



Genetic Improvement of Cottonwood and Hybrid Poplar for Short Rotation Woody Crop Systems

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Who We Are: Focused on the Future of Forestry

- Leading producer of purpose grown trees
 - Produce nearly 300 million seedlings per year
 - Drawing on 50+ years of forestry and technology experience
 - Multi-national team of dedicated conservationists, biologists, foresters, researchers and scientists
- Technology leader
 - Innovative product platform: Pine and hardwood
 - Pipeline of world-class elite germplasm
 - More forestry field / regulatory trials than any other companies



Our Approach: Providing Better, More Sustainable Purpose Grown Trees

- Conventional tree improvement
 - Breeding and selection
- Accelerated improvements through advanced genetic technologies
 - Hybrids
 - Advanced propagation technologies
 - Introduced traits
 - Marker assisted breeding

Products include both hardwood & pine



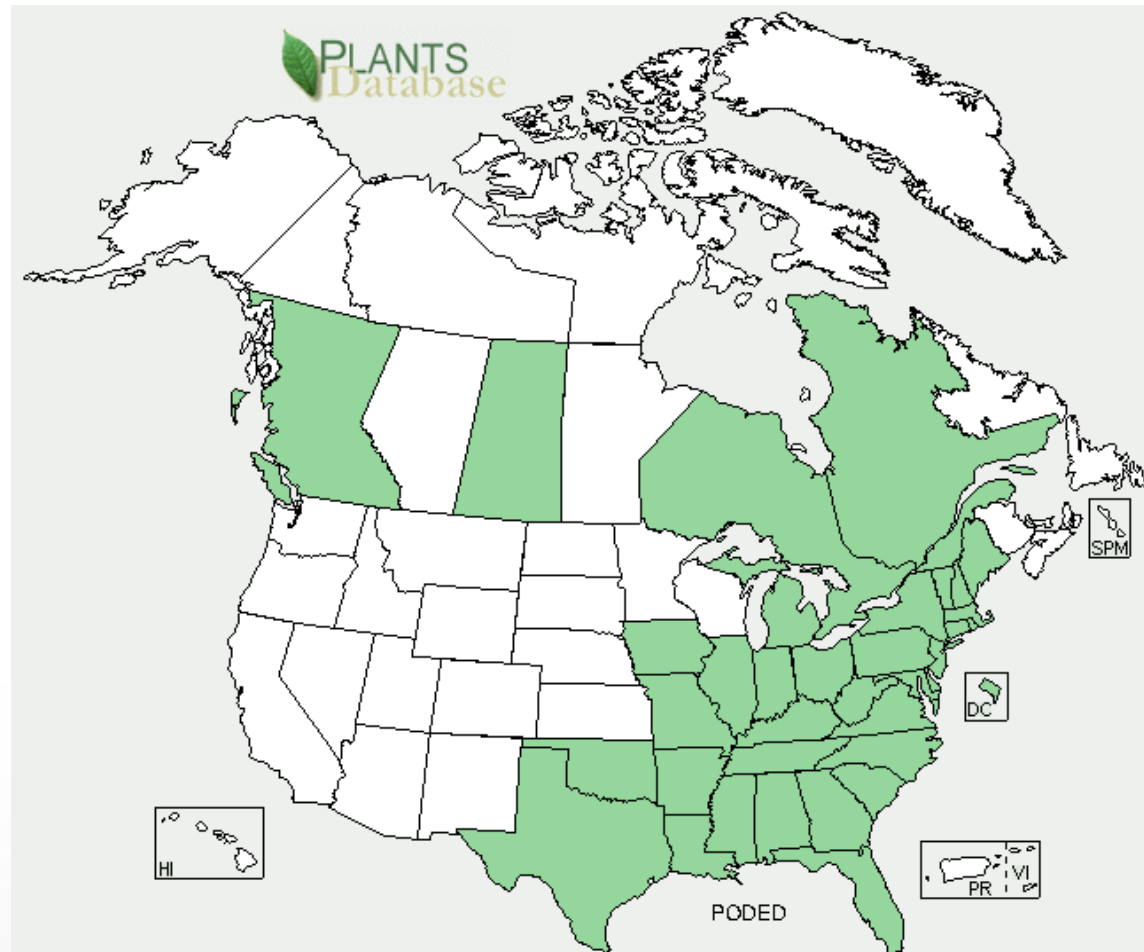
Our Focus Today: Cottonwood/Hybrid Poplar

- Widely distributed in North America
- Fast growing & highly productive
- 10 to 15 green tons/ac/yr (2-6 year rotation)



6-year-old cottonwood in Loxley, AL

Distribution of Eastern Cottonwood (*Populus deltoides*)



ArborGen's purpose grown hardwood portfolio



* Not yet commercially available

Genetic Improvement (422 varieties total)

Tests include:

- Wooten Farm, NC – Ag. field
 - Age: 2 yrs
 - Spacing: 10' x 4' (87 varieties)
- Eastover, SC – Ag. field
 - Age: 4 yrs
 - Spacing: 10' x 4' (243 varieties)
- Moultrie, SC – Former pine site
 - Age: 3 yrs
 - Spacing: 12' x 7' (161 varieties)
- Floyd, GA – Former pine site
 - Age: 8 yrs
 - Spacing: 12' x 8' (120 varieties)
- Randolph, AL (2 tests) – Former pine site
 - Age: 3 yrs
 - Spacing: 12' x 7' (162 varieties) & 12' x 4' (124 varieties)



- Design:
 - Randomized Complete Block
 - 4 replications at Floyd, 6 replications at all other sites

Tree Performance (5 sites; 422 varieties total)

Average tree height & DBH (range in parentheses)

Test	Age (yrs)	Height (ft)	DBH (in)
Wooten Farm, NC	2	14.2 (6.0-18.8)	1.4 (0.8-2.1)
Eastover, SC	4	30.0 (12.4-37.7)	3.1 (0.9-5.2)
Moultry, SC	3	11.9 (5.7-20.5)	1.2 (0.2-2.9)
Floyd, GA	8	55.9 (41.2-69.9)	6.2 (3.5-8.3)
Randolph-1, AL	3	18.0 (13.0-22.9)	1.9 (1.1-2.5)
Randolph-2, AL	3	17.2 (10.5-25.5)	1.6 (0.7-2.7)



4-year-old tree in
Moultry, SC test

Data Analysis: Best Linear Unbiased Prediction (BLUP)

- Developed for and widely used in animal breeding
- Also adopted in plant breeding but not used as widely as in animal breeding
- Uses a mixed-model regression approach
- Produces predicted values for each level of a random variable
- Predicts genetic merit (breeding values) for plants and animals in genetics trials

BLUP Model – 5 sites; 6 tests; 422 varietals

Standardized data prior to analysis to account for different ages

$$Y_{ijk} = \mu + t_i + b(t)_{ij} + v_k + (tv)_{ik} + e_{ijk}$$

Y_{ijk} is the observation in the j^{th} block on the k^{th}
varietal at the i^{th} test

μ is the intercept

t_i is the effect of the i^{th} test

$b(t)_{ij}$ is the effect of the j^{th} block within the i^{th} test

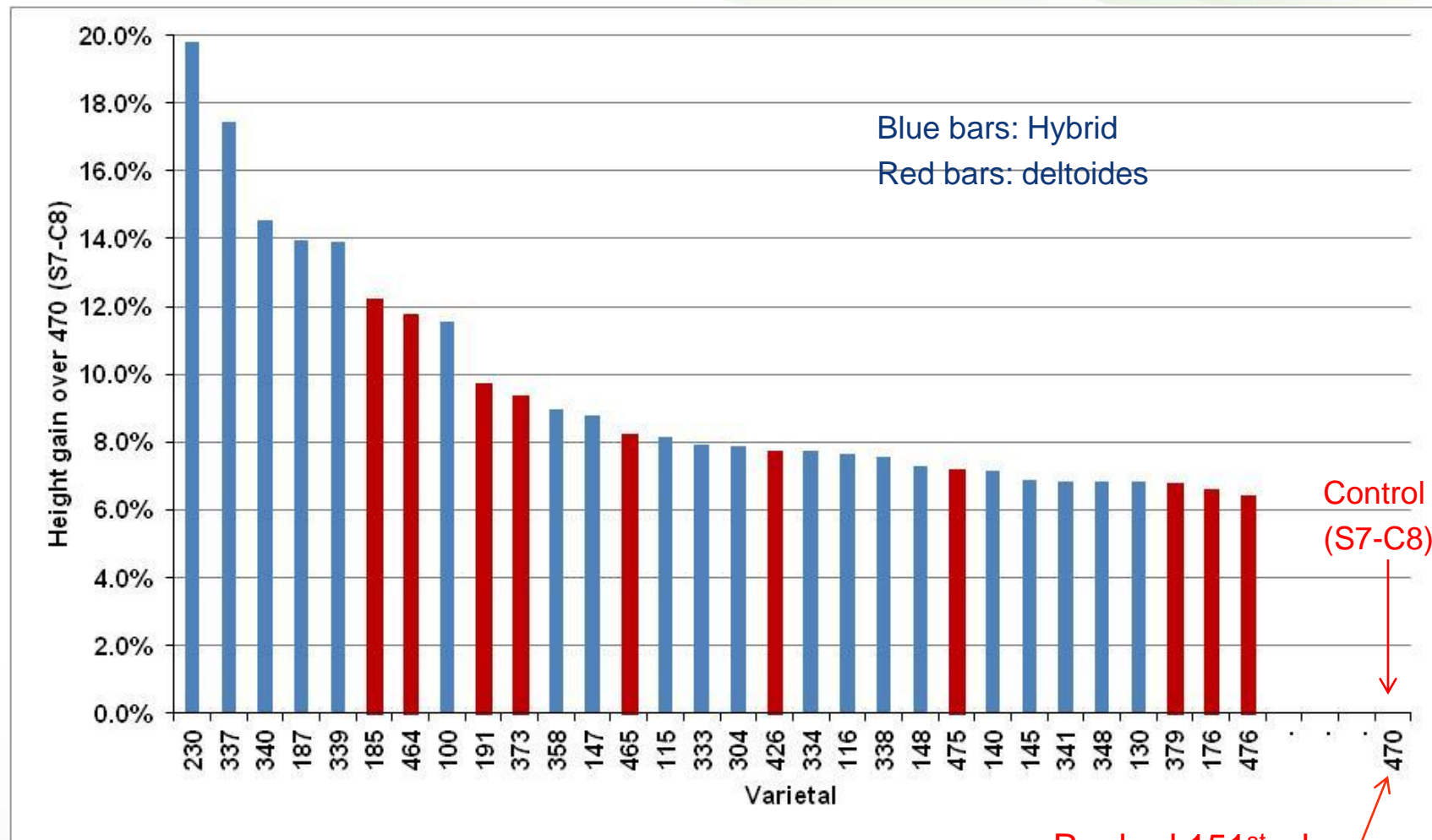
v_k is the effect of the k^{th} varietal

$(tv)_{ik}$ is the ik^{th} test-by-varietal interaction

e_{ijk} is the random error

BLUP Analysis – Standardized Height

(Top 30 varietals)

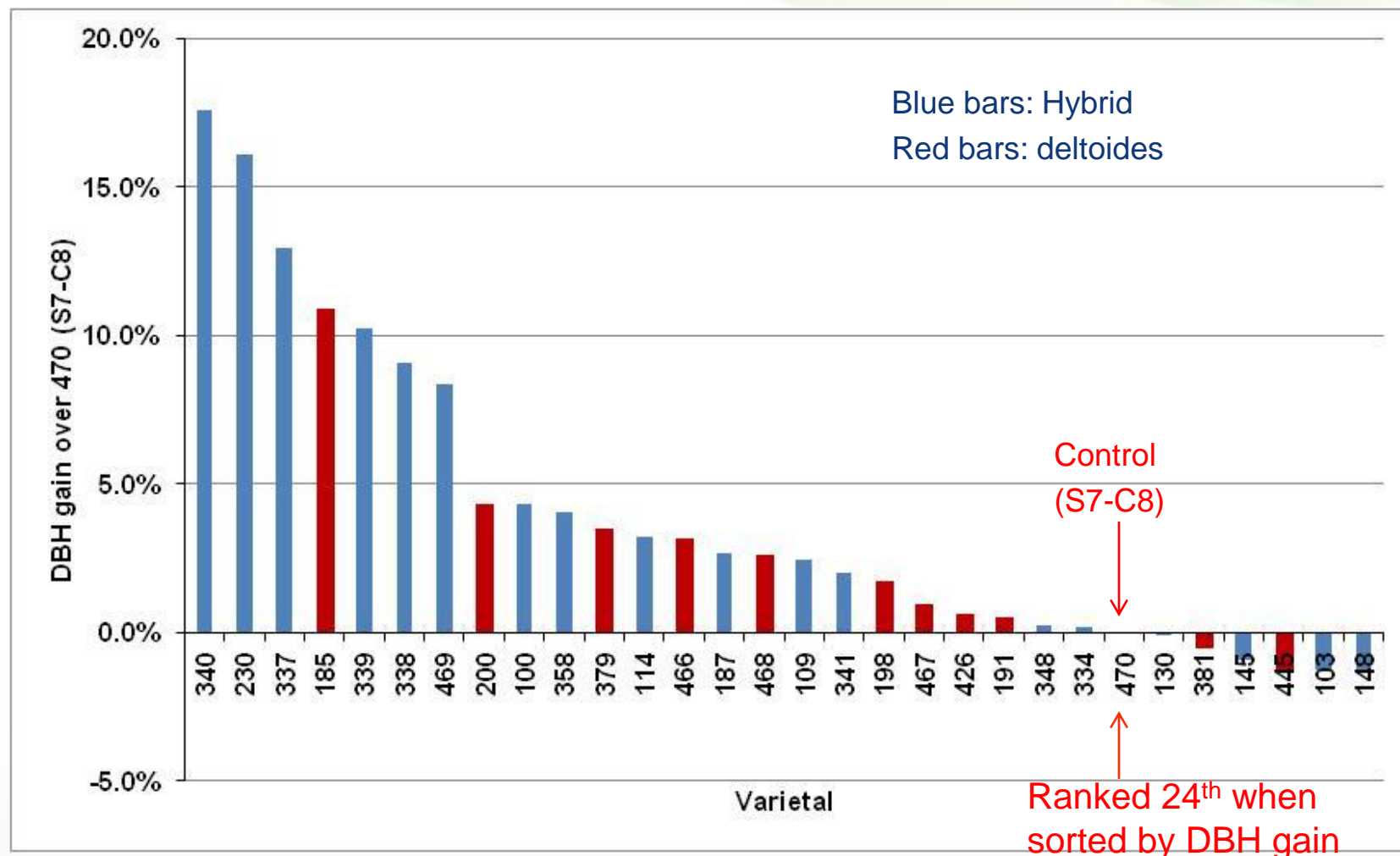


Control
(S7-C8)

Ranked 151st when
sorted by Height gain

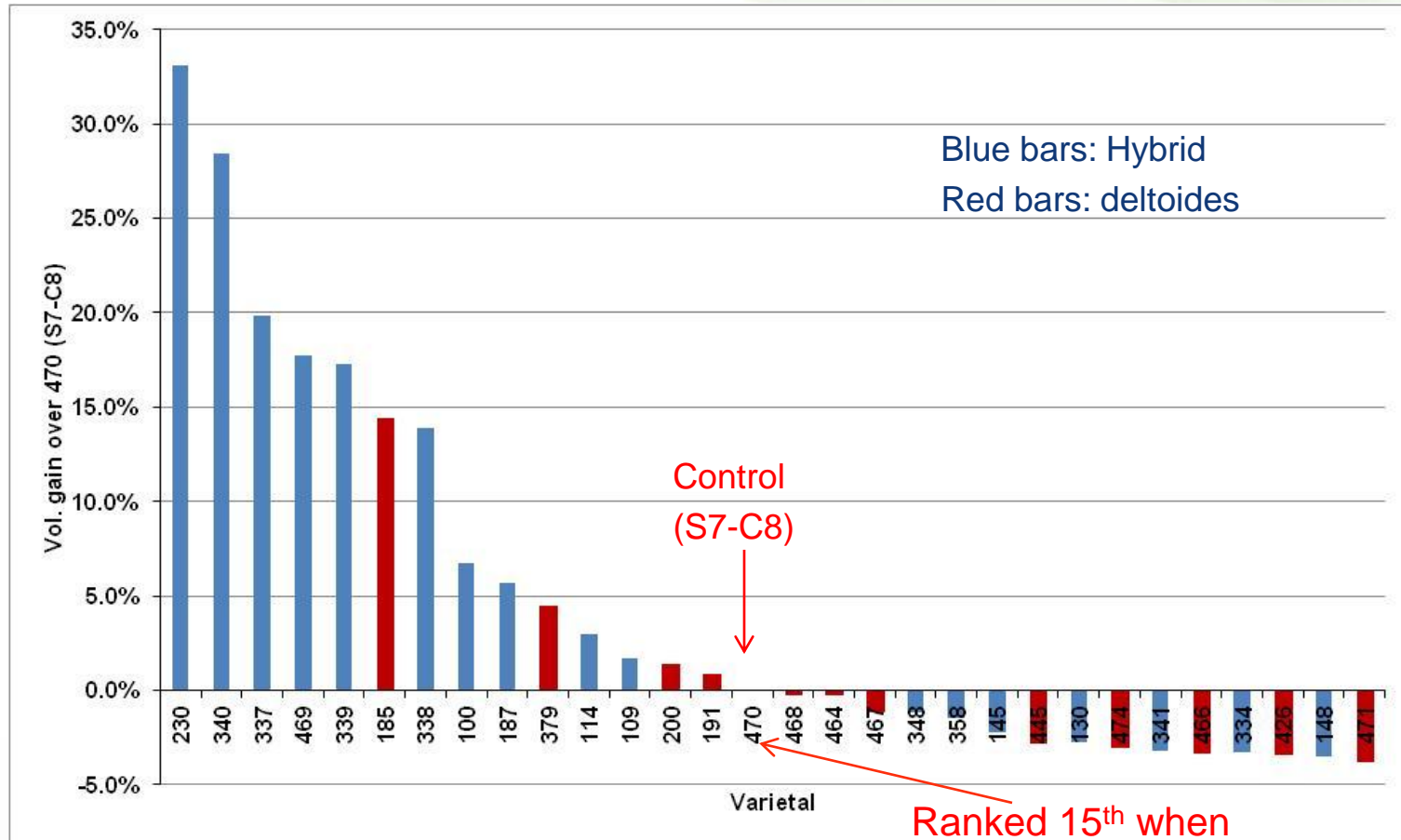
BLUP Analysis – Standardized DBH

(Top 30 varieties)



BLUP Analysis – Standardized Volume

(Top 30 varieties)



Vol. outside bark (ft³) = 0.06 + 0.00221 D²H

Krinar, RM. 1988. Volume equations for plantation cottonwood trees (*Populus deltoides*). Research Note SO-347, USDA Forest Service

Is the Gain Significant?

Results from individual contrast with varietal 470 (S7-C8)

Standardized Height				
Varietal	Least Sq Mean	Std Error	Contrast vs S7-C8	
			F Ratio	Prob > F
230*	120.66	4.86	9.7044	0.0019
337*	118.58	5.29	7.0733	0.0080
340*	115.31	5.35	4.6872	0.0308
187*	115.04	4.91	5.0031	0.0256
339*	114.73	5.61	4.0759	0.0439
185*	113.28	4.48	4.2685	0.0392
464	112.62	6.64	2.3652	0.1250
100	112.34	5.44	2.9375	0.0870

Standardized DBH				
Varietal	Least Sq Mean	Std Error	Contrast vs S7-C8	
			F Ratio	Prob > F
340	131.52	8.38	1.066	0.3023
230	130.18	7.62	3.063	0.0805
337	127.01	8.29	1.6849	0.1947

Standardized Volume				
Varietal	Least Sq Mean	Std Error	Contrast vs S7-C8	
			F Ratio	Prob > F
230*	162.86	11.38	7.2982	0.0071
340*	155.93	12.52	4.512	0.0340
337	147.11	12.40	2.5111	0.1135
469	143.44	13.12	1.6257	0.2027

**Statistically significant contrasts*

Blue: Hybrid, Red: deltoides

Wood Properties: Randolph (AL) Test

(Top varieties from BLUP analysis;
Age: 4 yrs)

- Specific gravity
 - 3 trees/variety
 - Cores extracted in Oct. 2012
 - 5.1 mm core diam
 - Volume estimated using water immersion method
 - Cores dried at 101°C for 72 hrs (constant weight)
- More cores from other sites (to be collected)

Varietal	Avg. Basic	
	Sp. Gravity	Std. Dev.
174	0.407	0.031
109	0.395	0.029
470	0.384	0.056
200	0.383	0.018
100	0.381	0.022
379	0.376	0.021
445	0.376	0.021
114	0.371	0.012
340	0.369	0.043
148	0.369	0.031
426	0.363	0.034
185	0.363	0.010
191	0.361	0.048
348	0.356	0.038
338	0.351	0.016
145	0.344	0.051
187	0.343	0.017
130	0.343	0.031
405	0.341	0.014
339	0.333	0.044
341	0.333	0.000
334	0.332	0.032
358	0.330	0.021
230	0.327	0.010
337	0.322	0.019
176	0.294	0.042

← Control



n = 3; Blue: Hybrid, Red: deltoides

Other Tests: ETREC Tests



Location: University of Tennessee
East Tennessee Research & Education
Center, Knoxville

Tests: 10 acre demo & a genetic trial (5 replications)
(Other demo & a genetic trial in AL)

Planted: March 2012 under IBSS grant



Demo planting at ETREC (Oct. 2012)

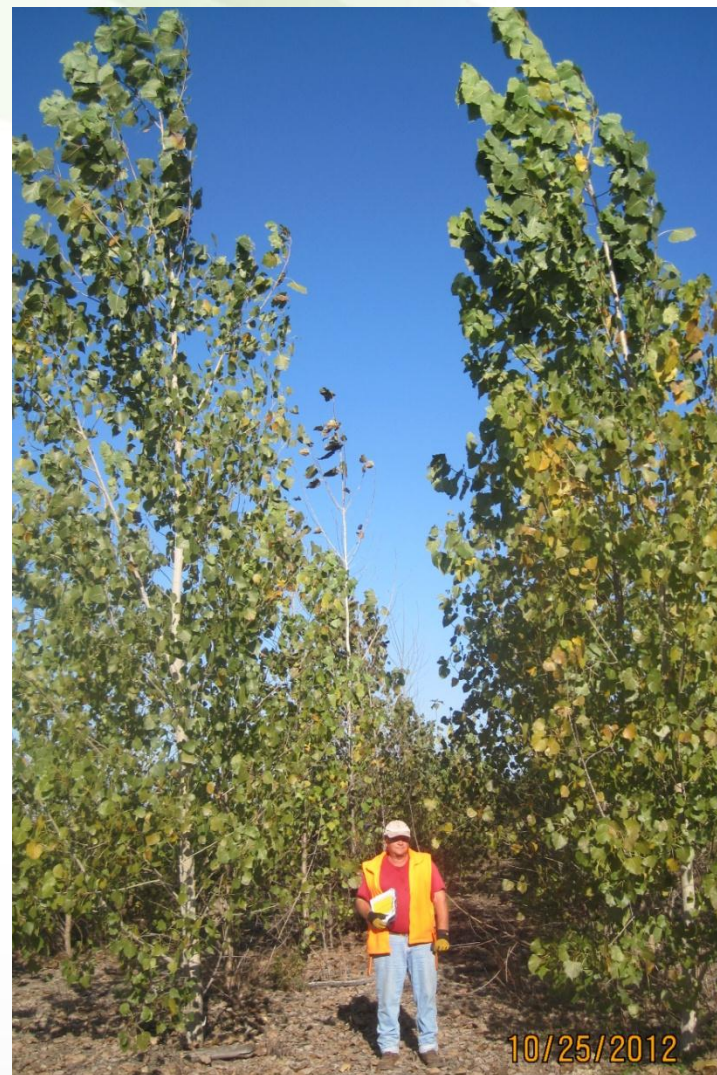
Top 20 varieties from ETREC
genetic trial (1st growing season)

Varietal	Avg. HT (ft)	Std. Dev.	Survival (%)
304	7.5	1.7	100
303	7.0	1.1	100
342	7.0	1.6	100
339	6.5	1.0	100
337	6.5	0.6	100
341	6.1	1.8	100
188	6.1	1.0	80
449	5.4	0.7	80
427	5.2	0.3	60
409	5.0	1.0	60
176	5.0	1.0	80
379	5.0	0.9	80
140	4.9	1.2	80
345	4.9	2.0	100
185	4.9	1.7	80
451	4.9	1.4	60
187	4.7	2.1	80
230	4.7	1.7	80
302	4.7	1.0	60
229	4.7	2.4	100

Blue: Hybrid, Red: *deltoides*

Summary

- Several varieties have shown superiority over the check in terms of height, DBH & volume gain
- Only few were significantly different from the check
- We continue to monitor these tests & plant more tests
- Pooled data from all tests should give us more confidence



4-year-old cottonwood in Moultrie, SC

Sun Grant (<http://www.sungrant.org>)
provided funding to maintain and manage 5
tests used in the BLUP analysis and also for
the specific gravity work



GreenWood Resources
(<http://www.greenwoodresources.com>)
provided some of the varieties



Questions/Comments?

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