Growth and Yield Model – Gaussian Form with Tempered Peaks

Ryan Smith

2025-08-06

Growth and Yield Model Form

Context & Data

- **Source:** SILC strategic planning dataset (periodic grow-only yield tables).
- **Growth metric:** Annualized yield, filtered to:
  - Total volume: 3–48 cords/acre
  - Growth: 0.25–0.75 cords/acre/year (to exclude outliers)
- **Species groups:**
  - Hardwood (HW): H, HS
  - Softwood (SW): S, SH, OS, C

Model Form: Gaussian Growth Curve

We use a **species-specific Gaussian model** to estimate growth as a function of current volume:

$$\text{growth}_w(V_w) = a_w \cdot \exp\left(-\frac{1}{2}\left(\frac{V_w - \mu_w}{\sigma_w}\right)^2\right)$$

Where: - V_w: volume of wood type w - a_w: peak growth rate - μ_w: volume at which peak occurs - σ_w: spread controlling the decline from the peak

Total growth is computed as a weighted average:

$$\text{growth}_{\text{total}} = \frac{V_{\text{HW}}}{V} \cdot \text{growth}_{\text{HW}} + \frac{V_{\text{SW}}}{V} \cdot \text{growth}_{\text{SW}}, \quad V = V_{\text{HW}} + V_{\text{SW}}$$

Fitted Parameters (Original, Unadjusted)

Table 1: Original Gaussian Parameters (Unadjusted)

unit	wood	a	mu	sigma
RY	HW	0.552	27.3	22.3
RY	SW	0.629	29.1	20.2
SP	HW	0.554	29.5	25.0
SP	SW	0.583	25.5	22.0
AE	HW	0.553	28.4	23.7
AE	SW	0.606	27.5	21.1
AW	HW	0.553	28.4	23.7
AW	SW	0.606	27.5	21.1

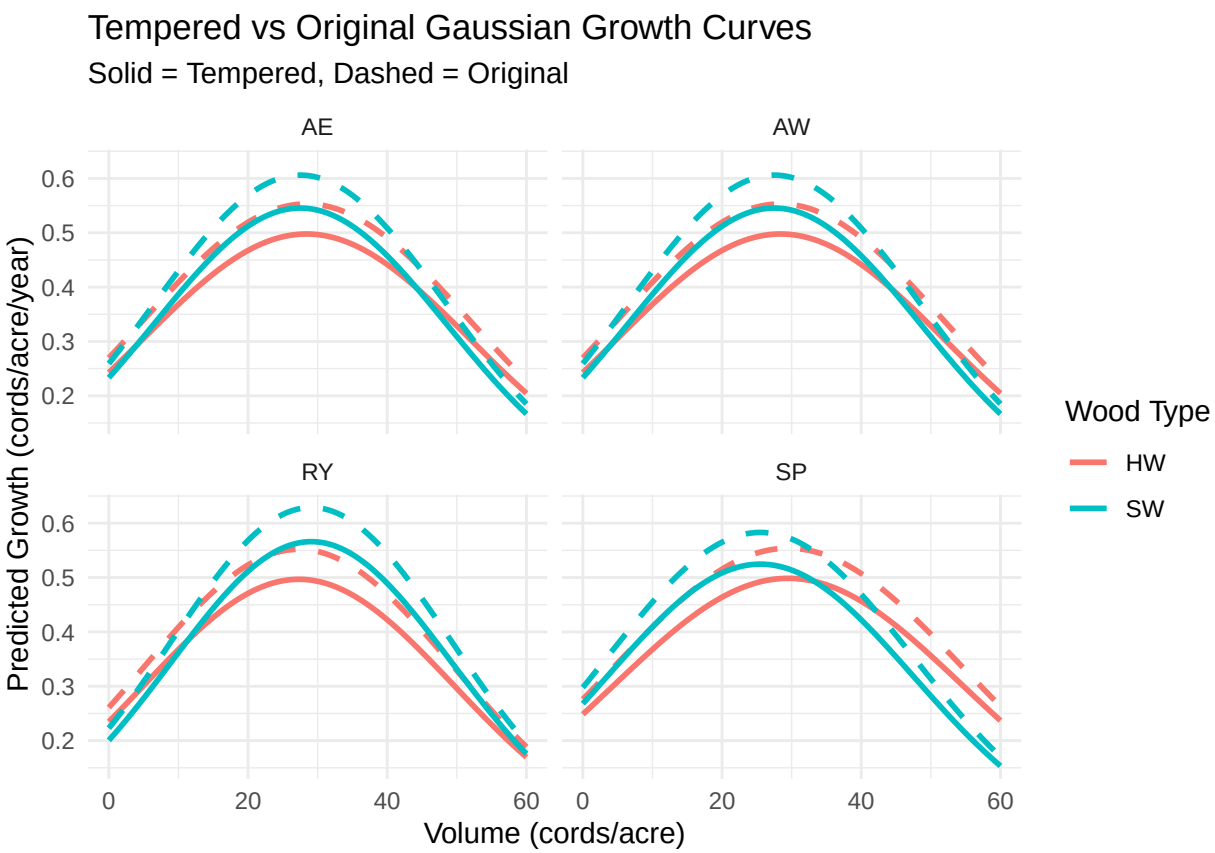
Tempered Parameters (90% of Original Peak)

Although the original model fits had strong empirical performance, the peak `a` values exceeded known growth limits for similar stand types in Maine. A uniform **0.9 scaling** was applied to all peak values a to temper projections while preserving shape and relative differences across species and site types.

Table 2: Tempered Gaussian Parameters (Peak a × 0.9)

unit	wood	a	mu	sigma
RY	HW	0.497	27.3	22.3
RY	SW	0.566	29.1	20.2
SP	HW	0.499	29.5	25.0
SP	SW	0.525	25.5	22.0
AE	HW	0.498	28.4	23.7
AE	SW	0.545	27.5	21.1
AW	HW	0.498	28.4	23.7
AW	SW	0.545	27.5	21.1

Visual Comparison of Growth Curves



Justification for Tempering

The original fitted curves estimated peak softwood growth rates in excess of **0.65 cords/acre/year**, which was deemed inconsistent with field observations and long-term plot trends across Maine.

The revised curves:

- Retain the empirical form and relative differences.
- Reduce over-optimism in high-productivity scenarios.
- Improve alignment with stand-level outcomes for both inventory and planning use.

This tempering reflects a **judicious compromise** between statistical fit and field-informed expectation, and is now the preferred default for AAC and projection modeling.
