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Measurement Error in the Emissions Reduction Fund's Human-induced Regeneration (HIR) Method

Andrew Macintosh, Don Butler and Dean Ansell

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Corresponding authors:

Professor Andrew Macintosh and Professor Don Butler

ANU Law School

+61 2 6125 3832

Email: andrew.macintosh@anu.edu.au

Email: donald.butler@anu.edu.au

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The Australian National University

Canberra ACT 2600 Australia

www.anu.edu.au

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Executive summary

The Human-induced Regeneration (HIR) method is a centrepiece of the Australian Government's Emissions Reduction Fund (ERF). Broadly, the method allows landholders to earn carbon credits, known as Australian carbon credit units (ACCUs), for the regeneration of native forests through changes in land management. At present, the HIR method accounts for the most project registrations of any method under the ERF, the most Australian carbon credit units (ACCUs) issued of any method, and more than 50% of all ACCUs contracted through the ERF purchasing scheme, worth approximately $1.5-$1.6 billion. HIR project areas now stretch across more than 20 million hectares of Queensland, New South Wales, South Australia and Western Australia and, in these areas, the method is having a material influence on property markets.

The popularity of the HIR method may be partly explained by the way it is being administered by the Clean Energy Regulator. The Clean Energy Regulator has allowed proponents of HIR projects to include land areas containing mature woody vegetation at project commencement in their carbon estimation areas (CEAs) – being the parcels of land where the project mechanism is implemented and that are credited under the method. This runs contrary to the requirements of the method and directly conflicts with how the models that are used to estimate sequestration under the method are designed and calibrated. The approach adopted by the Clean Energy Regulator is likely to be resulting in the significant over-crediting of HIR projects. In colloquial terms, proponents are being issued ACCUs for growing trees that were already there when the projects started.

The simple solution to this issue is to require existing projects to re-stratify their CEAs to exclude areas that contained mature woody vegetation at the time of project commencement. This would bring the projects in line with the method's eligibility and stratification requirements. Beyond this, an investigation needs to be conducted into the response of the Clean Energy Regulator, Emissions Reduction Assurance Committee and Department of Industry, Science, Energy and Resources to this issue. All three organisations have ignored and sought to suppress a material integrity issue associated with the ERF's most popular method in circumstances where they knew, or should have known, that it was distorting the ACCU market.

1. Introduction

The Emissions Reduction Fund (ERF) is the centre-piece of the Australian Government's climate policy. It was first introduced in 2014 and is comprised of three main elements: a carbon offset crediting scheme, which provides for the issuance of Australian carbon credit units (ACCUs) to projects that abate emissions; a purchasing scheme, whereby the Clean Energy Regulator (on behalf of the Australian Government) voluntarily purchases ACCUs from eligible offset projects; and the 'Safeguard Mechanism', which imposes emission obligations on designated large facilities that can be met through the relinquishment of ACCUs. In simple terms, the purchasing scheme and Safeguard Mechanism are intended to provide the demand for the mitigation supplied by the offset scheme. Demand from the voluntary market, where companies, state and local governments and others seek to offset their emissions for marketing, social licence and altruistic purposes, provides a further source of ACCU demand.

For the ERF to serve its purpose of incentivising abatement that helps Australia to meet its international climate change obligations,[1] the offsets must have environmental integrity. While there is a need to balance integrity and efficiency, to the extent possible, ACCUs should represent 1 tonne of carbon dioxide equivalent (CO_2-e) avoided or sequestered. This principle is embodied in the legislation that underpins the ERF, the *Carbon Credits (Carbon Farming Initiative) Act 2011* (CFI Act), which requires all offset methods to meet six offsets integrity standards, including that the projects covered by the methods should result in abatement that is 'unlikely to occur in the ordinary course of business (disregarding the effects of this Act)', the methods should be 'supported by clear and convincing evidence', and the estimates, projections and assumptions in the methods 'should be conservative'.[2]

At the time of writing, there were more than 1,000 registered offset projects, which had received 103 million ACCUs.[3] The Clean Energy Regulator's purchasing scheme had committed $2.6 billion to purchase 209 million ACCUs, of which almost $920 million had been paid for 73 million ACCUs.[4] Demand from the Safeguard Mechanism has been limited: an average of 170,000 ACCUs had been surrendered by designated large facilities each year over the four years of the scheme's operation, excluding 'deemed surrenders' from offset projects undertaken by covered facilities.[5] The voluntary market, on the other hand, has proven to be a more vibrant source of demand, rising from 25,000 ACCUs in 2014-15 to 924,000 in 2020-21.[6]

On the supply side, uptake of offset projects has been dominated by vegetation projects – those involving either the natural regeneration or planting of forests or the avoidance of native forest clearing. The most popular of these has been Human-induced Regeneration (HIR). The HIR method has the most uptake of any method under the ERF and it makes up the largest portion of the abatement purchased by the Clean Energy Regulator.[7] As of November 2021, HIR projects

[1] *Carbon Credits (Carbon Farming Initiative) Act 2011*, s 3.
[2] *Carbon Credits (Carbon Farming Initiative) Act 2011*, ss 133(1)(a), (d) and (g).
[3] Clean Energy Regulator (2021), 'Emissions Reduction Fund project register', available at: http://www.cleanenergyregulator.gov.au/ERF/project-and-contracts-registers/project-register (1 December 2021).
[4] Clean Energy Regulator (2021), 'Auctions results', available at: http://www.cleanenergyregulator.gov.au/ERF/auctions-results (1 December 2021).
[5] Clean Energy Regulator (2021), 'Safeguard facility reported emissions', available at: http://www.cleanenergyregulator.gov.au/NGER/National%20greenhouse%20and%20energy%20reporting%20data/safeguard-facility-reported-emissions (1 December 2021).
[6] Clean Energy Regulator (2021), 'Voluntary cancellations', available at: http://www.cleanenergyregulator.gov.au/DocumentAssets/Pages/Voluntary-cancellations.aspx (1 December 2021).
[7] *Carbon Credits (Carbon Farming Initiative) (Human-Induced Regeneration of a Permanent Even-Aged Native Forest — 1.1) Methodology Determination 2013*.

accounted for 32% of all registered ERF projects, 27% of all issued Australian carbon credit units (ACCUs) and more than 50% of all ACCUs contracted through the ERF purchasing scheme, worth approximately $1.5-1.6 billion.[8]

Broadly, the HIR method allows landholders to earn ACCUs for the regeneration of native forests through changes in land management. Forests (and forest cover) are defined for these purposes as an area of at least 0.2 ha with trees that are two metres or more in height and provide crown cover of at least 20 per cent of the land. In order for regeneration to be eligible under the method:

- the land must not have had forest cover in the 10 years prior to the project application;
- during this 10 year period, the land must have been managed in such a way that clearing, livestock or feral grazing, or weeds (the 'suppressors') contributed to the suppression of the development of forest cover; and
- at the date of the project application, 'it is reasonable to expect that it would be necessary to undertake one or more HIR activities on the land in order for it to attain forest cover'.[9]

The 'HIR activities' are the management of grazing pressure from livestock and feral animals, weed management and the cessation of clearing of regrowth.

Projects are credited for the sequestration of CO_2 in eligible forest carbon pools (i.e. the live above- and below-ground biomass and debris carbon pools), minus emissions associated with fuel use and fire.[10] The amount of CO_2 sequestered in the regenerating forests is not estimated using direct measurements. Proponents are credited on the basis of modelled sequestration, with one of two models being used for these purposes:

- the Australian Government's Full Carbon Accounting Model (FullCAM); and
- a simplified version of FullCAM called the Reforestation Modelling Tool (RMT), which is only available for use by projects registered prior to March 2016.

The use of these models to estimate sequestration reduces transaction costs for proponents, thereby helping to promote uptake. This is particularly important for HIR projects because they involve extensive land areas across large parts of the rangelands in Queensland, New South Wales, Western Australia and South Australia. Directly measuring tree growth and associated sequestration across these areas would be costly and could deter participation. Using models to estimate project sequestration was seen as a pragmatic solution to this problem, providing a way of lowering transaction costs without necessarily substantially reducing integrity.

For this compromise to be valid, and for the method to meet the offsets integrity standards, the HIR method must ensure the modelled abatement estimates are accurate and unbiased.[11] The method contains rules that are designed to serve this purpose but they have been misinterpreted and misapplied, resulting in ACCUs being issued for regeneration that cannot

[8] Clean Energy Regulator (2021), 'Emissions Reduction Fund project register', available at: http://www.cleanenergyregulator.gov.au/ERF/project-and-contracts-registers/project-register (1 December 2021); Clean Energy Regulator (2021), 'Carbon abatement contract register', available at: http://www.cleanenergyregulator.gov.au/ERF/project-and-contracts-registers/carbon-abatement-contract-register (1 December 2021).
[9] *Carbon Credits (Carbon Farming Initiative) (Human-Induced Regeneration of a Permanent Even-Aged Native Forest — 1.1) Methodology Determination 2013*, s 4(c).
[10] The method does not credit changes in soil organic carbon associated for forest regeneration.
[11] Paul, K., Roxburgh, S. (2020) Predicting carbon sequestration of woody biomass following land restoration. Forest Ecology and Management 460, 117838.

occur because, at project commencement, the relevant land areas already contained mature woody vegetation. In colloquial terms, proponents are being issued ACCUs for growing trees that were already there when the projects started. This is resulting in the substantial over-crediting of HIR projects and is distorting the Australian carbon market.

This paper reviews this issue, analysing how the misapplication of the modelling and project stratification requirements is likely to be resulting in substantial over-crediting of HIR projects. The paper is set out as follows. Section 2 reviews the relevant provisions of the HIR method and provides an opinion on their intent and proper interpretation. Section 3 discusses how FullCAM (and by extension RMT) is designed and calibrated, and demonstrates why the model is being misused in HIR project areas that contain significant amounts of mature woody vegetation at project commencement. Section 4 provides an analysis of the implications of the misinterpretation of the method. Section 5 outlines how the Clean Energy Regulator, Emissions Reduction Assurance Committee and Department of Industry, Science, Energy and Resources have responded to this issue and section 6 provides a conclusion.

2. Mature woody vegetation in carbon estimation areas

Under the HIR method, proponents are required to delineate 'carbon estimation areas' (CEAs) within their project areas. CEAs are the parcels of land where the project mechanism is implemented and the native forests are meant to be regenerated. In simple terms, they are the areas credited under the method.

As is explained in greater depth in section 3, FullCAM and RMT model carbon sequestration on an area (per hectare) basis, not tree by tree. Due to this, the characteristics of the land that is included in the CEAs must reflect the assumptions that underpin the models. To ensure this occurs, the HIR method requires the areas of land included in CEAs to meet particular requirements that are intended to ensure the rates of carbon sequestration that are modelled in FullCAM and RMT reflect what occurs on the ground. The nature of these requirements depends on which version of the method projects are registered under: the RMT version (which was made in 2015 and uses the RMT to model sequestration); or the FullCAM versions (which were made in 2016 and 2018 and use FullCAM to model sequestration). Table 1 shows the number of projects registered under each version of the method. The details of these requirements are provided below.

Table 1. HIR project registrations under the RMT and FullCAM versions of the HIR method, as at 19 December 2021

Version	RMT version	FullCAM versions	
Year made	2015	2016	2018
Project no.	98	79	159

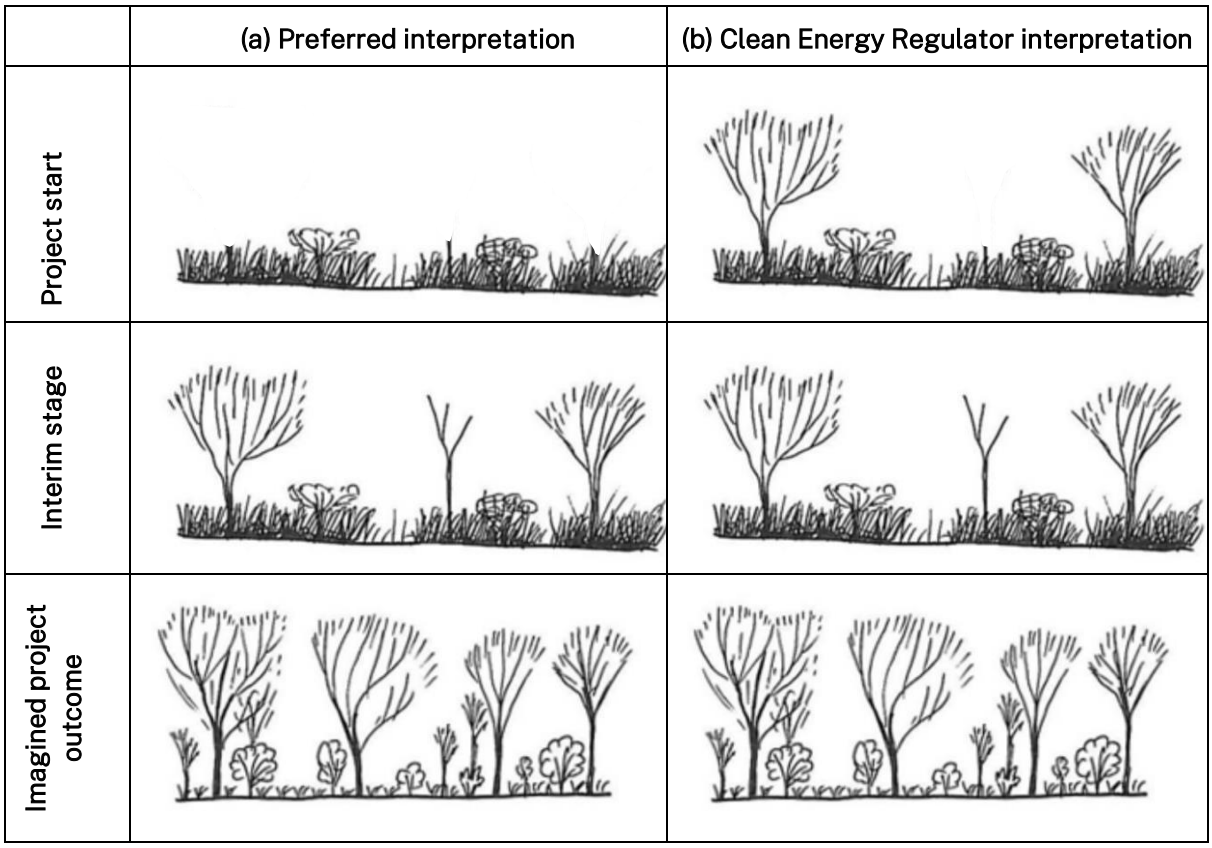
Source: Clean Energy Regulator (2021) 'Emissions Reduction Fund project register, 19 December 2021'. Available at: http://www.cleanenergyregulator.gov.au/ERF/project-and-contracts-registers/project-register (2 March 2022).

The Clean Energy Regulator has generally interpreted the relevant provisions in both the RMT and FullCAM versions of the method as requiring proponents to exclude areas that had forest cover in the baseline period from their CEAs. However, it has allowed proponents to include areas with mature woody vegetation in their CEAs if the crown cover of the vegetation is less than 20%.

The Clean Energy Regulator's interpretation of the methods are legally incorrect. The stratification requirements in the HIR methods require areas with forest cover *and* areas with material amounts of mature woody vegetation at commencement to be excluded from CEAs.

The two competing interpretations of the method are represented in Figure 1. Figure 1(a) shows what we regard as the preferred (and intended) interpretation of the method and HIR projects. Under this approach, at project commencement, HIR CEAs consist exclusively of even-aged juvenile regeneration. Through the implementation of the HIR activities, the projects are intended to facilitate the continued regeneration of the woody vegetation, initially through an interim sparse woody stage (where the CEA contains crown cover between 5% and 19%) and then through to forest cover, where crown cover exceeds 20% and the woody vegetation is 2 metres or more in height. For example, an area has been cleared of native forest to establish pasture for grazing might regenerate given sympathetic grazing management and forbearance of clearing activities that would usually be applied to maintain the pasture.

Figure 1. Assumed progression of regeneration under HIR and NFMR methods



Source: Adapted from Peeters, P., Butler, D. (2014) Mulga: regrowth benefits management guideline. Department of Science, Information Technology, Innovation and the Arts, Brisbane.

The Clean Energy Regulator's interpretation includes as eligible vast areas that already contain mature native vegetation at project commencement, so long as that vegetation is not currently forest. This approach is represented by Figure 1(b). Under this interpretation, at project commencement, HIR CEAs can consist of a mix of juvenile regeneration and mature trees and shrubs, provided the crown cover is less than 20%. Through the implementation of the HIR activities, the projects are supposed to result in the continued growth of the regeneration so the CEA achieves forest cover – but fewer new trees and shrubs are needed to achieve this outcome than is required in the approach represented in Figure 1(a).

As this simplified diagram demonstrates, the key differences between the two approaches relate to:

(a) how many additional trees and shrubs need to be regenerated to achieve forest cover – this is important because, subject to allowances for drought, 90% of the area in HIR CEAs are required to achieve forest cover within 15 years, otherwise crediting can be stopped and the proponent may be required to re-stratify the CEA to exclude areas without forest cover;[12] and

(b) how much additional carbon projects actually sequester if they do achieve forest cover, and whether models calibrated on the basis of the regeneration progression represented in Figure 1(a) should be used to credit projects following progression depicted in Figure 1(b)?

The following sections look at the CEA stratification requirements under the RMT and FullCAM versions of the method and analyse their meaning and application, focusing on the question of whether they require the exclusion of land areas containing significant amounts of mature woody vegetation at project commencement.

2.1 CEA stratification requirements under the RMT version of the method

Under the RMT version of the method, projects must meet the following relevant eligibility requirements.[13]

- The land on which the project activity is undertaken must have been subject to 'suppression activity' during the baseline period (i.e. the 10 year period prior to project commencement). 'Suppression activity' is defined for these purposes as 'a combination of land use and land management practices that prevents the regeneration of native vegetation on land due to the effects of one or more of … (a) livestock; (b) feral animals; (c) plants not native to the project area; (d) mechanical or chemical destruction, or suppression, of regrowth'.

- The land on which the project activity is undertaken must meet the zero baseline carbon stock test, which requires the carbon stocks in live trees (i.e. excluding tree debris and tree litter) to be less than 5% of their maximum (as modelled in RMT).[14]

- The proponent must undertake a 'human-assisted regeneration activity', defined as:

  … one or more of the following activities *undertaken to induce the establishment of a native forest* *from in situ seed, lignotubers or root stock (coppice) sources*:

  (a) exclusion of livestock;

  (b) management of the timing, and the extent, of grazing;

[12] *Carbon Credits (Carbon Farming Initiative) Rule 2015*, s 9AA. Clean Energy Regulator (2019) Guidelines on stratification, evidence and records: For projects under the Human-Induced Regeneration of a Permanent Even-Aged Native Forest and Native Forest from Managed Regrowth methods. Commonwealth of Australia, Canberra.
[13] *Carbon Credits (Carbon Farming Initiative) (Human-Induced Regeneration of a Permanent Even-Aged Native Forest — 1.1) Methodology Determination 2013*, ss 1.3 and 1.4 (https://www.legislation.gov.au/Details/F2015C00576).
[14] *Carbon Credits (Carbon Farming Initiative) (Human-Induced Regeneration of a Permanent Even-Aged Native Forest — 1.1) Methodology Determination 2013*, ss 1.4, 2.3 and 2.4 (https://www.legislation.gov.au/Details/F2015C00576).

(c) management, in a humane manner, of feral animals;

(d) management of plants that are not native to the project area;

(e) cessation of mechanical or chemical destruction, or suppression, of regrowth. [Emphasis added]

- There must be regeneration which is a direct result of a human-assisted regeneration activity. Regeneration is defined for these purposes as 'trees originating from the germination or growth of in situ seed, rootstock or lignotuber'.[15]

In addition to these requirements, the method requires land included in CEAs have to be within the project area, be a single area with an unbroken perimeter, consist of land with even-aged regeneration and have a uniform land management regime across the area.[16] Relevantly, the method also includes a requirement that:

> Any land in the project area that:
>
> (a) has forest cover immediately before project commencement;
>
> (b) does not have forest potential at the time of stratification; or
>
> (c) will not be used to undertake the project activity; or
>
> (d) fails to regenerate after undertaking the project mechanisms;
>
> must be defined as an exclusion area.

The method does not define 'project activity' but it defines the 'project mechanism' as:

> The project must aim to generate Australian carbon credit units by enabling native vegetation to grow to achieve forest cover through the promotion and management of regeneration from in situ seed, rootstock or lignotuber sources, applying a human-assisted regeneration activity, and not by direct seeding or planting.[17]

Project proponents are required to 'define in the project area one or more carbon estimation areas in accordance with the CFI Mapping Guidelines'.[18] Proponents are required to use the version of the CFI Mapping Guidelines that is in force at the time when they report. The current version of the CFI Mapping Guidelines provides that:

> Some methods require Exclusion Areas to be identified and delineated. An Exclusion Area may be an area of land where it is not possible to apply the project, for example a large rock outcrop or an access road, or an area of land that doesn't meet eligibility requirements. … If a method details that certain areas of land — for example areas of land without forest cover — must be identified as Exclusion Areas, then these provisions apply to:
>
> - features greater than five metres in width; and
> - areas less than five metres in width that total more than five per cent of the Project Area, for example, a Project Area that is one hectare in area [10,000 m^2]

[15] *Carbon Credits (Carbon Farming Initiative) (Human-Induced Regeneration of a Permanent Even-Aged Native Forest — 1.1) Methodology Determination 2013*, s 1.3 (https://www.legislation.gov.au/Details/F2015C00576).
[16] *Carbon Credits (Carbon Farming Initiative) (Human-Induced Regeneration of a Permanent Even-Aged Native Forest — 1.1) Methodology Determination 2013*, s 3.3 (https://www.legislation.gov.au/Details/F2015C00576).
[17] *Carbon Credits (Carbon Farming Initiative) (Human-Induced Regeneration of a Permanent Even-Aged Native Forest — 1.1) Methodology Determination 2013*, s 2.5 (https://www.legislation.gov.au/Details/F2015C00576).
[18] *Carbon Credits (Carbon Farming Initiative) (Human-Induced Regeneration of a Permanent Even-Aged Native Forest — 1.1) Methodology Determination 2013*, s 3.2, and s2.6 (https://www.legislation.gov.au/Details/F2015C00576).

> should exclude any and all areas where the project mechanism is not applied if the total of these areas exceeds 500 m^2.[19]

The eligibility and exclusion area requirements under the RMT version of the HIR method are unambiguous; they require areas where regeneration cannot occur, or is not occurring, to be excluded from CEAs where they exceed the above thresholds. The exclusion of these areas is essential as it ensures proponents are not credited for sequestration that has already occurred (e.g. mature woody vegetation) or cannot occur (e.g. rocky outcrops or other similar features that do not have forest potential). In both cases, it is not possible for the project activity – inducing the establishment of a native forest from in situ seed, lignotubers or root stock (coppice) sources by undertaking one or more human-assisted regeneration activity – to be undertaken so as to generate the relevant abatement. Accordingly, land areas that contain pre-existing mature woody vegetation or other features like rocky outcrops that prevent regeneration must be excluded from CEAs to satisfy the requirements of the CFI Mapping Guidelines.

Where areas contain pre-existing mature woody vegetation, there are two processes that prevent the project activity from being undertaken. First, the presence of the mature woody vegetation prevents regeneration in the same location; in simple terms, you cannot grow a tree on a tree. Secondly, the mature woody vegetation will compete with, and limit the growth of, any new regeneration achieved by a change in management. Hence, proponents may be able to encourage regeneration of individual plants by changing grazing management practices but, because of the existence of the pre-existing mature woody vegetation, they cannot induce the establishment of a native forest *from* in situ seed, lignotubers or root stock (coppice) sources (and certainly not an even-aged forest as the name of the method suggests).

This should not be controversial as it reflects the Clean Energy Regulator's approach to almost identical exclusion area requirements that apply under the Environmental Plantings method.[20] Like the HIR method, the Environmental Plantings method uses FullCAM to model sequestration. The fundamental difference between the methods is that the Environmental Plantings method requires projects to establish forests through planting seedlings or seed and does not include human-induced regeneration. In relation to exclusion areas, section 3.7 of the Environmental Plantings method states:

> Land in each project area on which the project mechanism is not implemented must be defined and mapped as an exclusion area in accordance with the CFI Mapping Guidelines.[21]

The 'project mechanism' is defined under the Environmental Plantings method as:

> The project must establish by planting, and maintain, the following types of permanent plantings:
>
> (a) a mixed-species environmental planting; or

[19] Department of the Environment and Energy (2018) Carbon Farming Initiative Mapping Guidelines, Version 5. Commonwealth of Australia, Canberra, p 7-8. The exclusion area requirements were drafted in the same terms in the version of the mapping guidelines that was in force when the method commenced: Department of the Environment (2015) Carbon Farming Initiative Mapping Guidelines, Version 4. Commonwealth of Australia, Canberra, p 7-8.
[20] *Carbon Credits (Carbon Farming Initiative) (Reforestation by Environmental or Mallee Plantings — FullCAM) Methodology Determination 2014*.
[21] *Carbon Credits (Carbon Farming Initiative) (Reforestation by Environmental or Mallee Plantings — FullCAM) Methodology Determination 2014*, s 3.7.

(b) a mallee planting.[22]

The Clean Energy Regulator requires proponents of Environmental Planting projects to exclude areas containing mature woody vegetation and features like rocky outcrops from CEAs. Given this, there should be no reason why HIR projects should not also be required to exclude such areas from their CEAs.

Despite these requirements, and its approach to the mirror provisions in the Environmental Plantings methods, the Clean Energy Regulator has seemingly allowed HIR projects on the RMT version of the method to include vast areas of land that contain significant amounts of pre-existing mature woody vegetation in their CEAs. The areas with pre-existing mature woody vegetation are likely to have contained far more than 5% of their potential maximum carbon stocks when the projects started, being the threshold used for the purposes of the zero baseline carbon stock test. The clearest evidence of this is in a report commissioned by the Clean Energy Regulator in 2021 on the additionality of the abatement credited under the HIR method (Beare and Chambers report).[23] The report analysed changes in woody vegetation cover in 123 HIR projects (72 in New South Wales and 51 in Queensland) that were registered prior to 2017. Data from the ERF Project Register suggest 94 of the projects analysed in the Beare and Chambers report (62 in NSW and 32 in Queensland) are registered under the RMT version of the HIR method. The report did not provide information in the amount of mature woody vegetation in the CEAs of these projects at project commencement. However, it included data on the average number of 25m x 25m pixels per hectare in the project CEAs that contained open cover (crown cover from woody vegetation of less than 5%), sparse woody cover (areas with crown cover from woody vegetation of between 5-7% and 19%) and forest cover (crown cover equal to or greater than 20%) over an undefined 'pre-start' period, which appears to be the period from 1988 to project commencement. As Table 2 shows, on average, 46% of the pixels in the CEAs of the analysed New South Wales projects had crown cover over the pre-start period that exceeded either the sparse woody or forest crown cover thresholds. For the analysed Queensland projects, on average, 41% of the pixels had crown cover over the pre-start period that exceeded either the sparse woody or forest crown cover thresholds. Given that 76% of the projects that were analysed are registered under the RMT version of the method, there seems little doubt that there was a substantial amount of mature woody vegetation in the CEAs of these projects when they started. This sense is reinforced by the fact that 97% of the area of HIR projects is 'extant' native vegetation (i.e. essentially intact native vegetation) based on data from the Commonwealth's Native Vegetation Information System (Figure 2).

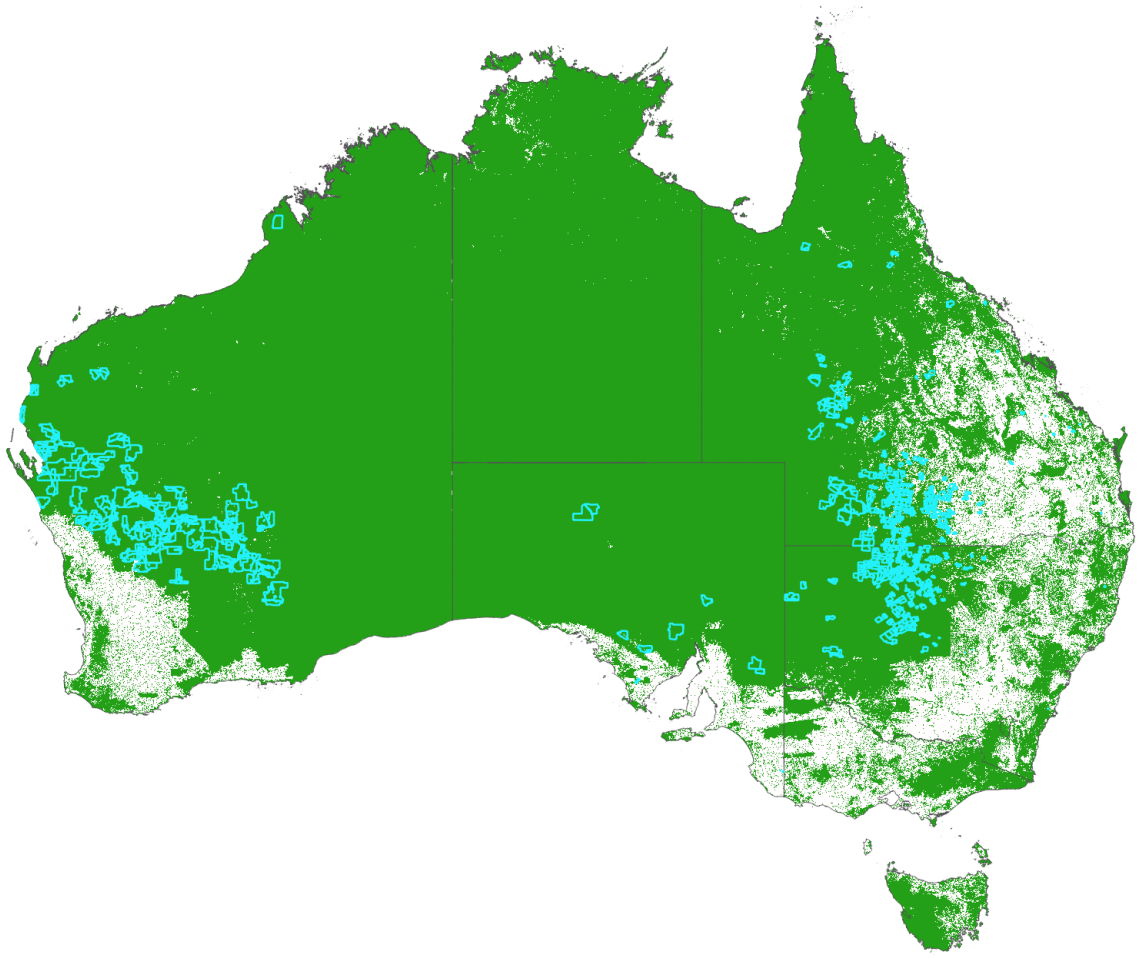
[22] *Carbon Credits (Carbon Farming Initiative) (Reforestation by Environmental or Mallee Plantings — FullCAM) Methodology Determination 2014*, s 2.2.
[23] Beare, S., Chambers, R. (2021) Human induced regeneration: A spatiotemporal study. AnalytEcon Pty Ltd, Berry, NSW.

Table 2. Beare and Chambers report, summary statistics for NSW and QLD CEAs, average pixel per ha and percentages, pre-start period

	NSW		QLD	
	Pixels	%	Pixels	%
Open	6.48	54%	6.83	59%
Sparse woody	4.17	35%	3.2	28%
Forest	1.26	11%	1.45	13%
Total*	11.91	100%	11.48	100%

* The pixel count should add to 16. The report explains this on the basis that CEAs have irregular shapes.
Source: Beare, S., Chambers, R. (2021) Human induced regeneration: A spatiotemporal study. AnalytEcon Pty Ltd, Berry, NSW, pp 11-12.

Figure 2. HIR project boundaries (turquoise outlines) and 'extant' native vegetation (green area)



Source: National Vegetation Information System (NVIS 6.0, MVG <> 25 or 29).

2.2 CEA stratification requirements under the FullCAM versions of the method

Under the FullCAM versions of the method, CEAs are required to meet the following key requirements.[24]

- They must not contain land that had forest cover at any time during the baseline period (10 years prior to the project application).
- They must consist only of land on which the project mechanism has been undertaken.
- They must consist only of land that has 'forest potential' – areas of at least 0.2 ha with woody vegetation with the potential to reach 2m in height and more than 20% crown cover.
- They must consist only of land where it would be necessary to undertake one or more HIR activities on the land in order for it to attain forest cover.
- They must consist only of land that first exhibited regeneration at or around the same time.
- They must consist only of land across which a similar mix of native vegetation is regenerating.
- They must consist only of land that can be modelled across the entire CEA using FullCAM to represent the management activities and disturbance events in the area of land.

As with the equivalent provisions of the RMT version of the method, these requirements — the division of projects areas into CEAs that contain relatively homogeneous even-aged regeneration — are intended to ensure the rates of regeneration that are modelled in FullCAM reflect what occurs on the ground. They are also intended to ensure areas of pre-existing vegetation that might briefly satisfy the definition of a forest in response to a period of wet weather are not included within CEAs.

The Clean Energy Regulator's interpretation of these provisions is that:

> Under the HIR Method, a project can include existing vegetation in carbon estimation areas where the land containing the existing vegetation does not meet the definition of forest cover (defined as land with an area of at least 0.2 of a hectare which has trees over two metres in height and provide crown cover of at least 20% of the land).[25]

From a legal perspective, the validity of the Clean Energy Regulator's position turns mainly on:

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[24] *Carbon Credits (Carbon Farming Initiative) (Human-Induced Regeneration of a Permanent Even-Aged Native Forest — 1.1) Methodology Determination 2013*, ss 4 and 16. Proponents are also required to re-stratify CEAs to exclude areas where regeneration fails or where there is a significant tree mortality event, and disturbances like bushfires must be modelled. Further, while FullCAM directly accounts for the impact of rainfall on the growth rates of trees, the rules require proponents to impose growth pauses on the model where drought and other similar events impede regeneration. For further details of the requirements, see Department of Industry, Science, Energy and Resources (2020) FullCAM Guidelines: Requirements for using the Full Carbon Accounting Model (FullCAM) in the Emissions Reduction Fund (ERF) methodology determination: Carbon Credits (Carbon Farming Initiative) (Human Induced Regeneration of a Permanent Even Aged Native Forest — 1.1) Methodology Determination 2013, Version 3.0. Commonwealth of Australia, Canberra; and Department of the Environment and Energy (2018) Carbon Farming Initiative (CFI) Mapping Guidelines, Version 5. Commonwealth of Australia, Canberra.

[25] Clean Energy Regulator (2021) pers. comms (anon).

- section 16(2)(c)(ii), which requires that CEAs 'consist only of land … on which the project mechanism has been undertaken'; and
- sectiond 16(4)(a), which requires that CEAs 'consist only of land … that first exhibited regeneration at or around the same time'.

The 'project mechanism' is defined in the FullCAM versions of the method as undertaking one or more HIR activities in a way that can reasonably be expected to result in an area of eligible land becoming native forest, and attaining forest cover, through regeneration. 'Regeneration' is defined in section 3 as 'the regrowth of trees from the germination of in situ seed, or the growth of in situ seedlings, rootstock or lignotuber'.

When read in context, the interpretation of sections 16(2)(c)(ii) and 16(4)(a) that best promotes the objectives of the CFI Act is that they require CEAs to consist only of land on which even-aged regeneration is occurring and where it is reasonable to expect that the HIR project activities are required for forest cover to be attained.[26] Areas that do not contain regeneration of the same age, including areas of mature woody vegetation, must be excluded. This interpretation is supported by two key factors.

(a) The CEA stratification requirements are intended to ensure CEAs consist of homogeneous even-aged regeneration; hence the full title of the method (*Carbon Credits (Carbon Farming Initiative) (Human-Induced Regeneration of a Permanent Even-Aged Native Forest—1.1) Methodology Determination 2013*). The Clean Energy Regulator's approach conflicts with this by allowing CEAs to be comprised of multi-age vegetation and potentially other areas where regeneration is not occurring.

(b) The Clean Energy Regulator's interpretation conflicts with how FullCAM (and the RMT) are designed and calibrated, resulting in the models being misapplied to estimate sequestration on land areas for which they are not suited.[27] The misapplication of the models results in the over-estimation of sequestration in regenerating forests, which, in turn, leads to over-crediting, contrary to the CFI Act's intention of ensure ACCUs represent real and additional abatement.

The following section explains how FullCAM (and by extension, RMT) are designed and calibrated and further elaborates on how they were not intended for use on land areas containing mature trees and shrubs at project commencement.

3. Design and calibration of FullCAM

Under the HIR method, proponents are required to select the date from which they will model a forest regeneration 'event', and the model then estimates how much carbon a forest that commenced growing on that date would be expected to hold (or a per hectare basis) using a two-step process. First, change in above-ground biomass (AGB) (i.e. the AGB yield) in the regenerating forest is predicted using a Tree Yield Formula (TYF). Second, parameters for biomass allocation (i.e. between tree components, including below-ground biomass), turnover

[26] The fundamental principle of statutory interpretation is that 'the interpretation that would best achieve the purpose or object of the Act (whether or not that purpose or object is expressly stated in the Act) is to be preferred to each other interpretation'. See *Acts Interpretation Act 1901*, s 15AA and *Legislation Act 2003*, s 13.
[27] FullCAM and RMT are extrinsic materials that can be used to aid the interpretation of ambiguous provisions of the method. See *Acts Interpretation Act 1901*, s 15AB(1) and *Legislation Act 2003*, s 13.

(litterfall and root slough), decomposition and carbon fractions are applied to the predicted AGB to estimate carbon stocks in all onsite live and dead biomass.[28]

The TYF in FullCAM is in the form:

$$\Delta AGB_i = M * r * y * [e^{-k/Ai} - e^{-k/Ai-1}] * (FPI_i/FPI_{ave})$$

Where:

ΔAGB_i = annual increment in above-ground biomass (AGB) in year *i*

M = maximum AGB in undisturbed native vegetation

r = non-endemic species-multiplier of the maximum AGB, which is set to 1 for natural regeneration

y = a type 2 multiplier that is applied to M to account for factors that increase the growth potential of a site (i.e. planting configuration), which is set to 1 for natural regeneration

e = Euler's number, i.e. the mathematical constant equal to ~2.71828

$k = 2 \times G - 1.25$, where *G* = age of maximum growth rate of the trees

A_i, A_{i-1} = age of regenerating forests in year *i* and *i-1* respectively

FPI = Forest Productivity Index, which is the sum of site-specific factors that affect growth (soil type, fertility and climate) (FPI_i is the FPI for the relevant year and FPI_{avg} is the average FPI of the site)

In the model, AGB at the commencement of natural regeneration is assumed to be zero. As the equation suggests, from the date of commencement onward, apart from the FPI, the key variables that drive AGB growth estimates in the model are *M* (maximum biomass), *y* (the growth multiplier) and *G* (age of maximum annual growth).

M is an estimate the maximum AGB in undisturbed native vegetation. In the FullCAM calibration that is used for HIR projects, *y* = 1. This means that:

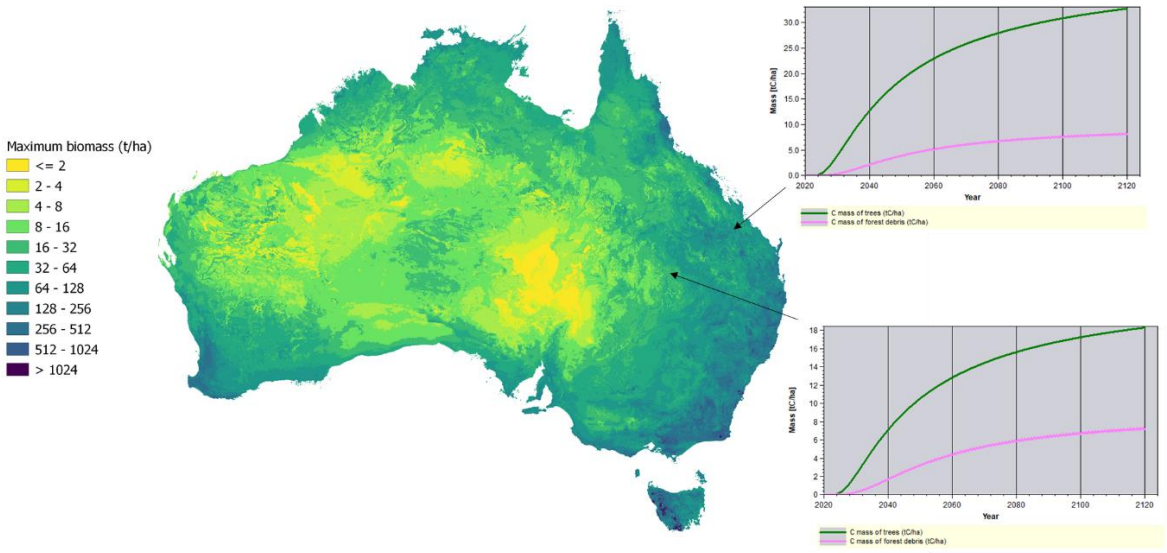
- at the commencement of an HIR project, AGB is assumed to be and is modelled as zero; and
- from project commencement onwards, the model:
    - 'grows' the forest towards a maximum set by *M*; and
    - follows a growth trajectory that is largely determined by the year of maximum growth (i.e. *G*, which is generally considered to be the point at which the regrowing trees switch from not competing to competing with one another for site resources).

In practical terms for HIR projects, the application of the TYF ensures slow early carbon accumulation as young trees become established, followed by rapid growth through years 5-20 (dictated by *G* and *M*). The rate of ongoing carbon sequestration slows afterwards, reflecting

[28] The model also predicts soil carbon stocks but they are excluded from the HIR method. Paul, K., Roxburgh, S. (2020) Predicting carbon sequestration of woody biomass following land restoration. Forest Ecology and Management 460, 117838

increasing competition between trees in the forest for resources such as water and light, and the forest approaches its natural carbon storage capacity, which is represented by *M*. Figure 3 shows the maximum AGB spatial layer applied in FullCAM (i.e. the so-called 'M layer'), and the resulting model of forest carbon accumulation for two example locations.

Figure 3. Maximum above-ground biomass potential in undisturbed native vegetation, with example growth plots for two areas in eastern Australia.



Source: Author derived using Department of Industry, Science, Energy and Resources (2017) Maximum Above Ground Biomass. Version 2.0. Commonwealth of Australia, Canberra; Department of Industry, Science, Energy and Resources (2020) Full Carbon Accounting Model (FullCAM). Commonwealth of Australia, Canberra.

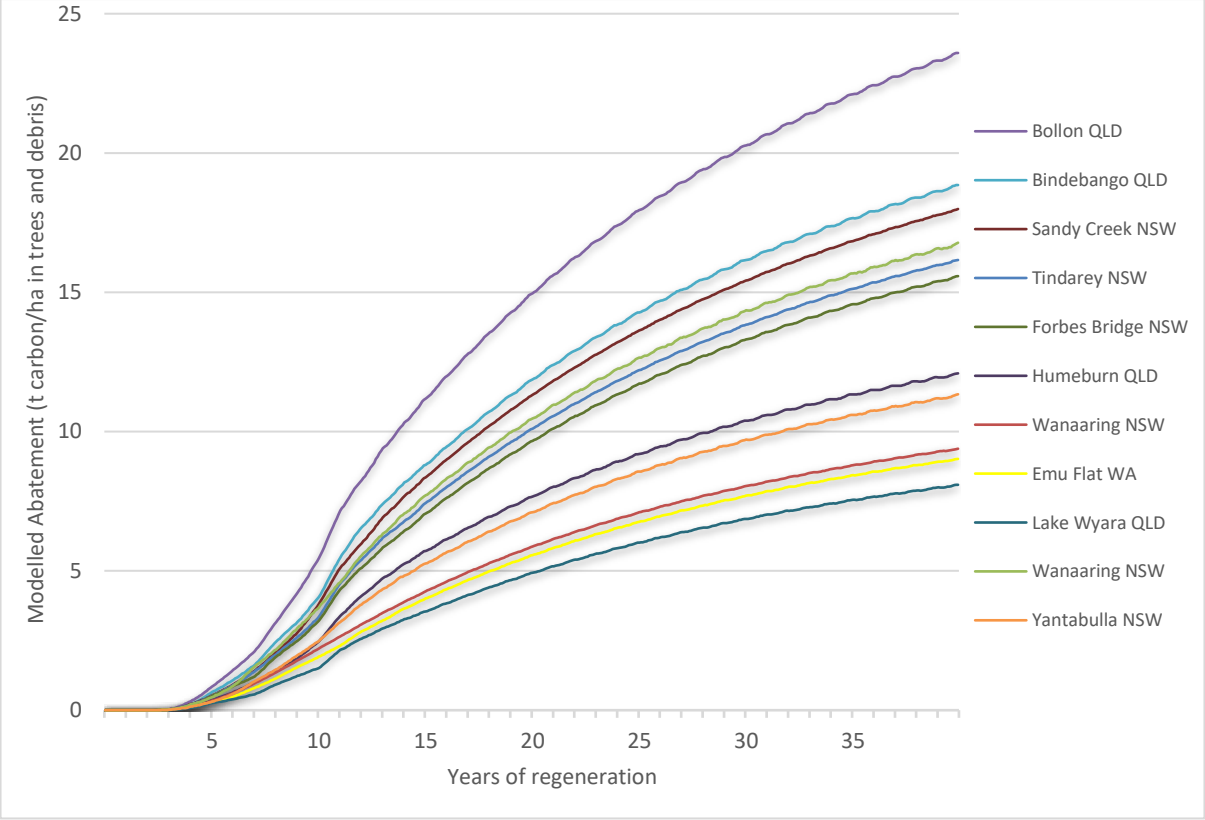
Consistent with the above modelling framework, the TYF used for HIR projects is calibrated on the basis that HIR CEAs contain no (or negligible) onsite woody vegetation at regeneration commencement. It is assumed for the purposes of the modelling that, at project commencement, the entirety of the CEA area contains only juvenile woody vegetation. The RMT version of the HIR method includes an explicit test of the 'zero baseline' assumption for this reason. Through the project activities, the vegetation is then assumed to regenerate uniformly across the site, eventually reaching 2 metres or more in height with a crown cover of at least 20% (consistent with Figure 1(a)). The period at which the regeneration is modelled to achieved forest cover differs depending on the productivity of the site and climatic conditions but it is generally between 5-15 years.[29]

The assumed progress of regeneration from zero (or near zero) woody biomass through to the attainment of forest cover is reflected in the shape of the FullCAM carbon accumulation curve. Figure 4 shows the modelled sequestration at 11 locations containing HIR and Native Forest from Managed Regrowth projects. The modelled biomass (live trees and debris) starts at zero, reaches its maximum growth rate at around years 8-12, and then the growth rate tapers off for the remainder of the modelling period, resulting in a sigmoidal carbon accumulation curve. If the model was calibrated on the basis there was significant woody biomass at commencement, and therefore significant competition from established native vegetation, the model of carbon accumulation would start further to the right (or further up the curve) in Figure 4, to reflect

[29] ERAC (2019) Review of the Human-Induced Regeneration and Native Forest from Managed Regrowth methods. Commonwealth of Australia, Canberra.

competition from pre-existing vegetation. If the vegetation has never been cleared (or otherwise substantially degraded in terms of carbon storage) then there would be nearly zero scope to increase carbon storage.

Figure 4. Modelled sequestration at 11 locations containing HIR and NFMR projects under average climate conditions



Source: Emissions Reduction Assurance Committee (ERAC) (2019) Review of the Human-Induced Regeneration and Native Forest from Managed Regrowth methods. Commonwealth of Australia, Canberra.

For the Clean Energy Regulator's interpretation of the method to align with FullCAM, the model would need to be able to account for the presence of mature woody vegetation at project commencement. Given the form of the TYF, there are only four ways this could occur:

- *A* (forest age) could be adjusted to reflect the effective age of the existing vegetation.
- the growth multipliers *y* or *r* could be set at less than 1 for CEAs that contain significant amounts of onsite woody vegetation at commencement;
- *M* could be decreased for CEAs contain significant amounts of onsite woody vegetation at commencement; and
- *G* could be 'artificially' increased to flatten the growth curve over the crediting period.

None of these have been used. Both *y* and *r* are set at 1 in the FullCAM calibration that is used for all HIR projects and all HIR CEAs. As is detailed in Roxburgh et al. (2019),[30] *M* is what it says

[30] Roxburgh et al (2019) A revised above-ground maximum biomass layer for the Australian continent. Forest Ecology and Management 432, 264–275.

it is (an estimate of maximum AGB in undisturbed native vegetation) and it is not decreased to account for the presence of mature woody vegetation at project commencement in any HIR CEAs. Similarly, *G* has not been 'artificially' increased to flatten the growth curve over the 25-year crediting period, and *A* has also never been adjusted. This is because the method assumes zero woody carbon stocks at commencement, and therefore minimal competition from pre-existing vegetation.

In 2020, the CSIRO recalibrated FullCAM's TYF for natural regeneration using an expanded dataset of 573 AGB measurements taken from 483 regenerating forest stands.[31] Reflecting the above modelling assumptions, where the measured stands contained mature woody vegetation, the CSIRO removed the associated biomass from the dataset prior to calculating the AGB attributable to the natural regeneration. The TYF was then calibrated using the modified AGB dataset that excluded the mature woody vegetation (what they call 'baseline biomass'). As the CSIRO's published paper states:

> The purpose of this study was to model biomass C [carbon] following restoration activities. Therefore, the biomass in remnant trees which existed in stands needed to be removed prior to modelling, with this biomass being considered 'baseline biomass'. Many of the stands of natural regeneration … had a small sub-set of individual trees or shrubs within the measurement plots that were remnant trees that were excluded from the calculation of stand AGB attributable to the restoration activity.[32]

Later the CSIRO researchers comment that, in calibrating the TYF for natural regeneration, '*y* was fixed at 1.0, and only *G* was optimised',[33] under the assumption that 'remnant trees and shrubs had negligible influence on growth of … regenerating trees'.[34] In simple terms, they optimised *G* to get a better fit of the AGB growth curve to ensure it better reflects the more gradual rate of tree growth in naturally regenerating sites. However, they did not artificially flatten the curve by increasing *G* to account for the presence of significant non-forest baseline biomass – they removed the baseline biomass from the dataset before fitting the curve.

To confirm this, the CSIRO was asked (in correspondence that included the Clean Energy Regulator and the Emissions Reduction Assurance Committee):

> From a scientific perspective, is it appropriate to use the current calibration of FullCAM to estimate AGB on sites that are being naturally regenerated and contain significant non-forest baseline biomass, where significant non-forest baseline biomass is defined as more than the lesser of:
>
> - 5% of M in the TYF (maximum AGB in undisturbed native vegetation); or
> - 5 tonnes of dry matter per hectare.[35]

The CSIRO answered:

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[31] Paul, K., Roxburgh, S. (2020) Predicting carbon sequestration of woody biomass following land restoration. Forest Ecology & Management 460 (2020) 117838.
[32] Paul, K., Roxburgh, S. (2020) Predicting carbon sequestration of woody biomass following land restoration. Forest Ecology & Management 460 (2020) 117838, p. 4-5. See also comments at p 11.
[33] Paul, K., Roxburgh, S. (2020) Predicting carbon sequestration of woody biomass following land restoration. Forest Ecology & Management 460 (2020) 117838, p. 9.
[34] Paul, K., Roxburgh, S. (2020) Predicting carbon sequestration of woody biomass following land restoration. Forest Ecology & Management 460 (2020) 117838, p. 11.
[35] Macintosh, A. (2021) Email to David Byers and ERAC Secretariat. RE: Letter from David Byers - HIR issues. 29 September 2021.

> Our answer to this question is 'no'. We have prepared the attached document to explain why this is the case.[36]

The attached document clarifies that:

> The premise of the TYF is to predict yields of AGB at sites with near-zero baselines. This is because the TYF is 'blind' to the baseline AGB. Hence, application of the TYF is only valid for sites with near-zero baselines, as it predicts the stand will grow towards *M* from a near-zero starting point. If the TYF is applied to stand with moderate-high AGB baselines, this will erroneously predict a final maximum AGB that exceeds *M*. The final maximum AGB effectively being assumed to be *M* plus the baseline AGB.[37]

As is evident from the form of the TYF and the way it was most recently calibrated, FullCAM (and the RMT) is not designed for use on sites that contain significant amounts of mature woody vegetation at project commencement.[38] For the model to provide robust and unbias estimates of sequestration in regenerating native forests, areas containing mature woody vegetation at commencement need to be excised from the modelled area (i.e. the CEA). Given the FullCAM versions of the method are explicitly designed around FullCAM, this aspect of the model is critical to the interpretation of the methods' stratification requirements. The interpretation adopted by the Clean Energy Regulator conflicts with this reality, which is resulting in the misapplicaiton of the models and over-estimation of the resulting sequestraiton in regeneration.

4. Implications of including mature woody vegetation in CEAs

As a consequence of the Clean Energy Regulator's misapplication and misinterpretation of the methods, it is likely that HIR projects that contain significant amounts of mature woody vegetation in their CEAs are being over-credited. The magnitude of the over-crediting will depend on a number of factors, including the extent of pre-existing mature vegetation in the CEAs and its age, the modelled rates of regeneration in the CEAs and the actual extent and rate of regeneration on the parts of CEAs of that do not contain pre-existing mature woody vegetation.

The importance of the first two of these factors is demonstrated in Figures 4 and 5, which provide illustrative examples of the potential magnitude of the resulting over-estimation of sequestration on a per hectare basis, based on a collection of randomly selected FullCAM plots in semi-arid regions in Queensland and New South Wales. Both examples assume that 30% of the land contains mature vegetation and that the remaining 70% of the land matches the modelled assumption of near zero biomass at project commencement. The main difference between the two is the Queensland site is less productive than the New South Wales site.

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[36] Paul, K. (2021) Email to Andrew Macintosh. RE: Letter from David Byers - HIR issues. 12 October 2021.
[37] CSIRO (2021) Baseline AGB: TYF calibration for natural regeneration in land managed for grazing. Attachment to Paul, K. (2021) Email to Andrew Macintosh. RE: Letter from David Byers - HIR issues. 12 October 2021.
[38] We note that, even if the CSIRO had recalibrated FullCAM in a way that accounted for the presence of mature woody vegetation at project commencement, most projects are probably not using the recalibrated version of the model. Projects that applied for registration prior to 1 September 2020 are able to use the 2016 version of FullCAM rather than the 2020 version, which contains the recalibration. Department of Industry, Science, Energy and Resources (2020) FullCAM Guidelines: Requirements for using the Full Carbon Accounting Model (FullCAM) in the Emissions Reduction Fund (ERF) methodology determination: Carbon Credits (Carbon Farming Initiative) (Human Induced Regeneration of a Permanent Even Aged Native Forest—1.1) Methodology Determination 2013, Version 3.0. Commonwealth of Australia, Canberra.

In the Queensland example (Figure 5), the project will be credited on the basis the regeneration sequestrated 8.0 tC per ha over 25 years. However, by virtue of the fact 30% of the site contained mature vegetation at commencement, it can only sequester 5.5 tC per ha. The outcome over 25 years is sequestration is over-estimated by 2.5 tC per ha (9.0 tCO_2 per ha). In the New South Wales example with a more productive site (Figure 6), the modelled sequestration is 11.3 tC per ha over 25 years but the actual is only 7.8 tC per ha, with a resulting over-estimation of 3.5 tC per ha (12.7 tCO_2 per ha). For illustrative purposes, if it is assumed these estimates are representative of existing HIR projects, and that their CEAs cover 25% of the total HIR project area (~5 million ha), the resulting over-estimation of the sequestration would equate to between 43-61 $MtCO_2$ over 25 years.

Figure 5. Illustrative example of the potential magnitude of the over-crediting (30% of CEAs contain mature vegetation, Queensland)

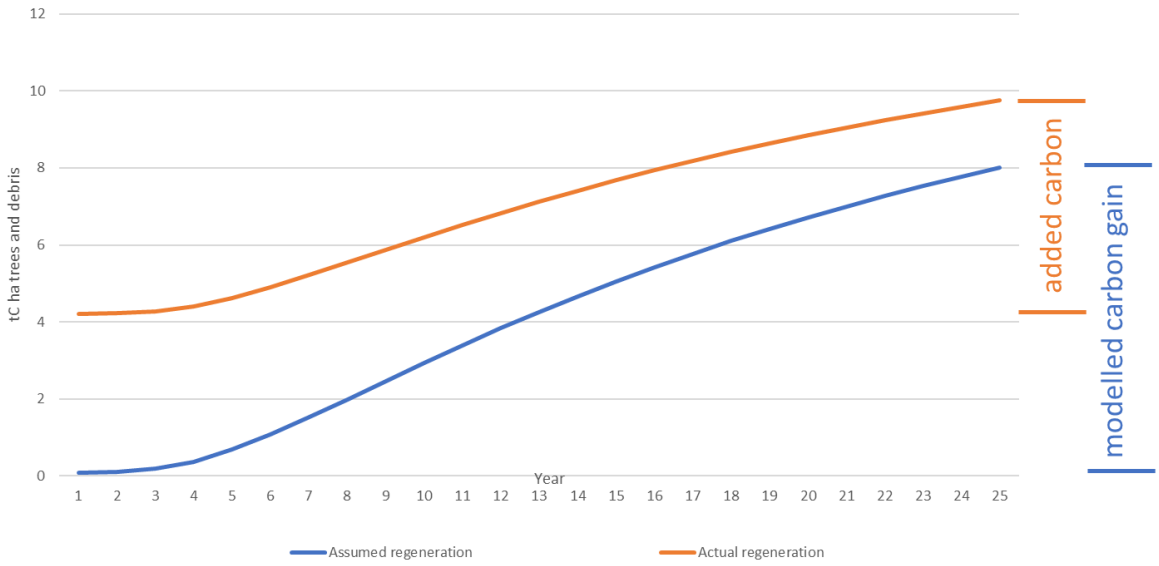
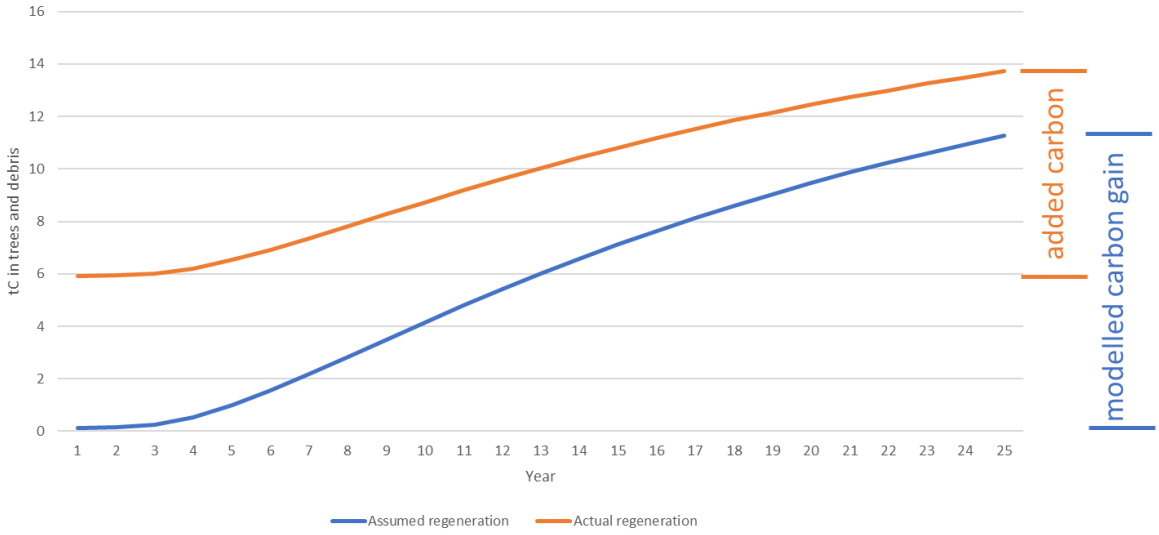


Figure 6. Illustrative example of the potential magnitude of the over-crediting (30% of CEAs contain mature vegetation, New South Wales)



While these illustrative examples provide some insights on the sensitivities, the true extent of the over-crediting that could result from the misinterpretation of the method cannot be

estimated without information on the location of CEAs, which is not publicly disclosed. However, given the location of HIR projects across the semi-arid and arid regions of New South Wales, Queensland, Western Australia and South Australia where clearing is not common land management practice (Figure 2), and the related fact that 97% of the area within the published boundaries of HIR projects is mapped as 'extant' native vegetation in the National Vegetation Information System, it appears a substantial number of CEAs may contain significant amounts of pre-existing mature woody vegetation. There is also a significant risk of CEAs containing other areas (e.g. rocky outcrops) where the project mechanism cannot be undertaken.

5. Government response

The misapplication of FullCAM (and RMT) under the HIR method and resulting risk of over-crediting were brought to the attention of the Clean Energy Regulator, Emissions Reduction Assurance Committee and Department of Industry, Science, Energy and Resources in June 2021. Papers were provided to these organisations about this issue and the need for it to be addressed, including by the authors of this paper. They were also personally briefed on the issue by the authors and other authoritative individuals involved in the carbon market.

Despite being provided with this information, and being privy to the materials supplied by the CSIRO, the Clean Energy Regulator and Emissions Reduction Assurance Committee have dismissed the issue as being a misunderstanding.

In correspondence dated 16 September 2021, the chair of the Emissions Reduction Assurance Committee, David Byers, stated in relation to this issue that:

> You have raised a further issue as to how the FullCAM tool accounts for existing vegetation in CEAs. I am advised that this concern may derive from a misinterpretation of the underpinnings of the model and that pre-existing vegetation is in fact factored into the FullCAM model assumptions.[39]

An issues paper prepared by the Clean Energy Regulator and attached to the correspondence similarly states:

> The tree yield formula is calibrated for existing mature vegetation through its exclusion of remnant carbon stock, meaning that pre-existing vegetation is factored into the model assumptions.[40]

As the material in section 3 demonstrates, both of these statements are wrong.

On 5 November 2021, the Emissions Reduction Assurance Committee issued a public statement on the concern, which stated:

> The Clean Energy Regulator is of the view that this concern reflects a misunderstanding of how the method works and no version of the method has ever required the removal of sub-forest mature vegetation in this way. … The model calibration is based on a range of forest densities short of forest cover. The ERAC notes that FullCAM is a well-established and highly credible model, and the method has been operating using FullCAM or related models since 2013. ERAC has not seen evidence to support this concern of over-crediting. However, ERAC is applying a risk-based approach to test this

[39] Byers, D. Correspondence with Professor Andrew Macintosh: Human-Induced Regeneration (HIR) Method. 16 September 2021. Commonwealth of Australia, Canberra.
[40] Clean Energy Regulator (2021) Issues Summary – Concerns about the ERF Human-Induced Regeneration method. Updated. Commonwealth of Australia, Canberra.

> concern further and the outcomes of this investigation will also be made public when complete.

To date, nothing else has been released from the Emissions Reduction Assurance Committee or the Clean Energy Regulator.

In an ABC program published in November 2021, the chair of the Clean Energy Regulator, David Parker, was asked about this issue and replied:

> … we're not really concerned about the precise amount that is credited on a particular project. We are actually more concerned about the aggregate amount that is credited. The aggregate crediting is conservative because there are conservative biases that are built in there. And of course, if your forest cover grows beyond 20 per cent, you don't get any credit for that. So there are some swings and roundabouts in this one.[41]

Again, this statement is wrong. The method over-estimates sequestration where HIR CEAs contain significant amounts of mature woody vegetation at commencement. Further, the method does not cease crediting regeneration in a CEA when 'forest cover grows beyond 20 per cent'. As the growth curves in Figure 4 show, modelled sequestration continues throughout the 25-year crediting period (and beyond), meaning the only way crediting can stop if there is a disturbance event that is required to be modelled through a growth pause.

6. Conclusion

The HIR method is a centrepiece of the ERF. It accounts for the most project registrations of any method, the most ACCUs issued of any method and more than 50% of all ACCUs contracted through the ERF purchasing scheme, worth approximately $1.5-$1.6 billion. HIR project areas now stretch across more than 20 million hectares of Queensland, New South Wales, South Australia and Western Australia and, in these areas, the method is having a material influence property markets.

The popularity of the HIR method may be partly explained by the way it is being administered by the Clean Energy Regulator. The Clean Energy Regulator has allowed proponents of HIR projects to include land areas containing mature woody vegetation at project commencement in their CEAs. This runs contrary to the requirements of the method and directly conflicts with how the models that are used to estimate sequestration under the method are designed and calibrated. The approach adopted by the Clean Energy Regulator is likely to be resulting in the significant over-crediting of HIR projects. In colloquial terms, proponents are being issued ACCUs for growing trees that were already there when the projects started.

The simple solution to this issue is to require existing projects to re-stratify their CEAs to exclude areas that contained mature woody vegetation at the time of project commencement. This would bring the projects in line with the method's stratification requirements. Beyond this, an investigation needs to be conducted into the response of the Clean Energy Regulator, Emissions Reduction Assurance Committee and Department of Industry, Science, Energy and Resources to this issue. All three organisations have ignored and sought to suppress a material integrity issue associated with the ERF's most popular method in circumstances where they knew, or should have known, that it was distorting the ACCU market.

[41] Parker, D. (2021) Cited in ABC (2021) Boom time in carbon farming country. Background Briefing, 21 Nov 2021. Available at: https://www.abc.net.au/radionational/programs/backgroundbriefing/boom-time-in-carbon-farming-country/13637436 (28 February 2022).