Australia's National
Science Agency

FullCAM-generated map layers for carbon emissions resulting from land clearing in the NT

Identification of scenarios

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Commercial-in-confidence

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1. Background

DEPWS requires a web-based option for use by potential applicants to provide them with a broad indication of the emissions implications of their land clearing plans prior to the formal application process. CSIRO will provide FullCAM-generated map layers for different scenarios to enable DEPWS to design a web-based service where users will be able to select areas on a map to estimate emissions for that location. The aim of this update is to describe the identification and justification of FullCAM modelling scenarios for generating these map layers.

2. Land clearing methods in the NT

To inform the identification of model scenarios, two land clearing datasets in the NT for the years 2003-2020 were provided to CSIRO by NT DEPWS:

1. Pastoral land, >300 ha clearing area; and
2. Unzoned land, >50 ha clearing area.

Below we have summarised the datasets for clearing method and post-clearing treatment combinations. The clearing methods provided in the dataset were categorised into the following eight types described in Table 1:

i) pulling (chaining);

ii) pulling + ploughing;

iii) pulling + raking;

iv) pushing;

v) pushing + ploughing;

vi) pushing + grading;

vii) pushing + raking; and

viii) slashing + burning.

From 2003-2020, there were 55 proposals of >300 ha on pastoral land, totalling 128,650 ha, and 116 proposals of >50 ha from 2003-2020 on unzoned land, totalling 64,177 ha, of which 32 (87,443 ha) and 106 (62,470 ha) had data on clearing method for pastoral and unzoned land, respectively. The most common clearing method based on both the number of proposals and the clearing area was pulling (chaining). However, for pastoral land a broader range of methods were applied (Table 1).

The post-clearing treatment methods from the datasets were categorised into five types: i) Burn, ii) Leave in situ, iii) Mulch, iv) Leave in situ + partial burn, and v) Mulch + burn. A summary of the combinations of clearing methods × post-clear treatments for the NT is provided in Table 2. The most common post-clearing treatment was burning.

Table 1 Categorisation and description of the eight categories of clearing methods defined for the NT, and the percentages by number of proposals (N) and area for pastoral and unzoned land.

Clearing method	Description	Methods in proposals	Soil Disturb.	% by *N*		% by area	
				Pastoral[1]	Unzoned[2]	Pastoral[3]	Unzoned[4]
Pulling (chaining)	Using a large chain dragged between two bulldozers/tractors to pull woody plants onto and out of the ground.	Bulldozer & chain; tractor & chain; slashing & light chaining	Medium-High	44	81	38	83
Pulling + ploughing	Pulling out woody plants and ploughing the ground to sever tree roots.	Bulldozer, chain & plough; Cutter bar/plough & chain	High	3	2	21	6
Pulling + raking	Pulling out woody vegetation and stick raking to clear debris (and sometimes unearth roots) including piling into windrows.	Chain & stick rake	High	13	-	7	-
Pushing	Using heavy machinery, typically bulldozers, to clear trees by pushing them over.	Bulldozer/tractor/grader	Medium	13	10	4	9
Pushing + ploughing	Pushing trees over and ploughing to break up tree roots in the soil.	Front end loader & plough; tractor & kelly chain; disc plough & kelly chain	High	16	-	7	-
Pushing + grading	Pushing trees over and leveling the ground with a grader.	Front end loader & grader	High	3	6	<1	2
Pushing + raking	Pushing trees over and stick raking to clear debris (and sometimes unearth roots) including piling into windrows.	Stick rake; Bulldozer & stick rake; Grubbing & stick rake	Medium-High	6	1	19	<1
Slashing + burning	Slashing and control burning to remove woody vegetation.	Slash & control burn	Low	3	-	3	-
Total				**100**	**100**	**100**	**100**

[1] Total $N = 32$; [2] Total $N = 106$; [3] Total area = 87,443 ha; [4] Total area = 62,470 ha.

Table 2 Combinations of clearing methods × post-clear treatments defined for the NT, and the percentages by number of proposals and area for pastoral and unzoned land.

Clearing method	Post-clearing treatment	% by N		% by area	
		Pastoral[1]	Unzoned[2]	Pastoral[3]	Unzoned[4]
Pulling (chaining)	Burn	31	80	20	83
	Leave in situ + partial burn	6	-	13	-
	Mulch + burn	3	-	1	-
	NA	3	1	4	<1
Pulling + ploughing	Burn	-	2	-	6
	NA	3	-	21	-
Pulling + raking	Burn	6	-	5	-
	Mulch + burn	6	-	2	-
Pushing	Burn	9	6	3	2
	Mulch + burn	-	4	-	2
	Leave in situ	-	1	-	5
	NA	3	-	1	-
Pushing + ploughing	Burn	6	-	<1	-
	Mulch	3	-	6	-
	NA	6	-	1	-
Pushing + grading	Burn	3	-	<1	-
	Leave in situ	-	6	-	2
Pushing + raking	Burn	-	1	-	<1
	Mulch	3	-	19	-
	NA	3	-	<1	-
Slashing + burning	Mulch	3	-	3	-
Total		**100**	**100**	**100**	**100**
All methods	Burn	56	88	28	91
	Leave in situ	-	7	-	5
	Mulch	9	-	28	-
	Leave in situ + partial burn	6	-	13	-
	Mulch + burn	9	4	3	2
	NA	19	1	28	<1
Total		**100**	**100**	**100**	**100**

[1] Total *N* = 32; [2] Total *N* = 106; [3] Total area = 87,443 ha; [4] Total area = 62,470 ha.

1. Identification of appropriate scenarios

It was initially envisaged that a series of scenarios for land clearing in the NT would be identified that encompassed clearing method and post-clearing management of debris (Table 1). However, following an analysis of the different clearing methods, it was decided to integrate all emissions into a single, mapped, emissions layer. For example, the net emissions associated with tree clearing and combustion of the resulting debris, and the net emissions associated with tree clearing and only partial burning of the debris (leaving the balance to decay *in situ*), are considered the same, with the only difference being the time course over which the emissions occur. This is because complete combustion leads to instantaneous loss, whereas decay of the residual material *in situ* leads to delayed losses. Whist this assumption holds for the impacts and subsequent losses to biomass and debris pools across the activities in Table 1, it would not hold for soil carbon, where, for example, pulling followed by ploughing may have different impacts to pulling alone. Because of high uncertainty on current stocks of soil carbon, and on future changes in soil carbon under different clearing methods, soil carbon was not included in the emissions estimates, thus allowing simplification of the analysis.

Two of the main drivers determining the amount of woody biomass potentially impacted by clearing activity are the vegetation type (varying by e.g. soil type and climate), and fire history, with both of these varying spatially across the Territory. Both of these drivers were included in the estimate of emissions. FullCAM was previously calibrated by Paul and Roxburgh (2020) to the nine vegetation fuel types mapped in the *Northern Savanna Vegetation Fuel Types Spatial Dataset (Map) (Version 1.0.1)*[1]. These calibrations were applied here, noting some simplification in the classification from nine to seven fuel classes. An additional category 'Arid' was also included to represent vegetation outside the 'savanna' zones. To include the impacts of fire history on standing dead and live biomass, fires were applied historically from 1900 to 2017 (the current limit of FullCAM climate data) with fire frequencies that ranged from 0 to 20 years, based on the 2000-2020 mapped fire frequency obtained from NAFI[2]. In order to provide generalised estimates of potential emissions associated with clearing, no attempt was made to include fire seasonality in the analysis, and the average standing stock of biomass and debris carbon over the 40-year period 1977-2017 was calculated to provide the basis for the emissions losses. FullCAM plot files were set up to include both woody vegetation, and a grassy understory, but only the woody vegetation components were included in the emissions estimates. The combination of seven modelled vegetation fuel type categories (Figure 1a) and 21 fire frequencies (0 …20 years) (Figure 1b), resulted in 147 unique scenarios of vegetation fuel type × fire frequency (Figure 1c), distributed spatially across the Territory.

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[1] https://v3.savbat.environment.gov.au/SavBAT_vegetation_fuel_type_base_map_metadata.pdf

[2] https://firenorth.org.au/nafi3/downloads/firehistory/Since_2000/250m%20pixel%202000-2020_Long%20Term%20Fire%20Frequency_Image%20File.zip

Table 3 Summary of Carbon Farming Initiative (CFI) vegetation fuel type categories used in the model scenarios

CFI vegetation fuel type category	Description
High rainfall zone	
hWMi[1]	Woodland with Mixed grasses (Tussock and Hummock)
hWHu[1]	Woodland with Hummock grass
hOFM	Open Forest with Mixed grasses (Tussock and Hummock)
hSHH	Shrubland (Heath) with Hummock grass
Low rainfall zone	
Arid	Lower rainfall regions outside the savanna zones
lWMi[2]	Woodland with Mixed grasses (Tussock and Hummock)
lWHu[2]	Woodland with Hummock grass
lWTu[2]	Woodland with Tussock grass
lOWM	Open Woodland with Mixed grasses (Tussock and Hummock)
lSHH	Shrubland (Heath) with Hummock grass

[1] Combined into a single 'HRZ' category; [2] Combined into a single 'LRZ' category.

2. Modelling approach

The analysis will be run at a 250 m x 250 m resolution, coincident with the FullCAM maximum biomass spatial layer that is the primary determinant of biomass growth in the model[3]. The included carbon pools are above and belowground living tree biomass, above and belowground standing dead tree biomass, and above-ground debris. The emission losses following clearing therefore include both the loss of living and dead standing trees (including their roots), and above-ground woody debris. Whilst 100% losses from all pools are assumed, this could be readily adjusted 'on-the-fly' if, for example, there was a desire to include the potential for users to specify partial clearing rates. In this way, the maximum losses could be discounted by the desired partial clearing fraction.

Case studies will be used to assess the impacts of:

1. Irregular fire events, and inclusion of patchiness
2. Alternative treatment of clearing residues (considering dead roots and soil)
3. Ploughing of clearing residues (considering dead roots and soil).

[3] https://data.gov.au/dataset/ds-dga-b46c29a4-cc80-4bde-b538-51013dea4dcb/distribution/dist-dga-1e3af98e-967a-4908-882f-2d217b0d0e5a/?q=FullCAM

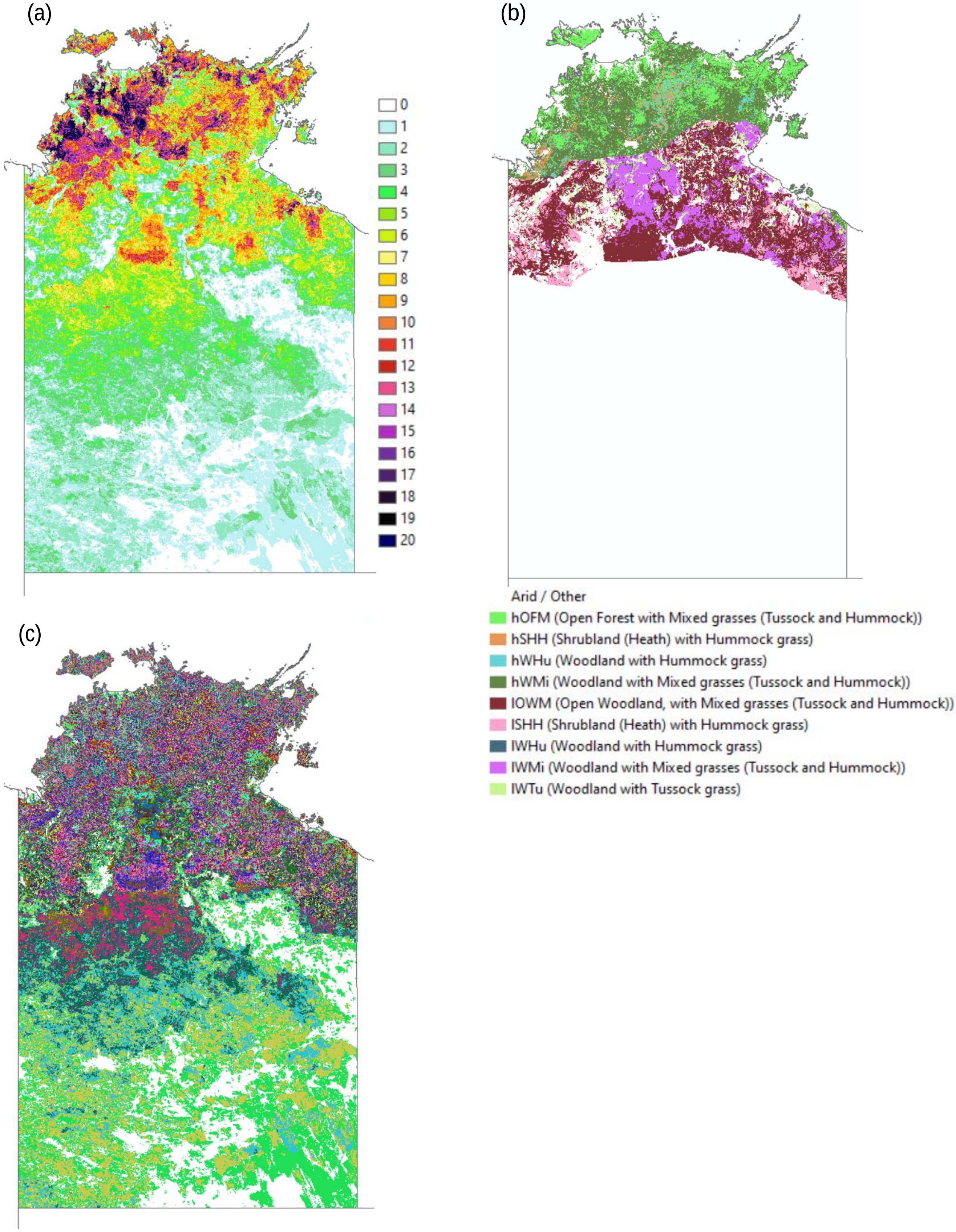

Figure 1 (a) Map of fire frequency (number of fires 2000-2020). (b) Vegetation fuel categories in the NT used in the FullCAM model scenarios. (c) 147 unique combinations of vegetation fuel type and fire frequency used in the modelling of emissions.

References

England, J, Roxburgh, S, Paul, K, Chilcott, C (2019) Carbon emissions and land clearing in the Northern Territory. Discussion Paper prepared for the Northern Territory Department of Environment and Natural Resources. CSIRO, Australia.

Paul K. & Roxburgh S.H. (2020) Carbon dynamics associated with savanna burning. Final Report Prepared for The Department of Industry, Science, Energy and Resources.