Department of Science, Information Technology and Innovation

Opportunities for greenhouse benefits from land use change in Queensland

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Prepared by

Don Butler and Jason Halford
Queensland Herbarium
Science Delivery Division
Department of Science, Information Technology and Innovation
PO Box 5078
Brisbane QLD 4001

Disclaimer

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Cover photo: Cleared brigalow country near Clermont, central Queensland. (D.Butler)

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Executive summary

Despite considerable reductions in deforestation since 1990, Queensland remains the hotspot for National emissions of greenhouse gases from land use and land-use change. This indicates an opportunity to change practices and secure benefits in terms of lower greenhouse gas emissions, reduced risk of species loss and landscape degradation associated with deforestation, and economic benefits to rural producers and their business partners.

This report details spatially explicit economic analyses of the potential for plantings, retention of native forest regrowth, and avoided deforestation to yield profits to landholders, as well as high level assessment of areas likely to support viable soil carbon and savanna burning projects.

The economic analysis of forest based activities reiterates the importance of project scale and long investment horizons to profitability. Large projects may yield net economic benefits within 25 years on cleared lands across most NRM regions in eastern Queensland even with carbon credit prices as low as $10 to $20 per tonne.

The high cost of establishing environmental plantings means that they require longer investment terms or carbon prices above $20 per tonne to achieve positive net present values compared to sequestration utilising native forest regrowth. At $20 per tonne, we identify potential for about 20 000 to 50 000 hectares to support plantings that could be profitable over a 25 year investment period, yielding 1.5 to 3.8 Mt CO_2-e of sequestration over ten years. Environmental plantings are most likely to be profitable in coastal and sub-coastal areas away from districts with high land prices associated with intensive agriculture or population centres in the south-east and the lowlands of the wet tropics.

Native forest regrowth projects benefit from methods that allow projects to register areas of young but established regrowth, so that the peak rate of sequestration is close to project establishment, reducing the investment period required to yield positive net present value. At $20 per tonne, we identify potential for about 190 000 to 6 890 000 hectares to support regrowth projects that could be profitable after 25 years, yielding 7.2 to 106.1 Mt CO_2-e of sequestration over ten years.

Avoided deforestation (AD) is currently not covered by a method suited to Queensland's vegetation management regime. This study compares profitability of a traditional AD scenario with a proposed AD scenario that may align with Queensland's regulatory structures, based on risk based additionality. Risk based additionality reduces the potential viable extent at $20 per tonne to about two thirds of that under the more traditional AD scenario. However, AD with risk based additionality is estimated to have potential for profitability over a 25 year investment period at $20 per tonne across 10 000 to 160 000 hectares, yielding 1.4 to 6.9 Mt CO_2-e over ten years. Risk based additionality also concentrates potential for profitable AD in land types and landscapes where potential co-benefits for biodiversity maintenance and landscape health are greatest.

Under the current measurement-based method for soil carbon, profitable projects are arguably most feasible in situations where current soil carbon stocks are far below their potential or are declining rapidly and decline can reliably be slowed by a change in management. Conversion of cropping land to pasture is the clearest evidence-based example of this scenario. We identify half a million hectares of cropping land that is not covered by the State's trigger map for Strategic Cropping Land, which is concentrated in semi-arid districts from Roma to west of Dirranbandi, as areas with the greatest potential for soil carbon sequestration projects in Queensland.

For savanna burning, fire frequency mapping is used to identify extensive areas in western Cape York and smaller areas in the western Gulf as having high potential for reductions in burnt extent and late dry season fires, and therefore as having the highest potential for savanna burning projects. Savanna burning has already seen significant uptake in these regions.

Uptake of carbon farming is currently lagging far behind potential for most land based emissions reduction fund methods, with the possible exception of savanna burning. However, even if a significant fraction of the potential identified in this study was realised it is unlikely that carbon projects would balance emissions from land clearing so that Queensland's landscapes could become a net greenhouse gas sink as is the case in other Australian states. Large permits for deforestation in northern regions targeted for agricultural intensification illustrate this point. Existing permits for clearing on two properties in north Queensland are estimated here to yield emissions from forest biomass alone of 9 Mt CO_2-e, which is roughly equivalent to the combined 10 year potential greenhouse gas benefits estimated here for both planting and avoided deforestation projects (optimistically assuming large project scales and a credit price of $20).

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Introduction

Reductions since 1990 in greenhouse gas emissions from land use change have been key to Australia meeting international commitments under the United Nations Framework Convention on Climate Change. In 2011-12 Australia reported 15 Mt CO_2-e net emissions from land use, land use change and forestry (LULUCF), down from 130 Mt in 1990 (Commonwealth of Australia 2014a). Most of this difference was due to slowing the rate of conversion of forest land into grassland or cropping land.

Queensland has been an integral part of this national story, with substantial reductions in deforestation since 1990. In 2011-12 Queensland's clearing rate had dropped to around 150 thousand hectares per year, compared to around half a million hectares per year in the 1990s. The proportion of clearing occurring in remnant native vegetation has also declined significantly, so that clearing is increasingly focused on regrowth forests of lower biomass.

Changes to land use in Queensland are nationally significant because Queensland consistently contributes disproportionately to Australia's national greenhouse gas emissions from LULUCF. In 1990, when clearing was affecting over half a million hectares per year, Queensland contributed 65% of national LULUCF emissions (Commonwealth of Australia 2014b). By 2011-12 the clearing rate had slowed significantly in Queensland, but had also dropped in all other States. In essence, Queensland has greatly reduced its LULUCF emissions, but nonetheless maintains its long dominance of national LULUCF. Queensland LULUCF contributed three percent of Australia's total greenhouse gas emissions in 2011-12.

Regulations restricting tree clearing were effective in reducing the deforestation rate across Australia, including Queensland. In principle, regulation could achieve further reductions. However, there are also options that could reduce land sector emissions and may yield direct economic benefit to rural producers. The question addressed in this report is "What activities are the best prospects for reducing greenhouse gas emissions from LULUCF in Queensland?"

Our focus is on extensive land uses, and particularly land use change, because they are likely to affect landscape processes and regional natural resource management planning, and because Queensland contributes disproportionately to land use emissions. Intensive agriculture, like other industrial activities, has several emerging opportunities to avoid or reduce emissions through changes to infrastructure. Prominent examples include capture and flaring of methane from effluent ponds, or the use of fertiliser containing nitrification inhibitors. However, they are outside the scope of this study.

Activities considered are:

1. Environmental plantings
2. Avoided deforestation
3. Forest regrowth, including avoided clearing of regrowth
4. Savanna burning
5. Soil carbon

These activities are all available in some form for participation in Australia's Emissions Reductions Fund. Between them, they account for just less than half of the Australian carbon credit units issued by the Commonwealth between 2011 and the time of writing in May 2015 (Table 1).

Table 1 A summary of the register of Emissions Reduction Fund projects from late May 2015. http://www.cleanenergyregulator.gov.au/ERF/Emissions-Reduction-Fund-project-register.

Activity	Projects registered	ACCU's issued
Landfill Gas	74	7 444 356
Avoided Deforestation	49	4 181 095
Savanna Burning	38	1 401 705
Plantings	46	678 004
Regrowth	27	555 548
Alternative Waste Treatment	12	442 737
Destruction of Methane in Piggeries	7	101 212
Soil Carbon in Grazing Systems	6	0
Other	6	0
Total	265	14 804 657

In the interests of brevity this report does not reprise the detailed policy and legislation of Australia's carbon markets. Information on the Emissions Reduction Fund is available here http://www.cleanenergyregulator.gov.au/ERF/About-the-Emissions-Reduction-Fund. Key points for understanding this document are:

1. ACCUs (carbon credits) are issued to registered projects.
2. Registering a project requires compliance with an approved method, which typically includes provision of technical information and documentation and restrict registered projects to those that represent additional greenhouse gas abatement (sequestration and/or avoided emissions), that wouldn't have happened without a crediting scheme.
3. Activities that take greenhouse gases from the atmosphere and sequester them in terrestrial pools, such as projects that increase carbon in forest biomass or soil, incur an obligation to maintain that pool for 100 years, or for 25 years if they accept 80% of the credits. This obligation is referred to as a permanence requirement.
4. Activities that avoid emission of greenhouse gases do not incur a maintenance obligation.
5. ACCUs are issued in response to project reports that may be submitted yearly or up to five yearly. Report submission involves audit costs, and reports typically require technical data processing and documentation.

Greenhouse gas abatement projects earn credits (ACCUs) for the difference between the greenhouse gas outcomes from the registered project and the relevant baseline. Baselines are essentially projections of greenhouse gas changes under business as usual scenario. For example, baselines for avoided deforestation projects reflect emissions from clearing that would have occurred but now won't occur because of the project.

The term 'forest' in carbon parlance has a very specific meaning, which is broader than its common usage. In carbon accounting a native forest needs crown cover of 20% or more of native trees more than 2m tall. Carbon stocks in live plants and debris in mature native forests in eastern Australia are typically around 200-700 t.CO_2-e/ha. So clearing one hectare of forest to derive permanent grassland for pasture would emit around 200-700 t.CO_2-e. This emission would occur over years to decades depending on how quickly residual woody debris from clearing decayed or burned. The CFI requires credits from avoided deforestation projects to be spread over 15 years, so an Avoided Deforestation project in eastern Australia might report abatement in the order of 13 to 47 t. CO_2-e per hectare per year, for fifteen years, and then be required to keep that forest for 100 years. Alternatively, to reduce the permanence obligation to 25 years, the project may claim ACCUs up to 80% of the carbon preserved, i.e.80% of 13 to 47 t. CO_2-e per hectare per year.

Determining whether 13 or 47 carbon credits per hectare per year is sufficient to warrant forgoing an opportunity to transform native forest (for example), requires consideration of numerous factors including:

- likely value of carbon credits
- likely value of opportunities and cost foregone by not clearing
    - opportunity for revenue forgone from ongoing use and not increasing pasture productivity
    - cost-saving from not clearing
    - cost-saving from not needing ongoing tree suppression
- discount rate for value of future income in today's dollars
- costs of project establishment
    - legal support
    - project registration requirements
    - technical support (surveys, maps, forest inventory)
    - any additional fencing, water infrastructure etc.
- running costs for project
    - additional fire management
    - additional weed management
    - monitoring
- reporting costs
    - data collection and processing
    - report writing
    - report audit requirements
- brokerage and accounting cost for credit disposal

Some of these factors are strongly dependent upon the methodology being applied, such as costs to establish, manage and report on the project. Others are highly specific to the landholder's business and values, particularly costs and benefits foregone, inherent value of project co-benefits such as biodiversity maintenance and salinity risk avoidance, and even the discount rate most appropriate for future income. Similarly, landholder values are pivotal to the impact of permanence requirements on willingness to participate. Perhaps most importantly the likely value of carbon credits is currently highly uncertain.

Polglase *et al.* (2013) analysed prospects for carbon forestry plantations and very clearly demonstrated the sensitivity of model results to variation within the plausible ranges of discount rates, carbon prices, establishment costs, and methods of forest carbon modelling. Their analysis considered a suite of scenarios, which were arguably all plausible, and suggested that the extent of cleared land where carbon plantations might be profitable in Australia ranged from zero to nearly 100 million hectares, depending on assumptions. Their modelling was spatially explicit, based on a 1km grid across Australia. The relative regional distribution of prospective areas was more stable across the various scenarios than the total extent that appeared potentially profitable. Eastern Australia contained several hotspots in many scenarios; particularly through the belt of subcoastal country from the Fitzroy Basin in the north and running south through the Dawson and upper Burnett, to the western slopes of the Great Dividing Range in northern NSW (Polglase *et al.* 2013).

Similarly, recent assessments of prospects for reforestation projects using regrowth or plantings in Queensland (Comerford *et al*. 2015; Evans *et al.*, 2015) and New South Wales and eastern Queensland (Butler *et al*. 2014) identified a concentration of land with relatively low carbon credit prices required to enable viable reforestation projects in eastern-central Queensland.

For this report we extend a methodology established by Evans *et al.* (2015) and Butler *et al*. (2014) to calculate costs and benefits, in terms of present-day dollar values, associated with carbon farming into the future. This quantitative method is applied to scenarios for environmental plantings, regrowth and avoided deforestation. A more qualitative approach is used to assess soil carbon and savanna burning because the relative costs and benefits are inherently more difficult to quantify for these activities. The main aim is to provide some guidance about the extent and location of land on which it may be economically positive to develop carbon farming projects under a range of prices for carbon credits, and how those variables depend on other economic factors such as management costs.

Brief description of assessment methods

For each of the five abatement activities we undertook an assessment of the extent of land likely to be suited to each activity, and the potential extent of greenhouse gas benefits (i.e. sequestration or avoided emissions) achievable without economic cost to landholders. Table 2 summarises key data sources used in the assessment.

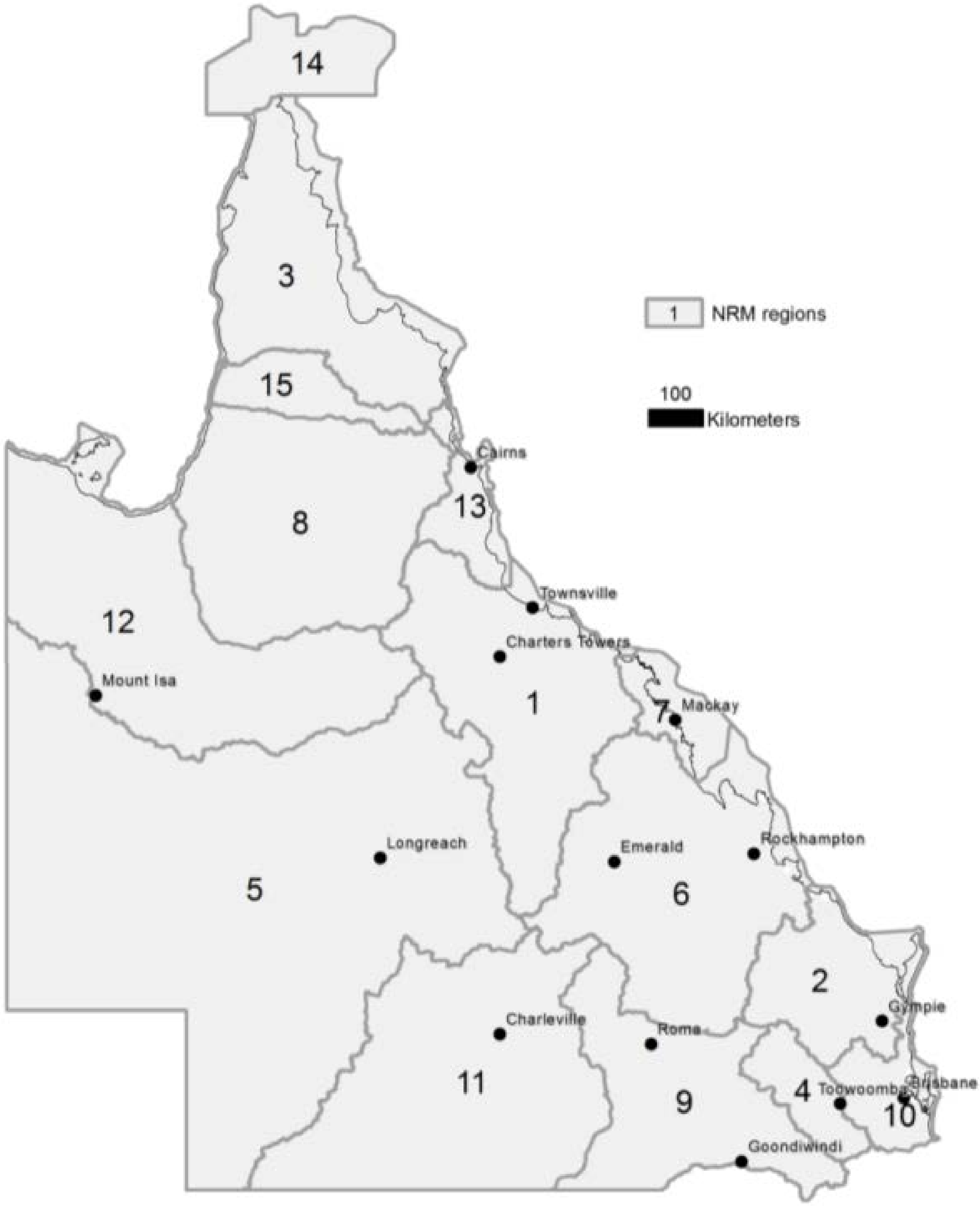
The forest based activities were subject to quantitative economic analysis, which follows method established by Evans *et al*. (2015) and also used by Butler *et al*. (2014). It involves calculation of net present value of economic value (benefit from ACCUs minus costs of project establishment, maintenance and opportunity cost from lost agricultural production with a 5% discount rate to calculate present value) for carbon farming projects represented by 42 scenarios. This approach enabled quantitative estimates of the ACCU price at which activities may become profitable in a given region, and the sensitivity of that price to factors such as project scale (small projects ~100ha or large projects ~1000 ha), choice of permanence period (i.e. 25 or 100 years) and assumptions in the modelling (variation or error in profit at full equity estimates). Appendix 1 provides further details on the method.

For soil carbon and savanna burning the assessment method is more qualitative and is described in the relevant sections.

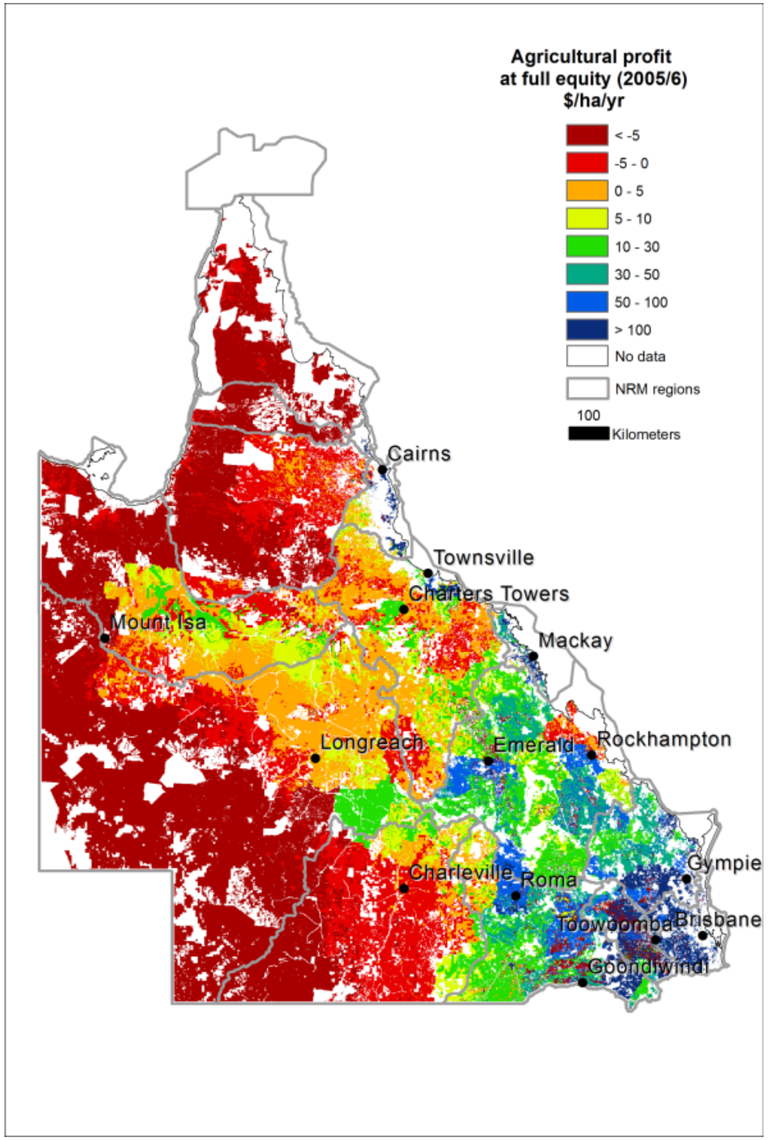
The main report primarily considers the State scale, giving an overview of geographic patterns and comparing scenarios. Larger scale maps and results for specific Natural Resource Management regions (Map 1) are provided in Appendix 2.

Table 2 Key data sources for identification of land suited to carbon farming using regrowth, environmental plantings, avoided deforestation, soil carbon and savanna burning.

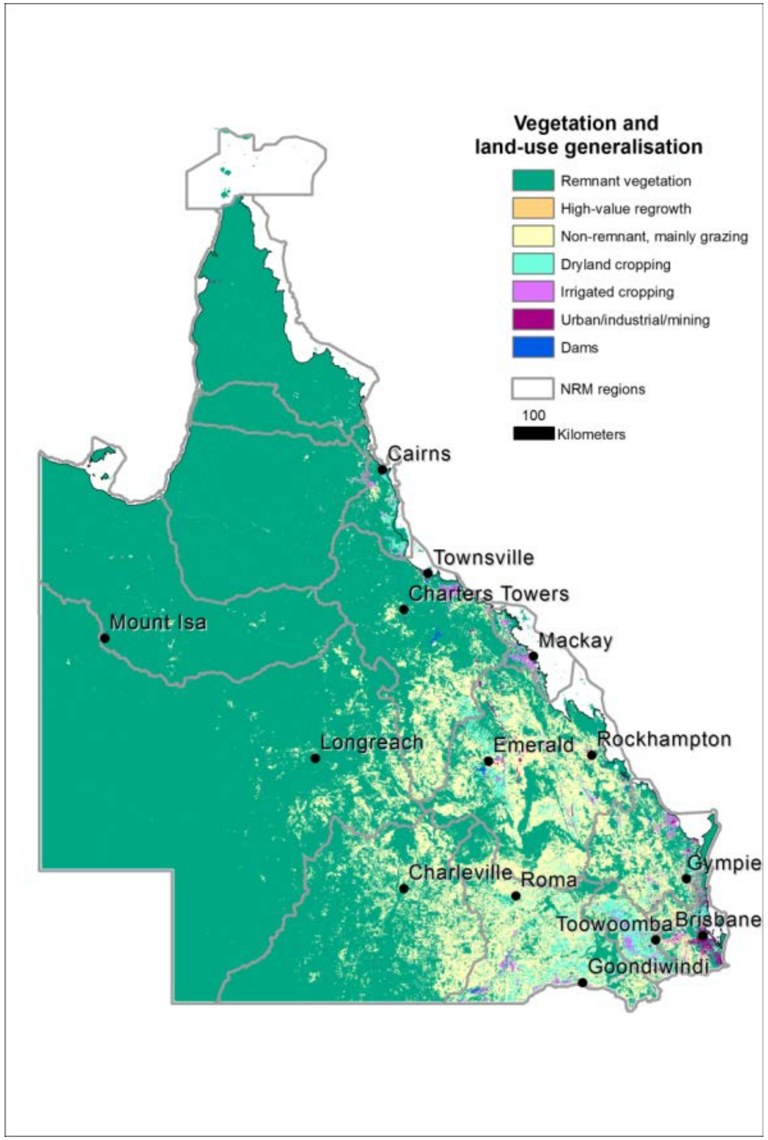
Attribute	Key Sources
Vegetation condition	Remnant Regional Ecosystem mapping (v9.0) (DSITI 2015), High-value regrowth (v2.1) (DNR 2012), Woody FPC data for 2011-12 from SLATS (DSITIA 2014)
Land-use	Queensland land use (QLUMP) 2009-12 (QLUMP 2014)
Rainfall	90m grid of annual mean rainfall from BOM
Vegetation type	Pre-clearing Regional Ecosystem mapping (v9.0), Dominant Broad Vegetation Group (1:5 Million scale classification)
Opportunity cost	Agricultural profit at full equity estimates for 2005-6 from Marinoni *et al*. (2012)
Carbon potential for forest based activities	Maximum biomass data from NCAS (Department of Climate Change and Energy Efficiency 2004)



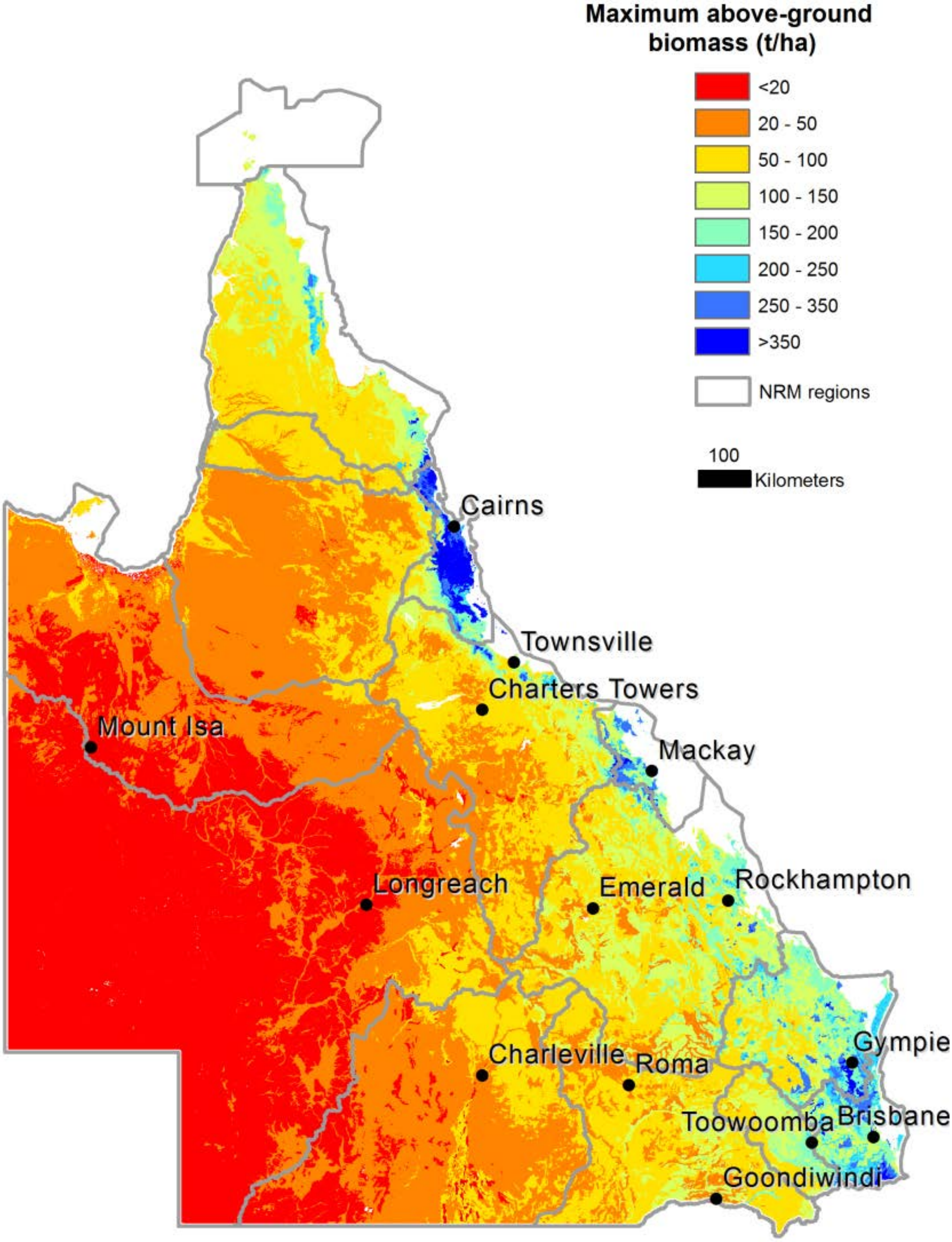
Map 1 NRM regions. These provide a regional scale spatial reference throughout this report. Maps and more detailed statistics for each region are provided in Appendix 2. The numbers correspond to each NRM region as follows: 1 Burdekin Dry Tropics NRM; 2 Burnett Mary Regional Group for NRM; 3 Cape York Development Association; 4 Condamine Alliance; 5 Desert Channels Queensland; 6 Fitzroy Basin Association; 7 Mackay Whitsunday NRM Group; 8 Northern Gulf Resource Management Group; 9 Queensland Murray-Darling Committee; 10 SEQ Catchments; 11 South West NRM; 12 Southern Gulf Catchments; 13 Terrain NRM; 14 Torres Strait Regional Authority; 15 area of cooperative arrangements between the Cape York and Northern Gulf NRM bodies. For this report, Torres Strait Regional Authority (14) has been omitted from the analysis, and the area of cooperative arrangements between the Cape York and Northern Gulf NRM bodies (15) has been merged with Cape York.



Map 2 Profit at full equity for agricultural lands in 2005/6 across Queensland as estimated by Marinoni *et al*. (2012).



Map 3 Generalised map of land-use and remnant vegetation extent in Queensland.



Map 4 Model of potential above ground native forest biomass model for Queensland, as used in calculation of Australia's National Carbon Account for land-use, land-use change and forestry.

Assessment of potential for each activity

Environmental Planting

The term “environmental planting” is used here in a broad sense, to cover the activity of establishing new forests by planting native species. This activity was the first land use change activity enabled to earn ACCUs. The method is simply called “environmental plantings”. There are now several methods that cover this broad activity, with technical differences. The most basic form, which uses forest growth modelling to estimate greenhouse gas abatement, is the approach we emulated in our assessment of economic viability and potential. More complex but flexible and/or accurate methods are also available. Including some where limited timber harvest may occur (Measurement Based Methods for New Farm Forestry Plantations) or where intensive inventory is used to accurately assess change in carbon stocks in forest biomass (Reforestation and afforestation). Methods with updated forest carbon modelling, increasing estimated abatement in particular domains (Paul *et al.* 2013), are also available for mallee and environmental plantings within specific geographic regions (Reforestation by environmental or mallee plantings – FullCAM).

For this assessment of potential we emulate the most basic and cheapest project type. The economic model included the following costs:

C1. One-off project establishment costs (contracts etc.)

a) $100/ha small-scale scenario (~100ha)
b) $10/ha large-scale scenario (~1000ha)

C2. Planting establishment costs [depend on land type and rainfall]:

a) $3000/ha if average annual rainfall <700mm
b) $8000/ha if former rainforest
c) $2000/ha otherwise

C3. Recurring project management costs (on-ground and administration/reporting)

a) $65/ha/yr for small-scale scenario (~100ha) ($35 on-ground + $10 reporting and other transactions + $20 for report audit)
b) $18/ha/yr for large-scale scenario (~1000ha) ($15 on-ground + $1 reporting and other transactions + $2 for report audit)

C4. Annual opportunity cost = Profit at full equity (PFE) 2005/6 spatial data from Marinoni *et al*. (2012) adjusted to current value assuming 2.7% annual inflation. Scenarios adjusting PFE by +/-20% also modelled to assess sensitivity to this parameter.

The major cost for environmental planting projects is establishing the planting. We varied this cost to reflect higher costs in areas that used to support rainforest (reflecting higher weed management costs and planting densities required), and also higher costs in areas with average annual rainfall lower than 700mm. This threshold was based on a high level analysis of the distribution of forestry plantations in Queensland, which are all in areas with more than 700mm average annual rainfall (Map 4, Fig 1.).

Modelling for environmental plantings included all non-remnant land with grazing or dryland cropping as the land use. It was represented by 240692 model locations, primarily in the south eastern third of the State.

Map 5 Location of existing forestry plantations in Queensland in relation to 700 mm average annual rainfall.

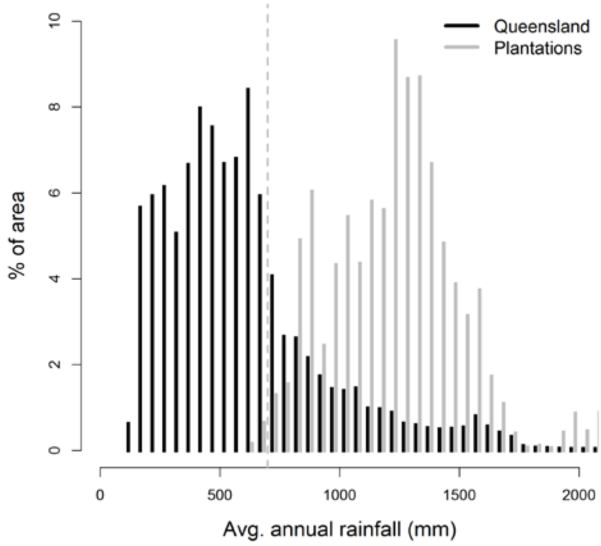


Figure 1 Frequency distributions of average annual rainfall for Queensland (black bars) and Queensland forestry plantations (grey bars). Grey dashed line is at 700 mm average annual rainfall.

Benefit was modelled using a simple forest growth model reliant on two parameters: 1. potential maximum forest biomass for a site (estimated using the Maxbio data from NCAS), and; 2. planting age at maximum biomass increment, which we set at 10 years for environmental plantings, consistent with the model used to calculate abatement for environmental planting projects (Richards and Brack 2004). For regrowth we assumed a slightly slower start, with peak growth at 12 years. The biomass model is depicted in Figure 2.

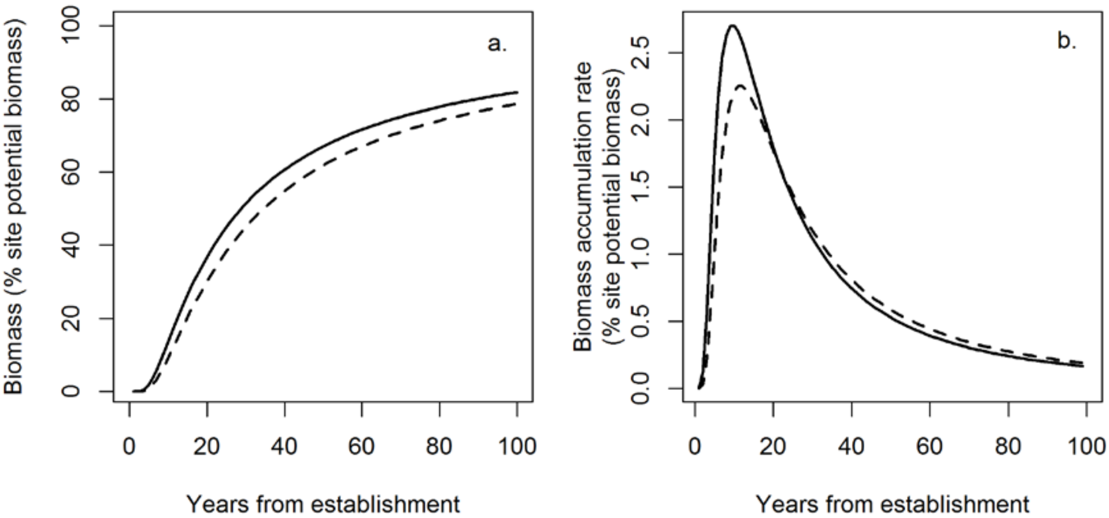
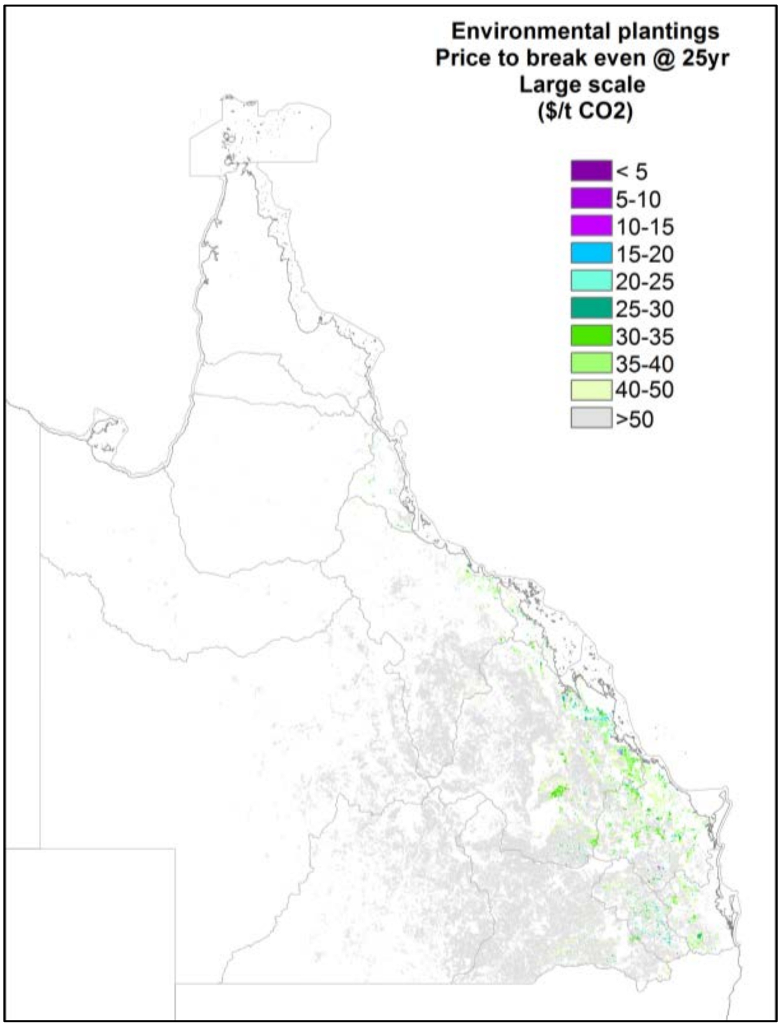


Figure 2 Forest growth model used to estimate carbon benefits from plantings and regrowth.



Map 6 Estimated ACCU price required for environmental plantings to break even over a 25 year investment period for a cost scenario modelled on large project scale with 100 year permanence. Grey areas indicate suitable land use and vegetation but high prices required for economic viability

Environmental planting required higher prices to break-even than regrowth or avoided deforestation (Figure 4). However, it also showed relatively low sensitivity to project scale, and the highest sensitivity to the time horizon over which profitability is assessed (Figure 4). This implies relatively high sensitivity to choice of discount rate. So a more risk-averse rate, such as 10%, would be likely to greatly reduce the extent of land on which environmental plantings would be profitable, at any particular price, compared to the 5% rate used here.

Environmental plantings look most economically viable over longer time horizons. Practically no modelling point yielded positive economic benefit after ten years, but things improved after 25 and were better still after 100 years. Net benefits for both regrowth and avoided deforestation were higher at ten years than at 100 years (Figure 4).

The impact of choosing 25 year permanence, with its 20% deduction in credits, was also greater for environmental plantings than for regrowth or avoided deforestation. These sensitivities to timescale and permanence period are presumably driven by the high upfront costs of planting. Clearly, an ability to establish plantings at less than the modelled estimate of $2000 per hectare ($3000 in semi-arid lands) would have a large effect on economic outcomes.

An important point about environmental plantings is that they are a ubiquitous option for any cleared country being used for grazing or cropping, in principle at least. Planting does not rely on the presence of native forest regrowth or forest under threat of clearing. Nevertheless, ACCU prices will need to exceed $30 before significant areas of environmental plantings become likely under the scenarios modelled here (Table 3).

The most prospective regions apparent on Map 6 include traditional forestry districts, particularly north of Rockhampton around Byfield, and in the north Burnett, as well as other regions less well known for forestry such as the western Broadsound district.

Regrowth

Regrowth is clearly an interesting option for carbon farming, not least because of its great potential for biodiversity benefit (Dwyer *et al*. 2009, Fensham and Guymer 2009). It is also cheaper to establish and therefore probably more economically feasible than plantings in most places (Evans *et al*. 2015). The modelling of regrowth economics for this study considered two scenarios for benefit as well as variation in project scale and permanence. One scenario is analogous to plantings, where regrowth is modelled as commencing at the same time as project establishment. This is effectively a “zero-baseline” scenario for regrowth, as required for the method called “[Human induced regeneration of a permanent even-aged native forest]”, and results in few credits during the first five years or so as the regrowth forest becomes established. This is the approach taken in previous studies by Evans *et al*. (2015) and Butler *et al*. (2014).

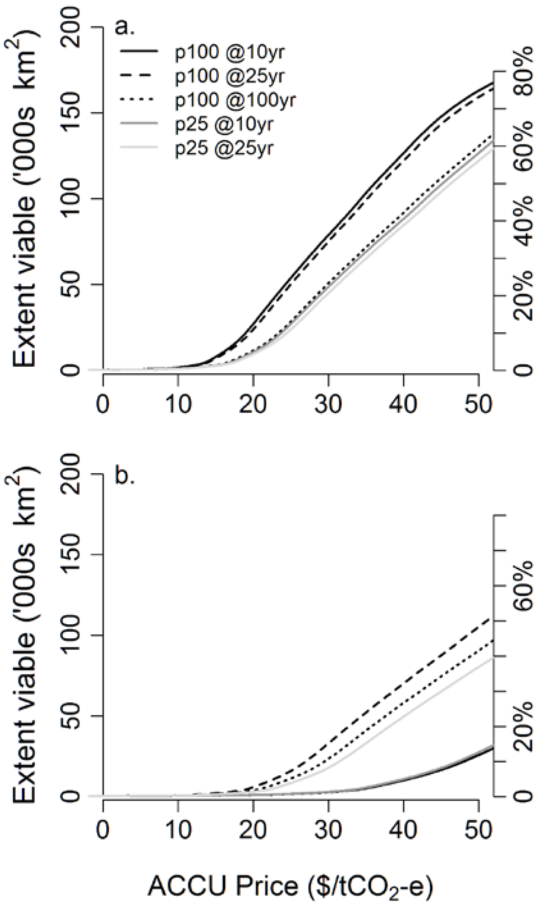


Figure 3 Comparison of relationship between ACCU price and extent of land where carbon farming with regrowth may be economically viable for large projects (~1000ha) if we assume regrowth is: a. seven years old at project commencement; or, b. begins at project commencement (zero baseline). p25 and p100 are 25 year and 100 year permanence periods.

The second scenario models a project established about seven years after regrowth commencement, as it is most likely that most regrowth projects will begin with young forests around five to ten years old. This is the type of scenario that could fit a dynamic baseline such as is available in the methods for “[Native forest from managed regrowth]” or “[Avoided clearing of native regrowth]”. These methods allow for crediting of avoided emissions but the model here considers only new sequestration, which is occurring at a much higher rate in seven year old regrowth than in one year old regrowth (Figure 3).

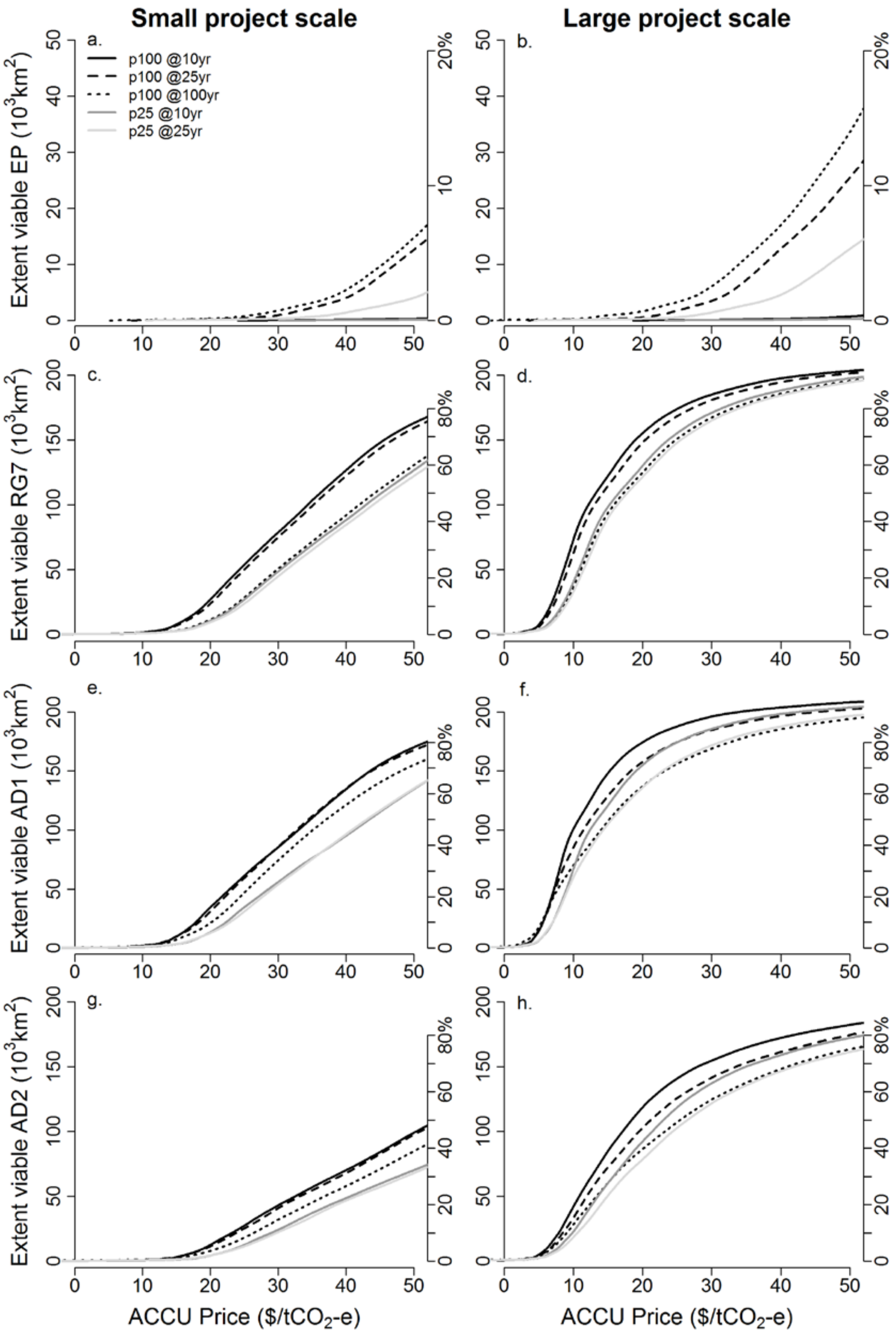
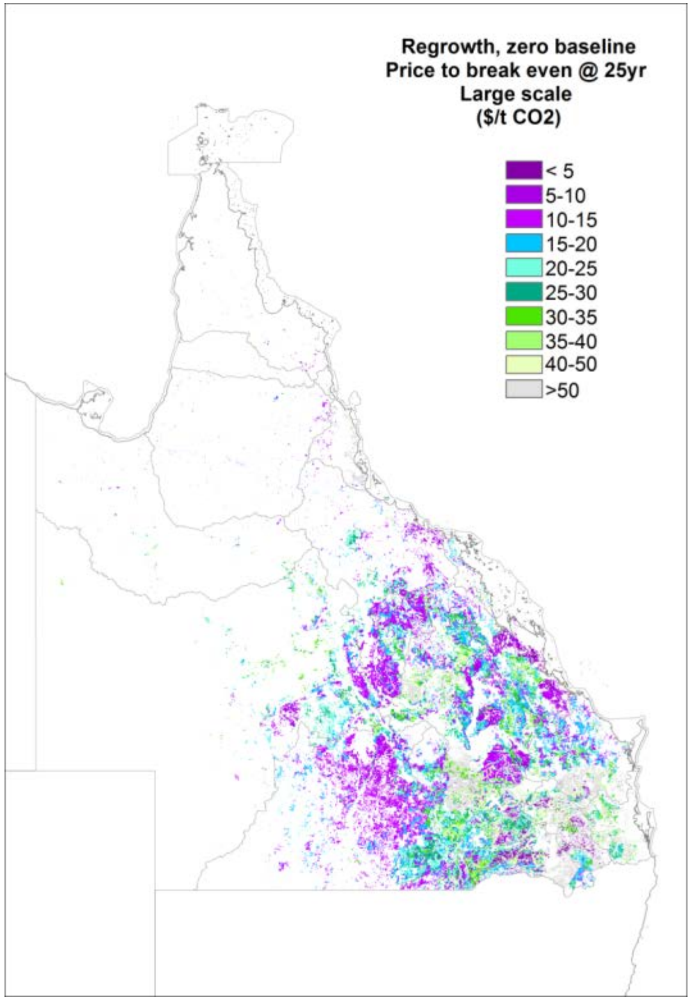


Figure 4 Modelled relationships between credit price and the extent of land on which different carbon farming scenarios may be economically beneficial in Queensland. a. small scale environmental planting; b. large scale environmental planting; c. small scale regrowth with a 7 year start; d. large scale regrowth with a 7 year start; e. small scale avoided deforestation with permit based additionality; f. large scale avoided deforestation with permit based additionality; g. small scale avoided deforestation with risk based additionality; h. large scale avoided deforestation with risk based additionality. The secondary y-axis shows the viable area as a percentage of land with suitable land use and vegetation status. p25 and p100 are 25 year and 100 year permanence periods.

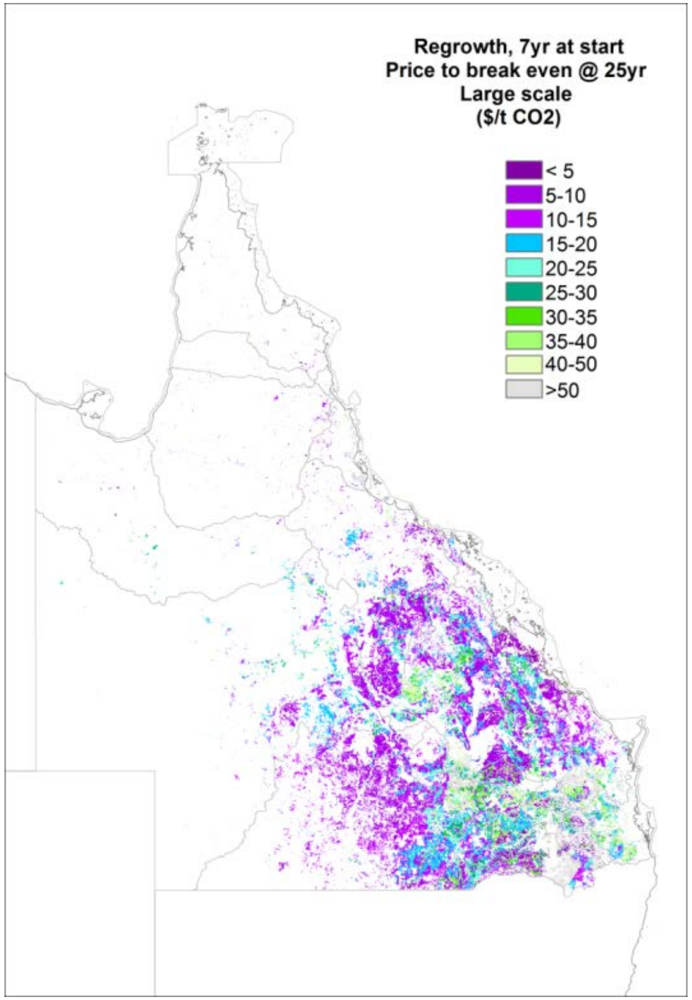
Table 3 Summary of economic model results for four forest based carbon farming activities in Queensland. Based on 25 year time horizon but 100 year permanence obligation, so that economic viability = positive net present value over a 25 year investment period.

Activity[1]	Project Scale	Extent of suitable land where it may be economically viable ('000s km^2)			Potential CO_2-e sequestered over 10 years (Mt CO_2-e)			Potential rate of ongoing sequestration after 10 years (Mt CO_2-e /year)			Potential CO2-e sequestered over 20 years (Mt CO_2-e)			Potential rate of ongoing sequestration after 20 years (Mt CO_2-e /year)		
		$15	$20	$30	$15	$20	$30	$15	$20	$30	$15	$20	$30	$15	$20	$30
Environmental plantings	~1000ha	0.2	0.5	3.5	1.6	3.8	21.1	0.3	0.8	4.2	4.4	10.5	57.4	0.2	0.5	3.06
	~100ha	0.07	0.2	1.0	0.5	1.6	6.9	0.1	0.3	1.3	1.4	4.4	18.7	0.07	0.2	1.007
Regrowth – zero baseline	~1000ha	37.2	52.5	72.6	59.4	83.8	110.9	13.9	19.5	26	196.9	278.2	368.2	12.1	17.1	22.7
	~100ha	0.5	1.9	11.1	2.5	7.2	33.3	0.4	1.8	7.8	8.6	24.3	110.2	0.4	1.6	6.8
Regrowth – 7yo	~1000ha	54.1	68.9	81.6	86.1	106.1	123.6	20	25	28.9	286.1	352.7	410.6	17.4	21.7	25.2
	~100ha	2.2	8.1	27.8	8.7	25.3	67.2	2.1	5.9	15.8	28.2	83.8	223	1.8	5.2	13.7
Avoided deforestation – permit based	~1000ha	1.4	1.6	2.1	8.5	10.5	12.4	0.9	1	1.2	12.9	15.8	18.8	0	0	0
	~100ha	0.1	0.4	1	1.4	3.9	8.6	0.2	0.4	0.9	2.1	6	13.1	0	0	0
Avoided deforestation – risk based	~1000ha	0.7	1.1	1.7	4.9	6.9	9.8	0.6	0.7	1	7.6	10.4	14.8	0	0	0
	~100ha	0	0.1	0.5	0.4	1.4	4.4	0	0.1	0.3	0.5	2	6.5	0	0	0

[1] Extent is based on land with appropriate land use and non-remnant vegetation for plantings. Regrowth and avoided deforestation require regrowth availability or forest subject to clearing, so the figures for those methods are based on estimates of the land area with appropriate land use, non-remnant woody vegetation, and modelled to have economic viability (positive net present value after 25 years) at each specific price.



Map 7 Price to break even for a large scale (~1000 ha) project with 100 year permanence over a 25 year investment period for regrowth, assuming growth begins at project commencement (zero baseline).



Map 8 Price to break even for a large scale (~1000 ha) project with 100 year permanence over a 25 year investment period for regrowth, assuming regrowth is seven years old at project commencement

Table 4 Regional break down of results for the activities modelled. This comparison assumes 100 year permanence, a 25 year investment period and $20/ACCU for large scale (~1000 ha) projects.

NRM Region	N (model points on suitable land, '000s)		Estimated extent of land where activity may be break even after 25 years at $20/ACCU ('000s km^2)[2]					Estimated potential CO_2-e abatement over 10 years assuming activity wherever viable at $20/ACCU (Mt CO2-e)				
Activity	EP	RG& AD	EP	RG0	RG7	AD	ADD	EP	RG0	RG7	AD	ADD
Burdekin Dry Tropics NRM	25.9	24.8	0.004	6.6	7.8	0.2	0.2	0.02	9.7	10.8	0.9	0.7
Burnett Mary Regional Group	19.2	18.7	0.1	3.2	4.4	0.3	0.2	1.01	10.6	13.5	3.1	1.6
Cape York Development Association	0.3	0.3	0.02	0.2	0.2	0.0	0.0	0.2	0.5	0.5	0.0	0.0
Condamine Alliance	10.9	6.2	0.07	0.2	0.3	0.0	0.0	0.4	0.4	0.8	0.1	0.1
Desert Channels Queensland	16.6	16.0	0.0	7.8	12.8	0.1	0.0	0.0	8.3	12.7	0.4	0.2
Fitzroy Basin Association	65.4	61.4	0.19	9.4	12.0	0.4	0.3	1.4	24.0	28.4	2.9	2.3
Mackay Whitsunday NRM Group	1.0	1.0	0.03	0.2	0.2	0.0	0.0	0.2	0.6	0.8	0.2	0.1
Northern Gulf Resource Management Group	0.7	0.7	0.001	0.6	0.7	0.0	0.0	0.003	0.7	0.7	0.0	0.0
Queensland Murray-Darling Committee	55.0	45.3	0.0	3.1	5.6	0.2	0.2	0.0	5.5	9.4	1.2	0.9
SEQ Catchments	6.4	6.2	0.05	0.2	0.7	0.0	0.0	0.3	1.0	3.1	0.6	0.2
South West NRM	36.7	36.1	0.0	20.7	23.7	0.4	0.2	0.0	21.9	24.6	1.1	0.8
Southern Gulf Catchments	1.0	0.7	0.0	0.2	0.4	0.0	0.0	0.0	0.2	0.3	0.0	0.0
Terrain NRM	1.5	0.5	0.03	0.1	0.1	0.0	0.0	0.3	0.4	0.5	0.0	0.0
Total NRM Regions	240.7	217.8	0.5	52.5	68.9	1.6	1.1	3.8	83.8	106.1	10.5	6.9

[2] Extent of land viable for regrowth and avoided deforestation depends on the availability of regrowth or forest, so these figures for these activities are based on estimates of the land area with appropriate land use, non-remnant woody vegetation, and modelled to have economic viability (positive net present value after 25 years) at each specific price..

Costs modelled for regrowth projects are similar to those for environmental plantings, without the up-front cost of plantation establishment.

C1. One-off project establishment costs (contracts etc.)

a) $100/ha small-scale scenario (~100ha)
b) $10/ha large-scale scenario (~1000ha)

C2. Recurring project management costs (on-ground and administration/reporting)

a) $65/ha/yr for small-scale scenario (~100ha) ($35 on-ground + $10 reporting and other transactions + $20 for report audit)
b) $18/ha/yr for large-scale scenario (~1000ha) ($15 on-ground + $1 reporting and other transactions + $2 for report audit)

C3. Annual Opportunity cost = Profit at full equity (PFE) 2005/6 data from Marinoni *et al*. (2012) adjusted to current value assuming 2.7% annual inflation. Scenarios adjusting PFE by +/-20% also modelled to assess sensitivity to this parameter.

All regions show fairly extensive opportunities for economically beneficial carbon farming with regrowth. The south-east of the state is probably the most restricted region, in that the modelling suggests that higher prices are required to break even.

Avoided deforestation

To date, avoided deforestation is the most significant methodology for greenhouse gas abatement applicable to extensive land uses under the ERF, with more ACCUs issued than for all other ERF methods that achieve greenhouse gas abatement through land use change combined (Table 1). However, in its current form there is little if any scope for avoided deforestation projects in Queensland. This is because of a mismatch between the eligibility requirements for the current avoided deforestation methodology and the approach to regulation of tree clearing in Queensland.

At the time of writing, the methodology for avoided deforestation under the ERF (link to determination) requires a written permit to clear native forest. The permit must have been issued before July 2010 and must still be valid when the avoided deforestation project is activated. The permit must specify that clearing is to convert the forest to grassland or cropping land, and not to plantation forest or settlements. The permit must not require vegetation offsets. The permit must require the change from forest to grassland or cropland be maintained in perpetuity.

The reason the methodology is so prescriptive is easy to understand. It ensures that the greenhouse benefits from avoiding clearing of native forest in the project area are additional to the most plausible future without the project. The ERF follows established practice for carbon-credit scheme and offsets more generally. ACCUs are issued to projects for delivering greenhouse outcomes that are different to whatever would have happened without the carbon project. This approach is quite unlike the concept of stewardship, where resource managers are rewarded for maintaining valued landscape features. Forest eligibility for avoided deforestation requires imminent threat, especially if ACCUs are to be traded as direct offsets for emissions.

However, in Queensland most clearing for agricultural purposes does not require written permits. Regulation of vegetation management is achieved in large part through maps that show where vegetation may be cleared for agricultural purposes and where it may not. This system has been in place for fifteen years and has greatly reduced the rate of deforestation (broadscale clearing of well-established native forests (remnant vegetation) for agricultural purposes was tightly restricted in Queensland from 2006).

If permits are issued for specific activities, not covered by the routine activities available to landholders under Queensland's vegetation management codes, they typically expire after five years. So, despite consistently accounting for well more than half of Australia's annual native forest clearing, there are no avoided deforestation projects registered in Queensland under the ERF, and this is unlikely to change without a different mechanism or approach to establish additionality in a way that is consistent with Queensland's regulatory framework.

For this study we modelled two benefit scenarios for AD. One assumed existing approaches to additionality (AD type 1), whereby a permit establishes that all biomass carbon in a given forest is at risk of emission as greenhouse gases following clearing, so that credits can safely be issued for the whole amount. The second option (AD type 2) could conceptually fit vegetation that is not protected, because it is subject to implicit permission to clear rather than having a permit issued over it. We refer to this second suggestion as "risk based additionality" because it applies a discount to reflect the likelihood of clearing. This discount is based on the extent of the ecosystem type that is remnant vegetation (i.e. structurally intact).

Avoided deforestation is typically thought about in relation to mature forest. However, in Queensland, as discussed above, clearing of remnant vegetation is strictly controlled. So the greatest opportunity is arguably for older regrowth and non-remnant vegetation. With this in mind, we discounted biomass estimates for models of avoided deforestation to 40% of maximum potential biomass (NCAS), which approximates biomass in 30-40 year old regrowth.

Benefits from the two types of avoided deforestation where modelled for non-remnant grazing lands as follows:

1. Avoided deforestation type 1, permit based additionality. - Live biomass modelled as 40% of maximum biomass from NCAS. This discount approximates biomass in regrowth 30-40 years old

   Annual CO2-e benefit = 0.95 * C/15

   and C = (1.25*0.5*(44/12)*M*0.4)

   Where:

   15 is the length of the crediting period over which avoided emissions are distributed

   0.95 reflects the 5% risk of reversal buffer retained by the Clean Energy Regulator

   C = forest carbon stock (t CO_2-e / ha)

   M = maximum above ground biomass (t/ha)

   1.25 adds 25% of above ground biomass for roots

   0.5 converts biomass to carbon

   44/12 converts carbon mass to CO_2-equivalent mass

   and 0.4 reflects likely lower biomass of forests outside remnant vegetation

2. Alternate scenario (AD2) – Biomass as above but further discounted for extent of remnant for pre-clearing ecosystem type

   Ca = (0.95*C*PrNR)/15

   Where:

   Ca = additionality adjusted forest carbon stock (t CO_2-e / ha)

C = forest carbon stock (t CO_2-e / ha) calculated as for Base scenario above

PrNR = based on pre-clearing regional ecosystem mapped at each model point, equals proportion of that ecosystems pre-clearing extent that is non-remnant vegetation.

Costs are the same for both avoided deforestation types and include expenses for detailed inventory and development or validation of allometric equations to estimate forest biomass from tree measurements.

C1. One-off project establishment cost, includes expensive inventory involving destructive harvest and weighing of trees)

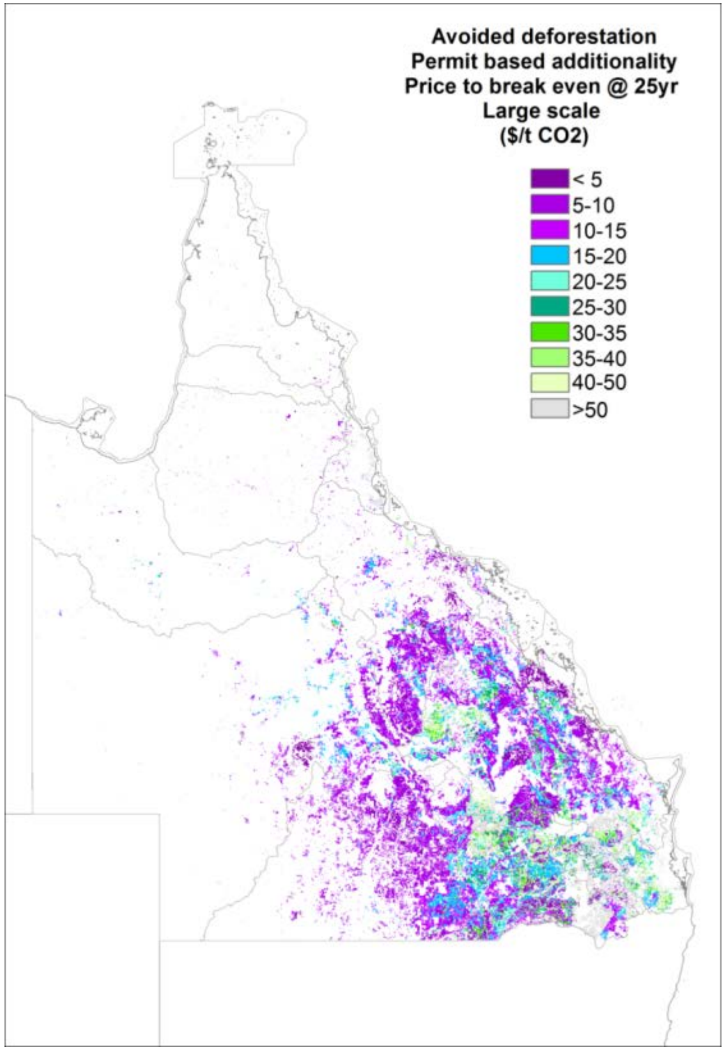
a) $300/ha small-scale scenario (~100ha): $200 for inventory, $100 for paperwork
b) $30/ha large-scale scenario (~1000ha): $20 inventory/$10 paperwork

C2. Recurring project management costs (includes on-ground and administration/reporting)

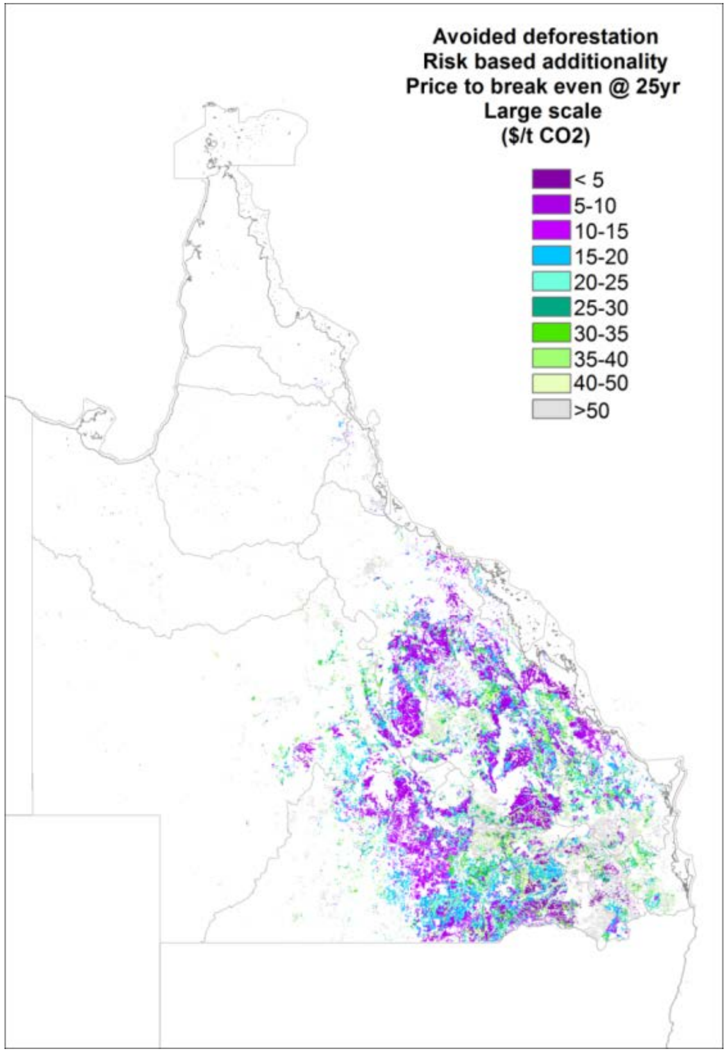
a) $65/ha/yr for small-scale scenario (~100ha) ($35 on-ground + $10 reporting and other transactions + $20 for report audit)
b) $18/ha/yr for large-scale scenario (~1000ha) ($15 on-ground + $1 reporting and other transactions + $2 for report audit)

C3. Yearly Opportunity cost = Profit at full equity 2005/6 data from Marinoni *et al*. (2012) adjusted to current value assuming 2.7% annual inflation. Scenarios adjusting PFE by +/-10% modelled to assess sensitivity to this parameter.

The two models of avoided deforestation result in differences in the extent of land where avoided deforestation might be economically viable. Applying the discount to carbon benefits under the risk based method for additionality (ADD) reduced the extent of viable land but this effect was most noticeable in areas with relatively high proportion of forest remaining, where the biodiversity and landscape co-benefits of avoided deforestation are also more questionable because of lower clearing risk. Overall, the risk based approach to additionality appears to be a viable option for further consideration and method development.



Map 9 Price to break even for models of avoided deforestation assuming permit based additionality for large scale (~1000 ha) projects with 100 year permanence over a 25 year investment period



Map 10 Price to break even for models of avoided deforestation assuming risk based additionality for large scale (~1000 ha) projects with 100 year permanence over a 25 year investment period

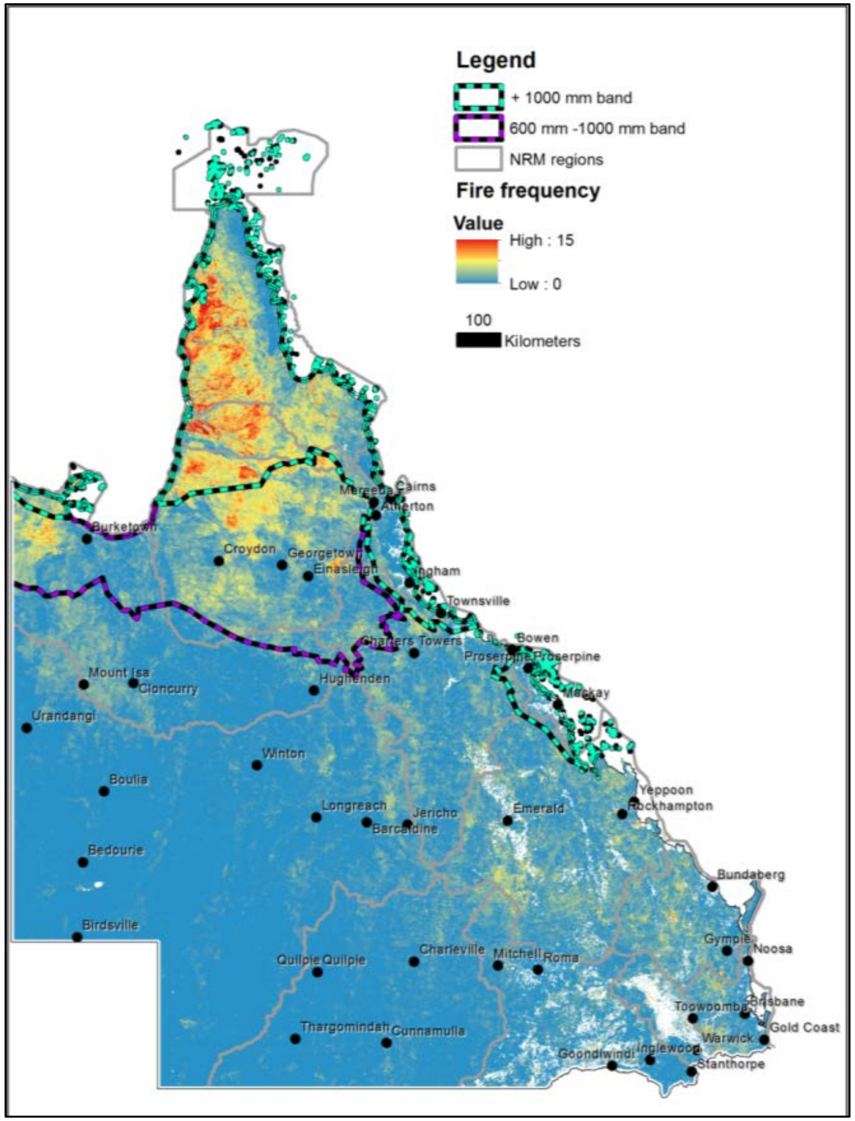
Savanna Burning

Under the ERF, Savanna Fire Management activities are focused on both the high rainfall (>1000mm) and low rainfall (600-1000mm) tropical savanna lands across Australia's north. The activity achieves greenhouse gas benefits by reducing methane and nitrous oxide emissions generated by fires, especially extensive late dry season fires, by carrying out fire management in the early dry season (before 1 August). Some fire management can still take place in the late dry, provided this is in addition to early dry season fire management. Fire management must be carried out with the intention of increasing the proportion of fire within the project area that occurs in the early dry season on an annual basis. Projects must contain at least one vegetation fuel type that is consistent with that of savanna (see Schedule 1 http://www.environment.gov.au/system/files/pages/8826c419-099b-41f6-8ef7-e6a27e84dc7d/files/savanna-fire-management-draft-determination.pdf). The project area must be stratified into carbon estimation areas (one or more) for the calculation of net annual abatement.

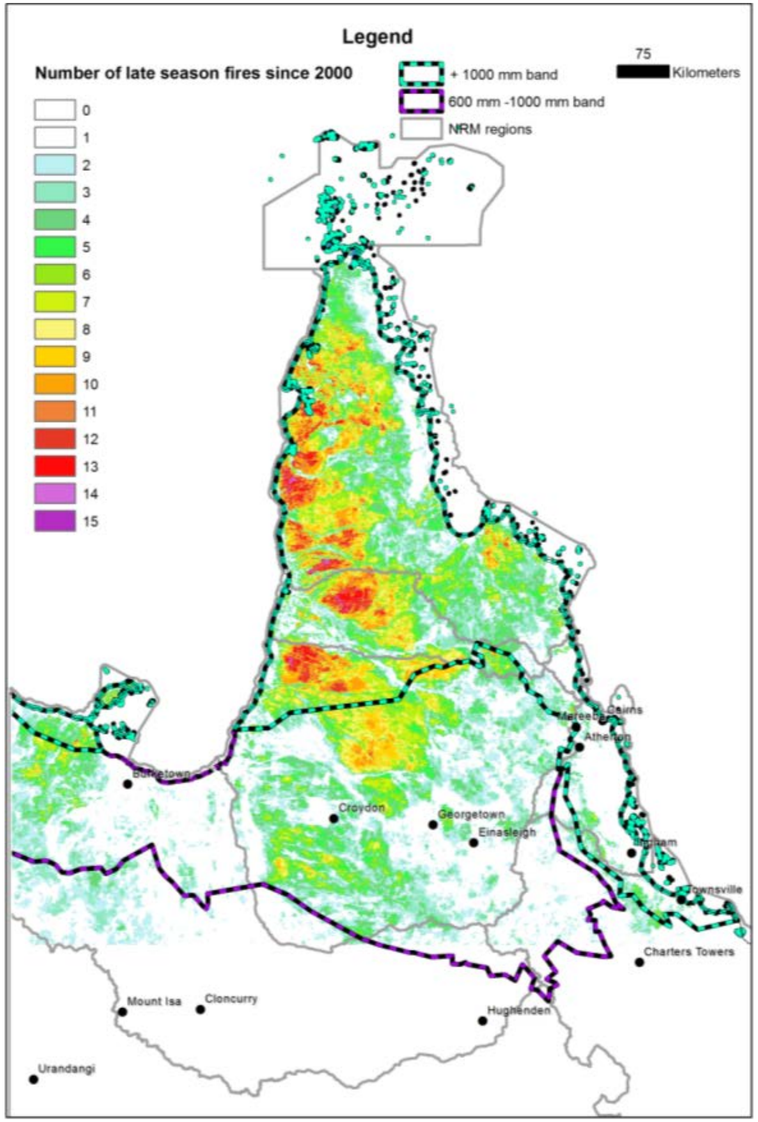
The savanna fire management methodology also requires landholders manage stock numbers so that they do not increase over time within the project area. Landholders are required to acquire a "baseline mean annual number of stock". This is calculated in adult animal equivalents for all properties on which a given project is to occur for the six years prior to project commencement (see the above link). The project mean annual stock number must not exceed the baseline mean annual number of stock, plus an increment of diminishing standard deviations, based on time since project commencement.

Economic viability of savanna projects is not directly assessed in this report. However, in principle, Savanna Fire Management projects could have limited impacts on current land use and grazing production, compared with reforestation, and therefore would have relatively low opportunity costs. Project establishment is also relatively straightforward. Vegetation fuel-type maps are reasonably simple to create with the availability of existing spatial data in Queensland, including 1:100,000 Regional Ecosystem maps (see http://www.environment.gov.au/system/files/pages/8826c419-099b-41f6-8ef7-e6a27e84dc7d/files/savanna-fire-management-draft-explanatory-statement.pdf) and fire mapping from the North Australian Fire Information (NAFI) service. The Savanna Burning Abatement Tool (SavBAT2) also makes reporting a relatively simple process. However, there is still sufficient complexity in project establishment and reporting, including report audit costs, to suggest that economies of scale, so clearly important to the quantitative models of forest-based methods presented above, will also be very important considerations for savanna burning projects. Since properties in the Gulf and western Cape York Peninsula typically cover many tens of thousands of hectares, economies of scale should be readily achieved.

Given sufficient scale, the primary constraint to economically viable savanna burning projects is likely to be the difference between the baseline fire regime and the potential regime that may be achieved after implementing increased early season fire ignition. That is, how much fire extent, and especially late dry season fire extent, can be reduced. Map 11 shows that the regions already covered by the high and low rainfall bands of the savanna burning method are the most fire prone regions in Queensland. Within these regions, western Cape York Peninsula and the far western Gulf are the most prone to late dry season fires. These regions would intuitively represent the best prospects for economic benefit from savanna burning.



Map 11 Fire frequency across Queensland (DSITI, unpublished)



Map 12 Frequency of late dry season fires (after June) since 2000 (NAFI http://www.firenorth.org.au/nafi3/).

Soil Carbon

The soil carbon sequestration methodology aims to provide low-cost project options for land managers involved in cropping, pasture and mixed farming systems. Eligible land must have been cropped and/or grazed with production livestock at least once during the 5 years prior to an application being made to establish the project under the ERF (a 5 year baseline emissions period). Land types not eligible for soil carbon sequestration projects are forest land, areas with organic (peat) soils, areas containing settlement (dwellings or other built infrastructure) or land that has been cleared of native forest cover or drained of wetlands within the 5 year baseline emissions period.

Eligible soil carbon projects are sustainable intensification projects, stubble retention projects or conversion to pasture projects, the eligibility requirements of which can be viewed at: http://www.environment.gov.au/system/files/pages/933770fe-2943-47f4-88dd-4f0fccc88978/files/soil-carbon-draft-determination.pdf . For sustainable intensification projects, two of the following activities are required to be carried out:

- Nutrient management
- Soil acidity management
- Introducing irrigation
- Pasture renovation

The details of which can also be viewed at the above link. If these activities are to be carried out on a project area that is to remain under cropping, the area must also be managed with the implementation of the requirements set out for stubble retention projects.

Proponents of soil carbon sequestration projects must stratify project land into one or more carbon estimation areas and nominate one of the three project types (sustainable intensification, stubble retention or conversion to pasture) for each carbon estimation area. Geographic boundaries of each carbon estimation area must be in accordance with CFI mapping guidelines.

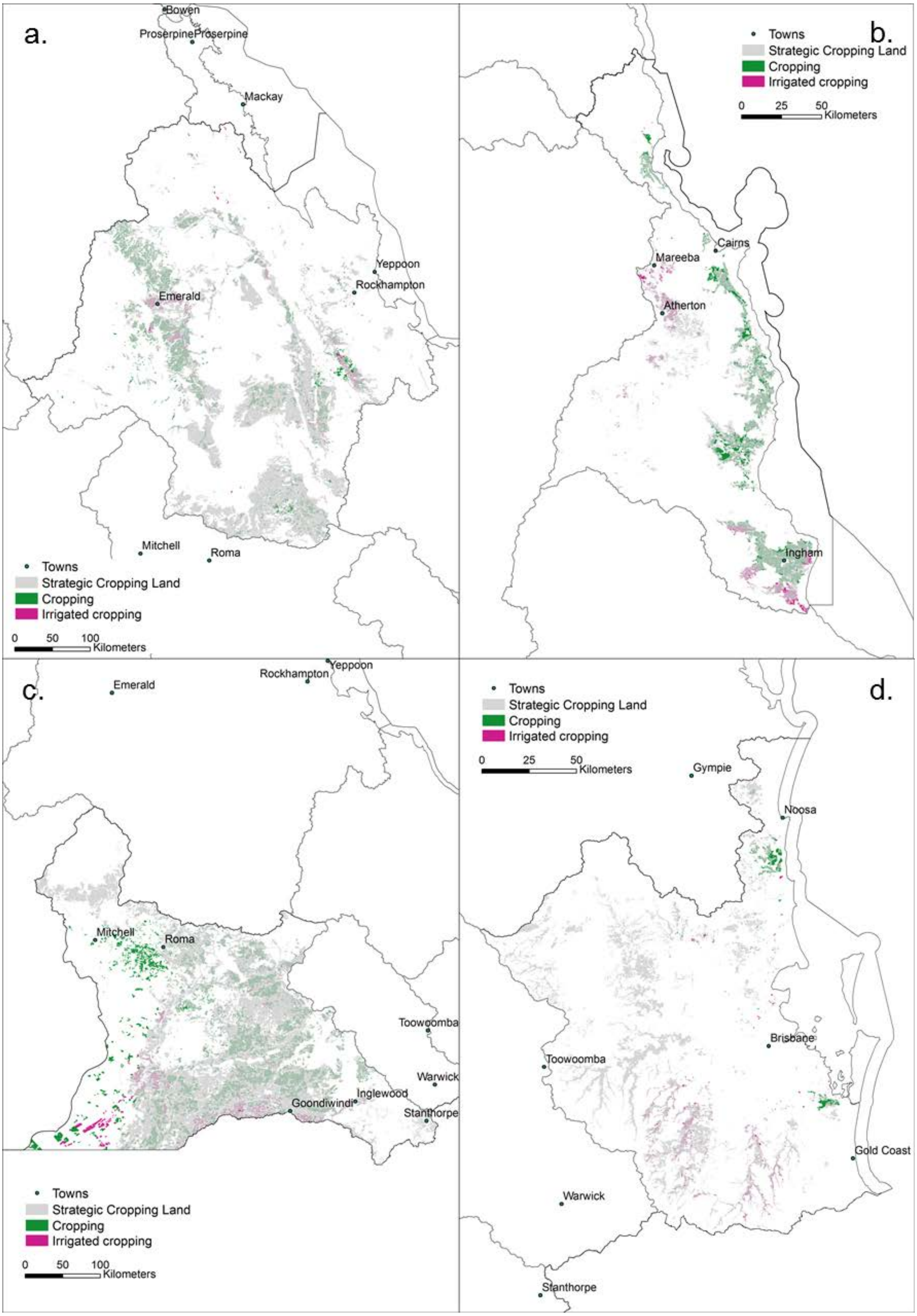
Development of methods for soil carbon activities under the ERF is in its infancy. Current methods require sampling and measurement of soil carbon change through time. The cost effectiveness of soil carbon activities could improve if model-based methods currently under consideration prove sufficiently robust. Such changes in methodology could see soil carbon sequestration projects being initiated over extensive grazing lands, and may also see soil carbon being added as a sequestration pool in planting and regrowth projects.

However, the soil carbon sequestration methodology in its current form is likely to prove most economically viable where changes in soil carbon concentration will be most readily detected, and will most reliably result from land use change. Rather than undertake an economic analysis we have focused our analysis on identifying cropping lands that could most beneficially be converted to pasture, as we considered this change in land use to offer the greatest potential for reliable soil carbon sequestration per unit area (see Dalal *et al*. 1995; Post and Kwon 2000; Cotnant *et al*. 2001). Due to the generally high financial returns of much of the states cropping lands, we aimed to identify the least profitable cropping lands, which could presumably be converted to pasture with the smallest opportunity cost. As a first cut we quantified the extent of land mapped as having cropping land use that fall outside the footprint of the Strategic Cropping Land (SCL) trigger map. SCL is land that has been identified as, or is likely to be suitable for cropping based on soils, climate and landscape features. Table 5 shows the extent of such areas in each of the target NRM regions.

The total amount of cropping land to fall outside the SCL footprint state-wide was more than 508,000 ha, more than 330,000 of which is dryland cropping (see Table 7). The NRM regions with the greatest soil carbon sequestration potential via the conversion of low PFE dryland cropping land to pasture are Queensland Murray-Darling Committee (> 188,000 ha), Fitzroy Basin Association(> 52,000 ha), Terrain NRM (> 30,000 ha), Condamine Alliance (>20, 000 ha) and both SEQ Catchments and Burdekin Dry Tropics NRM (> 10,000 ha). Some significant focal areas for potential soil carbon sequestration projects in dry cropping lands are the areas west and south west of Roma, parts of the Callide Valley, parts of the Wet Tropics coastal floodplains and some low elevation coastal areas of the Sunshine Coast and northern Gold Coast (see Figure 5). Mackay Whitsunday NRM Group (> 47,000 ha), Burnett Mary Regional Group (> 30,000 ha) and Burdekin Dry Tropics NRM (> 26,000 ha), have the greatest potential for soil carbon sequestration projects where low PFE irrigated cropping lands are converted to pasture.

Table 5 Summary of the extent of non-strategic cropping land potentially available for conversion to permanent pasture for each NRM region.

NRM Region	Non-SCL Dryland Cropping (ha)	Non-SCL Irrigated Cropping (ha)	Total non-SCL Cropping (ha)
Burdekin Dry Tropics NRM	10,395	26,468	36,863
Burnett Mary Regional Group	6,635	30,794	37,428
Cape York Development Association	2,099	3,125	5,224
Condamine Alliance	20,876	2,193	23,069
Desert Channels Queensland	0	274	274
Fitzroy Basin Association	52,940	7,539	60,479
Mackay Whitsunday NRM Group	1,128	47,455	48,584
Northern Gulf Resource Management Group	1,176	9,098	10,274
Queensland Murray-Darling Committee	188,078	36,745	224,823
SEQ Catchments	10,409	5,146	15,555
South West NRM	6,219	1,342	7,561
Southern Gulf Catchments	574	1,082	1,656
Terrain NRM	30,099	6,239	36,338
Total NRM Regions	330,629	177,500	508,129



Map 13 The potential for permanent pasture conversion of non-strategic cropping lands in four NRM regions. a. Fitzroy Basin Association; b. Terrain NRM; c. Queensland Murray-Darling Committee; and d. SEQ Catchments.

Discussion

There is clearly ample opportunity for greenhouse gas benefits from land use change in Queensland with direct economic benefit to rural producers. The upper limit of that potential over the next ten years is estimated to be in the order of 4 Mt CO_2-e for plantings and more than 100 Mt CO_2-e for regrowth. This would require considerable expansion in activity from current levels but is comparable with the 17.9 Mt CO_2-e per annum of LULUCF emissions reported for Queensland in the latest National Inventory Report (2011-12, Commonwealth of Australia 2014b)

It is important to consider these figures as the potential that can be obtained from the total viable amount of land for each methodology and realise that only a fraction of this viable land will likely be considered for uptake. Likewise it is also important to consider any potential gains made in sequestration under the CFI, within the broader context of the current Queensland agricultural landscape and the potential for such gains to be offset by increases in LULUCF emissions. Changes in recent years to Queensland vegetation laws, such as those that allow for some broad acre clearing of remnant vegetation for high value agriculture (see https://www.qld.gov.au/environment/land/vegetation/agriculture/) have the potential to significantly increase state LULUCF emissions. Due to their potential size, just one deforestation project can greatly impact on gains made through carbon farming initiatives. For example, an analysis of the emissions potentially generated from recent high-profile deforestation permitted as Clearing for High-value Agriculture at Strathmore and Olive Vale stations in northern Queensland, are estimated to be in the region of 9 Mt CO_2-e. This would be emitted over several years but is more than the entire annual emissions of the Tasmanian economy and is also more than double the upper limit to potential sequestration from plantings estimated in this study.

Project scale and up-front costs are critical components of profitability for carbon farming activities based on land use change. Policies that enable aggregation and minimise costs for project establishment will maximise opportunities for land holder participation. Increased availability of easy to use tools for project reporting (akin to SavBat2 for savanna burning) would also increase the likely uptake of forest based carbon farming through regrowth or plantings. For avoided deforestation, assessment and adoption of generic allometric equations with wide domains will greatly reduce costs and further improve economic viability.

The apparent mismatch between the eligibility requirements for the current avoided deforestation method and the structure of Queensland's vegetation management regulations is perhaps the most apparent gap between potential and current policy setting. The risk based approach to additionality assessment, modelled here, appears to present a feasible option for further consideration and potential development into a method. Note that the carbon benefits from avoided deforestation were modelled as just 40% of forest biomass potential, but there were significant areas where this conservative assumption would still yield economically positive outcomes.

The economic modelling presented in this report is less conservative than past studies by Evans *et al.* (2015) and Butler *et al.* (2014), which both considered only the zero-baseline scenario for regrowth. However, even the novel regrowth scenario modelled in this report, assuming regrowth was seven years old at project establishment, is still conservative. This is primarily because it assumes complete displacement of all other economic activity upon establishment of a regrowth project. In reality, conservatively managed grazing can co-occur with regrowth carbon farming, and the economic benefit from grazing will decline as the regrowth develops, rather than immediately upon project establishment.

The higher level assessments provided here for savanna burning and soil carbon in grazing systems also indicates considerable potential for economic and greenhouse benefit. This potential is already well proven for savanna burning, which has the strong benefit of providing economic benefit in some very remote regions. Soil carbon is a new domain for carbon farming in Australia. However, we identified over half a million hectares of cropping land outside of the “Strategic cropping land” footprint, where a change to lower cultivation frequency and increase time under pasture would be highly likely to result in readily measured increases in soil carbon; the greatest extent of these areas in the Maranoa district. Given the current high cost nature of the measurement based method for soil carbon, it is probably unlikely that land use change of more subtle nature would prove economically beneficial. However, much anticipated new methods for soil carbon projects may change this outlook, so that more extensive projects with more subtle changes to management and soil carbon stocks could be contemplated.

The potential identified in this report far exceeds likely uptake, this is to be expected given that carbon farming is a new domain for Australian rural economies. However, slow uptake may also reflect uncertainty pervading carbon farming policy and climate change policy more broadly. Greater awareness of project options, projects in progress, and benefits from involvement will all tend to reassure potential participants and increase uptake over the short to medium term.

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Appendix 1

The quantitative analysis implemented for regrowth, environmental plantings and avoided deforestation differed slightly for the three methodologies but all involved three dimensions; suitability, costs and benefits. These were quantified by sampling spatial data listed in Table 2 across a grid of points covering Queensland at 0.01 degree spacing (~1km2). Costs and benefits were used to calculate the ACCU price at which each type of carbon farming would break even after 10, 25 and 100 years (i.e. price at which net present value = zero at those time horizons) for each cell of suitable land. Suitability was assessed against spatial data for land-use and vegetation extent, and was used to estimate the extent over which particular activities may be profitable and to identify regions where activities tend to be profitable too.

Assessment included 44 scenarios:

4 activities (EP, RG, AD1 & AD2)

x

2 permanence periods (25 or 100 yrs)

x

2 project scales (100 ha or 1000 ha)

x

2 time horizons (10 and 25 yrs) to assess net present value for the 16 combinations of activity/permanence/scale

+

8 combinations of 4 activities and 2 scales with 100 year permanence assessed at 100 yr time horizon

+

4 scenarios with variation in profit at full equity (PFE plus or minus 20%), assessed for EP and RG with 100 year permanence at a 25 year time horizon and large project scale.

= 44 scenarios

Suitability

Land potentially suited to carbon farming activities was identified using spatial data on vegetation condition and land-use. Principal sources are described in Table 2.

The extent of potentially suitable land in Queensland varied between activities (Table 4). Environmental planting has the largest potentially applicable area, covering grazing and dryland cropping land uses, but all activities were represented by more than two hundred thousand model points from the 0.05 degree grid across Queensland. Grazing is the most extensive land use in Queensland (Map 4) and is broadly compatible with regrowth, plantings or avoided deforestation. Land with intact or remnant native vegetation was excluded as suitable for activities for new forests from regrowth and plantings. All activities were also excluded from irrigated land for cropping or horticulture, and mining, urban and other intensive land uses. Land used for dryland cropping was included in analysis of plantings but not regrowth. These exclusions are consistent with the requirements of the applicable methodologies, but the regional scale of the analysis undoubtedly glosses over local complexities in landuse and the options for carbon farming that may be suited.

Note that no attempt was made to restrict the analysis for regrowth to land with current regrowth, within the broad extent of lands with appropriate land-use and cleared native vegetation. Instead, estimates of viable extent and sequestration potential were adjusted to reflect the proportion of suitable land likely to support suitable vegetation (either regrowth or forest suitable for AD). This is primarily because available methodologies for regrowth require relatively young regenerating forest, which in the authors experience is extremely difficult to map with any reliability. Similarly local constraints on suitability for plantings, such as site access and water availability, were not considered. The results are not recommended for property scale use.

The proportion of suitable land likely to support regrowth vegetation was estimated for each NRM region as the percentage of non-remnant woody vegetation that is not mapped high value regrowth (HVR) (i.e. younger and/or sparser than regrowth that qualifies as HVR), plus 90% of the mapped HVR, within the total extent of non-remnant grazing land for each region (Table 6). In areas where much of the remnant woody vegetation is naturally sparse (i.e. Desert Channels Queensland, Northern Gulf Resource Management Group and Southern Gulf Catchments), all non-remnant grazing lands were considered to have the potential for regrowth. For avoided deforestation we estimated the extent of land with suitable vegetation within each NRM as 10% of the mapped HVR within non-remnant grazing land.

Table 6 Percentage of suitable non-remnant area for regrowth and avoided deforestation for each NRM region.

NRM Region	Percentage of non-remnant grazing land with potential for regrowth	Percentage of non-remnant grazing land with potential for avoided deforestation
Burdekin Dry Tropics NRM	35%	1%
Burnett Mary Regional Group	40%	3%
Cape York Development Association	65%	2%
Condamine Alliance	20%	1%
Desert Channels Queensland	100%	1%
Fitzroy Basin Association	30%	1%
Mackay Whitsunday NRM Group	30%	2%
Northern Gulf Resource Management Group	100%	1%
Queensland Murray-Darling Committee	25%	1%
SEQ Catchments	50%	3%
South West NRM	70%	1%
Southern Gulf Catchments	100%	1%
Terrain NRM	40%	1%

Perhaps the most significant obvious disconnect between this analysis and reality was for the extent of land potentially suited to avoided deforestation projects. Prospects for application of the current methodology for avoided deforestation to Queensland are extremely restricted by the requirement for a permit to clear vegetation, issued before July 2010, which specifies that the clearing must result in permanent pasture or crop land. This requirement has been achievable under the regulatory framework in New South Wales. However, in Queensland the regulatory framework for most agricultural vegetation-clearing works through maps, identifying go and no-go zones, but rarely involves issuing permits to landholders. Without an historical document indicating intent to clear, it is hard to argue that the right to clear vegetation equals the intent to clear that vegetation. Therefore, either methodologies must be narrowly constrained to situations where clearing is clearly business as usual (e.g. regrowth from clearing in recent decade), or different approaches need to be applied to estimate the fraction of potential abatement that is actually additional when protecting native forest biomass open to clearing but without an historical permit (pre-dating carbon farming uptake).

For the economic assessment we considered two different approaches to additionality for avoided deforestation activity.

1. Avoided deforestation established as additional by permit (AD1).
2. Avoided deforestation with discount for likely additionality proportional to remnant proportion of pre-clearing ecosystem (AD2).

Costs

Costs included estimates for: on-ground management, plantation establishment (environmental plantings only), project administration, reporting and compliance. These costs were estimated based on literature searches and expert consultation. Cost also included opportunity costs, from foregone agricultural activity, based on a spatial dataset developed for profit at full equity for Australian agricultural enterprises (Marinoni *et al.* 2009). This basic structure follows Evans *et al.* (2015) and Butler *et al*. (2014) but has been modified slightly for this study to better reflect variation in costs across the landscape. For example, costs for plantation establishment in this study impose greater costs in rainforest lands (as per Evans *et al.* 2015) but also impose higher costs for areas with annual average less than 700 mm. 700mm is our evidence-based approximation of the current limit of plantation forestry in Queensland (Appendix 1).

The costs outlined in Table 6 include scenarios to reflect two different project scales. A small project scale, modelled on an environmental planting project in the order of 100 ha, with annual costs for maintenance and paperwork running to $65/ha/year ($35 on-ground, $10 for reporting, $20 for auditing), and $100/ha for paperwork at project establishment. Larger scale projects are expected to have lower costs per unit area. To assess the potential increase in economic viability that may arise from economies of scale, a large-scale scenario (~1000 ha) was also modelled with annual costs of $18/ha/year for maintenance and ongoing paperwork, plus the same $100/ha establishment fee.

Table 7 Summary of cost models for quantitative assessment of three carbon farming activities.

Environmental plantings (non-remnant grazing or dryland cropping country, n=240692)	Regrowth (non-remnant grazing country that wasn't grassland pre-clearing, n=217728)	Avoided deforestation (all grazing country except natural grasslands)
C1. One-off project establishment costs (contracts etc.) c) $100/ha small-scale scenario (~100ha) d) $10/ha large-scale scenario (~1000ha) C2. Planting establishment costs [depend on land type and rainfall]: d) $3000/ha if average annual rainfall <700mm e) $8000/ha if former rainforest f) $2000/ha otherwise C3. Recurring project management costs (on-ground and administration/reporting) c) $65/ha/yr for small-scale scenario (~100ha) ($35 on-ground + $10 reporting and other transactions + $20 for report audit) d) $18/ha/yr for large-scale scenario (~1000ha) ($15 on-ground + $1 reporting and other transactions + $2 for report audit) C4. Annual opportunity cost = Profit at full equity 2005/6 spatial data from Marinoni *et al*. (2011) adjusted to current value assuming 2.7% annual inflation. Scenarios adjusting PFE by +/-20% also modelled to assess sensitivity to this parameter.	C1. One-off project establishment costs (contracts etc.) c) $100/ha small-scale scenario (~100ha) d) $10/ha large-scale scenario (~1000ha) C2. Recurring project management costs (on-ground and administration/reporting) c) $65/ha/yr for small-scale scenario (~100ha) ($35 on-ground + $10 reporting and other transactions + $20 for report audit) d) $18/ha/yr for large-scale scenario (~1000ha) ($15 on-ground + $1 reporting and other transactions + $2 for report audit) C3. Annual Opportunity cost = Profit at full equity 2005/6 data from Marinoni *et al*. (2011) adjusted to current value assuming 2.7% annual inflation. Scenarios adjusting PFE by +/-20% also modelled to assess sensitivity to this parameter.	C1. One-off project establishment cost, includes expensive inventory involving destructive harvest and weighing of trees) c) $300/ha small-scale scenario (~100ha): $200 for inventory, $100 for paperwork d) $30/ha large-scale scenario (~1000ha): $20 inventory/$10 paperwork C2. Recurring project management costs (includes on-ground and administration/reporting) c) $65/ha/yr for small-scale scenario (~100ha) ($35 on-ground + $10 reporting and other transactions + $20 for report audit) d) $18/ha/yr for large-scale scenario (~1000ha) ($15 on-ground + $1 reporting and other transactions + $2 for report audit) C3. Yearly Opportunity cost = Profit at full equity 2005/6 data from Marinoni *et al*. (2011) adjusted to current value assuming 2.7% annual inflation. Scenarios adjusting PFE by +/-10% modelled to assess sensitivity to this parameter.

Economic analysis requires numerous assumptions about costs and benefits. Previous economic research has demonstrated substantial sensitivity in the outcomes of economic models of carbon farming to such assumptions about costs, carbon prices and discount rates. We undertook to assess model sensitivity to a few key issues, particularly sensitivity to variation in costs for different project scales, sensitivity to variation in profit at full equity, and sensitivity to project policy decisions on permanence (25 yr vs 100), the time horizon over which profitability is to be judged and the approach taken to additionality for avoided deforestation. This is justified because: sensitivity to price is directly addressed by evaluating price-to-break-even; sensitivity to discount rate is already well established by previous work (Polglase *et al.* 2011, Evans *et al*. 2015), and; cost is sensitive to project scale which, in turn, is highly relevant to the potential to influence natural resource management at landscape scale.

Beside fixed project costs, another key cost variable is opportunity cost. Estimating opportunity cost for our grid of sample points is clearly highly uncertain. Past studies have used land value as an index of opportunity coast. For this analysis an estimate of profit at full equity for agricultural enterprises across Australia, in units of dollars per hectare per year, was used as opportunity cost (Marinoni *et al.* 2012, Map 3). Marinoni *et al.* (2012) derived their estimate from a range of data, primarily from ABARE, gathered for the 2005/2006 financial year.

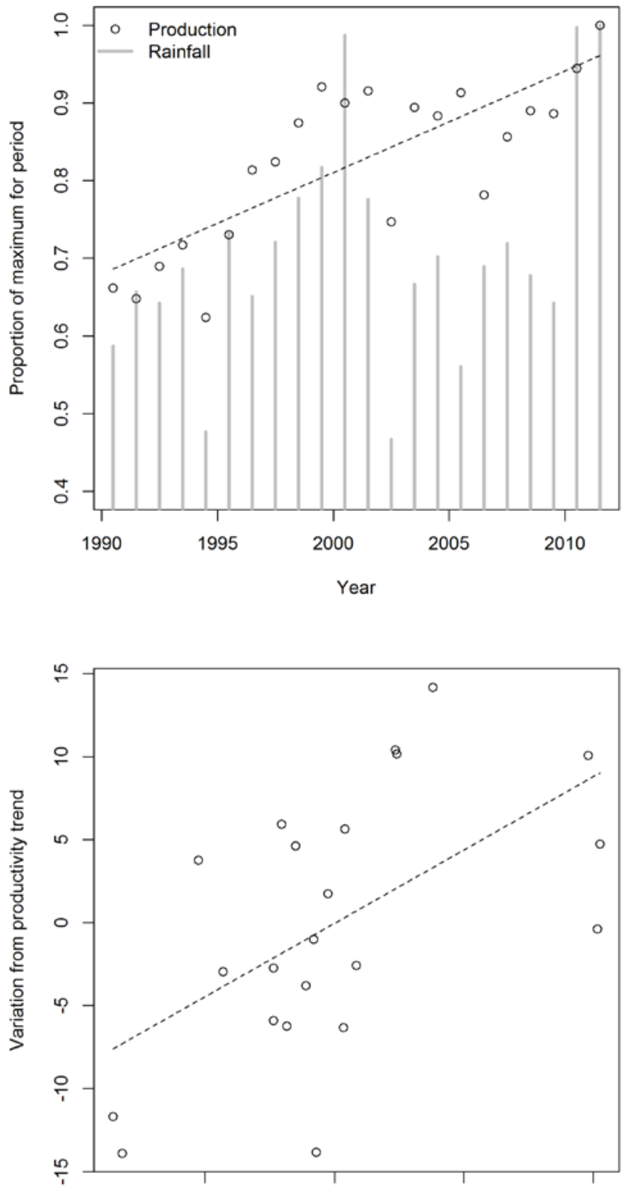


Figure 5 Relationship between agricultural productivity and rainfall for Australia. a. the basic relationship showing an increasing trend in productivity alongside variable rainfall, and b. correlation between rainfall and residuals from the trend of increasing productivity with time.

The 2005/6 financial year was not an outstanding year for Australian agriculture (Figure 5). Across eastern Australia a dry year in 2004 was followed by average to slightly below average rainfall in 2005 and below average rainfall in 2006 (http://www.bom.gov.au/climate/annual_sum/2005/page12.pdf & http://www.bom.gov.au/climate/annual_sum/2006/page12.pdf). This weather scenario implies that the estimate may be relatively low, which would tend to make carbon farming look more profitable than it should. The concentration of negative profit at full equity in major grain growing regions across eastern Australia in Map 3 (including the Darling Downs, Queensland's central highlands, the Moree Plain, and the Liverpool Plain) certainly suggests that the profit at full equity estimate may reflect austere times. However, even with this limitation, an estimate of profit at full equity is conceptually more suitable as an estimate of opportunity cost than the value of land, as has been used in other studies.

Given the potential for the profit at full equity data to be a low estimate or for profitability to change, we undertook a small sensitivity analysis for plantings and regrowth. Figure 6 shows that a 20% change in profit at full equity had minimal impact on the modelling results (divergence between the black and two grey solid lines) compared to choosing 25 year permanence (dashed lines), particularly for plantings.

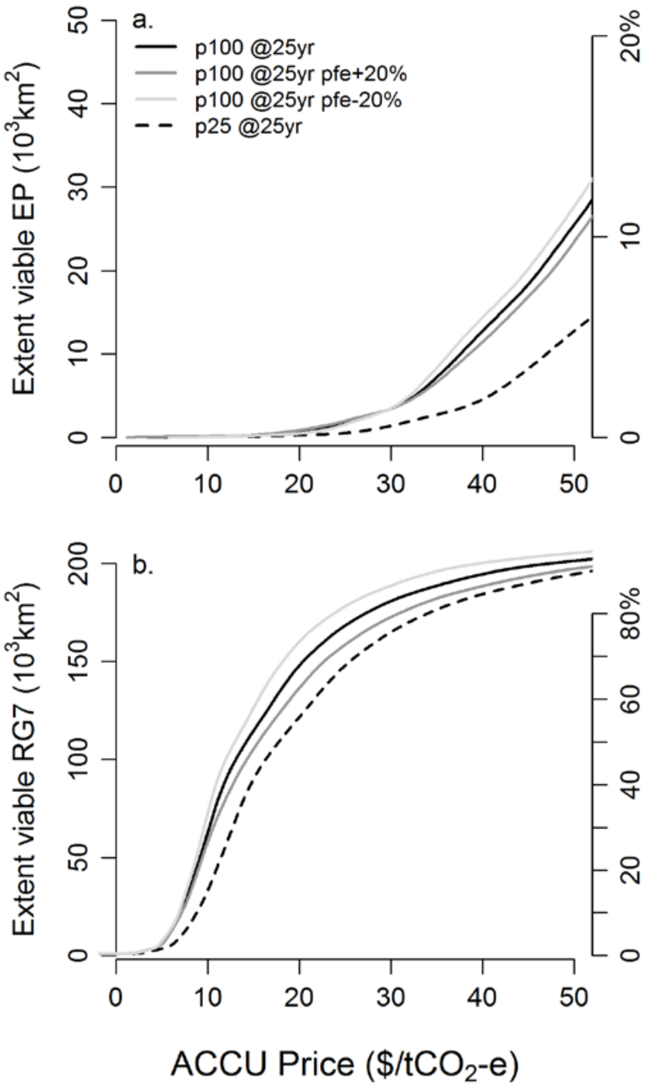


Figure 6 Sensitivity of economic models to variation in profit at full equity (+/-20%), compared to choice of permanence period for plantings and regrowth.

Benefits: biomass and carbon

The data and techniques used to model carbon benefits from carbon farming activities are consistent with approaches under Australia's National Greenhouse Gas Inventory (Commonwealth of Australia 2014a). This is most appropriate because carbon farming methodologies are required to be consistent with the National Greenhouse Gas Inventory. The spatial patterns in carbon dynamics for native vegetation in the National Greenhouse Gas Inventory are driven by a spatial model of forest productivity (Kesteven and Landsberg 2004). The same spatial model of forest productivity was used for this analysis but the model of temporal changes in carbon stock was a slightly simplified version of the method used for the National Greenhouse Gas Inventory and for carbon farming projects (i.e. FullCAM).

Forest carbon stocks were modelled for each cell in the one kilometre grid as a function of time since hypothetical forest establishment and the maximum above-ground biomass in native forests for each cell (i.e. from the national forest productivity model, Map 5, Eq. 1). This approach was developed by Richards and Brack (2004) and remains the basis of modelling carbon dynamics involving native forests in Australia's National Greenhouse Gas Inventory.

The model calculates above-ground biomass (*B*) a number of years (*a*) after forest establishment:

$$B_a = M.e^{(-2k/a)} \qquad \text{Eq. 1}$$

Where *M* is maximum above-ground biomass and *k* is a parameter that determines the age of maximum biomass increment and *e* is Euler's number (2.7183). *k* was set at 10 for plantations and 12 for regrowth (Richards and Brack 2004). We added biomass for roots, equal to 25 per cent of above-ground biomass, and converted biomass to carbon dioxide equivalent units by multiplying by 0.5 (a standard ratio for converting biomass to carbon) and then by 3.67 (the ratio of the molecular mass of CO_2 to the atomic mass of carbon is 44:12). This formulation ignores debris, and is therefore somewhat conservative.

A key point about the rate of carbon accumulation into regrowth or planted forests is that it changes as the forest develops (Fig. 1). The rate of forest growth typically increases with age in very young forests, peaks in the second decade or so, and subsequently declines with age (Fig. 1b).

Note that the models used to predict carbon benefits from new forest in this analysis assume ongoing average forest productivity reflected in the model of potential biomass (Map 5). Actual accounting for carbon sequestration in carbon farming projects (and the National Greenhouse Accounts) will produce rate of carbon gain that reflect variation in rainfall.

In our previous work on eastern QLD and NSW, regrowth biomass gains were modelled as if the regrowth only commenced at project commencement, as it does for plantings. However, this is a somewhat conservative assumption because project establishment under available methodologies requires regrowth to be sufficiently advanced to have potential to form native forest. It is likely that most regrowth projects will begin with a young forest around five to ten years old. To test the effect of this difference we have added a scenario where regrowth is seven years old at project commencement.

Carbon abatement estimates for avoided deforestation were also based on the potential biomass dataset. Abatement under avoided deforestation is spread over a 15 year period as outlined in the project methodology. We also used the maximum biomass dataset, intersected with clearing permit layers to obtain emission estimates for Olive Vale and Strathmore.

Data management and calculation

The analysis began by converting the profit at full equity layer into a grid of points at 0.05 degree spacing (~1km). This grid is essentially a systematic sample of Queensland. Each point was intersected with the other key data sets including maximum biomass, pre-clearing regional ecosystems, remnant regional ecosystems and land use.

Points without data for profit at full equity or maximum biomass were discarded. Points were also discarded if they fell outside the grazing and cropping land uses where carbon farming with land use change methods is applicable. All three methods were assessed for non-remnant areas. Only avoided deforestation was assessed for points that fell within remnant vegetation. An R script was used to loop through the points in one at a time, to calculate a 100 year sequence of net present value for costs and benefits. Price to break even was calculated as the price at which net present value of cost and benefits would be equivalent at either 10, 25 or 100 years after project commencement. These values were written to an output file and used to create the plots and spatial grids present in this report.

Table 8 Summary of models of economic benefit for quantitative assessment of three carbon farming activities.

Environmental plantings (non-remnant grazing or dryland cropping country)	Regrowth (non-remnant grazing country)	Avoided deforestation (non-remnant or remnant grazing country) – 2 scenarios
Live biomass modelled as function of NCAS maximum biomass data set (M) after Richards and Brack (2004). $C = 1.25*0.5*(44/12)*M^{(-2k/a)}$ Where: C = forest carbon stock (t CO_2-e / ha) k = forest age at peak growth rate = 10 years a = forest age, zero at project commencement M = maximum biomass	Live biomass modelled as function of NCAS maximum biomass data set (M) after Richards and Brack (2004). $C = 1.25*0.5*(44/12)*M^{(-2k/a)}$ Where: C = forest carbon stock (t CO_2-e / ha) k = forest age at peak growth rate = 12 years a = forest age, assumed to be 7 years at project commencement (sensitivity to this assumption assessed by comparing results to scenario assuming age zero at project commencement) M = maximum biomass	Base scenario (AD1) - Live biomass modelled as 40% of maximum biomass from NCAS. This discount approximates biomass in regrowth 30-40 years old C = 1.25*0.5*(44/12)*M*0.4 Where: C = forest carbon stock (t CO_2-e / ha) M = maximum biomass Alternate scenario (AD2) – Biomass as above but further discounted by 1-%remnant for pre-clearing ecosystem type Ca = C*PrNR Where: Ca = additionality adjusted forest carbon stock (t CO_2-e / ha) C = forest carbon stock (t CO_2-e / ha) calculated as for Base scenario above PrNR = based on pre-clearing regional ecosystem mapped at each model point, equals proportion of that ecosystems pre-clearing extent that is non-remnant vegetation

Appendix 2 – Region specific results

Burdekin Dry Tropics NRM

Table 9 Summary of potential for Burdekin Dry Tropics NRM region.

Activity[3]	Project Scale	Extent of suitable land where it may be economically viable ('000s km^2)			Potential CO_2-e sequestered over 10 years (Mt CO_2-e)			Potential rate of ongoing sequestration after 10 years (Mt CO_2-e /year)			Potential CO2-e sequestered over 20 years (Mt CO_2-e)			Potential rate of ongoing sequestration after 20 years (Mt CO_2-e /year)		
		$15	$20	$30	$15	$20	$30	$15	$20	$30	$15	$20	$30	$15	$20	$30
Environmental plantings	~1000ha	0.0	0.004	0.08	0.0	0.02	0.4	0.0	0.004	0.09	0.0	0.06	1.2	0.0	0.003	0.06
	~100ha	0.0	0.0	0.007	0.0	0.0	0.05	0.0	0.0	0.01	0.0	0.0	0.1	0.0	0.0	0.007
Regrowth – zero baseline	~1000ha	5.2	6.6	8.0	8.2	9.7	11.0	1.9	2.3	2.6	27.3	32.4	36.4	1.7	2.0	2.2
	~100ha	0.0	0.1	1.1	0.0	0.3	2.4	0.0	0.1	0.6	0.1	1.1	7.9	0.0	0.1	0.5
Regrowth – 7yo	~1000ha	6.7	7.8	8.5	9.9	10.8	11.2	2.3	2.5	2.6	32.8	35.8	37.3	2.0	2.2	2.3
	~100ha	0.1	0.7	3.7	0.4	1.6	6.7	0.1	0.4	1.6	1.4	5.4	22.3	0.1	0.3	1.4
Avoided deforestation – permit based	~1000ha	0.2	0.2	0.2	0.9	0.9	0.9	0.1	0.1	0.1	1.3	1.4	1.4	0.0	0.0	0.0
	~100ha	0.0	0.0	0.1	0.1	0.2	0.6	0.0	0.0	0.1	0.1	0.3	1.0	0.0	0.0	0.0
Avoided deforestation – risk based	~1000ha	0.1	0.2	0.2	0.6	0.7	0.8	0.1	0.1	0.1	1.0	1.1	1.2	0.0	0.0	0.0
	~100ha	0.0	0.0	0.1	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0

[3] Extent is based on land with appropriate land use and non-remnant vegetation for plantings. Regrowth and avoided deforestation require regrowth availability or forest subject to clearing, so the figures for those methods are adjusted using the estimated proportions in Table X of the land area with appropriate land use, non-remnant vegetation with regrowth potential or avoided deforestation potential and modelled to have economic viability (positive net present value after 25 years) at each specific price.

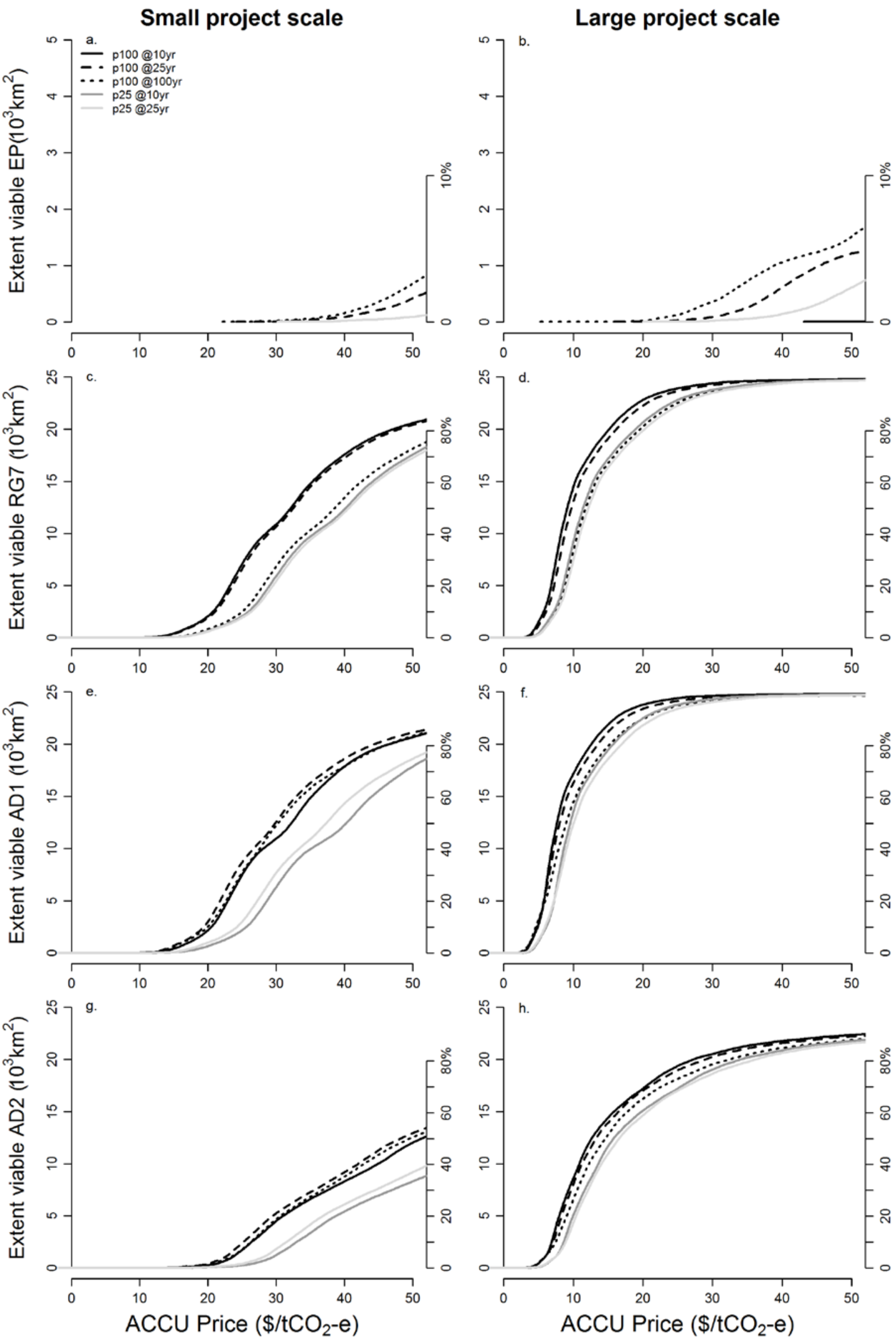
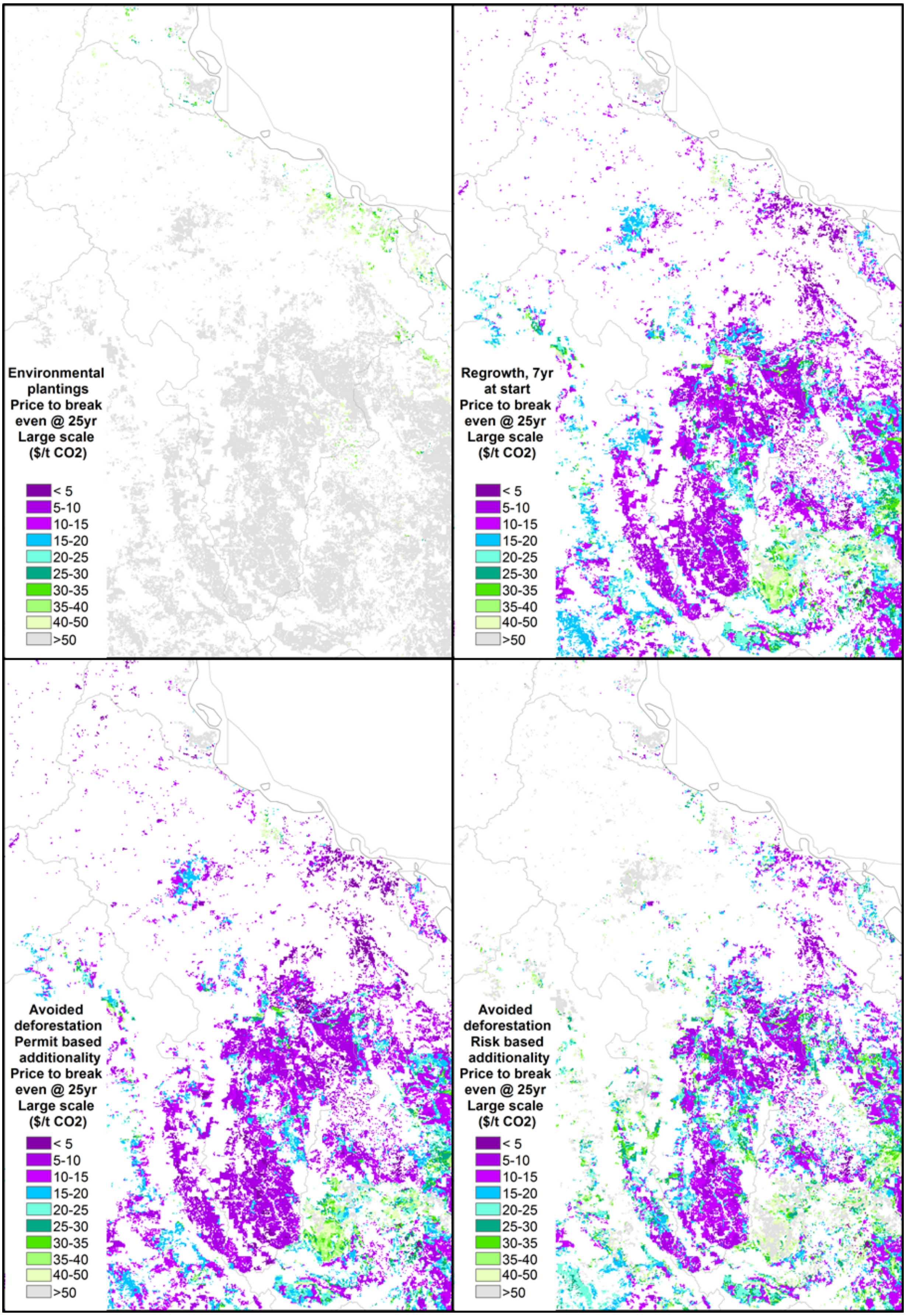


Figure 7 Economic models of land use change activities for Burdekin Dry Tropics NRM



Map 14 Price to break even for large scale projects with 100 year permanence over a 25 year investment period for Burdekin Dry Tropics NRM.

Burnett-Mary NRM

Table 10 Summary of potential for Burnett Mary Regional Group.

Activity[4]	Project Scale	Extent of suitable land where it may be economically viable ('000s km^2)			Potential CO_2-e sequestered over 10 years (Mt CO_2-e)			Potential rate of ongoing sequestration after 10 years (Mt CO_2-e /year)			Potential CO2-e sequestered over 20 years (Mt CO_2-e)			Potential rate of ongoing sequestration after 20 years (Mt CO_2-e /year)		
		$15	$20	$30	$15	$20	$30	$15	$20	$30	$15	$20	$30	$15	$20	$30
Environmental plantings	~1000ha	0.08	0.14	0.8	0.6	1.01	5.4	0.1	0.2	1.07	1.6	2.8	14.6	0.08	0.1	0.7
	~100ha	0.06	0.07	0.3	0.4	0.5	2.0	0.09	0.1	0.4	1.2	1.4	5.4	0.06	0.07	0.3
Regrowth – zero baseline	~1000ha	1.6	3.2	4.7	5.7	10.6	14.2	1.3	2.5	3.3	19.0	35.3	47.2	1.2	2.2	2.9
	~100ha	0.1	0.4	2.2	0.4	1.8	8.2	0.1	0.4	1.9	1.3	6.1	27.3	0.1	0.4	1.7
Regrowth – 7yo	~1000ha	3.4	4.4	5.3	11.0	13.5	15.8	2.6	3.2	3.7	36.6	44.8	52.6	2.2	2.7	3.2
	~100ha	0.4	1.6	4.0	2.1	6.4	13.3	0.5	1.5	3.1	6.9	21.4	44.1	0.4	1.3	2.7
Avoided deforestation – permit based	~1000ha	0.3	0.3	0.4	2.6	3.1	3.5	0.3	0.3	0.4	3.9	4.6	5.3	0.0	0.0	0.0
	~100ha	0.0	0.2	0.3	0.6	1.7	3.0	0.1	0.2	0.3	0.8	2.5	4.5	0.0	0.0	0.0
Avoided deforestation – risk based	~1000ha	0.1	0.2	0.3	1.0	1.6	2.7	0.1	0.2	0.3	1.5	2.4	4.0	0.0	0.0	0.0
	~100ha	0.0	0.0	0.1	0.2	0.5	1.2	0.0	0.0	0.1	0.2	0.7	1.8	0.0	0.0	0.0

[4] Extent is based on land with appropriate land use and non-remnant vegetation for plantings. Regrowth and avoided deforestation require regrowth availability or forest subject to clearing, so the figures for those methods are adjusted using the estimated proportions in Table X of the land area with appropriate land use, non-remnant vegetation with regrowth potential or avoided deforestation potential and modelled to have economic viability (positive net present value after 25 years) at each specific price.

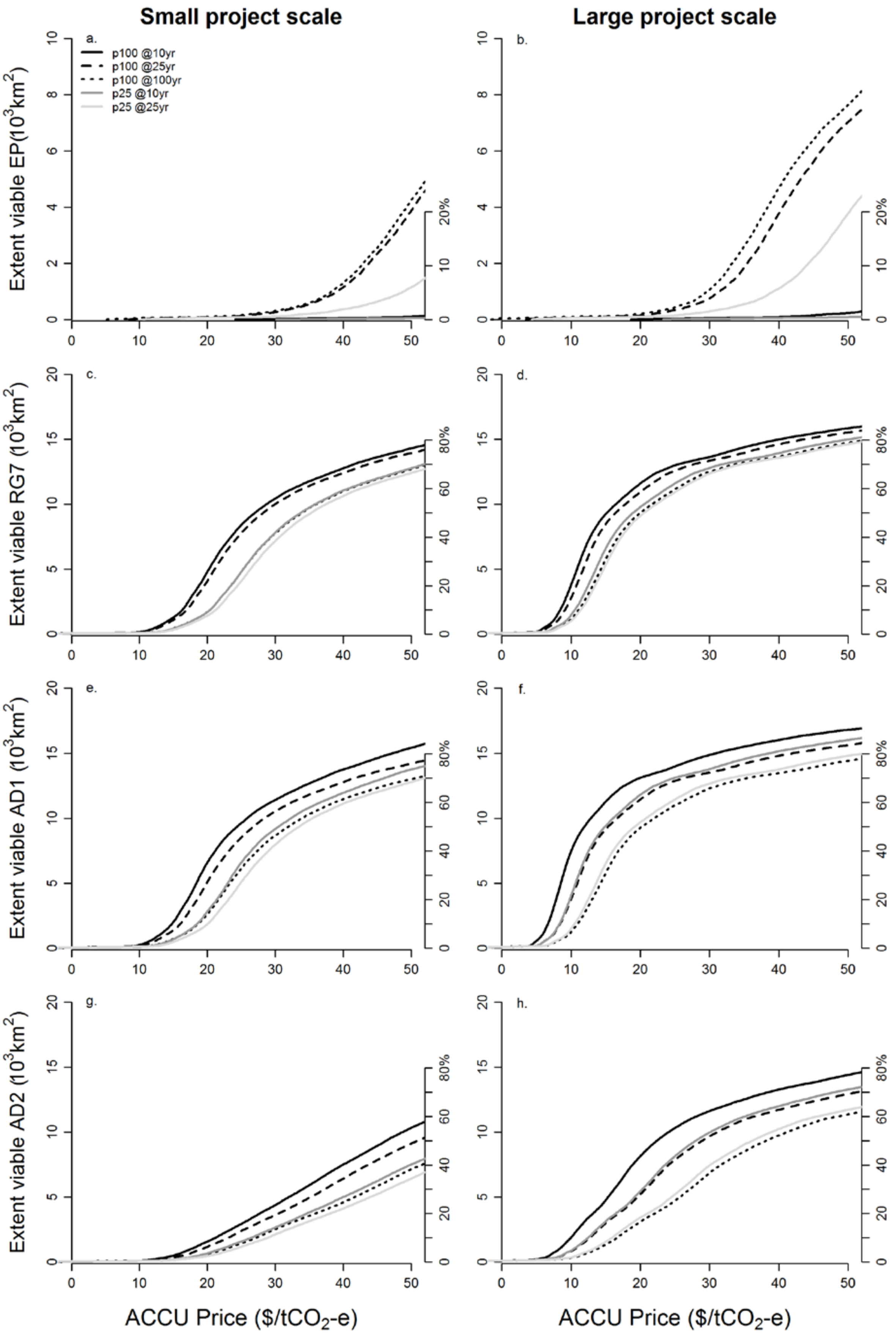
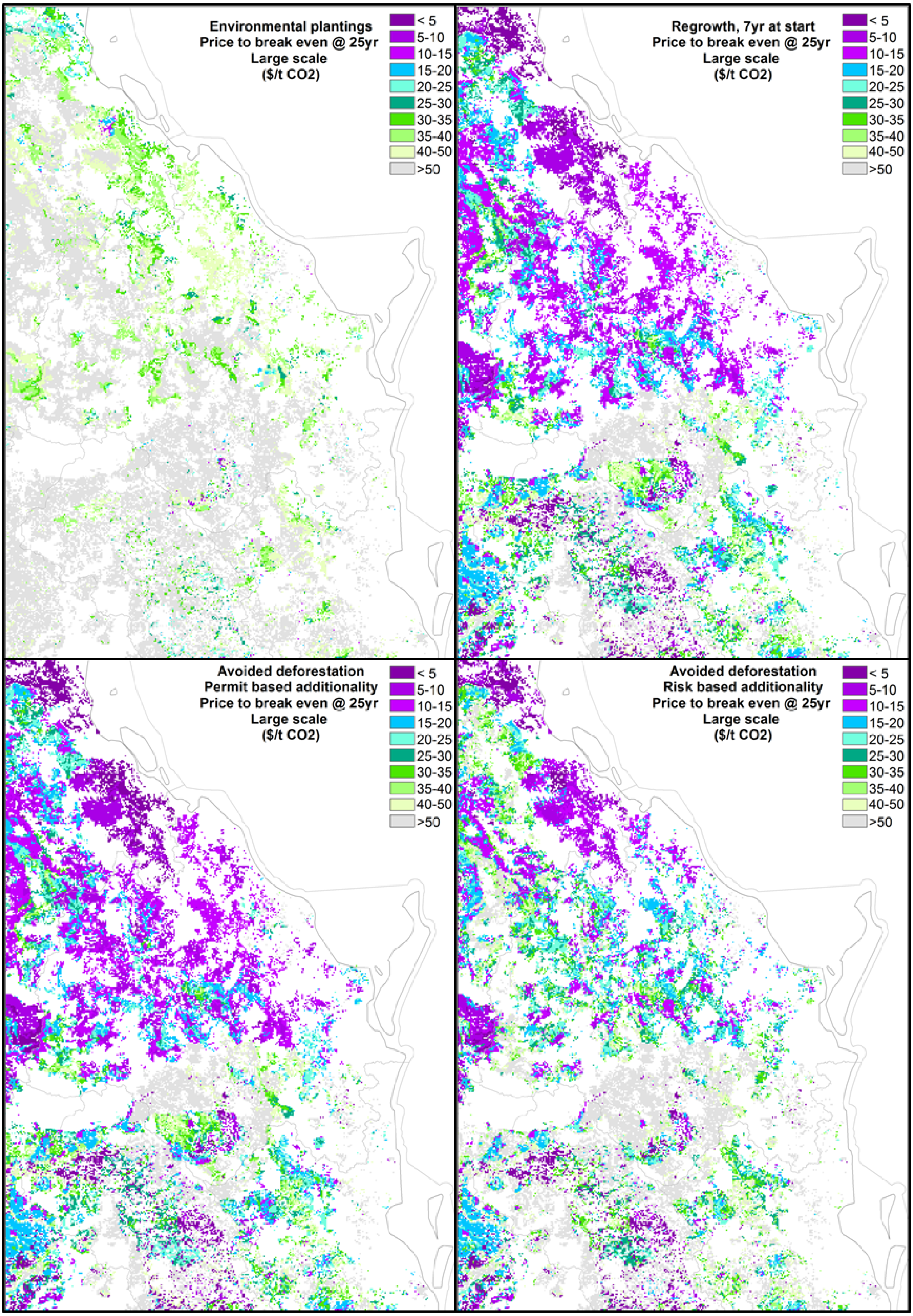


Figure 8 Economic models of land use change activities for Burnett Mary Regional Group.



Map 15 Price to break even for large scale projects with 100 year permanence over a 25 year investment period for Burnett Mary Regional Group.

Cape York Development Association

Table 11 Summary of potential for Cape York Development Association.

Activity[5]	Project Scale	Extent of suitable land where it may be economically viable ('000s km^2)			Potential CO_2-e sequestered over 10 years (Mt CO_2-e)			Potential rate of ongoing sequestration after 10 years (Mt CO_2-e /year)			Potential CO2-e sequestered over 20 years (Mt CO_2-e)			Potential rate of ongoing sequestration after 20 years (Mt CO_2-e /year)		
		$15	$20	$30	$15	$20	$30	$15	$20	$30	$15	$20	$30	$15	$20	$30
Environmental plantings	~1000ha	0.008	0.02	0.06	0.09	0.2	0.4	0.02	0.04	0.08	0.3	0.5	1.1	0.01	0.03	0.06
	~100ha	0.001	0.008	0.03	0.01	0.09	0.2	0.002	0.02	0.04	0.03	0.3	0.6	0.002	0.01	0.03
Regrowth – zero baseline	~1000ha	0.2	0.2	0.2	0.5	0.5	0.5	0.1	0.1	0.1	1.5	1.5	1.5	0.1	0.1	0.1
	~100ha	0.0	0.1	0.1	0.2	0.2	0.4	0.0	0.1	0.1	0.6	0.8	1.3	0.0	0.1	0.1
Regrowth – 7yo	~1000ha	0.2	0.2	0.2	0.5	0.5	0.5	0.1	0.1	0.1	1.5	1.5	1.5	0.1	0.1	0.1
	~100ha	0.1	0.1	0.2	0.3	0.4	0.5	0.1	0.1	0.1	0.8	1.3	1.5	0.1	0.1	0.1
Avoided deforestation – permit based	~1000ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.0
	~100ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0
Avoided deforestation – risk based	~1000ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	~100ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

[5] Extent is based on land with appropriate land use and non-remnant vegetation for plantings. Regrowth and avoided deforestation require regrowth availability or forest subject to clearing, so the figures for those methods are adjusted using the estimated proportions in Table X of the land area with appropriate land use, non-remnant vegetation with regrowth potential or avoided deforestation potential and modelled to have economic viability (positive net present value after 25 years) at each specific price.

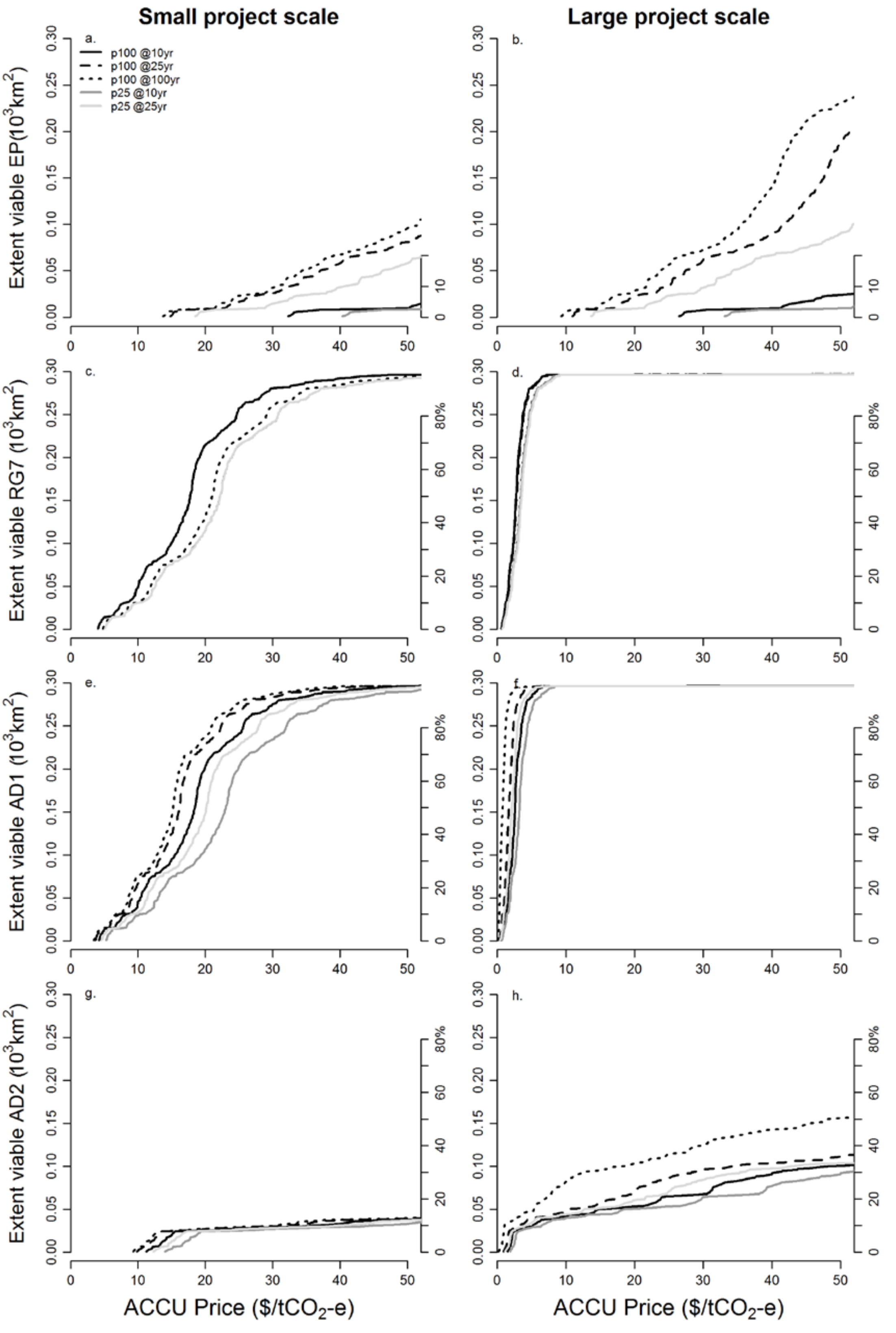
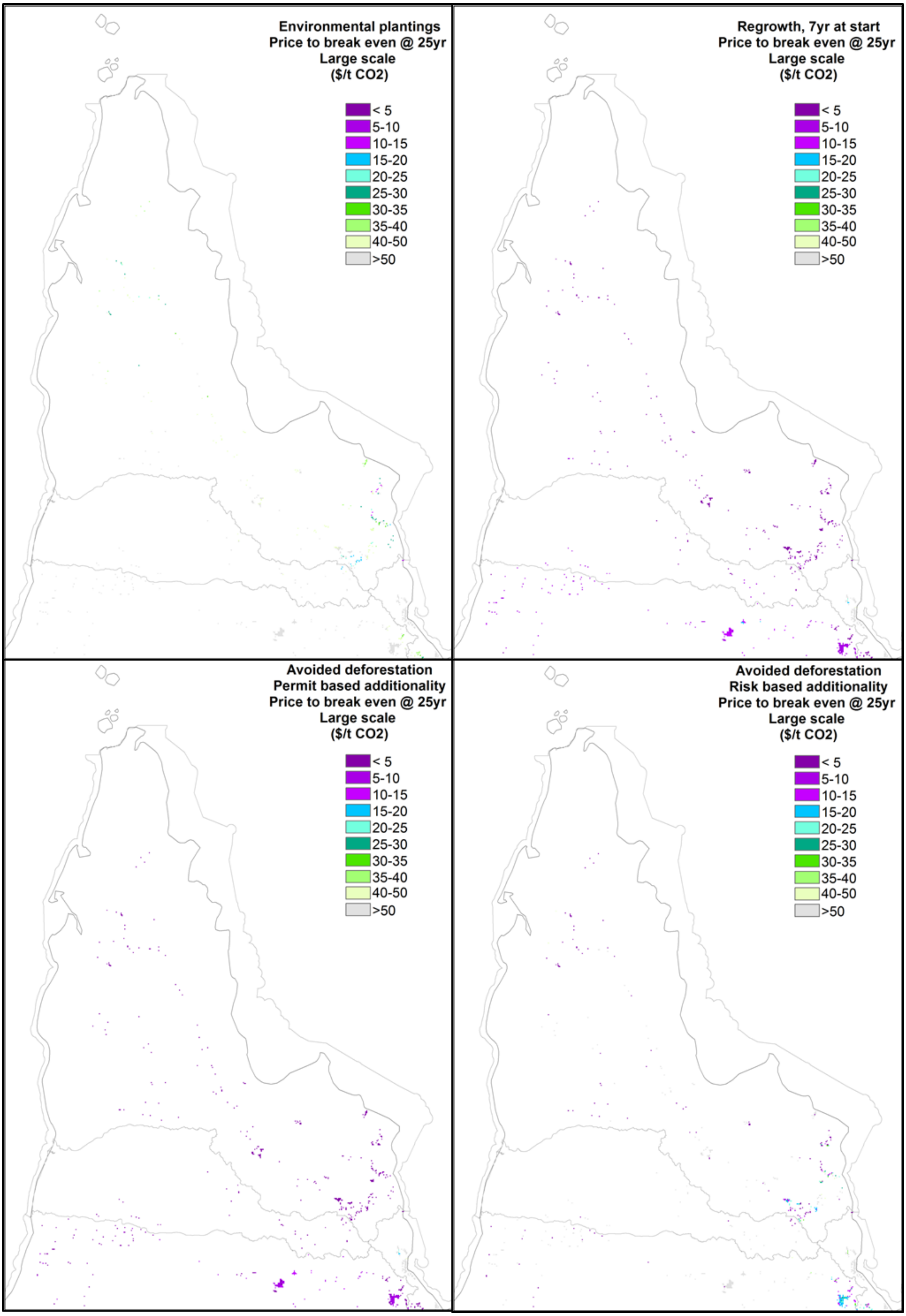


Figure 9 Economic models of land use change activities for Cape York Development Association.



Map 16 Price to break even for large scale projects with 100 year permanence over a 25 year investment period for Cape York Development Association.

Condamine Alliance

Table 12 Summary of potential for Condamine Alliance.

Activity[6]	Project Scale	Extent of suitable land where it may be economically viable ('000s km^2)			Potential CO_2-e sequestered over 10 years (Mt CO_2-e)			Potential rate of ongoing sequestration after 10 years (Mt CO_2-e /year)			Potential CO2-e sequestered over 20 years (Mt CO_2-e)			Potential rate of ongoing sequestration after 20 years (Mt CO_2-e /year)		
		$15	$20	$30	$15	$20	$30	$15	$20	$30	$15	$20	$30	$15	$20	$30
Environmental plantings	~1000ha	0.03	0.07	0.6	0.1	0.4	2.6	0.02	0.08	0.5	0.3	1.0	7.2	0.02	0.05	0.4
	~100ha	0.002	0.02	0.1	0.01	0.09	0.6	0.002	0.02	0.1	0.03	0.2	1.6	0.002	0.01	0.08
Regrowth – zero baseline	~1000ha	0.1	0.2	0.4	0.2	0.4	0.9	0.0	0.1	0.2	0.6	1.5	3.0	0.0	0.1	0.2
	~100ha	0.0	0.0	0.1	0.1	0.1	0.2	0.0	0.0	0.1	0.3	0.4	0.7	0.0	0.0	0.0
Regrowth – 7yo	~1000ha	0.2	0.3	0.5	0.5	0.8	1.1	0.1	0.2	0.3	1.6	2.8	3.8	0.1	0.2	0.2
	~100ha	0.0	0.1	0.3	0.1	0.2	0.7	0.0	0.0	0.2	0.4	0.6	2.3	0.0	0.0	0.1
Avoided deforestation – permit based	~1000ha	0.0	0.0	0.0	0.1	0.1	0.2	0.0	0.0	0.0	0.1	0.2	0.3	0.0	0.0	0.0
	~100ha	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0
Avoided deforestation – risk based	~1000ha	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.1	0.1	0.2	0.0	0.0	0.0
	~100ha	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0

[6] Extent is based on land with appropriate land use and non-remnant vegetation for plantings. Regrowth and avoided deforestation require regrowth availability or forest subject to clearing, so the figures for those methods are adjusted using the estimated proportions in Table X of the land area with appropriate land use, non-remnant vegetation with regrowth potential or avoided deforestation potential and modelled to have economic viability (positive net present value after 25 years) at each specific price.

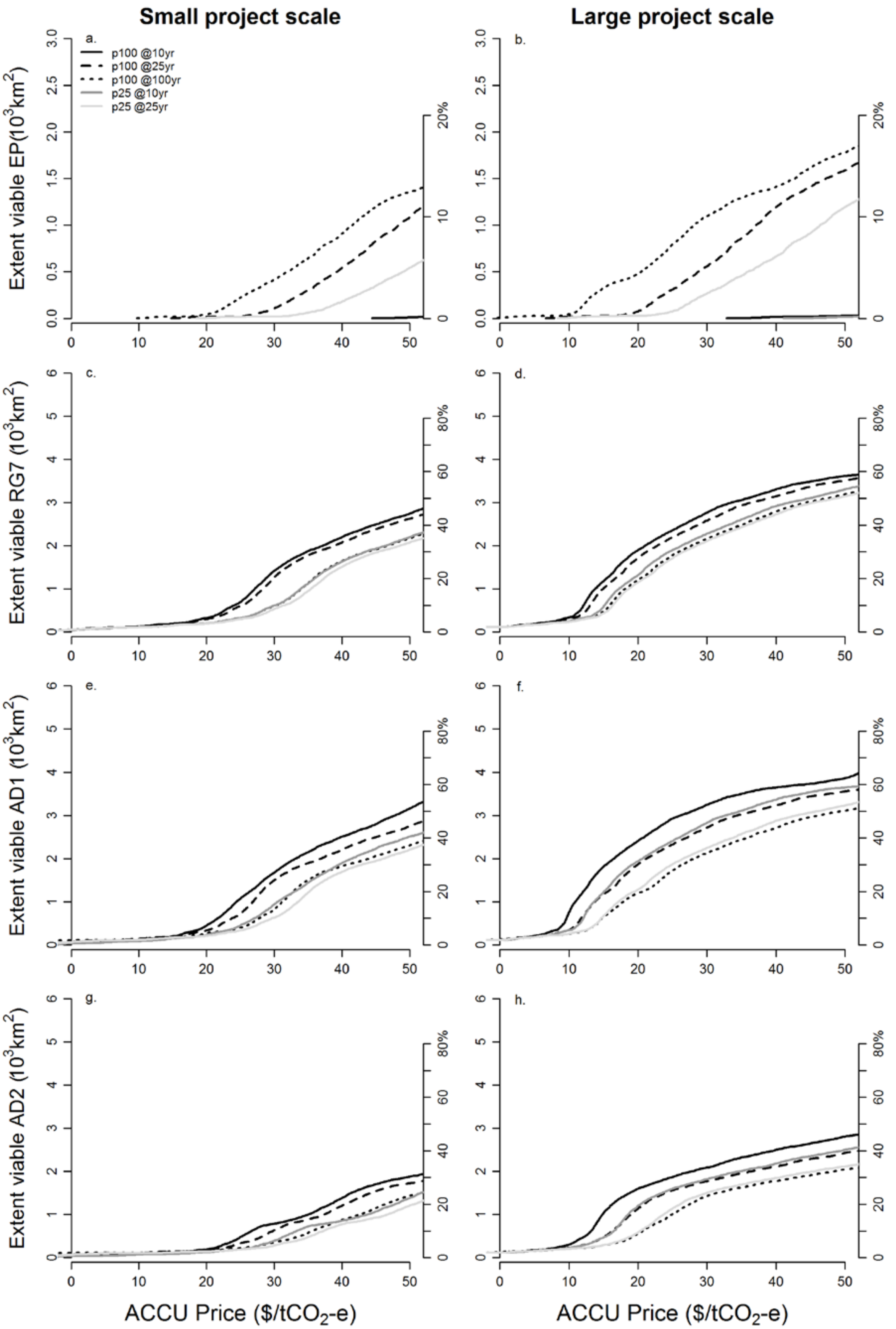
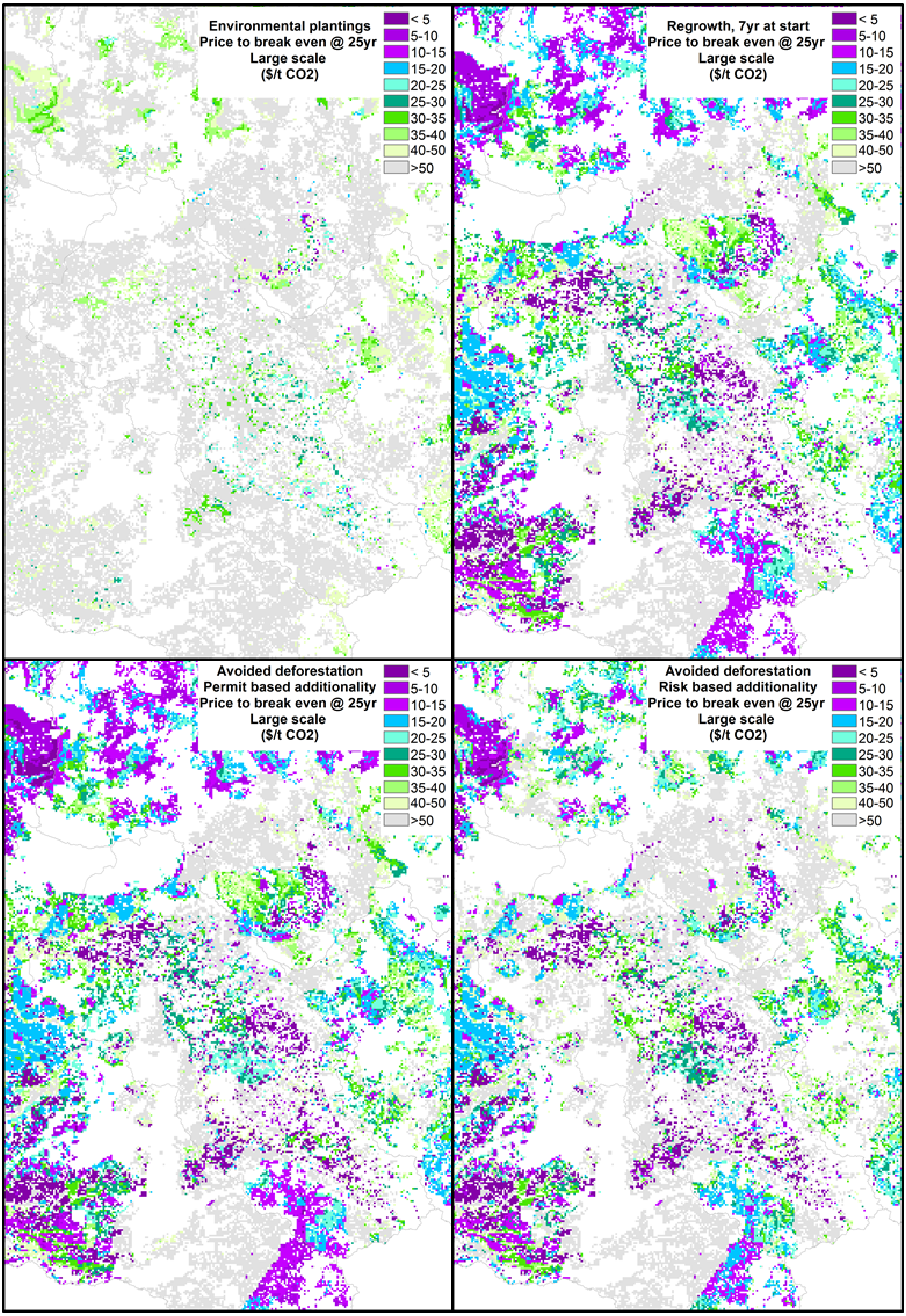


Figure 10 Economic models of land use change activities for Condamine Alliance.



Map 17 Price to break even for large scale projects with 100 year permanence over a 25 year investment period for Condamine Alliance.

Desert Channels Queensland

Table 13 Summary of potential for Desert Channels Queensland.

Activity[7]	Project Scale	Extent of suitable land where it may be economically viable ('000s km^2)			Potential CO_2-e sequestered over 10 years (Mt CO_2-e)			Potential rate of ongoing sequestration after 10 years (Mt CO_2-e /year)			Potential CO2-e sequestered over 20 years (Mt CO_2-e)			Potential rate of ongoing sequestration after 20 years (Mt CO_2-e /year)		
		$15	$20	$30	$15	$20	$30	$15	$20	$30	$15	$20	$30	$15	$20	$30
Environmental plantings	~1000ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	~100ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Regrowth – zero baseline	~1000ha	5.0	7.8	13.6	5.5	8.3	13.2	1.3	1.9	3.1	18.1	27.4	43.9	1.1	1.7	2.7
	~100ha	0.0	0.0	0.1	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0
Regrowth – 7yo	~1000ha	8.3	12.8	15.3	8.7	12.7	14.0	2.0	3.0	3.3	28.9	42.3	46.5	1.8	2.6	2.8
	~100ha	0.0	0.0	1.3	0.0	0.1	2.0	0.0	0.0	0.5	0.0	0.2	6.7	0.0	0.0	0.4
Avoided deforestation – permit based	~1000ha	0.1	0.1	0.2	0.3	0.4	0.4	0.0	0.0	0.0	0.5	0.6	0.6	0.0	0.0	0.0
	~100ha	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0
Avoided deforestation – risk based	~1000ha	0.0	0.0	0.1	0.1	0.2	0.3	0.0	0.0	0.0	0.1	0.3	0.4	0.0	0.0	0.0
	~100ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

[7] Extent is based on land with appropriate land use and non-remnant vegetation for plantings. Regrowth and avoided deforestation require regrowth availability or forest subject to clearing, so the figures for those methods are adjusted using the estimated proportions in Table X of the land area with appropriate land use, non-remnant vegetation with regrowth potential or avoided deforestation potential and modelled to have economic viability (positive net present value after 25 years) at each specific price.

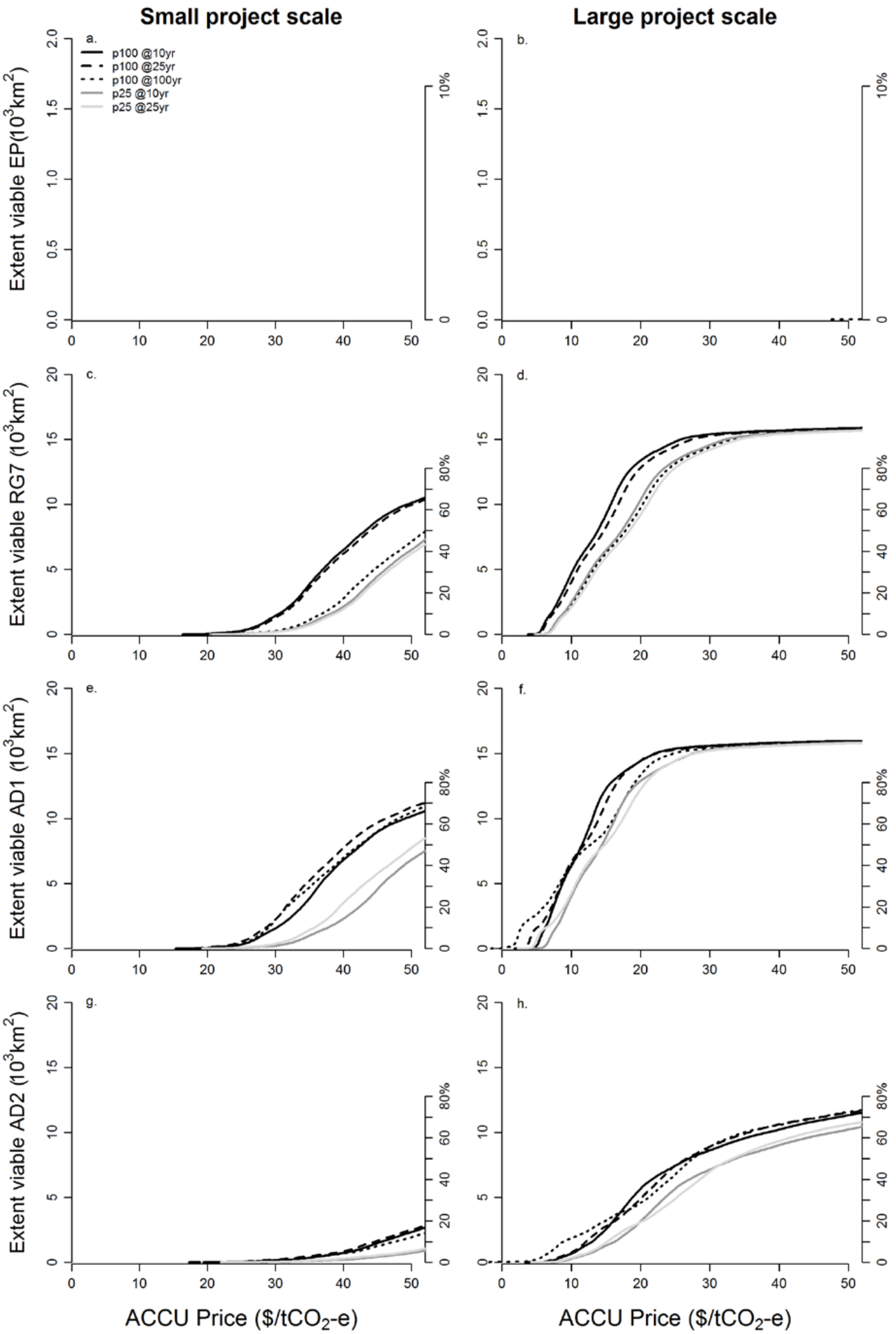
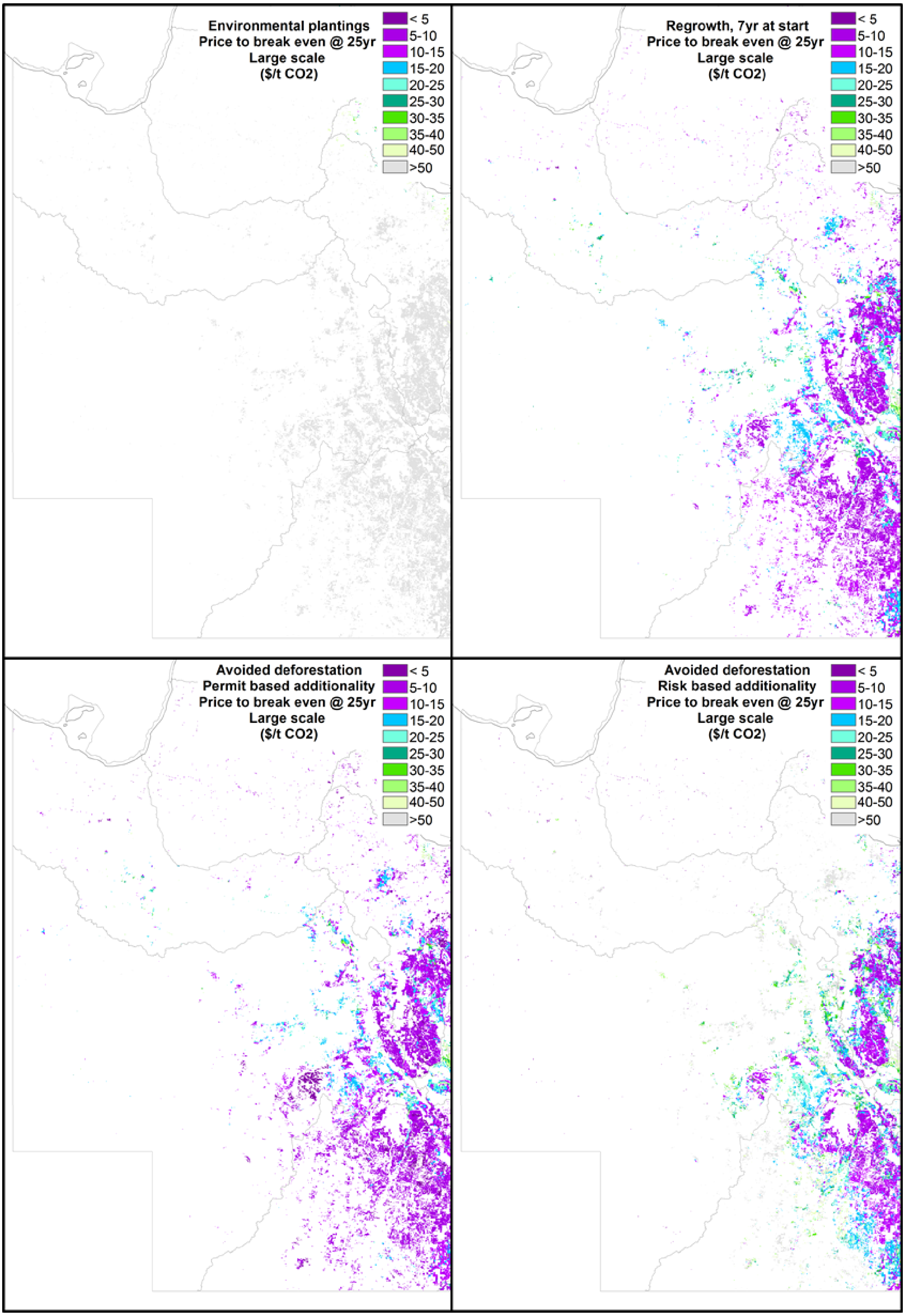


Figure 11 Economic models of land use change activities for Desert Channels Queensland.



Map 18 Price to break even for large scale projects with 100 year permanence over a 25 year investment period for Desert Channels Queensland.

Fitzroy Basin Association

Table 14 Summary of potential for Fitzroy Basin Association.

Activity[8]	Project Scale	Extent of suitable land where it may be economically viable ('000s km^2)			Potential CO_2-e sequestered over 10 years (Mt CO_2-e)			Potential rate of ongoing sequestration after 10 years (Mt CO_2-e /year)			Potential CO2-e sequestered over 20 years (Mt CO_2-e)			Potential rate of ongoing sequestration after 20 years (Mt CO_2-e /year)		
		$15	$20	$30	$15	$20	$30	$15	$20	$30	$15	$20	$30	$15	$20	$30
Environmental plantings	~1000ha	0.06	0.19	1.5	0.5	1.4	8.3	0.1	0.3	1.7	1.3	3.9	22.5	0.07	0.2	1.2
	~100ha	0.001	0.07	0.4	0.006	0.6	2.7	0.001	0.1	0.5	0.02	1.6	7.4	0.000 8	0.08	0.4
Regrowth – zero baseline	~1000ha	6.3	9.4	12.8	16.8	24.0	29.6	3.9	5.6	6.9	55.8	79.6	98.2	3.4	4.9	6.0
	~100ha	0.3	1.0	5.9	1.4	3.8	17.1	0.3	0.9	4.0	4.6	12.5	56.7	0.3	0.8	3.5
Regrowth – 7yo	~1000ha	9.7	12.0	15.6	24.5	28.4	33.8	5.7	6.7	7.9	81.3	94.4	112.3	5.0	5.8	6.9
	~100ha	1.3	4.4	9.2	4.6	13.1	24.7	1.1	3.1	5.8	15.1	43.6	82.0	0.9	2.7	5.0
Avoided deforestation – permit based	~1000ha	0.3	0.4	0.5	2.5	2.9	3.4	0.3	0.3	0.3	3.8	4.3	5.0	0.0	0.0	0.0
	~100ha	0.1	0.2	0.3	0.6	1.6	2.5	0.1	0.2	0.3	0.9	2.4	3.8	0.0	0.0	0.0
Avoided deforestation – risk based	~1000ha	0.2	0.3	0.4	1.9	2.3	2.8	0.2	0.2	0.3	2.9	3.5	4.3	0.0	0.0	0.0
	~100ha	0.0	0.1	0.2	0.2	0.7	1.7	0.0	0.1	0.2	0.3	1.1	2.6	0.0	0.0	0.0

[8] Extent is based on land with appropriate land use and non-remnant vegetation for plantings. Regrowth and avoided deforestation require regrowth availability or forest subject to clearing, so the figures for those methods are adjusted using the estimated proportions in Table X of the land area with appropriate land use, non-remnant vegetation with regrowth potential or avoided deforestation potential and modelled to have economic viability (positive net present value after 25 years) at each specific price.

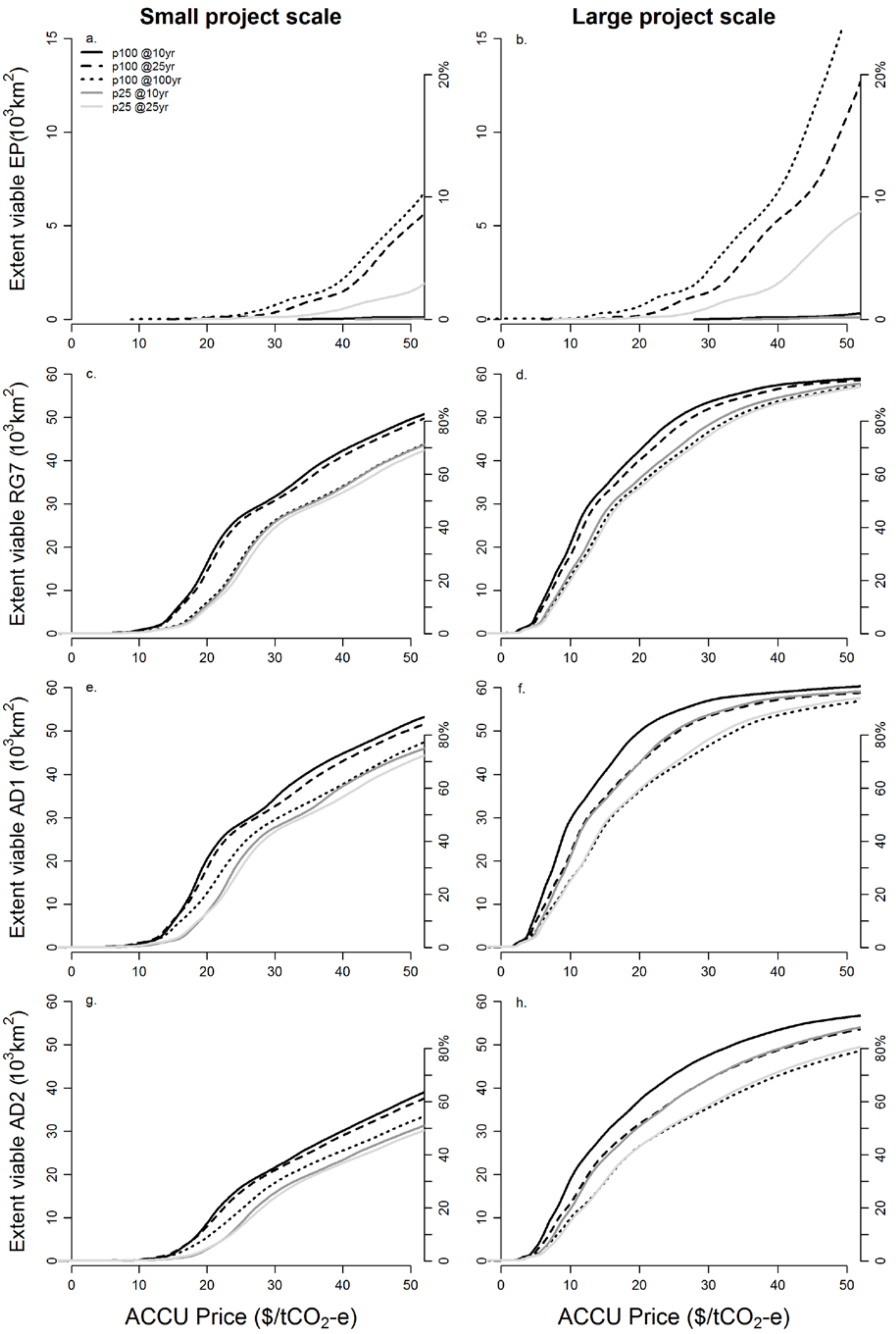
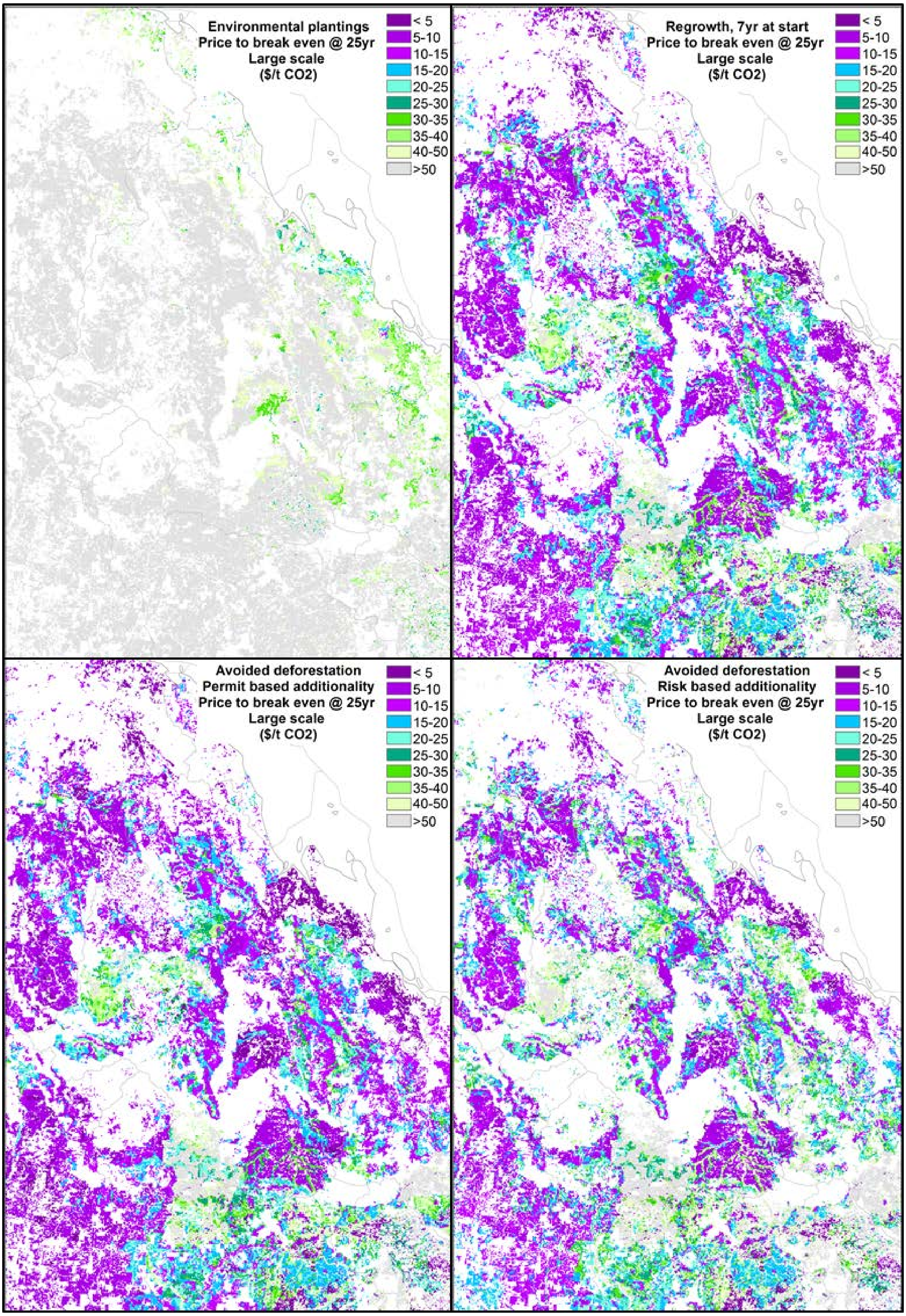


Figure 12 Economic models of land use change activities for Fitzroy Basin Association.



Map 19 Price to break even for large scale projects with 100 year permanence over a 25 year investment period for Fitzroy Basin Association.

Mackay Whitsunday NRM Group

Table 15 Summary of potential for Mackay Whitsunday NRM Group.

Activity[9]	Project Scale	Extent of suitable land where it may be economically viable ('000s km^2)			Potential CO_2-e sequestered over 10 years (Mt CO_2-e)			Potential rate of ongoing sequestration after 10 years (Mt CO_2-e /year)			Potential CO2-e sequestered over 20 years (Mt CO_2-e)			Potential rate of ongoing sequestration after 20 years (Mt CO_2-e /year)		
		$15	$20	$30	$15	$20	$30	$15	$20	$30	$15	$20	$30	$15	$20	$30
Environmental plantings	~1000ha	0.008	0.03	0.1	0.08	0.2	1.1	0.02	0.04	0.2	0.2	0.6	3.0	0.01	0.03	0.2
	~100ha	0.0	0.009	0.06	0.0	0.1	0.5	0.0	0.02	0.1	0.0	0.3	1.3	0.0	0.01	0.07
Regrowth – zero baseline	~1000ha	0.1	0.2	0.3	0.3	0.6	0.8	0.1	0.1	0.2	1.1	1.8	2.7	0.1	0.1	0.2
	~100ha	0.0	0.0	0.1	0.1	0.2	0.4	0.0	0.0	0.1	0.3	0.6	1.4	0.0	0.0	0.1
Regrowth – 7yo	~1000ha	0.2	0.2	0.3	0.6	0.8	0.9	0.1	0.2	0.2	2.0	2.6	2.8	0.1	0.2	0.2
	~100ha	0.0	0.1	0.2	0.2	0.4	0.8	0.0	0.1	0.2	0.7	1.2	2.6	0.0	0.1	0.2
Avoided deforestation – permit based	~1000ha	0.0	0.0	0.0	0.1	0.2	0.2	0.0	0.0	0.0	0.2	0.2	0.3	0.0	0.0	0.0
	~100ha	0.0	0.0	0.0	0.0	0.1	0.2	0.0	0.0	0.0	0.1	0.1	0.2	0.0	0.0	0.0
Avoided deforestation – risk based	~1000ha	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.1	0.1	0.2	0.0	0.0	0.0
	~100ha	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0

[9] Extent is based on land with appropriate land use and non-remnant vegetation for plantings. Regrowth and avoided deforestation require regrowth availability or forest subject to clearing, so the figures for those methods are adjusted using the estimated proportions in Table X of the land area with appropriate land use, non-remnant vegetation with regrowth potential or avoided deforestation potential and modelled to have economic viability (positive net present value after 25 years) at each specific price.

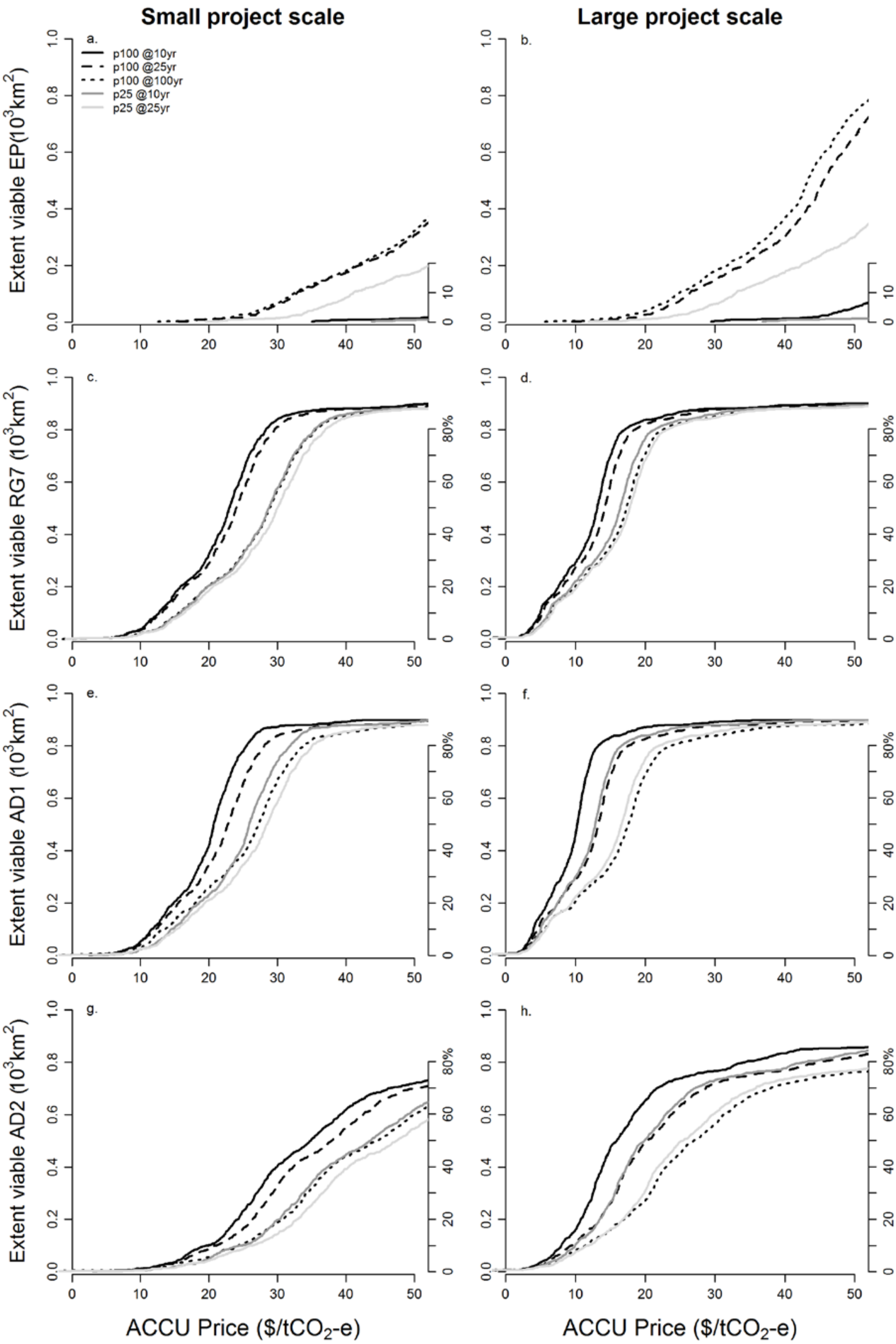
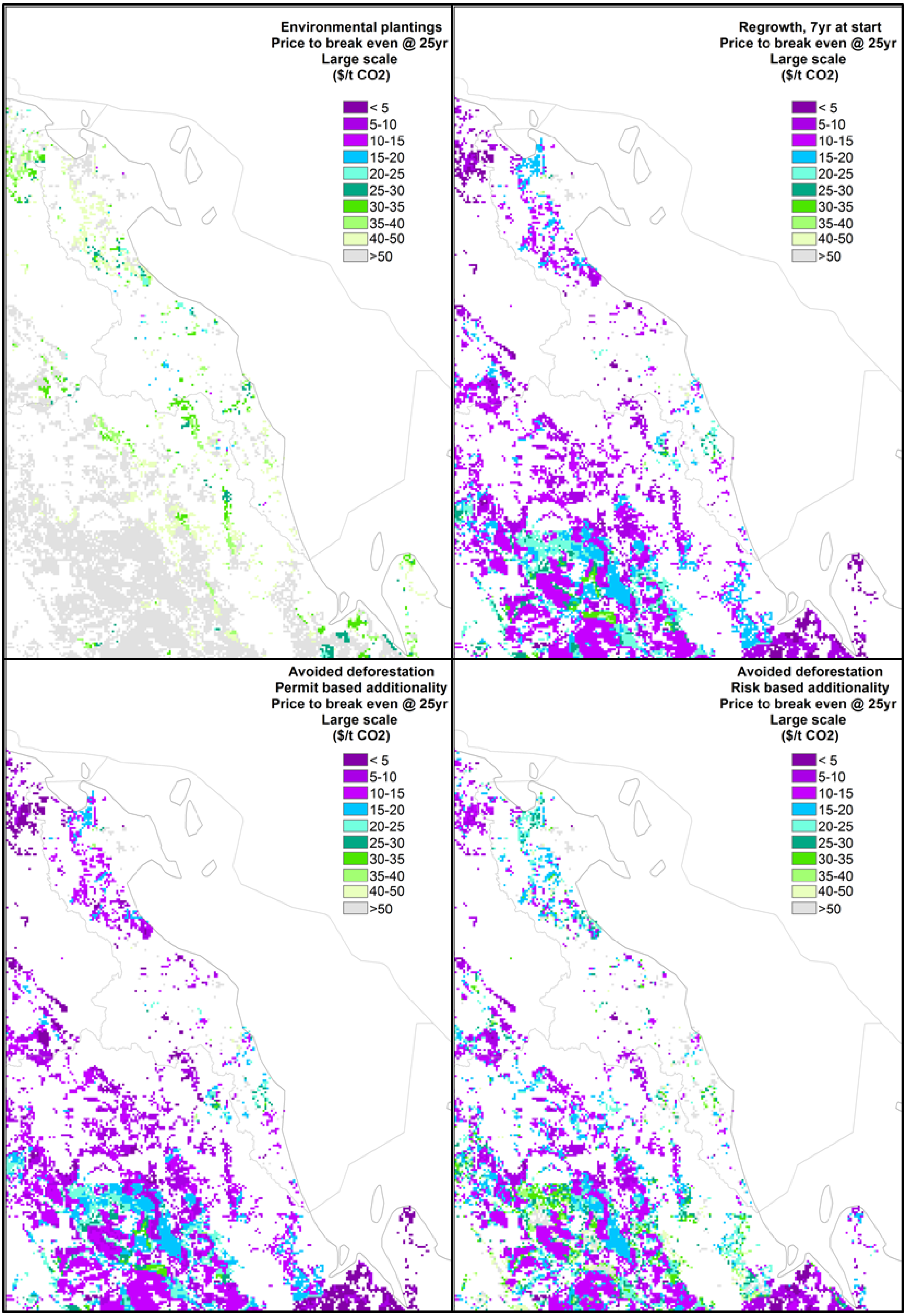


Figure 13 Economic models of land use change activities for Mackay Whitsunday NRM Group



Map 20 Price to break even for large scale projects with 100 year permanence over a 25 year investment period for Mackay Whitsunday NRM Group.

Northern Gulf Resource Management Group

Table 16 Summary of potential for Northern Gulf Resource Management Group.

Activity[10]	Project Scale	Extent of suitable land where it may be economically viable ('000s km^2)			Potential CO_2-e sequestered over 10 years (Mt CO_2-e)			Potential rate of ongoing sequestration after 10 years (Mt CO_2-e /year)			Potential CO2-e sequestered over 20 years (Mt CO_2-e)			Potential rate of ongoing sequestration after 20 years (Mt CO_2-e /year)		
		$15	$20	$30	$15	$20	$30	$15	$20	$30	$15	$20	$30	$15	$20	$30
Environmental plantings	~1000ha	0.001	0.001	0.003	0.003	0.003	0.01	0.0006	0.0006	0.002	0.008	0.008	0.03	0.0004	0.0004	0.001
	~100ha	0	0	0.001	0.0	0.0	0.003	0.0	0.0	0.0006	0.0	0.0	0.008	0.0	0.0	0.0004
Regrowth – zero baseline	~1000ha	0.6	0.6	0.7	0.7	0.7	0.7	0.2	0.2	0.2	2.2	2.4	2.5	0.1	0.1	0.2
	~100ha	0.0	0.0	0.1	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.2	0.6	0.0	0.0	0.0
Regrowth – 7yo	~1000ha	0.6	0.7	0.7	0.7	0.7	0.7	0.2	0.2	0.2	2.4	2.5	2.5	0.1	0.2	0.2
	~100ha	0.0	0.1	0.3	0.1	0.2	0.4	0.0	0.0	0.1	0.2	0.5	1.4	0.0	0.0	0.1
Avoided deforestation – permit based	~1000ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	~100ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Avoided deforestation – risk based	~1000ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	~100ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

[10] Extent is based on land with appropriate land use and non-remnant vegetation for plantings. Regrowth and avoided deforestation require regrowth availability or forest subject to clearing, so the figures for those methods are adjusted using the estimated proportions in Table X of the land area with appropriate land use, non-remnant vegetation with regrowth potential or avoided deforestation potential and modelled to have economic viability (positive net present value after 25 years) at each specific price.

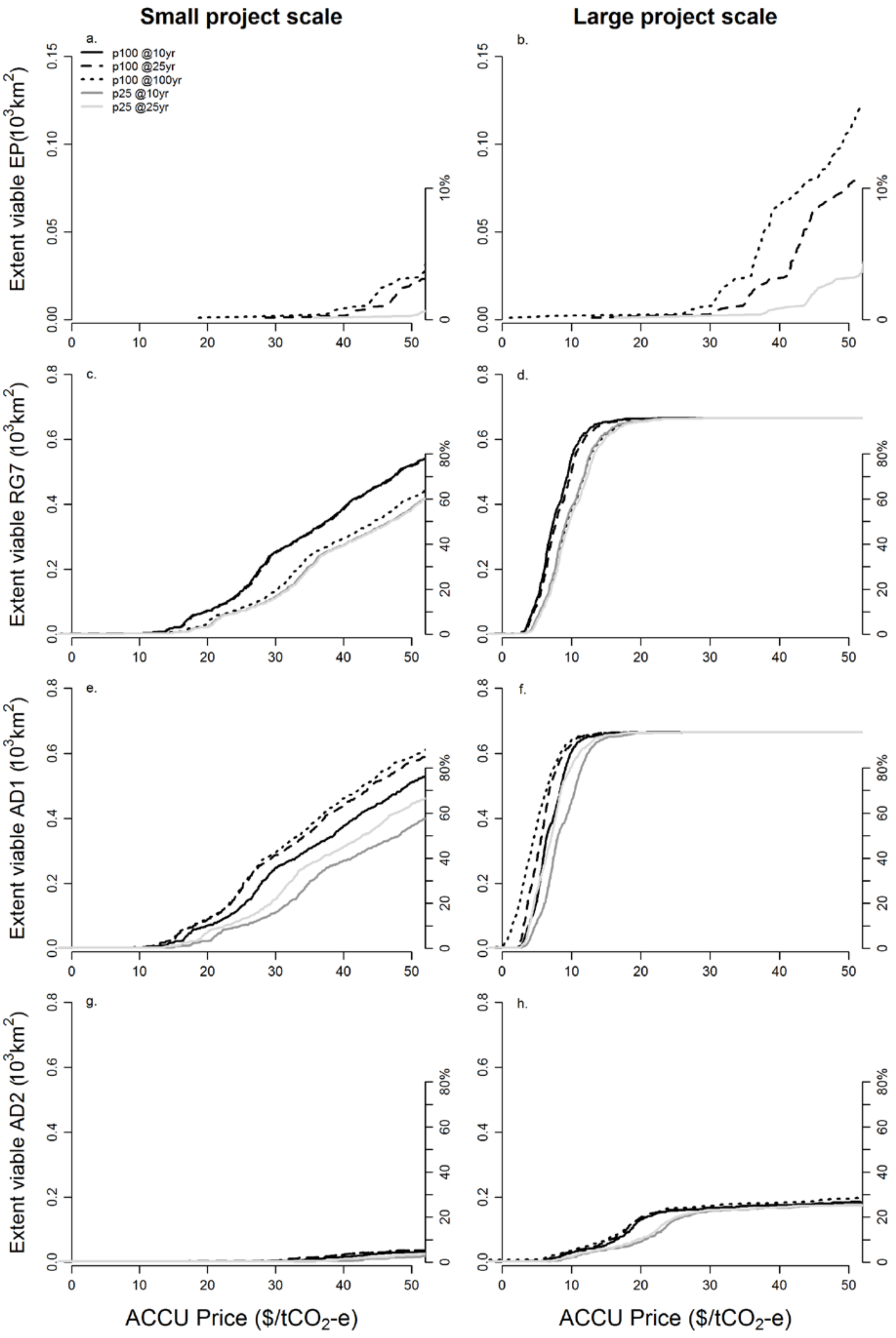
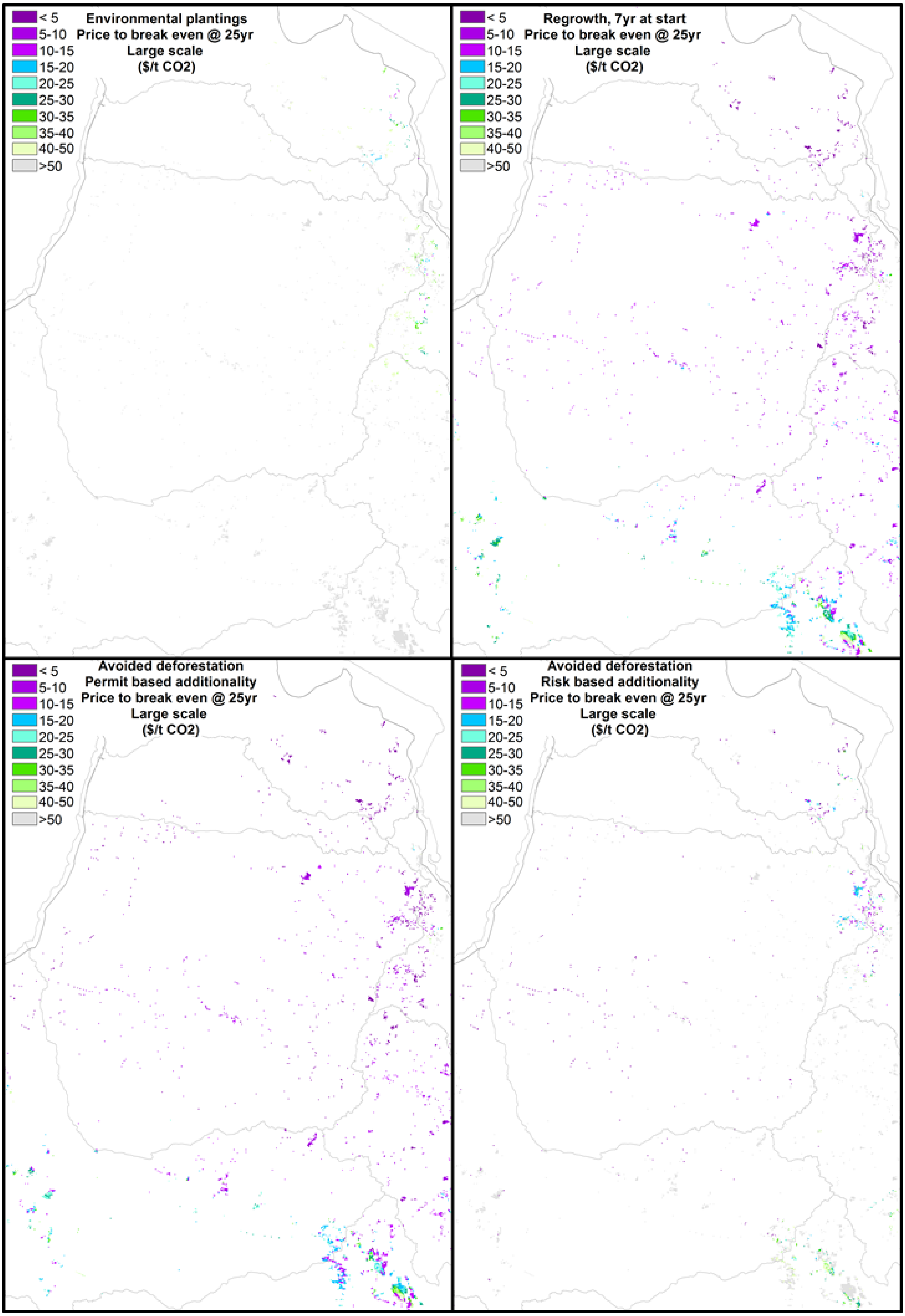


Figure 14 Economic models of land use change activities for Northern Gulf Resource Management Group.



Map 21 Price to break even for large scale projects with 100 year permanence over a 25 year investment period for Northern Gulf Resource Management Group.

Queensland Murray-Darling Committee

Table 17 Summary of potential for Queensland Murray-Darling Committee.

Activity[11]	Project Scale	Extent of suitable land where it may be economically viable ('000s km^2)			Potential CO_2-e sequestered over 10 years (Mt CO_2-e)			Potential rate of ongoing sequestration after 10 years (Mt CO_2-e /year)			Potential CO2-e sequestered over 20 years (Mt CO_2-e)			Potential rate of ongoing sequestration after 20 years (Mt CO_2-e /year)		
		$15	$20	$30	$15	$20	$30	$15	$20	$30	$15	$20	$30	$15	$20	$30
Environmental plantings	~1000ha	0.0	0.0	0.08	0.0	0.0	0.3	0.0	0.0	0.06	0.0	0.0	0.8	0.0	0.0	0.04
	~100ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Regrowth – zero baseline	~1000ha	1.6	3.1	6.1	2.8	5.5	10.2	0.7	1.3	2.4	9.4	18.2	33.9	0.6	1.1	2.1
	~100ha	0.1	0.1	0.5	0.1	0.2	1.3	0.0	0.1	0.3	0.5	0.8	4.3	0.0	0.0	0.3
Regrowth – 7yo	~1000ha	3.2	5.6	7.9	5.7	9.4	12.6	1.3	2.2	2.9	19.1	31.3	41.7	1.2	1.9	2.6
	~100ha	0.1	0.4	2.7	0.3	0.8	5.7	0.1	0.2	1.3	0.8	2.7	19.1	0.1	0.2	1.2
Avoided deforestation – permit based	~1000ha	0.2	0.2	0.3	0.8	1.2	1.5	0.1	0.1	0.2	1.2	1.8	2.3	0.0	0.0	0.0
	~100ha	0.0	0.0	0.1	0.0	0.1	0.8	0.0	0.0	0.1	0.1	0.2	1.2	0.0	0.0	0.0
Avoided deforestation – risk based	~1000ha	0.1	0.2	0.3	0.5	0.9	1.3	0.1	0.1	0.1	0.8	1.4	2.0	0.0	0.0	0.0
	~100ha	0.0	0.0	0.1	0.0	0.1	0.5	0.0	0.0	0.0	0.0	0.1	0.7	0.0	0.0	0.0

[11] Extent is based on land with appropriate land use and non-remnant vegetation for plantings. Regrowth and avoided deforestation require regrowth availability or forest subject to clearing, so the figures for those methods are adjusted using the estimated proportions in Table X of the land area with appropriate land use, non-remnant vegetation with regrowth potential or avoided deforestation potential and modelled to have economic viability (positive net present value after 25 years) at each specific price.

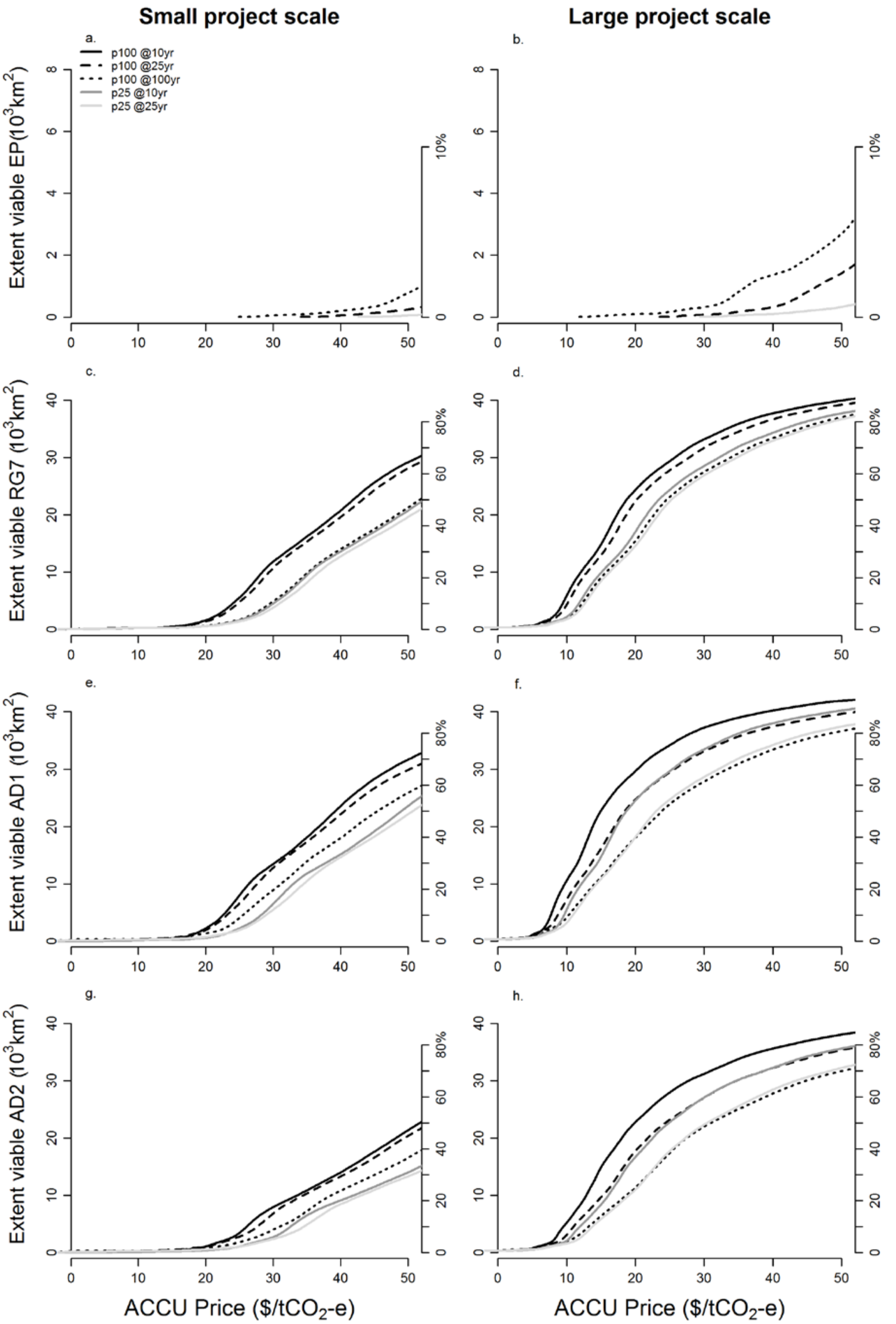
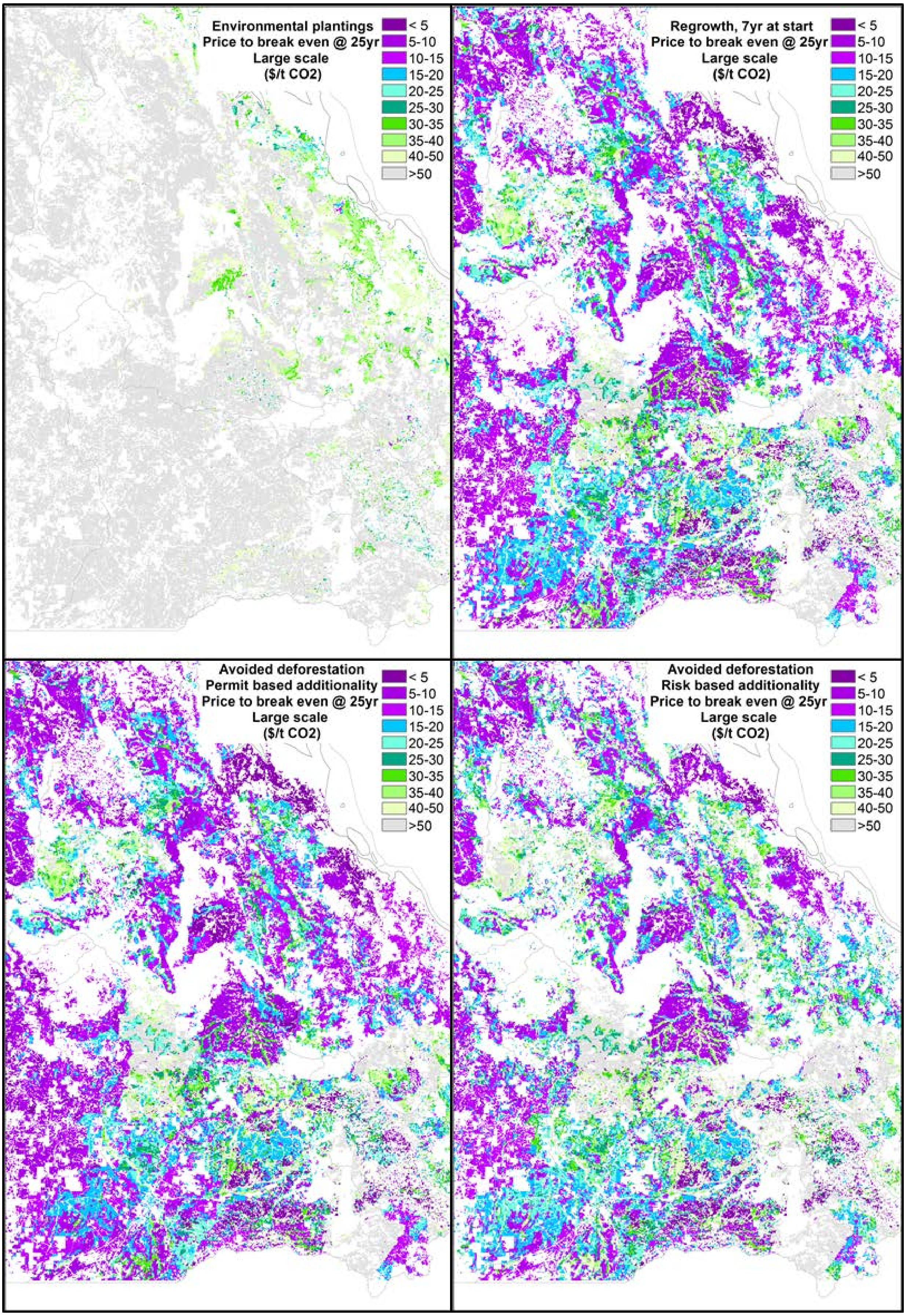


Figure 15 Economic models of land use change activities for Queensland Murray-Darling Committee.



Map 22 Price to break even for large scale projects with 100 year permanence over a 25 year investment period for Queensland Murray-Darling Committee.

SEQ Catchments

Table 18 Summary of potential for SEQ Catchments.

Activity[12]	Project Scale	Extent of suitable land where it may be economically viable ('000s km^2)			Potential CO_2-e sequestered over 10 years (Mt CO_2-e)			Potential rate of ongoing sequestration after 10 years (Mt CO_2-e /year)			Potential CO2-e sequestered over 20 years (Mt CO_2-e)			Potential rate of ongoing sequestration after 20 years (Mt CO_2-e /year)		
		$15	$20	$30	$15	$20	$30	$15	$20	$30	$15	$20	$30	$15	$20	$30
Environmental plantings	~1000ha	0.02	0.05	0.2	0.1	0.3	1.9	0.03	0.06	0.4	0.4	0.8	5.1	0.02	0.04	0.3
	~100ha	0.003	0.01	0.07	0.03	0.1	0.5	0.005	0.02	0.1	0.07	0.3	1.5	0.004	0.01	0.08
Regrowth – zero baseline	~1000ha	0.1	0.2	0.9	0.4	1.0	3.9	0.1	0.2	0.9	1.2	3.2	12.9	0.1	0.2	0.8
	~100ha	0.0	0.1	0.3	0.1	0.3	1.4	0.0	0.1	0.3	0.4	0.9	4.5	0.0	0.1	0.3
Regrowth – 7yo	~1000ha	0.2	0.7	1.5	1.1	3.1	6.5	0.3	0.7	1.5	3.7	10.4	21.6	0.2	0.6	1.3
	~100ha	0.1	0.2	1.0	0.3	0.9	4.6	0.1	0.2	1.1	1.0	3.1	15.2	0.1	0.2	0.9
Avoided deforestation – permit based	~1000ha	0.0	0.0	0.1	0.2	0.6	1.2	0.0	0.1	0.1	0.3	0.9	1.8	0.0	0.0	0.0
	~100ha	0.0	0.0	0.1	0.1	0.2	0.9	0.0	0.0	0.1	0.1	0.3	1.3	0.0	0.0	0.0
Avoided deforestation – risk based	~1000ha	0.0	0.0	0.1	0.1	0.2	0.8	0.0	0.0	0.1	0.2	0.3	1.1	0.0	0.0	0.0
	~100ha	0.0	0.0	0.0	0.0	0.1	0.4	0.0	0.0	0.0	0.0	0.1	0.6	0.0	0.0	0.0

[12] Extent is based on land with appropriate land use and non-remnant vegetation for plantings. Regrowth and avoided deforestation require regrowth availability or forest subject to clearing, so the figures for those methods are adjusted using the estimated proportions in Table X of the land area with appropriate land use, non-remnant vegetation with regrowth potential or avoided deforestation potential and modelled to have economic viability (positive net present value after 25 years) at each specific price.

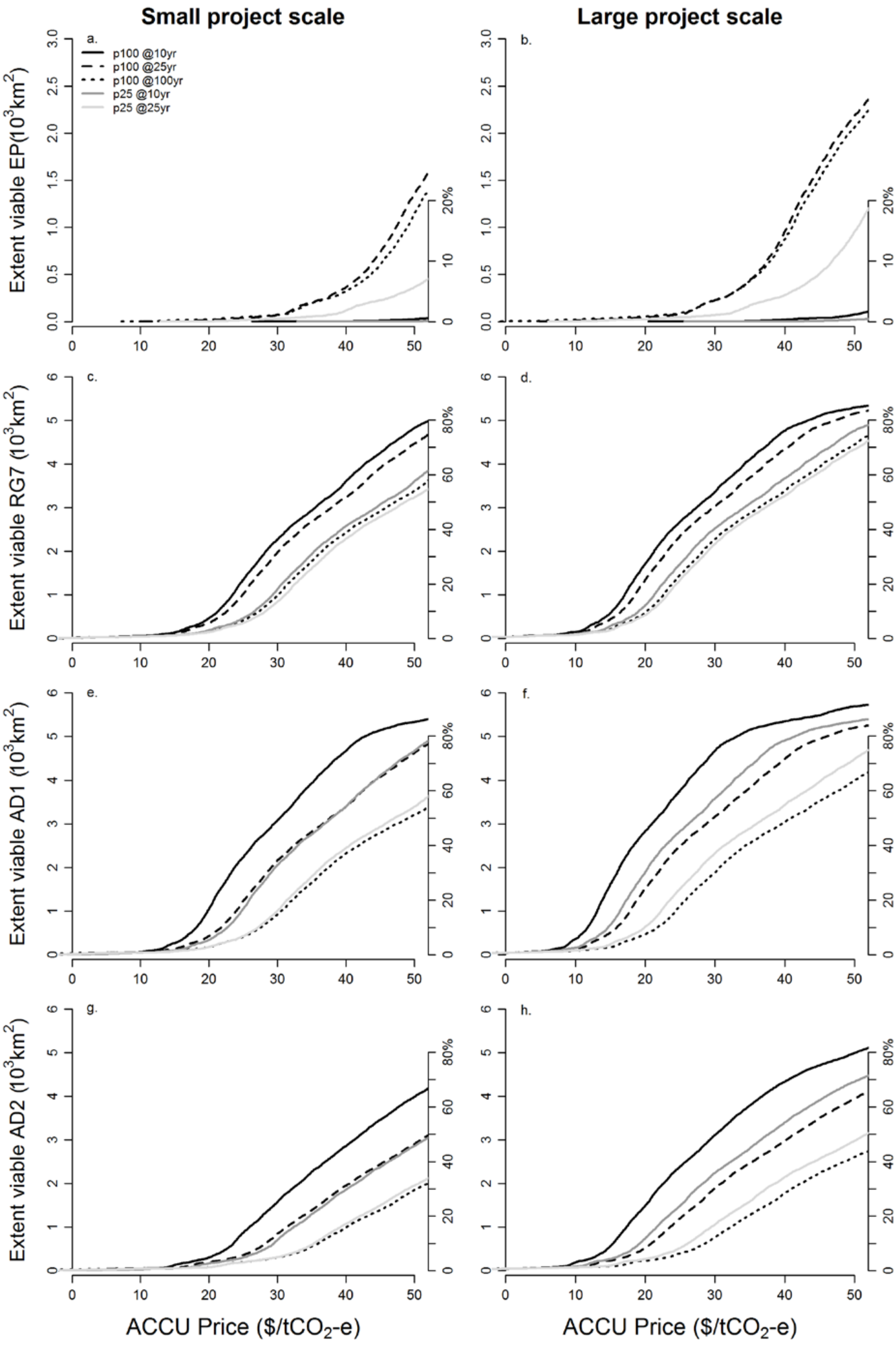
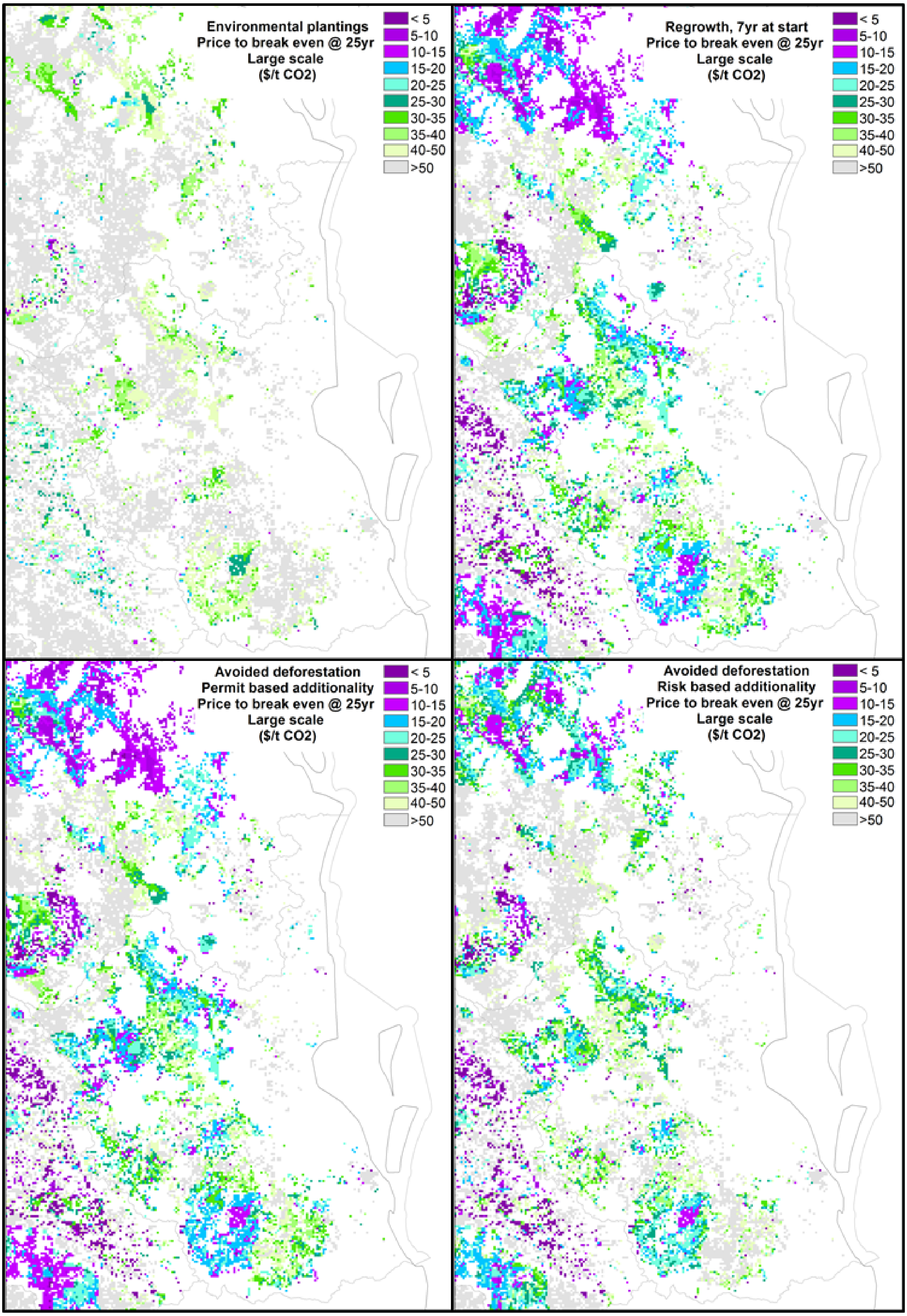


Figure 16 Economic models of land use change activities for SEQ Catchments.



Map 23 Price to break even for large scale projects with 100 year permanence over a 25 year investment period for SEQ Catchments.

South West NRM

Table 19 Summary of potential for South West NRM.

Activity[13]	Project Scale	Extent of suitable land where it may be economically viable ('000s km^2)			Potential CO_2-e sequestered over 10 years (Mt CO_2-e)			Potential rate of ongoing sequestration after 10 years (Mt CO_2-e /year)			Potential CO2-e sequestered over 20 years (Mt CO_2-e)			Potential rate of ongoing sequestration after 20 years (Mt CO_2-e /year)		
		$15	$20	$30	$15	$20	$30	$15	$20	$30	$15	$20	$30	$15	$20	$30
Environmental plantings	~1000ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	~100ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Regrowth – zero baseline	~1000ha	16.1	20.7	24.3	17.7	21.9	25.1	4.2	5.1	5.9	58.9	72.9	83.3	3.6	4.5	5.1
	~100ha	0.0	0.0	0.5	0.0	0.0	1.1	0.0	0.0	0.3	0.0	0.0	3.6	0.0	0.0	0.2
Regrowth – 7yo	~1000ha	21.1	23.7	25.1	22.3	24.6	25.6	5.2	5.8	6.0	74.1	81.8	85.0	4.5	5.0	5.2
	~100ha	0.0	0.3	4.7	0.0	0.8	7.2	0.0	0.2	1.7	0.0	2.6	24.0	0.0	0.2	1.5
Avoided deforestation – permit based	~1000ha	0.3	0.4	0.4	1.0	1.1	1.1	0.1	0.1	0.1	1.5	1.6	1.6	0.0	0.0	0.0
	~100ha	0.0	0.0	0.1	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.1	0.6	0.0	0.0	0.0
Avoided deforestation – risk based	~1000ha	0.2	0.2	0.3	0.6	0.8	0.9	0.1	0.1	0.1	0.9	1.2	1.4	0.0	0.0	0.0
	~100ha	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0

[13] Extent is based on land with appropriate land use and non-remnant vegetation for plantings. Regrowth and avoided deforestation require regrowth availability or forest subject to clearing, so the figures for those methods are adjusted using the estimated proportions in Table X of the land area with appropriate land use, non-remnant vegetation with regrowth potential or avoided deforestation potential and modelled to have economic viability (positive net present value after 25 years) at each specific price.

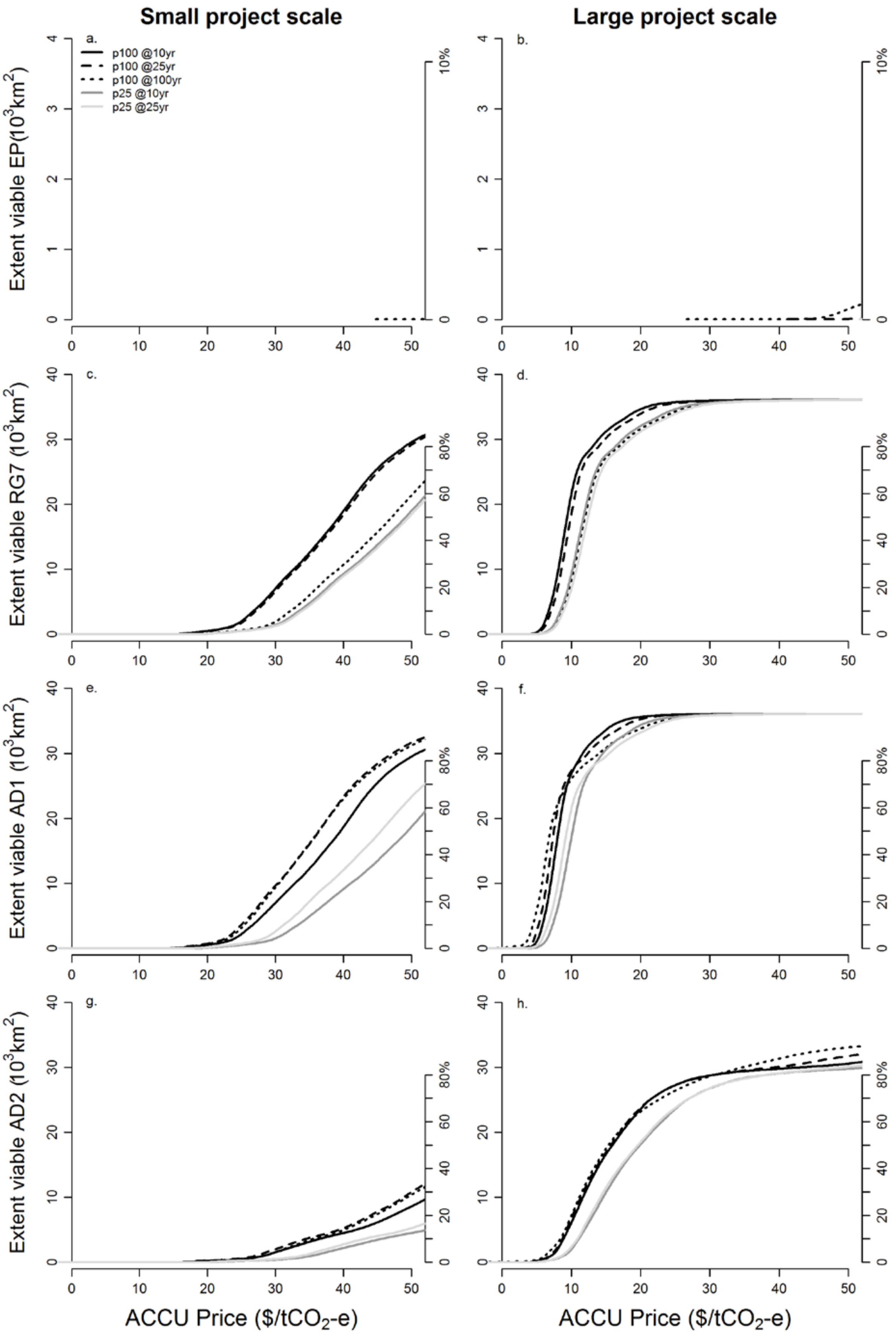
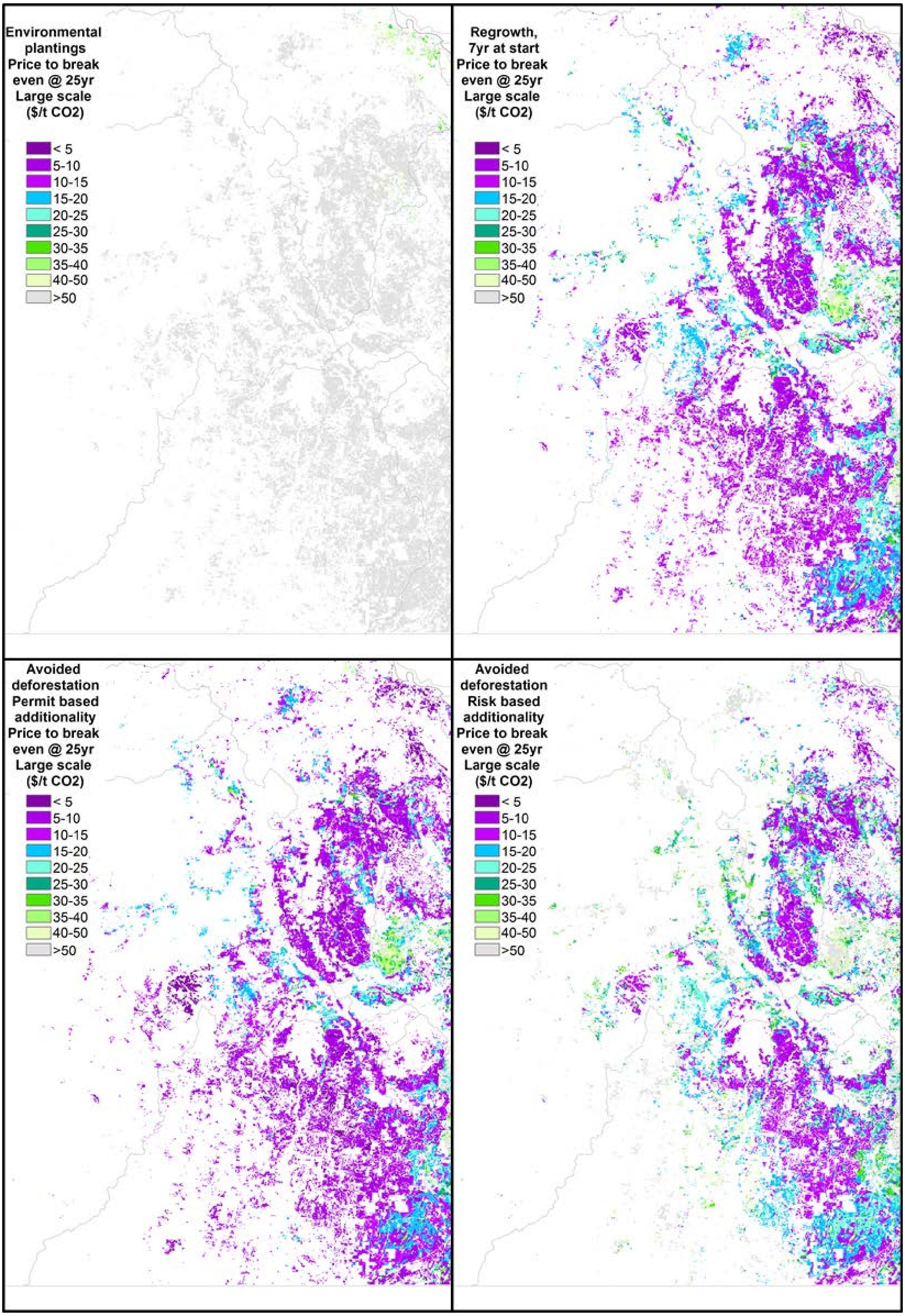


Figure 17 Economic models of land use change activities for South West NRM.



Map 24 Price to break even for large scale projects with 100 year permanence over a 25 year investment period for South West NRM.

Southern Gulf Catchments

Table 20 Summary of potential for Southern Gulf Catchments.

Activity[14]	Project Scale	Extent of suitable land where it may be economically viable ('000s km^2)			Potential CO_2-e sequestered over 10 years (Mt CO_2-e)			Potential rate of ongoing sequestration after 10 years (Mt CO_2-e /year)			Potential CO2-e sequestered over 20 years (Mt CO_2-e)			Potential rate of ongoing sequestration after 20 years (Mt CO_2-e /year)		
		$15	$20	$30	$15	$20	$30	$15	$20	$30	$15	$20	$30	$15	$20	$30
Environmental plantings	~1000ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	~100ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Regrowth – zero baseline	~1000ha	0.2	0.2	0.5	0.2	0.2	0.3	0.0	0.0	0.1	0.5	0.6	1.1	0.0	0.0	0.1
	~100ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Regrowth – 7yo	~1000ha	0.2	0.4	0.6	0.2	0.3	0.4	0.0	0.1	0.1	0.7	1.0	1.4	0.0	0.1	0.1
	~100ha	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0
Avoided deforestation – permit based	~1000ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	~100ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Avoided deforestation – risk based	~1000ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	~100ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

[14] Extent is based on land with appropriate land use and non-remnant vegetation for plantings. Regrowth and avoided deforestation require regrowth availability or forest subject to clearing, so the figures for those methods are adjusted using the estimated proportions in Table X of the land area with appropriate land use, non-remnant vegetation with regrowth potential or avoided deforestation potential and modelled to have economic viability (positive net present value after 25 years) at each specific price.

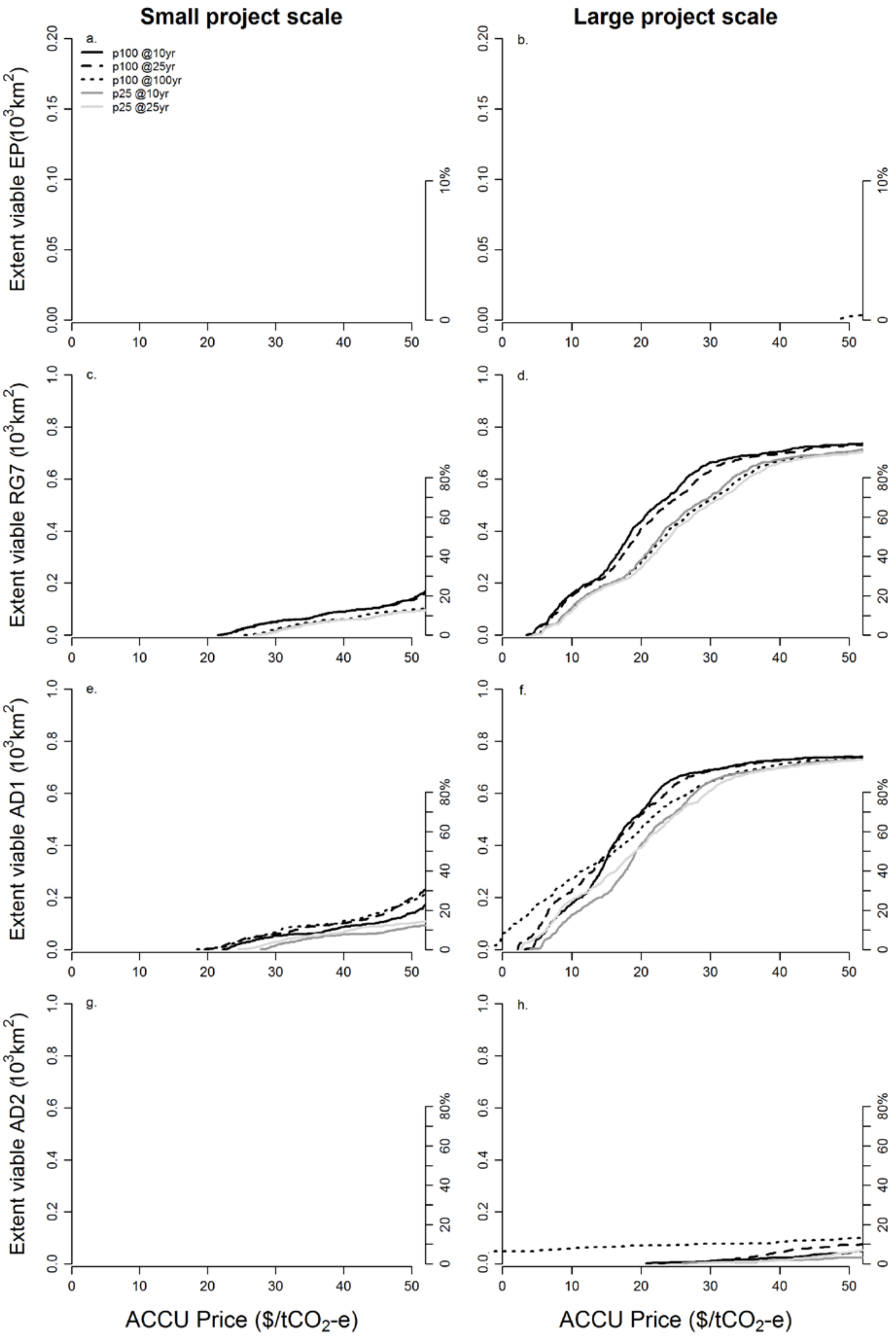
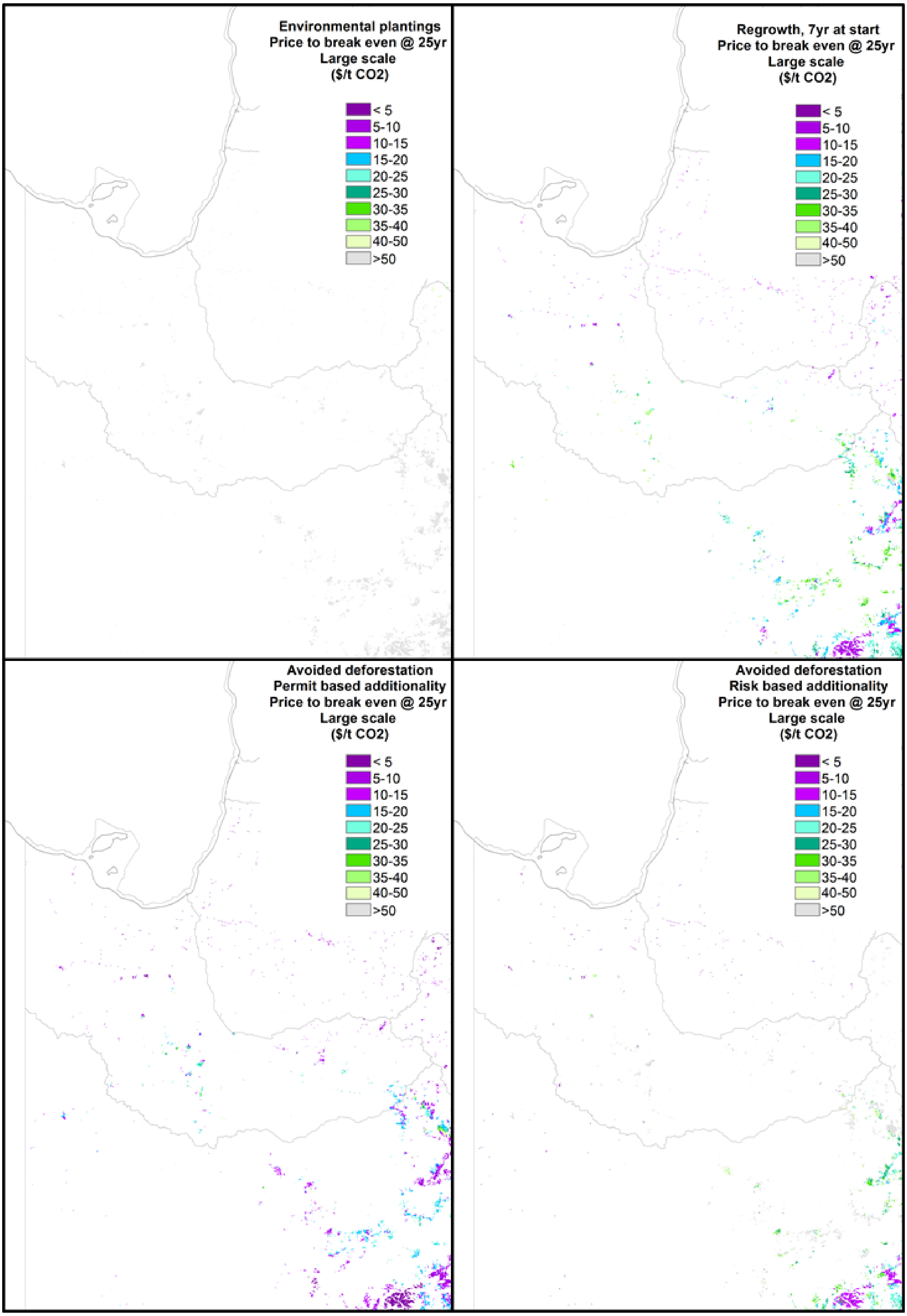


Figure 18 Economic models of land use change activities for Southern Gulf Catchments.



Map 25 Price to break even for large scale projects with 100 year permanence over a 25 year investment period for Southern Gulf Catchments.

Terrain NRM

Table 21 Summary of potential for Terrain NRM.

Activity[15]	Project Scale	Extent of suitable land where it may be economically viable ('000s km^2)			Potential CO_2-e sequestered over 10 years (Mt CO_2-e)			Potential rate of ongoing sequestration after 10 years (Mt CO_2-e /year)			Potential CO2-e sequestered over 20 years (Mt CO_2-e)			Potential rate of ongoing sequestration after 20 years (Mt CO_2-e /year)		
		$15	$20	$30	$15	$20	$30	$15	$20	$30	$15	$20	$30	$15	$20	$30
Environmental plantings	~1000ha	0.01	0.03	0.1	0.1	0.3	0.7	0.03	0.06	0.1	0.3	0.8	1.9	0.02	0.04	0.1
	~100ha	0.002	0.01	0.03	0.03	0.1	0.3	0.006	0.03	0.06	0.08	0.3	0.8	0.004	0.02	0.04
Regrowth – zero baseline	~1000ha	0.1	0.1	0.1	0.4	0.4	0.5	0.1	0.1	0.1	1.3	1.4	1.6	0.1	0.1	0.1
	~100ha	0.0	0.1	0.1	0.1	0.3	0.4	0.0	0.1	0.1	0.5	0.9	1.3	0.0	0.1	0.1
Regrowth – 7yo	~1000ha	0.1	0.1	0.1	0.4	0.5	0.5	0.1	0.1	0.1	1.4	1.5	1.6	0.1	0.1	0.1
	~100ha	0.1	0.1	0.1	0.3	0.4	0.5	0.1	0.1	0.1	0.9	1.2	1.6	0.1	0.1	0.1
Avoided deforestation – permit based	~1000ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0
	~100ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0
Avoided deforestation – risk based	~1000ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	~100ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

[15] Extent is based on land with appropriate land use and non-remnant vegetation for plantings. Regrowth and avoided deforestation require regrowth availability or forest subject to clearing, so the figures for those methods are adjusted using the estimated proportions in Table X of the land area with appropriate land use, non-remnant vegetation with regrowth potential or avoided deforestation potential and modelled to have economic viability (positive net present value after 25 years) at each specific price.

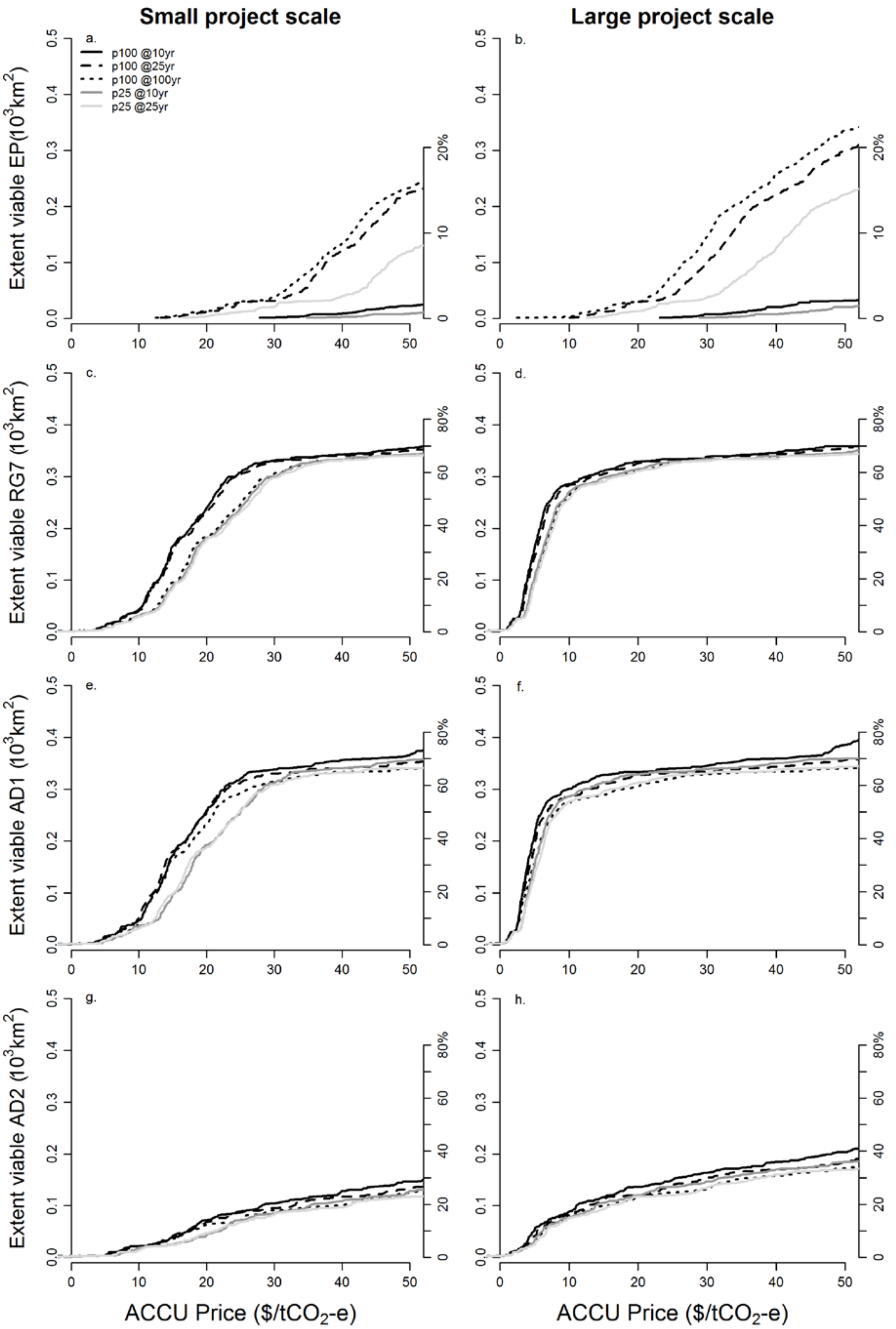
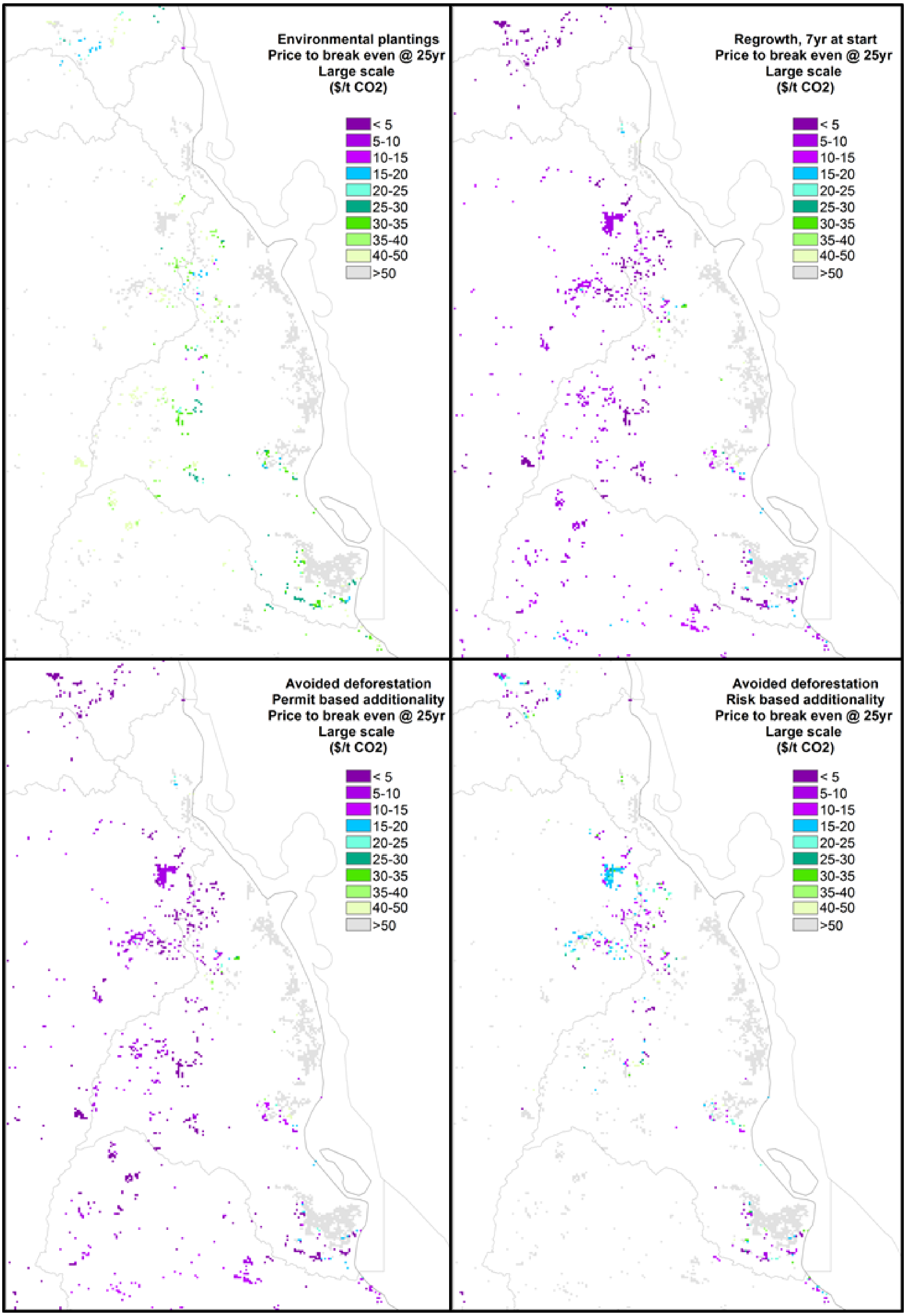


Figure 19 Economic models of land use change activities for Terrain NRM.



Map 26 Price to break even for large scale projects with 100 year permanence over a 25 year investment period for Terrain NRM