# Non-Typical DBH Growth Calibration On Research Plots Using ORGANON

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# Tree Model Diameter Growth Calibrations

Tree-list growth models like ORGANON and FVS have the ability to calibrate DBH growth as a way to "localize" growth projections.

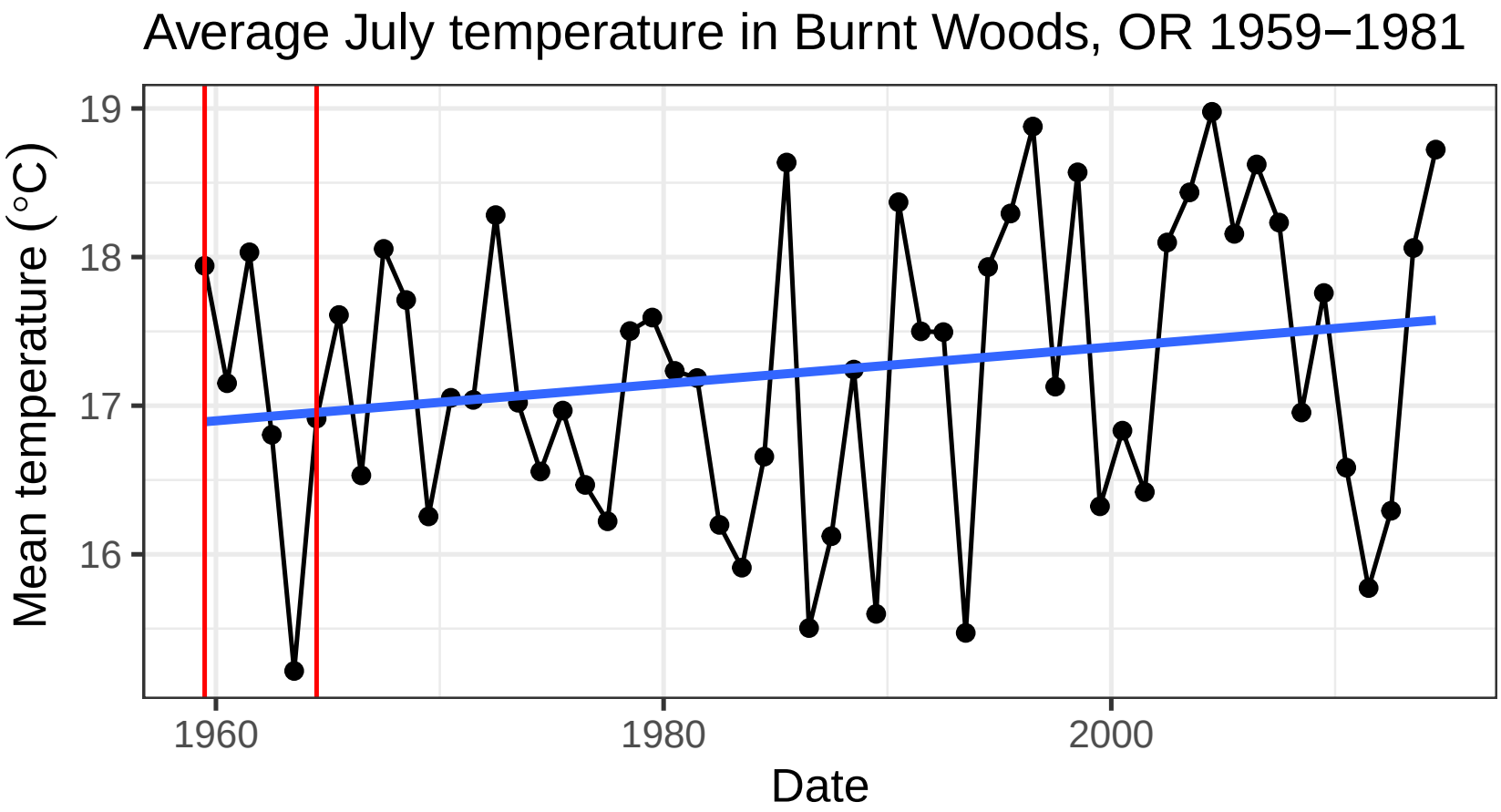
Requires input of a sample of trees with measured radial growth or a second DBH:

- Prognosis (Pre-FVS, Stage 1973, Appendix II)
  - DG = Past DBH growth or DBH (IDG card 7 and DF card 8)
- ORGANON (Hann 2011, page 14)
  - 5-year inside bark radial growth at DBH (i.e. increment cores)
- FVS has more options (keywords):
  - TREEFMT - tree-list data with DBH Increment (page 93)
  - CALBSTAT - outputs calibration factors (page 17)
  - GROWTH - defines DBH growth measurement type and period length (page 35)
    - 0 = past DBHib growth (increment core) - defult
    - 1 = past DBHob
    - 2 = "future" DBHib growth (increment core)
    - 3 = "future" DBHob
  - READCORD - input DBH growth calibration factors for growth (page 55)
  - BAIMULT is another option (page 13)

# Tree Model Diameter Growth Calibrations

Providing a calibration option presents some problems for the models on how to use it. How much "weight" do you give a periodic measurement for a long projection compared to the modeling data?

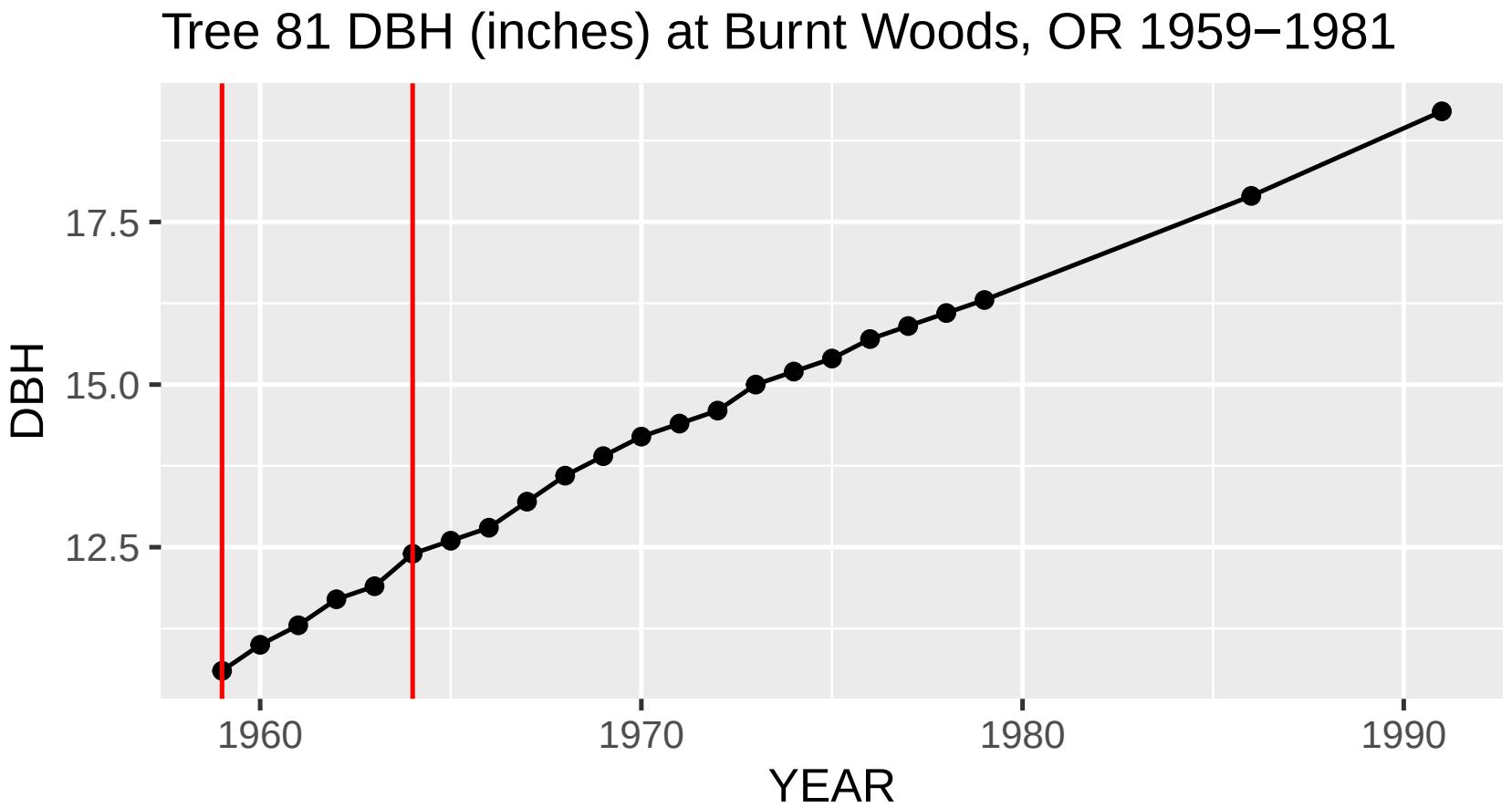
- Weather effects



# Tree Model Diameter Growth Calibrations

Providing a calibration option presents some problems for the models on how to use it. How much "weight" do you give a periodic measurement for a long projection compared to the modeling data?

- Weather effects
- DBH measurement "errors"

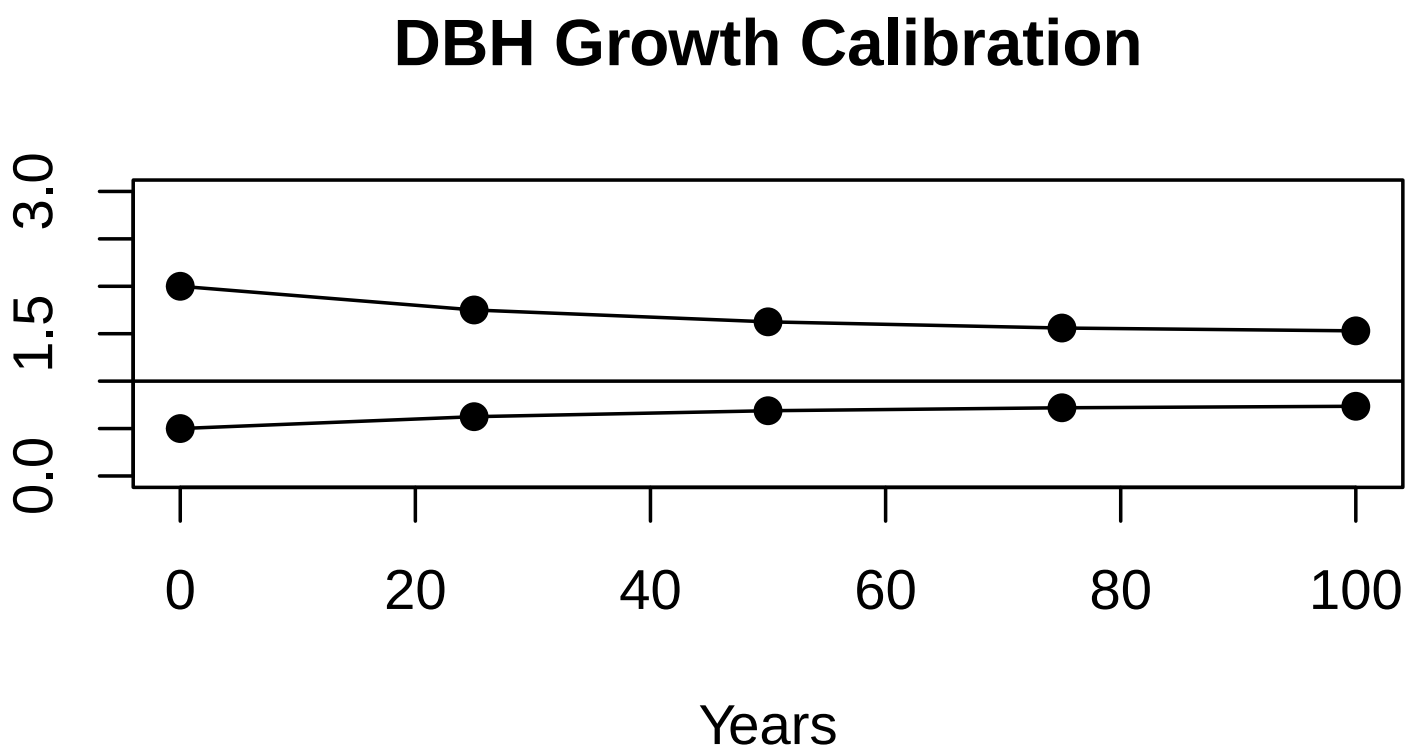


# Tree Model Diameter Growth Calibrations

Providing a calibration option presents some problems for the models on how to use it. How much "weight" do you give a periodic measurement for a long projection compared to the modeling data?

FVS uses a calibration attenuation to half-way between the calibration factor and 1.0 with a 25-year half-life (Dixon 2024, page 149).

ORGANON followed the same logic as Stage (1973).



# Tree Model Diameter Growth Calibrations

Not a lot of published work on using DBH growth calibrations (other than refitting the equations).

Cankaya , E.C. 2018. Testing methods for calibrating Forest Vegetation Simulator (FVS) diameter growth predictions. MS Thesis, VPI.

- Compared 5 methods of computing calibrations
- Found any calibration improved accuracy
- Median and regression (through the origin) estimates performed better than random effects

## My Problem

I want to project some research plots to get estimates of stand TPA, BAPA and BAL (maybe HTs).

- Large plots in 6 stands (1.4-2.1 acres) with treated and untreated trees.
- Individual trees randomly selected and treated (damaged).
- Complete plot measurements in 2005, 2006, 2007, 2009, 2011 and 2013.
- Partial measurements of treated trees in 2015, 2020 and 2024.

Calibration of DBH growth could improve projections because:

- Site index estimates were not great.
- Past stand treatments were not well defined.

The problems for calibration are:

- No past 5-year measurement period (2, 4, and 6 year periods) requiring interpolation.
- Sample of trees measurements in 2015, 2020 and 2024 (2, 7 and 11 year periods).
- Some impact to growth on (random) treated trees before 2013/2015 (Jones and other 2018a) and last full measurement was in 2013.

Question: How can I best calibrate ORGANON DBH growth?

FVS offers a way to do this, but I wanted to use ORGANON-SMC.

# Data for Demonstration/Proof of Concept

- Burnt Woods Thinning study.
- Established in 1959 by Alan Berg (OSU).
- 25 miles west of Corvallis, OR.
  - 18 years BH age
  - 25 year stand age
  - 134 foot site index (King 1966)
- 3 thin treatments and control (2 reps)
- 0.1-acre plots.
- Will use control (plot 2) to demonstrate
  - All Douglas-fir
  - Measured annually from 1959-1979 (5-year growth periods)

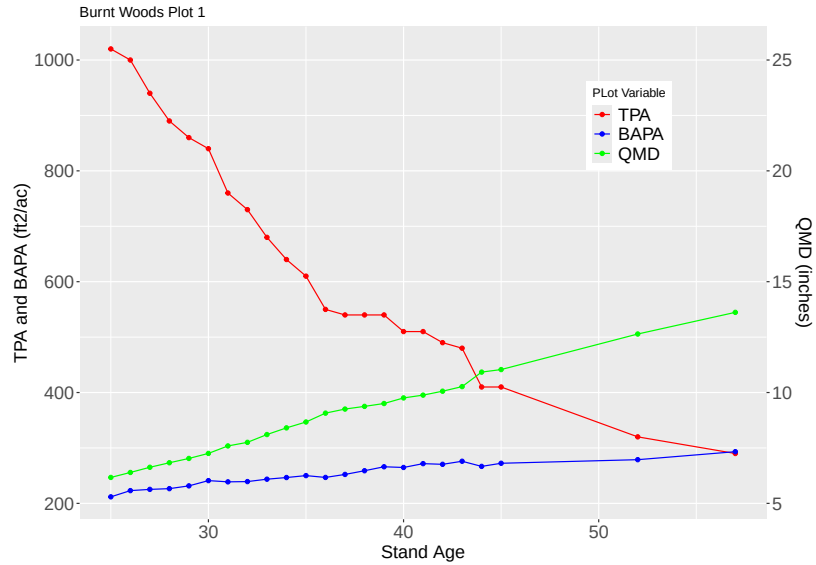



Table 1: Actual Plot Summary.

| STage | TPA | BAPA | QMD |
|---|---|---|---|
| 30 | 840 | 241.1 | 7.254 |
| 35 | 610 | 250.1 | 8.67 |
| 40 | 510 | 264.8 | 9.757 |
| 45 | 410 | 272.3 | 11.04 |

# Methods

Using the SMC version of ORGANON 10 (64-bit DLL)

Using R version 4.3.3 (R Core Team, 2024).

Compare predicted-actual using the mean difference (MD) and root mean squared error (RMSE) and available measured trees for ages 35, 40 and 45 grown from age 30.

$$MD = \sum_{i=1}^{n} (DBH_i - \hat{DBH_i})$$

$$RMSE = \sqrt{\frac{1}{n} \sum_{i=1}^{n} (DBH_i - \hat{DBH_i})^2}$$

WARNING: a 1 plot demonstration . . . mileage will vary (think growth trajectories, weather, mortality growth rate and measurements).

# Grow With No Calibration (Age 30 to Age 45)

Table 2: No calibration growth.

| STage | TPA | BAPA | meanHT |
|---|---|---|---|
| 30 | 840 | 241.1 | 56.76 |
| 35 | 657.1 | 241.2 | 63.9 |
| 40 | 542.1 | 245.9 | 70.05 |
| 45 | 462.1 | 252.3 | 75.44 |
| 50 | 403.2 | 259.2 | 80.25 |
| 55 | 358.2 | 266.3 | 84.58 |
| 60 | 322.8 | 273.3 | 88.55 |

DBH Calibration = 1

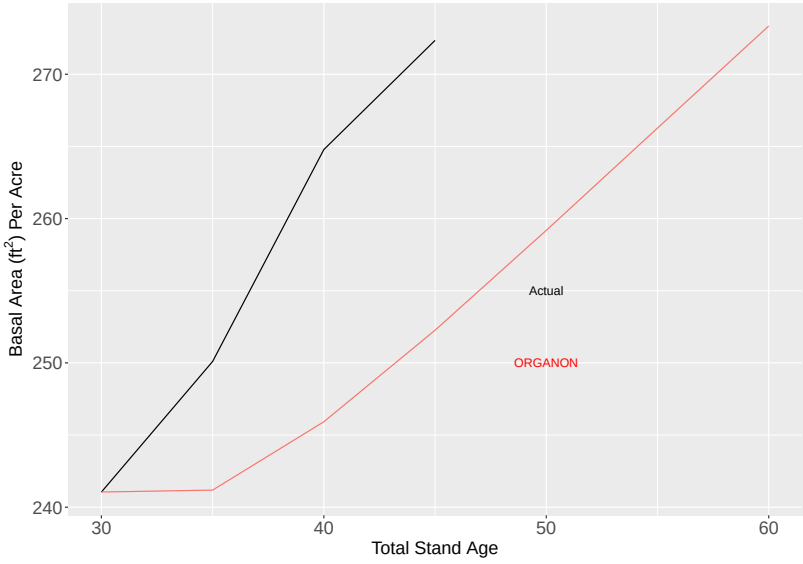



Table 3: No calibration growth.

| AGE | NOBS | MD | RMSE |
|---|---|---|---|
| 35 | 61 | -0.1913 | 0.3262 |
| 40 | 51 | -0.3535 | 0.5958 |
| 45 | 41 | -0.5417 | 0.8902 |

# Growth With Typical Calibration (25-30 years)

Table 4: Typical calibrated (25-30 years) growth.

| STage | TPA | BAPA | meanHT |
|---|---|---|---|
| 30 | 840 | 241.1 | 56.76 |
| 35 | 657.1 | 258 | 63.9 |
| 40 | 525.1 | 269.6 | 69.81 |
| 45 | 433.8 | 279.7 | 74.88 |
| 50 | 369.5 | 289 | 79.33 |
| 55 | 322.7 | 297.8 | 83.31 |
| 60 | 287.5 | 306.4 | 86.97 |

DBH Calibration = 1.593

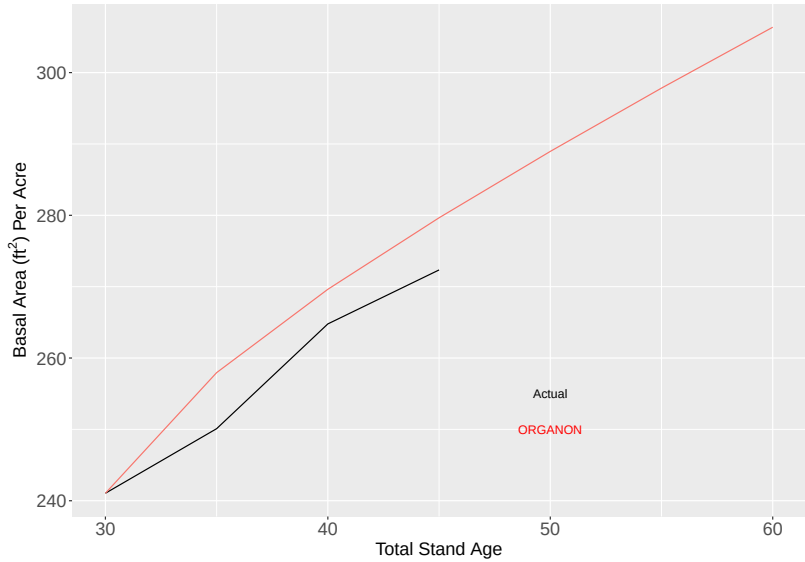



Table 5: Typical calibration (25-30 years) growth.

| AGE | NOBS | MD | RMSE |
|---|---|---|---|
| 35 | 61 | 0.05503 | 0.3305 |
| 40 | 51 | 0.0749 | 0.6286 |
| 45 | 41 | 0.06142 | 0.919 |

# A Non-Typical Calibration Method

- Using R version 4.3.3 (R Core Team, 2024).
- Use the R "optim" function (part of base R)
  - A general purpose optimization routine.
  - Offers several optimization methods (used the "Brent" method which is suited for one-dimensional problems).
- Pseudo Code
  1. set trial DBH growth calibration value
  2. create or modify ORGANON input file (prepare function)
  3. grow tree-list with calibration ORGANON (execute function)
  4. if needed: select species for calibration and interpolate measurement
  5. align and merge actual and predicted DBHs
  6. minimize $sum((actualDBH - predictedDBH)^2)$
  7. repeat 2-7 with new trial calibration value until (6) is minimized

# Growth With A Non-Typical Calibration (30-35 years)

Table 6: Non-Typical calibration (30-35 years) growth.

| STage | TPA | BAPA | meanHT |
|---|---|---|---|
| 30 | 840 | 241.1 | 56.76 |
| 35 | 657.1 | 248.4 | 63.9 |
| 40 | 534.8 | 256.4 | 69.95 |
| 45 | 449.7 | 264.6 | 75.19 |
| 50 | 388.1 | 272.7 | 79.83 |
| 55 | 341.9 | 280.6 | 84 |
| 60 | 306.4 | 288.3 | 87.82 |

DBH Calibration = 1.26

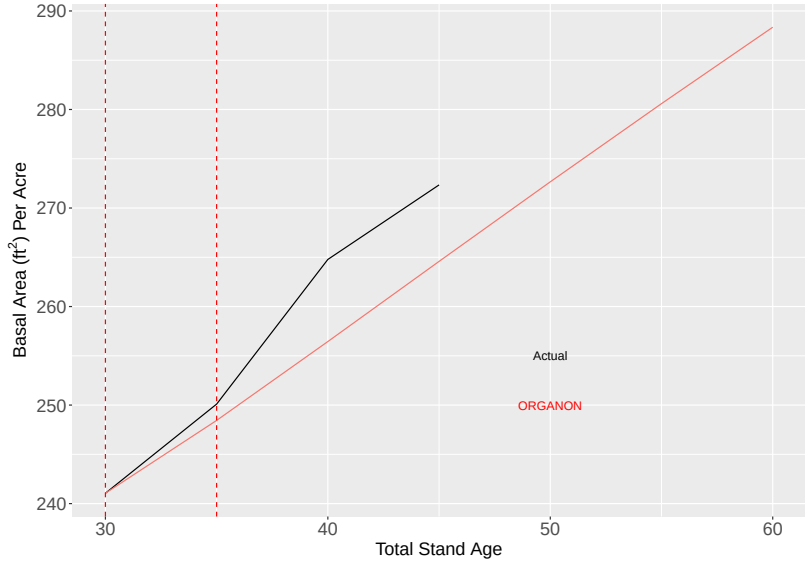



Table 7: Non-Typical calibration (30-35 years) growth.

| AGE | NOBS | MD | RMSE |
|---|---|---|---|
| 35 | 61 | -0.08344 | 0.2871 |
| 40 | 51 | -0.161 | 0.5438 |
| 45 | 41 | -0.2671 | 0.8173 |

# Growth With A Non-Typical Calibration (30-40 years)

Table 8: Non-traditional calibration (30-40 years) growth.

| STage | TPA | BAPA | meanHT |
|---|---|---|---|
| 30 | 840 | 241.1 | 56.76 |
| 35 | 657.1 | 247.6 | 63.9 |
| 40 | 535.7 | 255.3 | 69.96 |
| 45 | 451.1 | 263.2 | 75.22 |
| 50 | 389.8 | 271.2 | 79.88 |
| 55 | 343.7 | 279 | 84.06 |
| 60 | 308.2 | 286.7 | 87.9 |

DBH Calibration = 1.231

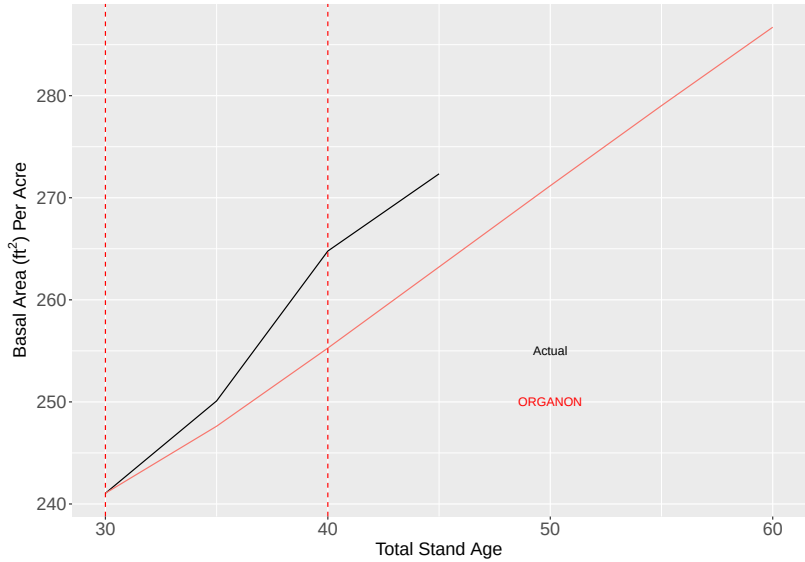
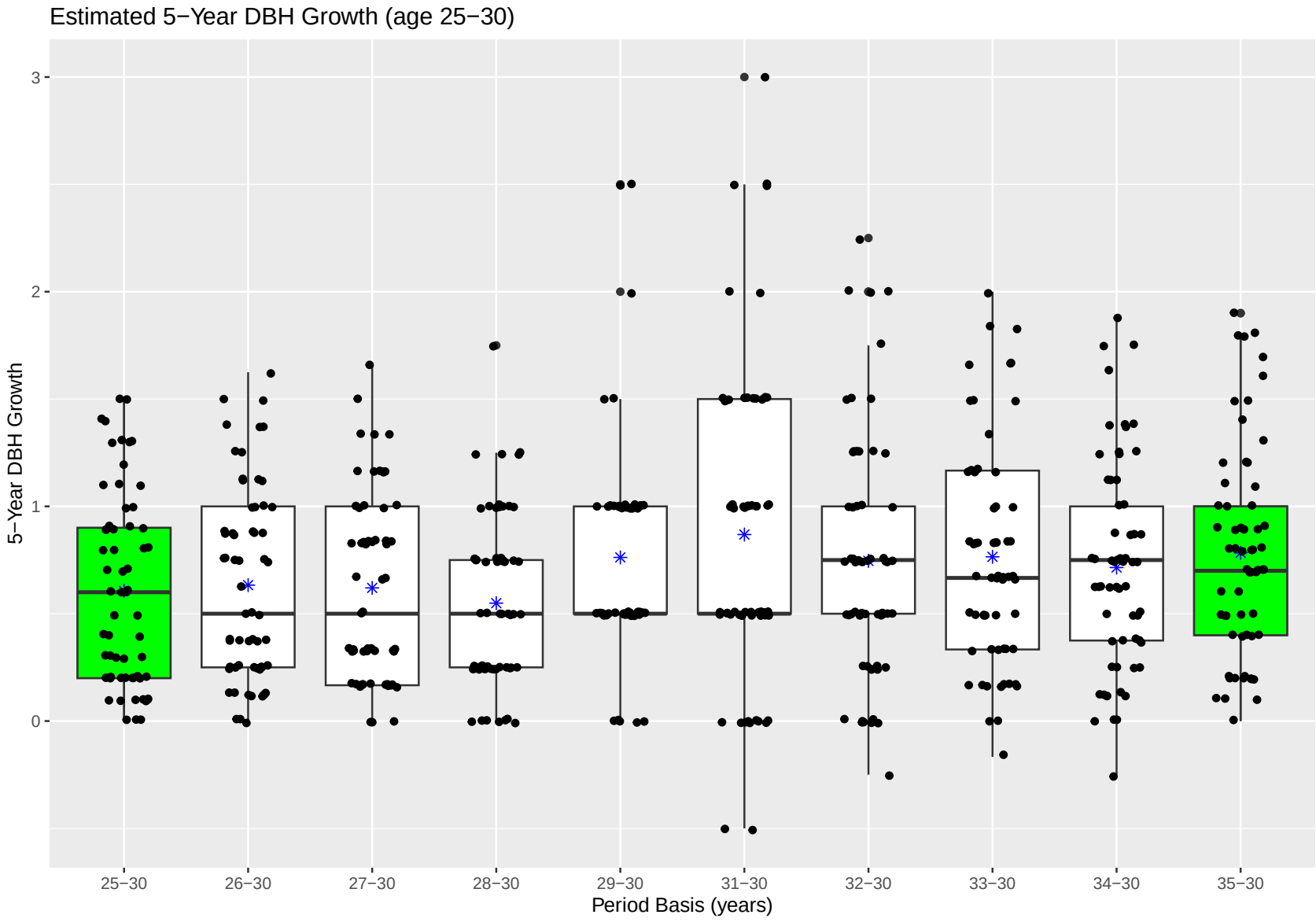



Table 9: Non-Typical calibration (30-40 years) growth.

| AGE | NOBS | MD | RMSE |
|---|---|---|---|
| 35 | 61 | -0.09557 | 0.2884 |
| 40 | 51 | -0.1823 | 0.5442 |
| 45 | 41 | -0.2972 | 0.8184 |

# Calibration with Non 5-year Periods (25-30 years and 30-35 years)



# Growth With A Non-Typical Calibration (30-33 years)

Table 10: Non-Typical calibration (30-40 years) growth.

| STage | TPA | BAPA | meanHT |
|---|---|---|---|
| 30 | 840 | 241.1 | 56.76 |
| 35 | 657.1 | 247.5 | 63.9 |
| 40 | 535.7 | 255.1 | 69.96 |
| 45 | 451.2 | 263.1 | 75.22 |
| 50 | 389.9 | 271 | 79.88 |
| 55 | 343.9 | 278.9 | 84.07 |
| 60 | 308.3 | 286.5 | 87.91 |

DBH Calibration = 1.227

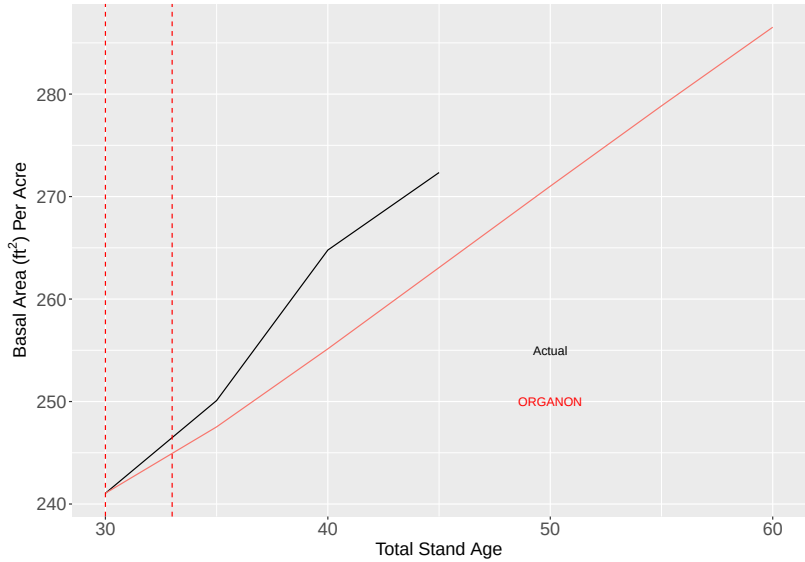



Table 11: Non-Typical calibration (30-33 years) growth.

| AGE | NOBS | MD | RMSE |
|---|---|---|---|
| 35 | 61 | -0.09692 | 0.2886 |
| 40 | 51 | -0.1847 | 0.5443 |
| 45 | 41 | -0.3005 | 0.8186 |

# Example Summary

Again, this is just 1 plot (n=1) presented as a demonstration so be careful with generalizations!

Table 12: Non-Typical calibration (30-33 years) growth.

| RUN | STage | TPA | BAPA | QMD | NOBS | MD | RMSE |
|---|---|---|---|---|---|---|---|
| ACT | 45 | 410 | 272.3 | 11.04 | NA | NA | NA |
| None | 45 | 462.1 | 252.3 | 10 | 41 | -0.5417 | 0.8902 |
| Trad | 45 | 433.8 | 279.7 | 10.87 | 41 | 0.06142 | 0.919 |
| NTradA | 45 | 449.7 | 264.6 | 10.39 | 41 | -0.2671 | 0.8173 |
| NTradB | 45 | 451.1 | 263.2 | 10.34 | 41 | -0.2972 | 0.8184 |
| NTradC | 45 | 451.2 | 263.1 | 10.34 | 41 | -0.3005 | 0.8186 |

Cankaya (2018) concluded "Results showed that any of the calibration approaches tested in general led to improved accuracy of DBH growth predictions" and some were better than others.

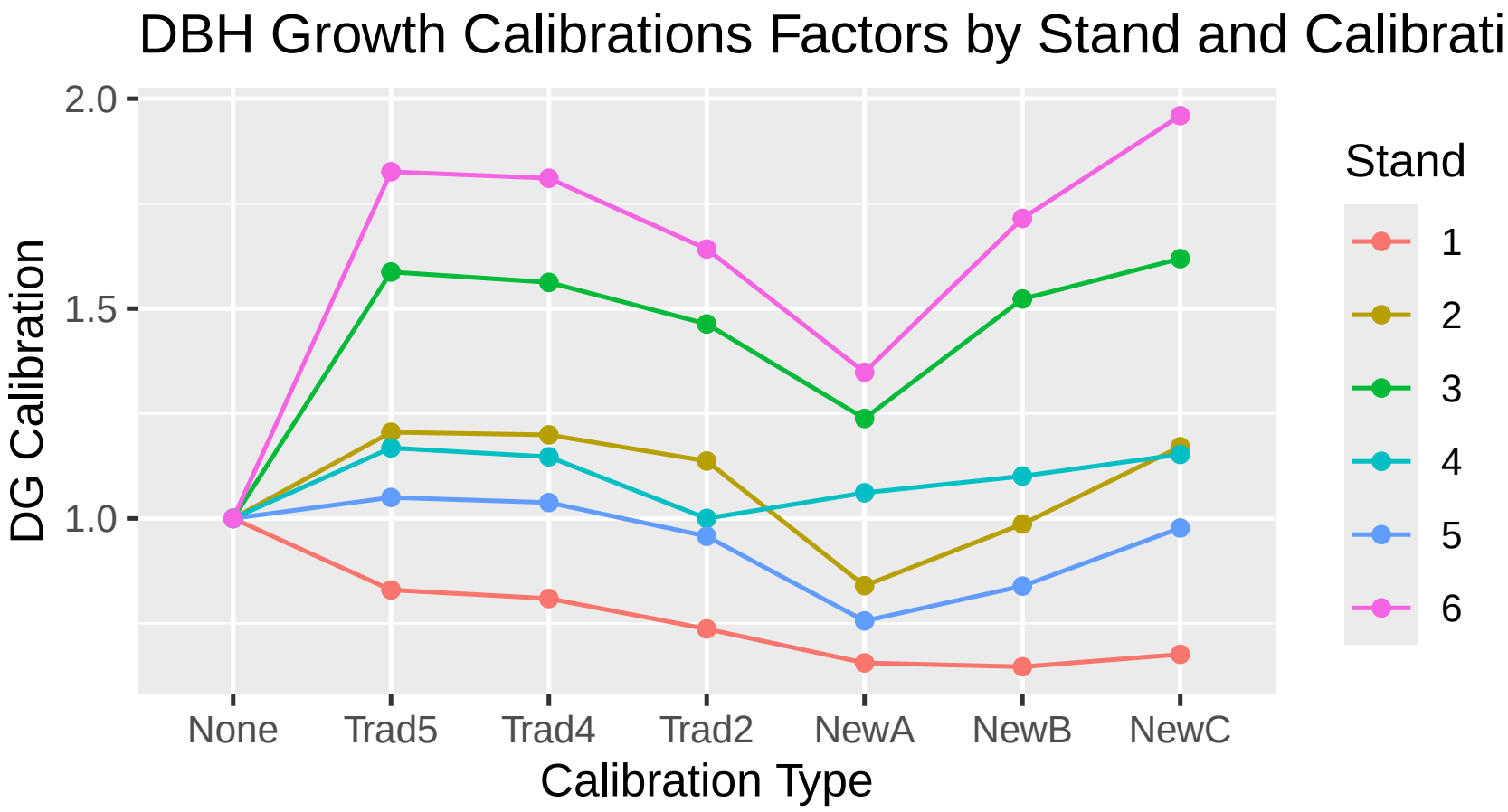
# Back To My Original Problem – Capitol Forest Damage Study

Grown from 2013 (last complete measurement) with and without calibrations

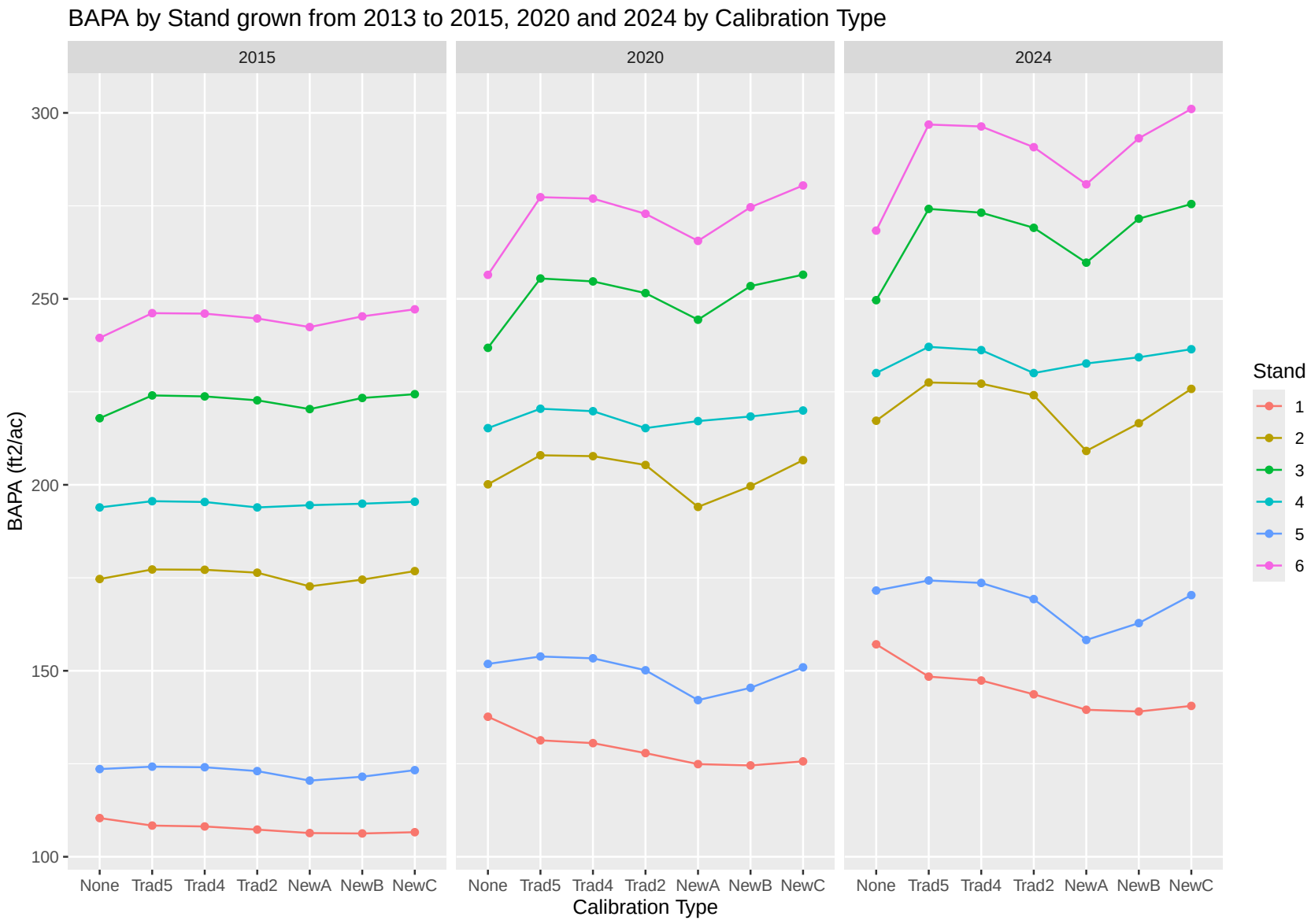
- None - no calibration
- Trad5 - typical calibration (2008-2013 with 2008 interpolated)
- Trad4 - typical calibration (2008-2013 with 2008 extrapolated from 2009-2013 PAI)
- Trad2 - typical calibration (2008-2013 with 2008 extrapolated from 2011-2013 PAI)
- NewA - non-typical calibration (2013-2015)
- NewB - non-typical calibration (2013-2020)
- NewC - non-typical calibration (2013-2024)

Treatment effects on DBH growth minimal 2015 so some advantage of calibrating on growth after 2013 rather than before (Jones and other 2018b)

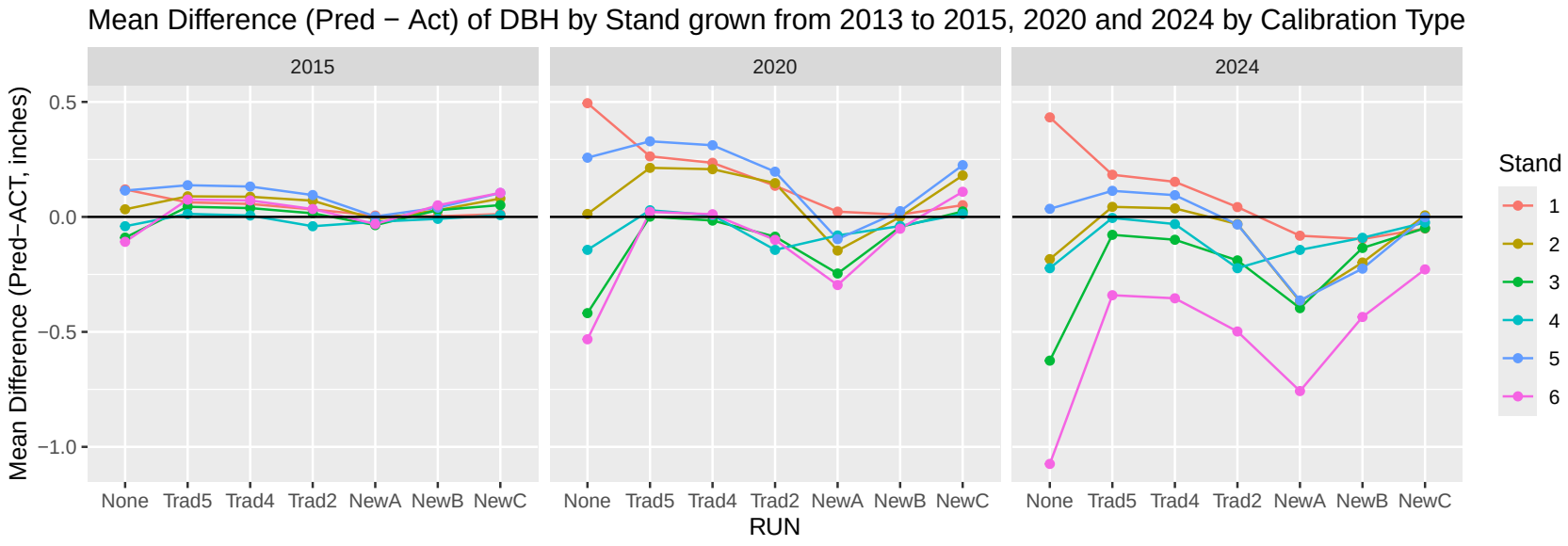
# Back To My Original Problem – Capitol Forest Damage Study

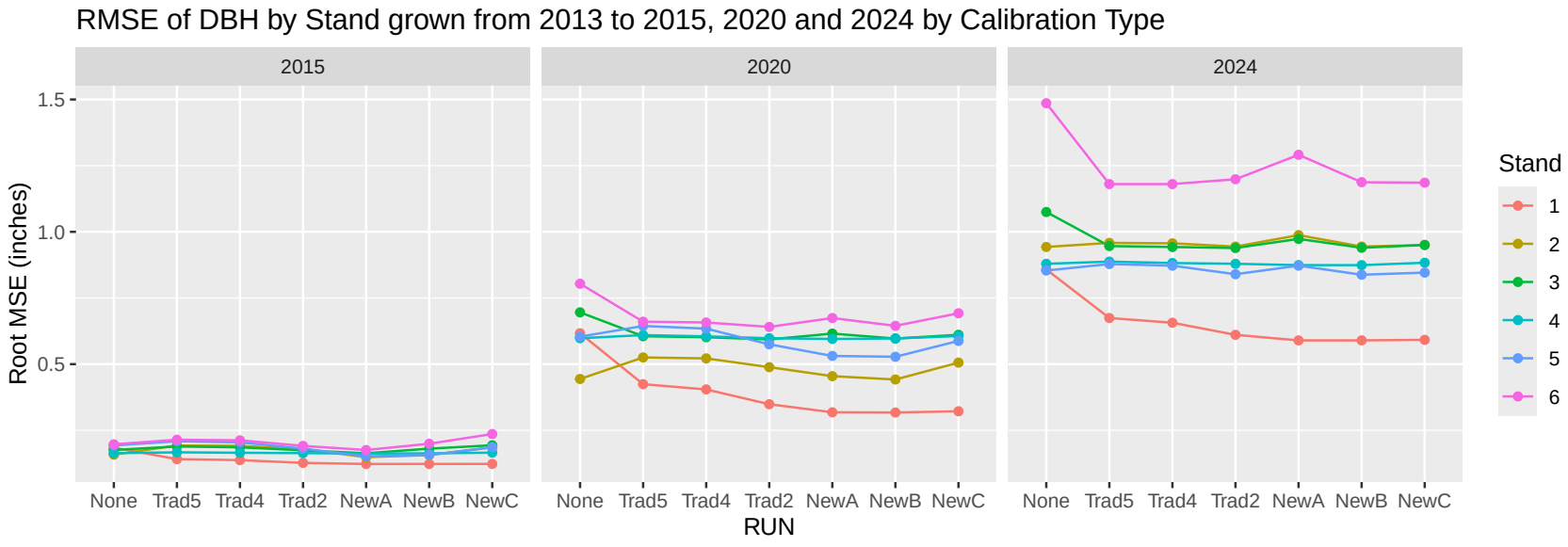


# Back To My Original Problem – Capitol Forest Damage Study



# Back To My Original Problem – Capitol Forest Damage Study



# Calibration Abuse Ahead?

THE FOLLOWING CONTENT MAY BE DISTURBING

VIEWER DISCRETION IS ADVISED

# Growth With A Non-Typical Calibration (30-35 years) - BA growth

What if we calibrated on BA growth rather than DBH growth (remember ORGANON uses DBH growth)?

Table 13: Non-Typical calibration (30-35 years) growth.

| STage | TPA | BAPA | meanHT |
|---|---|---|---|
| 30 | 840 | 241.1 | 56.76 |
| 35 | 657.1 | 245.7 | 63.9 |
| 40 | 537.6 | 252.5 | 69.99 |
| 45 | 454.4 | 260 | 75.29 |
| 50 | 393.8 | 267.6 | 79.99 |
| 55 | 348 | 275.2 | 84.21 |
| 60 | 312.4 | 282.8 | 88.09 |

DBH Calibration = 1.161 – remember ORGANON uses DBH growth.

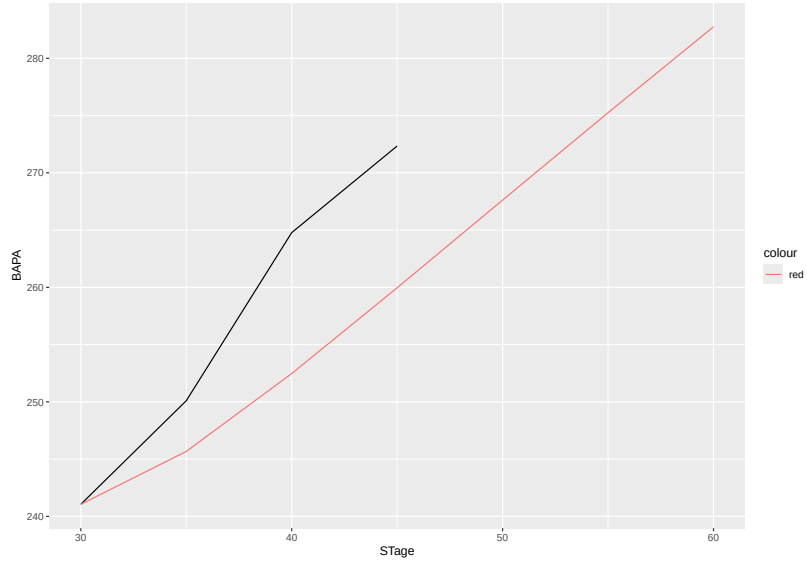



Table 14: Non-Typical calibration (30-35 years) growth.

| AGE | NOBS | MD | RMSE |
|---|---|---|---|
| 35 | 61 | -0.1244 | 0.2948 |
| 40 | 51 | -0.2333 | 0.5508 |
| 45 | 41 | -0.3695 | 0.8282 |

# Calibration Over Multiple Measurements (35 & 40 years)

What if we calibrated DBH growth using samples at different future ages?

Table 15: Non-Typical calibration (30-35 years) growth.

| STage | TPA | BAPA | meanHT |
|---|---|---|---|
| 30 | 840 | 241.1 | 56.76 |
| 35 | 657.1 | 248.5 | 63.9 |
| 40 | 534.7 | 256.6 | 69.95 |
| 45 | 449.5 | 264.7 | 75.19 |
| 50 | 387.9 | 272.8 | 79.82 |
| 55 | 341.7 | 280.8 | 83.99 |
| 60 | 306.2 | 288.5 | 87.81 |

DBH Calibration = 1.263 compared to 1.26 and 1.231 (Weighted estimate? Handling same remeasured trees?).

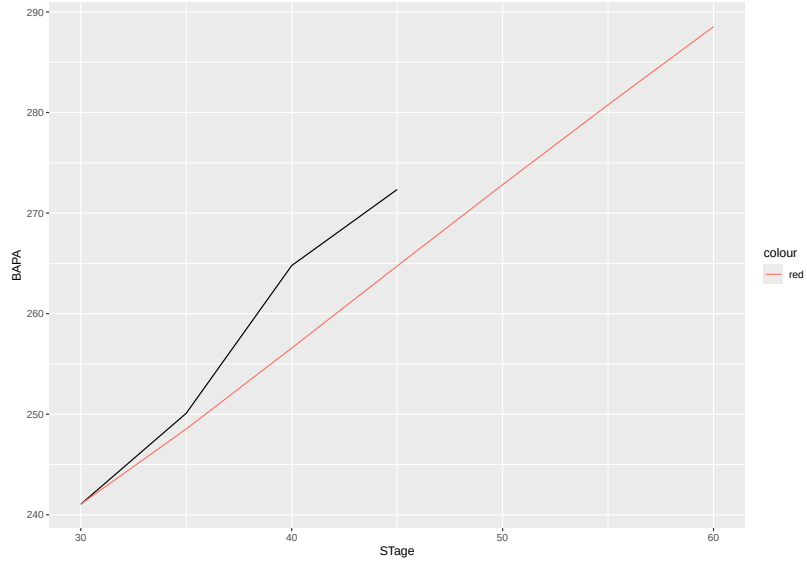



Table 16: Non-Typical calibration (30-35 years) growth.

| AGE | NOBS | MD | RMSE |
|---|---|---|---|
| 35 | 61 | -0.08209 | 0.287 |
| 40 | 51 | -0.1587 | 0.5439 |
| 45 | 41 | -0.2638 | 0.8173 |

# Discussion/Conclusions

Calibrations need to be used with care and after carefully considering the data available (measurements matter).

Good (possibly even modest) calibrations can improve the accuracy of projections.

This non-typical method appears to work and offers an option when projecting remeasured plots.

Have not considered:

- best way to evaluate optimization (alternatives to sum of squares).
- best way to sample trees for calibration or how may trees is needed.

I think this method should work with FVS and it might be interesting to compare with the built in keyword methods available for future measurements and non-10-year periods.

# References


Cankaya , E.C. 2018. Testing methods for calibrating Forest Vegetation Simulator (FVS) diameter growth predictions. MS Thesis, VPI.

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