Jigsaw Farms Emissions balance summary: Jan 2024

Emissions

In 2021, a carbon audit conducted on Jigsaw Farms determined that the combined sheep and beef enterprise produced **9,543 t $CO_{2\text{-}e}$** of on farm emissions (Table 1). The largest source of emissions was enteric methane, which produced 7,367 t $CO_{2\text{-}e}$. Emissions were calculated utilising animal numbers taken from Jigsaw farms and validated with the GrassGro model, before being entered into to the SB-GAF tool.

Excluding sequestration, the emissions intensity was **8.3 kg $CO_{2\text{-}e}$**/ kg LW for sheep meat, **30 kg $CO_{2\text{-}e}$** /kg greasy wool and **11.3 kg $CO_{2\text{-}e}$** for beef.

Sequestration estimates ranged between **6,704 t $CO_{2\text{-}e}$** to **7,936 t $CO_{2\text{-}e}$** in 2021 (Figure 1, Table 3). This means that during the 2021 calendar Jigsaw farms inset a minimum of **70.3%** of GHG_e and a maximum of **83.2%** of GHG_e. If carbon sequestration can be averaged over 10 years (2012-2021), this increases to **88.8%** and **105.8%** respectively (Table 3).

Table 1. Jigsaw Farms emissions in the 2021 calendar year, determined by SB-GAFv2.3, not including sequestration and assuming the GWP for CH_4 is 27.

Outputs	beef t CO_2e/farm	sheep t CO2e/farm	total t CO2e/farm
Scope 1 Emissions			
CO_2 - Fuel	23.85	95.41	119.26
CO_2 - Lime	142.96	571.82	714.78
CO_2 - Urea	5.09	20.36	25.45
CH_4 - Fuel	0.00	0.02	0.02
CH_4 - Enteric	1,225.43	6,141.34	7,366.77
CH_4 - Manure Management	55.70	331.63	387.33
CH_4 - Savannah Burning	0.00		0.00
N_2O - Fertiliser	4.49	17.96	22.46
N_2O - Urine and Dung	94.51	364.50	459.01
N_2O - Atmospheric Deposition	10.42	40.25	50.67
N_2O - Leaching and Runoff	68.31	264.28	332.59
N_2O - Savannah Burning	0.00		0.00
N_2O - Fuel	0.15	0.61	0.76
Scope 1 Total	**1,631**	**7,848**	**9,479**
Scope 2 Emissions			
Electricity	12.75	51.00	64
Scope 2 Total	**13**	**51**	**64**
Scope 3 Emissions			
Fertiliser	31.90	112.12	144.02

Purchased mineral supplementation	0.00	0.00	0.00
Purchased feed	151.18	604.70	755.88
Herbicides/pesticides	3.25	6.88	10.13
Electricity	1.05	4.20	5.25
Fuel	5.94	23.75	29.69
Lime	9.03	36.10	45.13
Purchased livestock	25.27	24.41	49.68
Livestock on agistment			
Scope 3 Total	**228**	**812**	**1040**
Net Farm Emissions	**1,871**	**8,711**	**10,583**
			Emissions intensity
Sheep meat (breeding herd) excl. sequestration	**8.3**		kg CO2-e / kg LW
Wool excl. sequestration	**30.0**		kg CO2-e / kg greasy
Beef excl. sequestration	**11.3**		kg CO2-e / kg LW

Sequestration

The Trees on Farm project team ran 5 models to calculate the carbon sequestration of environmental and agroforestry plantings on Jigsaw farms (Figure 1) detailed below.

Modelling of carbon sequestration

We estimated carbon sequestration in the agroforestry and permanent revegetation plantings using the predictions from the FullCAM model (2020 Public release version). FullCAM has various calibrations to estimate forest growth and hence carbon sequestration to cater for different species, planting densities and planting configurations. The default calibration of 'Mixed species environmental planting temperate – Block planting' provides the most conservative estimate of forest growth. If a plantation species is planted, as in the case of agroforestry plantings at Jigsaw Farms, calibrations specific to these species can be applied which will result in a higher rate of carbon sequestration. We set up five models using different calibrations (Table 1).

Table 2. Models used to estimate carbon sequestration by trees planted at Jigsaw Farms.

Model	Tree planting type	Tree growth calibration
1	Permanent revegetation Agroforestry	'Mixed species environmental planting temperate – Block planting' for all CEAs (the default).
2	Permanent revegetation Agroforestry	As for Model 1, except that 'Mixed species environmental planting temperate – Belt plantings <1500 sph' was applied to eligible CEAs in permanent revegetation.
3	Permanent revegetation Agroforestry	As for Model 2. 'Plantation' calibration after Paul et al. (2022).
4	Permanent revegetation Agroforestry	As for Model 2. 'Plantation' calibration after Paul et al. (2022) adjusted using measurements of site-specific growth collected at Jigsaw Farms.
5	Permanent revegetation Agroforestry	Estimates from Model 2 adjusted using measurements of site-specific growth collected at Jigsaw Farms. As for Model 4.

All plantings were modelled with a start date of 1 July in the year the plantings were established. The model for each CEA was run from the planting date until 2046, using a modelling point that was in the approximate centre of the CEA. The details of the five models are provided below.

Model 1

Under the Methodology Determination we followed we initially modelled the permanent revegetation and agroforestry as 'Mixed-species environmental planting temperate – Block configuration'.

Model 2

Under the Methodology Determination, a 'belt' planting means a planting that is established in a belt configuration, follows landscape contours, or is arranged in a straight line, and is no more than 40 m wide. Plantings that do not meet these requirements are 'block' plantings. FullCAM has calibrations for belt plantings with <1500 stems per ha and belt plantings with >1500 stems per ha. There are further calibrations for different establishment methods (the use of weed control and application of fertiliser). For Jigsaw Farms for Model 2, we used 'Mixed-species environmental planting temperate – Belt configuration, <1500 stems per ha (sph)' for those permanent plantings that met the requirements of a belt configuration.

In applying the calibration for the belt configuration, we applied the test for 'material competition' from adjacent trees specified in the Methodology Determination and adjusted where necessary the length of the belt to which we could apply the calibration. At Jigsaw Farms most of the material competition was caused by remnant River Red Gum trees.

At both Hensley Park and Melville Forest, 34 per cent of the area of permanent revegetation plantings were modelled using the calibration for belt configurations.

Model 3

For the Jigsaw Farms location, FullCAM had calibrations for three eucalypt plantation species but not for species established in the agroforestry plantings. We discussed this with a FullCAM expert and developed an approach to model abatement in the agroforestry plantings, which led to the use of a user-defined calibration in FullCAM. This was based on recently published information that is being used in the recalibration of FullCAM for a new version expected to be released in 2023[1] (Appendix 1).

Model 4

We collected tree inventory data from the agroforestry plantings at Jigsaw Farms to improve the user-defined calibration we used in FullCAM. We did this by adjusting the tree growth calibration in FullCAM after comparing measured tree growth with growth predicted by FullCAM. Details of the method are provided at in the sequestration report[2].

Model 5

In our analysis of carbon sequestration by permanent revegetation plantings at Jigsaw Farms, we considered the possibility that FullCAM underpredicted the actual rate of carbon sequestration. To test this, in April 2023 we collected field measurements of the growth of the permanent revegetation plantings including those that were direct seeded with high plant densities. The aim was to measure

[1] See Appendix 1. Hugh Stewart and Rod Keenan (2023). Carbon sequestration at Jigsaw farms, Report to Mark Wootton and Eve Kantor, October 2023

[2] See Appendix 2. Hugh Stewart and Rod Keenan (2023). Carbon sequestration at Jigsaw farms, Report to Mark Wootton and Eve Kantor, October 2023

carbon stocks in the live aboveground biomass and compare the results with those predicted using the FullCAM model.

From a sample of permanent revegetation tree plantings 13 to 31 years of age at Jigsaw Farms, we found that FullCAM (2020 Public Release version) consistently predicted lower carbon stocks in the live above-ground biomass relative to estimates derived from field measurements. The results indicated that the measured carbon stocks were in the order of **2x to 4x those predicted by FullCAM – equivalent to 100% to 300% higher** (Appendix 3).

Based on these findings, we applied a *conservative* **multiplier of 2x** to the FullCAM carbon predictions for the permanent revegetation plantings that we assessed as being closed forest (i.e., having a crown cover >80%). For plantings established between 1987 and 2017 we did this from Google Earth imagery with ground-truthing in April 2023 of some plantings close to the lower bounds of the crown cover class of closed forest. We assumed that plantings established since 2017 would become closed forest.

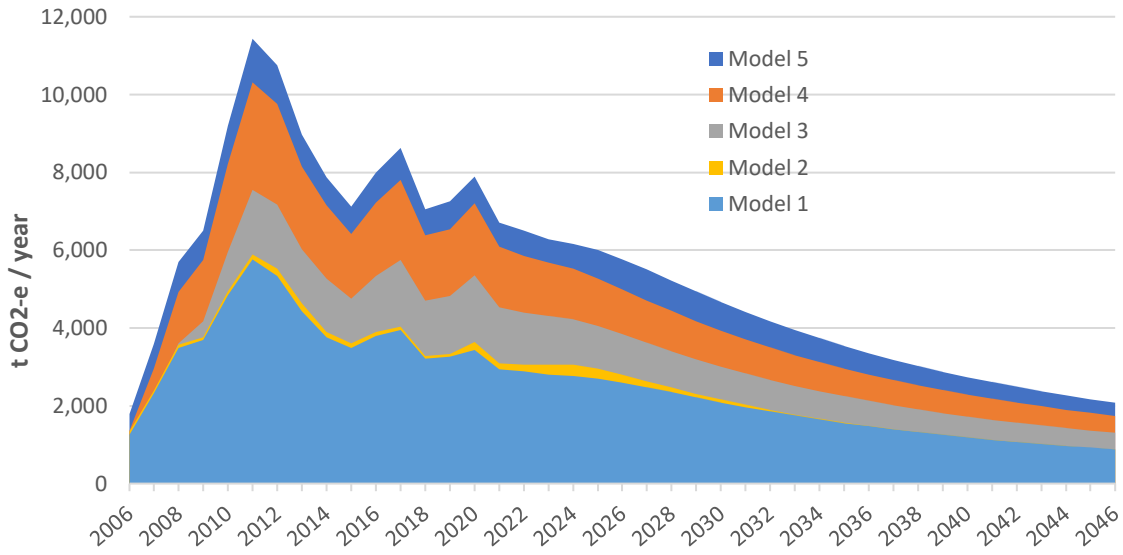

Figure 1. Annual sequestration of carbon in trees planted on Jigsaw farms from 2006 to 2046 determine by models 1-5.

These models calculated that Jigsaw farms sequestered a minimum of **6,704 t $CO_{2\text{-}e}$** (Figure 1), and a maximum to **7,936 t $CO_{2\text{-}e}$** during the 2021 calendar year. The range of sequestration is due to model 5, which adjust for FullCAM's underestimation of carbon sequestered in environmental plantings, by incorrectly determining the ratio of Eucalyptus to Acacias. **6,704 t $CO_{2\text{-}e}$** is the conservative estimate which doubled carbon stocks in environmental plantings (Figure 1, Model 5) and **7,936 t $CO_{2\text{-}e}$** assumes carbon stocks in environmental plantings were the maximum difference measured, which was 4x higher than FullCAM initially estimated. Both values are provided, for transparency and to show that although the conservative number is favoured by modellers, likely the impact of trees on Jigsaw farms as seen by the atmosphere was higher.

Table 3. The minimum and maximum sequestration t of CO_2 sequestered by Jigsaw farms between 2012 – 2031 based on Models 1-5.

Last 10 years			Next 10 years		
Year	**Min**	**Max**	**Year**	**Min**	**Max**
2012	11,434	13,674	**2022**	6,236	7,625
2013	9,717	11,615	**2023**	6,236	7,625
2014	9,717	11,615	**2024**	6,236	7,625
2015	9,717	11,615	**2025**	6,236	7,625
2016	8,000	9,556	**2026**	5,768	7,314
2017	7,352	8,746	**2027**	5,092	6,575
2018	7,352	8,746	**2028**	5,092	6,575
2019	7,352	8,746	**2029**	5,092	6,575
2020	7,352	8,746	**2030**	5,092	6,575
2021	6,704	7,936	**2031**	4,416	5,836
10-year avg	**8,469.7**	**10,100**	**10-year avg**	**5,549.6**	**6,995**