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Carbon farming on the margins: Unlocking carbon sequestration potential in rangelands under expanded eligibility criteria

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Abstract

Adoption of the Paris Climate Agreement has expanded Kyoto Protocol rules for carbon abatement actions from forest vegetation to include all land management actions. This change has the potential to significantly increase the area eligible for vegetation-based carbon sequestration actions and will allow countries to include these actions across extensive areas of low-biomass within national carbon abatement plans. Using the Australian rangelands as a case study, an area comprising approximately 5.55 million km^2, we assess the latent terrestrial carbon abatement potential under two eligibility scenarios. Firstly, areas of the Australian rangelands that meet the Kyoto Protocol minimum 20% tree canopy cover potential (forest) and secondly the large, previously unaccounted for part of the Australian rangelands where dominant cover potential is less than the Kyoto 20% requirement (sub-forest). We define areas eligible for assisted natural regeneration under the Australian national Emissions Reduction Fund ACCU Scheme using national scale land use, forest and vegetation spatial datasets and model carbon abatement potential across these areas using the Full Carbon Accounting Model (FullCAM 2.0). Results show up to 512,089 km^2 and 354,770 km^2 of eligible land under the forest and sub-forest scenarios respectively providing a total abatement potential of 1,882.4 MtCO_2e and 866.4 MtCO_2e over a 25-year modelling period. In an economic assessment of this opportunity, we found most of this latent abatement potential was economically viable at current low carbon prices (between AUD 17 tCO_2e^{-1} and AUD 32 tCO_2e^{-1}) available within the Australian government and secondary markets. This is the first study that assesses latent carbon sequestration potential in Australian "sub-forest" ecosystems. We highlight the prospects for (particularly Indigenous) economic development in remote Australia.

Introduction

Regeneration using assisted natural regeneration (ANR) was included in the definition of afforestation and reforestation under the Kyoto Protocol and the UN Clean Development Mechanism if the vegetation met minimum thresholds for stand size (0.05-1.0 ha), canopy cover (10-30 per cent) and height (2-5 m) (Chazdon et al., 2016; Smith, 2002; UNFCCC, 1992). However, with the adoption of the Paris Agreement, eligible abatement actions have been expanded while removing specific reference to forests and the requirement that vegetation meet the threshold definition of forest cover for eligibility (Dooley, 2018).

Currently large areas of Australia's rangelands deemed capable of regenerating Kyoto compliant forests are home to carbon sequestration projects incentivized by Australia's national carbon policy, the ACCU Scheme. However, the Paris Agreement changes provide new impetus for Australia's carbon abatement plans to now include areas of sparse woody vegetation (what we term sub-forests) that were previously ineligible including recently modified rangeland areas, particularly across drier biomes. However, the size and economic viability of this opportunity is yet to be investigated.

This article presents a bioeconomic assessment of latent terrestrial carbon abatement potential across extensive marginal and low-biomass Australian Rangeland zones. We explore two vegetation canopy cover scenarios, firstly Kyoto compliant forest with a minimum canopy cover of 20% and sub-forest which does not meet this threshold, having canopy covers between zero and 20%. We estimated carbon sequestration potential in rangelands Australia for both forest types. We report the carbon prices required for land use change to be profitable under conventional investment criteria and discuss implications for economic development in remote communities.

Methods

This case study covers the extensive Australian Rangelands (Figure) and includes vast tracts of northern and central Australia and incorporates climates and biomes ranging from tropical grasslands, savanna and shrublands in the north to deserts and arid shrublands in the south (Department of Agriculture, 2021).

Suitable areas for the Forest and sub-forest scenarios ((Figure) were defined using a series of spatial datasets relating to forest cover, land use and vegetation type. Forest cover was defined using the Australian National Carbon Accounting System (NCAS) forest mapping dataset (DISER, 2021; Furby, 2002). Current land use was defined using the Australian Land Use and Management (ALUM) data (ABARES, 2016). Vegetation types were defined using the Australian National Vegetation Information System (NVIS) major vegetation groups (MVG) data (NVIS, 2017). Areas were included in the analysis as eligible for Forest carbon farming if they were defined as having non-forest or sparse woody vegetation in the NCAS data and having MVGs that can achieve forest cover (e.g. forest, closed woodlands, tall closed shrublands) in the NVIS data. In contrast, areas were included as eligible for Sub-Forest carbon farming if there was no forest or sparse woody vegetation present in the NCAS data and only MGVs that can achieve between zero to twenty per cent canopy cover (e.g., open woodland) in the NVIS data.

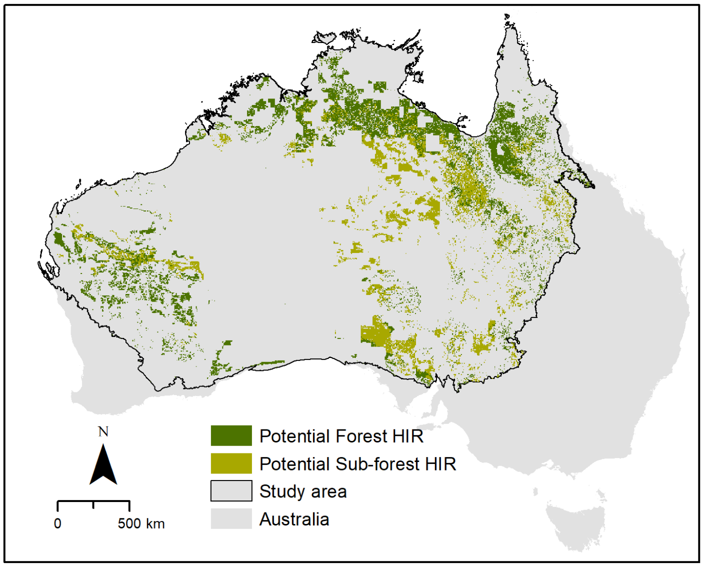

Figure 1: The Australian Rangelands study area and potential areas for regeneration under current forest and sub-forest suitability requirements.

Annual carbon sequestration estimates in tonnes of CO_2e per hectare were modelled using the ERF approved software Full Carbon Accounting Model (FullCAM) 2020 (DISER, 2020a). Carbon estimates were modelled on a 0.05-degree grid across all suitable areas and over a 25-year timeline starting in 2020. The same FullCAM settings were used for both the Forest and sub-forest scenarios. The difference between the two scenarios was based solely on location. All FullCAM modelling was carried out in line with the legislation (Commonwealth of Australia, 2013) and the FullCAM Guidelines for the Human Induced Regeneration method (DISER, 2020b)

Net present value (NPV) was used to evaluate the economic viability of land use change from the business-as-usual land use to carbon using the ACCU Scheme HIR methodology. The NPV of the Forest and sub-forest scenarios was calculated considering project establishment costs including the opportunity of lost agricultural revenue, fencing costs, brokerage/transactions costs and maintenance costs.

Functionally, the NPV_{ANRp} of changing from current agricultural land use to carbon land use ANR at carbon credit price p can be expressed as:

$$NPV_{hir} = PVR_{ANRp} - PVC_{ANR} \quad (1)$$

In equation 1, PVR_{ANRp} is the present value of returns to ANR at price p was calculated as:

$$PVR_{ANRp} = \sum_{t=0}^{T} \frac{p \times Cseq_{ANR}}{(1+r)^t} \quad (2)$$

Where $Cseq_{ANR}$ described sequestered carbon in each year t. Spatially differentiated estimates of $Cseq_{ANR}$ annual incremental and cumulative values over a 25-year and 100-year horizon were estimated across relevant areas for ANR using the FullCAM model.

The term r is the discount rate applied in discounting future costs and returns and T is the time horizon in our case 25 years and 100 years. We assumed a real rate of 5.25%.

The term PVC_{ANR} in equation 1 is the present value of all costs for ANR: it is calculated as:

$$PVC_{ANR} = FC_{ANR} + \sum_{t=0}^{T} \frac{MC_{ANR} + BC_{ANR} + PFE_t}{(1+r)^t} \tag{3}$$

Four elements of cost are considered in equation 3: FC_{ANR} is the fencing costs assumed to be \$24 ha^{-1} for ANR. This value is not discounted as it occurs at project initiation. MC_{ANR} are the maintenance costs that occur in each year t over the investment horizon and assumed to be \$1 ha^{-1} over the first 5 years following establishment and \$0.5 ha^{-1} for every year thereafter (Cockfield et al., 2019). And brokerage costs BC_{ANR} (including measurement, compliance and auditing costs) assumed to be 20 percent of the total value of the carbon. This percentage was considered fixed with no spatial variation and were taken from Cockfield et al. (2019). The final term considered in calculating the present value of costs is the opportunity cost of forgoing previous agricultural land use returns. This is expressed as the profit at full equity (PFE_t) at time t. These spatially explicit layers of agricultural profit at full equity (PFE), produced by Marinoni et al. (2012), were updated following the method outlined in (Regan et al., 2020). Consistent with this approach, the input layers were updated with price and inflation indices from the Australian Bureau of Statistics (ABS) (ABS, 2017a, b) yield data from the ABS Agricultural Commodities 2015/16 dataset at SA2 resolution (ABS, 2016). It should be noted that arid areas, in particular have very low to negative returns for agriculture. In this analysis, we assumed all positive agricultural revenue was ceased (e.g. the areas is destocked) with implementation of an HIR project.

Results

Over the 25-year period total carbon abatement potential across all eligible areas was estimated to be 1,882.4 MtCO_2e and 866.4 MtCO_2e for the Forest and sub-forest scenarios respectively. Figure 2 shows the spatial distribution of total per hectare carbon abatement across the study area over the 25-year modelling period.

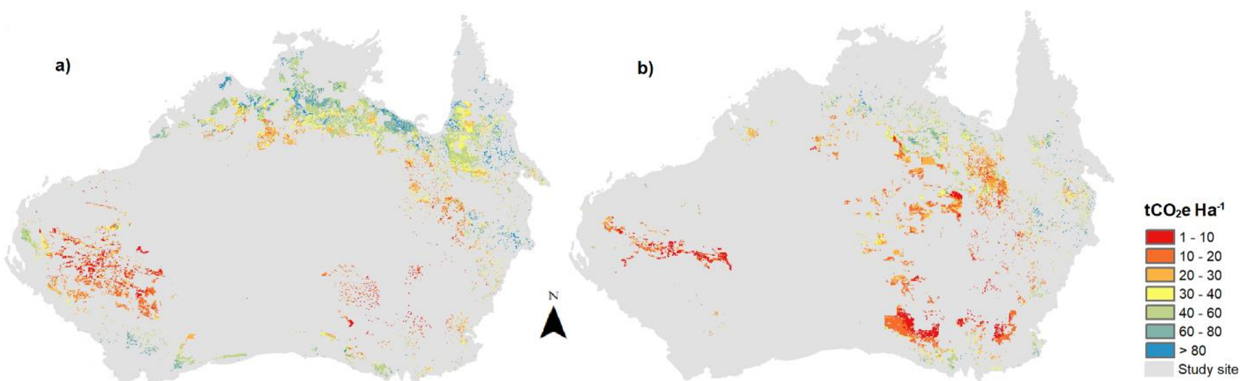

Figure 2: Estimated total carbon abatement (tCO_2e ha^{-1}) over 25 years for forest (a) and sub-forest (b) eligible areas.

Figure 3 shows the spatial distribution of the minimum carbon prices required for a project to be viable for the Forest (a) and sub-forest (b) scenarios.

Under the Forest scenario, economically viable carbon is available from AUD 2 tCO_2e^{-1} with 21.4 MtCO_2e available at this price. At the low carbon price (AUD 17 tCO_2e^{-1}) there are 1569.0 MtCO_2e available while at the high market price (AUD 32 tCO_2e^{-1}) 1855.5 $MtCO_2e$ is economically viable. These carbon sequestration amounts account for approximately 83% and 98% respectively of the total latent abatement potential under this scenario.

Under the sub-forest scenario limited carbon abatement potential is available at very low prices with just 2.4 $MtCO_2e$ available at AUD 2 tCO_2e^{-1}. At the low carbon price (AUD 17 tCO_2e^{-1}) there is 661.2 $MtCO_2e$ available while at the high carbon price (AUD 32 tCO_2e^{-1}) there is 834.4 $MtCO_2e$ available. This accounts for approximately 76% and 96% respectively of the total estimated carbon available under the sub-forest scenario across the modelling period.

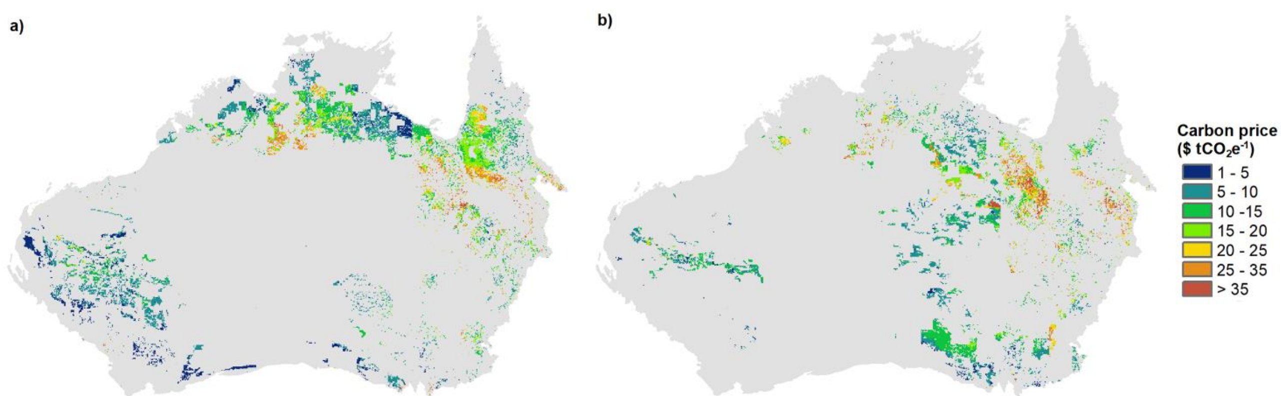

Figure 3: Estimated minimum carbon price ($ tCO_2e^{-1}) at which the carbon becomes economically viable for forest (a) and sub-forest (b) eligible areas.

Discussion [Conclusions/Implications]

Despite recognition in the Paris Agreement, no method currently exist in the Australian ACCU scheme that would include non-Kyoto compliant forest types like those found over much of the Australian rangelands. However, our results found that despite the low per hectare biomass productivity, significant abatement potential is available from this *sub-forest* category across the extensive rangeland areas of central and northern Australia. We found latent potential for economically viable carbon storage on over 350,000 km^2 using ANR for the sub-forest canopy cover scenario.

Relevant globally and in Australia is the potential for regeneration projects to produce significant co-benefits such as improved biodiversity and habitat provision, soil quality and fertility, water quality, reduced salinity and nutrient cycling (Baumber et al., 2020; Crossman et al., 2011; Lin et al., 2013; Muenzel and Martino, 2018; Tang et al., 2016). Consequently, revegetation projects over such a vast area have the potential to contribute simultaneously to Australia greenhouse gas mitigation and nature repair objectives.

In addition, evidence suggests carbon abatement actions can also promote a flow of positive economic benefits to participants including increases in landholder income, diversification of income sources and increased availability of capital for farm improvement (Baumber et al., 2020; Cowie et al., 2019). This may be particularly relevant for remote Indigenous communities where the income from carbon projects can offer transformative benefits for community well-being, economic and social development (Russell-Smith et al., 2015). Evidence from ACCU Scheme projects to date demonstrate that Indigenous environmental planting and fire management projects can deliver multiple benefits (Robinson et al., 2016; Russell-Smith et al., 2015; Sangha et al., 2021). Indeed, Sangha et al. (2021) estimated Indigenous well-being benefits from fire management activities in northern Australia to be in the order of USD 189 million $year^{-1}$. While connection to and interaction with 'Country', specifically the opportunity to care for Country, have been recognised as a key health determinant for Indigenous people (Garnett et al., 2009; Robinson et al., 2016).

The results suggest that developing a scientifically robust methods for inclusion of sub-forests in the ACCU Scheme, alongside revised HIR methods for Kyoto-compliant forests, could provide a significant economically viable additional carbon sink while catalysing remote community economic development and enhancement of ecosystem function and should be prioritised.

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