Drought and climate adaptation program

DCAP3

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

MILESTONE REPORT 4

Assessing the potential ecosystem service effects of natural capital schemes for agriculture

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Summary

Assessing the value of environmental credit schemes for the agricultural community poses significant challenges due to uncertainties surrounding prices, regulations, and availability of natural capital.

Externalities of natural capital schemes, whether positive, neutral, or negative, on farm productivity further complicate this assessment. Positive externalities, termed ecosystem services, encompass benefits such as windbreaks, soil moisture conservation, and natural pest control, which can enhance agricultural productivity and farmer income. Conversely, negative impacts on productivity may arise from changes in nutrient, water, and light availability that are important for agricultural productivity from the establishment of natural capital schemes.

To evaluate the potential impact of natural capital on farm productivity, 82 studies were reviewed, focusing on various management actions across different crop types and production systems. While most studies demonstrated positive effects, the impact varied depending on factors such as crop type and the type of ecosystem service benefit.

Scenario analyses were conducted to estimate the potential value of environmental credit schemes, incorporating factors like carbon sequestration potential, carbon prices, biodiversity credit values, and establishment costs. Over one million scenarios were run, revealing varying outcomes depending on crop type, region, and gross margin fluctuations. Despite uncertainties, environmental credit schemes showed potential value under certain conditions, particularly in low gross margin years.

Incorporating externalities from ecosystem services further expanded the range of potential values, influencing the feasibility of transitioning to environmental credit schemes. Scenarios indicated that when considering negative ecosystem service impacts on production, farmers might only consider switching to such schemes if production values fall significantly (i.e. to below AUD 13 ha/yr). Conversely, under scenarios with strong positive externalities, transition points for considering natural capital schemes were higher (i.e. over AUD 101 ha/yr).

Assumptions were made in the analysis, including uniform effects across all productive land, which may not reflect reality. Effects of environmental planting could vary based on factors like farm scale and crop mix. Nonetheless, the scenarios provide a starting point for farmers and policymakers to evaluate the value, positive or negative, of natural capital schemes.

In conclusion, while uncertainties abound, environmental credit schemes hold promise for enhancing agricultural sustainability and farmer income. However, careful consideration of externalities and scenario analysis is crucial for informed decision-making regarding the adoption of such schemes.

Background – why do ecosystem services need to be considered when assessing the value of environmental credit schemes for farmers

The objective assessment of the value of environmental credit schemes for the agricultural community is a significant challenge. There is currently great uncertainty about the prices, regulation and availability of natural capital. Prices for natural capital schemes per hectare range widely, from well below AUD100 ha/yr to well over several thousand dollars ha/yr in some recent Queensland government land restoration funding (for further details, see DCAP Milestone report 2b). Further complicating the assessment of natural capital schemes are the potential effects (or 'externalities') of such schemes to farm productivity and activities outside of the physical area where an environmental planting or associated credit scheme may be established. The externalities of a natural capital scheme to a farmer's enterprise (and possibly surrounding farmers in the region) may be positive, neutral or negative.

The potential positive externalities of natural capital are often referred to as ecosystem services. Ecosystem services "*are the benefits provided to humans through the transformations of resources (or environmental assets, including land, water, vegetation and atmosphere) into a flow of essential goods and services, e.g., clean air, water, and food*" (Constanza et al. 1997). In production systems, this could include the benefits that shelter belt vegetation provides as windbreaks or through shading that may help conserve soil moisture (Oliver et al. 2005; Cleugh et al. 2020). Native vegetation can also provide important ecosystem services by hosting insects, which predate on pest insects in crops (Port Phillip and Western Port CMA. 2018). The establishment of natural capital schemes that provide ecosystem services could, therefore, have a benefit on agricultural productivity and, thus, farmer income.

Alongside possible positive ecosystem service externalities, the possibility of negative impacts on farm productivity and, thus, income also needs to be carefully considered. Agricultural productivity is tightly linked with nutrient, water and light availability. Any additional forest vegetation for natural capital schemes in the landscape has the potential to interfere with the availability of nutrients, water and light and, therefore, with productivity. This may be particularly true for the establishment of large forest areas linked to natural capital schemes. For example, forest areas are known to change the hydrological dynamics of large areas (Harper et al. 2019). The potential for negative externalities from natural capital schemes, while rarely measured, is an important factor in any farmer's consideration of exploring natural capital schemes.

In the following, we (1) assess the current state of knowledge about how management actions linked to natural capital may impact on farm productivity and (2) incorporate this into our framework for assessing the value of natural capital to farmer's income under a range of scenarios (see report DCAP Milestone report 3b3c for detail on the scenarios assessed).

Assessing actions associated with ecosystem service effects of natural capital schemes

We reviewed available information (in scientific articles and reports) on management actions linked to natural capital that may impact farm productivity. Management actions reviewed included the planting of shelter belts, the establishment of native vegetation and the maintenance of groundcover. We evaluated these activities across a range of crop types across cropping and pasture systems. In total, 82 studies were reviewed.

We focused on studies available from Australia, but where appropriate, also considered international information from various countries, including the USA, UK, China and Canada, amongst others. We classified the studies into different focuses based on crop type, production system (cropping vs. pasture), management action and ecosystem service benefit that was documented. Where possible, we recorded the effect on production (as a percentage impact). If a quantifiable benefit was not documented, we then provided a qualitative assessment (positive, negative or unknown) of the management action and associated natural capital impact.

It is important to note that this was not a systematic review of the literature. A range of search terms were used in several different databases. Our approach ensured a broad assessment of available current knowledge, which also includes unpublished scientific studies, was carried out. In our analysis, no assessment of the veracity of each of the 82 studies is made. However, the reader should be aware that because of the wide range of information sources considered there will be differences in the quality of information assessed. With these caveats in mind, for the 82 studies reviewed, we calculated the number of studies showing some potential effect of natural capital (positive, negative or unknown) and, where information was provided, the mean percentage effect on agricultural productivity.

Incorporating ecosystem service effects into assessing the income generation potential of switching to environmental credit schemes in Queensland's climatically marginal cropping areas

Taking the range of values of ecosystem services from the studies reviewed (as outlined in the above section), we ran scenarios on the potential benefit, or otherwise, of natural capital to farmer income. We incorporated five values as a percentage of a farmer's gross income (-20%, -10%, 0%, +10% and +20%). Using these values, 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,

$PEV = CSP*CPr - CSP*RkB - CSP*Bf + BV - Cst*CSP – AgGM + ES*|AgGM|$ (Eq.1).

Here, ES is the potential ecosystem service effect (here modelled as percentage effect on gross margins). Here, we assume the effect carried through from any change on production to the farmer's gross margins. As before, PEV (AUD/ha/yr) is the estimated potential environmental credit value, CSP is carbon sequestration potential (Mg C/ha/yr), CPr is the price for carbon, RkB is the risk reversal buffer, which applies to all carbon abatement projects, 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 (AUD/ha/yr), which takes into account possible density of plantings / tonnes of sequestration and AgGM (AUD/ha) is the gross margins for different cropping options (wheat, sorghum and cotton were assessed).

Table 1 (in DCAP Milestone report 3b3c) gives details of variable ranges used in the analysis. In total 1,049,760 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 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 consider 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 a scenario analysis that 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 5,890,320 scenarios were run for these analyses.

Finally, we also assessed how incorporating externalities from ecosystem services from natural capital may change the value below which average cropping gross margins fall before farmers consider natural capital schemes. Our previous value, which did not consider ecosystem service externalities, estimated this value at 57 AUD/ha/yr across the crops, regions and scenarios we analysed.

The potential ecosystem service benefits of environmental credit schemes for agriculture

Across the 82 (10 on artificial shelters) studies reviewed, all but one study showed that management actions related to environmental schemes were positive. The one study that suggested a negative ecosystem service effect on agriculture (Waterhouse et al. 2017) was carried out in cropping areas in the tropics and was focused on maintaining adequate ground cover, not on the establishment of trees (Figure 1). Most studies reviewed showed that the planting of shelter belts, as well as the maintenance or establishment of biodiverse vegetation, had a qualitatively positive effect on production. Although it should be noted that for many studies no effects (shown as unknown) were documented (Figure 1).

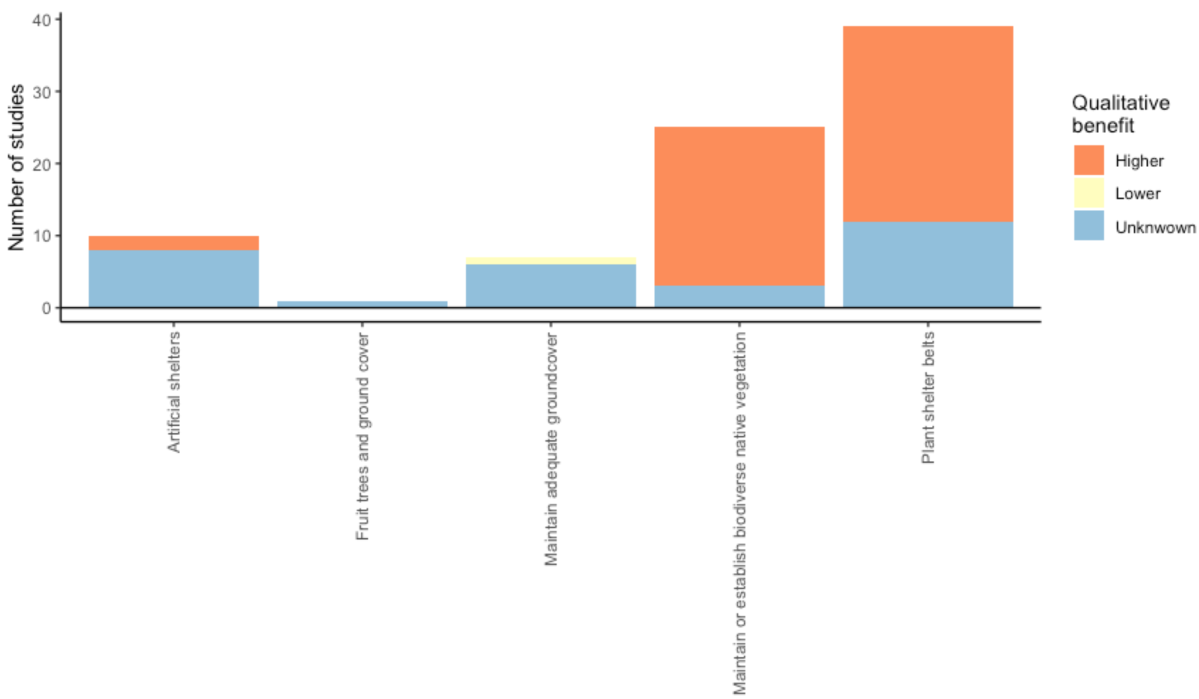

Figure 1. Number of studies across different management actions related to potential environmental credit schemes and whether they have shown a qualitative benefit to agricultural production (either higher, lower or unknown). Note: Artificial shelters are not related to revegetation or environmental credit schemes and are provided as a comparison management action.

Across studies that did quantify the effects of environmental management actions, the one study (Waterhouse et al. 2017), found a -10% impact on cropping. In contrast, studies on the planting of shelter belts showed on average a positive effect on agriculture of around 20% (Figure 2).

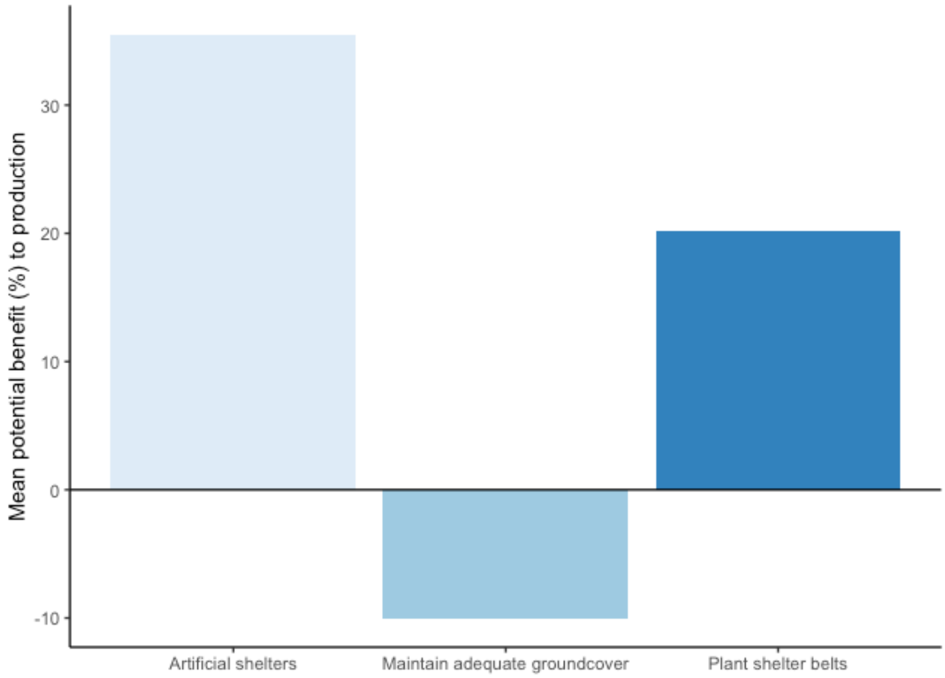

Figure 2. Mean percentage benefit to the agricultural productivity of revegetation or similar environmental management action related to a potential environmental credit scheme. The mean benefit is calculated across all agricultural systems and crop types for which data was available. See Appendix Table 1 for a full list of the studies assessed.

When looking at the range of ecosystem benefits (e.g., soil moisture conservation or the natural predation of pest insects in crops) that environmental plantings may provide these were again generally positive (i.e., resulted in higher agricultural productivity) (Figure 3). Across the benefits assessed, most studies were on natural predation of pest insects in crops (N=23) and on soil moisture benefits (N=40). There were fewer than 10 studies on other factors, such as the benefits of lowering saline water tables and shelter from winds (Figure 3).

Of the studies that quantified the effect of ecosystem service benefits (Figure 4), these showed benefits of up to 20% on average and negative effects of -10%. The conservation of soil moisture was the ecosystem service that had the largest average effect (20%), followed by a 10% positive effect by providing shelter from wind (Figure 4).

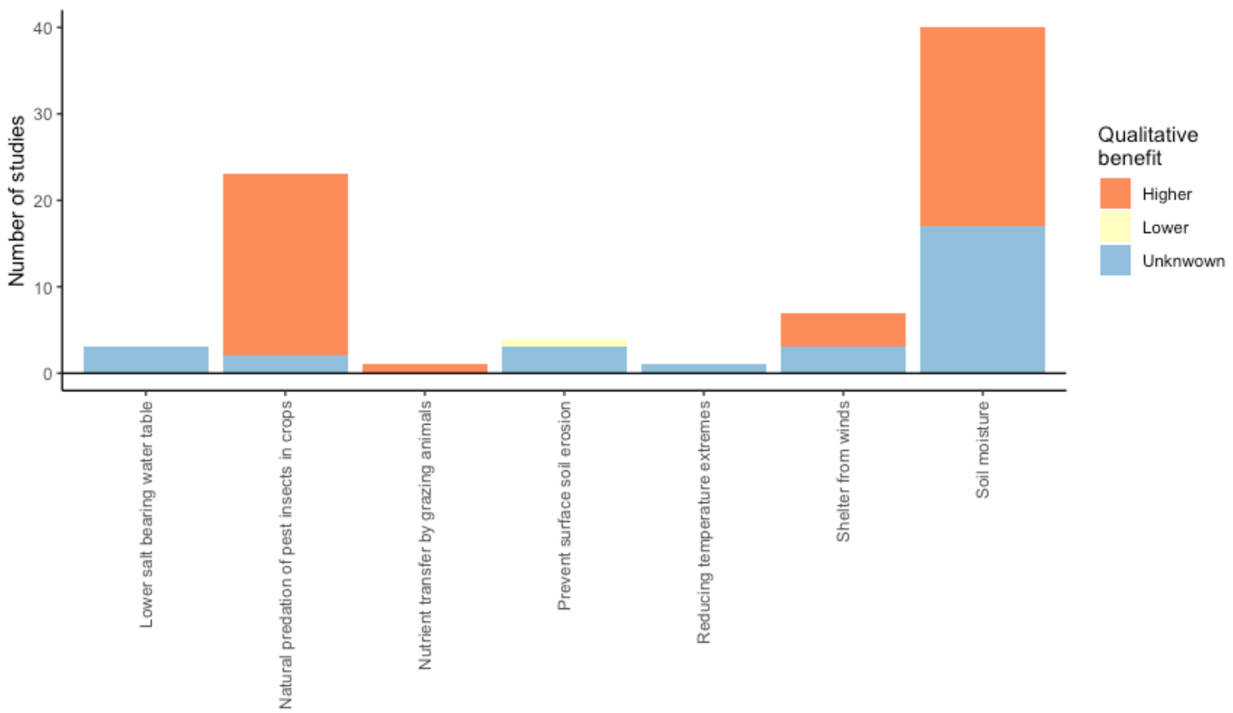

Figure 3. Number of studies across the different ecosystem service benefits related to revegetation associated with potential environmental credit schemes and whether they have shown a qualitative benefit to agricultural production (either higher, lower or unknown).

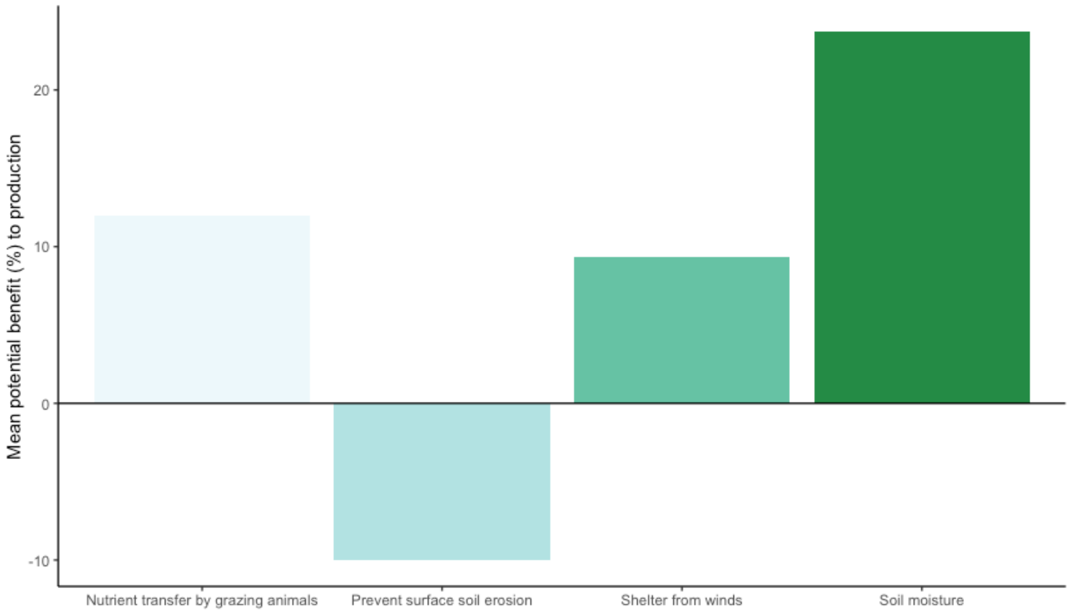

Figure 4. Mean percentage benefit to the agricultural productivity of different ecosystem services related to a potential environmental credit scheme. The mean benefit is calculated across all agricultural systems and crop types for which data was available. See Appendix Table 1 for a full list of the studies assessed.

When looking across different types of agricultural systems, most studies (N=39) were focussed on cropping (Figure 5). Of the studies in cropping systems one study reported a negative effect (Waterhouse et al. 2017), while the majority had positive effects (i.e., higher productivity). Studies in horticultural and pastoral systems were the next most commonly assessed (Figure 5). Notably, studies in mixed systems were infrequent (N=1) and the effects of ecosystem service benefits were unclear or not assessed.

Across cropping and pasture systems where the ecosystem service effects were quantified, results were similar, with an approximate average benefit of 20% to productivity (Figure 6).

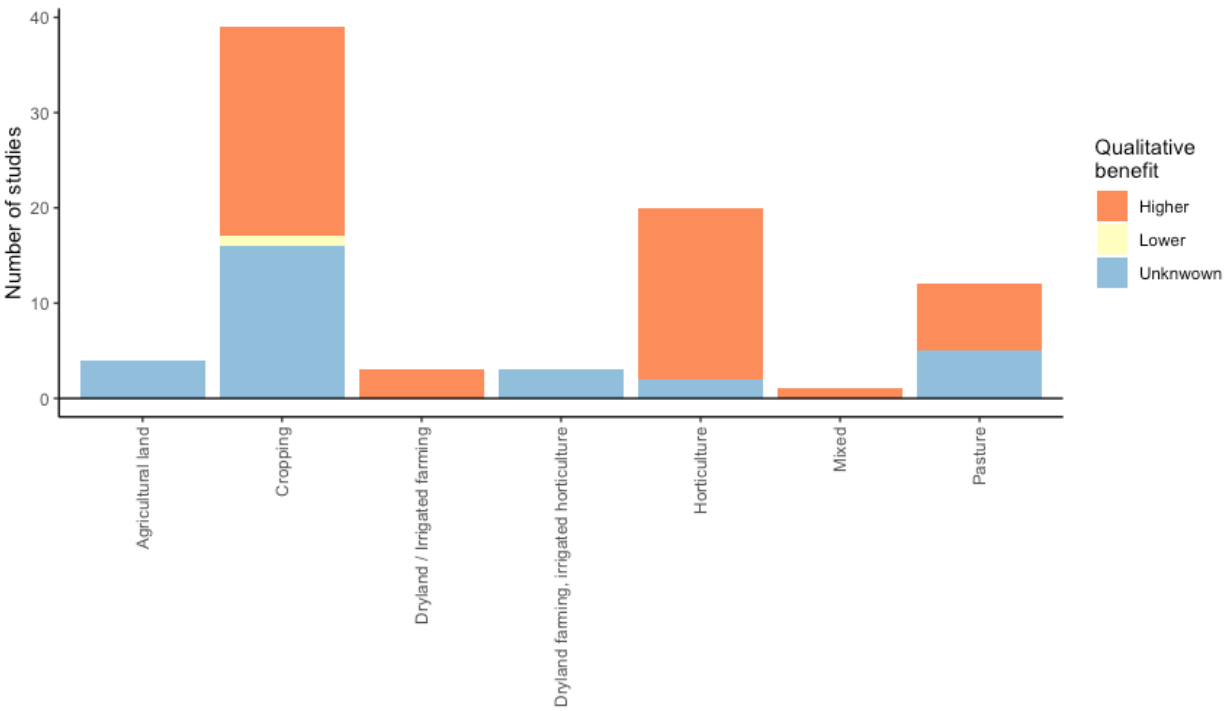

Figure 5. Number of studies across different agricultural systems that have assessed ecosystem service benefits related to revegetation associated with potential environmental credit schemes and whether they have shown a qualitative benefit to agricultural production (either higher, lower or unknown).

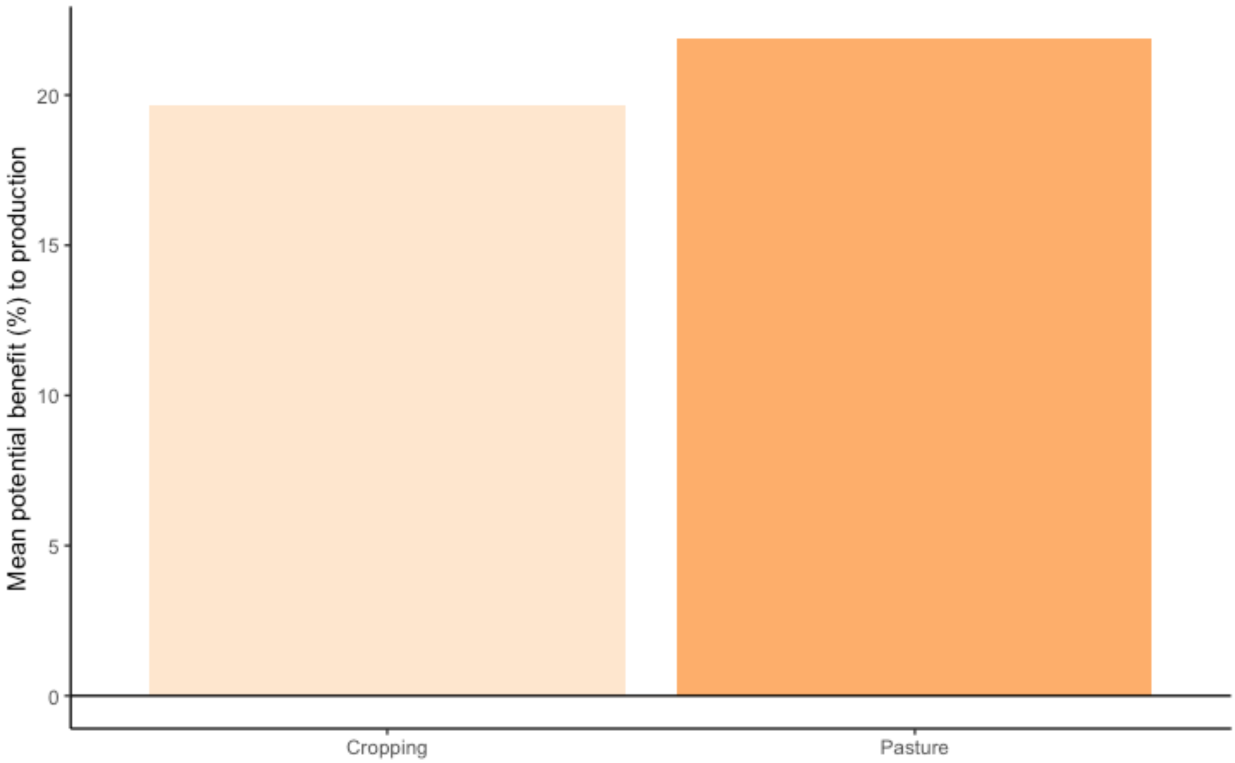

Figure 6. Mean percentage benefit to the agricultural productivity in cropping and pasture agricultural systems related to the potential environmental credit scheme. The mean benefit is calculated across all agricultural systems and crop types for which data was available. See Appendix Table 1 for a full list of the studies assessed.

More detailed breakdowns by crop type showed that most studies have been conducted in pastures, vineyards and wheat (Figure 7). Aside from studies on wheat, there was relatively little research on cropping systems. For barley, cereals, maize and other grains there was only one study and the ecosystem service benefit was not assessed. For crops where ecosystem service benefits were assessed and quantified canola, showed the largest average benefit (of around 40%) (Figure 8). For the other crops where information was available effects ranged from -10% (for an unspecified cropping system), to around positive 30% (e.g., for faba beans and lupin) (Figure 8).

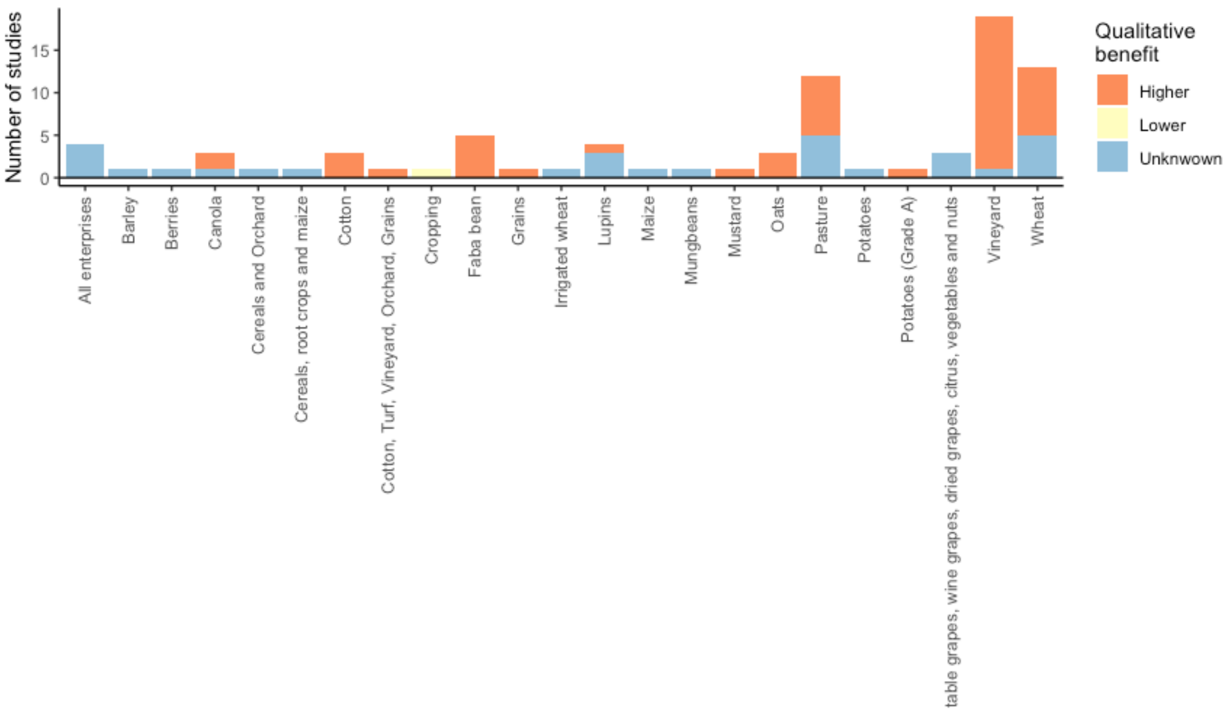

Figure 7. Number of studies across different crop types that have assessed ecosystem service benefits related to revegetation associated with potential environmental credit schemes and whether they have shown a qualitative benefit to agricultural production (either higher, lower or unknown).

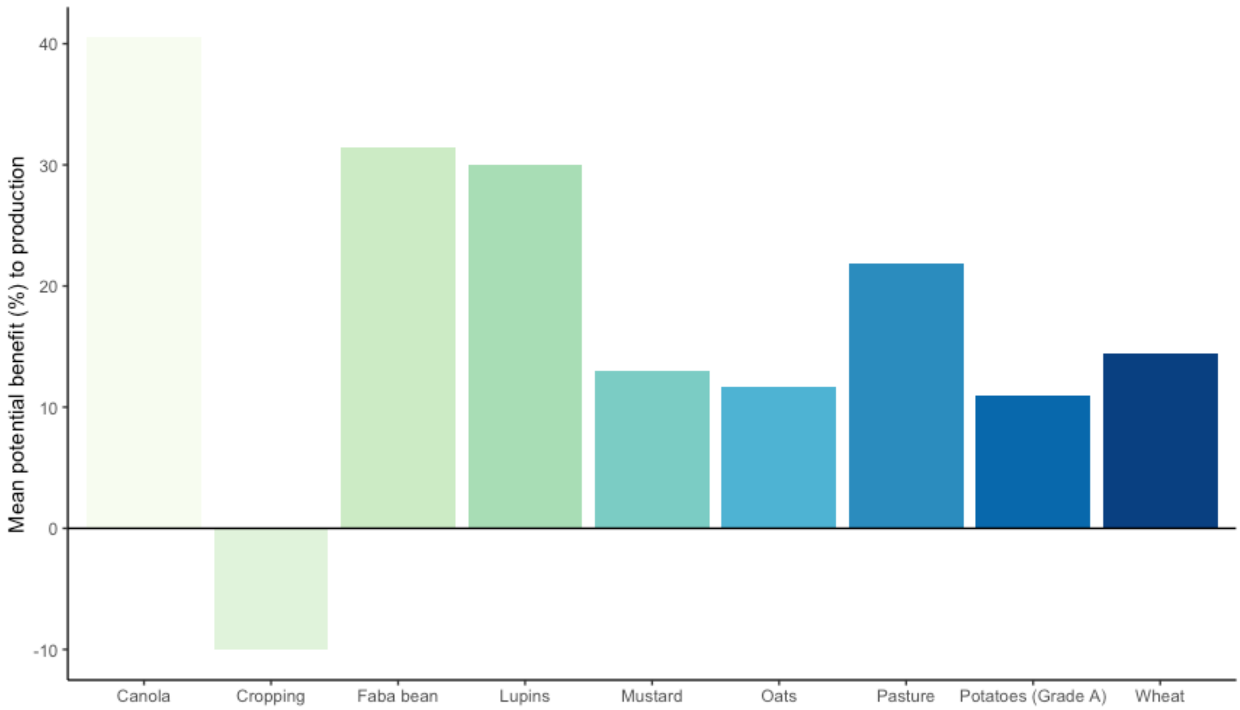

Figure 8. Mean percentage benefit to agricultural productivity across different crop types related to potential environmental credit scheme. The mean benefit is calculated across all agricultural systems and crop types for which data was available. See Annex Table 1 for a full list of the studies assessed.

Incorporating ecosystem service effects into farmer considerations of environmental credit scheme options

Incorporating ecosystem service benefits (here we assessed five options, -20%, -10%, 0, 10% and 20%) increased the uncertainty around the potential value of environmental credit schemes (Figure 9). In Figure 9, the grey areas show boxplots without ecosystem service benefit scenarios, while the black boxes incorporate ecosystem service scenarios. Still, regardless of this, as previously reported the potential value of natural capital 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 (approximately -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.

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 5-7 or more years of out 10 are low gross margin years (and assuming the remaining are average gross margin years) then environmental credit schemes start showing potential value (Figure 10). Importantly, the different ecosystem service scenarios assessed seem to have a relatively minor impact on the outcome. At most high ecosystem service value scenarios seem to increase the potential value most when a range of other factors are also favourable (e.g., carbon prices are high and low establishment costs are low etc.)

Figure 10). It is also 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.

More details of these results can be found in MS3b3c

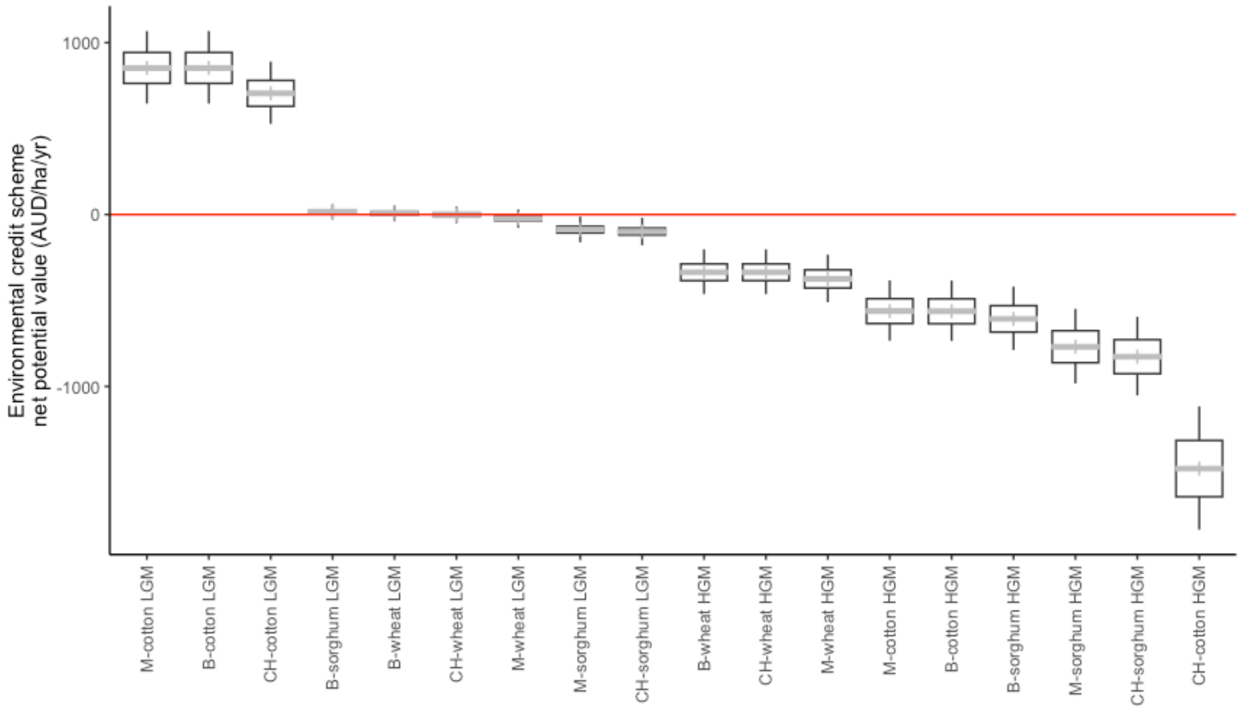

Figure 9. Scenarios showing the range of potential values of switching to environmental credit schemes across a range of crops under low and high gross margin scenarios across potentially climatically marginal cropping zones of Queensland (see Figure 1 and 2 for climatically marginal zone mapping). LGM=low 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. The grey boxplots are results without the five ecosystem service benefit (-20%,-10%,0%,10%,20%) scenarios that were tested.

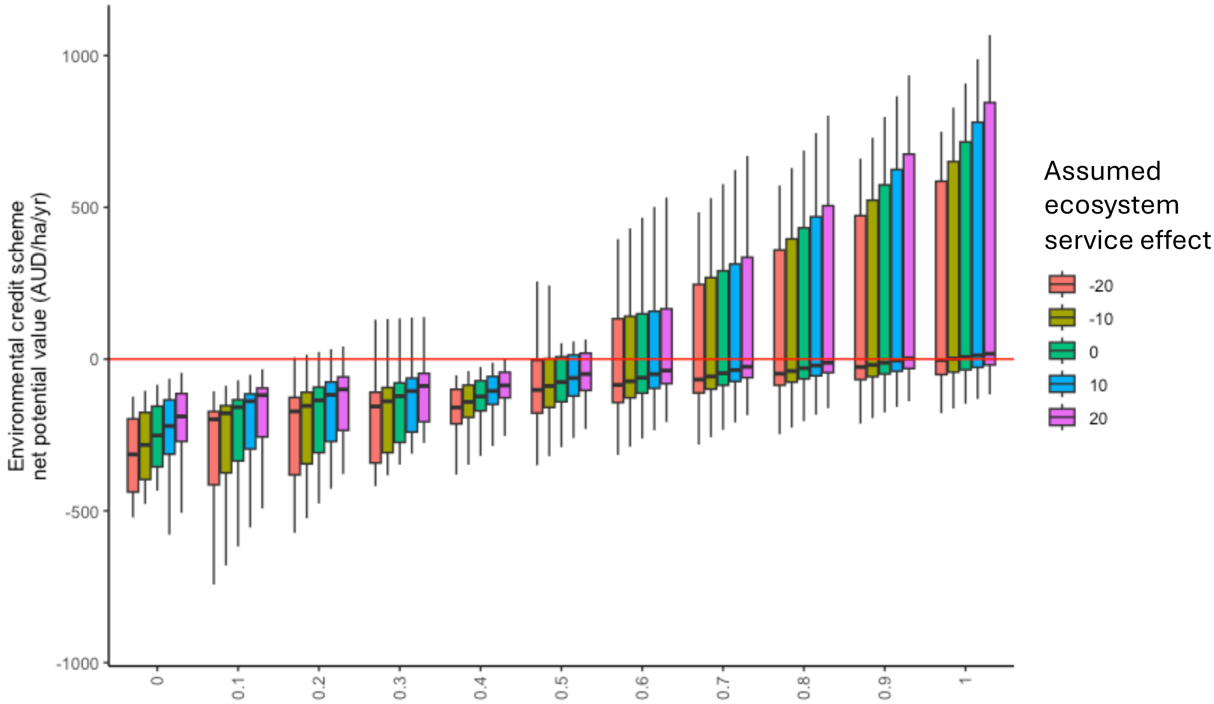

Figure 10. Relationship between the proportion of LGM years (relative to 50% of a HGM year) (on the x-axis) over a hypothetical 25-year contract period to the estimated potential value of environmental credit scheme values. Results are the combined average across all regions and crops. Results are shown 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. The different coloured boxed represent the five ecosystem service benefit (-20%,-10%,0%,10%,20%) scenarios that were tested.

Our scenario analysis, which excluded ecosystem service externalities from natural capital, suggested that when average cropping gross margins fall below 57 AUD/ha/yr farmers could start considering environmental credit schemes. However, when ecosystem service externalities are considered the range of values considered expands considerably. If a natural capital scheme were to have a negative impact on production, then a farmer would not consider switching unless production values fell to below 13 to -31 AUD/ha/yr (Figure 10). In contrast, under scenarios with strong positive externalities from natural capital, if production values begin to fall below 101 to 146 AUD/ha/yr, natural capital schemes may be worth considering (Figure 10).

It is important to note that these values are based on the range of values used in scenario analysis (DCAP Milestone report 3b3c, Table 1). Under scenarios where payments from schemes are higher (e.g., up to AUD100) and the costs of establishment, brokerage fees are lower than this transition point could be higher.

Further, we make several assumptions in this analysis, the most important being that effects are uniform across all of the farmer's remaining productive land. This is unlikely. The effect of environmental planting is likely to be more impactful for cropping immediately adjacent. The effects of natural capital schemes may also be variable across a farm, depending not only on scale, but also on the mix of crops and type of native vegetation that has been established. Still, nonetheless, our scenarios, while not accounting for this complexity, do provide a reasonable bound within which farmers and policymakers can start considering the value (positive or negative) of natural capital schemes.

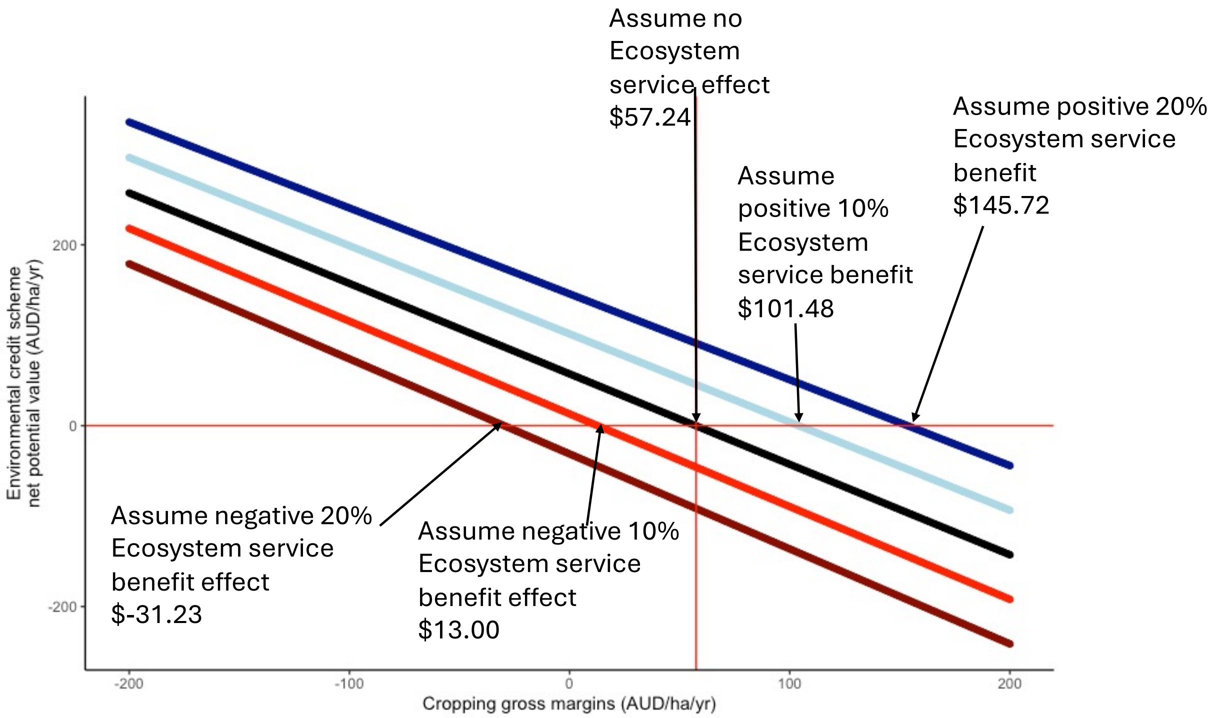

Figure 11. The average estimated transition point between agricultural gross margins and potential environmental credit schemes (based on the assumptions as outlined in Table 1, DCAP Milestone report 3b3c). On average at cropping gross margins of below 57 AUD/ha/yr is the point at when environmental credit schemes start having greater potential benefit. The different coloured lines represent the five ecosystem service benefit (-20%,-10%,0%,10%,20%) scenarios that were tested. The dollar values shown correspond to what average cropping gross margins should fall below before farmers could start considering environmental credit schemes.

Next steps

- 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.
- Carry out preliminary cost/benefit analysis mapping of the different option and how they related to climate risk

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