

Long-term woodland tree-growth monitoring supports sustainable landscape management

LESSONS FROM TEAK WOODLANDS IN ZIMBABWE

This brief highlights key findings from 27 years (1994–2021) of monitoring protected teak woodlands in north-western Zimbabwe.

Zimbabwe's indigenous teak woodlands support timber production, biodiversity, carbon storage, and local livelihoods. Across Africa, sustainable forest and landscape management is increasingly recognised as important for climate resilience, ecosystem integrity, and long-term development goals. This brief's findings have direct relevance for landscape managers, forestry stakeholders, conservation planners, and institutions working to support sustainable woodland management.



Photo: Naturalist/dune-ninja

African Teak (*Baikiaea plurijuga*), Zimbabwe



Drone aerial view of the Teak woodlands in Gwaai Forest Reserve, Zimbabwe.

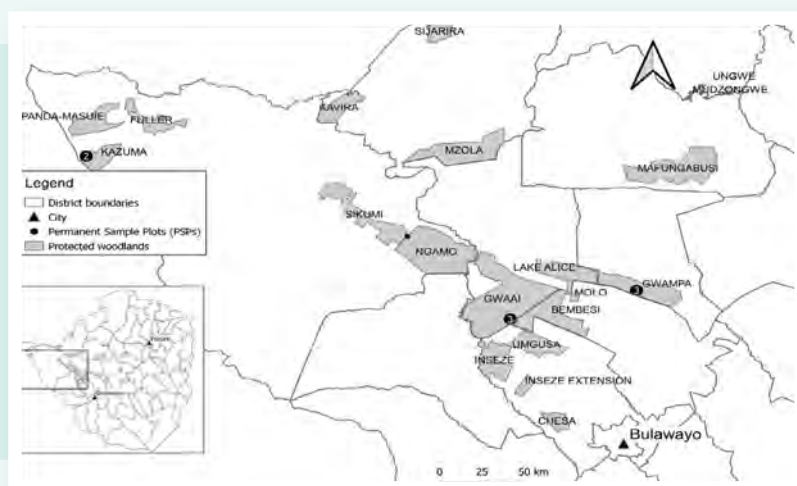
Drawing on permanent sample plots that tracked 2,466 tree stems across 33 woodland species, the brief spotlights evidence on tree growth rates, tree-to-tree competition, environmental conditions influencing growth, and variation in growth rates within and among species. Over 27 years, growth increased with water availability and atmospheric CO₂, while competition strongly constrained growth. Doubling stand basal area nearly doubled the estimated time for trees to reach harvestable size from about 150 to 292 years. These findings provide practical evidence for aligning harvesting cycles, management interventions, and long-term monitoring with the ecological dynamics of woodlands. The findings improve understanding of how woodland systems may respond to environmental change and contribute to ongoing efforts to support sustainable woodland management, restoration, and long-term ecological stewardship across African landscapes.

Study location and research approach

The research was conducted in protected teak woodlands in north-western Zimbabwe.

The monitoring network covered:

- 11 permanent sample plots
- Protected woodland areas
- Long-term ecological monitoring sites established to assess woodland productivity and tree growth dynamics over time



The study analysed:



27 years
of ecological
monitoring



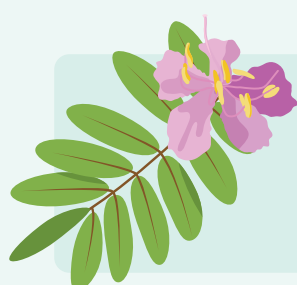
2,466
individual tree
stems



33
woodland
species

Repeated measurements from permanent sample plots were used to assess:

- Tree growth rates
- Tree-to-tree competition
- The influence of environmental conditions on woodland productivity
- Species-specific growth patterns



Baikiaea plurijuga is the dominant species in these woodlands, occurring alongside *Pterocarpus angolensis*, *Entandrophragma caudatum*, *Guibourtia coleosperma*, and *Brachystegia spiciformis*.

This long-term dataset provides one of the most extensive ecological monitoring records currently available for southern African woodlands.

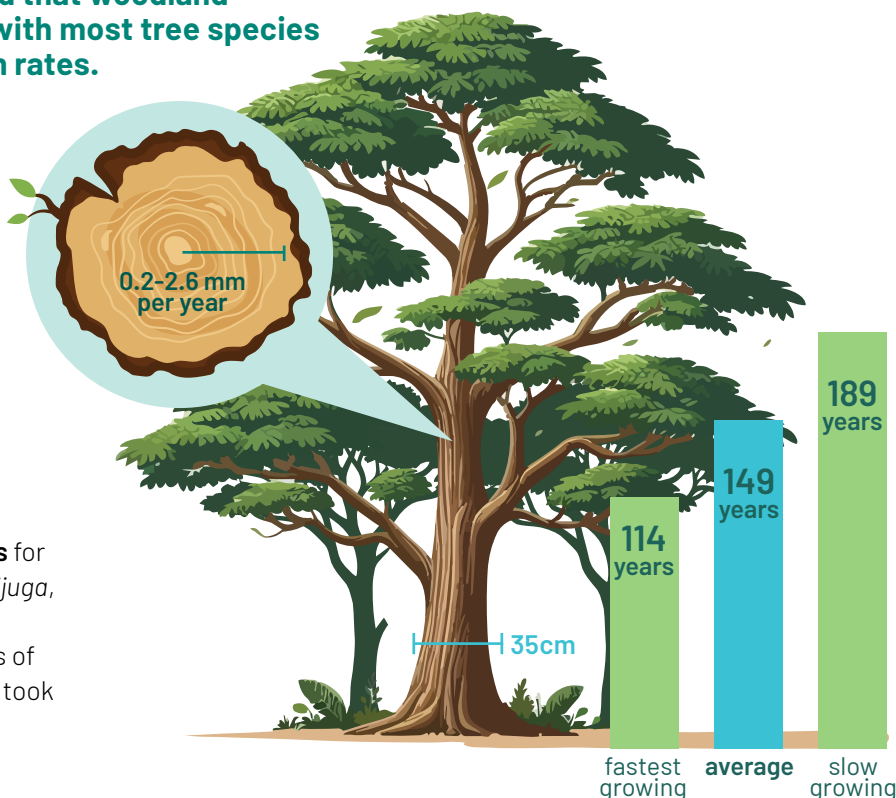
1 Woodland recovery occurs over long time periods

The monitoring data revealed that woodland recovery is a slow process, with most tree species exhibiting low annual growth rates.

The predicted median growth rate of a species growing in a plot with a median basal area of $11 \text{ m}^2 \text{ ha}^{-1}$ was 0.8 mm per year, with species mean growth rates ranging from 0.2 mm to 2.6 mm per year.

The time for key timber species to reach a harvestable size (35 cm in diameter) was, on average, 149 years for *G. coleosperma*, 189 years for *B. plurijuga*, and 114 years for *P. angolensis*. Even the fastest-growing individual stems of timber species (the 90th percentile) took 121 years to reach harvestable size.

These growth rates translate into **exceptionally long recovery periods for commercially important timber species**. This highlights the importance of adopting long-term approaches to harvesting and woodland management, that can help forestry stakeholders align harvesting cycles and growing-stock assessments with the actual rate of woodland recovery.



Policy insight:

Harvesting cycles and woodland management plans should account for long recovery periods and species-specific growth rates when setting sustainable harvesting thresholds.

What is the basal area of a forest?

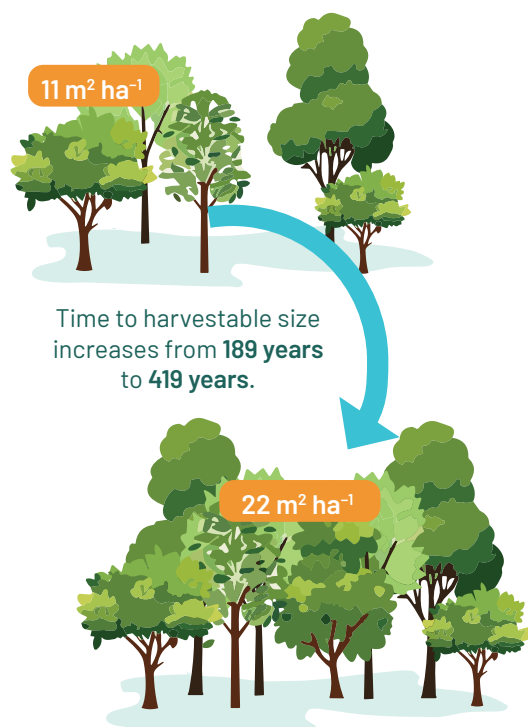
Basal area is a common way to describe the density of a stand of trees (in forest management, specifically the density of merchantable timber).

The basal area of a forest is estimated by measuring the diameter of each trunk at breast height (DBH), or 1.3 m above the ground, and then adding the basal areas of all of the trees and dividing by the area of land in which the trees were measured. Basal area is scaled to m^2/ha to compare forest productivity and growth rate among multiple sites.



2 Tree-tree competition influences long-term productivity

Tree-to-tree competition was found to be as important as water availability in influencing tree growth rates.



Higher plot-level basal area, a proxy indicator for tree-tree competition, was associated with lower growth rates. Competition effects were particularly pronounced where basal area exceeded approximately $18 \text{ m}^2 \text{ ha}^{-1}$. For *B. pluri-juga*, doubling the basal area from $11 \text{ m}^2 \text{ ha}^{-1}$ to $22 \text{ m}^2 \text{ ha}^{-1}$ increased the estimated time to harvestable size from 189 to 419 years.

This highlights the strong influence of tree-to-tree competition on woodland productivity and recovery over time. It points to the potential of intermediate thinning and selective harvesting to ease competition within stands and increase growth rates.

Policy insight:

Woodland productivity can be enhanced through management approaches that account for stand structure and competition. Carefully planned thinning and selective harvesting reduce competition among trees and promote recovery.

3 Environmental conditions shape woodland growth

Woodland productivity is influenced by environmental conditions.

Over the 27-year monitoring period, annual rainfall ranged from 327–990 mm per year, potential evapotranspiration ranged from 1,586–1,652 mm, and atmospheric CO_2 increased from 359–417 ppm. The annual water balance was calculated to provide insight into the extent of water stress experienced by the trees.

Tree growth rates increased during periods with higher water availability and at higher atmospheric CO_2 concentrations. Although annual rainfall and temperature did not increase significantly within the study area, there were large variations between census intervals due to extreme drought and flooding events. This matters for long-term planning because woodland productivity is not fixed

but shifts with environmental conditions, making **sustained monitoring essential for tracking trends across variable climates.**

Policy insight:

Looking ahead, woodlands may maintain or even increase their productivity under rising atmospheric CO_2 and future environmental change. However, this potential should not be mistaken for resilience to drought: periods of low rainfall can substantially slow tree growth and delay recovery. Woodland management and harvesting decisions must therefore account for water availability and climatic variability to safeguard productivity and long-term woodland resilience.



Photos: Aaron Chirofunga

Ground level vegetation in some sections of the Teak woodlands in Zimbabwe.

4 Wide variation in tree growth rates within and among species

Indigenous woodlands are not uniform systems. Growth rates varied substantially among species and between individual trees, with species mean growth rates ranging from 0.2 to 2.6 mm per year.

Some important timber species grew faster than the predicted median, including *G. coleosperma* at 1.2 mm per year and *B. plurijuga* at 0.9 mm per year. Growth trajectories also differed with age and size: *B. plurijuga* grew faster as it aged, *G. coleosperma* slowed over time, and *P. angolensis* maintained a constant rate as stem size increased.

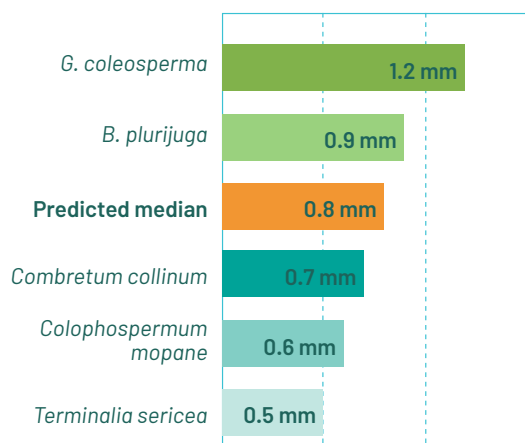
Several species commonly used by communities for fuelwood and poles grew more slowly – *Combretum collinum* at 0.7 mm per year, *Colophospermum mopane* at 0.6 mm, and *Terminalia sericea* at 0.5 mm. However, because their harvestable sizes are smaller (for example, 4–10 cm for fuelwood), their production cycles and appropriate harvesting intervals differ from those of timber species.

These differences in growth rate matter for management because species do not recover at the same pace or respond in the same way to woodland conditions. Further, it suggests that policies allowing charcoal and fuelwood harvesting of non-timber species could reduce competition and benefit timber production, while providing much-needed resources to people in the region.

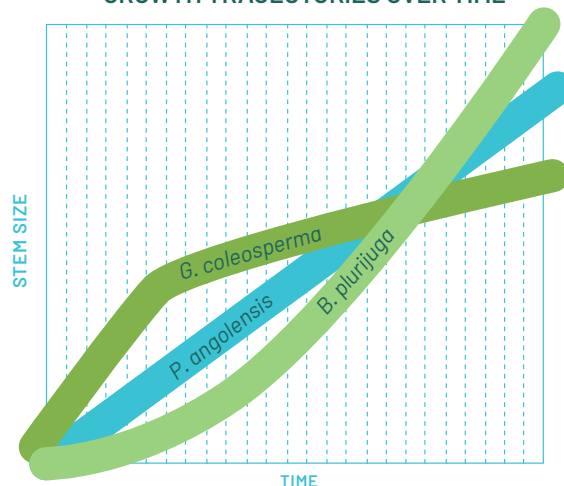
Policy insight:

Species-specific silvicultural prescriptions and harvesting approaches are likely to better reflect woodland recovery patterns than uniform harvesting systems.

ANNUAL GROWTH RATE PER SPECIES



GROWTH TRAJECTORIES OVER TIME



5 Long-term monitoring is a strategic investment

Long-term ecological datasets from African woodlands remain rare, yet they are essential for understanding how these systems change over time.

Permanent, protected sample plots provide important information on woodland productivity, tree growth dynamics, and sustainable harvesting rates. Long-term ecological datasets can support:



Woodland management planning



Sustainable harvesting approaches



Monitoring of woodland productivity



Improved understanding of woodland dynamics



Adaptive planning under variable environmental conditions

The monitoring network used in this work represents one of the longest ecological datasets currently available for southern African woodlands.

This type of investment is particularly valuable under increasingly variable environmental conditions. Monitoring over decades makes it possible to track woodland recovery, growth dynamics, and changing productivity in ways that short-term assessments cannot.

Policy insight:

Continued investment in permanent sample plots and long-term monitoring networks strengthens evidence-based woodland management and improves understanding of trends under changing environmental conditions.



A tagged tree inside a PSP; SEOSAW and Zimbabwe Forestry Commission Team collecting data from the PSPs in the Teak woodlands in Gwampa Forest Reserve, Zimbabwe.

Why it matters

Woodland ecosystems recover over long time periods and support multiple social, ecological, and economic functions. Understanding how they respond to harvesting pressure, competition, and environmental conditions is essential for sustainable management and long-term planning.

This work demonstrates the value of long-term ecological monitoring for informing woodland management decisions and improving understanding of woodland productivity in southern Africa. Strengthening long-term evidence bases can support more informed management, sustainable harvesting practices, and continued ecological stewardship across southern African woodland landscapes.



Tree tagging and measurement in one of the Teak woodlands PSPs at Gwaai Forest Reserve.

Implications for woodland management and planning

The evidence here shows that, at average basal areas of $11 \text{ m}^2 \text{ ha}^{-1}$, key timber species take about 150 years (species means ranging from 114 to 189 years) to grow from 5 cm to a harvestable diameter of 35 cm.

This is somewhat shorter than previous estimates of around 200 years, but still implies that — given slow growth rates, the effect of competition, and the long period to harvestable size — harvesting cycles should assume that trees may take 150 years or more to mature.

This study adds to a growing regional pool of tree-growth data that can support better harvesting guidelines and management interventions to promote tree production.

On this basis, suggested sustainable harvesting guidelines for Zimbabwean teak woodlands include:

- 1 Harvesting cycles aligned with tree growth rates and growing stock.
- 2 Intermediate thinning to provide firewood and poles while reducing competition.
- 3 Species-specific silvicultural prescriptions to manage residual stock.
- 4 Continuous monitoring via permanent sample plots.

Together, these point to the need to align woodland management with ecological recovery rates, woodland structure, species-specific growth patterns, and long-term environmental variability.



Landscape view of the Teak woodlands in Zimbabwe

Suggested citation:

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<https://seosaw.github.io/>



SEOSAW
A Socio-Ecological Observatory for Study of African Woodlands



This brief was produced by the Future Ecosystems for Africa (FEFA) programme and the Socio-Ecological Observatory for Studying African Woodlands (SEOSAW), and summarises findings from long-term ecological monitoring in Zimbabwe's protected teak woodlands. The work contributes to ongoing efforts to support sustainable woodland management, restoration, and long-term ecological stewardship across African landscapes.

SEOSAW is a network of scientists and vegetation survey plots across southern and eastern Africa, managed communally. SEOSAW connects researchers and their data, facilitating collaborative research via standardised methods and a curated, accessible database, in order to understand the response of African woodlands to global change. The network is expanding geographically into arid savannas, coastal East Africa, and towards western Africa and is actively building towards African-managed distributed database nodes.