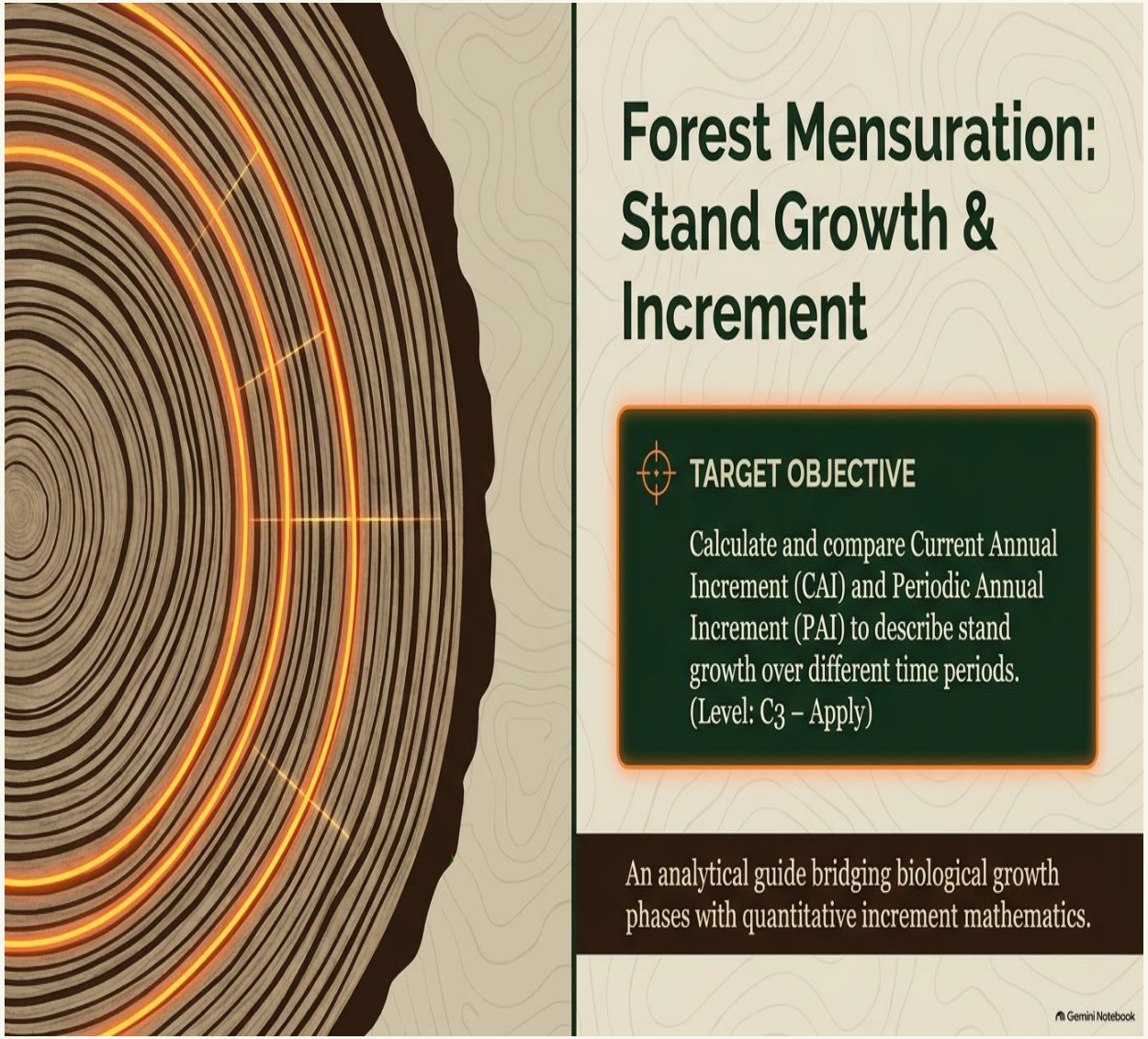
CALCULATING ANNUAL AND PERIODIC GROWTH

A practical guide to CAI, PAI and growth interpretation

Measure the change. Understand the trend. Support better forest decisions.

TARGET OBJECTIVE

Calculate and compare Current Annual Increment (CAI) and Periodic Annual Increment (PAI).



Growth and Increment: Two Related Ideas

Use clear terms before starting any calculation.

GROWTH

The biological increase in tree or stand size.

Can involve height, diameter, basal area or volume.

Describes the total increase over time.

INCREMENT

The amount of growth during a defined period.

Can be measured for one year or several years.

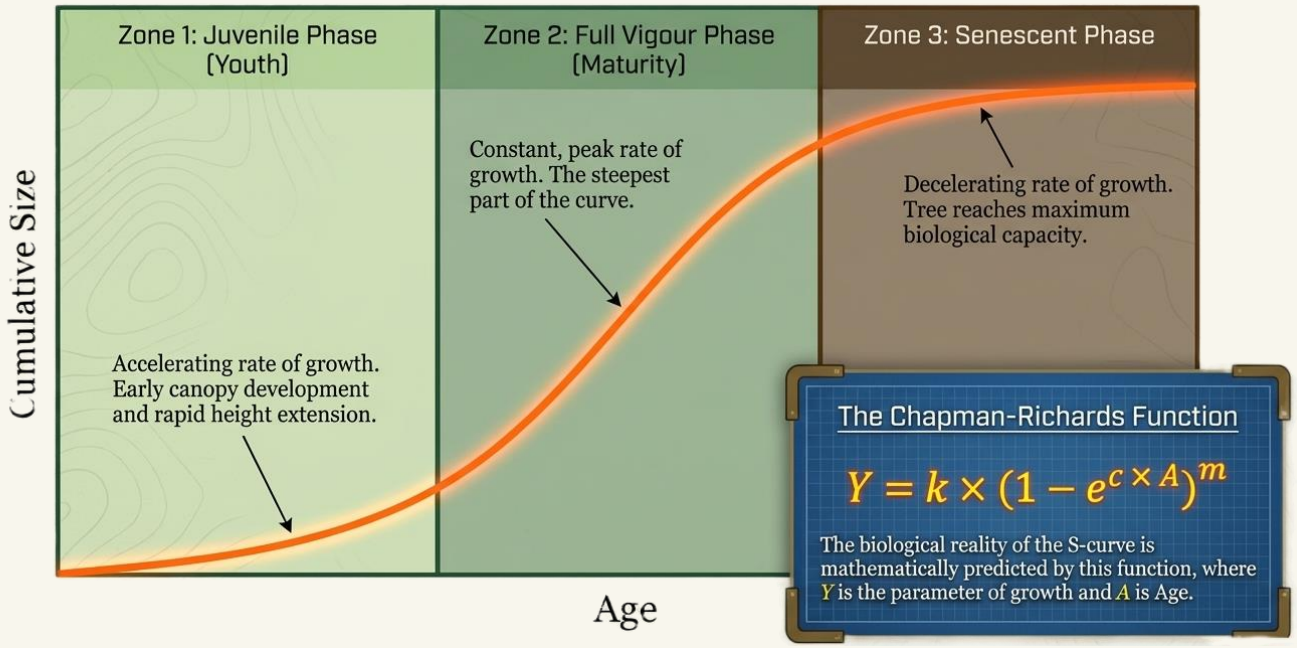
Helps us compare productivity between periods or stands.

KEY MESSAGE

Always state the measurement period when reporting increment.

The Three Phases of a Cumulative Growth Curve

The rate of growth changes as the stand develops.



Three phases

Juvenile phase: growth starts slowly.

Full-vigour phase: growth is rapid.

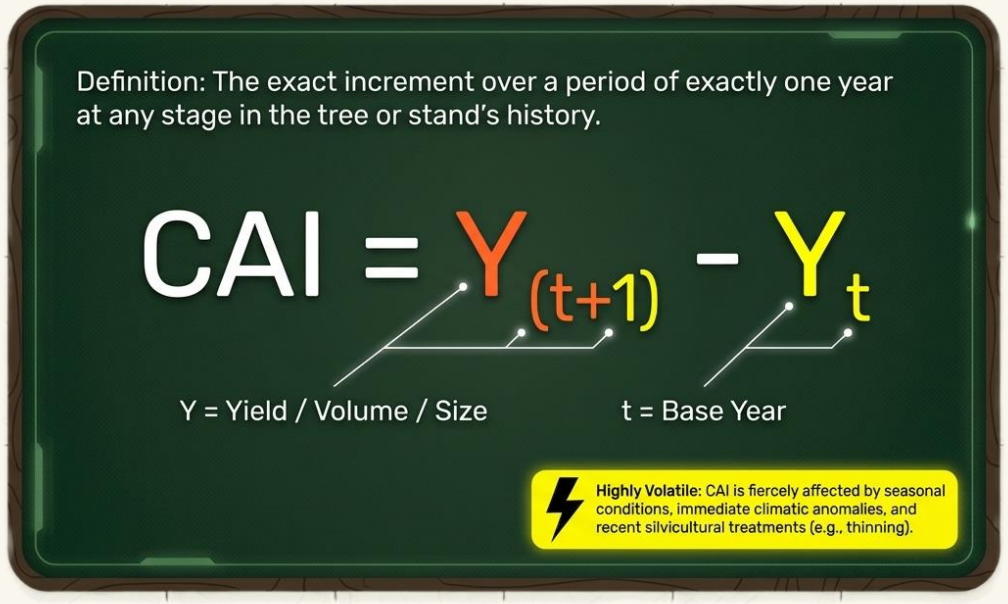
Senescent phase: growth slows as the stand matures.

READ THE CURVE

A steep curve means faster growth. A flatter curve means slower growth.

Metric 1: Current Annual Increment (CAI)

CAI measures the increase over exactly one year.



$CAI = Y(t+1) - Y(t)$

Y = yield, volume or another size measure

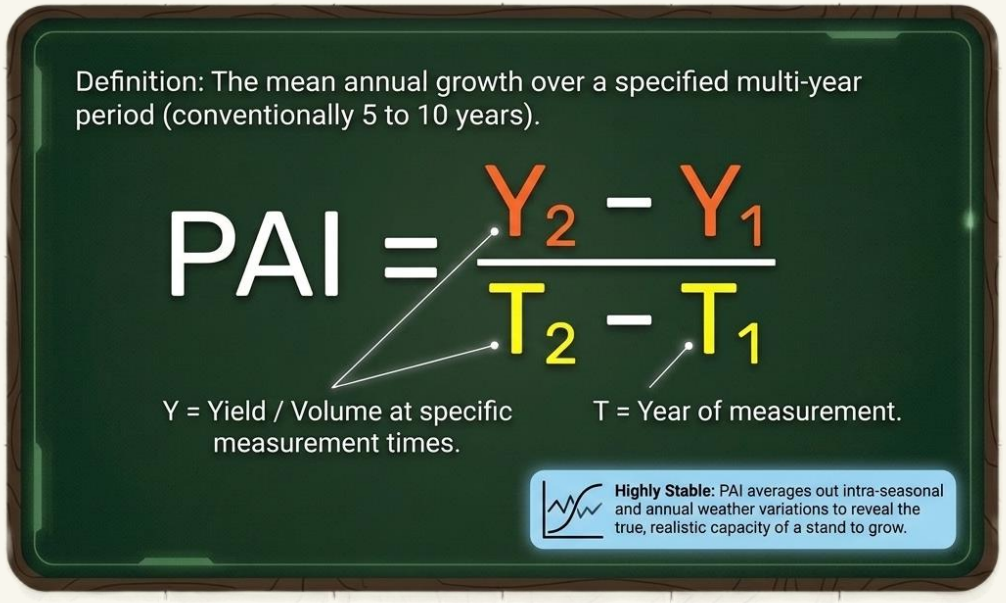
Use two measurements taken one year apart.

CAI shows the recent annual change.

Report the unit, such as m^3/ha/year.

Metric 2: Periodic Annual Increment (PAI)

PAI averages growth over a multi-year period.



$$PAI = (Y_2 - Y_1) / (T_2 - T_1)$$

Y = yield, volume or another size measure
T = year of measurement

Use measurements taken several years apart.

PAI smooths short-term fluctuations.

Useful for longer-term stand assessment.

CAI or PAI? Choose the Right Measure

The measurement period affects what the result tells us.

Dimensions	Current Annual Increment (CAI)	Periodic Annual Increment (PAI)
Measurement Period	Exactly 1 Year (n = 1).	Multi-Year Period (n > 1, typically 5-10 years).
Data Stability	Volatile. Highly sensitive to isolated climate events or localized pest attacks.	Stable. Averages out annual variance to reveal underlying growth trends.
Primary Management Use	Assessing the immediate, short-term impact of a specific silvicultural treatment (e.g., annual fertilization).	Estimating mid-to-long-term growth rates and determining rotation ages when annual measurement is impractical or too costly.

Use CAI when you need:

A one-year change.

Recent growth information.

A short-term diagnostic.

Use PAI when you need:

A multi-year average.

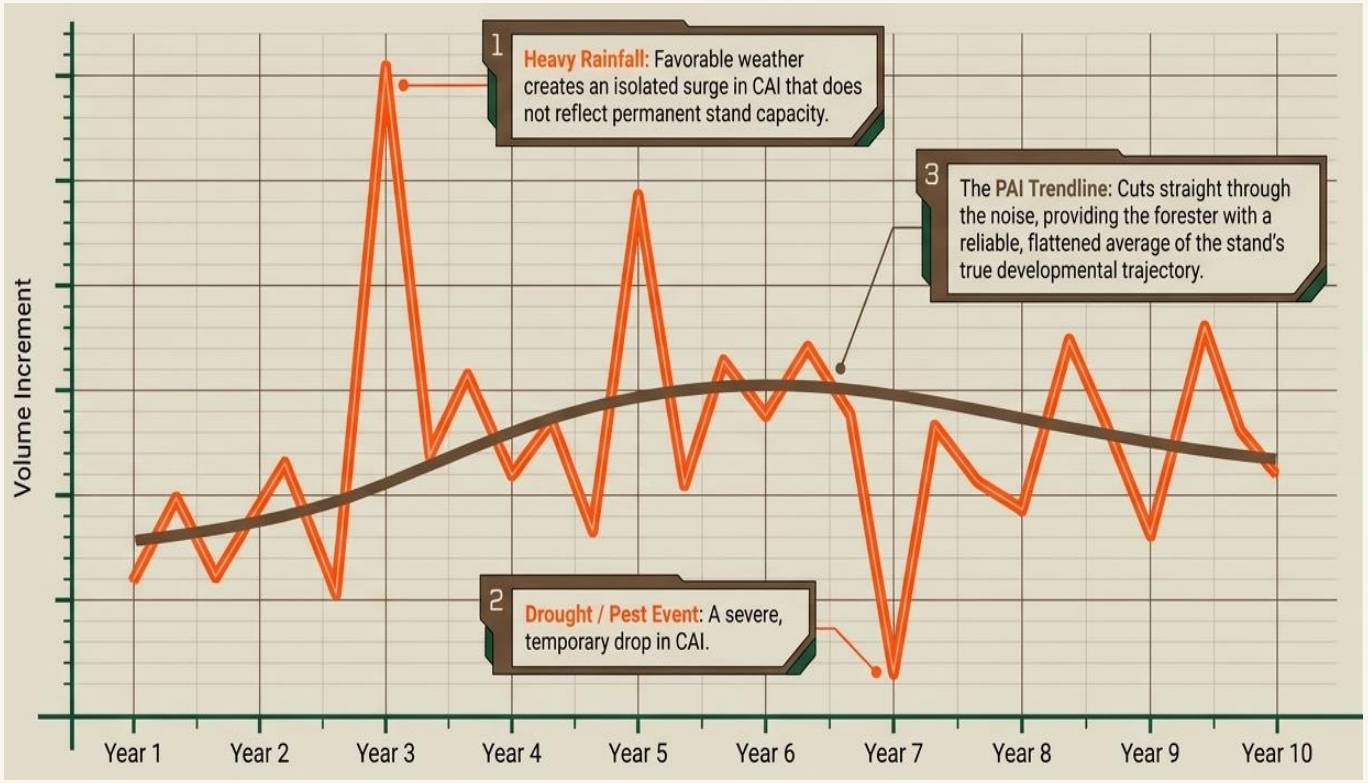
A more stable trend.

Longer-term planning support.

Why Multi-Year Measurements Can Be Useful

Short-term growth may fluctuate because of temporary events.

Visualising Volatility vs Underlying Capacity



Possible causes of variation

Weather and drought.

Disturbance or damage.

Thinning and competition.

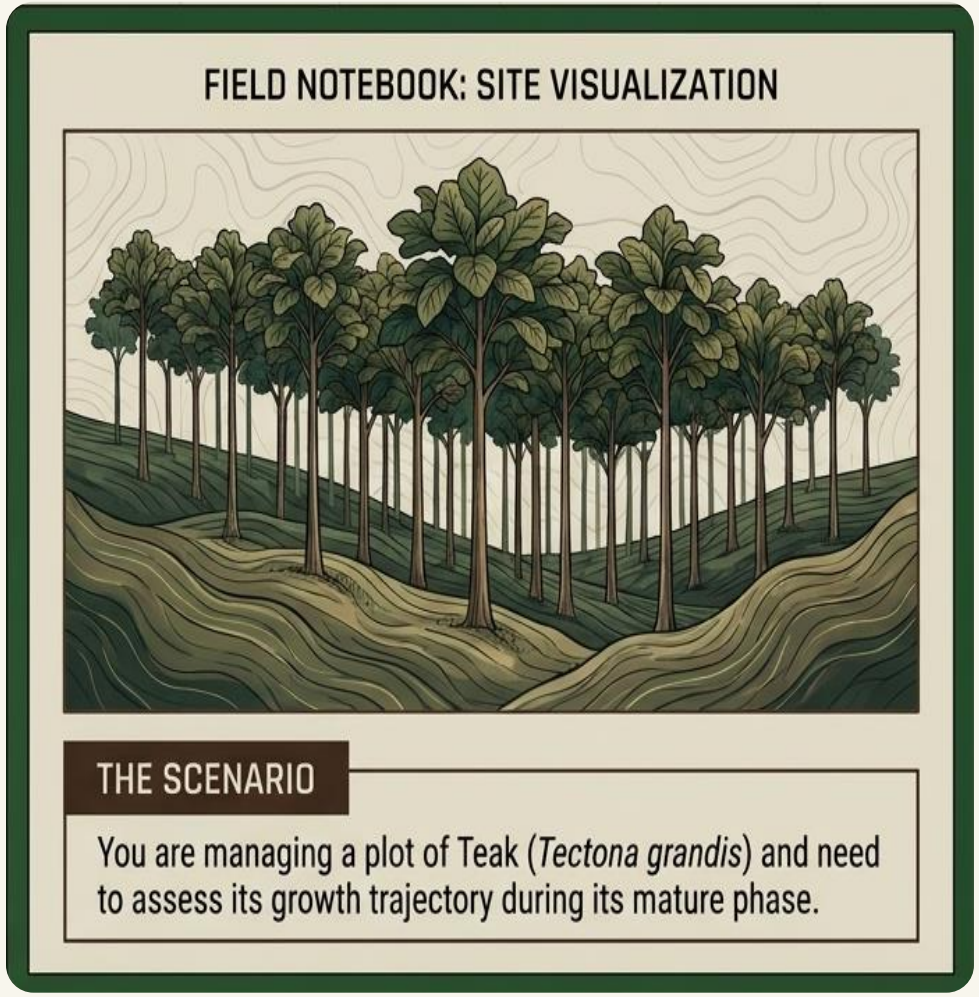
Measurement error.

PRACTICAL TIP

PAI can help reveal the underlying trend when yearly values are unstable.

Application Walkthrough: The Teak Plot

We will use a simple field example to calculate CAI and PAI.



Raw Field data

Age 10: stand volume = 120 m^3/ha

Age 11: stand volume = 135 m^3/ha

Age 15: stand volume = 195 m^3/ha

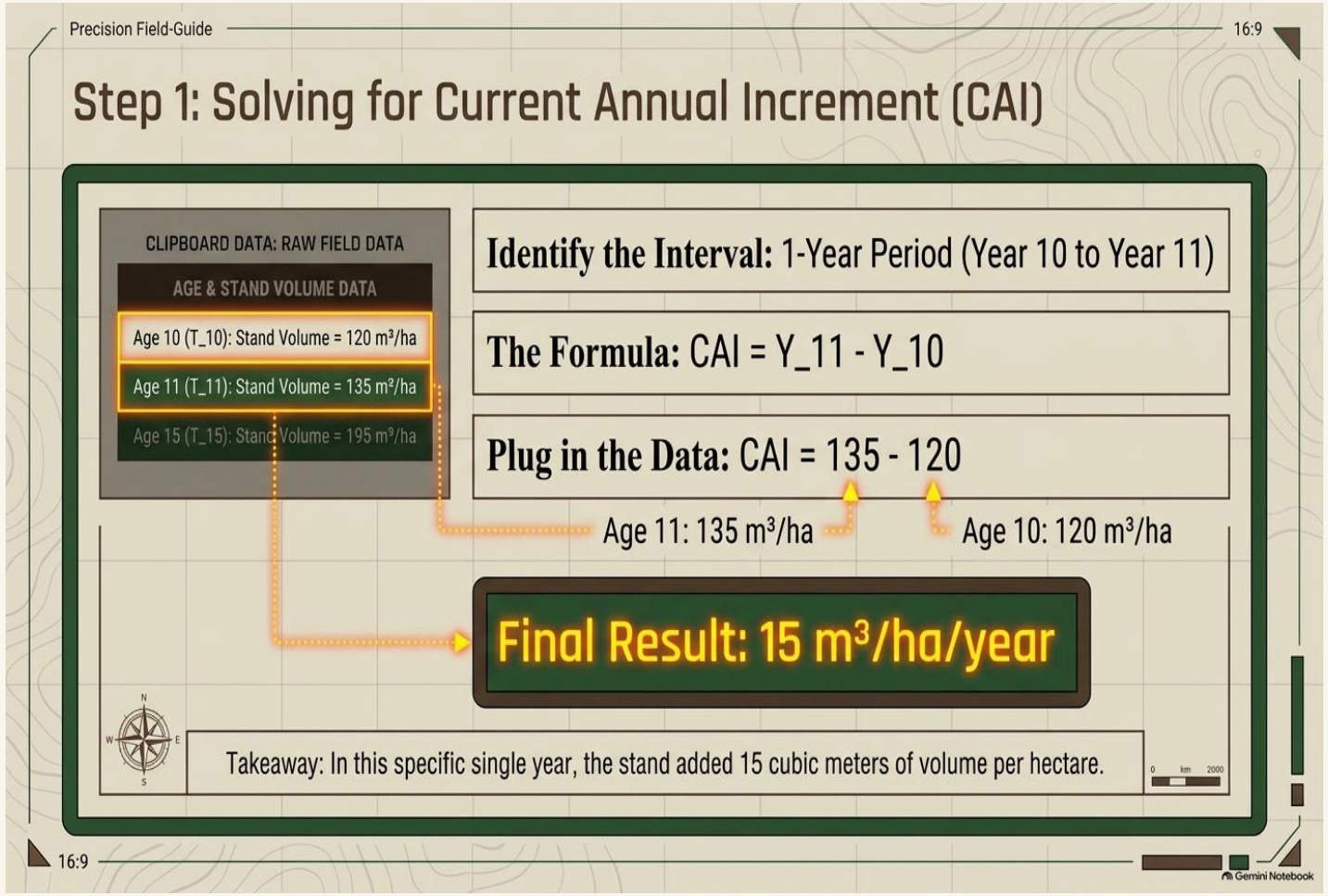
Tasks

Calculate CAI from age 10 to 11.

Calculate PAI from age 10 to 15.

Step 1: Calculate Current Annual Increment (CAI)

Use the two values that are exactly one year apart.



Formula

$$CAI = Y_{11} - Y_{10}$$

$$CAI = 135 - 120$$

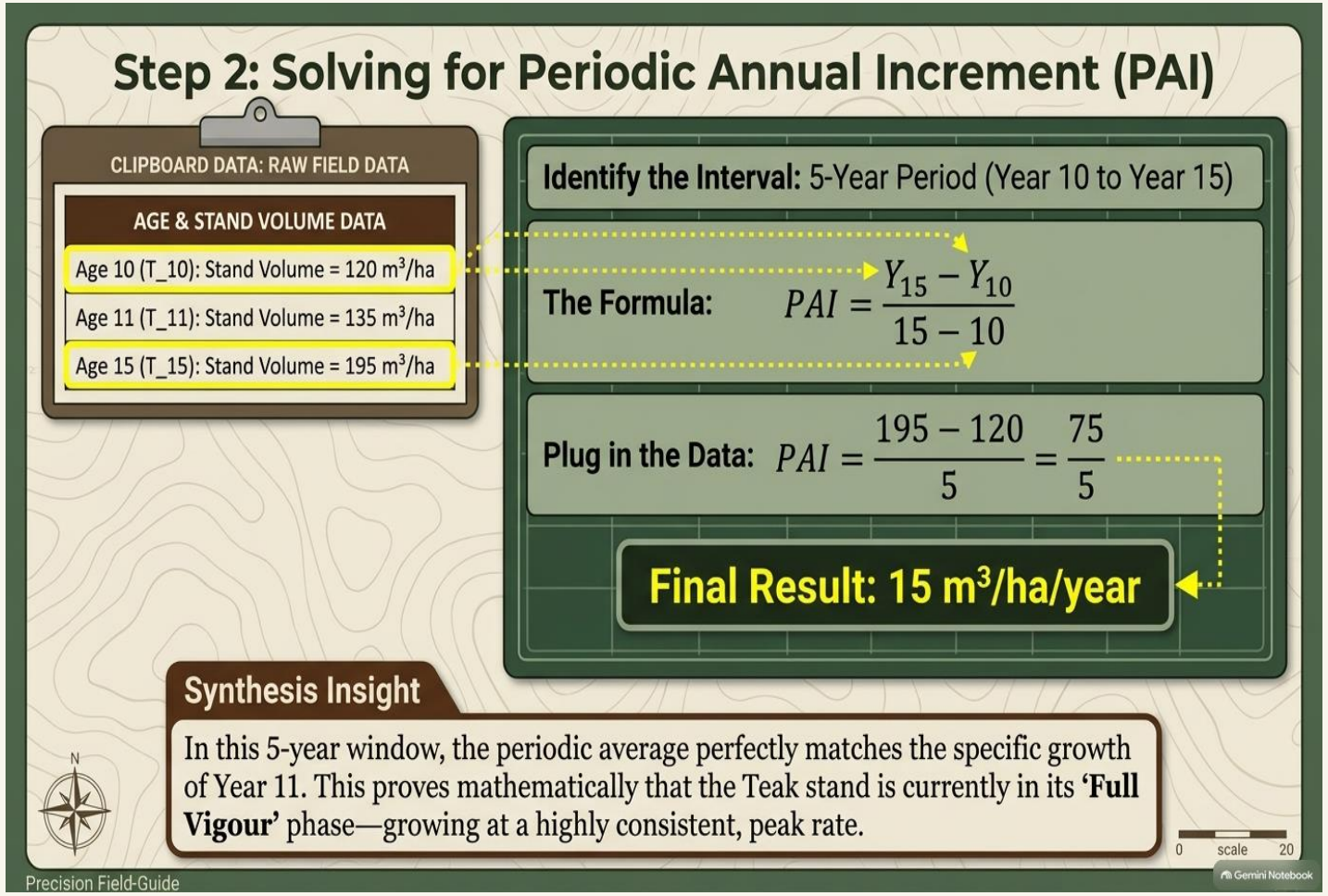
$$CAI = 15\ m^3/ha/year$$

INTERPRETATION

The stand added 15 m^3 per hectare in one year.

Step 2: Calculate Periodic Annual Increment (PAI)

Use the first and last measurements in the selected period.



Formula

$$PAI = (Y_{15} - Y_{10}) / (15 - 10)$$

$$PAI = (195 - 120) / 5$$

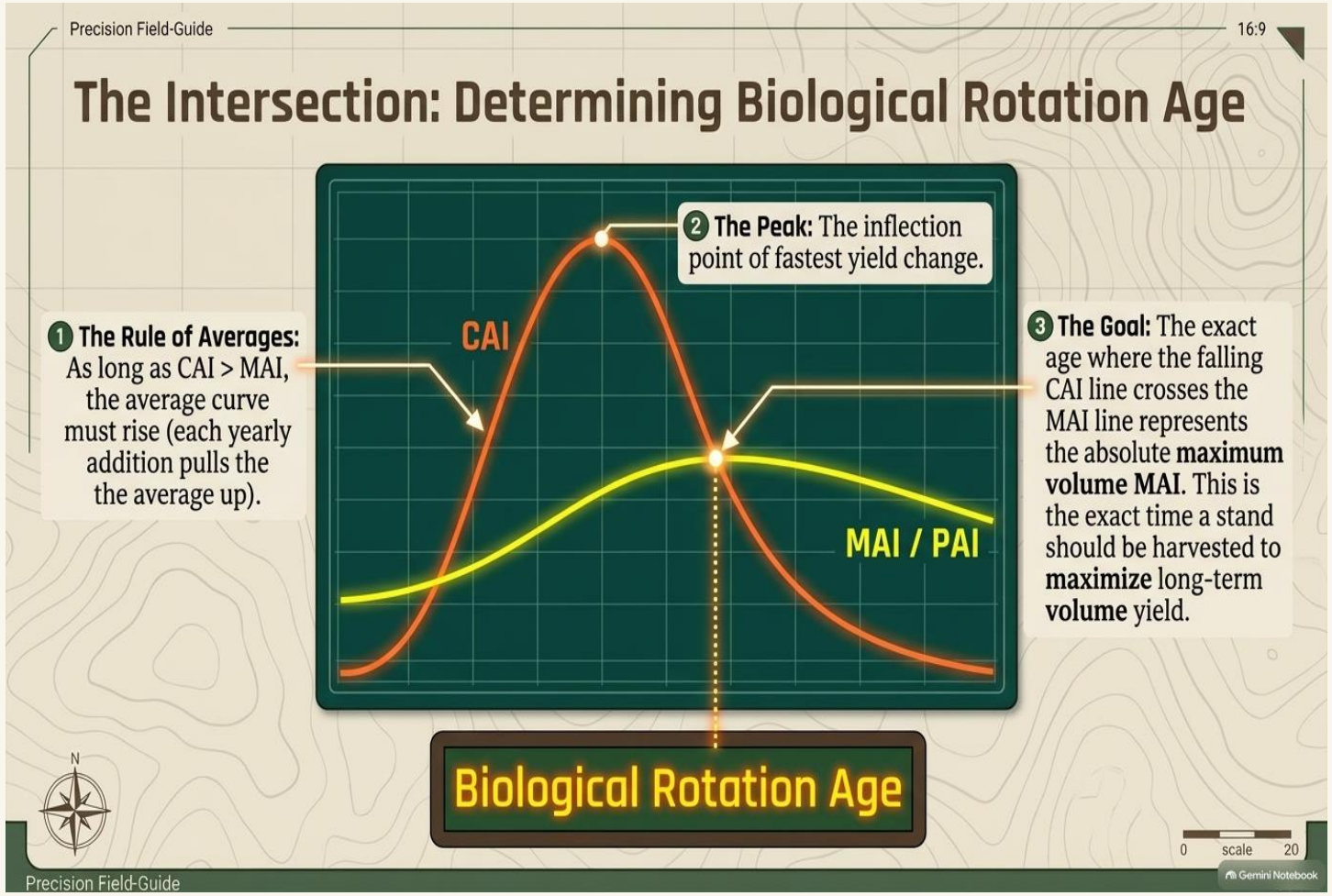
$$PAI = 15\ m^3/ha/year$$

INTERPRETATION

Across five years, the average annual increase was 15 m^3/ha.

CAI and PAI: Understanding the Intersection

The relationship between the curves helps explain biological rotation age.



The key idea

CAI and PAI meet when CAI equals PAI.

At this point, PAI reaches its maximum.

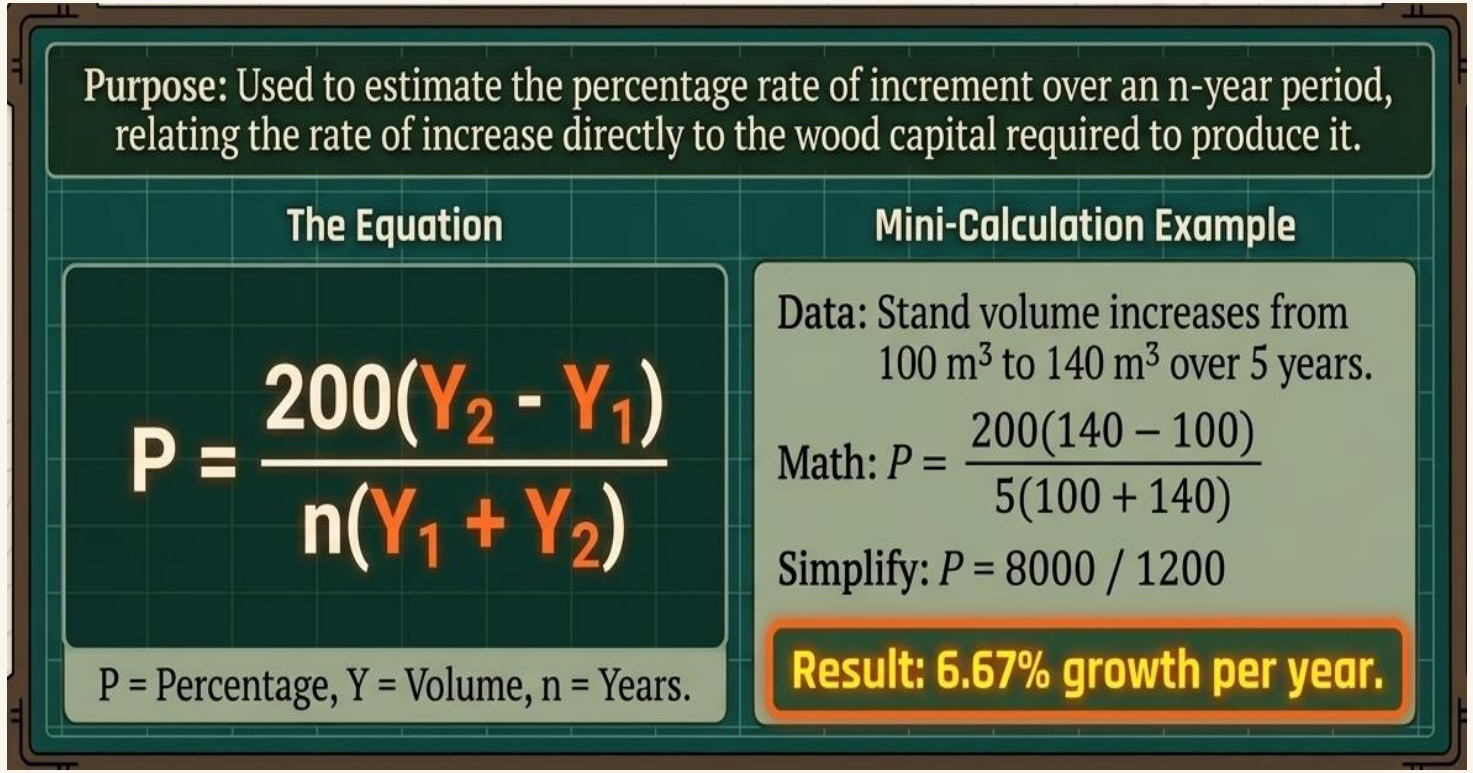
This is one indicator used in biological rotation analysis.

IMPORTANT

Rotation decisions should also consider ecology, economics and management objectives.

Advanced Tool: Pressler’s Increment Percentage

This measure expresses periodic growth as a percentage of average volume.



When is it useful?

Compare growth rates between stands with different volumes.

Express change as a percentage.

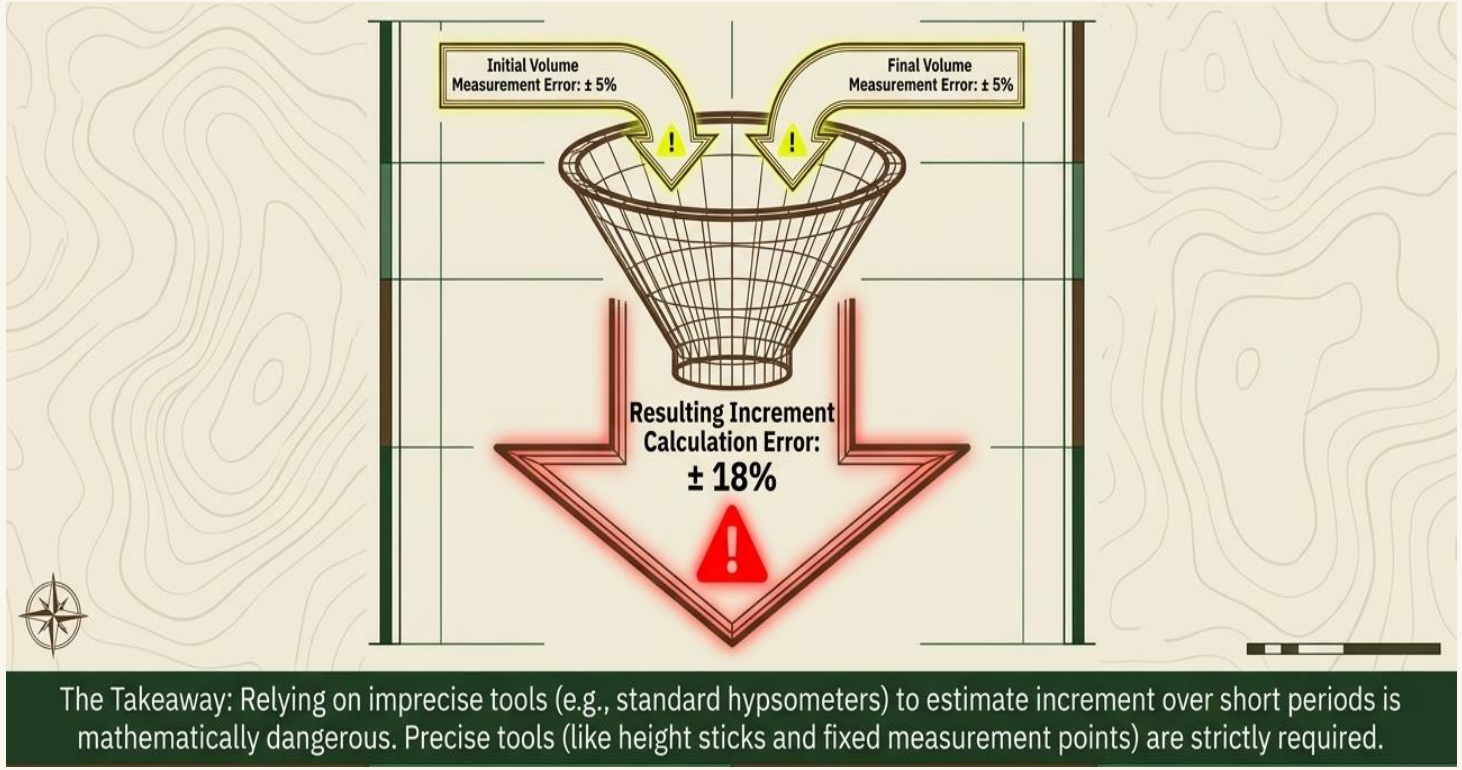
Use only when the measurement assumptions are appropriate.

CAUTION

Check the formula, units and measurement period before comparing results.

Field Realities: The Risk of Measurement Error

Small errors during initial or final field measurements can change the calculated increment. Measuring increment requires significantly more precision than simply measuring standing volume.



The Takeaway: Relying on imprecise tools (e.g., standard hypsometers) to estimate increment over short periods is mathematically dangerous. Precise tools (like height sticks and fixed measurement points) are strictly required.

Common sources

Different observers or methods.

Inconsistent plot boundaries.

Incorrect tree or volume records.

Low precision in repeated measurements.

GOOD PRACTICE

Use consistent methods, trained measurers and careful data checking.

Summary and Key Takeaways

Use the right metric, the right period and reliable measurements.

1 Understand

Growth is the increase in size.

Increment is the amount added during a period.

2 Calculate

CAI uses one year.

PAI uses several years.

Always include units and the time period.

3 Apply

Compare growth patterns.

Check measurement quality.

Use results to support management decisions.

REFLECTION

Why might PAI be more informative than CAI when annual growth is highly variable?