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Lost in the Forest:
Methods To Estimate GHG Emissions from Project-Related Vegetation Clearing in Australia

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Introduction

Vegetation Clearing:

- Can be a significant contributor to GHG emissions associated with industrial development:
  - ➢ open cut mining
  - ➢ transmission lines and pipelines
  - ➢ Major transport routes
  - ➢ pumped hydro energy storage projects
- Accurate quantification is therefore critical for regulatory compliance, project approval processes, and the development of mitigation strategies.
- But how?

Outline

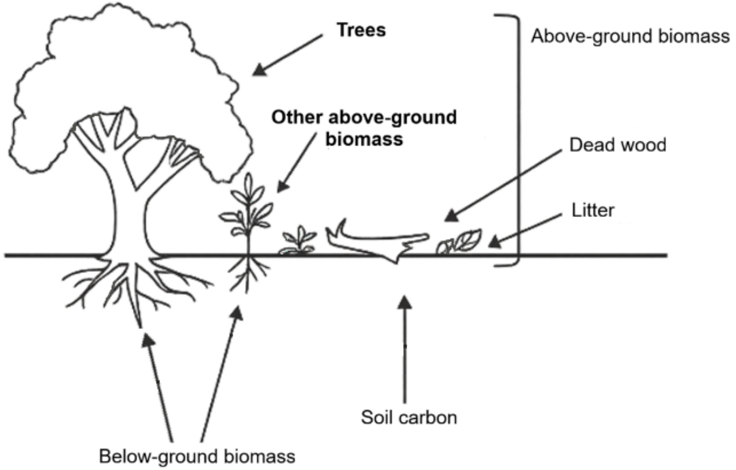
1. How is carbon stored in vegetation?
2. What methods can you use to estimate the carbon stock in existing vegetation?
3. How have the regulatory requirements evolved for approvals?
4. Are we getting it right?
5. What do we need to be able to present robust estimates of GHG emissions?

Preparing the Soil

How is carbon stored in vegetation?

Carbon Stock

- Carbon stock is the quantity of carbon held within a given pool at a point in time, typically expressed in tonnes of carbon per hectare (t C/ha).
- These stocks are distributed across several key pools, including:
  - ➢ Above ground biomass (AGB): *including trees, shrubs, and ground vegetation*
  - ➢ Below ground biomass (BGB): *comprising large and fine tree roots*
  - ➢ Dead organic matter (DOM): *including litter and coarse woody debris*
  - ➢ Soil organic carbon (SOC): *relating to non-living, decomposed carbon in soil*



Impact of Clearing

- Carbon pools are either immediately or gradually depleted:
  - Above-ground biomass is often removed or burned, resulting in rapid oxidation of stored carbon to carbon dioxide (CO_2).
  - Below-ground biomass and soil carbon may be released more slowly through decomposition and soil disturbance processes.
  - Methane (CH_4) and nitrous oxide (N_2O) may also be emitted under certain conditions, particularly where burning or anaerobic decomposition occurs.

Impact of Clearing

- The magnitude of CO_2-e emissions is therefore directly related to both the initial carbon stock of the vegetation community and the fate of that carbon following disturbance:

  - High-biomass forest ecosystems >>> low-biomass shrublands

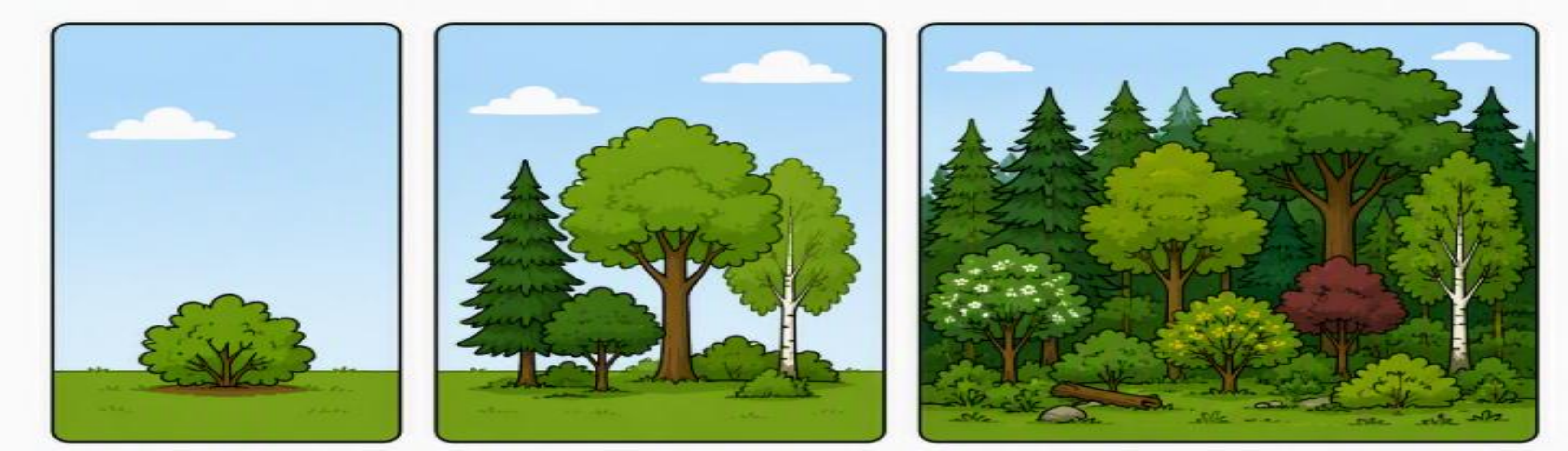
  - Stockpiling, mulching, burning, or salvage for timber use, influences the timing and extent of emissions released to the atmosphere.

t carbon / hectare x hectares cleared x $^{44}/_{12}$ = t CO_2-e emitted

Getting out the Tools

What methods can you use to estimate the carbon stock in existing vegetation?

Evolution of Vegetation Clearing GHG Methods



- Intergovernmental Panel on Climate Change (IPCC) *Good Practice Guidance for Land Use, Land-Use Change and Forestry*

- Transport Authorities Greenhouse Group (TAGG) *Greenhouse Gas Assessment Workbook for Road Projects* method for estimating vegetation clearing emissions associated with road projects
- In the Northern Territory, the spatial Carbon Emissions Estimate Calculator, an online tool available through the NR Maps platform

- FullCAM - the modelling tool underpinning the National Greenhouse Accounts (NGA), originally developed by the Australian Greenhouse Office
- FullCAM Guidelines: *Requirements for use of the Full Carbon Accounting Model (FullCAM) with the Emissions Reduction Fund (ERF) methodology determination: Carbon Credits (Carbon Farming Initiative - Avoided Clearing of Native Regrowth) Methodology Determination 2015*, Version 3.0,

Using FullCAM

Download options: Full Carbon Accounting Model (FullCAM)

FullCAM 2020 public release

[Default: 2020 FullCAM option]

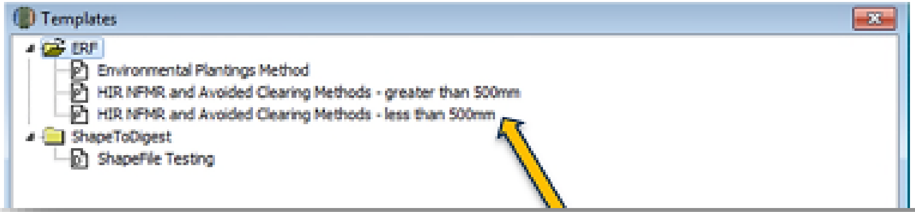
1. ACCU scheme projects must use the default option unless they meet requirements for the alternative option that are listed in the relevant method specific FullCAM guideline.

[Alternative: 2016 FullCAM option]

2. ACCU scheme projects that meet specific requirements listed in the relevant method specific guidelines for the project may use this alternative option

FullCAM 2024 public release beta version for testing

The 2020 and 2024 Public Release (PR) versions of FullCAM are now available on the web interface.




Australian Government

Department of Industry, Science Energy and Resources

FullCAM

Requirements f... the F... ...M) with ...nination: ...d Clearing of Native ...nination 2015

Version 3.0

(published and in force from 1 September 2020)

Avoided clearing of native regrowth method

Last updated: 04 August 2026

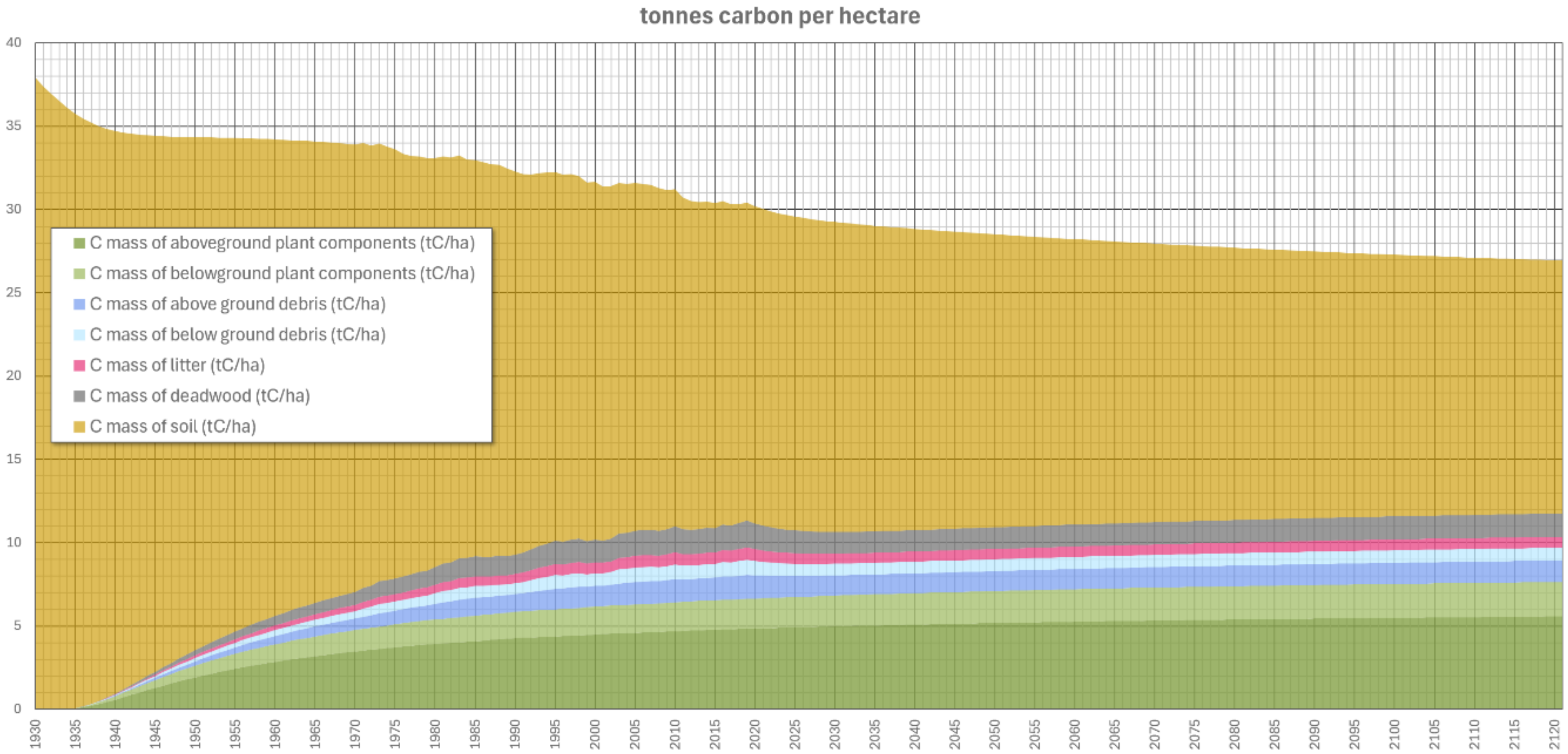
This method is expired. New projects cannot be registered under the method. Projects that were already registered under it are not affected and can continue.

Using FullCAM

Table 2 FullCAM Inputs

Parameter	Value/Setting
Template	HIR NFMR and Avoided Clearing Methods - greater than 500 mm
Location	Lat: -22.283360° ; Long: 148.254316°
Configuration	Forest System
Start and end of simulation	January 1930 - Jan 2120 (190 years)
Simulation steps	Annual
Data	Apply downloaded spatial data Native species regeneration ≥500 mm rainfall, average over 1ha All other settings at default options Maximum above ground biomass = 12.7964 t dry mass / hectare
Site	All settings at default options
Trees	All settings at default options
Soil	All settings at default options
Initial conditions	The forest has trees growing in it at the start of the simulation: Off Debris: All values set to zero All other settings at default options
Event	Plant trees: Natural regeneration in regeneration systems, 1 day after start of simulation, standard values used Thinning event: Not modelled Forest fire: Not modelled

Using FullCAM



Soil Organic Carbon

- *Carbon Credits (Carbon Farming Initiative—Avoided Clearing of Native Regrowth) Methodology Determination 2015* does not include estimating SOC as part of the FullCAM template.

- Inclusion of SOC removal could be a reasonable assumption for:
  - Permanent land conversion (e.g. urban development)
  - Severe erosion and soil export
  - Stripping and disposal of soil in spoil dumps where SOC is expected to mineralise
  - Methodologies that treat mining disturbance as a complete loss of ecosystem carbon stocks.

Soil Organic Carbon

- However, if the topsoil is stripped, stockpiled and reused, a portion of the SOC is potentially temporarily displaced rather than permanently lost
- Losses would be limited to oxidation and handling losses during stripping, stockpiling and redistribution
- Based on a literature review, perhaps:

➢ Complete loss (highly conservative)	100%
➢ Topsoil removed and not reused	50 - 100%
➢ Topsoil stockpiled long-term (>5–10 years) then respread	20 - 60%
➢ Topsoil stockpiled short-term (<1–3 years) then respread	10 - 30%
➢ Progressive mining with rapid salvage and replacement	0 - 20%

Limitations of Using FullCAM for Clearing Estimates

- FullCAM was designed as a national inventory and carbon accounting tool, not a generalised impact assessment tool.
- It is calibrated for large-scale, long-term accounting, not for rapid, site-specific assessments.
- The FullCAM avoided clearing method is not really designed for this purpose, so requires the user to modify the method themselves.
- The results are highly sensitive to input assumptions that may be poorly understood or defined in development contexts.

As a result, while FullCAM provides a scientifically robust modelling framework, its application to development-scale vegetation clearing calculations can introduce uncertainty, and require significant expert judgement

Designing the Garden

How have the regulatory requirements evolved for approvals?

Regulatory Requirements

- Recently, at least one state regulatory agency has mandated the use of FullCAM in development applications.
- The estimated emissions are becoming more heavily scrutinised.
- Simplified methods such as IPCC and TAGG are no longer being accepted.

Requests for Additional Information

Item #	Matter	Additional information required
Greenhouse gas assessment – Appendix I information request response (IRR)		
1	*Emissions from land clearing* Sections 5.4.1 and 5.4.4 of Appendix I state that greenhouse gas (GHG) emissions from vegetation clearing were estimated using the method outlined in the 2013 Transport Authorities Greenhouse Group (TAGG) Workbook. [redacted] Furthermore, for estimating GHG emissions from land clearing, the Full Carbon Accounting Model (FullCAM) is generally preferred. While the TAGG workbook provides a guideline based on FullCAM for road projects, FullCAM is the primary model used for national and project-based GHG emissions assessment in Australia, including those related to land clearing. It is also noted that the TAGG workbook was developed in 2013 and some of the emission factors might now be outdated. In comparison, FullCAM is continuously updated and incorporates the most recent emission factors, making it more reliable and accurate for estimating GHG emissions from land clearing.	The applicant is required to: (a) Re-estimate GHG emissions from land clearing using FullCAM, in accordance with the requirements in both the Australian Carbon Credit Unit (ACCU) Scheme methods and the FullCAM guideline[1], and (b) Provide assumptions and input data that are used in the FullCAM simulation. Re-estimation of GHG emissions using FullCAM will provide true and accurate estimation and address limitations as noted of TAGG workbook guidelines.

Requests for Additional Information

The FullCAM model has been applied to estimate greenhouse gas emissions from vegetation clearing. While the methodology is overall reasonable and conservative, it is noted that the disturbance footprint contains two distinct vegetation types: 308.1 ha of non-remnant vegetation and 16.26 ha of remnant 'Of Concern' RE 11.3.3 (refer to 'Section 12.4.2.2 Terrestrial flora' and Figure 12-7 of the supporting document). Only the former area was included in the FullCAM modelling.

As remnant vegetation may have a higher carbon mass intensity, its exclusion may result in a material underestimation of emissions. Additionally, the template selected in 'Table 15-4 FullCAM

(a) Provide justification for excluding emissions from the remnant vegetation area and, if necessary, update the FullCAM model to include this part to ensure a complete emissions inventory.

(b) Provide justification for the exclusion of diesel consumption during the construction phase, or update the emissions inventory to include the construction

Are We Really Addressing the Core Issues Though?

Are We Getting it Right?

What are the implications of these increasing requirements?

Sensitivity Analysis

- Three projects for which vegetation clearing estimates were included in the publicly-available GHG Assessment were used to test the sensitivity of the estimated emissions to the method used:
  - Carmichael Coal Mine and Rail Project, Queensland (GHD 2013)
  - Arrowsmith North Silica Sand Project, Western Australia (Kewan Bond, 2022)
  - Holtze Development Area, Northern Territory (EcOz Pty Ltd, 2022)
- GHG emissions estimated using:
  - TAGG Method
  - Carbon Emissions Estimate Calculator (NT project only)
  - FullCAM

Sensitivity Analysis Results

Table A-4. Comparison of Emission Factors Derived Using Each Method (t CO_2-e /ha)

ID	Project	TAGG Workbook	NT Carbon Emissions Estimate Calculator	FullCAM 2020
1	Arrowsmith	113	N/A	227
2	Holtze	209	227	219
3	Carmichael	197	N/A	181

- Emission factors given by the methods are very similar for the Carmichael and Holtze projects,
- For the Arrowsmith project, however, the TAGG Workbook gave an emission factor that is half the factor derived using the FullCAM model.
- Concluded to be due to the relatively coarse mapping of Maxbio and associated Vegetation Class categories used to define the emission factors

Comparison with Reported Emissions

Table A-4. Comparison of Emission Factors Derived Using Each Method (t CO_2-e /ha)

ID	Project	TAGG Workbook	NT Carbon Emissions Estimate Calculator	FullCAM 2020	GHG Assessment Report (FullCAM) *
1	Arrowsmith	113	N/A	227	83
2	Holtze	209	227	219	144
3	Carmichael	197	N/A	181	163

* Note: Gaps in the information presented in the reports mean that the average t CO_2-e/ha calculated from the available data has a high uncertainty in some cases. Importantly, the differences compared to the FullCAM estimates derived in this review do not mean that the original GHG assessments are incorrect, but instead reflect the sensitivity of the results to methodological choices and assumptions that need to be clearly outlined in reports to facilitate traceability and repeatability.

- For all projects, the GHG assessment appeared to have applied a lower emission factor than that derived in this study. For one site, the applied factor appeared to be 63% lower, while the closest was 10% lower.

Weeding and Pruning

What do we need to be able to present robust estimates of GHG emissions?

Conclusions

- The differences, and the difficulty in performing the comparison, therefore highlight two key issues:
  - The lack of clear, fit-for-purpose guidance on the most appropriate use of FullCAM to undertake clearing emission estimates means that users are developing different approaches to configure the simulations, which appears to be having a significant impact on the reported results.
  - If FullCAM is to be continued to be used for this purpose, a standardised method including reporting requirements needs to be developed so that the estimates presented in GHG assessments are verifiable and traceable.

Do you have any questions?

References

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