



Department of Defense Legacy Resource Management Program

PROJECT NUMBER 10-401

Ongoing Maintenance and Monitoring of Established American Chestnut (*Castanea dentata*) Test Orchards on Two TNARNG Installations

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**General Data Summary for Project 10-401:
On-going maintenance and monitoring of established American chestnut (*Castanea dentata*) test
orchards on two TNARNG installations.**

Orchards were established at the Tennessee Army National Guard's (TNARNG) Volunteer Training Sites (VTS) – Catoosa and Milan in 2008-09 under Legacy project number 08-401 to grow seeds and seedlings provided by the American Chestnut Foundation (TACF). The planting stock is the result of TACF's backcross breeding program which seeks to instill resistance to the chestnut blight through hybridization of the American chestnut (*Castanea dentata*) with the Chinese chestnut (*Castanea mollissima*) followed by repeated backcrossing of the blight resistant offspring to pure American chestnut stock. After about 6 generations this backcrossing is expected to produce individuals which are genetically 94% American chestnut but are able to survive the chestnut blight.

Seeds and seedlings were planted in spring 2009 with some additional stock being added in spring 2010. Maintenance of the orchards requires care for the seedlings which are watered and fertilized throughout the growing season, as well as maintenance of the grounds – mowing, weedeating, and use of herbicide to minimize grass and weed competition with the chestnuts and maintain appearances. The young trees are inventoried two to three times during the summer to monitor general health and survival, and then are measured in the fall to determine height and basal diameter growth.

Success to date has been mixed. The attached spreadsheet (Appendix 1) provides the complete data set of survival and growth for the two orchards. General trends for each site are presented below. Photographs of the orchards and trees are presented in Appendix 2.

VTS-Catoosa

A total of 225 individuals were planted in spring of 2009 (see Table 1 for general summary metrics). Of those, 43 were seedlings already started in the greenhouse at the University of Tennessee – Chattanooga (UTC) and 182 were seeds. In addition to the “controls” represented by pure American chestnut stock (Whigg Meadow), pure Chinese chestnut stock (Qing x O.P.), and a first generation hybrid (50% American, 50% Chinese – TNMON5 x Gideon), a variety of hybrids were planted. The most numerous were AG247 x TNPOLK1 and TNMON8 x JB271, both planted as seeds. The other varieties were planted as seedlings and represented individuals of differing backgrounds that TACF had available; most significant were CH102 x MAR1 and AG387 x TNMAC2, represented by 20 and 8 seedlings, respectively. The other varieties are not addressed in this discussion due to the small numbers planted.

From the start there were apparent differences. While the controls and AG247 x TNPOLK1 had germination rates of over 80%, TNMON8 x JB271 germinated only 57% of its seeds. Survival at the end of 2009 was very low at 55% for all varieties. The hybrids typically ranged from 45-60% survival, while the controls had 87-100% survival. The exception was the Whigg Meadow pure American chestnut stock which had incredibly poor survival, with only 1 seedling remaining from the 8 which germinated in 2009.

In spring 2010 new seeds and seedlings were planted to replace germination failures and mortality from 2009. The controls were replaced with new seeds or seedlings (in the case of the TNMON5 x Gideon

hybrid). Another 13 TNMON8 x JB271 seedlings were planted, as well as 8 seedlings of AG247 x TNPOLK1. In addition, a new backcross, CH88 x TNGRU1, was introduced with 56 seeds.

First year survival for the 2010 additions was somewhat better than the 2009 stock: the seedling hybrids had 60-65% survival, while the CH88 x TNGRU1 saw 91% germination and 88% first year survival. The pure American stock (labeled American O.P. in 2010) again had low germination and extremely low survival at 25%.

The overall survival rate for 2010 – calculated based on seedlings alive at the end of 2009 or successfully planted/germinated in 2010 – was 67%. During 2011, the orchard again lost approximately 32% of the plants it started with in the spring. After 2-3 years, the 313 seeds/seedlings that were introduced into the VTS-Catoosa orchard had dwindled to 80 surviving individuals.

Those survivors, however, are generally doing quite well. Heights range from 1 ft to over 12 ft. The tallest individuals are not limited to those started in the greenhouse and planted as seedlings (thus having a 1-2 year age advantage over the seed stock): the top six trees – each over 100 inches tall – are evenly divided between 2009 seeds and seedlings. Average height for the 80 survivors is 60.9 ± 27.1 inches. Average root collar diameter is 0.8 ± 0.5 inches, and three individuals have a diameter of over 2 inches. Average size of the different varieties is variable and confounded by the different sample sizes as well as different planting dates.

Average height growth between 2010 and 2011 was 18.6 ± 15.7 inches, and diameter growth was 0.25 ± 0.27 inches. These simple averages are somewhat misleading, as they include several individuals that died back and resprouted from the root stock, in some cases resulting in “negative” growth as the new shoot is smaller than the existing stem at the end of 2010.

Two of the small trees, a 2009 TNMON5 x Gideon seed and a 2010 TNMON5 x Gideon seedling, produced fruit in 2011.

VTS-Milan

A total of 554 seeds were planted in the spring of 2009 representing six varieties: three “control” groups of pure American chestnut stock (Whigg Mon), pure Chinese chestnut (E30 Qing), and the 50/50 hybrid (TNMON5 x Gideon) and three backcross hybrids (AG247 x TNPOLK1, O-7 x I-II, and TNMON5 x M-19). The backcross hybrids were significantly more numerous than the controls (see Table 2 for general summary metrics).

The overall germination rate at the VTS-Milan orchard was surprisingly low at only 50%. We speculate that there were issues with the seeds being buried too deep by some volunteers. There were, however, distinct differences in germination rate for the different varieties, which may be inherent to the crosses or may be a product of the practice of allowing one volunteer group to plant most of the seeds of a variety rather than planting a random selection of multiple varieties. The O-7 x I-11 individuals were off to an early lead with the highest germination rate, 76%. The controls were close at 63-75%. The other two backcross varieties had much less success with only 35-37% seed germination.

Once germinated all varieties had acceptable survival rates for the first year, except for the pure American Whigg Mon stock which had only six of the ten new seedlings make it through the first growing season. O-7 x I-11 again was most successful with 94% survival of newly germinated seedlings, AG247 x TNPOLK1 with 79% survival, and TNMON5 x M-19 in the middle at 86%.

In spring 2010 an additional 123 seeds and 22 seedlings were planted to replace germination failures and mortality from 2009. The controls were replaced with seed (pure American and pure Chinese) or seedlings (TNMON5 x Gideon). Several nursery-grown seedlings of O-7 x I-11 and TNMON5 x M-19 were added, and an additional backcross variety, AG200 x TNHAM2, was added with 97 seeds.

Germination of the 2010 seed was high for the Chinese O.P. and the AG200 x TNHAM2, but very low for the American O.P. First year survival for the 2010 additions was highly variable, from a low 25% for the American O.P. to 80% for the AG200 x TNHAM2 and 85% for the Chinese O.P.

The overall survival rate for 2010, based on seedlings alive at the end of 2009 or successfully planted/germinated in 2010, was 83%. The following year was much harder on the orchard, and only 57% of the seedlings alive at the end of 2010 were still alive in the fall 2011. Of the total 699 individuals planted over the two years at the VTS-Milan orchard, only 160 remain alive. There is a visually significant difference in survival rates of the hybrids; the rows of O-7 x I-11 seedlings remain much more densely stocked than any other rows, and this difference is also apparent in the overall survival rates, although statistical calculations of significance have not been made.

Most of the surviving seedlings are doing quite well. Heights range from a few inches to almost 10 ft. Average height for the VTS-Milan seedlings is 54.8 ± 21.5 inches. Seven individuals are over 8 ft in height: one pure Chinese O.P. and six O-7 x I-11 seedlings. Average root collar diameter is 0.88 ± 0.5 inches, and four individuals have a diameter of over 2 inches. It is hard to distinguish any clear trends in the average size of the different varieties, other than a notable, and expected, difference between the 2009 seedlings and the smaller plants started from seed in 2010.

Average height growth between 2010 and 2011 was 14.8 ± 12.1 inches, and diameter growth was 0.38 ± 0.33 inches. More individuals died back and resprouted in the VTS-Milan orchard, so there were more examples of “negative” growth than in the Catoosa data.

Two of the small trees, a 2009 O-7 x I-11 seed and a 2010 TNMON5 x Gideon sapling, produced fruit in 2011.

Summary

While disappointing after all the hard work of planting and maintaining the orchards, these results appear to be within the range of typical survival rates for American chestnut hybrid plantings. A brief survey of orchard data reports shows early success rates from 18% to 90%, but the majority appear to lie within 60-80% survival of seedlings in the first few years. There are any number of threats to the young trees, including improper planting technique, physical damage from maintenance or wildlife, heat and drought. In addition, there is a pathogen, *Phytophthora cinnamomi*, present in many soils which destroys the root systems of American chestnuts and can devastate an orchard.

Additional plantings at both orchard sites will likely be made in the spring of 2012, if seed is available from TACF. The TNARNG will continue to maintain these orchards for the foreseeable future. At 5-7 years of age (around 2015-16), the American Chestnut Foundation will inoculate the trees with the chestnut blight to test resistance. If trees show susceptibility to the blight, they will be culled from the orchard. The survivors exhibiting blight resistance will be maintained and introduced into TACF's breeding program.

Table 1: VTS-Catoosa Metrics

Variety	2009 planting	# Germ. (Rate)	# Alive Fall 2009 (Rate)	2010 planting	# Germ. (Rate)	# Alive Fall 2010 (Rate)	# Alive Fall 2011	To Date Survival Rate	2011 Height (in)	2011 Diameter (in)
AG247 x TNPOLK1	84 seed	68 (0.810)	30 (0.441)			15	4	0.059	47.9 ± 10.1	0.70 ± 0.42
TNMON8 x JB271	71 seed	38 (0.535)	23 (0.605)			9	5	0.132	28.5 ± 9.9	0.30 ± 0.08
AG387 x TNMAC2	8 splg		4 (0.500)			3	3	0.375	117.3 ± 51.9	1.50 ± 0.57
CH102 x MAR1	20 splg		12 (0.600)			8	7	0.350	73.0 ± 25.0	1.10 ± 0.50
C. pumila – Chestnut Mtn.	2 splg		2 (1.00)			1	0	0		
D-5-26-181	1 splg		0 (0)			0	0	0		
D-6-26-17	7 splg		5 (0.714)			2	2	0.286	79.8 ± 20.9	1.30 ± 0.37
Pocket GA-FLO-1	2 splg		1 (0.500)			0	0	0		
Pocket GA-FLO-7	2 splg		1 (0.500)			1	0	0		
Qing x O.P.	9 seed	8 (0.889)	8 (1.0)			8	8	1.0	77.0 ± 14.1	1.30 ± 0.46
Whigg Meadow	10 seed	8 (0.800)	1 (0.125)			1	1	0.125	72.0 ± 0	0.84 ± 0
TNMON5 x Gideon	9 seed	8 (0.889)	7 (0.875)			7	5	0.625	78.8 ± 42.9	1.10 ± 0.77
AG247 x TNPOLK1				8 splg		5 (0.625)	2	0.250	56.5 ± 26.2	0.70 ± 0.33
TNMON8 x JB271				13 splg		8 (0.615)	7	0.538	62.7 ± 12.7	0.70 ± 0.23
CH88 x TNGRU1				56 seed	51 (0.911)	45 (0.882)	32	0.627	52.0 ± 19.8	0.50 ± 0.26
Chinese O.P.				1 seed	1 (1.00)	1 (1.0)	1	1.0	56.5 ± 0	0.79 ± 0
American O.P.				7 seed	4 (0.571)	1 (0.250)	1	0.250	36.5 ± 0	0.27 ± 0
TNMON5 x Gideon				3 splg		2 (0.667)	2	0.667	63.5 ± 26.2	1.20 ± 0.23
Totals	225	130 (0.710)	94 (0.547)	88	56 (0.875)	117 (0.672)	80	0.684	60.9 ± 27.1	0.8 ± 0.5

Table 2: VTS-Milan Metrics

Variety	2009 planting	# Germ. (Rate)	# Alive Fall 2009 (Rate)	2010 planting	# Germ. (Rate)	# Alive Fall 2010 (Rate)	# Alive Fall 2011	To Date Survival Rate	2011 Height (in)	2011 Diameter (in)
AG247 x TNPOLK1	81 seed	28 (0.346)	22 (0.786)			13	4	0.143	62.2 ± 14.3	0.97 ± 0.25
TNMON5 x M-19	273 seed	102 (0.373)	88 (0.863)			77	36	0.353	44.5 ± 18.0	0.67 ± 0.39
O-7 x I-11	148 seed	113 (0.764)	106 (0.938)			100	75	0.664	61.5 ± 21.8	1.05 ± 0.51
E30 Qing	16 seed	12 (0.750)	11 (0.917)			11	11	0.917	74.1 ± 13.5	1.20 ± 0.34
Whigg Mon	16 seed	10 (0.625)	6 (0.600)			5	2	0.300	47.5 ± 4.0	0.62 ± 0.03
TNMON5 x Gideon	20 seed	14 (0.700)	12 (0.857)			10	4	0.286	38.5 ± 14.8	0.51 ± 0.36
AG200 x TNHAM2				97 seed	56 (0.804)	45 (0.804)	15	0.268	41.7 ± 13.4	0.54 ± 0.27
TNMON x M-19				7 splg		4 (0.571)	0	0		
O-7 x I-11				5 splg		2 (0.400)	0	0		
Chinese O.P.				10 seed	7 (0.857)	6 (0.857)	4	0.571	39.9 ± 16.2	0.54 ± 0.37
American O.P.				16 seed	8 (0.250)	2 (0.250)	2	0.250	23.3 ± 12.4	0.52 ± 0.31
TNMON5 x Gideon				10 splg		7 (0.700)	6	0.600	59.3 ± 20.5	0.98 ± 0.49
Totals	554	279 (0.504)	245 (0.878)	145	71 (0.577)	282 (0.834)	160	0.567	54.8 ± 21.5	0.88 ± 0.49

Appendix 1:

Orchard Data

Please see Excel Spreadsheet for this information.

File posted as:

Ongoing Maintenance and Monitoring of Established American Chestnut (*Castanea dentata*) Test Orchards on Two TNARNG Installations. Final Report December 2011: Appendix 1. (Legacy 10-401)

Appendix 2:
Photos

Legacy Project #10-401

Ongoing Maintenance and Monitoring of
Established American Chestnut
(*Castanea dentata*) Test Orchards on
Two TNARNG Installations

Appendix 2 - Photographs

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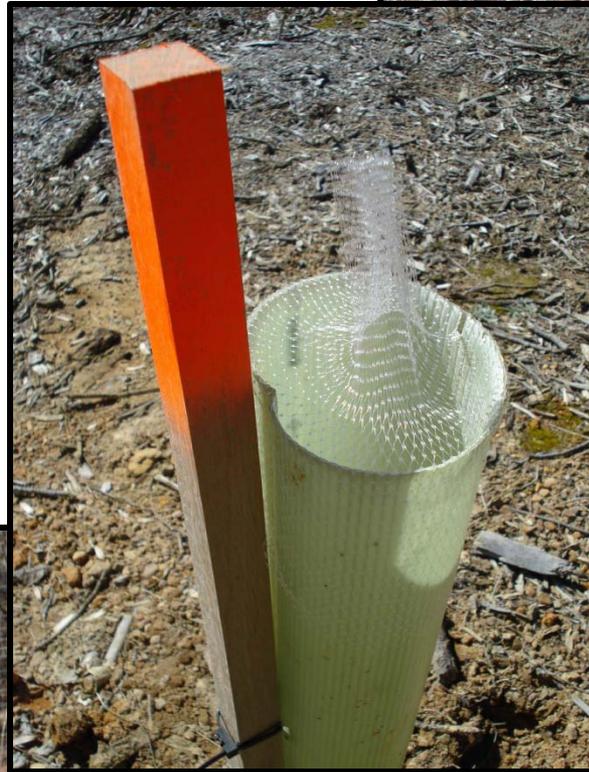


VTS-Milan



VTS-Catoosa

In February 2009, the TNARNG established two American chestnut test orchards. In total, 533 seeds were planted at the VTS-Milan orchard, and 173 seeds and 42 seedlings were planted at the VTS-Catoosa orchard. The plants germinated and grew into small seedlings during the 2009 growing season.



In spring 2010, more seeds and seedlings were planted: 145 at VTS-Milan and 91 at VTS-Catoosa .



Things are pretty unimpressive in February at VTS-Catoosa.....



...and in early March at VTS-Milan.

But soon enough, everything greens up and the chestnuts, small and large, leaf out.

VTS-Catoosa May 2011



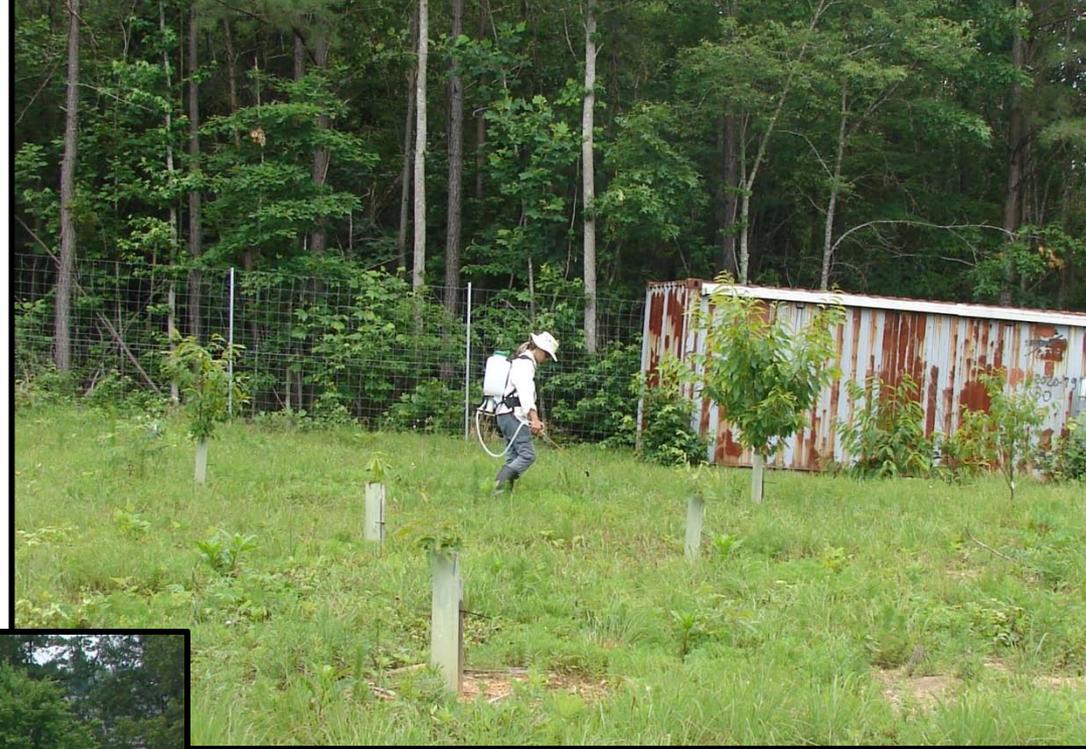


VTS-Milan in June 2011.

In some cases, new sprouts appeared from the root stock of apparently dead seedlings – a trait that has helped stave off the extirpation of this species by the blight.



But with the growing season come all of the maintenance requirements....



Rows at both orchards are sprayed several times during the summer with a glyphosate herbicide to minimize competition for the chestnut seedlings.

Now that the seedlings are well out of their protective tree-tubes, it is essential to avoid herbicide drift or accidental application to the young trees.



Once or twice a month during the growing season, as the grass gets tall, it's time to bring out the mowers and string trimmers.

Keeping the vegetation around the trees cut low not only maintains a tidy appearance but helps to limit competition from some of the more aggressively growing weeds, including Japanese honeysuckle, pokeweed, and woody species.





Fertilizing began in May/June.

The old method at VTS-Milan involved a lot of bucket-carrying....



But the new pump tank and trailer take a lot of the effort out of the process.



The slope at Catoosa makes the use of rainwater feasible – with enough hoses and a bit of bucket carrying, water is run from the two containers to the entire orchard. In the event of a severe drought, water may have to be trucked in, but so far this system has been sufficient – and easier than maneuvering a trailer up to and around the orchard.

Despite the weed control efforts, there were times when other species got in the way:



Pokeweed often grew up within the tree-tube with the chestnut. It didn't appear to significantly harm the seedlings, and the weed was easily pulled out.



Horse nettle was another common weed at VTS-Milan – but much harder to remove from the tubes, especially bare-handed.



Grasses could also be a problem; both within the tube and without.



The trees at VTS-Catoosa started the summer looking quite healthy.



Although there were noticeable differences in size and growth form:

The two trees above are the same age.

The tree to the right is typical of the pure Chinese chestnut growth form.





The VTS-Milan also had a high sapling size variability.



At VTS-Milan the differing success rates of the hybrid varieties was also apparent: the right-hand row above is the 0-7 x I-11 cross which had the highest germination, survival, and growth rates of the seeds planted at that site, while the left row is TNMON-5 x M-19.



The American chestnut is a precocious tree species:
In June a number of the 2- and 3-year-old seedlings flowered, and several set fruit.





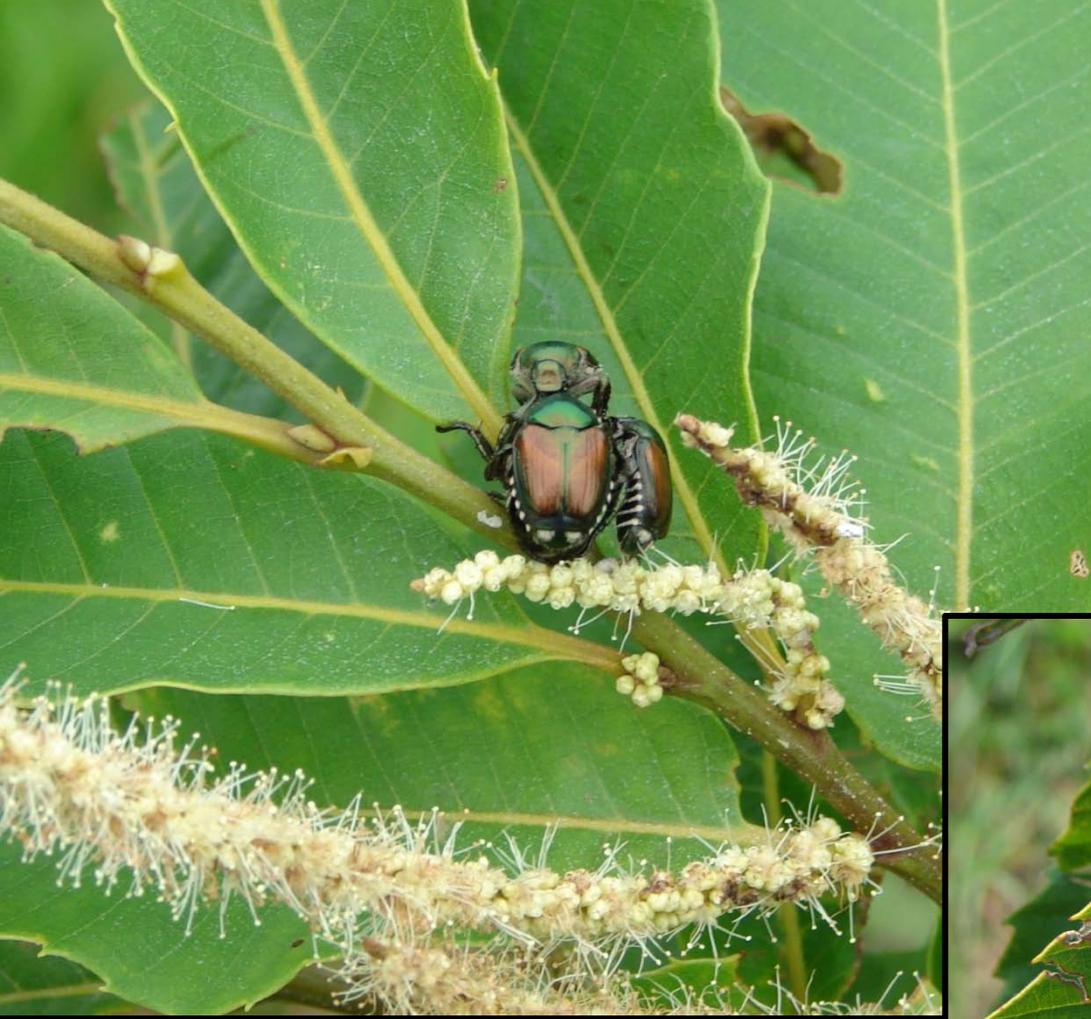
At last count, two saplings at VTS-Catoosa and three at VTS-Milan (including the two year old above) appeared to be growing healthy fruits.



One of the chestnuts at VTS-Milan carried its fruit to the final stage of dehiscing or splitting open. Two of the fruits had split and fallen to the ground; no seeds were found – they were probably eaten by a small mammal.



The third fruit had split but remained on the tree. Clearly two of the seed are non-viable, but the third looks quite healthy. Time will tell.



Japanese beetles found the orchards this year. While they did some damage to leaves, there did not appear to be any substantial impact on the seedlings.



Of more concern was the unexplained wilting of seedlings that had appeared healthy just a few weeks earlier. This did not appear to be related to water availability.





These seedlings have not been declared “dead” yet because there is the possibility they will re-sprout from the rootstock next spring.

Both orchard sites experienced this wilting and apparent dieback, often affecting several seedlings in a row among healthy individuals.





To be continued...