24. Brundage_Wilson_HTIRC Select Clonal Evaluation

John Kelsey Rev: 2023g 2024 May

2023 July 26, was the closing day of the Walnut Council annual meeting in Columbia, MO. A group of interested people* traveled to the nearby Brundage_Wilson_HTIRC** Select Clonal Evaluation Planting. The Plot was planted in 2006 April and consist of three rows of HTIRC "Select" grafted clones (including wild control seedlings) separated by row of various "trainer species". The Select trees consisted of about 10 replications of 18 grafted clones plus two groups of state tree nursery control seedlings, one group from Indiana and one group from Missouri.

The three "Select" rows were measured every year starting in 2007, but the measuring stopped in 2017. It was of interest to make a new set of measurements for various reasons:

1. Are the trees still growing a full speed?
2. What defects are present that would impact timber value?
3. Can early growth measurements predict future growth?
4. How early in a tree's life can measurements project relative value at harvest time?
5. Do the trees need thinning?
6. Are any of the HTIRC Select clones significantly better (or worse) than the average wild seedlings available from state tree nurseries?
7. Could the planting be converted to a seed orchard?

The Diameters Breast High (DBH) of the 3 rows of the trial planting were measured using a pi tape. The merchantable lengths were estimated by the author, with occasional verification by Jim McKenna. The whole group watched for defects.

*Dan Jacobs, John Kelsey, Miles Kelsey, James McKenna, Shawn Mehlenbacher, Jim Middleton, Tom Molnar, Jeremy Wilson, Bryan Webber, and one more whose name I didn't get.

**Scot Brundage, Jeremy Wilson (owner), and The Hardwood Tree Improvement and Regeneration Center at Purdue University.

1. Tree Growth Rate

The usual way to judge the growing suitability of a site is the Site Index$_{50}$. The black walnut Site Index$_{50}$ is how tall black walnuts will be on the site at age 50. Figure 2. Shows the early average height measurements at the Brundage-Wilson-HTIRC planting. The site index for the planted area is clearly a 60. These trees will average 60 feet tall in 2056 – I'll pay $100,000 if I'm wrong.

Figure1. The early average measured heights of the Brundage-Wilson-HTIRC (BWH) select clones and controls compared to height expectations for various site indexes at age 50.

	DBH Average inch	DBH Stdev inch	DBH Growth inch/year	Height* Average feet	Height* Stdev feet	Height* Growth feet/year
2007				4.14	1.04	
2008				6.75	1.37	2.62
2009	1.15	0.47		8.81	2.22	2.05
2010	1.76	0.66	0.60	11.21	2.60	2.40
2011	2.27	1.07	0.51	12.48	4.17	1.27
2012	2.67	1.16	0.41	14.65	4.70	2.17
2013	3.05	1.23	0.37	16.60	4.94	1.95
2014	3.66	1.17	0.62	19.18	4.89	2.58
2015	4.19	1.20	0.53	20.76	4.95	1.58
2016	4.54	1.26	0.34	23.11	5.14	2.35
2017	4.92	1.32	0.39	25.91	5.46	2.80
2023	6.35	1.64	0.24	20.27	8.46	

* In 2023 the height measurement was changed to a merchantable length estimate

Figure 2. Diameter and height measurement average data

The HTIRC select trees averaged 1.41 inches of DBH growth between the 2017 and the 2023 measurements. Jerry VanSambeek suggests that most of the annual stem growth is complete by late July, so we should be dividing by 6 full years, giving only 0.24 inches per year of DBH growth. That is quite a drop. These trees were averaging about 0.4"/y diameter growth during the earlier measurements.

Knee-jerk thoughts were that this growth slowdown is the "We need thinning" message. In section 5 it will be shown that this is not so. There have been some other speculations for the cause of the slowdown, without some measurable proof, the cause of the slowdown needs to remain a mystery - - - a mystery worth solving.

2. Major Defects

In 2017 there were 10 trees with witch's broom. We saw no witch’s broom in the planting. We assume these trees have been removed. Whatever was done, it was perfectly effective.

We recorded serious Frost Cracks on 36 of 205 select trees. These defects do not heal and completely ruin the timber volume of the stem below the top of the crack. There were a lot more trees recorded with "seams" in 2017, and not the same trees??? What was a "seam" number in 2017? Maybe the frost crack event happened after 2017. It is easy to find out by cutting down one of the cracked trees and counting the annual rings back to the event. It is almost certain that all the cracks happened on the same winter morning. These cracked trees are poor candidates for final timber crop trees, but if they are otherwise impressive, they are probably okay for nut trees.

3. Can early growth measurements predict future growth?

There was one major change in the 2023 measurements, which makes comparisons somewhat problematic. The earlier measurements included total tree height. The 2023 measurements replaced the total height measurement with a "merchantable length" estimate. The reasons for the change were:

1. The trees have become tall and somewhat crowded.
2. The leaves were on in July.
3. Merchantable length is a standard cruising metric.
4. Merchantable length is roughly proportional to tree value – a more practical metric than total height once trees are big enough to make the estimations.

The change from full height to merchantable length measurement is necessary at some point. Merchantable height is not measureable for young trees, because the upper "stopper" flaws do not yet exist. Later, when trees become tall and crowded, full height measurement is difficult, besides, merchantable height is more desirable since it becomes proportional to true timber value at harvest time.

For a relative tree value score, we use $S = D^2 * L$, where D is the diameter breast high, and L is the merchantable length. This score is proportional to merchantable volume. We didn't have a professional black walnut cruiser, but we did the best we could. We only want compare competing trees, so we don't need true merchantable stem volume, only a stem score that is proportional to merchantable stem volume

In case you were sleeping through Linear Algebra class, R^2 is a measure of goodness-of-fit. An R^2 of 1.0 is a perfect fit, i.e., every point on a straight line. An R^2 of 0.0 is a horrible fit – no correlation between the two variables – like a circular shotgun blast.

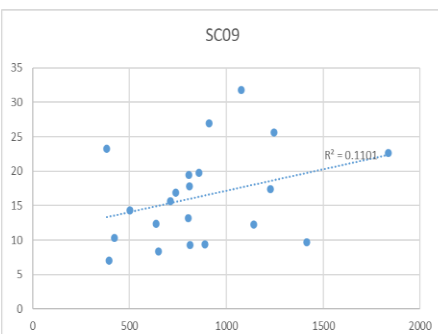

Figure 3 shows little correlation (R2 = 0.1) between the 2009 clone average volume scores and the 2023 measurements.

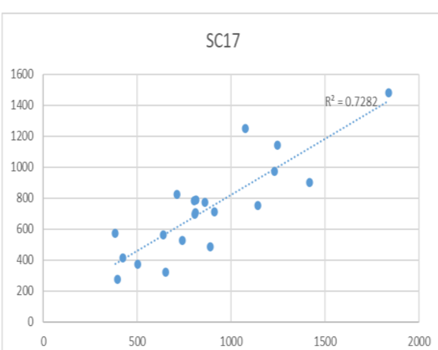

Figure 4. Shows the 2017 measurement somewhat predict (R2 = 0.7) the 2023 measurements. Likely the fit would have been even better if we had not changed the meaning of the vertical measurement.

year	leaf	ago	R^2
2009	4	14	0.11
2010	5	13	0.25
2011	6	12	0.39
2012	7	11	0.45
2013	8	10	0.50
2014	9	9	0.65
2015	10	8	0.66
2016	11	7	0.71
2017	12	6	0.73

Figure 5. Here is the goodness of fit (R^2) for years 4 to 12 compared to year 18. Notice that the closer in time, the better the agreement. In a few years, what's left of these trees should be measured again to see how stable the 18th-year estimates hold true.

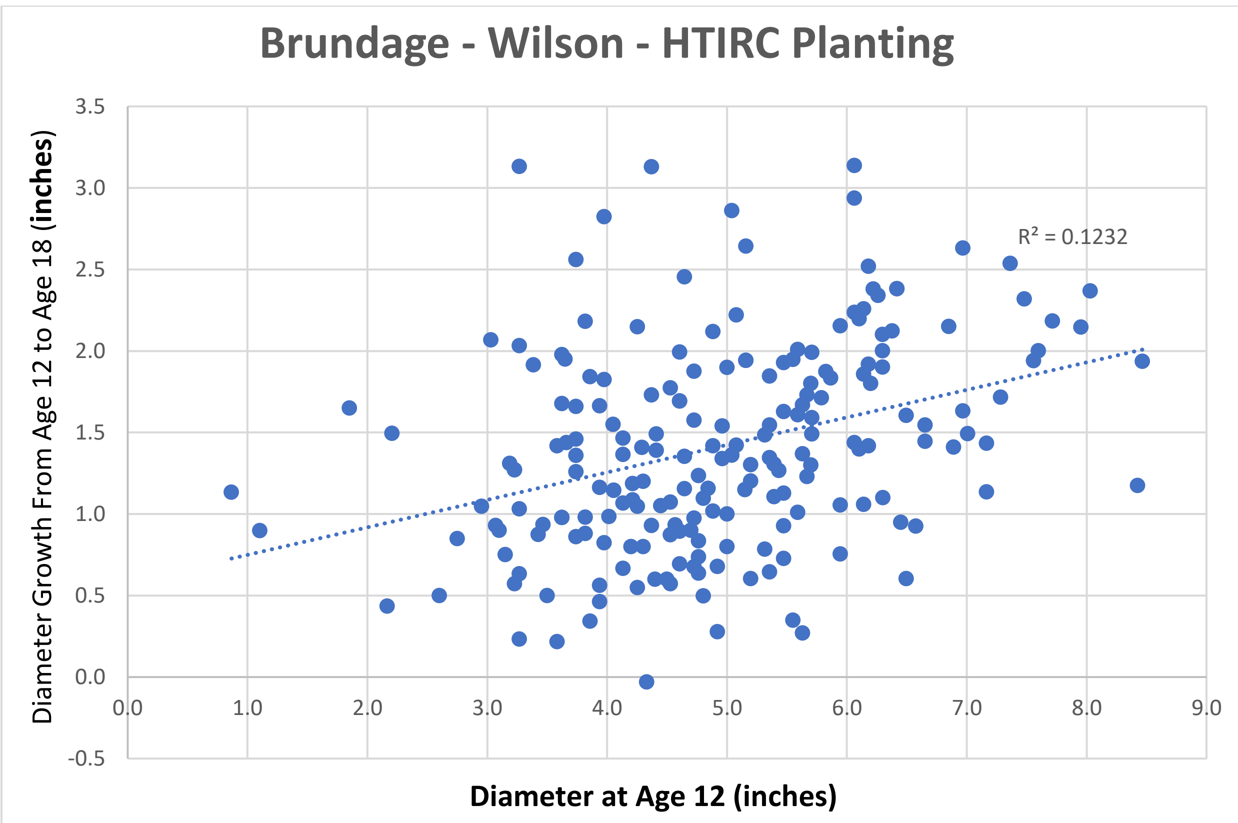

Figure 6. 6-year's diameter growth of all select trees vs. the diameter at the beginning of the 6-year period. R2 = 0.1, little correlation - a shotgun blast!

Can early growth measurements predict future growth? In this case the answer is clearly **NO**. This is an amazing result. Who would have guessed that the diameter growth from year 12 to 18 was completely oblivious to the first 12 year's growth?

4. How early in a tree's life can measurements project relative value at harvest time?

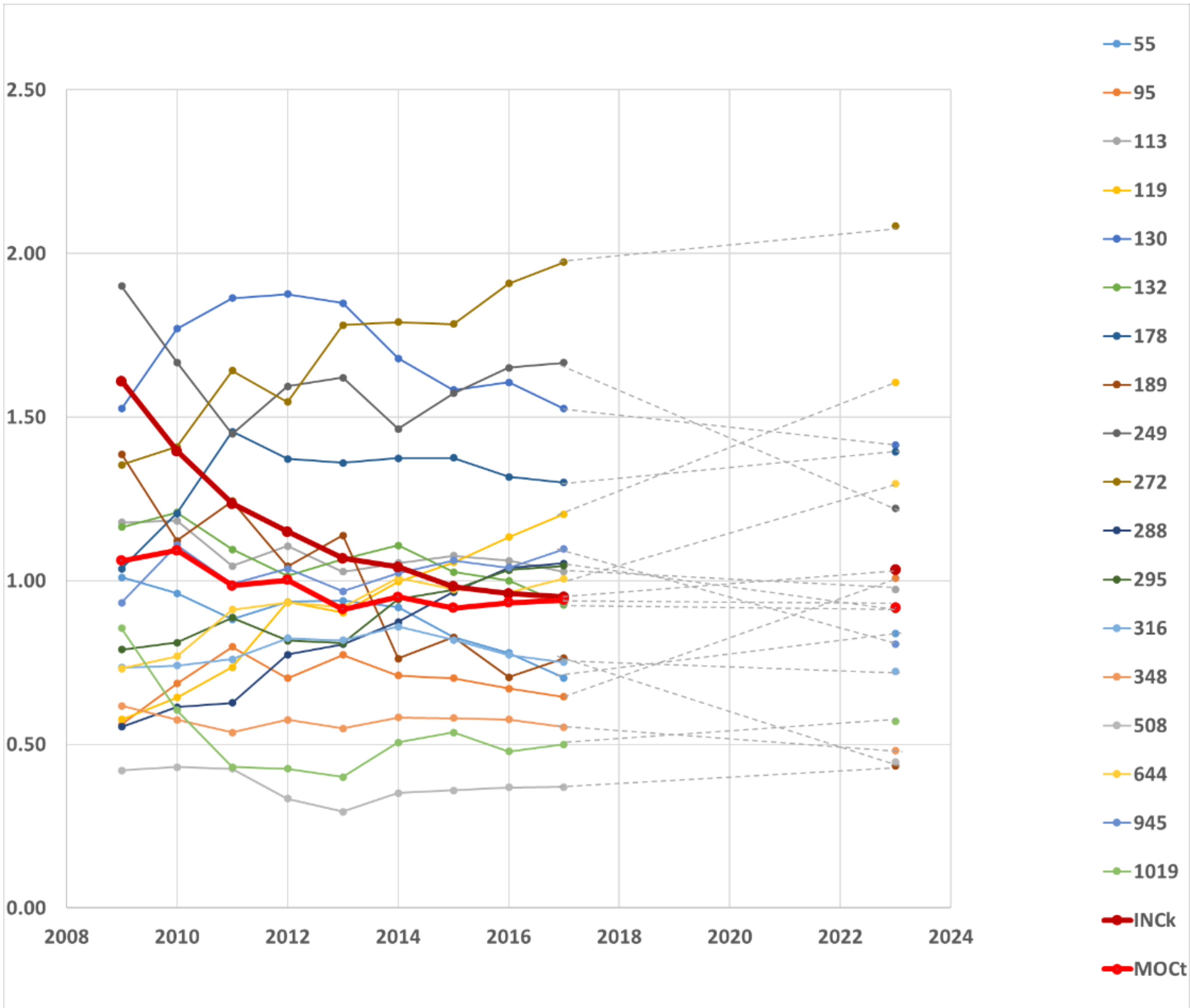

Figure 7. The stem scores measurements for the 18 clone groups plus 2 controls for ages 4 to 12, then again at age 18 (all compared to the annual average - - - average = 1.0).

The rankings of most clone groups seem to level off around year 9 (2014). Before age 9, some are slow starters and some are fast starters. It looks like attempting to identify timber crop trees before age 9 is a waste of time. The scrambling of rankings across the no-measurement-gap to age 18 is likely due to the change in the vertical measurement method.

5. Do the trees need thinning?

As shown in section 1, the growth gate has dramatically slowed since age-12. Our first thought was the need for thinning, since it is typical for overcrowding to cause a growth slowdown. There are several forestry metrics to assess crowding, but Crown Competition Factor (CCF) is the most logical. The CCF is the ratio of the canopy area needed for a tree to grow at full speed, divided by the spacing it has. From measurements of open-grown trees, the room needed for black walnut full speed growth is a canopy circle whose diameter (feet) is 2 times the DBH (inches) plus 5 feet. The space needed for a row is the sum the space needed for each tree in a row.

row	2	4	6	total	
Row width	14.25	14.25	15		feet
Row Length	1125	1125	1125		feet
growing space	**16031**	**16031**	**16875**	**48938**	sqft
needed space	**17250**	**18779**	**16207**	**52236**	sqft
CCF	**108%**	**117%**	**96%**	**107%**	

Figure 8. The CCF is calculated at 107% in 2023 for the select black walnut trees. The "needed space" is the sum of the needed space for each tree.

The measured growth rate during the last 6 years is 60% of the earlier growth rate. A CCF of 107% explains hardly any of the big growth slowdown. It only explains 7% of it during the last year. A CCF of 107% does indicate that the planting is at the beginning of overcrowding, but has not been overcrowded in the past.

row	2	4	6	total	
Row width	14.25	14.25	15		feet
Row Length	1125	1125	1125		feet
growing space17	**16031**	**16031**	**16875**	**48938**	sqft
needed space17	**11609**	**13496**	**11502**	**36607**	sqft
CCF17	**72%**	**84%**	**68%**	**75%**	

Figure 9. The CCF is calculated at 75% in 2017 for the select black walnut trees.

Since the CCF was 75% in 2017 and grew to 107% in 2023, that averages a CCF increase of 5.4% per year. Assuming linearity, we can calculate the CCF for the non-measurement years and somewhat into the future.

year	CCF
2017	**75%**
2018	80%
2019	86%
2020	91%
2021	97%
2022	102%
2023	**107%**
2024	113%
2025	118%

Figure 10. The interpolated and projected CCF for the select black walnut trees

So only this year has the CCF been significantly above 100%. The growth slowdown due to crowding should be only this year and almost imperceptible. In other words, we are just now at canopy closure. We need to look elsewhere for the cause of the growth slowdown. Here are some questions:

1. How abrupt was the growth slowdown?
2. Could we get some cores from ugly trees?
3. Has there been a serious drought during some of the last 6 growing seasons?
4. Is there any way fertility could change from the first 12 good growing years?
5. Is there a restrictive layer, like hardpan or water table, which would take effect at some size.
6. Looking up, did the trees look crowded? In other words is the CCF hogwash?
7. Any other ideas?

Getting back to the original question, "Do the trees need thinning?" The answer is yes. It is about time, and the crowding will get worse. The usual thinning practice is thinning to a CCF of 80%. That is 27% less than the current CCF, or culling about 1 tree in 4. This doesn't say which trees to cull, but it is a rough target. After thinning the CCF will increase 5% per year, so the planting will be back to its current state of crowding in 5 or 6 years. That is mathematical way of saying the canopy openings made by thinning will be closed in 5 or 6 years.

6. Are any of the HTIRC Select clones significantly better (or worse) than the average wild seedlings available from state tree nurseries?

A Size-Score was computed for each tree, which is proportional to usable volume. For the 2017 data the Size-Score is DBH squared times the tree height. For the 2023 data the vertical measurement was changed to "merchantable length", so a comparison of results between the two data sets is not quite "apples-for-apples". The 2017 Size-Score is proportional to stem volume up to the top. The 2023 Size-Score is proportional to merchantable volume up to a major sawlog "show-stopper" defect.

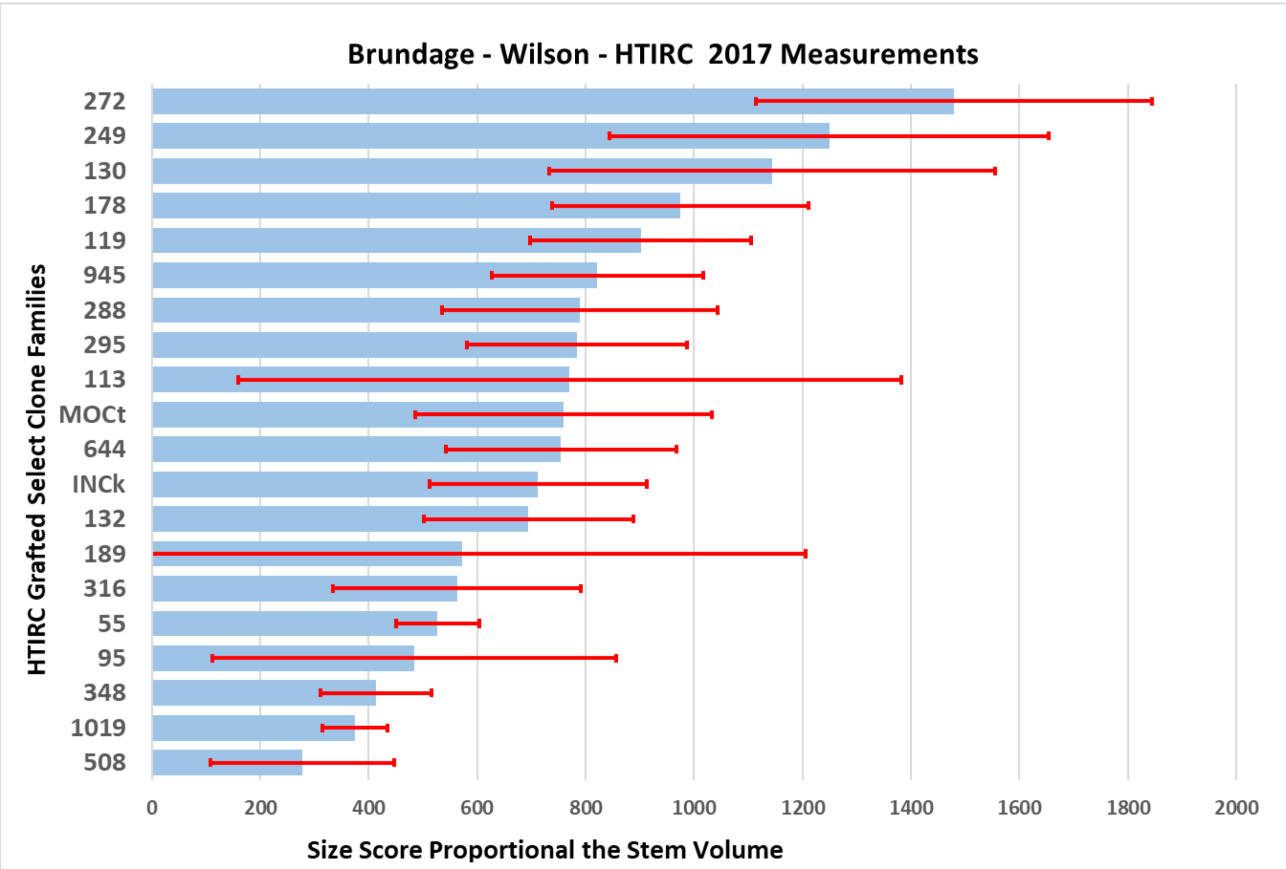

Figure 11. The 2017 size score for the 18 HTIRC select clones plus 2 control groups

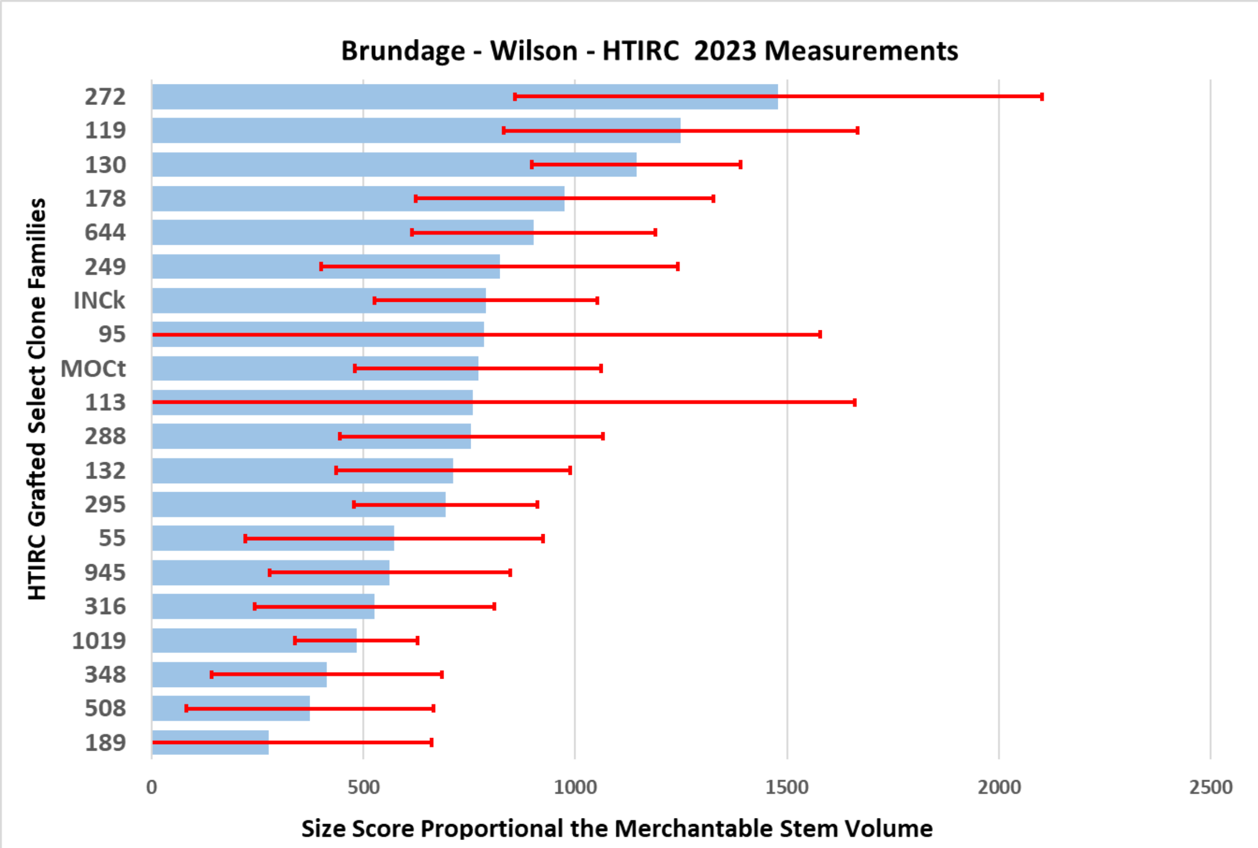

Figure 12. The 2023 size score for the 18 HTIRC select clones plus 2 control groups

The blue bars show the average Size-Score of the several HTIRC clone groups. The control entries, MOCt (Missouri Control), and INCk (Indiana Checks), are state tree nursery bed-run trees. They should represent average size of wild black walnut trees. The 95% confidence error bars are large, because the sample size for each clone family is small. Clone families 189, 113, and 95 only had 3 clones each, so that data is about worthless.

It looks like clone 272 is 5 times bigger than clone 189. One could get excited just looking at the clone average blue bars, but to confidently say one clone is bigger than another is a job for a LSD analysis. No, I'm not hallucinating, it's **L**east **S**ignificant **D**ifference).

DIFF/LSD		272	119	130	178	644	249	INCk	95	MOCt	113	288	132	295	55	945	ROOT	316	1019	348	508	189
	Score	1837	1416	1247	1229	1143	1076	911	889	883	859	813	808	804	740	711	691	638	502	423	393	383
272	1837	0.00	0.90	1.22	1.35	1.48	1.66	2.02	1.35	2.08	1.40	2.24	2.06	2.20	2.20	2.51	3.04	2.40	2.45	2.59	2.65	2.08
119	1416	-0.90	0.00	0.34	0.41	0.57	0.72	1.08	0.74	1.14	0.79	1.29	1.19	1.27	1.33	1.53	1.86	1.53	1.65	1.79	1.84	1.46
130	1247	-1.22	-0.34	0.00	0.04	0.21	0.35	0.70	0.50	0.75	0.54	0.90	0.84	0.90	0.97	1.13	1.37	1.17	1.32	1.45	1.51	1.21
178	1229	-1.35	-0.41	-0.04	0.00	0.19	0.34	0.71	0.49	0.77	0.53	0.93	0.86	0.92	1.00	1.18	1.47	1.20	1.35	1.50	1.56	1.22
644	1143	-1.48	-0.57	-0.21	-0.19	0.00	0.14	0.49	0.36	0.55	0.40	0.70	0.66	0.71	0.79	0.94	1.15	0.99	1.15	1.30	1.35	1.07
249	1076	-1.66	-0.72	-0.35	-0.34	-0.14	0.00	0.36	0.27	0.42	0.31	0.58	0.54	0.58	0.67	0.81	1.02	0.88	1.05	1.20	1.25	0.99
INCk	911	-2.02	-1.08	-0.70	-0.71	-0.49	-0.36	0.00	0.03	0.06	0.07	0.21	0.21	0.23	0.34	0.45	0.58	0.55	0.75	0.89	0.95	0.75
95	889	-1.35	-0.74	-0.50	-0.49	-0.36	-0.27	-0.03	0.00	0.01	0.03	0.11	0.11	0.12	0.20	0.26	0.30	0.35	0.51	0.61	0.65	0.58
MOCt	883	-2.08	-1.14	-0.75	-0.77	-0.55	-0.42	-0.06	-0.01	0.00	0.03	0.15	0.15	0.17	0.29	0.38	0.51	0.49	0.70	0.84	0.90	0.71
113	859	-1.40	-0.79	-0.54	-0.53	-0.40	-0.31	-0.07	-0.03	-0.03	0.00	0.07	0.07	0.08	0.16	0.21	0.26	0.30	0.47	0.57	0.61	0.54
288	813	-2.24	-1.29	-0.90	-0.93	-0.70	-0.58	-0.21	-0.11	-0.15	-0.07	0.00	0.01	0.02	0.14	0.23	0.32	0.35	0.57	0.71	0.77	0.61
132	808	-2.06	-1.19	-0.84	-0.86	-0.66	-0.54	-0.21	-0.11	-0.15	-0.07	-0.01	0.00	0.01	0.13	0.20	0.27	0.32	0.53	0.66	0.71	0.58
295	804	-2.20	-1.27	-0.90	-0.92	-0.71	-0.58	-0.23	-0.12	-0.17	-0.08	-0.02	-0.01	0.00	0.12	0.20	0.29	0.32	0.54	0.69	0.74	0.59
55	740	-2.20	-1.33	-0.97	-1.00	-0.79	-0.67	-0.34	-0.20	-0.29	-0.16	-0.14	-0.13	-0.12	0.00	0.06	0.11	0.19	0.41	0.55	0.60	0.49
945	711	-2.51	-1.53	-1.13	-1.18	-0.94	-0.81	-0.45	-0.26	-0.38	-0.21	-0.23	-0.20	-0.20	-0.06	0.00	0.05	0.15	0.39	0.54	0.59	0.47
ROOT	691	-3.04	-1.86	-1.37	-1.47	-1.15	-1.02	-0.58	-0.30	-0.51	-0.26	-0.32	-0.27	-0.29	-0.11	-0.05	0.00	0.12	0.39	0.56	0.62	0.47
316	638	-2.40	-1.53	-1.17	-1.20	-0.99	-0.88	-0.55	-0.35	-0.49	-0.30	-0.35	-0.32	-0.32	-0.19	-0.15	-0.12	0.00	0.23	0.37	0.42	0.35
1019	502	-2.45	-1.65	-1.32	-1.35	-1.15	-1.05	-0.75	-0.51	-0.70	-0.47	-0.57	-0.53	-0.54	-0.41	-0.39	-0.39	-0.23	0.00	0.13	0.18	0.16
348	423	-2.59	-1.79	-1.45	-1.50	-1.30	-1.20	-0.89	-0.61	-0.84	-0.57	-0.71	-0.66	-0.69	-0.55	-0.54	-0.56	-0.37	-0.13	0.00	0.05	0.05
508	393	-2.65	-1.84	-1.51	-1.56	-1.35	-1.25	-0.95	-0.65	-0.90	-0.61	-0.77	-0.71	-0.74	-0.60	-0.59	-0.62	-0.42	-0.18	-0.05	0.00	0.01
189	383	-2.08	-1.46	-1.21	-1.22	-1.07	-0.99	-0.75	-0.58	-0.71	-0.54	-0.61	-0.58	-0.59	-0.49	-0.47	-0.47	-0.35	-0.16	-0.05	-0.01	0.00

Figure 13. The 95% confidence LSD analysis for the 18 HTIRC select clones plus 2 control groups The numbers in the table are the difference in scores divided by the significant difference

Note: “ROOT” refers to several root stock sprouts where grafts failed. They are determined to be big trees, and sneak into the data.

In the LSD analysis a green square means the clone on the left is significantly bigger than the clone above. With 95% confidence, clone 272 is bigger than all famlies except clone 119. A pink square means the clone on the left is smaller than the clone above. Clone 189 on the bottom left is significantly smaller than the biggest 5 clones above. All the pairings in the central white area are not significantly different from each other.

Looking down the INCk and MOCt bed run columns, shows only families 272 and 119 are significantly bigger than wild trees. No families are significantly smaller. These inconclusive results points out the importance of sample size when trying to definitively evaluate differences between families. N = 10 is hardly enough, and more measurements in future years is not going to improve the sample size or tighten the margins of error. I do not see a way to squeeze more information from this planting in the future.

7. Could the Brundage-Wilson-HTIRC planting be converted to a seed orchard?

The LSD analysis above shows that only clone families 272 and 119 score significantly higher than bed run wild control trees. There are (11) 272s and (10) 119s in the planting. The first step would be to open space around these 21 trees to encourage nut production. Trees squeezed in the canopy are poor nut producers. The second step would be to improve the pollen source be thinning out the poorer trees from the entire plot. The pollen source for these 21 trees should continue to improve over the years as aggressive thinning improves the average genetics of the planting.