasus Mountains of southern Russia (Pridnya et ai, 1996). Tree ring studies show that the large trees now present in the forest originated at only a few times in the past. These pulses of reproduction probably corresponded to a time when specific conditions were favorable to the establishment of chestnut. Russian scientists otherwise express the same sort of concern about chestnut reproduction in their forests that is found in Thoreau's journals.

In summary, all the information available indicates that American chestnut had a complicated ecological role in the prehistoric and early

"Forest stand reconstructions suggest that chestnut had difficulty reproducing under itself, as well as in mature hemlock forests. For example, Thoreau cites an almost complete absence of chestnuts seedlings under established chestnut groves. . ."

historic forests of Jew England. The interaction between hemlock
and chestnut apparently involved much more than just shade tolerance and seed production. We know that land use practices first produced an increase in chestnut in New England, and then a combination of chestnut blight and other factors allowed hemlock groves to develop in areas previously occupied by chestnut. My own mapping of the dis¬tribution of chestnut sprouts demonstrates that chestnut was actively invading the young forests growing on recently abandoned agricultur¬al lands in about 1910. All of this evidence suggests that American chestnut had an ecological niche that was distinctly different from that of other deciduous nutproducing trees. Although there are very limit¬ed forests of American chestnut trees left for study, continued paleoe¬cological analyses and studies of the few wild, unblighted chestnut forests of Asia may help us learn how to effectively introduce a blight¬resistant American chestnut as a viable component in American forests of the future.

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BACKCROSS BREEDING SIMPLIFIED

The core of The ACF's effort to restore the American chesnut is our backcross breeding program. For those new members who aren't familiar with the effort, and for those old members who could use a short refresher course, we offer the following simplified summary prepared with the help of Dr. Fred Hebard at our Meadowview research farms.

Chestnut blight was first introduced to North America in 1904. Like many other pest introductions, it quickly spread into its new and defenseless host population. American chestnut trees had evolved in the absence of chestnut blight, and our native species lacks the genetic material to protect it from the fungus.

In Asia, however, where the pad10gen originated, most native chestnut species and particularly Chinese chestnut are well defended against the blight. Over the course of their millennia of coexistence wid1 the fungus, Chinese chestnuts acquired d1e genetic material d1at confers resistance to it. Blighted North American chestnut species die. Blighted Chinese chestnuts usually suffer only cosmetic damage. Since all chestnut species can be crossed wid1 relative ease, Chinese chestnut offers a potential solution to the American's susceptibility to chestnut blight.

But Chinese chestnut lacks many of the characteristics of the American. Most obvious is stature: the Chinese species is generally low growing and spreading, much like an old apple tree; an American chest¬nut can grow straight and strong to a hundred feet or more. This habit of growth combined with d1e quality of its wood makes the American a fine timber species.

Less obvious is the role the American chestnut played in its native forests. The blight is a very recent introduction to the chestnut ecosystem. In those thousands of years preceding the blight's arrival, an enormously complex set of relationships evolved which tied the chestnut together with innumerable bird, mammal, and insect species and other organisms, as well as rocks and waters and soils and fires and through them, the very shape of the hills and mountains on which chestnuts were found. This his¬tory of coevolution on the North American continent is carried in the genetic material only of the American, not the Chinese, chestnut .

The goal of The American Chestnut Foundation's breeding program is therefore twofold: to introduce into the American chestnut the genetic material responsible for the blight resistance of the Chinese tree, and at the same time preserve in every other way the genetic heritage of the American species.

THE GENETICS OF BLIGHT RESISTANCE

Many characteristics are passed on from generation to generation in a fairly simple fashion as in one of Mendel's experiments with flower color in peas. There, only one gene coded for color, it was either red or white, and the red form was dominant. When two red peas having both forms of the gene were crossed, on average threefourths of their offspring would carry at least one gene for red and would flower in red. Only one¬fourth would lack a gene for red and would therefore be white.

"The genetics of chestnut blight resistance are more complicated than predicted by the simple Mendelian model. It now appears that resistance in the Chinese species is probably carried on not one but two genes"

Many decades of breeding research by the D.S, Department of Agriculture and the Connecticut Agricultural Experiment Station, and more recently, at The ACF's research farms in Meadowview, Virginia, indicate that the genetics of chestnut blight resistance are more complicat¬ed than predicted by the simple Mendelian model. It now appears that resistance in the Chinese species is probably carried on not one but two genes (although to be safe the Foundation's breeding program assumes a worst case of three genes). And it is clear that the genes for resistance are only incompletely dominant. This means that in ChineseAmerican crosses, resistance is increased by the relative presence of "resistance" genes and diluted by the relative presence of native "susceptible" genes. It is as though Mendel's peas could have been pink as well as red or white. Full resistance, we now know, will be present only if all the genes controlling response to the blight are of the Chinese form.

Apparently believing that resistance is controlled by numerous genes, early breeders attempted to achieve this situation (called "homozygosity" or "identical gene form") by flooding their chestnut progeny with Chinese genes, that is, by crossing their ChineseAmerican hybrids with other promising ChineseAmerican hybrids. The result, as might be expected, was consistently a blightresistant but very Chinese chestnutlike chestnut tree.

By backcrossing to entirely American parents, however, the ACF's breeding program retains the resistance introduced to the original

ChineseAmerican hybrid but swamps the progeny with American genes. Although convention across the breeding world differs according to the organism a beefalo is considered a beefalo if it's at least 1/8th buffalo, a soybean is a soybean if it's at least 31/32nds soybean scientists working with The ACF predict that a chestnut at least 15/16ths American will exhibit virtually entirely American characteristics. Therefore, using Chinese¬American hybrids seedlings on average 1/2 Chinese and 1/2 American ¬produced by those earlier breeders and at our own Meadowview, Virginia research farms, at ACF we first backcross to an American parent. The result is a population of progeny on average 3/4 American and 1/4 Chinese. We then backcross again for a population of progeny averaging 7/8 American and 1/8 Chinese. By the third backcross, which yields a progeny on average 15/16 American and 1/16 Chinese, we should reacquire the American talltimbered growth habit and American adaptability.

CONFIRMING RESISTANCE

Although the Chinese genes for resistance are only incompletely domi¬nant, they nonetheless usually express themselves clearly when present in seedlings purposely inoculated with a virulent form of the blight fungus. And that is how each backcross generation is tested by inoculation. Only those seedlings that show the greatest resistance are used for further backcrossing to an American parent.

But every backcross, although necessary to recover desirable American traits, also reintroduces the genes for blight susceptibility from the American parent. In order to remove those genes, the next steps at The ACF are intercrosses. In the first intercross, the most blightresistant 'Y'6ths American trees are crossed with other blightresistant lYt6ths American trees. Again, only resistant seedlings are saved .

At the first intercross, it may prove difficult to distinguish inoculated seedlings with full resistance from those with threequarters two genes for resistance from one parent and one gene for resistance and one gene for susceptibility from the second. A test cross back to an American parent will confirm that first intercross trees contain only the Chinese genes for resistance. Compared to threequarters resistant parents, fullyresistant par¬ents testcrossed with an American will yield a population of progeny con¬taining on the average a larger proportion of resistant individuals.

When crossed with each other, these fi.ll1y resistant parents will also breed true for resistance, since they will have no American genes for susceptibility to blight. This second intercross will yield nuts for restoration.

GUARANTEEING REGIONAL ADAPTABILITY AND LONGTERM RESISTANCE

It's likely that natural selection has created populations uniquely adapted to regional conditions such as temperature, day length, soils, moisture, elevation and others. In order to preserve that wide range of genetic diver¬sity and adaptability, and in order to avoid problems associated with inbreeding, the ACF breeding program will use as American parents a number of populations of trees tram all over the present range of the chestnut. Our Connecticut, Indiana, and Pennsylvania chapters have active breeding programs that are extending the range of regional adapta¬tion in backcross trees.

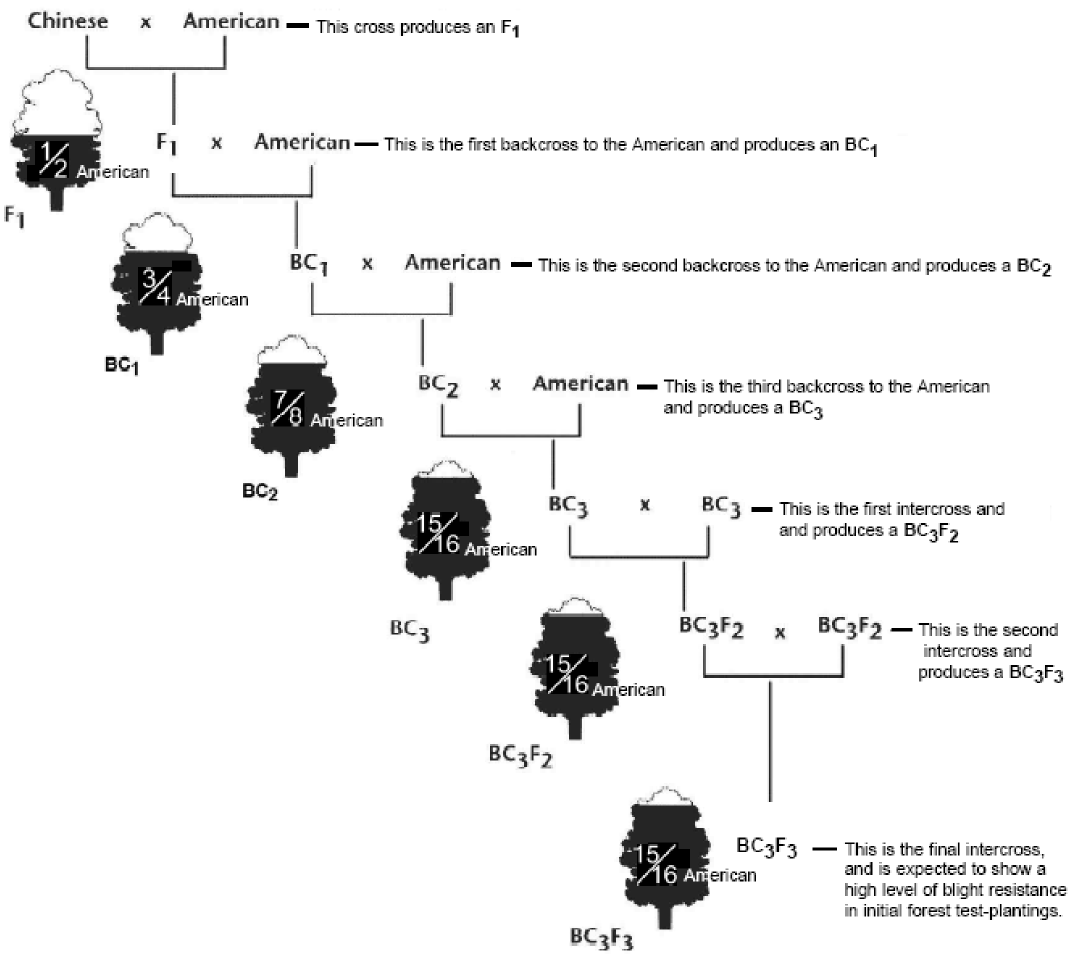
Plant pathogens frequently evolve to overcome plant defenses. Although there have been no known instances in Chinese chestnut trees planted in the US., a future "breakdown" of resistance in blightresistant American trees is possible. To minimize this possibility, the ACF's breed¬ing program also uses genetic material tram different Chinese chestnut trees. Our most advanced breeding lines, which is midway to the third backcross stage, are derived tram two Chinese chesu1l1t trees known as Mahogany and El'. 555. The Nanking, Kuling and Meiling cultivated varieties are the parents of a set of trees entering the first backcross stage. Other Chinese chestnut trees are being used to a lesser extent.

TIMETABLE

The process of producing seeds and testing those seeds for blight resis¬tance now requires about six years for each backcross generation and five years for intercross generations. Since our first group of third backcross seeds were planted in 1995, we can expect progeny tram the first inter¬cross in 2000. We'll have progeny tram the second intercross and blight resistant American chestnuts ready for planting in 2006. That's only ten years away

THE AMERICAN CHESTNUT FOUNDATION BACKCROSS BREEDING PROGRAM

With each cross, additional American chestnut characteristics are regained. Only at the final cross, however, is blight resistance equal to that of the Chinese parent again reintroduced.



Note: In each step, the Backcross is selected for resistance.

THANK YOU TO 1995 SPECIAL CAMPAIGN CONTRIBUTORS

Each year in June we ask you to support our Meadowview research farms, and then again each December we go to you with our year-end campaign. And each year you respond with enthusiasm and enormous generosity.

All your contributions to the farm campaign go to farm operations. Last year they bought fertilizer, seed protectors, ladders, telephone service. Your gifts paid for surveyor's stakes and computer equipment, black plastic and machine repairs. Farm campaign contributions covered the costs of acquiring a rear tiller and a subsoiler. They paid for seasonal labor and insurance. For diesel fuel. For boots.

Your gifts to the 1995 year-end campaign were matched dollar for dollar by a grant from the National Fish and Wildlife Foundation. The combined support funded several external research grants - to the University of Nebraska and Propagation Technologies Inc. for micro-¬propagation research; to the US Forest Service and the University of Massachusetts for genetic mapping; and to the University of Kentucky for research into blight resistance-related com¬pounds.

For all these items and efforts made possible by your support, we thank you ...

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