

Tree-Nation Carbon Methodology

Global structure

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Introduction

The Tree-Nation Carbon Methodology defines how Tree-Nation estimates **the conservative per-tree CO₂ sequestration** of planted trees over their growth period for carbon credit issuance.

It applies to:

- all Mission-certified projects
- all Tree-Nation methodology projects

and provides the ex-ante carbon estimation basis used across the Tree-Nation system, including as the issuance foundation for projects later verified under the Foundation certification pathway.

Unlike traditional certification standards (such as VCS, Gold Standard, or Plan Vivo), which calculate CO₂ per hectare using methodology-based sampling, Tree-Nation calculates CO₂ on a per-tree basis using the physical characteristics of each species. This enables Tree-Nation to fund a broad and diverse range of reforestation, afforestation, agroforestry, and conservation projects, from large-scale to modest, that would not otherwise have access to funding under traditional certification pathways.

The methodology is intentionally conservative: precision is traded for prudence so that any sponsor can confidently claim the resulting value as an offset.

Comparison with traditional certification:

Traditional certification	Tree-Nation methodology
Calculated per hectare	Calculated per tree
20-100 year crediting windows	10-year crediting window
Document-based modeling	Multi-sourced data + Calculation

Expensive	Low cost
Limited selection of species	Broad species support
Limited plantation methods	Broad method support
Large projects only	All projects

Changelog

This section records all material updates to the Carbon Methodology to ensure transparency, traceability, and audit readiness. Each entry documents the change introduced, the section affected, and the rationale for the update.

Version	Date	Summary of change	Affected sections	Rationale
Version 1.0	June 2022	Internal CO ₂ -per-tree offset formula defined using species morphology, growth parameters, and prudence adjustments.	CO ₂ Offset Formula	Establish a scalable and consistent carbon estimation approach compatible with Tree-Nation's per-tree sponsorship model.
Version 2.0	2026	Methodology consolidated into a fully ex-ante, per-tree carbon accounting framework. Details added on volume estimation, biomass conversion, growth-period cap, prudence ratio, and per-tree carbon ceiling, fully aligned with Tree-Nation's CO ₂ -per-tree methodology.	Entire methodology	Improve clarity, scalability, and consistency with the Tree-Nation certification approach.

Carbon Estimation Logic

Tree-Nation estimates carbon uptake at the **tree level**, using species-specific biological models.

Each tree's expected CO₂ uptake over 10 years is calculated using:

- species growth characteristics (fast-, moderate- or slow-growing)
- tree morphology (trunk height and trunk diameter) and wood density
- climate type of the region (tropical, subtropical, temperate, boreal, dry)
- average species lifespan and growth period
- expected survival rate and planting-site culling
- management factors
- prudence adjustments

Soil moisture is identified as a relevant variable but is not yet integrated into the calculation.

The model is **intentionally conservative**:

- input measures are capped to median values rather than ideal specimens, since scientific literature often reports best-case data
- survival and culling rates are built directly into the calculation
- prudence coefficients reduce overestimation risk
- results are cross-checked, where available, against existing certification calculations and scientific publications on similar species and systems
- per-tree results are prudently capped at 800 kg of CO₂

This produces a **risk-adjusted estimate of CO₂ uptake per tree over 10 years**, reflecting expected real-world performance rather than ideal growth conditions.

This estimate forms the basis for carbon credit issuance.

CO₂ Offset Formula

Tree-Nation calculates expected carbon sequestration using a species-level formula based on tree structure and biological growth parameters.

The formula follows a four-step process.

Step 1 – Tree Volume Estimation

Tree volume is estimated from species morphology by modelling the trunk as a cylinder, using:

- trunk diameter range
- height range

- wood density.

Two additional carbon pools are then added on top of the trunk volume:

- branches and leaves: +15% of trunk volume
- roots: +20% of total stored carbon

Prudence coefficients are applied to ensure conservative estimates.

Step 2 – Carbon Content Calculation

Tree biomass is converted to carbon using wood density and dry-mass ratios:

- Wood mass (kg fresh biomass) = Volume of the tree (m³) × wood density (kg/m³)
- Dry mass = Wood mass × 65% (dry mass ratio)
- Carbon sequestered per tree (kg) = Dry mass × 50% (carbon content of dry wood)

Combined formula:

$$C \text{ sequestered per tree (kg)} = \text{Volume (m}^3\text{)} \times \text{wood density (kg/m}^3\text{)} \times 65\% \times 50\%$$

Wood density varies with species genotype and environmental conditions: luminosity, water availability, temperature, soil fertility, spacing, and management. Dry wood has an elemental composition of approximately 50% carbon, 6% hydrogen, 44% oxygen, with trace inorganics, which justifies the 50% carbon ratio.

Step 3 – Conversion to CO₂

Carbon mass is converted to CO₂ equivalent using the standard molecular conversion ratio:

$$\text{CO}_2 = \text{Carbon} \times 3.67$$

This ratio reflects the relative molecular weights of CO₂ and carbon: atomic weight of C = 12, atomic weight of O = 16, and atomic weight of CO₂ (C + 2×O) = 44, giving 44 ÷ 12 = 3.667.

Step 4 – Biological and Management Adjustments

Results are adjusted using:

- survival rate
- stand thinning (cull-back)
- climate region factors

- prudence coefficient

In addition, the calculation applies two structural caps that reflect the conservative nature of the methodology:

- Growth-period cap: Carbon is accounted for only during the active growth period of the tree. While species growth periods range on average from 10 to 35 years, the calculation is capped at 10 years; carbon captured beyond this period is not counted.
- Per-tree cap: per-tree CO₂ values are prudently capped at a maximum of 800 kg of CO₂.

Where available, results are further refined by contrasting Tree-Nation's values with existing certification calculations and scientific publications on similar systems and species, and adjusted accordingly.

This produces an adjusted CO₂ uptake value for each species, used as the basis for carbon credit issuance on the Tree-Nation platform.