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Reply to: National-scale datasets underestimate vegetation recovery in Australian human-induced native forest regeneration carbon sequestration projects

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REPLYING TO T. Moore et al. *Communications Earth & Environment* https://doi.org/10.1038/s43247-025-02725-z (2025)

We analysed 182 human-induced regeneration of even-aged native forest (HIR) projects using the National Forest & Sparse Woody Vegetation dataset (NFSW), an Australian Government dataset that classifies 25 m grid cells as either non-woody, sparse woody (sub-forest woody cover where crown cover is between 5 and 19%) or forest (woody vegetation ≥2 m tall with crown cover >20% over at least 0.2 ha). Project performance was evaluated based on: (1) the extent to which forest cover and 'woody cover' (areas with either forest or sparse woody cover) had increased in the 'credited areas' (where the even-aged native forests are supposed to be regenerating) of the projects since they were registered; and (b) the extent to which changes in forest and woody cover in the credited areas mirrored trends in comparison areas comprised of 3 km wide buffer areas around the boundaries of the projects, excluding areas in other HIR projects. We found limited evidence of regeneration in credited areas and that the observed changes were predominantly attributable to factors other than the project activities[1].

NFSW is suitable for evaluating forest regeneration

Moore et al. contend that the NFSW and other similar national scale woody cover datasets are too inaccurate to be relied on to analyse HIR projects. They argue projects can only be reliably evaluated using proponent data, which is not published.

HIR projects cover ~42 million hectares (Mha), more than 5% of the Australian continent and an area almost as large as Iraq[2]. The projects in our sample cover 9.5 Mha and have an aggregate credited area of 3.4 Mha. Based on the levels of crediting, and accounting for the level of forest cover when the projects claim to have started, almost 50% of the entire credited area of the 182 projects should have had forest cover by late 2022 and the average across the projects should have been ~64%. Yet the NFSW dataset suggests the proportion of the aggregate credited area with forest cover in 2022 was only 16%, just 5% above the levels when the projects commenced, with a project average of just 19% (Fig. 1).

The levels of crediting suggest that, by late 2022, 62 of the 182 projects should have experienced a uniform increase in canopy cover of ≥20% across their entire credited area (0.68 Mha). That is, 100% of the credited areas of these projects should have had forest cover from the new regeneration alone. However, the observed level of forest cover has barely changed. Across the entire credited area of these 62 projects, forest cover increased by less than 2% between project commencement and 2022, from 16% to 18%. Average forest cover across the projects in 2022 was only 21% (sd 14%), a mere 1.7% higher than the levels at commencement (Supplementary Fig. S1).

There is a very large disparity between the levels of credited sequestration and observed increases in forest (and woody) cover, which Moore et al. argue is attributable to the inaccuracy of the NFSW dataset.

The contention that the NFSW is too inaccurate to rely on to evaluate reforestation over millions of hectares, and that the errors are large enough to explain the disparity between credited and observed changes in forest cover, is not sustainable. However, if it was true, it would raise multiple issues beyond our study. The Australian Government relies on the NFSW to estimate emissions and removals associated with woody vegetation in the national greenhouse gas accounts, prepared under the IPCC Guidelines for National Greenhouse Gas Inventories for the purposes of the United Nations Framework Convention on Climate Change and Paris Agreement[3]. The NFSW is the legally prescribed definitive data source for the purposes of analysing whether HIR projects have achieved forest cover under the laws that govern the Australian carbon credit unit (ACCU) scheme[4]. Since 2021, the Regulator and the ACCU scheme's Integrity Committee have repeatedly relied on the NFSW to claim HIR projects are performing as expected (Supplementary Table S1). Of the 70 HIR projects that have published

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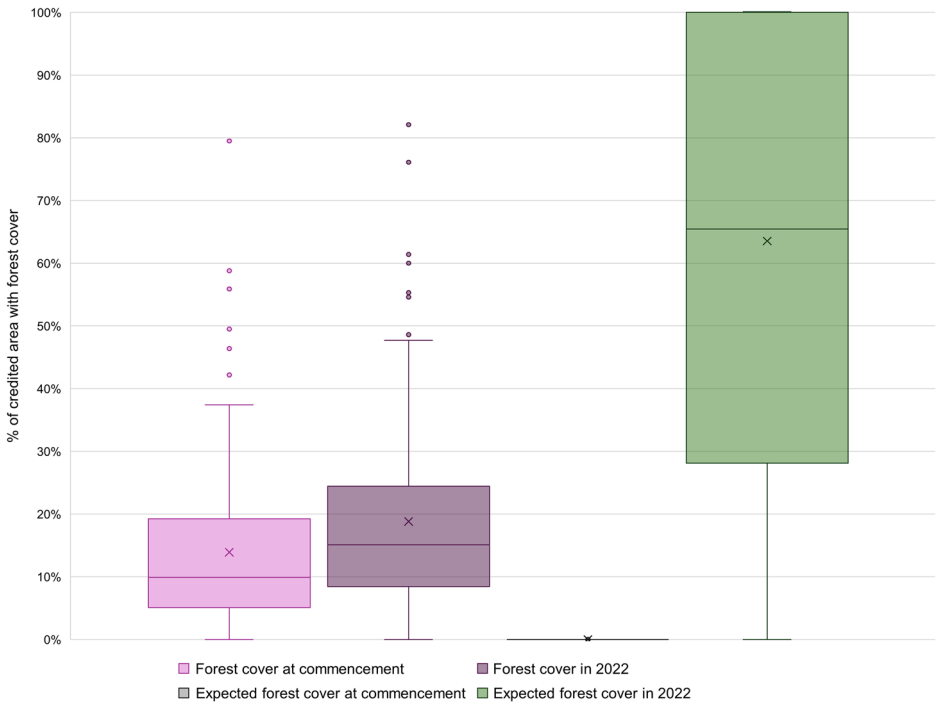

Fig. 1 | Percentage of credited areas with forest cover at project commencement and 2022, relative to proportion of credited areas expected to have forest cover at project commencement and in 2022 (n = 182). By law, areas with forest cover at project commencement must be excluded from credited areas, meaning expected forest cover at commencement is 0%. Expected forest cover in 2022 was calculated by converting credits issued to the end of 2022 to total credited sequestration in accordance with the method in Macintosh, Butler et al.[1], converting total credited sequestration into live biomass equivalent using representative Full Carbon Accounting Model (FullCAM) plots from project areas, and then using the live biomass to crown cover relationship from Larmour et al.[14] to derive an estimate of the credited increase in crown cover. The credited increase in crown cover was then applied to the non-woody and sparse woody areas in the year of project commencement, assuming median crown cover for each class (i.e. 2.5% for non-woody and 12.5% for sparse woody). If the sum of the estimated credited increase in crown cover to end 2022 and the cover at project commencement was ≥20%, we assumed the area should have forest cover in 2022. The proportion of credited areas that were expected to have forest cover in 2022 included areas with forest cover at project commencement.

information on the data they use for stratification and tracking regeneration, 100% say their data sources include NFSW[2].

To support their claims about the inaccuracy of the NFSW, Moore et al. present a comparison between LiDAR-derived crown projective cover (CPC) estimates and NFSW woody cover classifications for 500 0.56 ha sample locations. The 500 sample locations were drawn from five study sites in western Queensland, western New South Wales, and the Murchison region of Western Australia. They present a similar comparison between LiDAR CPC estimates and estimates derived from the Woody Cover Fraction (WCF) dataset[5] that is not relevant to our study, but was used in Macintosh, Evans et al.[6].

To evaluate whether Moore et al.'s comparisons affect our conclusions, it is necessary to assess their robustness. This requires information on the location of the study sites and how they were selected, the coordinates of the sample locations and how they were selected, and details of when the LiDAR data were collected and whether the LiDAR CPC estimates were compared to NFSW classifications from the same period.

Moore et al. do not provide this information. They provide a high-level map of the approximate location of the study sites, a comment that the sample locations were randomly selected and the statement that the 'analysed lidar surveys were collected in 2021 and 2022 and compared against contemporary national-scale estimates from NFSWVD'. No information is provided on how the study sites were selected, the dates of the surveys, the location of the sample areas or even details on the number of sample locations that were inside and outside of the credited areas.

Most notably, Moore et al. do not provide the data from the LiDAR surveys. This is particularly important in the current context because of the method Moore et al. used to undertake the comparisons, in which they assigned each 0.56 ha sample location to a single NFSW classification, 'based on the majority cover type within the 75 × 75 m window'. This approach could introduce a material source of error. The magnitude of this and other potential errors cannot be evaluated without access to the data.

Moore et al. published the source data for their figures and tables but not the primary data sources and sample locations, which they claim they cannot release due to privacy restrictions. Without this information, we were unable to fully assess the implications of Moore et al.'s analysis for the findings of our study. Notwithstanding this, it remains implausible that the inaccuracies in the NFSW dataset are large enough to explain the extent of the observed underperformance of HIR projects.

Comparison areas are appropriately delineated

Moore et al. argue that the comparison areas we used to analyse projects are invalid because there were significant disparities between the size of the credited areas and their corresponding comparison areas. On this basis, they contend our analysis is flawed.

Differences in the size of control and treatment areas can affect outcomes of ecological analyses. However, HIR projects are not credited based on subtle changes in vegetation structure, where the careful delineation of control sites can be required to accurately detect management-induced changes. HIR projects are supposed to be inducing the regeneration of even-aged native forests across millions of hectares and, if they were having the effects they are being credited for, the impacts on tree cover would be readily observable relative to the trends on adjacent lands where the project activities are not being carried out. The nature of the projects and credited impacts allows for the use of more coarsely defined comparison areas without materially affecting the results.

This is demonstrated by Macintosh, Evans et al.[6], who evaluated 116 HIR projects using the WCF dataset[5]. They analysed the performance of these projects by dividing the credited areas into 100 ha cells and matching each credited area cell to one of ~200 randomly selected 100 ha cells from 3 km buffers around the projects (excluding areas in other HIR projects), based on Euclidean distances. Despite the more complex construction of the comparison areas, the study found similar results to those in Macintosh, Butler et al.[1]: the projects had only a small, but statistically significant, effect on cover from woody vegetation.

To further interrogate this issue, we evaluated the extent to which modifying the comparison areas of the 20 projects with the largest mismatches in size—both oversized and undersized—effected the trends in woody cover. For the 10 projects where the comparison area was substantially larger than the corresponding credited area, we reduced the width of the comparison area from 3 km to 1 km, resulting in the modified comparison area being 1/3rd of its original size. For the 10 projects where the comparison area was substantially smaller than the corresponding credited area, the modified comparison area was constructed by adding the 3 km

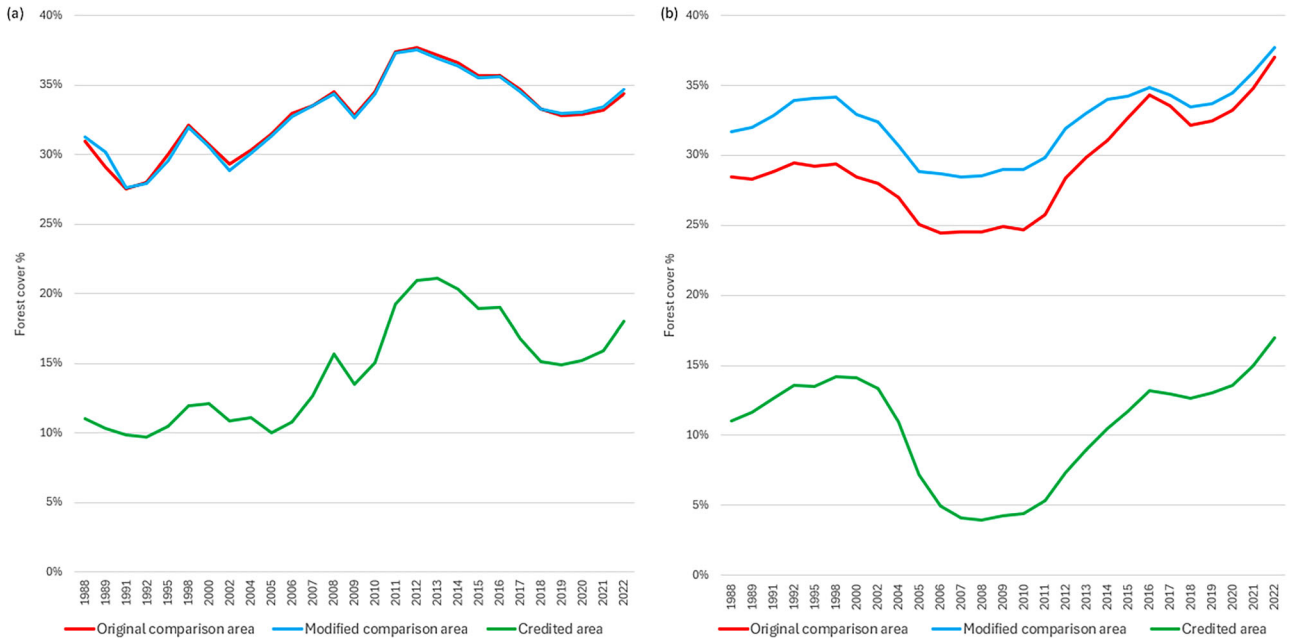

Fig. 2 | Proportion of original comparison areas (red), modified comparison areas (blue) and credited areas (green) with forest cover, 1988-2022. a Projects with oversized comparison areas ($n = 10$): ID nos. ERF101369, EOP100548, ERF110991, EOP100275, ERF123795, ERF101718, EOP101140, ERF101641, ERF101830, ERF101971. Original aggregate comparison area to credited area ratio: 6.36. Modified aggregate comparison area to credited area ratio: 2.11. **b** Projects with undersized comparison areas (and adjoining projects) ($n = 10$): ID nos. ERF104646 (ERF111058), ERF101380 (ERF103140), ERF103367 (ERF131090), ERF104559 (ERF101805), ERF101794 (ERF101308), ERF118275 (ERF101229), ERF101425 (ERF103193), ERF101519 (ERF101759), ERF103081 (ERF101733), ERF121770 (ERF123774). Original aggregate comparison area to credited area ratio: 0.18. Modified aggregate comparison area to credited area ratio: 0.74.

buffer area from an adjoining project. As Fig. 2 shows, despite these projects constituting the 20 most extreme cases in terms of the size differentials between the credited areas and comparison areas, there is little difference in the temporal trends in forest cover between the original and modified comparison areas. This further confirms that the use of the original 3 km comparison areas was appropriate.

Consistent with the results shown Macintosh, Butler et al.[1] [See Figure 3 in Macintosh, Butler et al.[1]], the aggregate trend in the proportion of forest cover in credited areas largely mirrors the trend in comparison areas, and the small observed increase in cover in credited areas after project commencement continued a trend that started in or around 2007, six years before the HIR method was even developed. In other words, the observed woody cover increases in credited areas are likely to be non-additional.

Another line of argument put forward by Moore et al. is that the comparison areas should have been matched based on 'vegetation condition, soil properties, hydrological regimes, fire history, historical and current land management practices'. This could only be done with access to relevant project data, which the companies that Moore et al. work for, who run most of the HIR projects in the sample, do not publish. Notwithstanding this, as Macintosh, Evans et al. show[6], more sophisticated delineation of control sites is unlikely to materially affect our conclusions.

The most significant issue with the comparison areas in our analysis is that they contain land areas that were either forested when the projects started or unsuitable for forest growth. Credited areas of HIR projects must exclude these areas. As we stated in our paper, the inclusion of these land areas in the comparisons creates a bias in favour of the projects – it is likely to result in the relative impacts of the projects on woody cover being overstated. We considered this to be inconsequential because, even with these lands included in the comparison areas, the analysis showed the impacts of the projects were very small, particularly relative to how they are credited.

No evidence to support claims of successful regeneration

Moore et al. claim that HIR projects are 'delivering large-scale carbon storage across approximately 3.4 million hectares' (the credited areas of HIR projects actually currently extend across almost 4.3 million ha and are likely to ultimately cover ~7–9 Mha)[2]. They state that, under scheme rules, HIR projects require 'high-quality evidence to verify project performance', the inference being that the companies they work for possess data showing the projects are inducing regeneration consistent with how the projects have been credited. Despite these claims, Moore et al. present no evidence to support the assertion that HIR projects are performing as expected.

The overwhelming majority of HIR projects purport to be regenerating even-age native forests primarily through grazing control. More than 50 years of scientific research shows grazing in uncleared rangeland areas generally has limited impact on woody cover and, if anything, is more likely to increase woody cover than decrease it (i.e. the opposite of the premise behind HIR projects, see Supplementary references). Consistent with the published scientific literature, three peer-reviewed studies have been conducted on HIR projects and they have all reached similar conclusions: that the projects have had a statistically significant but small effect on woody cover in the credited areas[1,6,7].

Given the existing literature, for Moore et al.'s claim that HIR projects are 'delivering large-scale carbon storage' to affect our conclusions, it would need to be supported by robust and verifiable evidence showing increases in both absolute and relative woody cover since the projects were registered. Increases in absolute cover would show that regeneration has occurred since the project activities commenced, and relative increases compared to the trends on adjoining lands would support claims that the regeneration is additional. Moore et al. do not provide any evidence related to either of these issues. They merely claim that these data exist and that satellite-based estimates of tree cover are unreliable.

By 2022, the effects of HIR projects on woody cover should have been readily detectable by satellite. Moore et al. seek to downplay this by repeatedly suggesting the projects are characterised by 'early-stage regeneration'. This is false. Data released for the first time in July 2025 show that, by 2022, almost 80% ($n = 142$) of the projects in our sample had been credited for 10–15 years of regeneration[2]. Consistent with this, by late 2022, 77% of the projects ($n = 140$) should have experienced ≥10% uniform increase in crown cover across the entirety of

their credited areas from new regeneration (Supplementary Fig. S2). This is not 'early-stage regeneration'.

Moore et al. could address the questions around the changes in tree cover by releasing the information the companies they work for possess on the projects. They choose not to. They have not even published the offset reports they submit on projects that are used to justify crediting or the audit reports that verify project compliance and abatement claims. The ACCU scheme is the only major carbon offset scheme in the world that does not mandate the publication of this type of information[8–11] and its public release is considered one of the basic markers of scheme integrity[12].

Under Australian law, there is a rule of judicial evidence known as the 'rule in Jones v Dunkel'[13], which states that, where a party who should be able to tender evidence on a factual matter fails to do so, courts may draw an adverse inference that the failure to present the evidence is because it would not assist their case. It seems apt in the present circumstances.

Data availability

The data used in this reply are available on Figshare at: https://figshare.com/ [https://doi.org/10.6084/m9.figshare.25199786, https://doi.org/10.6084/m9.figshare.25199789 and https://doi.org/10.6084/m9.figshare.29672537].

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Author contributions

A.M., M.E. and D.B. designed the study and prepared the response, with drafting contributions from P.L., M.W., D.E., D.L., P.G., R.F. and D.A.

Competing interests

The authors declare the following competing interests. A.M. is a non-executive director of Paraway Pastoral Company Ltd. Paraway Pastoral Company Ltd has offset projects under Australia's offset scheme. Paraway Pastoral Company Ltd does not have any human-induced regeneration projects. A.M., D.B., D.A. and M.W. advise public and private entities on environmental markets and Australia's carbon offset scheme, including on the design of carbon offset methods. The remaining authors have no competing interests.

Additional information

Supplementary information The online version contains supplementary material available at https://doi.org/10.1038/s43247-025-02726-y.

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