Converting between Western North American log scaling methods

BC Firmwood and Northwest Log Rules Cubic

Neal Hart Jendro & Hart, LLC Sunriver, Oregon

Timber Measurement Society Annual Meeting, April 2013

Today I'll discuss:

1 How Smalian's formula tends to overstate cubic volume where butt dia. is > 30% larger than top

2 How NWLR's 0.7 inch diameter correction factor overstates Scribner diameter bias in today's harvest

3 How Scribner's truncation of fractional diameters causes significant variability in NWLR Cubic volumes

4 That improving accuracy of NWLR Cubic requires adoption of unbiased diameter measurement

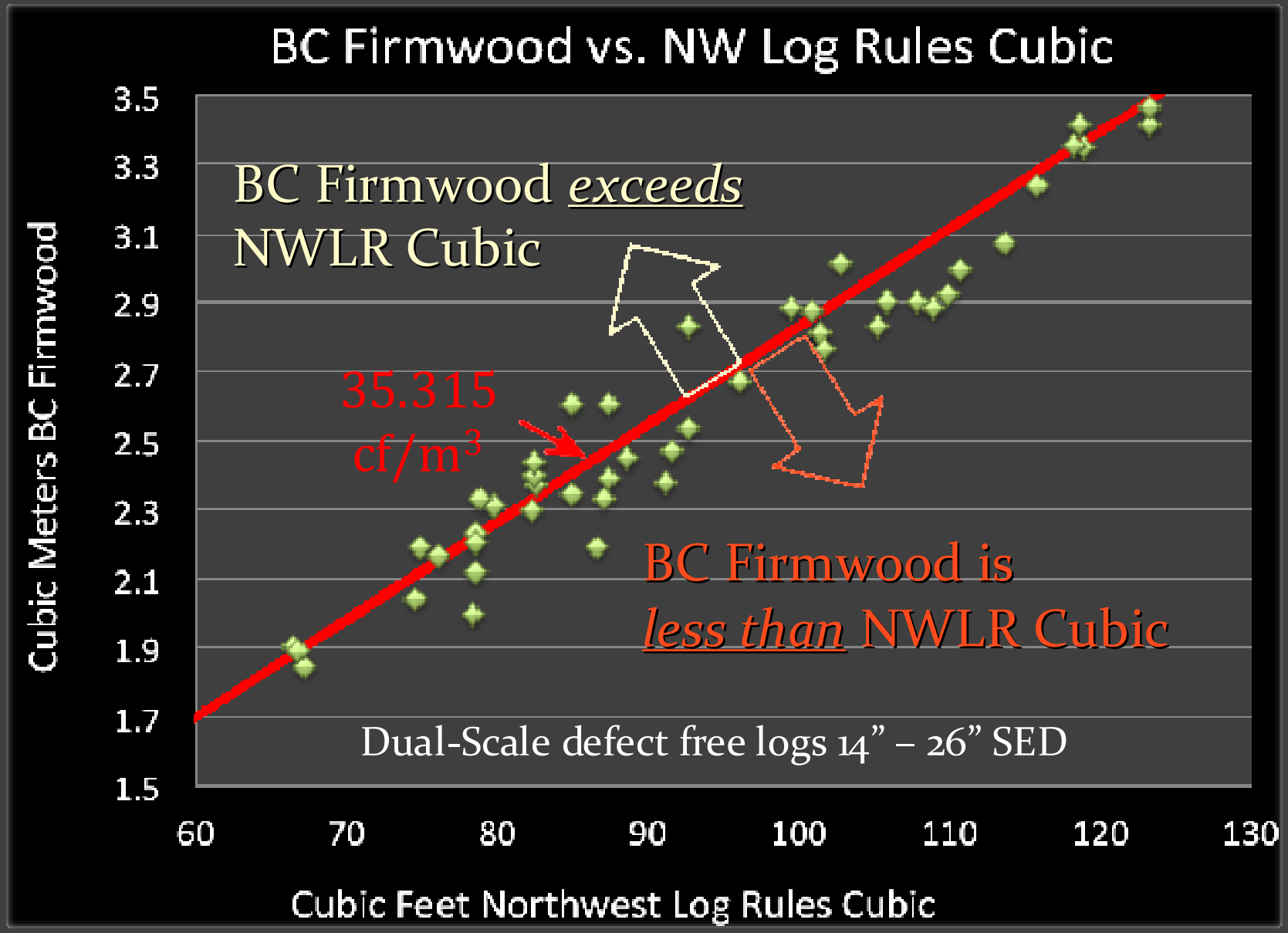
If BC Firmwood and Northwest Log Rules Cubic scales gave the same results…

The conversion between them would be the ratio of their measurement units, or 35.315 cf/m^3:

1 meter = 3.28084 feet

3.28084 feet cubed = 35.31467 cf

If BC Firmwood and Northwest Log Rules Cubic scales gave the same results…



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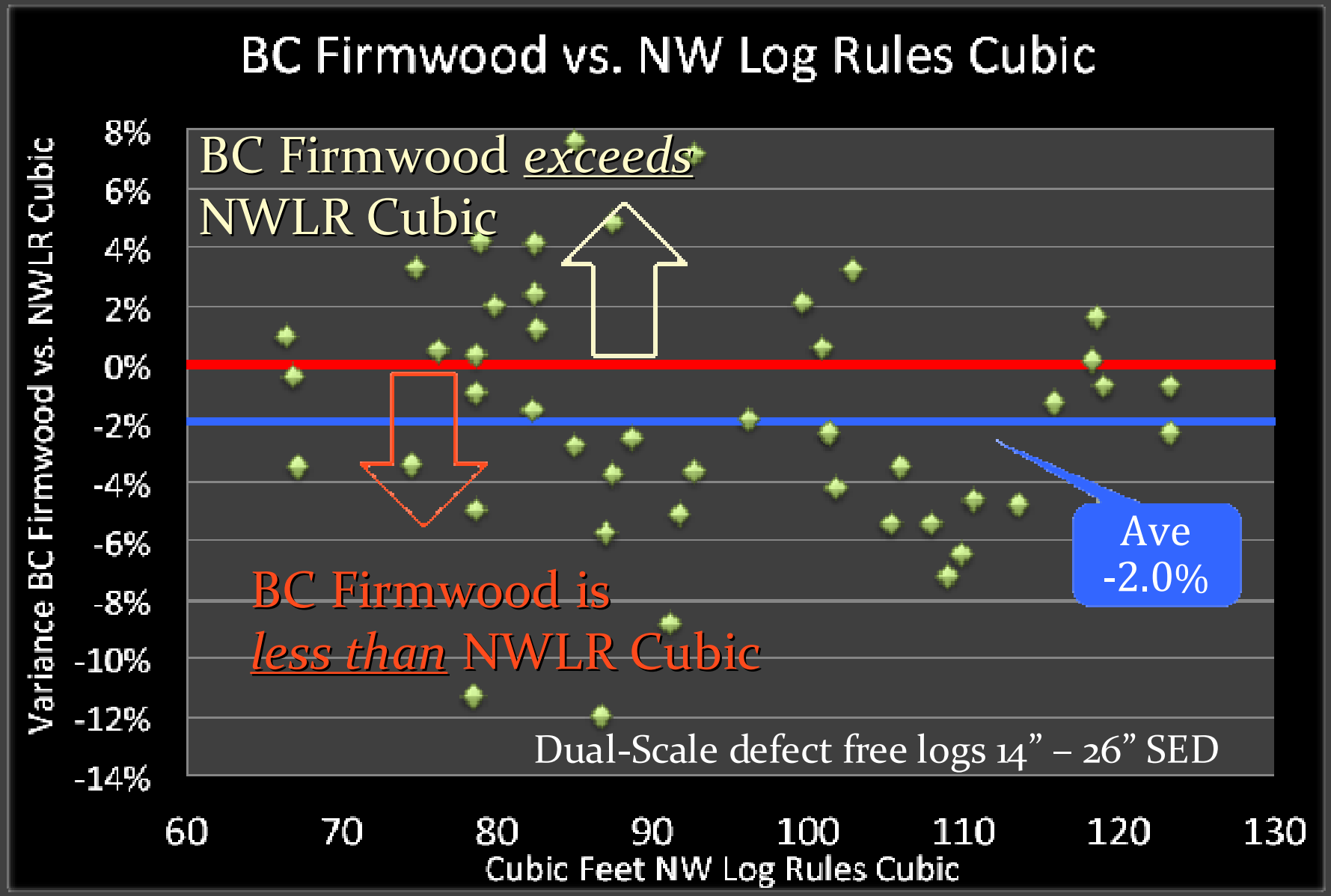

What causes variance in the ratio between BC Firmwood and Northwest Log Rules Cubic Scales?

	BC Firmwood	NW Log Rules
Formulas	Smalian's $C \times L \times (d1^2 + d2^2)/2$	Two-End Conic $C \times L \times (d1^2 + d2^2 + (d1 \times d2))/3$
Diameter	Nearest 2 cm	Scribner + 0.7 in.
Length	Nearest dm	Scribner + 1 ft *
Deducts	Unsound Only	Unsound – Gross & Solid – Merch

* Logs 17'+, Scribner + 0.5' for logs <17'

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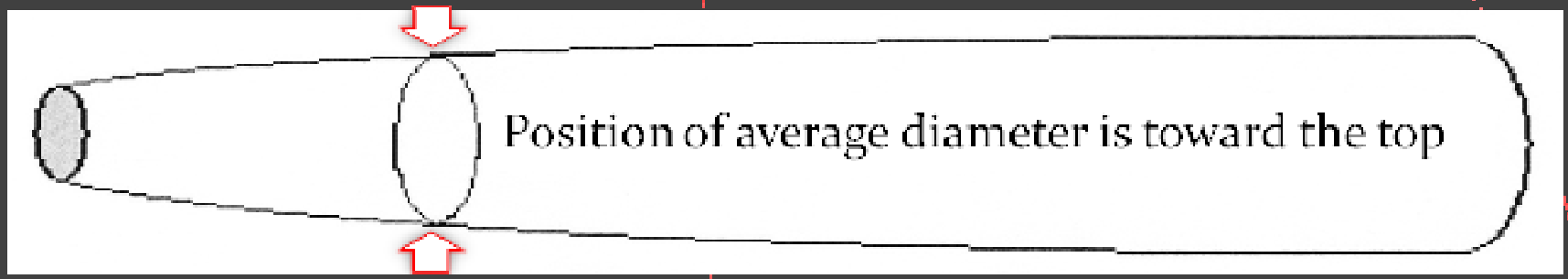
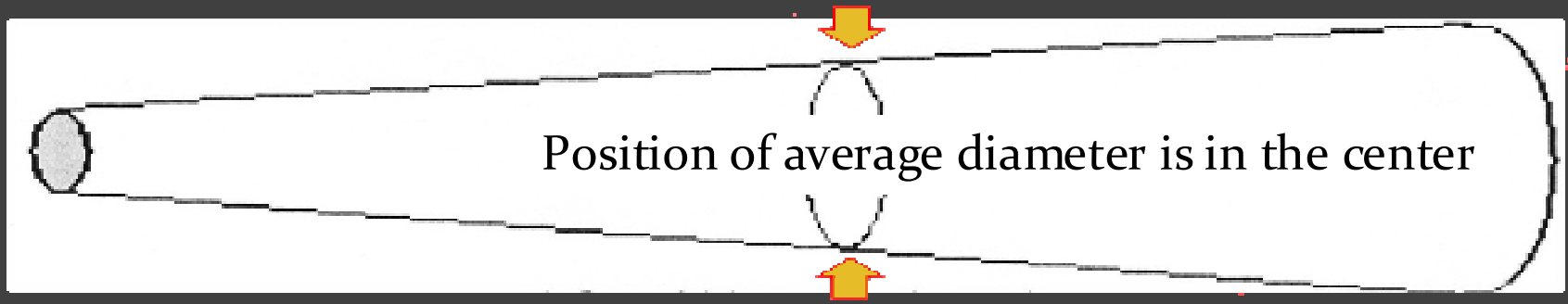
The difference between Smalian's and the Two-End Conic formula derives from their estimates of average diameter and is independent of log length (L):

Smalian's $C \times L \times (d1^2 + d2^2)/2$



Two-End Conic $C \times L \times (d1^2 + d2^2 + (d1 \times d2))/3$



Smalian exceeds Two-End Conic with decreasing log diameter and increasing difference between top and butt diameter

If Top & Butt Dia. Difference is: 2 inches:

Top	Butt	Ave.	Two-End Conic in^2	Ave. Dia.	Smalian in^2	Ave. Dia.	% Diff. in^2
6	8	7.0	49.3	7.0	50.0	7.1	1%
				0.7 in^2			
12	14	13.0	169.3	13.0	170.0	13.0	0%
				0.7 in^2			
24	26	25.0	625.3	25.0	626.0	25.0	0%
28	**30**	29.0	784	900	840	**841.3**	29.0	**842.0**	29.0	0%
30	**32**	31.0	900	1024	960	**961.3**	31.0	**962.0**	31.0	0%
32	**34**	33.0	1024	1156	1088	**1089.3**	33.0	**1090.0**	33.0	0%

Smalian exceeds Two-End Conic with decreasing log diameter and increasing difference between top and butt diameter

If Top & Butt Dia. Difference is: 4 inches:

Top	Butt	Ave.	Two-End Conic in^2	Ave. Dia.	Smalian in^2	Ave. Dia.	% Diff. in^2
6	10	8.0	65.3	8.1	68.0	8.2	4%
				2.7 in^2			
12	16	14.0	197.3	14.0	200.0	14.1	1%
				2.7 in^2			
24	28	26.0	677.3	26.0	680.0	26.1	0%
28	**32**	30.0	784	1024	896	**901.3**	30.0	**904.0**	30.1	0%
30	**34**	32.0	900	1156	1020	**1025.3**	32.0	**1028.0**	32.1	0%
32	**36**	34.0	1024	1296	1152	**1157.3**	34.0	**1160.0**	34.1	0%

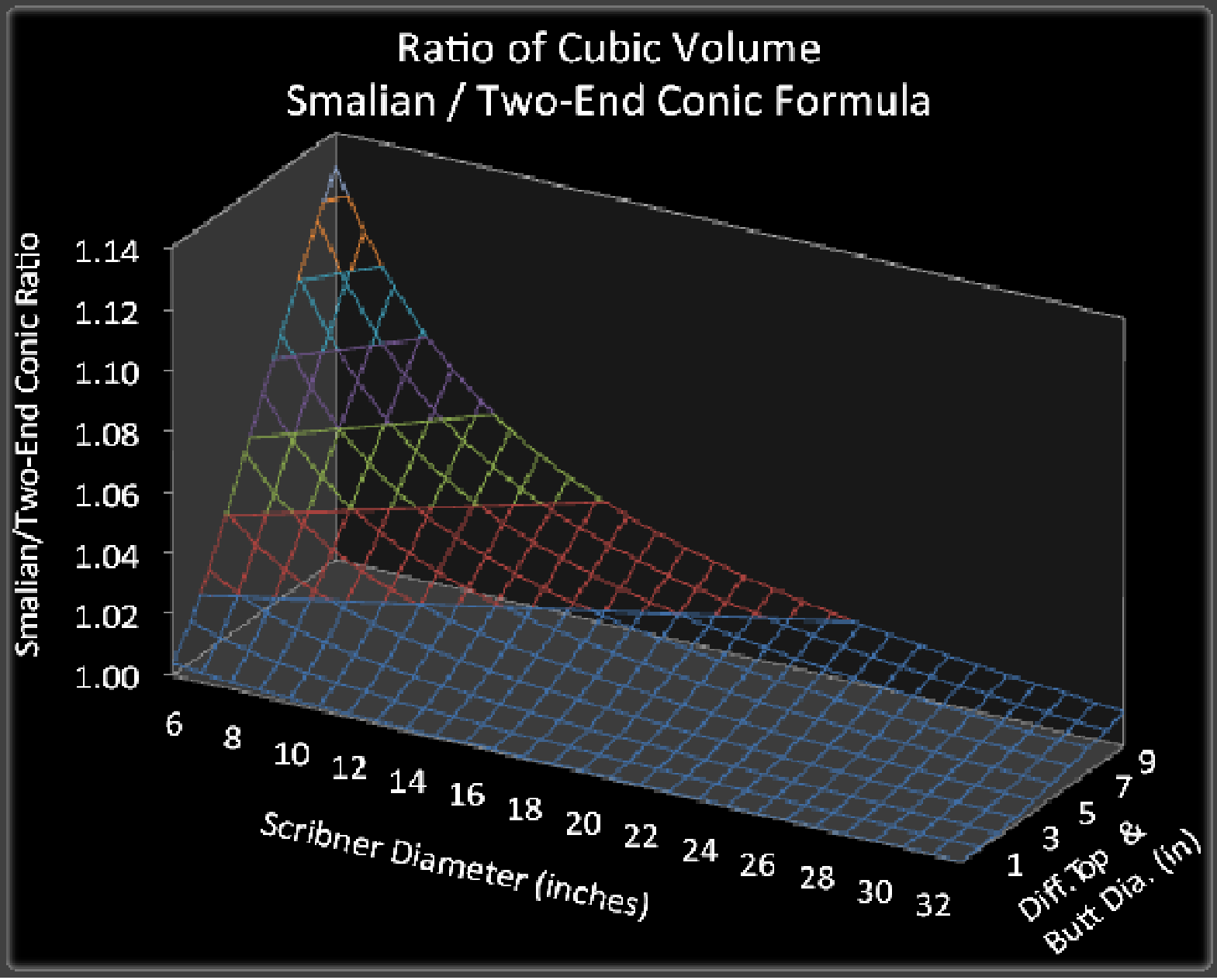
Smalian exceeds Two-End Conic with decreasing log diameter and increasing difference between top and butt diameter

If Top & Butt Dia. Difference is: 6 inches:

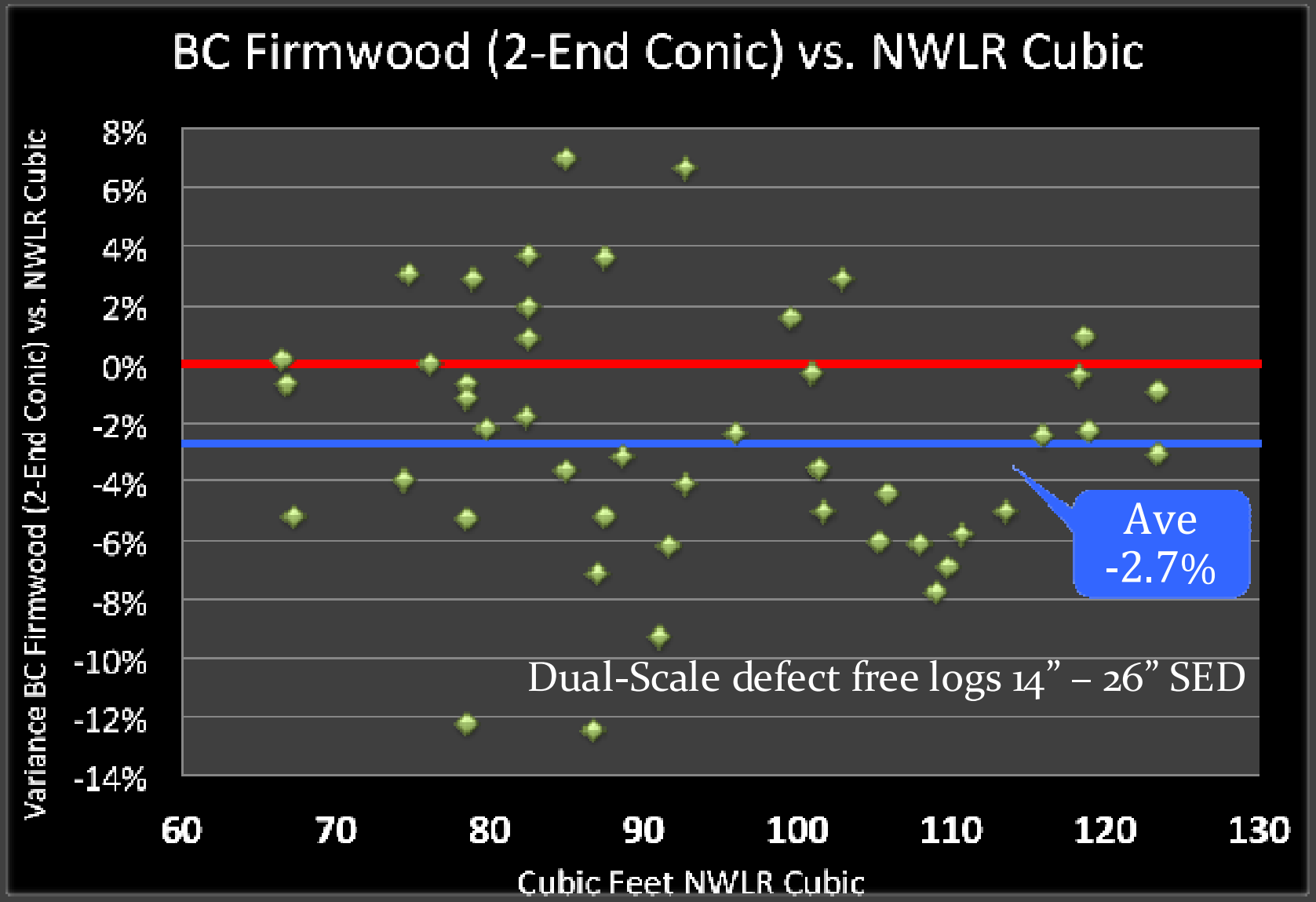
Top	Butt	Ave.	Two-End Conic in^2	Ave. Dia.	Smalian in^2	Ave. Dia.	% Diff. in^2
6	12	9.0	84.0	9.2	90.0	9.5	7%
			6.0 in^2				
12	18	15.0	228.0	15.1	234.0	15.3	3%
			6.0 in^2				
24	30	27.0	732.0	27.1	738.0	27.2	1%

28	**34**	31.0	784	1156	952	**964.0**	31.0	**970.0**	31.1	1%
30	**36**	33.0	900	1296	1080	**1092.0**	33.0	**1098.0**	33.1	1%
32	**38**	35.0	1024	1444	1216	**1228.0**	35.0	**1234.0**	35.1	0%

The amount Smalian exceeds Two-End Conic increases with the difference between top and butt diameter and with decreasing top diameter



Adjusting for formula difference increases variance between BC Firmwood & Northwest Log Rules Cubic:



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Diameter	Nearest 2 cm	Scribner + 0.7 in.
Length	Nearest dm	Scribner + 1 ft *
Deducts	Unsound Only	Unsound – Gross & Solid – Merch

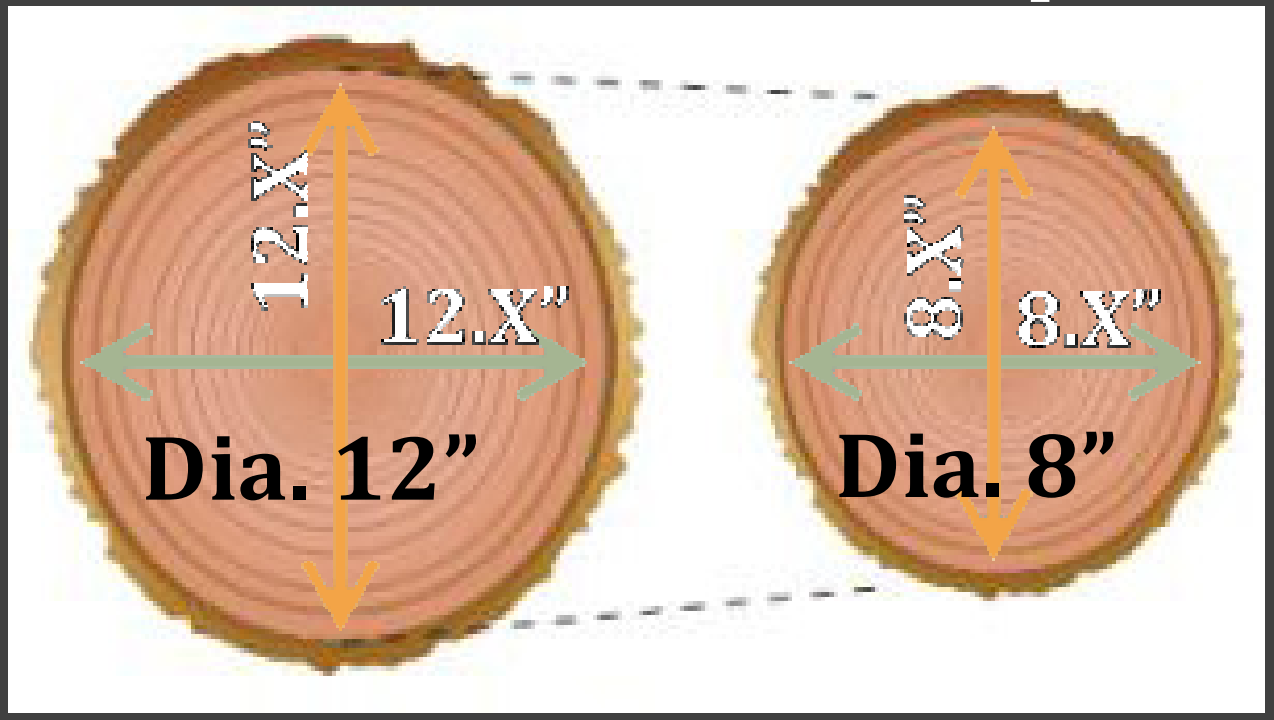
* Logs 17'+, Scribner + 0.5' for logs <17'

BC Firmwood	NW Log Rules
Lengths: Unbiased – accurate to nearest 1 dm (~3.9 in)	Scribner length + trim minimal bias 1.0 ft for logs 17'+ 0.5 ft for logs <17'
Diameters: Unbiased – accurate to nearest 2 cm (~0.79 in)	Scribner (biased) – truncated fractional diameters plus 0.7 in

Basis for 0.7 inch bias correction factor:

- Scribner's truncation of diameter fractions for logs with zero or even-inch ovality: 0.5 in.

Butt Top

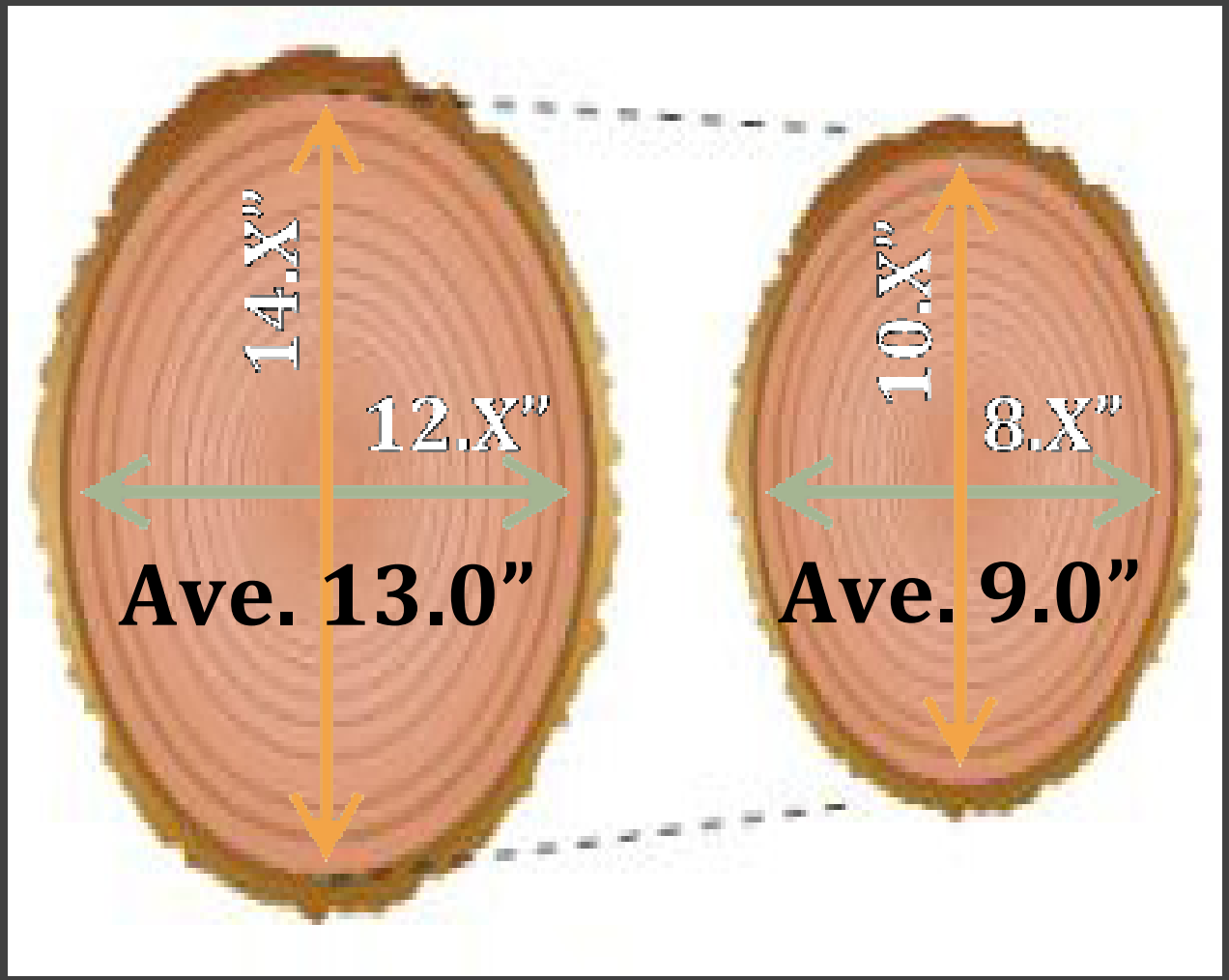


Log with "zero" ovality Butt & Top

Basis for 0.7 inch bias correction factor:

- Scribner's truncation of diameter fractions for logs with zero or even-inch ovality: 0.5 in.

Butt Top

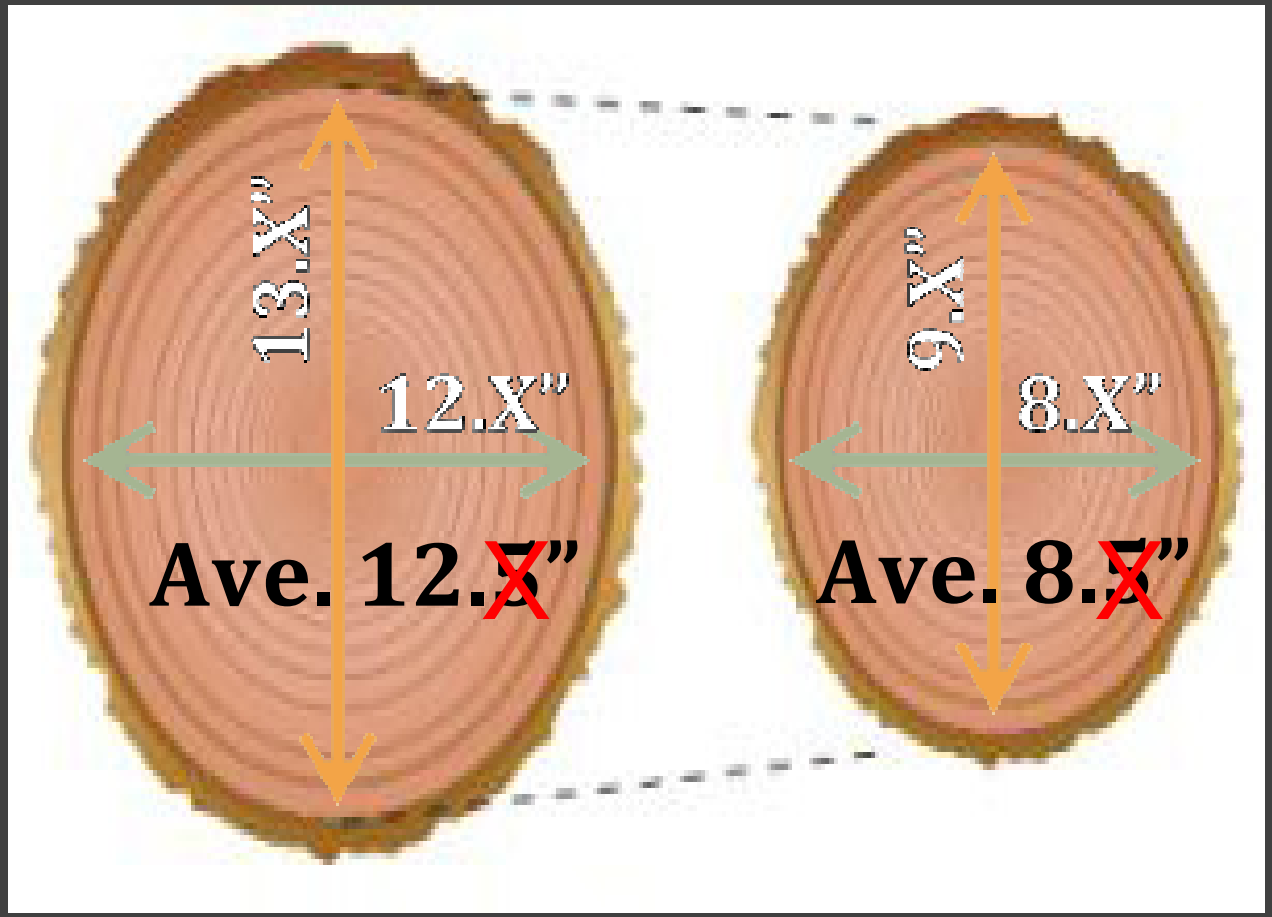


Log with "even-inch" ovality Butt & Top

Basis for 0.7 inch bias correction factor:

- An additional 0.5” diameter truncation occurs for logs with odd-inch ovality e.g., 1”, 3”, etc.

Butt Top



Log with 1” ovality Butt & Top

Basis for 0.7 inch bias correction factor:

- Scribner's truncation of diameter fractions for logs with zero or even-inch ovality: 0.5 in.

- Scribner's additional 0.5" diameter truncation for logs with odd-inch ovality: 0.2 in.

0.7 in.

Additional 0.2 inch bias correction assumes odd-inch ovality occurs almost half the time at *both* the Top and Butt

Scribner diameter truncation for round logs and logs with ovality

Logs with 1/16 inch ovality

Actual Diameter (in)			Truncated Diameter				Amount	
Narrow	Wide	Average	Narrow	Wide	Average	Scribner	Truncated	Average
5.9375	6	5.96875	5	6	5.5	5	0.96875	
6.0000	6.0625	6.03125	6	6	6	6	0.03125	
6.0625	6.1250	6.09375	6	6	6	6	0.09375	
6.1250	6.1875	6.15625	6	6	6	6	0.15625	
6.1875	6.2500	6.21875	6	6	6	6	0.21875	
6.2500	6.3125	6.28125	6	6	6	6	0.28125	
6.3125	6.3750	6.34375	6	6	6	6	0.34375	
6.3750	6.4375	6.40625	6	6	6	6	0.40625	0.5000
6.4375	6.5000	6.46875	6	6	6	6	0.46875	
6.5000	6.5625	6.53125	6	6	6	6	0.53125	
6.5625	6.6250	6.59375	6	6	6	6	0.59375	
6.6250	6.6875	6.65625	6	6	6	6	0.65625	
6.6875	6.7500	6.71875	6	6	6	6	0.71875	
6.7500	6.8125	6.78125	6	6	6	6	0.78125	
6.8125	6.8750	6.84375	6	6	6	6	0.84375	
6.8750	6.9375	6.90625	6	6	6	6	0.90625	
6.9375	7.0000	6.96875	6	7	6.5	6	0.96875	

Scribner diameter truncation for round logs and logs with ovality

Logs with 1/8 inch ovality

Actual Diameter (in)			Truncated Diameter				Amount	
Narrow	Wide	Average	Narrow	Wide	Average	Scribner	Truncated	Average
5.875	6	5.9375	5	6	5.5	5	0.93750	
5.9375	6.0625	6	5	6	5.5	5	1.00000	
6.0000	6.1250	6.0625	6	6	6	6	0.06250	
6.0625	6.1875	6.125	6	6	6	6	0.12500	
6.1250	6.2500	6.1875	6	6	6	6	0.18750	
6.1875	6.3125	6.25	6	6	6	6	0.25000	
6.2500	6.3750	6.3125	6	6	6	6	0.31250	
6.3125	6.4375	6.375	6	6	6	6	0.37500	
6.3750	6.5000	6.4375	6	6	6	6	0.43750	0.5313
6.4375	6.5625	6.5	6	6	6	6	0.50000	
6.5000	6.6250	6.5625	6	6	6	6	0.56250	
6.5625	6.6875	6.625	6	6	6	6	0.62500	
6.6250	6.7500	6.6875	6	6	6	6	0.68750	
6.6875	6.8125	6.75	6	6	6	6	0.75000	
6.7500	6.8750	6.8125	6	6	6	6	0.81250	
6.8125	6.9375	6.875	6	6	6	6	0.87500	
6.8750	7.0000	6.9375	6	7	6.5	6	0.9375	

Scribner diameter truncation for round logs and logs with ovality

Logs with 3/16 inch ovality

Actual Diameter (in)			Truncated Diameter				Amount	
Narrow	Wide	Average	Narrow	Wide	Average	Scribner	Truncated	Average
5.8125	6	5.90625	5	6	5.5	5	0.90625	
5.8750	6.0625	5.96875	5	6	5.5	5	0.96875	
5.9375	6.1250	6.03125	5	6	5.5	5	1.03125	
6.0000	6.1875	6.09375	6	6	6	6	0.09375	
6.0625	6.2500	6.15625	6	6	6	6	0.15625	
6.1250	6.3125	6.21875	6	6	6	6	0.21875	
6.1875	6.3750	6.28125	6	6	6	6	0.28125	
6.2500	6.4375	6.34375	6	6	6	6	0.34375	
6.3125	6.5000	6.40625	6	6	6	6	0.40625	0.5625
6.3750	6.5625	6.46875	6	6	6	6	0.46875	
6.4375	6.6250	6.53125	6	6	6	6	0.53125	
6.5000	6.6875	6.59375	6	6	6	6	0.59375	
6.5625	6.7500	6.65625	6	6	6	6	0.65625	
6.6250	6.8125	6.71875	6	6	6	6	0.71875	
6.6875	6.8750	6.78125	6	6	6	6	0.78125	
6.7500	6.9375	6.84375	6	6	6	6	0.84375	
6.8125	7.0000	6.90625	6	7	6.5	6	0.90625	

Scribner diameter truncation for round logs and logs with ovality

Logs with 1 inch ovality

Actual Diameter (in)			Truncated Diameter				Amount	
Narrow	Wide	Average	Narrow	Wide	Average	Scribner	Truncated	Average
5	6	5.5	5	6	5.5	5	0.50000	
5.0625	6.0625	5.5625	5	6	5.5	5	0.56250	
5.1250	6.1250	5.625	5	6	5.5	5	0.62500	
5.1875	6.1875	5.6875	5	6	5.5	5	0.68750	
5.2500	6.2500	5.75	5	6	5.5	5	0.75000	
5.3125	6.3125	5.8125	5	6	5.5	5	0.81250	
5.3750	6.3750	5.875	5	6	5.5	5	0.87500	
5.4375	6.4375	5.9375	5	6	5.5	5	0.93750	
5.5000	6.5000	6	5	6	5.5	5	1.00000	0.9688
5.5625	6.5625	6.0625	5	6	5.5	5	1.06250	
5.6250	6.6250	6.125	5	6	5.5	5	1.12500	
5.6875	6.6875	6.1875	5	6	5.5	5	1.18750	
5.7500	6.7500	6.25	5	6	5.5	5	1.25000	
5.8125	6.8125	6.3125	5	6	5.5	5	1.31250	
5.8750	6.8750	6.375	5	6	5.5	5	1.37500	
5.9375	6.9375	6.4375	5	6	5.5	5	1.43750	
6.0000	7.0000	6.5	6	7	6.5	6	0.5	

Scribner diameter truncation for round logs and logs with ovality in increments of 1/16 in

Ovality (in)	Average Truncation
Zero & even-inch	0.50000
1/16	0.50000
1/8	0.53125
3/16	0.56250
1/4	0.59375
5/16	0.62500
3/8	0.65625
7/16	0.68750
1/2	0.71875
9/16	0.75000
5/8	0.78125
11/16	0.81250
3/4	0.84375
13/16	0.87500
7/8	0.90625
15/16	0.93750
1 & odd-inch	0.96875
All Ave.	0.72059

Assuming an equal probability of logs in each class, average truncation is 0.72 in. and 50% have odd-inch ovality at *both* Top and Butt

Given Scribner diameter truncation just discussed…

What's the impact of Scribner diameter bias on the difference between BC Firmwood and Northwest Log Rules Cubic?

Range of Scribner diameter bias relative to BC Firmwood scale:

Where Scribner Diameter (Inches) is:	Metric Diameter in centimeters is:											
	For Round Logs:				For Logs With Ovality of 1":							
					Narrow		Wide					
	Met											's
	Mi											
6	16											
7	18											
8	20											
•	•											
•	•											
•	•											
30	76	78	38	39	76	78	78	82	78	80	39	40
31	78	82	39	41	78	82	82	84	80	84	40	42
32	82	84	41	42	82	84	84	86	84	86	42	43

Scribner	BC Firmwood
6”	16 – 20 cm
32”	82 – 86 cm

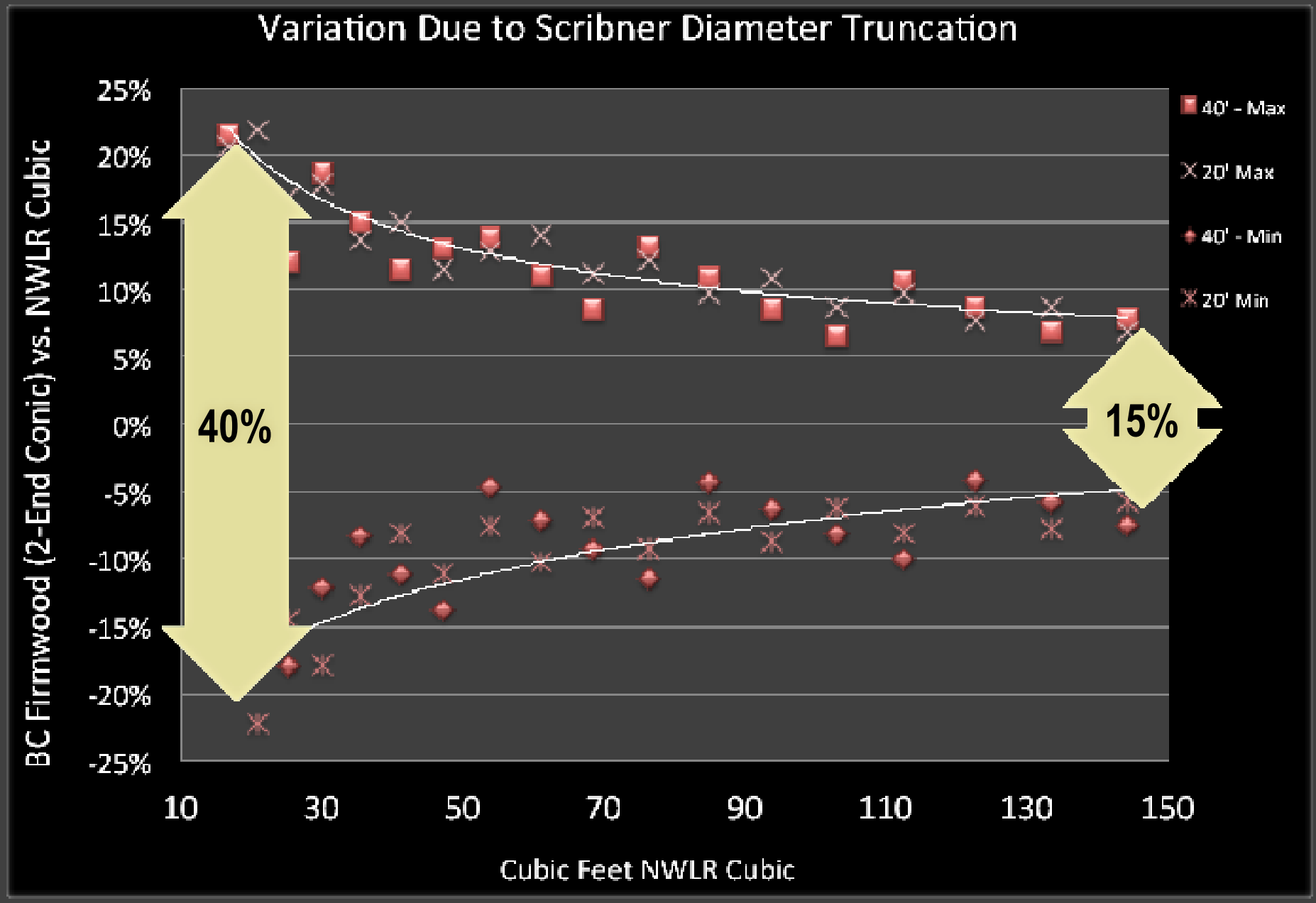
Variance in cubic volume caused by Scribner diameter bias:

Scribner Diameter	40' Log w/1" in 10' Taper		
	BC Firm. Minimum	NWLR	BC Firm. Maximum
6	*15.2* **-11%**	*16.8*	*21.4* **22%**
7	*18.2* **-15%**	*20.8*	*24.9* **17%**
8	*21.4* **-18%**	*25.3*	*28.7* **12%**
• • •	• • •	• • •	• • •
30	*222.1* **-5%**	*233.6*	*244.6* **5%**
31	*233.2* **-6%**	*248.1*	*268.1* **7%**
32	*256.2* **-3%**	*263.0*	*280.3* **6%**

Variance in cubic volume caused by Scribner diameter bias:

Scribner Diameter	20' Log w/1" in 10' Taper BC Minimum	NWLR	BC Maximum
6	*5.5* **-18%**	*6.5*	*8.2* **21%**
7	*6.8* **-22%**	*8.3*	*10.6* **22%**
8	*9.0* **-15%**	*10.3*	*12.4* **17%**
⋮	⋮	⋮	⋮
30	*105.6* **-4%**	*109.6*	*116.5* **6%**
31	*111.0* **-5%**	*116.7*	*125.1* **7%**
32	*119.3* **-4%**	*123.9*	*131.0* **5%**

Variance in cubic volume caused by Scribner diameter bias:



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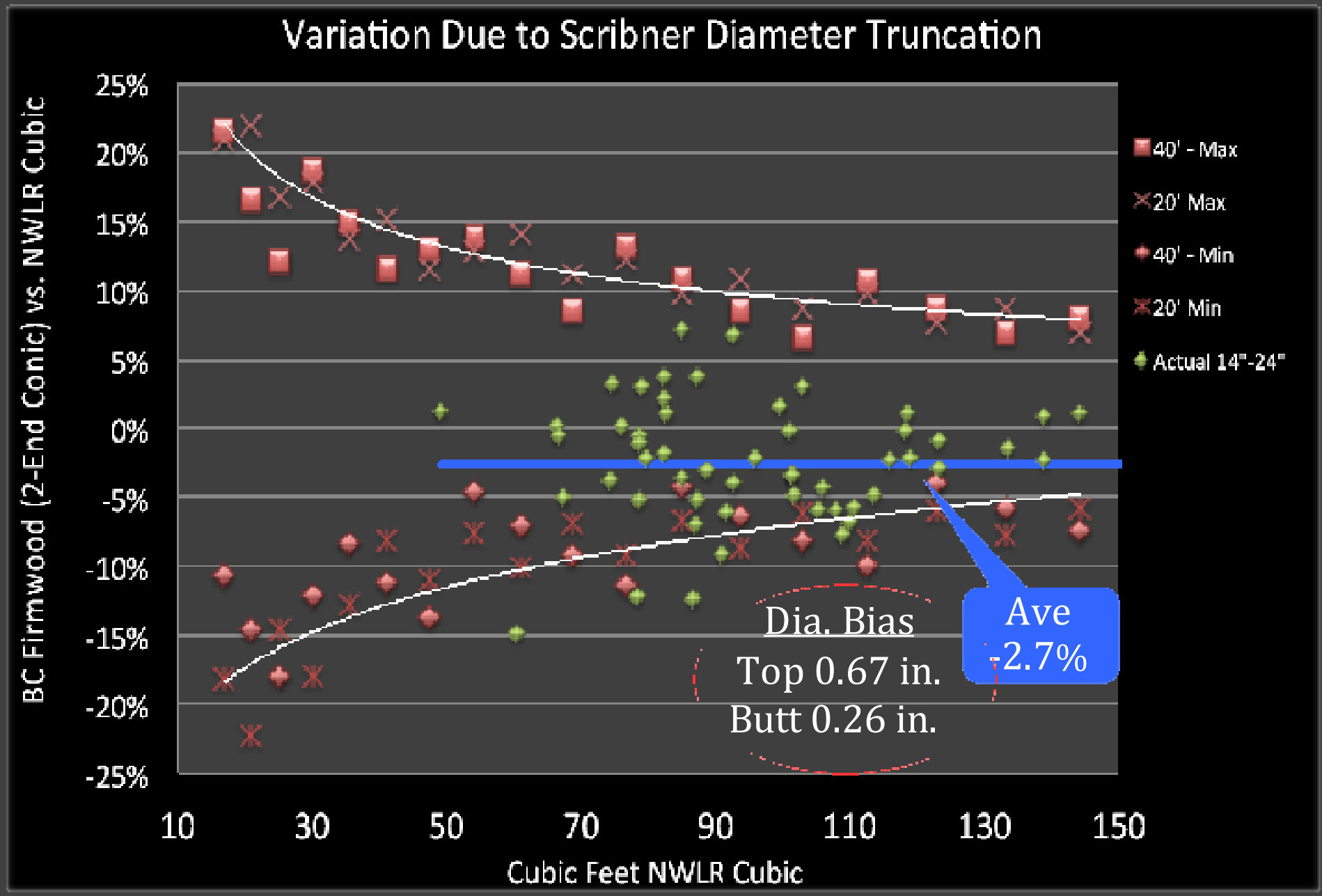

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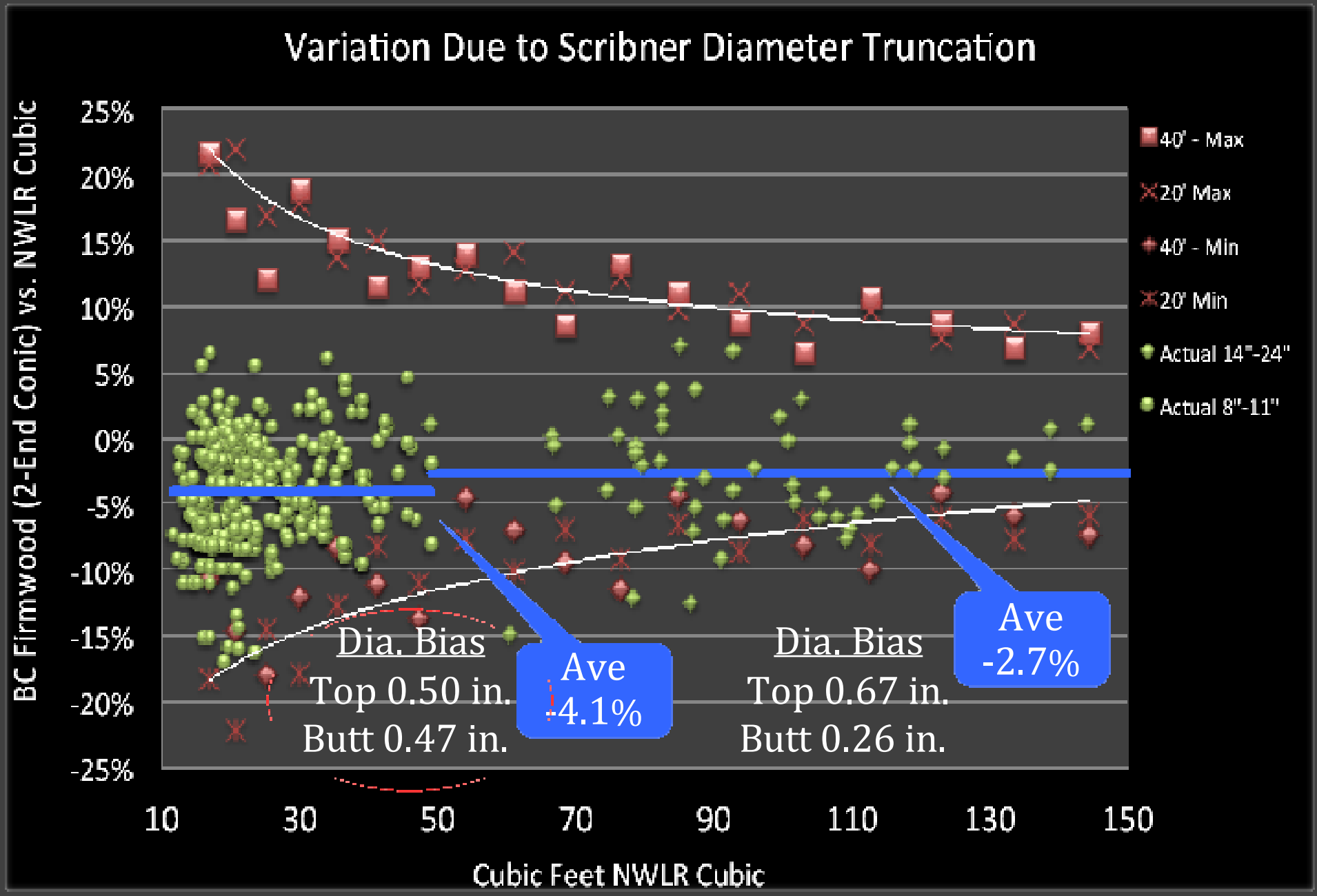
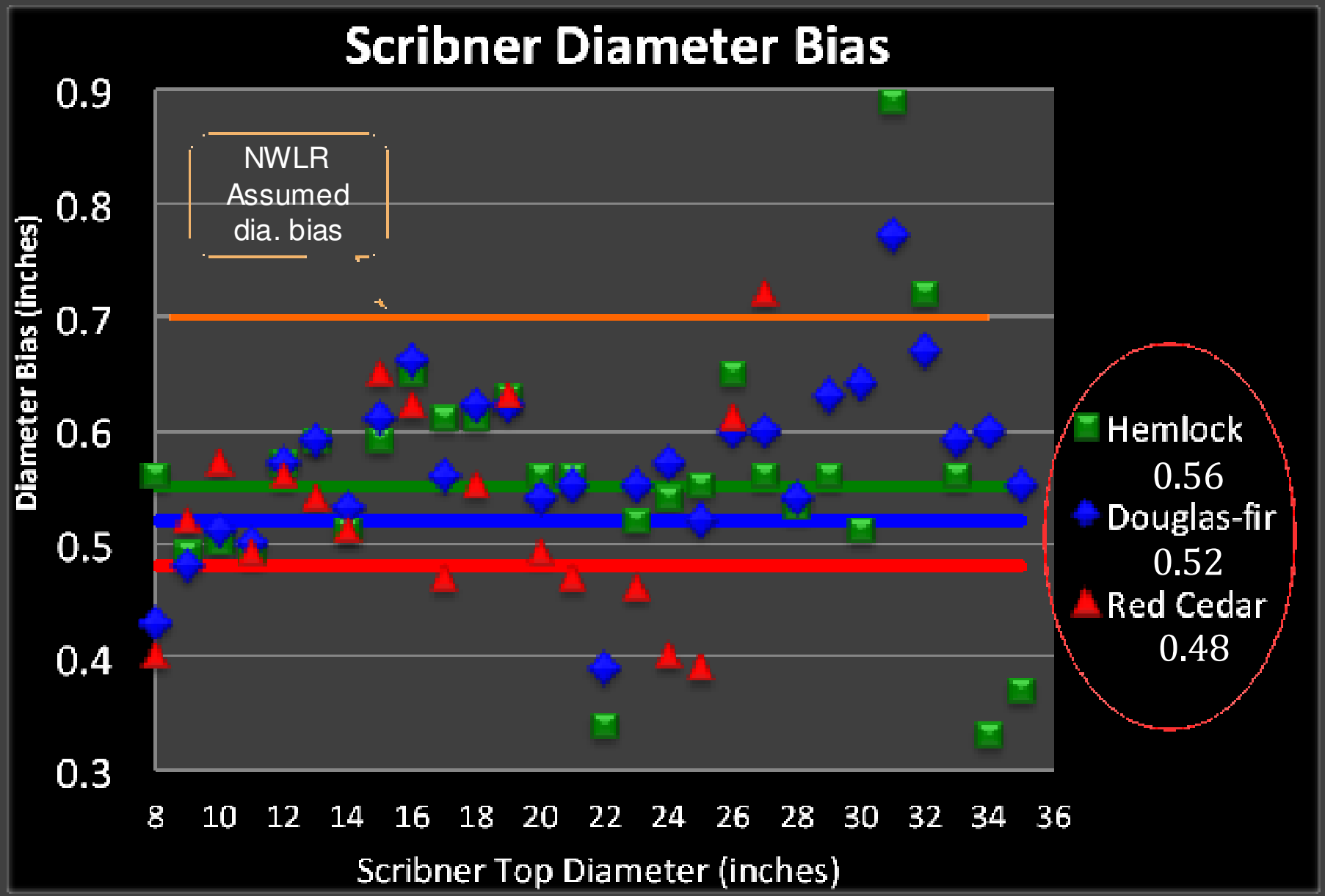
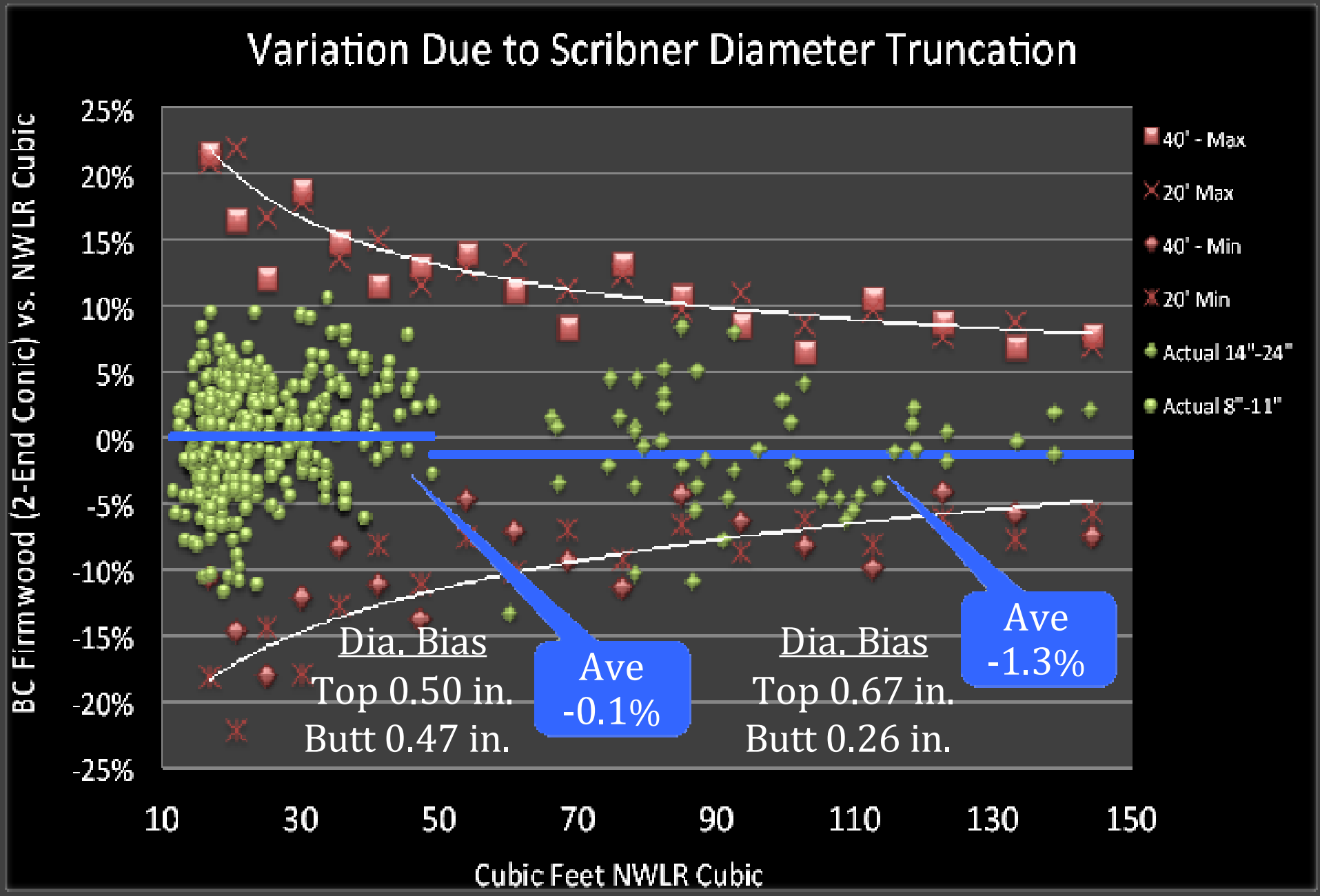


Ave. Scribner diameter bias by diameter class
~500,000 logs exported from BC to US in 2000



Variance in cubic volume using 0.55” instead of 0.7” correction for Scribner diameter bias:



To sum things up:

1 Smalian's formula tends to overstate cubic volume where butt dia. is > 30% larger than top

2 NWLR's 0.7 inch bias correction factor overstates Scribner diameter bias for today's harvest

3 Scribner diameter truncation causes significant variability in NWLR Cubic volumes

4 Improving accuracy of NWLR Cubic requires adoption of unbiased measurement protocol

Some recommendations:

BC Firmwood:

- Adopt Two-End Conic formula

NW Log Rules Cubic:

- Adopt unbiased diameter measurement protocol
- Adopt more representative correction factor for Scribner diameter bias

Questions or Comments?

Neal Hart

Jendro & Hart, LLC

Sunriver, Oregon

Thank You

Neal Hart

Jendro & Hart, LLC

Sunriver, Oregon