Drought and climate adaptation program

DCAP3

CREATING ALTERNATE INCOME STREAMS TO INCREASE FARM PROFITABILITY AND BENEFIT THE ENVIRONMENT (UNISQ)

MILESTONE REPORT 3B AND 3C

MAPPING AND QUANTIFYING ENVIRONMENTAL CREDIT OPPORTUNITIES IN QUEENSLAND CROPPING ZONES

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Background and summary of key findings

Within the context of Australia, substantial efforts are presently underway to foster the development of novel financial mechanisms, particularly market-based instruments, that aim to support and compensate land managers for the delivery of environmental benefits on privately-owned lands, predominantly within the agricultural domain. Prominent among these initiatives is the 'Agriculture Biodiversity Stewardship – Carbon + Biodiversity Pilot.' Such pioneering programs have the dual advantage of bolstering the income streams of agricultural producers and land managers while also contributing to broader environmental conservation goals.

This report explores the potential for environmental credit opportunities in Queensland's cropping zones, focusing on marginal land mapping and assessing the income generation potential for producers of switching to environmental credit schemes in climatically marginal cropping areas.

Marginal Land Mapping:

The study employed sub-basin analysis to identify areas exhibiting a net loss of cropping land between 2003 and 2019. This assessment correlated these losses with climate drivers linked to crop loss. Important drivers included rainfall, soil moisture, vapour pressure deficit, and minimum temperatures. Using this information, a combined rank across all climate drivers was utilized to map areas with the greatest climate marginality.

Mapping Results:

The Balonne, Central Highlands, and Maranoa sub-basins emerged as having the highest climatic marginality, primarily driven by negative trends in soil moisture, reduced rainfall, and increased night-time temperatures. These conditions have likely collectively intensified the challenges of productive cropping in these regions. Future work will address the sustainability of these trends under different climate change scenarios.

Climate and Credit Value Assessment:

Carbon and biodiversity credit potential across climatically marginal cropping land were evaluated. Carbon sequestration values were mapped based on predicted aboveground carbon accumulation rates. The study assumed a current price of $38 for each ACCU, aligning with CSIRO's LOOC-C values. Biodiversity credit options were assessed using ranked values from Jung et al. (2020), with values scaled between 29-65 $AUD/ha/yr. Mapping overlaid these values with areas of marginal crop land and related them to various climate variables. Carbon values were strongly related to climate, being lower in hotter and drier areas, while estimated biodiversity value were not related to climate. This could suggest that biodiversity credit schemes may offer more value per ha than carbon schemes for producers in climatically marginal areas.

Income Generation Potential Assessment:

The report explored scenarios to determine the income generation potential of switching to environmental credit schemes. An equation considered carbon sequestration potential, carbon price, risk reversal buffer, brokerage fees, biodiversity credit value, planting costs, and crop gross margins. Over 200,000 scenarios were run, emphasizing the hypothetical nature of the values due to the evolving nature of these schemes.

Switching Considerations:

Results indicated varied potential for environmental credit schemes, highly dependent on factors such as crop type, region, and gross margin year. The study highlighted sensitivity to scenario values, emphasizing the crucial role of payment and cost considerations in determining the feasibility of environmental credit schemes.

Timing and Long-Term Viability:

The analysis suggested that farmers could consider environmental credit schemes when average cropping gross margins fall below 57 AUD/ha/yr. Long-term viability was explored over a hypothetical 25-year contract period, indicating that schemes become more viable with a greater proportion of bad years, although crop-specific and region-specific differences were also evident.

In summary our report provides a detailed exploration of the factors influencing the environmental credit landscape in Queensland's cropping zones. It underscores the dynamic and scenario-specific nature of these opportunities and offers valuable insights for stakeholders navigating this complex terrain.

Marginal land mapping – where are the environmental credit opportunities across Queensland cropping zones?

Marginal land mapping methods

To map marginal cropping we assessed Queensland's sub-basins that have shown a net loss of crop land over the recent past (2003-2019) (from Potapov et al. 2020) and linked this with climate drivers important for driving crop loss (see Milestone report 1b for details). We then assessed the trends in these important climate drivers (i.e. rainfall, soil moisture, vapour pressure deficit and minimum temperatures) and ranked each of these across areas of crop loss. A combined rank across all climate drivers was then mapped to identify areas of greatest climate marginality.

Marginal land mapping results

The sub-basins covering the Balonne, Central Highlands and Maranoa showed the highest ranking for the index of climatic marginality (Figure 1). These regions also coincide with some of western most, and hence driest and hottest cropping areas in Queensland. The high ranking of climate marginality across these areas was driven largely by negative trends in soil moisture, and to a lesser extent rainfall, coupled with increasing night-time (i.e. minimums) temperatures and vapour pressure deficit (Figure 2). Combined these conditions have been making these cropping areas hotter and drier, and thus likely productive cropping more challenging. Future work in the project will assess whether these trends will continue under different climate change scenarios.

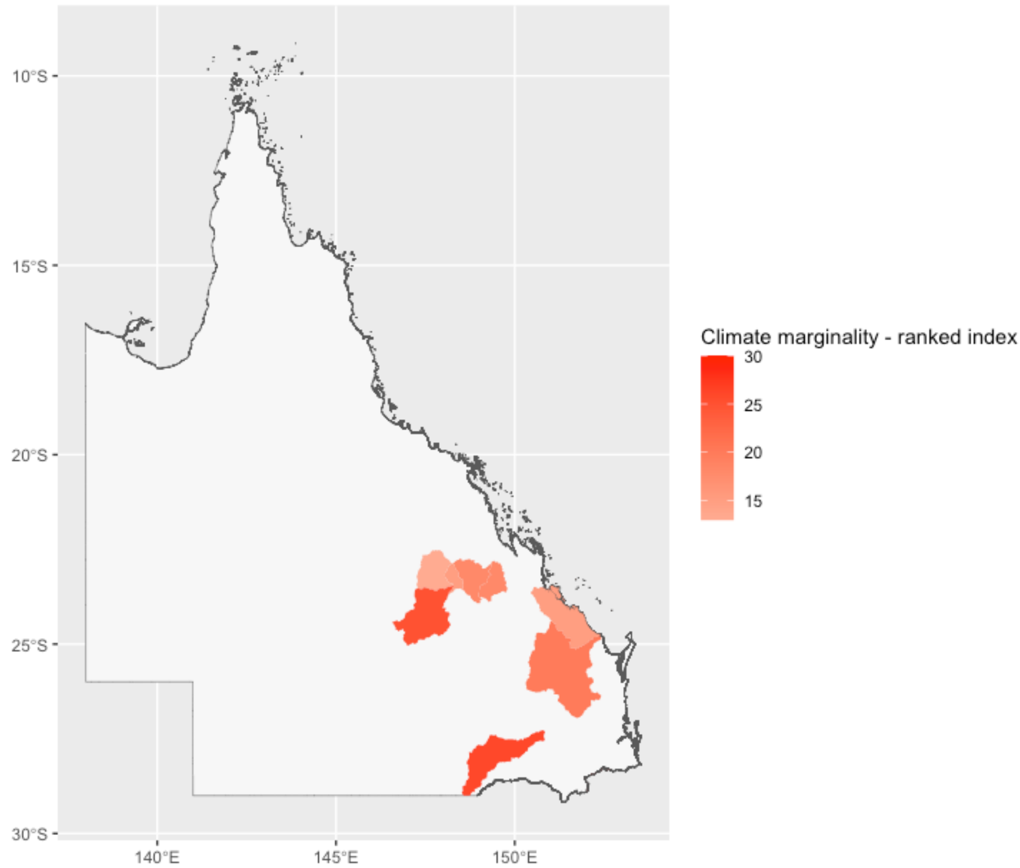

Figure 1. Mapping showing key cropping areas that have undergone net crop loss over the past two decades and how these are related to trends in climatic variables related to crop loss (see Milestone report 1b for further details). Areas with a higher rank (deeper red) are more climatically marginal.

Figure 2. Trends in climatic variables related to crop loss (see Milestone report 1b for further details) underpinning the calculation of the climate marginal index. Top left is the trend in annual soil moisture, top right trend in annual mean minimum temperatures (TMIN), bottom left trend in annual vapour pressure deficit (VPD) and bottom right is trend in annual total rainfall.

Climate and its relationship with carbon and biodiversity credit value potential across Queensland

Methods

Across climatical marginal cropping land we assessed the potential value of carbon and biodiversity credit schemes. Mapped values of carbon sequestration values were taken from Cook-Patton et al. 2020. Values are based on predicted aboveground carbon accumulation rates (Mg C/ha/yr) in naturally regrowing forest and savanna biomes across Australia. To map out the potential $value of carbon credits we assumed a price $38 for each ACCU, which is the current price as of the end of 2023 (Table 1). We also compared the values from our mapping with CSIRO's landscape options and opportunities for carbon abatement calculator (LOOC-C) and values were similar.

There is less information on biodiversity credit options, so we used mapping on ranked biodiversity values from Jung et al. 2020, which was used as a proxy for biodiversity credit value calculations. Values were scaled between 29-65 $AUD/ha/yr based on available information (Table 1). The biodiversity credit options are thus largely hypothetical and may not necessarily reflect future values. Anecdotally though it seems as though, like carbon schemes, biodiversity schemes will be outcome based and as such their potential value will also vary across the landscape depending on variations in the landscapes ability to support biodiversity.

We overlayed the mapped values of carbon and biodiversity credit value with areas of marginal crop land (i.e. where crop lands have been lost from 2003-2019, see Milestone report 1) and related these to a range of climate variables.

Carbon and climate results

Carbon sequestration potential is much higher along the wetter areas of Queensland's Coast (Figure 3). In the areas with high carbon sequestration potential the ACCU value per hectare and thus potential return to farmers is therefore also much higher. In these wetter coastal areas, the potential value of ACCU is in the vicinity of 150 AUD/ha/yr, while in drier western parts of Queensland it is 50 AUD/ha/yr and less (Figure 3).

The geographic pattern between potential carbon sequestration (and thus the dollar value of potential carbon related environmental credit schemes) is strongly related to climatic conditions across Queensland (Figure 4 & 5). Generally, in areas with higher soil moisture, higher rainfall and lower vapour pressure deficit the potential value of carbon credit schemes is much larger (Figure 4). Likewise in areas where there have been positive trends in rainfall and soil moisture, and negative trends in vapour pressure deficit the potential value of carbon credit schemes is greater (Figure 5). There is also a notable non-linear relationship between climate and the potential value of carbon credit schemes, which suggests that when soil moisture > 100mm, annual rainfall > 1000mm and vapour pressure deficit < 1 kPa carbon credit schemes become more consistently high value (Figure 4).

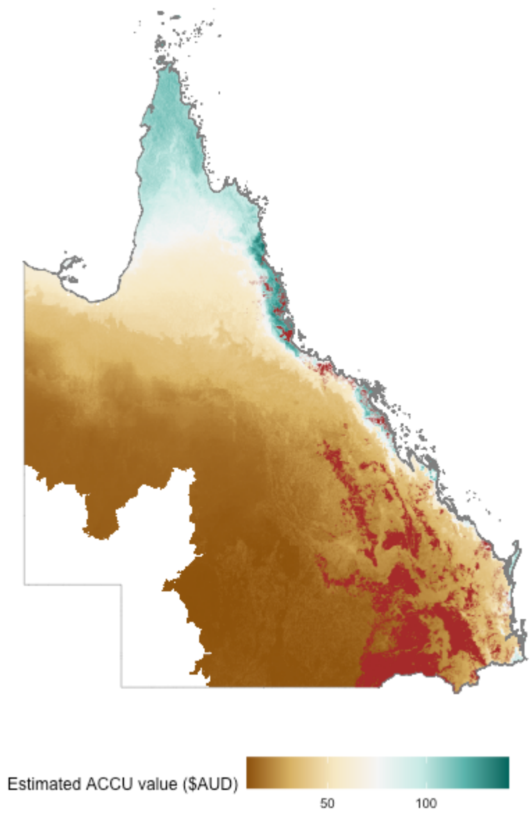

Figure 3. The estimated value of carbon credits (AUD) across Queensland based on carbon sequestration potential. Dark red areas are high value strategic cropping areas. Carbon sequestration values are taken from Cook-Patton et al. 2020. Values are based on predicted aboveground carbon accumulation rates (Mg C/ha/yr) in naturally regrowing forest and savanna biomes across Queensland and a price $38 ACCU price.

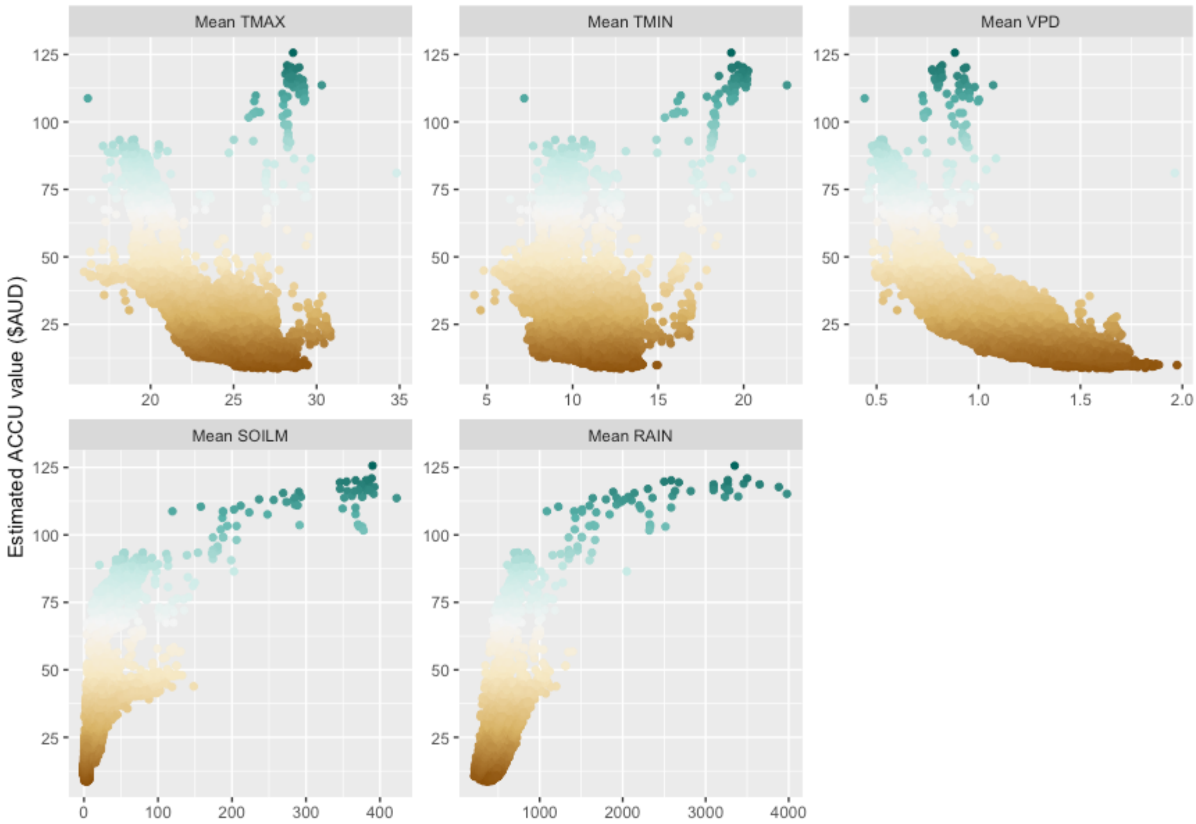

Figure 4. Relationship between estimated value of carbon credits (AUD) and mean climatic conditions (2003-2019) in areas where crops have been lost (i.e. marginal land). This analysis includes data from crop loss from across all of Australia to show the relationship between these two variables. Carbon sequestration values are taken from Cook-Patton et al. 2020. Values are based on predicted aboveground carbon accumulation rates (Mg C/ha/yr) in naturally regrowing forest and savanna biomes across Queensland and a $38 ACCU price.

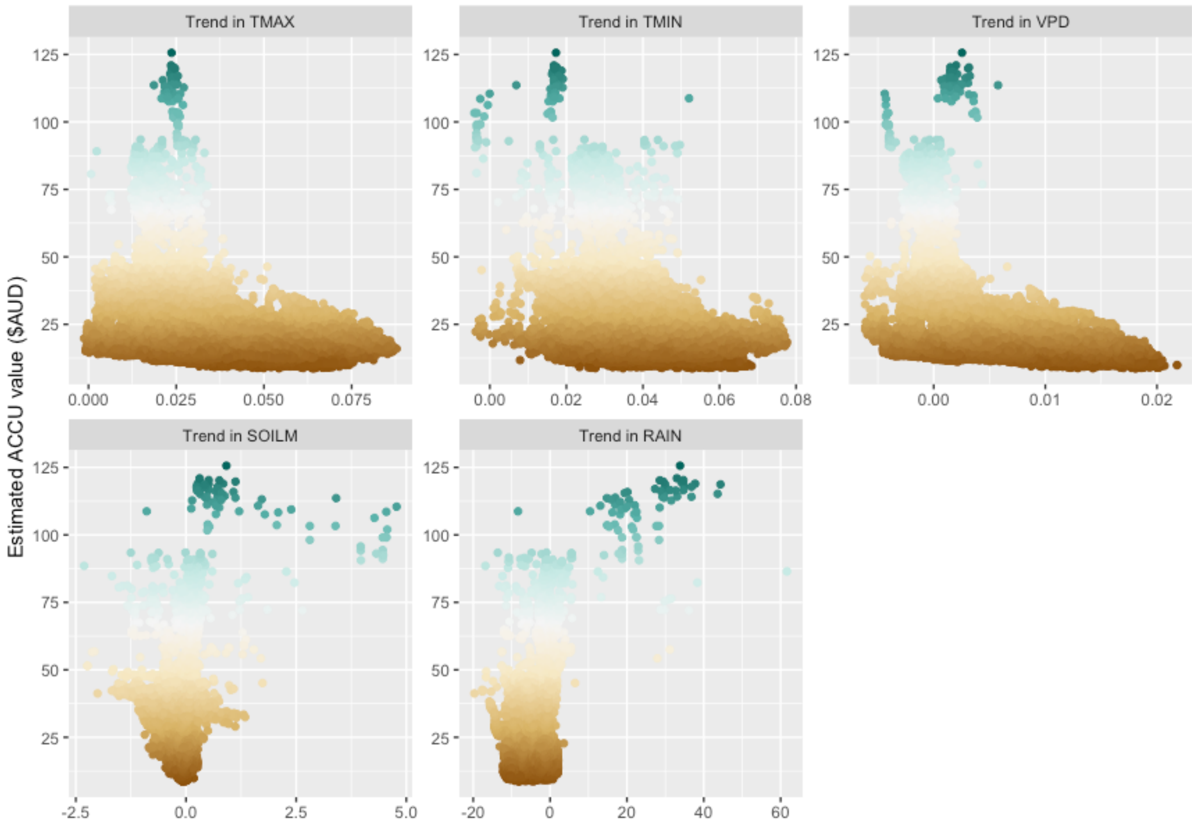

Figure 5. Relationship between ACCU and trend in climate in areas across Australia where crops have been lost (i.e. marginal land). (Per ha per annum) . Carbon sequestration values are taken from [Cook-Patton et al. 2020](). Values are based on predicted aboveground carbon accumulation rates (Mg C/ha/yr) in naturally regrowing forest and savanna biomes across Queensland and a $38 ACCU price.

Biodiversity and climate results

In contrast to the strong climatic and geographic pattern between carbon sequestration potential and climate, biodiversity values are spatially heterogenous and range from low to high across a range of areas and climatic conditions (Figure 6). The lack of a clear geographic relationship with biodiversity is evident when considering climate (Figure 7 & 8). Across, soil moisture, rainfall, minimum temperature, and vapour pressure deficit there is no pattern with biodiversity values (Figure 7 & 8). Notably even in hotter and dry areas there are very high potential biodiversity values and thus potential for relatively high biodiversity credit values per ha (Figure 7 & 8).

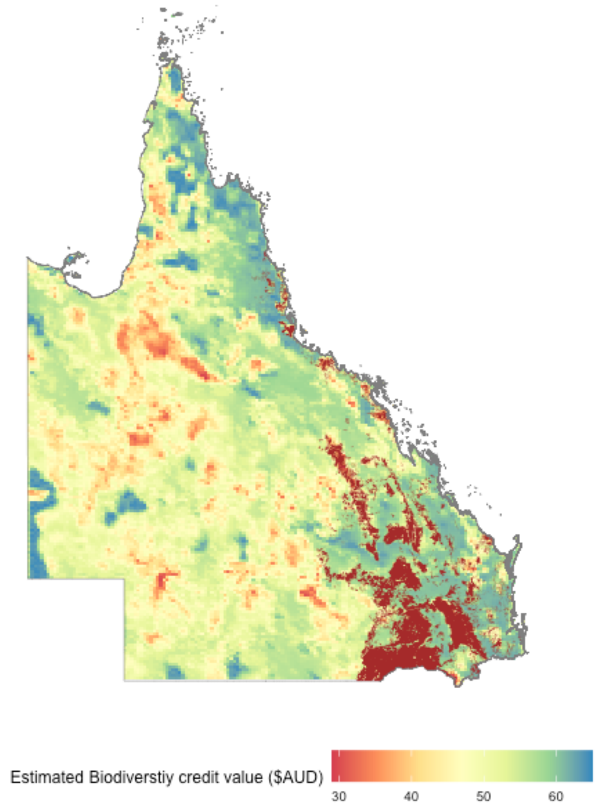

Figure 6. Estimated biodiversity credit values. Values are scaled based on ranked biodiversity importance from [Jung et al. 2020](#) , which was used as a proxy for biodiversity credit value calculations. Values were scaled between 29-65 $AUD/ha/yr.

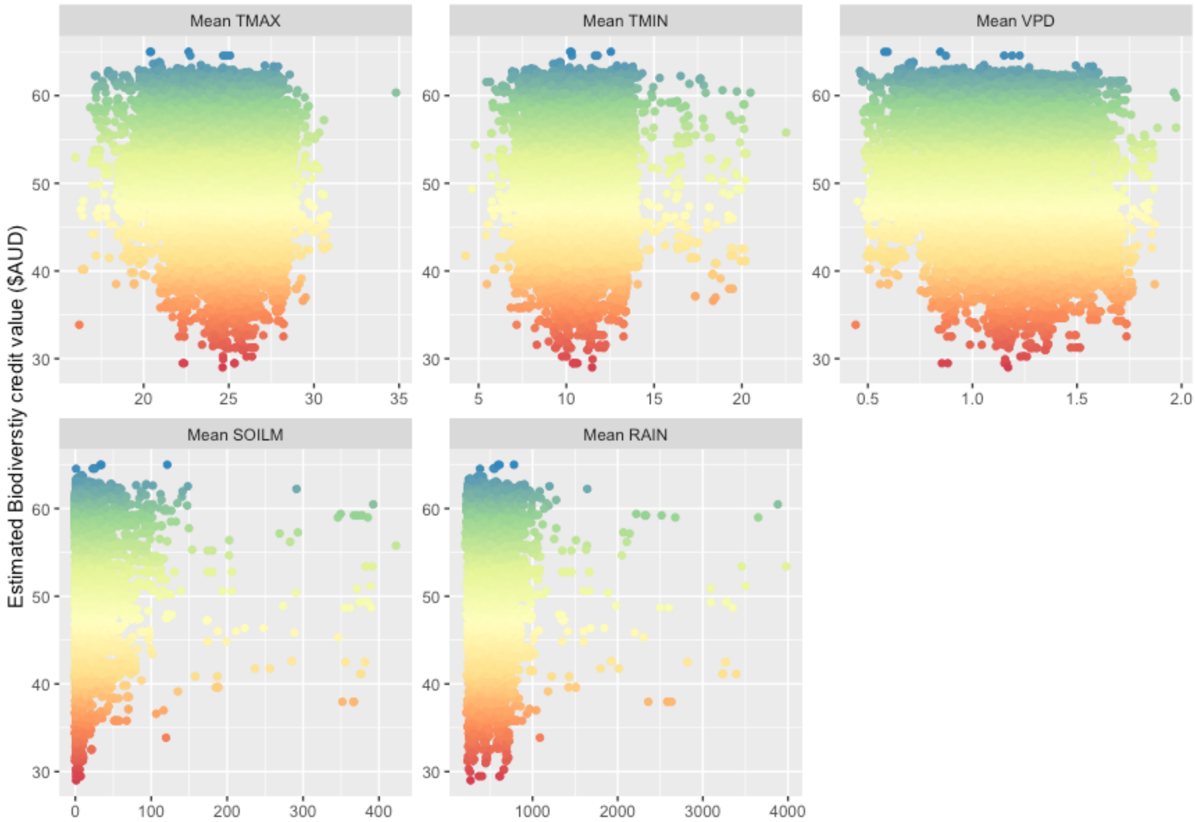

Figure 7. Relationship between potential biodiversity credit value and the mean of climatic variables across Australia. Estimated biodiversity credit values are based on ranked biodiversity importance from [Jung et al. 2020](#) , which was used as a proxy for biodiversity credit value calculations. Values were scaled between 29-65 $AUD.

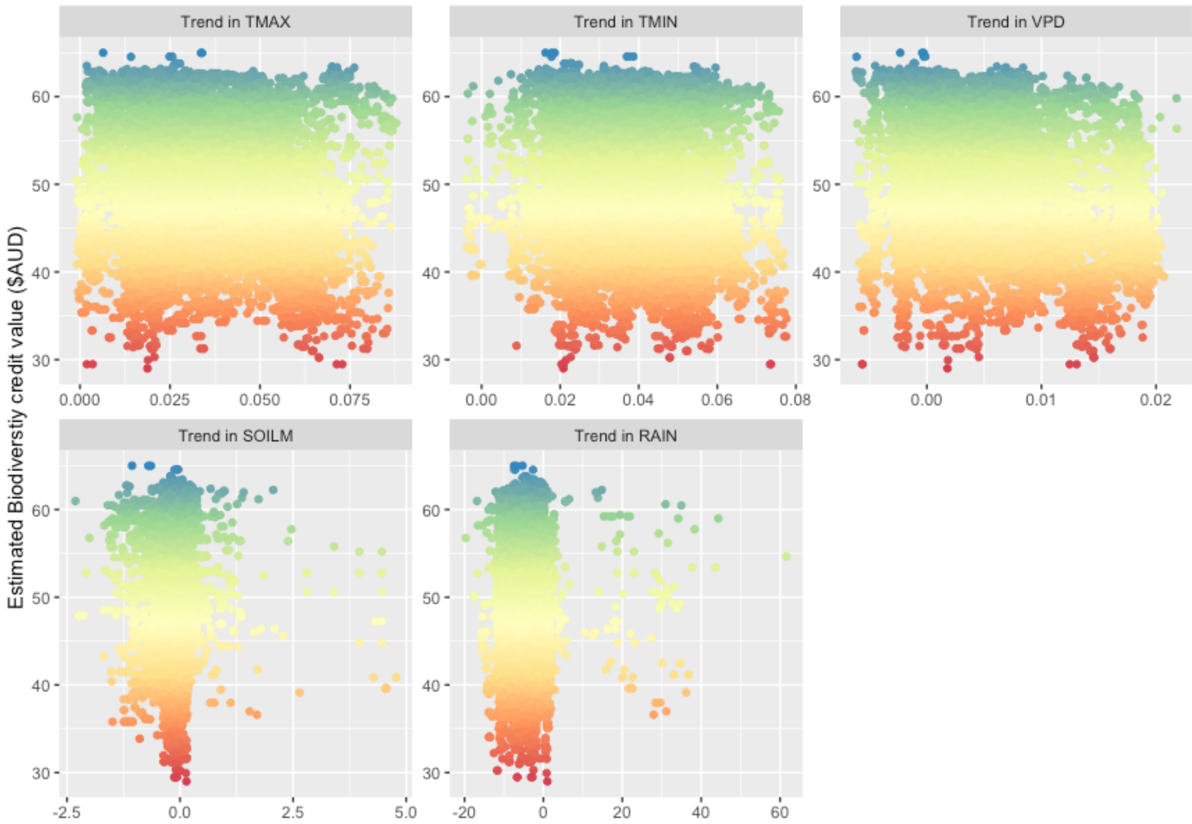

Figure 8. Relationship between potential biodiversity credit value and the trend of climatic variables across Australia. Estimated biodiversity credit values are based on ranked biodiversity importance from [Jung et al. 2020](), which was used as a proxy for biodiversity credit value calculations. Values were scaled between $29-65 AUD.

Assessing the income generation potential of switching to environmental credit schemes in Queensland's climatically marginal cropping areas

Methods

We ran a range of scenarios assuming all possible combinations of a range of values important for determining the income generation potential of switching to environmental credit schemes in Queensland's climatically marginal cropping areas. To calculate potential value of environmental (PEV) credits across climatically marginal climatic areas we used Equation 1 below,

Equation 1. $$PEV = CSP*CPr - CSP*RkB - CSP*Bf + BV - Cst*CSP - AgGM$$

Where PEV is the estimated potential environmental credit value, CSP is carbon sequestration potential, CPr is the price for carbon, RkB is the risk reversal buffer (this applies to all carbon abatement projects. It does insure participants against loss – see here for further information), Bf is brokerage fees, BV is the potential biodiversity credit value adjusted for biodiversity importance, Cst is the cost of establishing an environmental planting for carbon and biodiversity credits (which takes into account possible density of plantings / tonnes of sequestration) and AgGM are the gross margins for different cropping options (wheat, sorghum and cotton were assessed). Table 1 gives details of variable ranges used in the analysis. In total 209,952 scenarios were run based on Equation 1 and the variables ranges in Table 1. We emphasise that these values are hypothetical ranges and should be taken as static. Many of these schemes are rapidly evolving and so changes in prices and costs will occur in coming years. Despite this the analyses does still provide a starting point for considering the possible value of switching to environmental credit schemes and when they could be considered beneficial.

In addition to the analysis above we also ran scenarios that considers the variable nature of agricultural profitability, with many farmers making most of their income in a few good years and then experiencing sequential bad years, for example from long-term droughts. This especially likely in the climatically marginal lands that we focus on. This is also an important consideration when considering environmental credit schemes, which may require 25–100-year contracts. To this end we ran two scenario analysis. The first looking at the proportion of low gross margin to high gross margin years and how this relates to the potential benefit of environmental schemes – i.e. how many ‘bad’ years before environmental schemes become worthwhile. The second scenario was more conservative and looked at how many ‘bad’ years relative to ‘average’ years (here an average year was 50% of a high gross margin year) before environmental schemes become worthwhile. A total 1,178,064 scenarios were run for these analyses.

Table 1. Variables used in the scenario analysis to assess the value of switching from cropping (cotton, wheat and sorghum were assessed) to a potential environmental credit scheme (here a carbon credit scheme + co-benefit biodiversity credits). Descriptions of each variable, the range of values used in analysis and source of data is also given.

Variable	Description	Value range used in analysis	Data source	Notes
Carbon sequestration potential	Predicted aboveground carbon accumulation rates (Mg C/ha/yr) in naturally regrowing forest and savanna biomes	0.2969 to 0.8269 Mg C/ha/yr, based on carbon sequestration potential of climatically marginally areas (0.1 Mg/C/ha/yr increments)	Cook-Patton et al. 2020 https://www.nature.com/articles/s41586-020-2686-x	1 Mg C/ha/yr, is equivalent to 1 tonne C/ha/yr and 1 Australian Carbon Credit Unit (ACCU)
Carbon **price**	Australian price of carbon - ACCU	A range from 10 (lowest ERF auction price) to 65 per ACCU AUD was assessed (at $5 AUD increments)	Mean spot price for carbon at the time of writing (Q4, 2023) is 33-38 AUD. Although it is important to note that the auction price can be lower 17.12AUD (ERF auction price) (see Milestone report 2b) https://www.cleanenergyregulator.gov.au/Infohub/Markets/Pages/qcmr/march-quarter-2023/Australian-Carbon-Credit-Units.aspx https://accus.com.au/	Our analysis is based on current prices, but it is important to note that some project a near doubling of ACCUs in the next decade to between AU$65 and AU$125 per ACCU.
Biodiversity value	Ranked biodiversity value scaled to a hypothesised range of biodiversity value credit per ha	38 to 63 AUD/ha/yr (after being scaled the mapped values in Jung et al. 2020) (at $5 AUD increments)	Jung et al. 2020 https://www.nature.com/articles/s41559-021-01528-7	Recent Australia case studies linked to federal government prices have biodiversity credit values of 25 AUD/ha/yr and 35 AUD/ha/yr https://www.agriculture.gov.au/sites/default/files/documents/agriculture-stewardship-program-guidelines.pdf Reports from Carbon Neutral give a wider range of values of between $29 and $65. 20 Nov 2022 **Are biodiversity credits the next market evolution? - AFR** CSIRO has also developed a biodiversity monitoring platform for measuring the possible outcomes of actions related to biodiversity, that may link with biodiversity credit schemes in the future. https://looc-b.farm/introduction
Establishment costs **for e**nvironmental credit **scheme**	Range of costs depending on scheme (Permanent Plantings = 20-30$/t; Plantation and farm forestry = 10-30$/t; Human induced regeneration of native forest = 5$/t; Avoided clearing = 5-10$/t; Savanna fire management = 5$/t; *Soil Carbon = 7-13$/t	5 to 45 AUD/t (at $5 increments)	Based on Table 2.1 Australia's Carbon sequestration potential report https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwie3pKTt4aDAxV2Q_UHHYcnBSkQFnoECBgQAQ&url=https%3A%2F%2Fwww.csiro.au%2F-%2Fmedia%2FMissions%2FTNZ%2FCCA-report%2FCCA-Report-Australias-Potential-Sequestration-Final-28-November-2022.pdf&usg=AOvVaw2N5xaEf72FYKlIQ0xL04gq&opi=89978449	Costs of 35-42 AUD/ha/yr are given here https://www.agriculture.gov.au/sites/default/files/documents/agriculture-stewardship-program-guidelines.pdf
Risk of reversal buffer	*A 25 per cent deduction of Australian carbon credit units will be made for 25-year permanence period projects.*	25% (i.e.0.75 of the ACCU is received).	Here we assume a risk of reversal buffer of 25%, which is made for ACCU with a 25-year performance period. https://www.cleanenergyregulator.gov.au/ERF/Choosing-a-project-type/Opportunities-for-the-land-sector/Risk-of-reversal-buffer	The risk of reversal buffer applies to all sequestration projects and reduces the carbon abatement issued during a reporting period by a given amount. It is important to note that, "*the risk of reversal buffer does not insure participants against loss of income from the sale of Australian carbon credit units following fire or other natural disturbance or for the costs of re-establishing carbon stores. The risk of reversal buffer may be adjusted over time in the legislative rules*." https://www.cleanenergyregulator.gov.au/ERF/Choosing-a-project-type/Opportunities-for-the-land-sector/Risk-of-reversal-buffer
Brokerage fees	Costs to brokers for the management of environmental credit schemes.	20-30% (at 5% increments)	Sources for information about this are not readily available, but estimates of 20-30% are given in some places. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwjWnb3Ft42DAxUcT2wGHVBtDV4QFnoECAgQAQ&url=https%3A%2F%2Fwww.westpaciq.com.au%2Fthought-leadership%2F2022%2F08%2Fcheat-sheet-carbon-trading-in-australia-and-beyond&usg=AOvVaw1y98yHgq45vtzdl__IWmg9&opi=89978449	"*They usually charge a commission* **between 20–30 per cent**, *which is quite high. But it's pretty tough and bureaucratic if you're a farmer and you're trying ...*" westpaciq.com.au https://www.westpaciq.com.au › 2022/08 › cheat-sheet...
Cropping gross margins	Assessed for three crops (Wheat, Sorghum and Cotton). Assessment is based on rainfed crops only and only in the areas identified as climatically marginal (i.e. Central Highlands, Maranoa and Balonne). Taking the lowest and highest gross margins from past (2016-2021)	Values range from -796 AUD/ha to 1535 AUD/ha depending on the crop.	Queensland Government Agricultural Gross Margin Calculator https://agmargins.net.au	-

Results – when is it worth switching?

The potential value of environmental credit schemes is radically different depending on whether a low or high gross margin year are considered (Figure 9). For all crops and regions assessed under a high gross margin year there is a large negative value (approx.–300 to –1500 AUD/ha) of switching from cropping to environmental credits (Figure 9). This is particularly the case for cotton in the central highlands, which is highly profitable in good, high gross margin years. In contrast, in low gross margin years environmental credit schemes start showing some potential for some crops and in some regions (Figure 9). It is most beneficial to switch from cotton in low gross margin years – it is important to note this is because of the high input costs associated with cotton.

Across all regions there is also an indication that in low margin years switching from wheat may at times be beneficial. However, as the boxplots overlap with the red solid line (which indicates the transition point to environmental credit schemes being beneficial) this suggest the outcome is sensitive to the values used in the scenario (Table 1). So, scenarios where environmental credit scheme payments are higher and costs lower are likely to be beneficial, while lower payment and high costs schemes are likely not. This is an important result and highlights that the potential value of environmental credit schemes will be highly payment and cost dependent across marginal wheat growing areas.

Sorghum, unlike cotton and wheat, only showed some potential value of switching in the Balonne. In the central highlands, sorghum was still beneficial even under the low gross margin scenarios assessed. This suggests that in the marginal cotton and wheat areas of the central highlands and Maranoa farmers may be better off switching to sorghum rather than to environmental credit schemes. This requires further investigation.

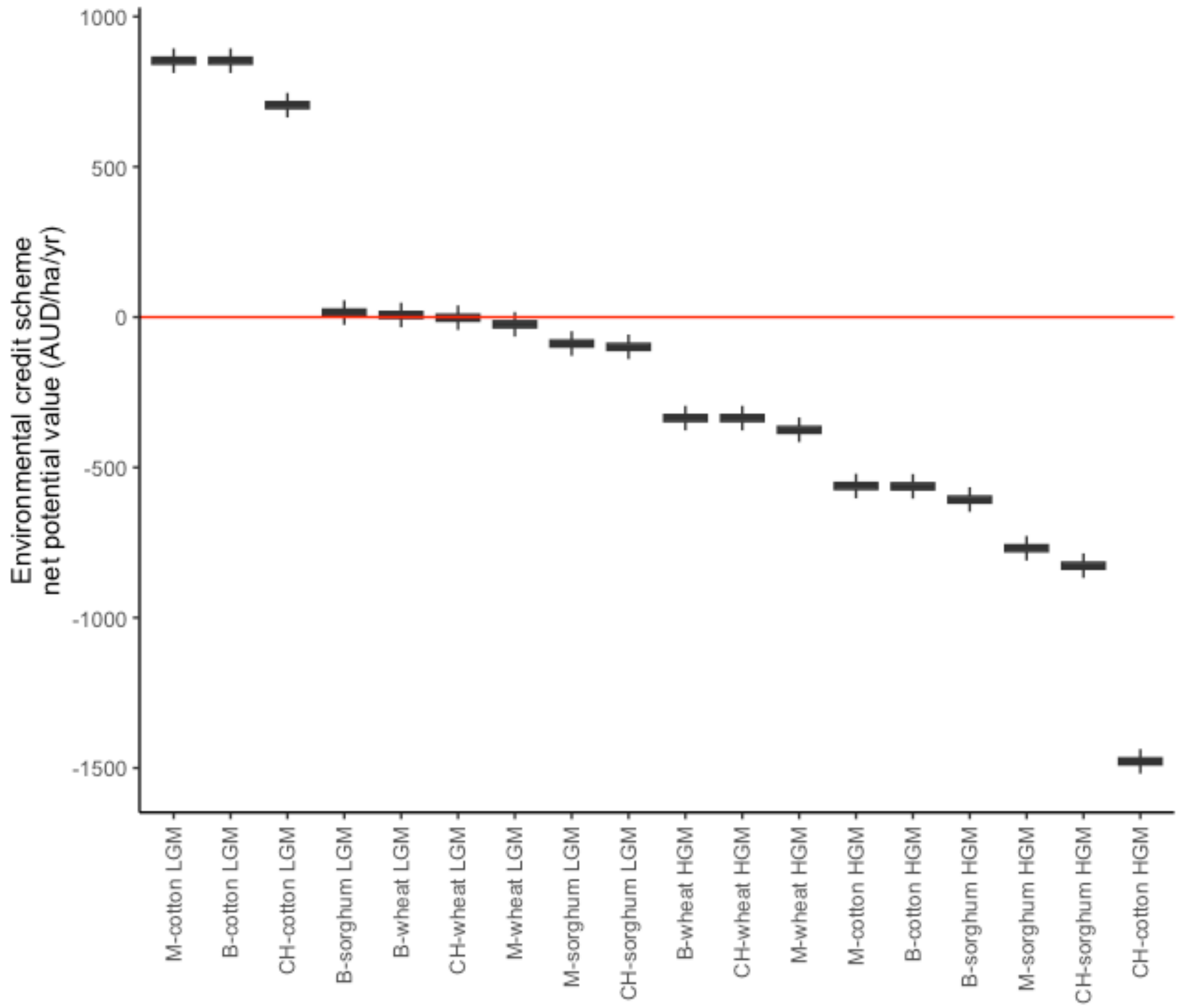

Figure 9. Scenarios showing the range of potential values of switching to environmental credit schemes across a range of crops under low and high gross margin scenarios across potentially climatically marginal cropping zones of Queensland (see Figure 1 and 2 for climatically marginal zone mapping). LGM=low gross margin scenario; HGM = high gross margin scenario. B=Balonne; CH=central highlands; M=Maranoa. The solid red line represents the break point between switching to environmental credit. Results are shown as boxplots the distribution (center horizontal line is the median, lower and upper sections are 25th and 75th percentiles, respectively, whiskers show the full range of the data, except for outliers

When should farmers start considering environmental credit scheme options?

Our scenario analysis suggests that when average cropping gross margins fall below 57 AUD/ha/yr farmers could start considering environmental credit schemes. This average value is however based on the range of values used in scenario analysis (Table 1). Under scenarios where payments from schemes are higher (e.g. up to $100 and the costs of establishment, brokerage fees are lower than this transition point could be higher.

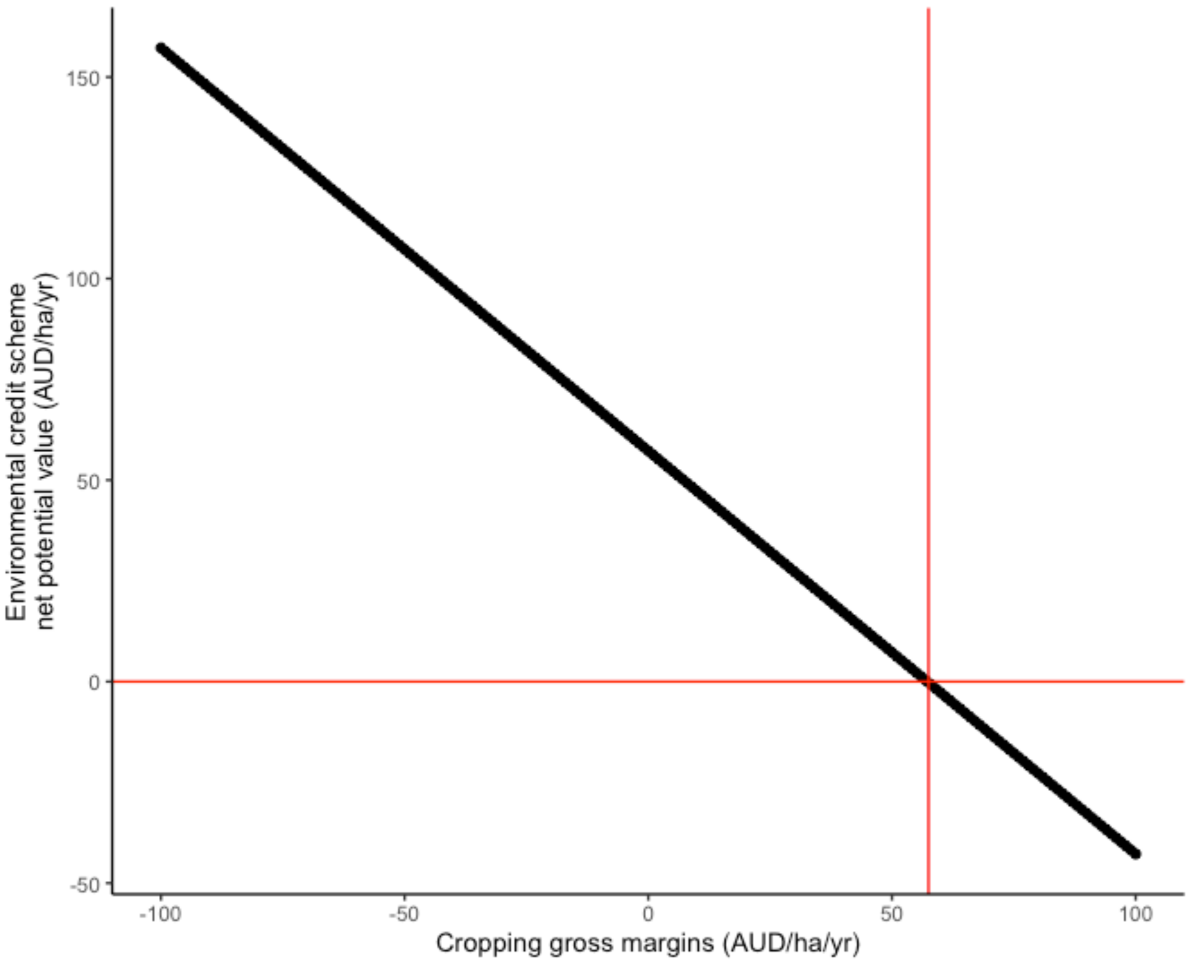

Figure 10. The average estimated transition point between agricultural gross margins and potential environmental credit schemes (based on the assumptions as outlined in Table 1). On average at cropping gross margins of below 57 AUD/ha/yr is the point at when environmental credit schemes start having greater potential benefit.

Results - Are environmental credit schemes worth it over the long term?

Over a hypothetical 25-year contract period if we assess the relationship between gross margins when a mix of good and bad years are considered if on average 7 or more years of out 10 are low gross margin years (and assumed the remaining are high gross margin years) then environmental credit schemes start showing potential value (Figure 11). If instead of high gross margin years, we assume 'average' years (here 50% of a high gross margin year), then with 5 or more low gross margin years environmental credit schemes start showing potential value (Figure 12). It is important to note the wide range of values here. The type of crop, and costs and benefits of the schemes create a wide range of variation in values.

When we break down the analysis into the different assessed regions and crops, we see important differences between crops and regions (Figure 13 and 14). In the Balonne and Maranoa, switching from cotton to environmental credit schemes begins to show value if 30-50% or more of years are low gross margin (Figure 13 and 14). In the Central Highlands switching from cotton to environmental credit schemes begins to show value if 60-80% or more of years are low gross margin (Figure 13 and 14).However, switching from sorghum or wheat is far less likely to be of value, only when 90% or more of years are low gross margin does it show a benefit in the Balonne In the Maranoa and Central Highlands all scenarios for wheat and sorghum show no, or little, value in switching (Figure 13 and 14).

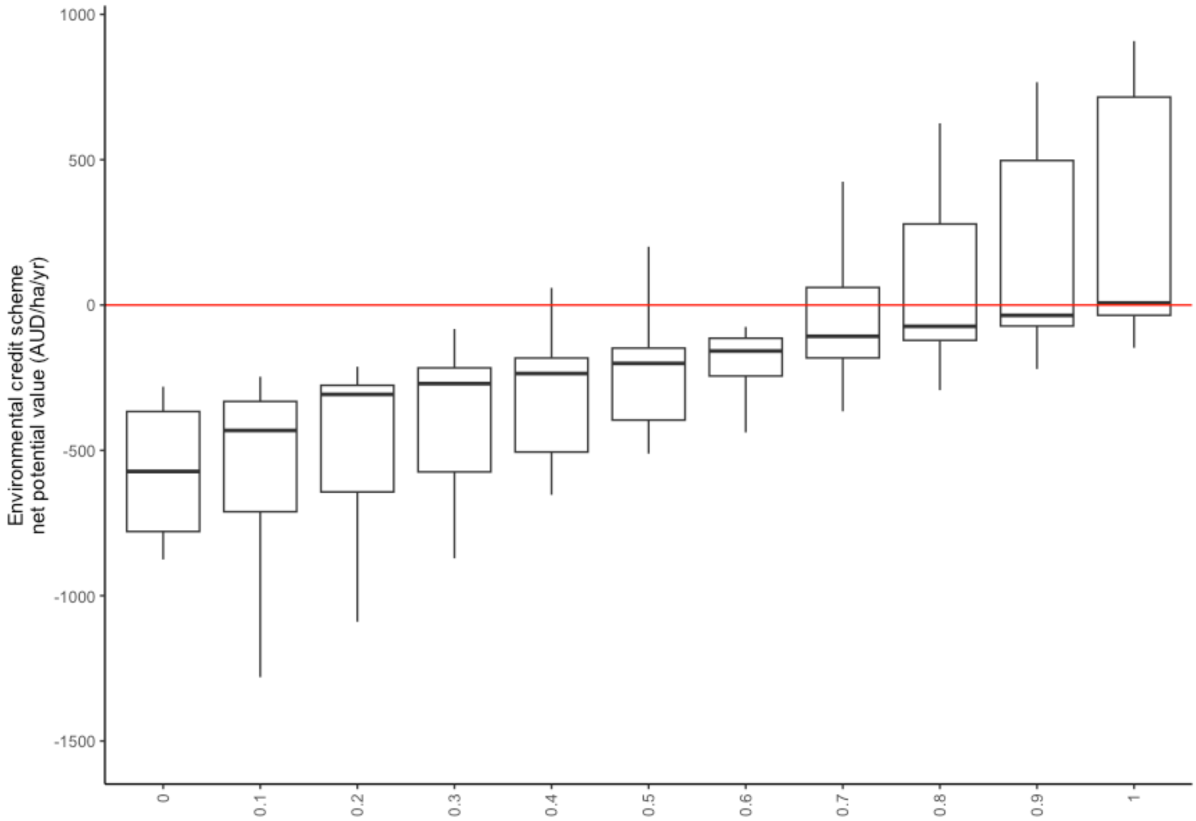

Figure 11. Relationship between the proportion of LGM years (relative to HGM years) (on the x-axis) over a hypothetical 25-year contract period to the estimated potential value of environmental credit scheme values. Results are the combined average across all regions and crops. Results are shown as boxplots the distribution (center horizontal line is the median, lower and upper sections are 25th and 75th percentiles, respectively, whiskers show the full range of the data, except for outliers. LGM = low gross margin and HGM = high gross margin.

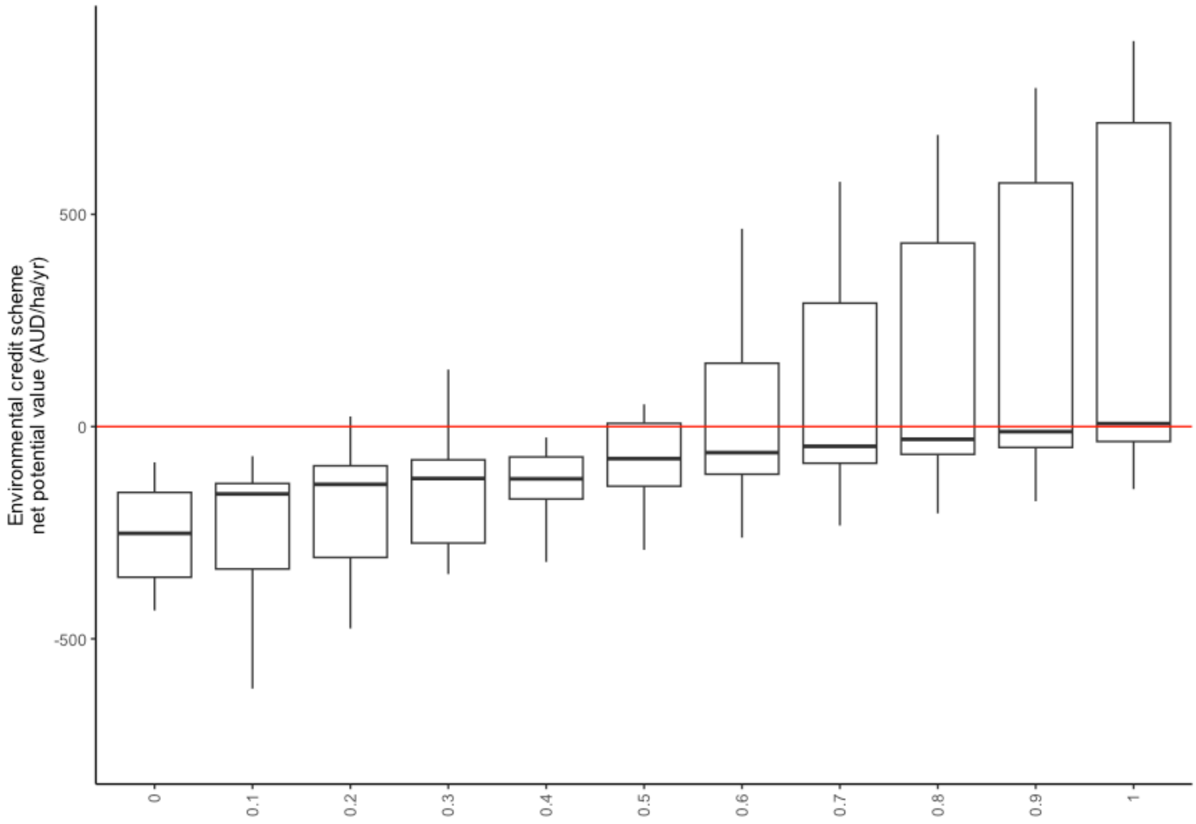

Figure 12. Relationship between the proportion of LGM years (relative to 50% of a HGM year) (on the x-axis) over a hypothetical 25-year contract period to the estimated potential value of environmental credit scheme values. Results are the combined average across all regions and crops. Results are shown as boxplots the distribution (center horizontal line is the median, lower and upper sections are 25th and 75th percentiles, respectively, whiskers show the full range of the data, except for outliers. LGM = low gross margin and HGM = high gross margin.

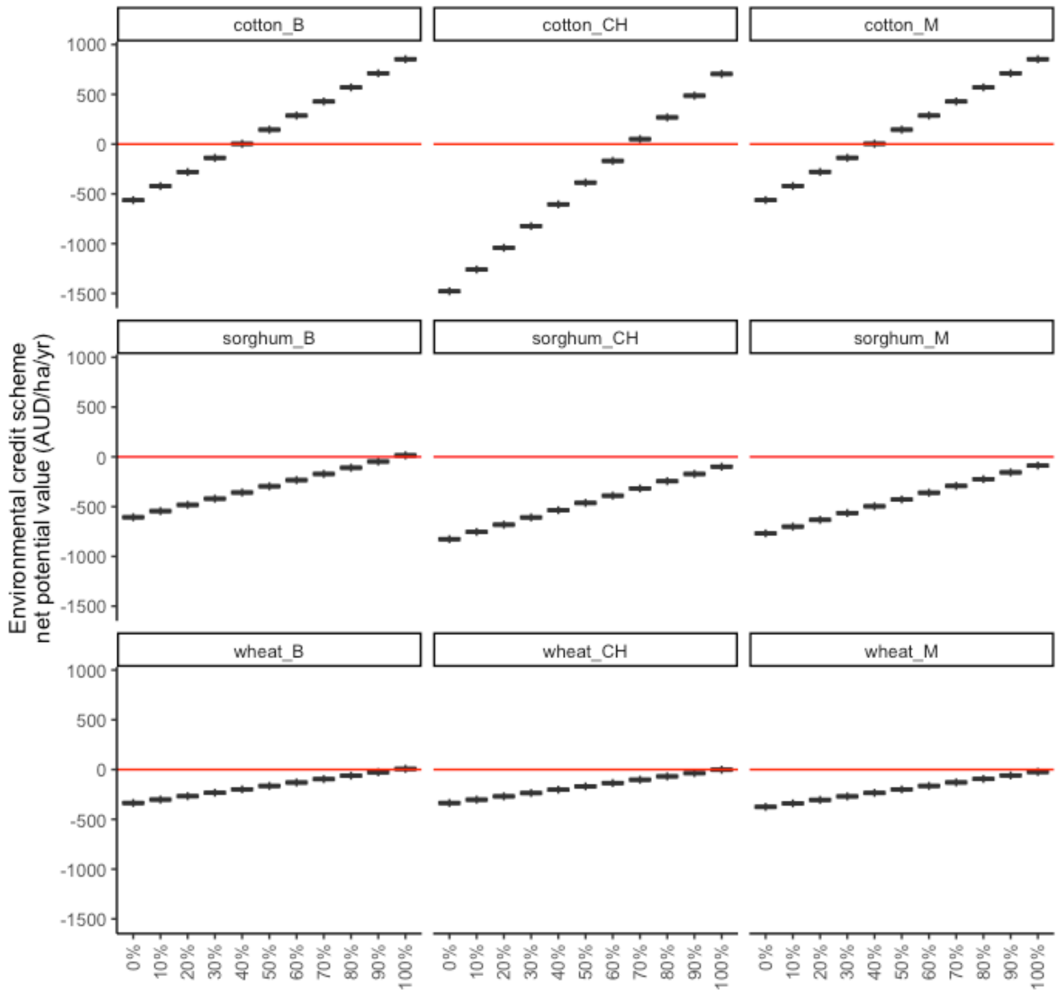

Figure 12. Relationship between the proportion of LGM years (relative to HGM years) over a hypothetical 25-year contract period to the estimated potential value of environmental credit scheme values. Results are shown for each region (B = Balonne, CH = Central Highlands, M = Maranoa) and crop separately. Results are shown as boxplots the distribution (center horizontal line is the median, lower and upper sections are 25th and 75th percentiles, respectively, whiskers show the full range of the data, except for outliers. LGM = low gross margin and HGM = high gross margin.

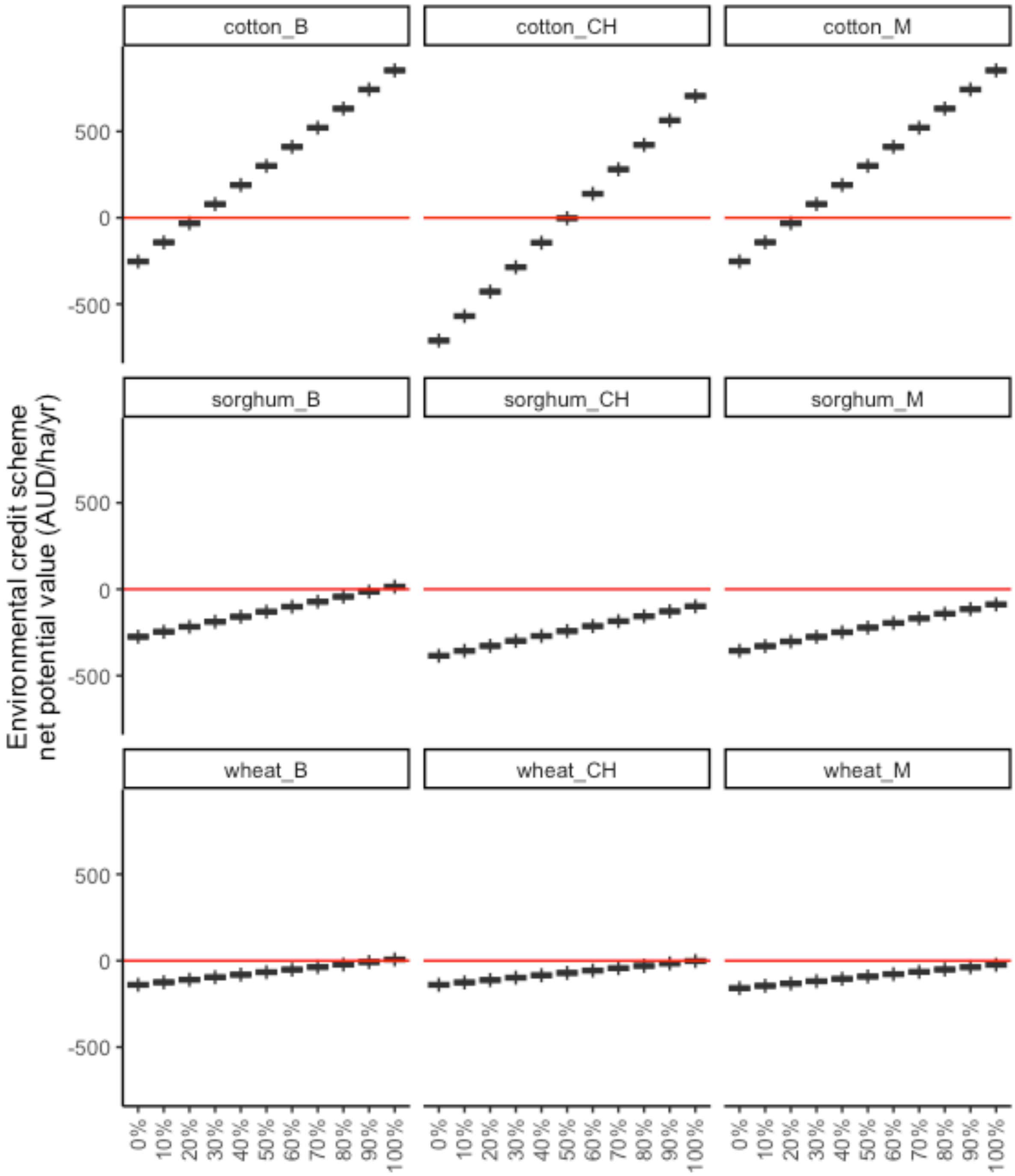

Figure 14. Relationship between the percentage of LGM years over a hypothetical 25-year contract period to the estimated potential value of environmental credit scheme values. Results are shown for each region (B = Balonne, CH = Central Highlands, M = Maranoa) and crop separately. Results are shown as boxplots the distribution (center horizontal line is the median, lower and upper sections are 25th and 75th percentiles, respectively, whiskers show the full range of the data, except for outliers

Next steps

- Quantify the benefits of revegetation, soil carbon and biodiversity for remaining productive land. This information will help complement the scenario analysis we run here and when will allow farmers to make an informed decision about the potential value of switching some marginal land to environmental credit schemes.
- Identify actions that could use a portion of generation income to re-invest in risk management / adaptation options that increase farm drought risk mitigation and adaptation capacity.

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Appendix

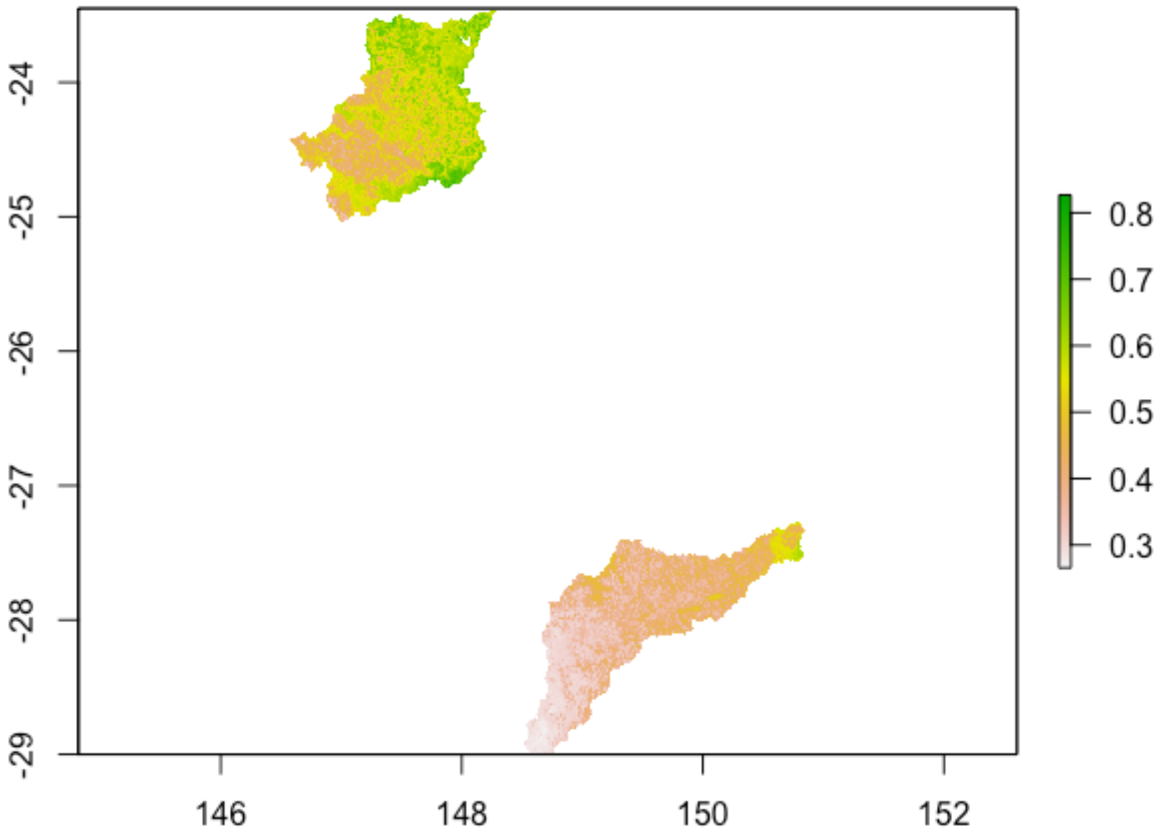

Figure S1. Carbon sequestration values (Mg C/ha/yr) for the marginal climatic cropping at that were assessed. Carbon sequestration values are taken from Cook-Patton et al. 2020. Values are based on predicted aboveground carbon accumulation rates (Mg C/ha/yr) in naturally regrowing forest and savanna biomes across Queensland.

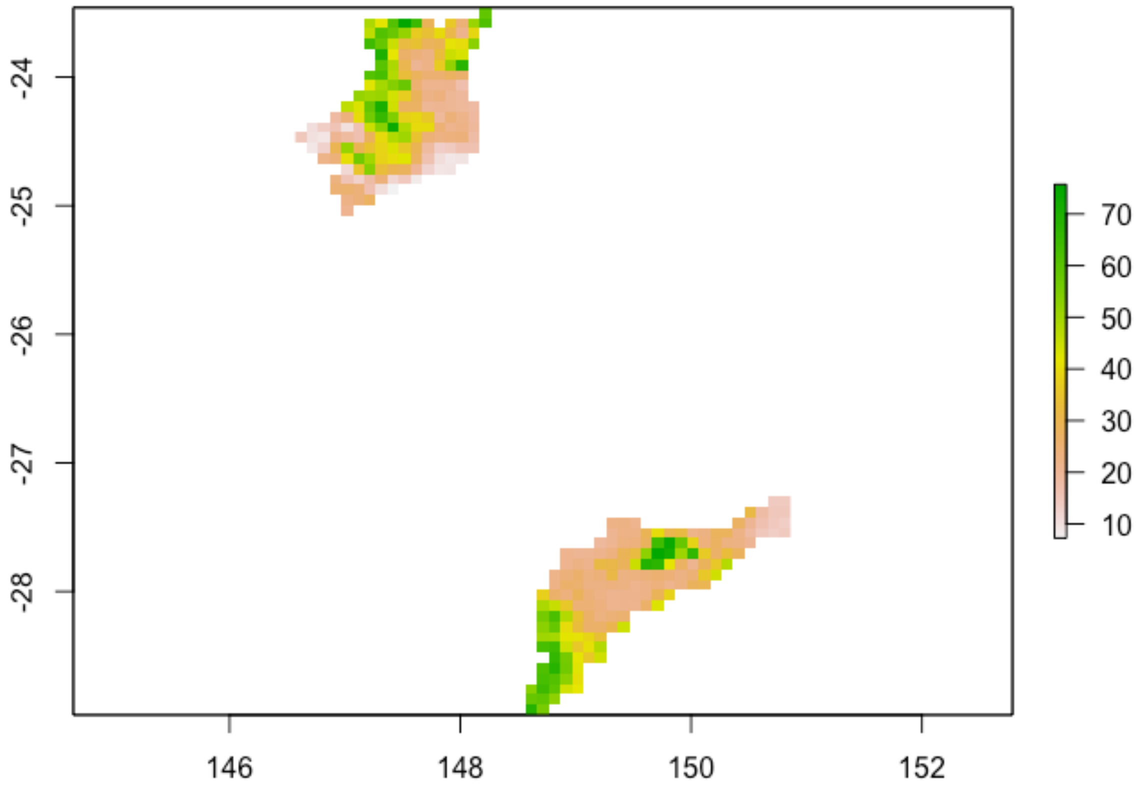

Figure S2. Ranked biodiversity importance from [Jung et al. 2020](#) for the marginal climatic cropping at that were assessed which was used as a proxy for biodiversity credit value calculations throughout the report.