The 2024 FullCAM Public Release. Technical information on updates.

Background

In August 2024, the Department consulted on the 2024 version of the Full Carbon Accounting Model (FullCAM). The updates included in this new version were outlined in high level in the initial consultation paper, however feedback from users was that additional information on the changes was needed to support testing of impacts on ACCU projects. This document provides information on the technical model updates that were implemented with the 2024 public release version. It does not provide any further information on the new user interface (UI), nor does it provide information on the Application Programming Interface (API). These two new features are further described in the initial consultation paper and the API Usage Guide, respectively.

The technical updates in the 2024 public release version can be broadly split into two categories: new calibrations and new climate data (including Forest Productivity Index). These are further described below. Please note that this paper will not be discussing the revisions to the maximum aboveground biomass (M) layer that were included in the 2020 public release version of FullCAM, as these were consulted on at that time[1].

New calibrations

Yield curves for plantations and mallee plantings

Within FullCAM, growth rates are influenced predominantly by the combination of the spatial data layers and calibrated yield curve parameters. These yield curve parameters are derived from a database of field observations in a range of environmental situations. Because the yield curve parameters work in tandem with the underlying spatial data (and particularly the M layer), it is important to ensure that updates are managed in parallel. When the M layer was updated in 2019[2], the need was identified for a full update to the calibrated yield curves for commercial plantation species drawing on new information and more recent data from the industry. Rather than delaying the entire 2020 FullCAM Public Release update while plantation forestry modelling was recalibrated, the Department decided to release the updated M layer for use in other ACCU scheme methods, and (together with CSIRO) instigated the update process for the plantation yield curves. Proponents under the plantation forestry method were required to remain using the 2016PR version of FullCAM in the interim.

The plantation forestry yield curve updates were completed in late 2022, and are described below. These updates were consulted on with a targeted group of plantation forestry users and were also described in the National Inventory Report 2021 submission to the United Nations Framework Convention on Climate Change (UNFCCC).

[1] See Roxburgh et al. (2019) for further information
[2] See Roxburgh et al. (2019) for further information

The updated yield curves (i.e. the modelled amount of carbon sequestered in each month of a tree's growth) were calibrated based on new observation datasets, including observations outside the National Plantation Inventory (NPI) regions[3]. The original yield curves in FullCAM for plantations species had been calculated from NPI averages (Waterworth et al. 2007). These new observation datasets include 8,739 calibration plots across which there were 16,749 measurements of aboveground biomass to constrain model predictions - see Paul et al. 2022a for more detail. In practice, this means that the 2024 public release version is able to predict carbon sequestration in plantations outside the NPI regions, unlike the 2016 public release, which was limited to areas within the NPI.

Due to the larger volume and broader coverage of calibration data used for the yield curves, the new version provides more tree species options for users to model abatement, including some generic tree species options (e.g. calibrations for 'other eucalypts', 'other hardwood species' and 'other softwood species'). Species were included in these generic calibrations where species-specific modelling did not increase the accuracy of the calibrations, because:

1. there was insufficient calibration data (less than 200 observations); or
2. where the model fit did not improve by moving them into their own calibration[4].

In practice, this means that some species that previously had bespoke calibrations in the 2016PR have now been moved into the generic calibrations, but overall more species can be modelled and the results are more accurate using the new 2024PR version of FullCAM including the generic calibrations.

Because the new calibration datasets are derived from commercial operations, there is a relative paucity of observations from sites that had not applied fertiliser and/or weed control measures. This means that, in practice, the growth boosts that are normally received from good-practice fertiliser and weed control actions are already built into the growth curves in the model, and don't need to be modelled separately. Due to this, the ability to model these events has been removed from the FullCAM Guidelines for the reforestation by environmental or mallee planting and plantation forestry methods.

Calibrating the model using a large and geographically representative dataset has significantly improved the accuracy of the model. The calibration process was designed to make the model estimates unbiased, and was able to explain an average of 60% of the variation in these site measurements. This means that at any given location, the model will over- or under-predict the carbon stored in a plantation, but that those differences will balance out at regional- or national-scales.

For more information on the updated yield curve work, please see Paul et al. (2022a).

[3] See https://www.agriculture.gov.au/abares/forestsaustralia/plantation-inventory-and-statistics for more information on the NPI regions.

[4] For example, *E. Cladocalyx* has 388 observations in the updated dataset, however observed growth parameters for this species were similar enough to the other species in the 'Other Eucs' category that there was no benefit to be gained from splitting it into a bespoke calibration.

Thinning response (Biomass Recovery Formula)

In parallel to the new yield curves, the Biomass Recovery Formula (BRF) has also been introduced. This is a change to previous FullCAM modelling of thins and harvest events. Previously, users modelling plantation forestry species were required to select whether their forest was being managed as a long- or short-rotation forest, and the associated parameters were then applied to the model. The new model calibrations no longer require a selection of rotation type, and instead rely on the BRF to model the growth of the thinned stand continuing towards the calibrated site potential biomass. The BRF does this by apportioning a period of enhanced growth over the 20 years after a thin event, to allow the stand to continue to progress towards the calibrated site potential biomass.

This change also resolves a known bug in the 2016 public release version of FullCAM, which necessitated the use of a manual calculator external to FullCAM for the G and r parameters in certain circumstances. This calculator is no longer required under the 2024 public release.

Please note that in the first consultation version of the 2024 Public Release version of FullCAM (released in August 2024), the FullCAM guidelines were missing key instructions on how to implement the BRF, instructing projects to model in such a way that the BRF was not implemented at all. The FullCAM Guidelines have been updated in subsequent releases, and modelled growth should be appropriately adjusted for the 20 year period after a thinning event. Additionally, new thinning events have been added for ease of use for ACCU scheme participants, and these new events have the relevant BRF parameters prefilled, meaning participants will not need to input them manually.

For more information on the biomass recovery formula, please see Paul et al. (2022a).

Forest debris modelling for plantations and environmental and mallee plantings

As part of the work described above to recalibrate plantation forestry species within FullCAM, CSIRO also undertook a recalibration of the litterfall and decomposition parameters within established and managed tree plantings, including plantations and environmental and mallee plantings. This recalibration process involved the collection and collation of 5,655 observations of biomass allocation, litterfall, litter decomposition, litter/harvest residue mass and soil organic carbon.

In previous communications about this work, the Department has focused on the impacts of the recalibration for plantation forestry and mallee plantings, and not highlighted that this work has also resulted in a recalibration of the debris and litterfall dynamics for mixed species environmental plantings. This was an oversight in the Department's communications papers, and we apologise for any confusion this caused. The updated debris parameters for environmental plantings species can be found in Table 4 of Paul et al. (2022b).

For proponents who are familiar with the internal structure of FullCAM plot files, you will notice that the key litterfall and turnover parameters are now a monthly dataset, rather than a static value year-round. At this stage, there is insufficient data to calculate turnover parameters for managed plantings at the monthly timescale (i.e. the values are the same in every month), however this update provides the option to calibrate debris dynamics for seasonal impacts in the future. This necessitated a change to the format of plot files under the 2024PR, as the XML tags pertaining to litterfall have been split into 12. A flow-on effect of this is that plots created under the 2020PR version cannot be rerun in the

2024PR version without first updating the spatial and species data on the location info tab. The Department is investigating options for bulk updates of 2020PR plots to the new 2024PR format via the FullCAM API. This functionality is expected to be available for most plot/species types in March 2025.

Please note that while the size and diversity of datasets utilised in this work improved overall model confidence, there were still large uncertainties in the observed results. This ultimately means that the possibility of over- or under-predictions at the site level is similar to that described in the updated yield curve work above. Model predictions remain overall unbiased, however, and as such these over- or –under-predictions are expected to balance out at the regional- or national-scales.

For more information on the updated forest debris modelling, please see Paul et al. (2022b).

New climate data (including Forest Productivity Index)

FullCAM relies on an underlying site information database, which provides key climate and productivity information, for use in the Tree Yield Formula (TYF). This site information database has been updated to include climate data and a revised forest-productivity index up to December 2022. This is an update to the 2020 PR version, which only contains climate data to December 2018. The updated layers include the following time-series datasets:

- Rainfall
- Open-pan evaporation
- Temperature
- Topsoil Moisture Deficit (TSMD)
- Forest-productivity index (FPI)

The spatial time-series for the Forest Productivity Index (FPI) used in FullCAM's Tree Yield Formula has been changed. This variable affects the rate of tree growth based on seasonal and inter-annual variations in local growing conditions. Previous public release versions of FullCAM have relied on the NOAA/AVHRR satellite, but sensors on this satellite were found to be degraded such that the data in more recent years is no longer accurate. This is why the climate data in the 2020 PR version is fixed at end-2018.

New spatial data has been introduced for FPI using MODIS (Moderate Resolution Imaging Spectroradiometer) time series data beginning from 2001. In practice, this means that users will see different results for all years since 2001 when using the 2024 PR version, however the impact of the difference should be more pronounced in recent years.

For more information on the updates to the Forest Productivity Index, please see section 6.5.2.4 of the 2021 National Inventory Report[5], and '*Technical Report for Project "Improved NDVI data for the National Inventory Report*' – available by request from fullcam@dcceew.gov.au

[5] https://www.dcceew.gov.au/climate-change/publications/national-inventory-report-2021

FullCAM Public Release Change Log

User feedback during the first consultation period indicated that a 'change log' for FullCAM changes between the 2020 and 2024 PR versions would be helpful. This is included below. For more detail on any of the changes, please contact fullcam@dcceew.gov.au. This change log can also be accessed via the user interface of the public release version, by clicking on your username in the top right, and selecting 'About FullCAM'.

Changes between 2020PR and 2024PR:

- **Updated calibrations for commercial plantation forestry species**
    - Combined calibrations for species with minimal observations into generic calibrations
    - Added additional calibrations for mallee plantings in varying planting configurations
    - Removed restrictions tying plantation species to NPI regions
    - Altered tree yield formula parameters (*G*, *ar* and *br*) for all commercial plantation species and mallee species to match Table 4 of Roxburgh et al. (2022a)
        - Note that the revised approach means that users no longer need to manually calculate and enter *G* and *r* parameters for plantation species
    - Added new biomass recovery function and associated calculation changes
- **Debris modelling**
    - Updated key allocation, litterfall and litter decomposition parameters as per Roxburgh et al. (2022b)
    - Updated database to facilitate seasonal litterfall modelling
        - Note that this is in anticipation of future updates. For now, litterfall parameters are still calibrated to an annual rate
        - In plot file XMLs, this results in the parameters turnFracBran, turnFracBark and turnFracLeaf being replaced with turnFracBranF01-F12, turnFracBarkF01-12 and turnFracLeafF01-12, respectively.
- **New climate/spatial data**
    - Added additional years of data for rainfall, open-pan evaporation, temperature, topsoil moisture deficit and forest productivity index (FPI)
    - Resolved legacy issues relating to the FPI dataset, causing recalculations for all years from 2001
        - Note that this will also impact modelling in years prior to 2001, as the tree yield formula relies on a calculation of long-term average FPI, regardless of the model-year.
- **Other changes**
    - Moved to modernised, web-based user interface
    - Added Application Programming Interface (API) functionality

Changes since last consultation:

- **Bug fixes**
    - Fixed bug that occasionally caused ‘copy to csv’ function to scramble column headings
    - Fixed an issue that caused debris accumulation to calculate differently to the 2020PR when using calendar timing, even for calibrations where the parameters remained unchanged (e.g. natural regeneration calibrations)
    - Fixed an error that caused the biomass recovery function to cease functioning when a debris fire was modelled during the recovery period after a thinning event.
    - Fixed an error that occasionally caused a blank error message when entering project or collection names
    - Added Australian Carbon Credit Unit Scheme standard fire events that had been omitted
        - Also fixed an error that caused these events to not appear when using a template plot file.
    - Fixed an error with plot digest where the output page would not load PerOutput simulation results
    - Fixed an error where cloning a plot digest scenario would behave inconsistently when closing and reopening the plot digest file
    - Fixed a bug where plots would sometimes not be displayed based on Project and Collection
    - Fixed a bug where FullCAM was treating the ‘Maximum Years to Regrow Post-Thin – Stems’ value as 0, regardless of the value entered by the user.
    - Fixed an error where access for the 2020 version was not granted, even in situations where it should be automatically granted.
- **Accessibility**
    - Added species-specific standard thinning events for plantation species to match Appendix 2 of the FullCAM guidelines for the 2022 Plantation Forestry Method
    - Updated FullCAM 2024 API endpoints from ‘2023’ to ‘2024’
    - Added a ‘No initial trees or debris’ button on the Initial Conditions tab. This button sets all initial debris values to 0, and turns off the option for ‘The forest has trees growing in it at the start of the simulation’
- **Batch processing**
    - Added UI function to convert 2020 plot files to 2024 plots.
    - Added UI function to update spatial data (climate and species) within a bulk upload of plot files.
    - Added new API endpoints:
        - ‘Convert-plotfile’ – endpoint available only in the 2024 API, input must be a 2020 plot file.
        - ‘Update-spatialdata’ – available for 2020 and 2024.

References

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