

Evidence for the economic impacts of investment in National Landcare Programme activities



Natural Decisions



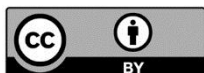
Advanced Choice Economics Pty Ltd

International applied research specializing in agricultural, environmental and fisheries economics



Copyright

© Copyright Commonwealth of Australia, 2015.



'Evidence for the economic impacts of investment in National Landcare Programme activities' is licensed by the Commonwealth of Australia for use under a Creative Commons By Attribution 3.0 Australia licence with the exception of the Coat of Arms of the Commonwealth of Australia, the logo of the agency responsible for publishing the report, content supplied by third parties, and any images depicting people. For licence conditions see: <http://creativecommons.org/licenses/by/3.0/au/>

This report should be attributed as 'Natural Decisions Pty Ltd, 2015, *Evidence for the economic impacts of investment in National Landcare Programme activities*', prepared for the Department of the Environment and Energy, Commonwealth of Australia'. Use of the systems model or systems model methodology must also be attributed to the Commonwealth.

The Commonwealth of Australia has made all reasonable efforts to identify content supplied by third parties using the following format '© Copyright, [name of third party]'.

Enquiries concerning reproduction and rights should be addressed to:

Department of the Environment and Energy, Public Affairs
GPO Box 787 Canberra ACT 2601
Or by email to: public.affairs@environment.gov.au

This publication can be accessed at: www.nrmonline.gov.au

Acknowledgements

This report was commissioned by the Department of the Environment and Energy on the advice of the National Landcare Advisory Committee.

The report was prepared by Natural Decisions Pty Ltd and Advanced Choice Economics Pty Ltd. The primary authors of the report and project team were Anna Roberts, Elizabeth Petersen, Geoff Park, Michelle Dickson and David Pannell. The authors would particularly like to thank Crystal Bradley (Department of the Environment and Energy), Sue Middleton, Allan Williams, James McKee and Cathy Phelps (National Landcare Advisory Committee) for active guidance and support. The authors would also like to thank people who participated in the expert workshops and peer-review process. Their names are outlined in Appendix 1.

Disclaimer

The views and opinions expressed in this publication are those of the authors and do not necessarily reflect those of the Australian Government, the Minister for the Environment and Energy, the Minister for Agriculture

and Water Resources or the National Landcare Advisory Committee.

While reasonable efforts have been made to ensure that the contents of this publication are factually correct, the Commonwealth and National Landcare Advisory Committee do not accept responsibility for the accuracy or completeness of the contents, and shall not be liable for any loss or damage that may be occasioned directly or indirectly through the use of, or reliance on, the contents of this publication.

Contents

Key findings.....	vii
Executive summary.....	viii
1. Introduction	1
2. Literature review.....	3
3. Recommendations on indicators	16
4. Systems model methodology.....	22
5. Case study results - Grains and mixed livestock zone, Western Australia.....	31
6. Case study results – Cotton in Queensland and NSW	45
7. Case study results – Dairy in Gippsland, Victoria.....	59
8. Analysis across industries	71
9. Opportunities for future work	72
10. Conclusions	73
11. References	75
Appendices	78
Appendix 1 – List of stakeholders who participated in expert workshops and reviewers of the modelling results.....	78
Appendix 2 - Timeline of phases of the Landcare movement and comments on implications from the literature.	78
Appendix3 - Systems model conceptual thinking and methodology	78
Appendix 4 – Grains and mixed livestock, WA results	78
Appendix 5 – Cotton Queensland and NSW results	78
Appendix 6 – Dairy, Gippsland Victoria results	78

Figures

Figure 1. Vision for the scope and scale of evidence to assess economic, social and environmental impacts of Landcare investment.	23
Figure 2. Interim biogeographic regionalisation units for Australia.	27
Figure 3. Estimated adoption of liming with and without Landcare funding.	33
Figure 4. Estimated adoption of no-till with and without Landcare funding.	34
Figure 5. Estimated adoption of kikuyu with and without Landcare funding.	35
Figure 6. Estimated adoption of revegetation on marginal land with and without Landcare.	36
Figure 7. Direct on-farm and direct off-farm benefits of practice adoption in the grains and mixed grains/livestock zone in Western Australia.	38
Figure 8. Estimated adoption of improved water use efficiency in irrigated cotton (NSW and QLD) with and without Landcare funding.	48
Figure 9. Estimated adoption curve for reduced tillage in dryland cotton (NSW and QLD) with and without Landcare funding (ha/year).	49
Figure 10. Estimated adoption of riparian management with and without Landcare funding in cotton growing areas (NSW and QLD).	50
Figure 11. Direct on-farm and direct off-farm benefits of practice adoption in the cotton industry (NSW and QLD).	52
Figure 12. Estimated adoption of improved dairy effluent management (Gippsland VIC) with and without Landcare.	62
Figure 13. Estimated adoption of improved nutrient management on dairy farms (Gippsland VIC) with and without Landcare funding.	63
Figure 14. Estimated adoption of riparian management on dairy farms (Gippsland VIC) with and without Landcare funding.	64
Figure 15. Direct on-farm and direct off-farm benefits of practice adoption in the dairy industry, Gippsland VIC.	66

Tables

Table 1. Estimated direct economic benefits (on-farm and off-farm) from 'Landcare' from 1988-2015 for three agricultural industries in Australia.	xiii
Table 2. Examples of potential impacts of Landcare investment at different scales.	9
Table 3. Recommended indicators which provide a simple basis for improving economic assessment of the impacts of Landcare.	21
Table 4. Elements of the systems model to enable evidence-based assessment of economic impacts of Landcare investment.	25
Table 5. Characteristics of candidate dairy practices for the purposes shortlisting three practices.	29
Table 6. Estimated direct economic benefits (on-farm and off-farm) from 'Landcare' from 1988-2015 for grains and mixed grains/livestock in Western Australia.	39
Table 7. Additional impacts associated with practice adoption not captured in the systems model.	42
Table 8. Major cotton growing areas in Australia and associated geography.	45
Table 9. Estimated direct economic benefits (on-farm and off-farm) from 'Landcare' from 1988-2015 for the Australian cotton industry (NSW and QLD).	53
Table 10. Additional impacts associated with practice adoption in the cotton industry not captured in the systems model.	58
Table 11. Estimated direct economic benefits (on-farm and off-farm) from 'Landcare' from 1988-2015 for dairy industry (Gippsland VIC).	65
Table 12. Additional impacts associated with practice adoption not captured in the systems model.	70

Abbreviations

ABS – Australian Bureau of Statistics

BMP – Best management practice

CMA – Catchment Management Authority

IPM – Integrated Pest Management

MERIT – Monitoring Evaluation Reporting and Improvement Tool

NHT – Natural Heritage Trust

NLP – National Landcare Programme

NRM – Natural Resource Management

NSCP – National Soil Conservation Program

NSW – New South Wales

Qld - Queensland

WA – Western Australia

WANTFA – Western Australian No-Tillage Farmers Association

WUE – Water Use Efficiency

Key findings

- This study is the first rigorous attempt to assess the economic benefits of investment into Landcare and the National Landcare Programme (NLP). The work provides an important piece of evidence supporting Australia's global agricultural competitiveness.
- A review of literature showed that investment in Landcare has changed the mindset of landholders to be more environmentally conscious and engender a stewardship ethic. It has increased participation in sustainable agricultural and environmental activities.
- The literature review also suggests that Landcare has had significant national influence and impacts through sponsorship (on-ground projects and other sustainability initiatives) largely resulting from the value of the Landcare brand and has influenced activities in a number of countries.
- The economic impacts of Landcare activities cannot be assessed from the literature.
- A systems model was developed and applied in this project to geographic areas of the grains and mixed livestock zone (Western Australian wheatbelt), cotton (New South Wales and Queensland) and dairy (Gippsland in Victoria) industries. Several practices in each industry were selected that have been important in terms of Landcare investment. The systems model was able to quantify the key on-farm economic benefits including improved yields, increased farm income and reduced costs. Diversified farm income was assessed qualitatively. Key off-farm economic benefits were estimated very simply through assumptions on the impacts on farm profit and input changes, and included increased sales (e.g. rural input suppliers) and services (e.g. increased use of contractors).
- In excess of \$1 billion direct economic market value was estimated in these three case study industries, over 90% of which was estimated to go directly to landholders. Higher overall national economic impact would be estimated as the regions studied were only a sliver of Australian agriculture.
- Additional economic value would be expected if the study were expanded to selected practices covering the three agricultural industries across Australia, other Landcare practices relevant to the industries, additional monetised economic benefits related to the Landcare practices, other industries (e.g. other grazing industries, sugarcane etc.), and non-market valuation of the associated social and environmental benefits. Social and environmental benefits provide additional unmeasured value that was not possible to estimate in this study.
- Continued investment in Landcare along with independent evaluation of practice adoption, as is occurring in the cotton and dairy industries might be able to be used to brand Australian agriculture and improve global competitiveness, but was not done as part of this study.
- The systems model developed to quantify the economic benefits in this study is simple and transparent, and provides a powerful basis for further work.
- The work has not considered the costs of implementing Landcare programmes and therefore does not assess overall impact, cost-effectiveness or value for money from the investment.

Executive summary

Background and context of the project

The project was commissioned by the Australian Government Department of the Environment and Energy (the Department) at the request of the National Landcare Advisory Committee (NLAC). NLAC provides advice to the Natural Heritage Ministerial Board (the Board) on the development and implementation of the National Landcare Programme (NLP). This project was requested by NLAC to assess the evidence and extent to which economic impacts from the Australian Government's investment into Landcare can be demonstrated. The evidence-base could inform the Board, governments and the Landcare community/network. It would assist NLAC to give sound and evidence-based advice on program settings of the NLP to the Ministerial Board, and through them, the Australian Government.

The scope of the project was not tightly constrained. The Department and the NLAC recognised that there are significant time-lags between investment and achieving impacts and benefits. The evidence-base was not constrained to either the formal commencement of Landcare or the NLP and/or its current configuration. The emphasis was on privately held land but the results are directly applicable to public land that is managed for primary production. Landcare was considered in a broad sense, covering the Australian government investment in the NLP in its various iterations (e.g. Natural Heritage Trust 1 and 2, Caring for Our Country 1 and 2, National Action Plan for Salinity and Water Quality, National Landcare Programme) and encompasses the more formalised natural resource management (NRM) sectors and the more 'grassroots' movement of Landcare.

The major components of the project included: 1) review and analysis of literature; 2) recommendations on indicators for measuring economic impacts; 3) development of a systems model to assess economic impacts, including considerations of how it could be scaled from case studies to a national level; 4) application of the systems model to select Landcare practices relevant to three case studies (grains and mixed livestock, Western Australia; cotton farming systems in Queensland and NSW; dairy farms in Gippsland Victoria) which included modelled economic benefits and non-modelled broader additional benefits.

Literature review

Landcare and the NLP are aimed at balancing productivity and environmental outcomes. The literature review covered the evidence-base on direct and indirect gross economic impacts across scales (individual to global) and from the perspective of gross (not net) economic impact; the amount of investment into Landcare was not considered.

There is strong evidence in the literature to support the impact of Landcare investment at individual and local community scales in terms of participation in sustainable agricultural and environmental activities, education/training and the building of social capital. Landcare has changed the mindset of landholders to be more environmentally conscious and engender a stewardship ethic. This is a very important outcome which has not been valued quantitatively.

The economic impacts of the overall Landcare programme and NLP iterations could not be assessed from the literature. Economic impacts from Landcare are also difficult to distinguish from other government investments due to the influence of larger market forces. Direct economic impacts

from practice adoption are expected from particular sustainable land management practices. Overall the literature suggests that economic impacts could occur directly at the local level (particularly as a result of well-resourced and staffed natural resource management groups having improved access to resources, management and training) and through local employment and increased rural sales. While there are some 'win: win' outcomes in terms of positive financial/economic impacts and environmental improvements, these are context-specific.

The literature also suggests that Landcare has had significant national influence and impacts through sponsorship (on-ground projects and other sustainability initiatives) largely resulting from the value of the Landcare brand. Landcare has influenced a number of countries. The international economic value of Landcare could not be assessed from the readily available evidence but would be possible to do so through an in-depth study.

Recommendations on Economic Indicators

Selection of appropriate indicators to assess impacts of programmes including Landcare is complex and requires consideration of whether an impact can be directly measured and whether it helps make a management decision. Issues surrounding uncertainty, costs of measurement and complexity in both time and space are important. The most important challenge overall is that the impacts of the programme itself need to be distinguished from impacts that would have occurred regardless of investment. That Landcare has always had multiple objectives makes the task of assessing economic impacts difficult overall.

There are currently no economic indicators in the NLP monitoring, evaluation, reporting and improvement tool (MERIT) which was not designed for this purpose. Biophysical indicators (area and length measures) could be used as a basis of indicators to assess economic impacts. Financial data would be needed to assess the direct financial/economic impacts (expressed \$/ha or \$/km), which is better sourced through other means (industry gross margins for example).

Development of a systems model provided a concrete basis for recommending practical indicators to help assess economic impacts from Landcare investment. Financial impact (\$/ha or \$/km) of practice adoption, baseline level of practice adoption (ha) in the absence of the Landcare along with the scale and timing of practice adoption data need to be collected for this to be done in a rigorous way. Land management practices need to be defined in sufficiently specific terms, for example 'riparian management', 'reduced till', 'revegetation', 'effluent management' etc. Without more clarity about specific practices and practice adoption within regions and industries in current reporting processes it is not possible to assess economic impacts.

The degree to which baseline data on environmental and social indicators and changes are linked to NLP outcomes is currently unclear. If the impact of program investment cannot be separated from that of other investments (which it appears is the case) then impacts for particular investments cannot be assessed.

The priority recommendations from the work conducted in this project are to focus on short-term indicators, assess baseline land management (with and without investment), improve specific practice definition and associated practice recording and link practice adoption to assessment of economic/financial impacts. Without further attention, assessment of impacts over larger scales and

longer times may not be meaningful or possible. The linkage between data sets and sources from Australian Bureau of Statistics and the Department of the Environment and Energy information may need further consideration. Data relevant to assessing economic, social and environmental impacts are already being collected in areas other than MERIT and these can potentially provide useful sources to be linked or integrated with current Landcare/NRM reporting.

Systems model

A spreadsheet-based systems model was developed to underpin the economic analysis for this project, the rationale for which included that the project time-frame was limited and spreadsheet models are easy to develop and adapt. Furthermore, spreadsheet models are able to be viewed or perhaps used by non-modellers and enable scrutiny of assumptions and relationships often not possible in more complex modelling programs.

The model has a strong focus on the benefits from adoption of particular sustainable practices by landholders (farmers or other land managers who manage lands for primary production). The core concept was based on a sustainable land management practice adoption curve and assessment of the private net financial benefits, in both cases 'with' and 'without' Landcare investment. The concept was to value the economic benefits for particular land management practices that are promoted by Landcare.

Considered and deliberate decisions were made, which included the use of gross margins to assess financial benefits. The model has a strong emphasis on financial impacts (market) rather than non-market benefits due to complexities and contestability in non-market valuation techniques in addition to the practical issue that the project time-frame precluded this to be done meaningfully.

The model considered two main types of types of impacts:

- Direct on-farm economic impacts: Impacts were assessed in dollars due to increased yields, improved profitability and/or reduced costs. It did not capture biodiversity and broader outcomes;
- Direct off-farm economic impacts: The systems model captured dollar value impacts associated with direct impacts on rural industries resulting from practice adoption.

Populating the model involved facilitated workshops with people who had local history and context-specific knowledge of industries, practices and perspectives. Specific questions were asked to allow the quantification needed for the model and agreement on practices to be assessed. Development of the model itself required adaptive management to enable the economic benefits of practices to be estimated. Broader indirect off-farm social and environmental impacts were also considered in expert workshops but not used in the model. Peer-review of model inputs and results by nominated experts was also part of the process. Overall the process worked extremely well. Participants were actively engaged, often commented on the importance of the work being done and have shown strong interest in the results.

Landcare practices

Grains and mixed livestock zone, Western Australia

The grains and mixed livestock zone of south-west WA was the first of three case studies in this project. The grains industry is the largest agricultural sector in WA delivering more than \$4.5 billion

to the State economy each year. For this study we assumed the overall relevant area to be 16.9 million ha of privately owned land (the areas relevant for each practice are outlined below) and where grain only or mixed grains-livestock are important. Four practices were selected for this analysis:

- **Liming:** The use of lime to manage soil pH (surface or subsoil) to enable yields to be maintained and prevent soil acidification. The area of land requiring liming is estimated from previous work to be in excess of 11 million ha, and 2015 adoption was assumed as 1.6 million ha;
- **No-till:** No-tillage is a way of growing crops or pasture from year to year without disturbing the soil through tillage. Technically, it is one pass seeding with narrow or knife points with less than full cut-out (<20% soil disturbance). It has potential for all areas that are cropped (assumed as 16.9 million ha);
- **Kikuyu pasture:** Kikuyu is a sub-tropical perennial grass grown with subterranean clover in pastures. It is the most widely adoptable perennials pasture species in suitable areas (estimated to be approximately 300,000 ha);
- **Revegetation of marginal cropping land for biodiversity outcomes:** Strategic revegetation of land with limited agricultural productivity due to significant soil constraints. The area of marginal land was assumed as 825,000 ha.

Cotton, Queensland and NSW

The cotton industry is an integral part of the Australian economy, worth more than \$2 billion per annum in export earnings and with more than 99 percent exported. Growers must remain very efficient, produce high yields and keep their costs as low as possible to compete in a heavily subsidised world market. Cotton growing areas are in Queensland and New South Wales, typically on floodplains associated with river systems and tributaries, mostly under irrigation and increasing also dryland. Areas sown to cotton since 1989/90 have varied from 135,000-600,000 ha. Three practices formed this analysis:

- **Water Use Efficiency (WUE for irrigated cotton):** This practice, assumed to be relevant to all irrigated cotton areas (which have varied from approximately 61,000 to 450,000 ha), included components of paddock laser levelling to improve irrigation uniformity and speed of watering, fine-tuned water application (irrigation scheduling), use of in-field assessment often with consultants to assess crop stress and water needs, water re-use systems and overhead irrigation systems where suitable;
- **Reduced tillage:** A combination of as few tillage operations as possible, stubble retention and controlled traffic, noting that some tillage (pupae busting) is required for cotton growing as part of the regulatory requirement for growing genetically modified crops. This practice was assumed to be suitable for all dryland cotton growing regions, the area of which has varied from approximately 4,500 to 206,000 ha;
- **Riparian management:** Installation of stock-proof fencing and off-stream watering to manage grazing pressure on riparian areas. Stock exclusion though controlled or 'crash' grazing is often used to control weeds or provide drought fodder. The length of riparian vegetation in cotton growing areas in both Qld and NSW was estimated to be 4787km and waterways were assumed to be fenced to 50 m each side of the waterway.

Dairy, Gippsland Victoria

Dairying is Australia's third largest rural industry, valued at \$13 billion/year and representing 7% of global dairy export trade. In 2013/14 38% of Australia's dairy production was exported, totalling \$3.2 billion, of which \$2.3 billion came from Victoria. In 2014 there were 6,314 dairy farms in Australia and in Victoria there were 4,268 licenced dairies in 2013/2014. Victorian dairying occurs in three regions (northern Victoria, south west Victoria and Gippsland). Gippsland has approximately 1,430 dairy farms (total estimated dairy farm land in Gippsland is 265,980 hectares, of which 183,000 ha is used as the milking area with the remainder being used as 'run-off' areas where dry stock are grazed. Gippsland represents approximately one third of Victorian dairying and 23% nationally. The analysis was conducted for Gippsland but the practices themselves are important Australia-wide. The three practices analysed were:

- **Improved effluent management:** Improved utilisation of dairy effluent which involves containment and strategic re-use of effluent to grow fodder. The practice is linked to better nutrient management and it was assumed that landholders were already fully compliant with regulatory obligations. It was assumed to apply over the milking area (183,000 ha);
- **Nutrient management:** Soil testing and more targeted application (time and rate) of fertiliser according soil tests and pasture requirements. Nutrient budgets (all sources including bought feed) were assumed to be conducted, often using consultants. Nutrient management was assumed to apply to the whole farm area (265,980 ha);
- **Riparian management:** Installation of stock-proof fencing and off-stream watering to manage grazing pressure on riparian areas. Waterways and creeks were assumed to be fenced to a minimum of 10 m either side, revegetated with local native species in accordance with biodiversity guidelines and off-stream watering was installed. A total of 1,859 km waterways were assumed on Gippsland dairy farms.

Estimated economic benefits

Seven of the 10 practices selected were those likely to have positive economic benefits because of their known relationship to agricultural productivity. The remaining three were more environmentally focussed practices involving revegetation and vegetation management.

The following primary on-farm and off-farm economic benefits resulting from practice adoption across all case studies were identified as:

On-farm economic benefits for selected practices within industry case studies:

- Improved yields: Liming and kikuyu pastures for grains/mixed livestock, water use efficiency and reduced tillage for cotton, effluent management for dairy;
- Increased farm income: Liming and no-till for grains/mixed livestock, water use efficiency and reduced tillage for cotton, effluent and nutrient management for dairy;
- Diversified income (assessed qualitatively): Kikuyu pasture for grains/mixed livestock;
- Reduced farm costs: Nutrient management for dairy;
- Reduced land available for agricultural use: Revegetation on marginal land for grains/mixed livestock, riparian management for dairy.

Off-farm economic benefits for selected practices were assessed very simply through assumptions on the impacts on farm profit and input changes, and included::

Increased sales:

- Lime suppliers: Liming for grains/mixed livestock;
- Seed merchants: Revegetation for grains/mixed livestock;
- Input suppliers: Kikuyu pastures and revegetation for grains/mixed livestock, water use efficiency, reduced tillage and riparian management for cotton, riparian management for dairy;
- Equipment for farm redesign: Water use efficiency for cotton;
- Nurseries: Riparian management for dairy.

Increased services:

- Rural contractors: Kikuyu pastures and revegetation for grains/mixed livestock, riparian management for cotton, effluent and riparian management for dairy;
- Machinery and harvesting contracting: Water use efficiency and reduced tillage for cotton;
- Agricultural consultants: Effluent and nutrient management for dairy;
- Soil testing laboratories: Nutrient management for dairy.

Table 1 shows the estimated value (\$ millions) of direct on-farm and off-farm economic benefits estimated for each sustainable land management practice examined in the three case studies. For practices generating positive economic values, the sum of benefits was in excess of \$1 billion. The majority of benefits (94% for practices with positive benefits) were estimated to accrue to landholders. For these practices, Landcare investment was estimated to increase the speed of adoption and sometimes also the scale. For the more environmentally focussed practices, Landcare was estimated to increase both the speed and extent or scale of adoption and produced positive off-farm economic values.

Table 1. Estimated direct economic benefits (on-farm and off-farm) from 'Landcare' from 1988-2015 for three agricultural industries in Australia.

\$ millions of economic benefit (present value, 1988 – 2015)				
GRAINS AND MIXED LIVESTOCK ZONE, WESTERN AUSTRALIA				
Direct benefits	Liming	No-tillage	Kikuyu pasture	Biodiversity revegetation on marginal land
On-farm value	131	790	8.8	-99
Off-farm value	48	0	0.6	25
Total estimated economic value	179	790	9.4	-74
Range	124 to 254	395 to 1580	4.2-18.3	-17 to - 115
COTTON INDUSTRY, QUEENSLAND AND NSW				
Direct benefits	Water use efficiency		Reduced tillage	Riparian management
On-farm value	37.0		30.6	-6.2
Off-farm value	9.8		3.4	1.5
Total estimated economic value	46.8		34.0	-4.7
Range	23 to 94		17-81	-3.4 to -5.9
DAIRY INDUSTRY, GIPPSLAND VICTORIA				
Direct benefits	Effluent management		Nutrient management	Riparian management
On-farm value	0.2		17.0	-2.1
Off-farm value	0.5		1.2	0.3

Total estimated economic value	0.7	18.2	-1.8
Range	0.4 to 0.9	12.3 to 20.6	-1.0 to – 2.9

Using and interpreting these results

The results presented can be viewed as a first attempt to assess the economic impacts of Landcare investment. The model method is simple, transparent and based on adoption theory from Australia's leading economists and social researchers. The inputs have been reviewed by experts who participated in the process and the approach developed worked very well using expert opinion. Sensitivity to model inputs has been done and the model itself can be scrutinised. That said there were very limited 'hard data' on which to base the model and comments are provided about overall confidence on the major model inputs:

- Level of overall adoption (moderate confidence);
- Level of adoption attributable to Landcare investment (low confidence);
- On-farm economic benefits and costs (moderate confidence, albeit that the heterogeneity experienced on farms has not been captured);
- Direct on-farm benefits (moderate-low confidence because of strong dependence on adoption attributable to Landcare);
- Direct off-farm benefits (low confidence as this has been captured very simply and is based on on-farm benefits).

Only readily quantifiable economic benefits were considered in the model. Social and environmental benefits that can be monetised could also be included in future and these benefits might be much larger than the economic benefits. In the time frame of the project it was not possible to include environmental and social benefits. Additional economic value would also be expected if the study were expanded to: the three industries as a whole, other Landcare practices relevant to the industries, more benefits related to the Landcare practices, other industries that interact with Landcare activities (e.g. cattle grazing), and non-market valuation of the associated social and environmental impacts. The figures are not measures of the cost-effectiveness, nor measures of the overall impact, efficiency or effectiveness of Landcare.

Opportunities for future work

Whilst there are many potential areas for future work in evaluating the effectiveness of Landcare the most important include:

- **Improvements in monitoring and reporting:** While MERIT provides a strong basis on which to record activities, there will be ways to improve reporting to better assess programme outcomes. Currently economic outcomes are not considered. Linkages between MERIT and other data sources is critical (or developing increased capacity within MERIT itself) if economic benefits are to be assessed. Without this, the current problem of lack of ability to assess economic outcomes will remain. Other data being collected by the Australian Government also need to be considered in this piece of work. The specificity of definition of sustainable land management practices within MERIT requires attention for economic

benefits of practice adoption to be assessed. Separating out the impacts of Australian government investment (the 'with' and 'without' issue) from that which would have occurred anyway is also critical;

- **Additional case studies:** The model developed can readily be expanded to other industries and geographic areas. It can also be used to assess the value of other program investments;
- **Further model development:** Further development of the systems model would be useful to enable it to be used nationally. Linkage of the model itself to MERIT reporting would be useful as would considering linkages with other information sources. If the model were to be used more broadly then moving from a spreadsheet based model would be useful, particularly to include a more spatial component;
- **Valuing of other benefits:** Assessing non-market benefits of sustainable land management practice adoption would be very beneficial and important to develop a more holistic view of the economic benefits.

Conclusions

Investment in Landcare activities over the past 25 years has changed the mindset of landholders to become more environmentally conscious and has engendered a greater stewardship ethic. This is critical for positioning Australian agriculture globally in marketing 'clean and green' credentials. For industries such as cotton, dairying and other intensive industries, helping maintain agriculture's social licence to farm is likely to be an important element of maintaining export competitiveness. Continued investment in Landcare along with independent evaluation of practice adoption could be used to brand Australian agriculture and improve global competitiveness in future.

There has not previously been a credible evidence-base to assess the economic impacts of Landcare investment and this is the first time such an assessment has been attempted. The economic impacts estimated only covered a subset of sustainable land management practices and impacts within a geographic subset of three industries (grains and mixed livestock in WA, cotton in Queensland and NSW and dairy in Gippsland, Victoria). In aggregate, direct economic impacts in excess of \$1 billion were estimated from 1988-2015, 94% of which accrued directly to landholders. National economic impact would be much higher as the regions studied were only a sliver of Australian agriculture and have not included additional social and environmental benefits.

Through adoption of practices that protect biodiversity and water quality (revegetation, fencing and off-stream watering) landholders are demonstrating strong environmental stewardship even though farmers were impacted by on-farm economic costs. Adoption of such practices is critical and provides tangible evidence of the long-term stewardship ethic of Australian farmers and landholders. Without continued financial support landholders are unlikely to be able to adopt these practices at scale.

This is the first time economic value of investment into Landcare has been estimated and the results are a first attempt to assess economic benefits. The work provides an important piece of evidence supporting Australia's global agricultural reputation and competitiveness. The model developed is simple and transparent. Further development plus refinements in assessing the adoption of sustainable land management practices provide a powerful basis for further work.

It is important to note that the work has not considered the costs of implementing Landcare programmes and therefore does not assess overall impact, cost-effectiveness or value for money from the investment.

1. Introduction

1.1 Background and context of the project

The project, called ‘Evaluating the evidence for economic impacts of investment in National Landcare Programme (NLP) activities’, was commissioned by the Australian Government Department of the Environment and Energy (the Department) at the request of the National Landcare Advisory Committee (NLAC). The NLAC provides advice to the Natural Heritage Ministerial Board (the Board) on the development and implementation of the National Landcare Programme (NLP). This project was requested by the NLAC to assess the evidence and extent to which economic impacts from the Australian government’s investment into Landcare can be demonstrated. The evidence-base can inform the Board, the government and the Landcare community/network. It will assist NLAC to give sound and evidence-based advice on program settings of the NLP to the Ministerial Board, and through them, the Australian government.

The scope of the project was not tightly constrained. The Department and the NLAC recognise that there are significant time-lags between investment and achieving impacts. The evidence-base was not constrained to either the formal commencement of the NLP and/or its current configuration. Landcare was considered in a broad sense, covering the Australian government investment in the NLP in its various iterations (e.g. Natural Heritage Trust 1 and 2, Caring for Our Country 1 and 2, National Action Plan for Salinity and Water Quality, National Landcare Programme) and encompasses the more formalised natural resource management (NRM) sectors and the more ‘grassroots’ movement of Landcare.

1.2 Components of the project

The major components of the project included: 1) review and analysis of literature; 2) recommendations on indicators for measuring economic impacts; 3) development of a systems model to assess economic impacts, including considerations of how it could be scaled from case studies to a national level; 4) application of the systems model to select Landcare practices relevant to three case studies (grains and mixed livestock, Western Australia; cotton farming systems in Queensland and NSW; dairy farms in Gippsland Victoria), which included modelled economic impacts and non-modelled broader additional impacts.

The project was ground-breaking in extent and ambitious, being conducted over a four month period including development of a new systems model. The extent to which the initial vision and concepts desired by the Department and NLAC could be achieved was unclear at the start of the project, but gradually became clearer as time progressed. The project required flexibility and adaptive management by the project team, the Department and NLAC and was a co-learning opportunity for all involved. Stakeholder management and communication between the project leader and the Department were crucial elements of the success of the project and took much time.

Overall the project was like putting together the pieces of a jigsaw where particular stakeholders held different pieces.

1.3 Structure of this report

This report is structured as follows:

- Section 2. Literature review
- Section 3. Economic indicator recommendations
- Section 4. Systems model methodology
- Sections 5 – 7. Results and analysis - Evidence of economic benefits from Landcare activities
- Section 8. Analysis across industries
- Section 9. Opportunities for future work
- Section 10. Conclusions
- Section 11. References

There are six accompanying appendices listed below and a copy of the systems model itself can be requested from the Department of the Environment and Energy.

Appendix 1 – List of stakeholders who participated in expert workshops and reviewers of the modelling results.

Appendix 2 – Timeline of phases of the Landcare movement and comments on implications from the literature.

Appendix 3 – Systems model conceptual thinking and methodology.

Appendix 4 – Grains and mixed grains/livestock, Western Australia (WA).

Appendix 5 – Cotton, Queensland (QLD) and New South Wales (NSW).

Appendix 6 – Dairy systems, Gippsland (VIC).

2. Literature review

A review of literature was conducted to understand the evidence-base to assess the economic impacts of investing in Landcare activities. The emphasis was on direct and indirect economic impacts across scales (from individual to global) and from the perspective of gross economic impacts. The amount of investment that has gone into Landcare was not considered.

2.1 Definitions of Landcare and the National Landcare Programme

As outlined in the introduction the scope of the project was not tightly constrained. From the perspective of reviewing the literature, as well as for the project overall, clarification of the definitions of Landcare and the National Landcare Programme were required and are outlined in this section.

Landcare is defined as a grassroots movement that harnesses individuals and groups to protect, restore and sustainably manage Australia's natural environment and its productivity. It is a national network of thousands of locally-based community groups who care for natural resources. Its origins came from initiatives to improve agricultural productivity through sustainable land management. Landcare is a partnership between local communities, governments and other interested organisations. Its philosophy is that improved agricultural productivity can be achieved with sustainable land management (Cullen et al. 2003, Curtis et al. 2014, Youl et al. 2006), also referred to in some circles as the 'win: win' outcome (good for both productivity and the environment).

The Landcare movement strongly reflects many of the national values and characteristics that Australians and outside observers like to ascribe to Australia (Youl et al. 2006). Over time, the movement has grown from locally-based community groups to encompass a broader focus on sustainable management of all of Australia's natural resource assets. Landcare now encompasses individuals and groups across the whole landscape from coastal to urban and remote areas of Australia with more than 4,000 community Landcare groups, 2000 Coastcare groups and many thousands of volunteers¹ Landcare has also increasingly involved and attracted indigenous people and communities because of the complementary philosophy of Landcare, namely respect for knowledge of the land and its climate, plants and animals, building on their communal traditions and powerful relationship with 'country' (Youl et al. 2006).

Given the evolution of the Landcare movement over time, Youl et al. suggest that a useful distinction between the more grass-roots and institutional versions of Landcare could be to use the term 'landcare' (small 'l') as a succinct, community-friendly term for holistic land and water (catchment) resource management, whereas 'Capital L' Landcare covers the broad community movement and its many initiatives, programs and formalised institutional arrangements (Youl et al. 2006). The movement to more formalised arrangements occurred from the late 1990s when Australian states began to institutionalise integrated catchment management through legislation or administrative arrangements, forming catchment management authorities (CMA) or catchment coordinating committees or councils or boards (depending on the state), with varying levels of powers and delegations.

2.2 History of Landcare

¹ http://www.landcareonline.com.au/?page_id=26

The history of the Landcare movement and the series of formal funding programs through the Australian government have been well covered and summarised by a range of authors. Some of the most useful publications can be found in the following publications (McVay et al. 2004, Cary 2010, Curtis et al. 2014, Curtis & De Lacy 1996, Hodges & Goesch 2006, Tennent & Lockie 2012, Robins & Kanowski 2011 and Youl et al. 2006). These publications provide an excellent overview of the phases of Landcare, the progression and expansion of funding to address sustainable agriculture and environmental problems, the rise of integrated catchment management and its impacts on the Landcare movement, the tensions between grassroots approaches and the need for accountability of public spending.

The first formalised National Landcare Program was launched in 1989 (Tennent & Lockie 2012) and commenced in 1992 (Hodges & Goesch 2006). A summary of the major timeline of phases of the Landcare movement, formal recognition of community and institutional groups through Australian government programs and some of the issues raised are summarised in Appendix 2.

Some of the major points from the literature include:

- The concept of Landcare started from attempts to address soil erosion (Youl et al. 2006 and Curtis et al. 2014);
- The unit for action was a small local group, often within in a small catchment erosion (Youl et al. 2006 and Curtis et al. 2014);
- The program's philosophy is that landholders working voluntarily together in a grassroots or 'bottom-up' way on locally relevant issues are better placed to solve local land conservation problems than more 'top-down' approaches and that improved agricultural productivity could be achieved with sustainable land management (the 'win: win' outcome) erosion (Youl et al. 2006 and Curtis et al. 2014);
- The philosophy of Landcare is closely aligned to Australia's national values and characteristics of ourselves that we like (Youl et al. 2006);
- As the concept gained popularity and the movement matured, funding increased and the program evolved from its roots to cover or partly cover a range of areas (Curtis et al. 2014, Hodges & Goesch 2006 and Tennent & Lockie 2012);
- As Landcare became increasing legitimised and with increased levels of funding there has been a need for increasing institutionalisation and accountability for funding. The form and functions of integrated catchment management have been institutionalised through legislation or administrative arrangements (Curtis et al. 2014, Tennent & Lockie 2012 and McVay et al. 2004);
- As funding increased and awareness regarding the costs and scale of degradation problems has increased there has been an increasing realisation that reliance on capacity building and voluntary programs is insufficient to achieve outcomes at the scale required to solve degradation problems. This was recognised in the 1990s (Cary 1994) and has continued to be reported in various ways since (Cary 2000, Cary 2010, Pannell 2008 and Pannell et al. 2006) amongst others;
- Both increased competition for funding and increased targeting have been features of the evolution of the formal NLP (Curtis et al. 2014, Tennent & Lockie 2012);
- The progression of small 'I' Landcare to 'Capital L' Landcare along with the progression to more formalised NRM institutional arrangements and increasing need for accountability has

drawn inevitable criticism. This includes that programs such as 'Caring for Our Country' have undermined the regional model for NRM, eroding gains made under earlier programs such as the Natural Heritage Trust. It is argued that increasing central government control, limited buy-in from state governments and a narrower agenda pose serious challenges for the regional NRM model (Robins & Kanowski 2011);

- Burn out amongst Landcare groups began to be reported from the early 2000s (Byron & Curtis 2001, Byron, Curtis and Lockwood 2001 and Simpson & Clifton 2010);
- Prolonged droughts have also been an important factor in reducing practice adoption (Curtis and Sample 2010);
- Landcare membership appears to have reached saturation, perhaps reflecting that early generous government funding has declined; and the Landcare program faces the on-going challenge of engaging landholders and the wider community (Cary 2010).

Overall, as concluded by (Tennent & Lockie 2012), Landcare is Australia's grand social experiment in community-based natural resource management. The Landcare movement and the phases of the more formalised NLP are subject to tension between the highly devolutionist model of community action and learning embedded in community Landcare groups, the cross-boundary dynamics of natural resource degradation, competing demands on government, and the need to demonstrate measurable improvements in natural resource condition with insufficient funding to achieve measurable outcomes.

2.3 Landcare aims

This section outlines what might be expected to be found in terms of economic impacts from Landcare from the perspectives of what the various programmes were set up to achieve and what practice adoption theory might suggest. Following this the evidence is assessed for what measurable impacts have been recorded in the literature.

Evolution of aims since NLP inception

Landcare programmes were developed alongside the *Natural Resources (Financial Assistance) Act 1992*, the objectives of which have been summarised (Hodges & Goesch 2006) as:

- To facilitate the development and implementation of integrated approaches to natural resource management in Australia in an efficient, sustainable and equitable manner consistent with ecologically sustainable development principles;
- Promote community, industry and government partnerships to manage natural resources, enhancing the long term productivity of natural resources;
- Assist in the development of approaches to resolve natural resource conflicts.

While there have been various iterations of Landcare programmes, the aims have been broadly similar over time and have involved the following elements:

- Community engagement and participation (information and awareness raising);
- Rural development, adult education and extension (skills and capacity building);
- Addressing natural resource management problems faced by local communities through implementing sustainable management practices.

The assumption at the core of programmes has been that Landcare farming is an approach that is more compatible with land use capability in Australia, and aims to be economically viable, while maintaining or enhancing the natural resource base (Cullen et al. 2003).

With the exception of an increased emphasis on targeting investment towards priority natural assets, the objectives of the current programme² largely reflect the intent of the earlier iterations. The current strategic objectives are:

- Communities are managing landscapes to sustain long-term economic and social benefits for the environment;
- Farmers and fishers are increasing their long-term returns through better management of the natural resource base;
- Communities are involved in caring for their environment;
- Communities are protecting species and natural assets.

An important point found both in Australia and internationally in agri-environmental land management policies, is that one clear and unambiguous management objective is more likely to achieve outcomes than having multiple objectives (Cary 2010). The NLP has multiple and complex objectives.

2.4 Consideration of public and private benefits of Landcare

Following the inception of the Landcare, there is some early literature noting that policies aimed at reducing land degradation on farms often made heroic assumptions about the relative importance of factors influencing individual adoption of conservation practices (Cary 1994). Cary questioned that while the assumption of raising awareness was a necessary condition to changing landholder attitudes to their land, it would be insufficient for widespread adoption of conservation practices. Other research from the 1990s, for example Curtis and De Lacy (Curtis & De Lacy, 1996), also suggested that low levels of profitability of some practices, the scale and intractability of some environmental issues and the considerable off-site benefits of remedial action meant that limited funding of a community development process would be unlikely to affect behavioural changes sufficient to make a difference at the landscape scale.

Since the 1990s there have been a range of research and publications (a selection of which are indicated in this review) about the importance of factors affecting landholder adoption of practices (Pannell et al. 2006 and Cary 2010) and development of an on-line practice adoption tool³. The degree to which voluntary adoption programs can be expected to achieve outcomes (Cary & Roberts 2011, Craig & Roberts 2015 and Pannell & Roberts 2010) given the scale required to achieve outcomes and the importance of thinking about the choice of policy tool (extension, small temporary incentives etc.) in association with assessing the public and private benefits associated with practice adoption (Pannell, 2008) are also important factors to think through in terms of what can be expected from voluntary programs. Thinking through the likely size of public and private net benefits of sustainable land management practices is a simple and powerful way to assess both the practices which are likely to generate economic benefits at and beyond the farm scale, as well as

² <http://www.nrm.gov.au/national-landcare-programme>

³ <http://www.futurefarmonline.com.au/research/agribusiness-education/adoptability-planning-tool.htm>.

helping think about the scale of adoption required to achieve measurable improvements in land condition and long-term benefits for the environment and the people who depend on it.

Implications for what could be expected in terms of assessment of economic benefits

Below is a summary assessment of what would be expected to be the size of economic benefits associated with the intent of the Landcare movement:

- Landcare and the NLP have multiple objectives and therefore achieving large economic benefits as a result of the Programme would not necessarily be expected;
- While some practices that Landcare and the NLP promote are likely to have private net benefits (minimum tillage and improved nutrient application being examples) many sustainable land management practices may not have direct positive private net economic benefits. Land managers may incur opportunity costs of taking land out of production and some sustainable land management practices may involve costs associated with tree planting and riparian fencing (with appropriate buffers to achieve biodiversity and/or water quality outcomes through reduced gully erosion);
- Information provision through extension and sometimes small temporary incentives will increase the scale and speed of practice adoption for practices that have positive private benefits to landholders but not for practices which have negative private benefits. Practices requiring increased management complexity compared with current practice, take land out of production and/or require large capital outlays are particularly difficult in terms of expecting widespread adoption and hence landscape scale benefits including economic ones.

Overall, from both the perspectives of the overall intent of Landcare and adoption theory only small positive economic impacts from the investment would be expected. This is based on the fact the program was developed to encourage participation and increase awareness and that a number of sustainable land management practices promoted through Landcare are likely to involve costs to landholders. While incentives have been provided to landholders for some practices, these may not cover the full costs incurred.

2.5 Evidence for impacts of Landcare

This section focuses on the evidence found in the literature in term of economic impacts from Landcare. The types of economic impacts that might be expected are outlined and then the evidence-base is reviewed.

We recognised that there were likely to be unpublished reports which were not able accessed in the literature. To try and maximise the chances of finding such information we used three main avenues:

- Direct contact with key researchers in the area;
- Supply of information from NLAC, the Department and stakeholders;
- Review of available literature (peer-reviewed and 'grey') with a focus on key words such as 'Landcare', 'practice adoption', 'economic impacts', 'Landcare brand' and 'global Landcare'.

Types and scales of impacts

Economic impacts include direct impacts such as increased profitability to landholders as well as economic benefits to others in the community (for example local rural suppliers who sell more fencing materials and other project resources and employment of local Landcare facilitators). Direct impacts are those with a direct cause and effect relationship with the actions taken in the programme. Indirect impacts are associated with the direct impact, not the action itself.

Impacts can also occur over a range of scales, from the individual (paddock or farm) though to larger scales (local community, regional, state, national, global) and over a range of time-frames. Table 2 illustrates some of the impacts that might be expected to occur over short (1-5 years) and long (greater than 10 year) time scales. These impacts can potentially be direct or indirect, with impacts at larger scales usually being more likely to be indirect, given that individual investments in Landcare are commonly made at smaller (individual and local) scales.

Impacts can potentially be individual or combined additively or cumulatively. Cumulative impacts are the combined, incremental effects of particular impacts. They can sometimes be insignificant by themselves but can accumulate over time, from one or more sources. Cumulative impacts result when the effects of an action are added to or interact with other effects in a particular place and within a particular time (Anonymous 1999).

Table 2. Examples of potential impacts of Landcare investment at different scales.

Timeframe	Scale of potential impact				
	Individual	Local	Regional/State	National	Global
Short term (1-5 years)	Changed attitude and practice adoption at the farm level; Changed visual condition/quality of on-farm natural assets (land, vegetation, streams); Changed crop yields or stocking rates; Changed profitability through improvements in management, technology or reduced input costs; Change in soil pH, sodicity or other soil constraints.	As for individual impacts but aggregated to the local level; Change in knowledge and capacity of local community; Change in local employment and volunteer opportunities; Small changes in environmental condition.	As for all local impacts but aggregated to the regional level.	National employment and participation figures; Gross domestic product (especially from agriculture); Balance of payments and international investment position; Small changes in environmental condition at scale.	Change in goods and services exports.
Long term (greater than 10 years)	As for individual impacts plus measurable changes in ecosystem function; Significant reduction in the number of events (e.g. bad erosion years); Long-term improvements in farm yields and profitability; Long term improvement in soil function as a result of removal of soil constraints (e.g. sodicity, pH, structure, salinity etc.).	Change in local employment, community capacity, economic viability, health and resilience; Social licence to farm; Changes in local ecosystem condition.	As for local impacts but aggregated to regional/state level Change in rural population trends; Change in regional services (e.g. shops, schools, hospitals, banks); Tourism (largely national) opportunities as a result of changed economic, social and/or environmental outcomes.	As for regional/state impacts but aggregated to national level; Long-term national employment and participation trends; Long-term change in gross domestic product (especially from agriculture); Balance of payments and international investment position; Tourism (national and international) opportunities; International export trade opportunities as a result of agriculture's reputation; Changes in ecosystem condition and function.	Trade and market opportunities as a result of increased sustainability and/or the 'Landcare brand'; Improved net position on international foreign investment position and debt; International tourism opportunities as a result of changed economic, social and/or environmental outcomes; Changes in ecosystem condition and function; improved outcomes for migratory species.

2.6 Evidence of impacts from the literature

It is estimated that there are around 6,000 groups (5,000 community groups plus up to 1,000 other production and conservation groups)⁴ participating in Landcare activities, and that over 140,000 land managers (94% based on Australian Bureau of Statistics 2006-07 figures) had delivered some type of sustainable agricultural and environmental activities.

The major impacts from Landcare have recently been summarised in a large literature review and case study analysis report by the consulting firm GHD (GHD 2013). They report a list of impacts including a claim that economic impacts from Landcare and sustainable agriculture can generate an economic return in the order of 2-5 times the original investment. The original report on which this conclusion was drawn (DSE 2008) provides no evidence to support the statement. Impacts are described in qualitative terms, with emphasis on case studies⁵.

The GHD report contained an appendix of underpinning 'synthesis of supporting evidence' which provided a better literature evidence-base than the main report. Looking across the GHD report and a range of other literature, we have assessed the evidence base and conclude that the direct on-farm economic impacts of Landcare cannot be determined. Little information is available in the literature and evidence to support claims of on-farm economic impacts was not found. The literature identified, outlined below, discuss indirect economic impacts mainly resulting from improved access to resources.

Participation, education and awareness

The GHD report (GHD 2013), suggests that Landcare has provided highly effective coordinated opportunities for inclusive participation experimentation, learning, increased awareness, observation, and skill development. This is also confirmed in other reports, for example (Byron et al. 2004)(Youl et al. 2006). Much of the work that has involved Allan Curtis, with eight references spanning 1995-2010 cited in the GHD report (GHD 2013) and including the following references (Curtis & De Lacy 1995, Curtis & De Lacy 1996 and Curtis & Sample 2010). A new recent overview paper also provides additional evidence (Curtis et al. 2014) as well as at least six other reference sources⁶ from the GHD report (GHD 2013) regarding the contribution of Landcare to participation, education and awareness raising. No doubt there are a range of others. Landcare has also supported intergenerational learning through group corporate knowledge, family knowledge through learning in schools (Love 2012) (Youl et al. 2006).

The development and enhancement of the relationships in a community that enables participants to more effectively act together is a particularly strong impact of Landcare. The synthesis of supporting evidence in the GHD report cites over 20 references in this area from a range of authors.

⁴ <http://www.agriculture.gov.au/ag-farm-food/natural-resources/landcare/publications/operating-environment-in-2012-for-landcare-and-related-community-based-groups-in-each-of-the-states-and-territories-across>

⁵ Five case studies were outlined. These were the upper Goulburn Landcare Network and Goulburn-Broken Catchment Management Authority – fire recovery; Otway Agroforestry project Yan Yan Gurt Catchment Victoria; Queensland Murray Darling Committee and Mitchell Landcare – Naturally Resourceful program; Friends of Narrabeen Lagoon (northern Sydney) – Creating a Sustainable Catchment program; Roper River Landcare Group –Building Capacity to Protect the Cultural and Production Values of Mangarrayi Traditional Lands.

⁶ Campbell 1992 and 1995; Cary and Webb 2000 and 2001, Vanclay and Lockie 2000; Walker 2000.

Partnerships and networks, political voice, governance/self-regulation, localism/empowerment, importance of women, personal growth and filling the void caused by rural decline have been major theme areas identified (GHD 2013, Curtis et al. 2014).

Practice change

Overall, with the exception of some notable groups including the Woody Yallock Catchment Group near Ballarat in Victoria (Nicholson 2012) and the Otway Agroforestry Network (Yan Yan Gurt Creek and Matthews Creek catchments which are Barwon River tributaries)(Austin 2015, GHD 2013), there is very little information about the scale of practice change adopted by farmers.

The Australian Bureau of Agriculture and Resource Economics and Sciences (ABARES) surveys from 1998 showed that 56% of all broadacre and dairy utilised Landcare groups for information regarding farm management, demonstrating that Landcare has been a major catalyst for practice change and increased adaptive management (Mues et al. 1998). Landcare members were also at least twice as likely as non-members to have participated in Landcare group workshops and field days, industry grower groups, property management planning activities (Mues et al. 1998). A report⁷ cited in ABARES work suggested that 77% of land managers might also accept a small decrease in farm profits to protect the environment (Mues et al. 1998). Overall there is strong evidence that Landcare has changed the mindset of landholders to engender a stronger stewardship ethic as a result of increased environmental awareness.

There have been several large national industry-led programs dealing with positive practice adoption (Sustainable Grazing Systems Key Program and the Grain & Graze Program being two). Even in large, coordinated programs such as Grain & Graze the recording of sustainable agriculture benefits was deemed inadequate and could not show the level to which these benefits accrue from adoption of recommended practices (Read & Petersen 2008).

Other work on adoption of practices widely promoted by Landcare, such as tree planting and riparian management also highlight serious challenges in terms of scale of adoption. Work on farm forestry adoption in Victoria, which has been widely promoted through Landcare, show that adoption is limited largely for reasons of costs (particularly high establishment costs) and high risks (Race & Curtis 2007). Riparian land management also faces serious adoption challenges, particularly in lower rainfall areas (Robins 2004).

The ABARES work provides the most rigorous basis we have found to assess the impacts of Landcare compared with non-Landcare effects (Mues et al. 1998, Alexander et al. 2000). An early ABARES survey covered five sustainable agriculture practices (formal pasture and vegetation condition monitoring in the pastoral zone, tree and shrub establishment by livestock producers in the wheat-sheep and high rainfall zones, regular soil testing by cropping specialists, watertable monitoring by mixed livestock-cropping enterprises and preservation of conservation areas by dairy farms). Only two of these practices could be attributed to Landcare membership (Mues et al. 1998).

A more detailed supplementary ABARES investigation was conducted (Alexander et al. 2000). This study showed that across the Australian broadacre and dairy industries, Landcare members had higher rates of practice adoption (ranging from small to large) than non-Landcare members in five

⁷ Reeve and Black 1993 – see page 46 in Mues et al.1998

major practice areas (preservation or enhancement of areas of conservation value; formal monitoring of pasture/vegetation condition; maintaining vegetative cover along drainage lines; stock exclusion from degraded areas; other preventative/control practices). Some of the major highlights were that Landcare members in the pastoral zone were almost three times as likely to practice formal monitoring of pasture/vegetation condition and almost twice as likely to exclude stock from degraded areas. Broadacre industry adoption in the wheat-sheep zone of both these practices as also substantially higher for Landcare members as it was for stock exclusion from degraded areas in the high rainfall zone. Impressive differences between Landcare and non-Landcare members were also shown for direct drilling and reduced minimum tillage. Conclusions on farm forestry were more nuanced, with benefits of tree planting being often related to indirect benefits (shelter and shade or treatment of degradation) and financial constraints being the major reason for limiting more widespread use.

More recent ABARES work highlights at complexities involved in assessing practice change impacts and acknowledgement that many sustainable land management practices can generate lower profit (Hodges & Goesch 2006). Increased land degradation was reported to be greater in 2004-05 than in 2001-02 survey but whether this was due to issues such as increased awareness was not possible to tell. Similarly although there is a known relationship between participation, reporting of land degradation and practice adoption, was is not possible to determine the level of influence that participation had on either reporting or adoption. The survey did clearly reveal, however, that landholders considered that a lack of time, finances and incentives were significant constraints on the adoption of more sustainable farming practices. This finding has implications for the degree to which the scale of practice adoption to achieve impacts is realistic.

The most recent ABARES work reports slightly increased adoption levels in 2012 compared with 2010 (Kancans et al. 2014). It also synthesises the current national level understanding of practice adoption on Australian farms (farm numbers not farm area) across industries, farm sizes, education levels, age, group membership and other factors. Financial constraints are major issues in terms of further adoption of sustainable land management practices.

Economic impacts

In addition to the unsubstantiated 2-5 times the investment claim in the GHD report, two other references (Curtis 2003 and Sobels et al. 2001) provide evidence of increased farm profitability. We looked at both and conclude that the strength of these papers on economic impacts is almost non-existent. One of the only pieces of evidence in terms of impacts of Landcare on profitability has come from a case study⁸ in the Woody Yallock Catchment. An increase in gross income from \$275/ha in 1990 to approximately \$335/ha in 2001 was reported but it was acknowledged as being partly due to an increase in commodity prices and property size; the impact of Landcare therefore was less than this and unquantified. The Woody Yallock experience however might be very useful to follow up on given this group appears to have done the most rigorous analysis of Landcare impacts found in the available literature. Conclusions are that there is very limited evidence of the impact that Landcare may have on farm profitability with the exception of specific case study examples which may not be representative of more typical group. The Woody Yallock group has developed important

⁸ Nicholson and Knight 2003 cited in the GHD report

partnerships with Alcoa, agribusiness and local companies (Youl et al. 2006) and the extent to which this applies over the majority of groups is unclear.

In terms of economic impacts of Landcare activities, it is usually assumed that management change always has a neutral or positive net benefit. While this is commonly the case, it needs to be noted that it is not always so. For example tree-planting can have very positive impacts in some circumstances (Alexander et al. 2000) (Austin 2014), but can be uneconomic in others (Bathgate et al. 2009)(Nordblom et al. 2010). There is also increasing evidence that landholders will need to be paid significantly more to adopt some practices (Patrick et al. 2009). Overall sustainable agricultural practices and profitability are highly spatially heterogeneous and context specific.

There is good evidence to conclude that well-resourced and staffed groups can have much improved access to resources and improved management and training. Improved access to resources were cited in six papers⁹ in the GHD report and at least one other (Byron et al. 2004) and improved access to training and techniques was cited in another four¹⁰ (GHD 2013). Employment of facilitators (often part-time) with a major contribution of women, and associated government agency support which also involves employment is an important local economic benefit (Youl et al. 2006) of Landcare. The Department of Agriculture and Water Resources Review of the National Landcare Program, 2003 (report not sourced directly but reported in GHD report) suggested that Landcare groups were able to draw down additional funding from non-government parties at a rate of at least \$2.60 for every \$1.00 spent by the government on Landcare projects. Provision of tax incentives to assist landholders conducting environmental works has been reported as another important economic impact (Byron et al. 2004, Youl et al. 2006).

Landcare groups have also been reported to help reconnect Indigenous people with country (Love 2012), with a further two references¹¹ linking this to enabling better participation in the economy. Development of community enterprises, operating nurseries, works teams, advisory services, small consultancies and ecotourism ventures with budgets of \$6-800 000/year have also been reported as economic impacts resulting from Landcare (Youl et al. 2006) although the scale of impact has not been quantified.

Another observation from the GHD report was that direct economic returns seemed to be more important to groups and communities that are struggling socially or that have suffered a significant shock (Roper River in terms of high indigenous unemployment and the fire recovery case-study in the upper Goulburn-Broken catchment). It was also concluded that all the five case studies in the report had accessed government or corporate support for their region and/or Landcare group, which they believe would otherwise not have been invested, sometimes amounting to millions of dollars. There was however no information available as to the economic impact of this investment (GHD 2013) .

National impacts of the Landcare brand and sponsorship.

⁹ Brown 1997; Catcutan 2009; Compton et al.; 2007; Curtis and Lockwood 2000; Curtis et al., 1999; Sobels and Curtis, 2001.

¹⁰ Campbell 1992; Hamilton 1995; Mues et al. 1998; Mullen, 2001.

¹¹ Altman and Whitehead 2003; Garnett et al. 2009.

Evidence found regarding the impacts of Landcare beyond the community scale involves a level of national impact from sponsorship and other forms of support largely resulting from the value of the Landcare brand and the expansion of Landcare internationally. The Landcare brand is highly recognisable through the 'caring hands' logo. The image of Landcare has led to corporate sponsorship from large companies including Telstra, BHP, Alcoa, Uncle Tobys, Fuji Xerox, Westpac and Amcor who have been involved through large number of projects (Youl et al. 2006). Sponsorship of \$10 million over three years through the Landcare Foundation sponsored by James Hardy and \$600,000 in sponsorship from Fuji-Xerox has been reported (Youl et al. 2006).

There are currently there are 28 companies listed as corporate Landcare partners, 23 of which provide project support and a further five provide in-kind services¹². Projects supported include development of re-useable plastic bags, protection of natural assets and ecosystems, support for awards and local groups, education and corporate volunteering.

In addition to corporate partners there are a large number of listed governments, community and workplace giving partners¹³. The economic impacts of these projects and activities might be large but cannot be estimated from the information on the website.

International impacts of Landcare

Internationally, through government and private networking, several initiatives overseas have developed or are evolving to promote Landcare's approach to sustainable landscapes. As reported by (Youl et al. 2006), there has been interest in Landcare from a range of countries including Canada Great Britain, Fiji, Iceland, Jamaica, Kenya, New Zealand, Philippines, Republic of South Africa (RSA), Sri Lanka, Uganda and the United States. These authors also report that Landcare has been promoted in Argentina, China, Italy, Inner Mongolia, Italy and Zimbabwe.

Two international examples (from the Philippines and South Africa) were found which report positive economic impacts of Landcare styled programs. Both examples involve improved livelihoods of poor landholders. In the Philippines the Landcare Programme commenced in the in the mid-1990s as a result of efforts by what was then the International Centre for Research on agroforestry (ICRAF) and by local landholder groups (Newby & Cramb 2011). There are reportedly around 600 groups in the Philippines (Youl et al. 2006). A study was conducted in the erosion prone rural area of the Bohol province (Newby & Cramb 2011). This work concluded that Landcare had a measurable economic impact due to the adoption of sustainable practices (contour farming and tree planting) and that these impacts were positive even when the prior investment in research and training was taken into account and leaving aside potential longer-term benefits from tree-planting. The major beneficiaries were individual households, with benefits occurring largely through opportunities arising once hillsides had been stabilized. The absolute increase in income was small, but its significance was large because adopting households had twice the level of farm income as that of non-adopters, giving the potential to lift households above the rural poverty line, allowing them to meet their basic requirements and possibly invest in further livelihood improvements.

¹² see <http://www.landcareonline.com.au/corporate-partners>

¹³ http://www.landcareonline.com.au/?page_id=42

The second example comes from South Africa and covers what is hoped to be achieved rather than evaluating actual impacts, economic or otherwise. South Africa commenced a national Landcare Program in 1997 a view to developing more sustainable agriculture (Mulder & Brent 2006). The mechanisms by which Landcare was expected to have benefits was through improved local economic sustainability through more efficient management of farms and other agricultural resources, thereby addressing the high levels of poverty in rural areas. The authors suggested that the structure of Landcare projects involves the creation of employment, transfer of skills and creation of entrepreneurial opportunities amongst other social development factors, thereby also contributing to social sustainability. They also suggested that Landcare would help achieve sustainable utilisation of natural resources to ensure long-term environmental preservation.

2.7 Conclusions from the literature

Landcare is aimed at balancing agricultural productivity and environmental outcomes. Overall it is concluded from the literature that there is strong evidence to support the impact of Landcare investment mostly at the individual and local community scales. This evidence exists for impacts of Landcare in terms of participation in sustainable agricultural and environmental activities, education/training and the building of social capital. Landcare has changed the mindset of landholders and this is a very important outcome which has not been valued in any quantitative terms.

The economic impacts of the Landcare programme cannot be readily distinguished from the literature and they will be difficult to distinguish from other government investments in rural areas and impacts due to larger market forces. Direct economic impacts from practice adoption would be expected from particular sustainable land management practices, but not all which have been actively promoted through Landcare. Overall the literature suggests that economic impacts are likely to be mostly at the local level (particularly for well-resourced and staffed groups having improved access to resources, management and training) through employment and rural sales.

Connected to the assessment of economic impacts there is moderate-strong evidence to show that Landcare has led to practice change by landholders, but there is little evidence in terms of the scale of practice adoption. Significant further adoption of many sustainable land management practices is likely to be limited by financial constraints and this result is not surprising given the scale of environmental challenges Australia faces.

Landcare has had significant national influence and impacts through sponsorship and other forms of support largely resulting from the value of the Landcare brand. The economic value of this was not possible to assess, but it would be possible to do so if the amount of investments from sponsorship and in-kind partners was revealed. Landcare has also had international influence in a number of countries, with particular examples from the Philippines and South Africa. Again, an assessment of the global economic value of Landcare was not possible to assess. Landcare is iconic and has given Australia a reputation as a world leader in participatory approaches in sustainable agriculture and voluntary environmental management.

3. Recommendations on indicators

3.1 Introduction

A key component of this project was to provide recommendations, informed by the literature review, on indicators for measuring (quantitatively and qualitatively) the economic, social and environmental impacts and outcomes of investment in the National Landcare (NLP) Programme activities.

The project team was asked to address the key challenges, available data and data gaps for such measurement. The Monitoring, Evaluation, Reporting and Improvement Tool (MERIT), which has been developed for project and programme reporting requirements of Australian Government natural resource management (NRM) programmes, was used as the basis to assess what indicators are currently being measured.

The project also developed a systems model (see Section 4 in this report) to provide an evidence-base for assessing the economic impacts of Landcare activities. The conceptualisation of the model also provided guidance about the usefulness of indicators.

3.2 Fundamental concepts about indicators

An indicator is a measure that is used to demonstrate change in a situation, or the progress in, or results of, an activity, project, or programme. There are many different types and scales of indicators (input, output, process, outcome, impact indicators for example) and indicators can be direct or indirect, quantitative or qualitative (Anonymous n.d.).

Assessing the value of sustainability indicators is complex (Pannell & Glenn 2000) and there are some fundamental concepts to consider before recommending potential indicators. Pannell (2003) and Pannell & Glenn (2000) raise most of the issues below, with additional issues identified by the project team:

1. An indicator is something that points to or shows something;
2. An indicator is only required when actual outcomes cannot be measured;
3. An indicator is only useful if it can be used to change a management choice;
4. Deciding which indicators are sensible to measure is complex and should be made considering the overall benefits and costs of measurement;
5. If a third party is monitoring, then it can be cheaper to use their monitoring than doubling up, although care needs to be taken to make sure that the indicator does meet the intended purpose or can be linked. Example of others measuring indicators or outcomes could be landholder monitoring at the local scale, or larger scale data collection such as that collected by the Australian Bureau of Statistics (ABS);
6. The larger the severity of threat and the scale over which this occurs, the closer the link between the indicator and the detectable management impact (the certainty between the indicator and the outcome being sought) the higher the chances are that using indicators to monitor the change will be worthwhile;
7. The greater the uncertainty about the relationship between the threat and the management response, the more valuable it can be to monitor, provided that the monitoring does lead to reduced uncertainty;

8. The value of monitoring indicators is heterogeneous in time and space. There is huge heterogeneity of environmental issues across different NRM regions (Ridley et al. 2007) which poses challenges in being able to report impacts of investment within different regions in a way that can also be aggregated at Australia-wide scales;
9. Evaluation of whether continued monitoring is worthwhile and adaptive management is important.

3.3 Indicators and outcomes in the context of Landcare

As raised above the link between indicators and outcomes is critical in deciding what indicators might be worth measuring.

Indicators and outcomes

The objectives of the overall Landcare movement have been covered in the literature review. With the exception of an increased emphasis around targeting of specific priority natural assets, the objectives of the current NLP largely reflect the intent of the earlier iterations of the Programme.

The current strategic objectives are:

- Communities are managing landscapes to sustain long-term economic and social benefits for the environment;
- Farmers and fishers are increasing their long-term returns through better management of the natural resource base;
- Communities are involved in caring for their environment;
- Communities are protecting species and natural assets.

The complexity of broad outcomes sought through the current NLP present challenges for selection of indicators for monitoring. As has been raised previously (Cary 2010), clear and unambiguous management objectives are more likely to achieve outcomes than having multiple objectives. Landcare programmes have had multiple objectives and outcomes which have evolved over time.

Indicators, time and scale

Consideration of issues of scale and evidence for economic impacts were asked to be considered in this project. The literature review conducted revealed that there is little literature to assess the economic impacts of Landcare at both small and large scales.

Impacts from Landcare investment will be much more difficult to assess as scale (from local to global) increases due to influences of other investments, climatic conditions and global factors. The confidence in cause and effect relationships at larger scales will be much lower than at smaller scales.

Long-term impacts are slow to be able to detect and long-term monitoring programs are required to detect changes. Depending upon the indicators such programs can be expensive, except for indicators/impacts that others are monitoring (e.g. using Australian Bureau of Statistics, ABS, economic data at larger scales is cheap and useful if the linkages can be made to indicators being collected at smaller scales).

Given the findings in the literature regarding lack of an evidence base for assessing economic impacts the immediate priority regarding indicators in the NLP should be to focus on short-term indicators, assessment of baseline land management, practice changes and assessment of economic/financial impacts. These need to become well embedded in monitoring and reporting efforts and without this, assessments of impacts over larger scales and longer times may not be meaningful or possible.

3.4 Available data

MERIT ready reckoner and family tree analysis

Much thought and effort has gone into previous monitoring and evaluation efforts in Australian government NRM programmes. The MERI framework and MERIT are well developed for the current NLP and are now embedded within NRM reporting systems. These have been used as the basis of assessing suitable indicators for reporting on the economic impacts of Landcare. MERI sets out the program logic, rationale, assumptions and evaluation approaches and covers both outputs and outcomes. It allows proponents to tease out relationships between the threat and the management response.

Both the MERIT ready reckoner (Anonymous 2014) and family tree (Anonymous 2015b) were assessed to consider the suitability of potential economic indicators¹⁴. The strength of causal link between the indicator and impact, stakeholder relevance and breadth of relevance across different regions was considered. Without further information it is not possible to estimate cost of data collection. Judgements and the concepts outlined by (Pannell & Glenn 2000) were used as the basis on which to recommend indicators. The MERIT ready reckoner (Anonymous 2014) lists 'target measures' and 'minimum data requirements' under heading themes of:

- Implementation Actions (activities undertaken to achieve project outputs and outcomes);
- Assessment Monitoring (activities involved in collecting data about the condition / status of a resource or the effectiveness of implementation actions);
- Project administration, management and reporting (activities which collect information about the administration, implementation, and outcomes of the project itself);
- Training (activities that aim to educate the community);
- All activity forms.

The MERIT 'target measures' can be considered as indicators. The indicators should be based on the minimum data requirements (given these data are already being collected), noting however that there are several target measures for which there are currently no minimum data requirements.

It is not apparent as to whether baseline levels of land management (e.g. amount of streams fenced, area of land under particular management practices) are collected.

The MERIT 'target measures' fall into 3 main categories:

Biophysical measures

- Area or length managed (ha or km) (e.g. area of implemented sustainable farming practices in the 'Management Practice Change' Implementation Actions; length of stream or coastline protected under the 'Erosion Management' Implementation Action);
- Weight or volume of debris removed (e.g. volume or weight of debris removed under the 'Debris Removal' Implementation Action);

¹⁴ The project team has considerable practical indicator experience, however are not MERIT experts. Comments can be modified based on input from those with greater experience in MERIT.

- Number of structures installed (e.g. Number of erosion structures installed under the 'Erosion Management' Implementation Action).

Participation/social measures

- Number of community participation and engagement events (under 'Community Participation and Engagement' Implementation Actions);
- Number of people engaged (e.g. number of indigenous people employed (part or full-time) under 'Project Administration and Reporting');
- Number of contracts or enterprises established (e.g. number of contractual agreements or enterprises established under 'Project Administration and Reporting').

Surveys

- Number of flora or fauna surveys undertaken (e.g. 'Flora Survey General' under 'Assessment and Monitoring').

Discussion on economic indicators from MERIT analysis

There are no direct economic indicators in MERIT. The biophysical outputs (area and length in particular) collected can be used as a basis of indicators to assess economic impacts. Additional information would be needed to assess the direct financial/economic impacts (expressed \$/ha or \$/km) associated with the biophysical indicators. In terms of assessing economic impacts from the NLP the most useful Primary Activity Areas are within the 'Implementation Actions'. Some of the most simple and direct Primary Activity Area categories are Conservation grazing management; Disease management; Pest Management; Erosion; Fencing; and Management Practice Change. Management Practice Change is a key area for attempting to measure economic impacts.

Other readily available data

The ABS collects, compile, analyses and disseminate information on a wide range of social and economic matters including families and communities which can be most readily applied to larger (e.g. national) scales such as the consumer price index and gross domestic product information. Business and environmental information is also collected and reported upon. Data collected by the ABS can be found through an online database.¹⁵

The Department has also developed a set of sustainability indicators for Australia¹⁶. The sustainability indicators have been designed to reflect both stocks (quantity and quality of resources) and flows (uses or drivers of change in stocks) of social and human, natural and economic capital. They cover:

- Social and human capital (skills and education; health; employment; security; institutions, governance and community engagement);
- Natural capital (climate and atmosphere; land, ecosystems and biodiversity; natural resources; water; waste);
- Economic capital (wealth and income; housing; transport and infrastructure; productivity and innovation).

¹⁵ <http://abs.gov.au/AUSSTATS/abs@.nsf/viewcontent?readform&view=ProductsbyTopic&Action=expandwithheader&Num=1>

¹⁶ <http://www.environment.gov.au/topics/sustainable-communities/measuring-sustainability/sustainability-indicators>.

The linkages between data sets and sources regarding ABS and the Department of the Environment and Energy information needs to be considered if this has not occurred already. Data relevant to assessing economic, social and environmental impacts are already being collected in areas other than MERIT and these can potentially provide useful sources to be linked or integrated with current Landcare reporting.

Conclusions from MERIT and other data analysis

In terms of assessing economic outcomes, the collection of financial data for on-farm practice changes would be impractical, expensive, subject to privacy considerations and highly heterogeneous. Based on our analysis it would seem more practical to source financial data through other means (industry gross margins for example).

The land management practices specified through MERIT are not sufficiently well specified to enable assessment of economic impacts. Specification of the baseline and recommended practices would be ideal. At least sufficient specificity of the nature of the recommended practice is required. Without greater clarity about both the nature of the specific practice and practice adoption by area within regions and industries it is not possible to assess economic impacts from programmes.

3.5 Consideration of indicators through development of the systems model

A major focus of this project was the development of a systems model to assess the economic impacts of Landcare and the NLP, the method for which is outlined in Section 4. Development of the systems model requires development of quantitative relationships to link 'cause and effect' assumptions. This provides a much more transparent and stronger evidence-base than is required using MERI and Program Logic approaches. Using the information and data requirements to populate the systems model provides another concrete basis for recommending practical indicators.

Simple and practical indicators to demonstrate economic impacts from the systems model are:

- Financial impact (\$/ha or \$/km) of practice adoption;
- Baseline level of practice adoption (ha) in the absence of the NLP;
- Scale of practice adoption as a result of practice adoption funded by the NLP (this requires a clear-headed assessment of the contribution of the NLP separated from other state and industry programs);
- Timing of practice adoption (this is non-linear and will be affected by the characteristics of the practice and the mechanism, for example the use of incentives might speed up practice adoption compared with relying only on an extension program).

3.6 Key challenges and data gaps

A large challenge is that the purpose of MERIT has not been to assess the economic impact of land management practice adoption. A key decision is needed as to whether assessing the economic impacts of Landcare is needed and if so then how best to achieve this – through links to MERIT or otherwise.

Given the industry, practice and regionally specific nature of agricultural profitability, MERIT appears not to be the vehicle through which to collect financial/economic information.

The issue of a sufficiently specific list of land management practices as raised in Section 3.4 applies to assessing not only the economic impacts but also the environmental and social impacts.

Another challenge is that to assess the economic impact of Australian Government investment in Landcare requires knowledge of both ‘with’ and ‘without’ investment. Knowledge of the amounts of money and impact that other programs (e.g. industry, landholder in-kind, state government investment etc.) along with Australian government investment have is required.

3.7 Recommendations on economic indicators

The overall recommendations on indicators to assess economic impacts of Australian Government investment in Landcare are summarised in Table 3. These have been developed from consideration of current reporting requirements and development of the systems model.

Table 3. Recommended indicators which provide a simple basis for improving economic assessment of the impacts of Landcare.

Individual scale	Local scale	Regional scale
<ul style="list-style-type: none"> • Scale of adoption of individual practices (ha); • Crop yield or stocking rate (t/ha, DSE/ha); • Amelioration rates (lime, gypsum, clay etc., t/ha); • Agricultural commodity prices (\$/t); • Other inputs such as fertiliser rates (kg/ha); • Erosion area treated (ha or km); • Length of stream treated – fenced and/or revegetated (km); • Value of adoption of individual sustainable farm practices (\$/ha or \$/t or \$/head). 	<p>Area of land (ha) on which improved management practices are implemented.</p>	<ul style="list-style-type: none"> • Maximum adoption of individual practices (ha); • Year in which maximum adoption of individual practices is expected.

The biophysical indicators (area and length in particular) in MERIT can be used as a basis to assess economic impacts. Additional information would be needed to assess the direct financial/economic impacts (expressed \$/ha or \$/km) associated with the biophysical indicators. Financial data is better sourced through means other than MERIT, such as industry gross margins for example.

Definition of the different types of management practice change is important for measuring the economic impacts of Landcare. For MERIT to be used to measure economic outcomes more specificity on land management practice by industry and geographic region is required.

There are a range of financial metrics which could be used to link the area and length indicators to assess economic impacts. The recommendation is to use gross margins to estimate financial impacts on the basis that they are a commonly accepted form of measuring economic benefits widely used by industry and are practical to collect. This information would be captured elsewhere (available for different industries from state, national and industry reporting sources, although not in a nation-

wide standardised format). It needs to be noted that gross margins do have some limitations, for example they do not capture the extent to which practices with markedly different up-front and ongoing costs differ in their attractiveness for landholders to adopt.

It is unclear whether data are collected to assess baseline levels of land management (e.g. amount of streams fenced, area of land under particular management practices) resulting from Australian government investment. Without this it will be very difficult to assess the contribution and impacts of Australian Government investment into the NLP or other programmes.

4. Systems model methodology

4.1 Rationale for the approach

The project brief requested development of a complex systems model. The literature review and recommendations on economic indicators revealed a very limited basis to inform the development of a model. Development of a working systems model became the centrepiece of the project to develop the evidence-base to estimate the economic impacts of Landcare investment.

The project brief specified the elements that the systems model needed to contain. These were:

- Descriptions of key activities under Landcare (sustainable land management practices);
- Analysis and descriptions of the relevant environmental, social and economic impacts of such activities;
- Descriptions, including visual and mathematical depictions of relationships and interactions between and within relevant activities and impacts (including at multiple scales);
- Evidence underpinning determination of impacts, relationships and interactions within the model;
- Transparency about the scope and limitations of the model;
- Selection of clusters that are key representative examples of investment in the Landcare.

Overall, the project team interpreted NLAC's vision for the scope and scale of evidence to assess economic, social and environmental impacts of Landcare investment as depicted in Figure 1. The model was only able to assess economic impacts at local to regional scales.

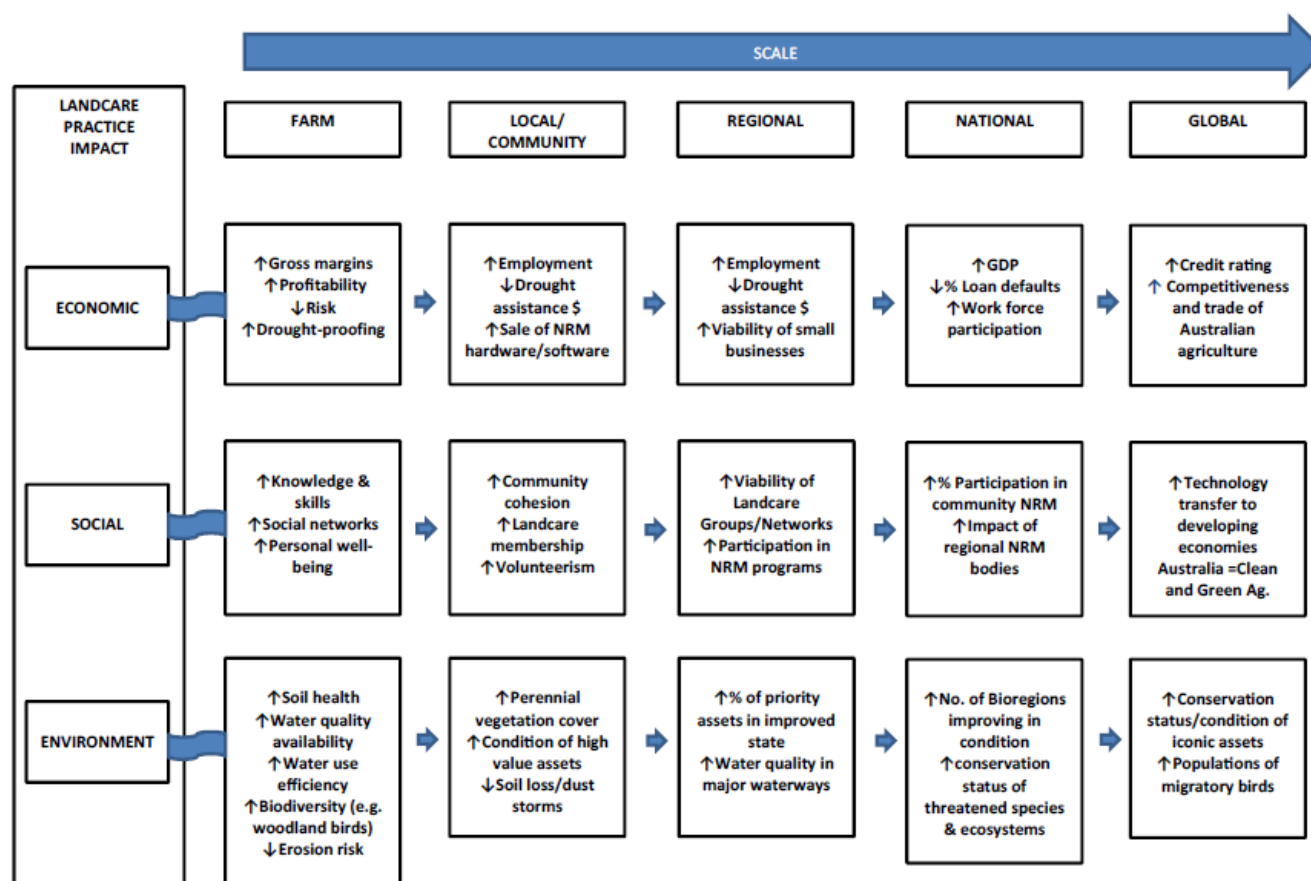


Figure 1. Vision for the scope and scale of evidence to assess economic, social and environmental impacts of Landcare investment.

4.2 Systems model overview

A spreadsheet based model was built which had a strong focus on the benefits from adoption of particular sustainable practices by private landholders. The concept was to value the economic benefits for particular land management practices promoted by Landcare. At the core of the model were the following concepts:

- Estimation of private benefits (to landholders) arising from practice adoption provided the basis for assessment of direct and quantifiable economic benefits;
- Landholder adoption of particular practices can be broken into two components: the peak level of adoption and the time lag until adoption occurs, and a previously developed tool ADOPT¹⁷ provided a suitable framework;
- That adoption can occur through different mechanisms (incentives to increase speed of adoption, education to increase knowledge);
- Understanding scale of adoption as a critical factor (the larger the area and proportion of landholders adopting the practice the larger the impacts);
- There can be time-lags before adoption occurs;

¹⁷ Kuehne, G., Llewellyn R., Pannell, D., Wilkinson, R., Dolling, P., Ouzman, J. (2013). ADOPT: the Adoption and Diffusion Outcome Prediction Tool (Public Release Version 1.0, June 2013) [Computer software] Adelaide SA; CSIRO. Available from www.csiro.au/ADOPT

- Many factors that can affect adoption (such as investment from other sources, climate and larger market forces) and assessment of impacts requires assessment of the contribution of the Landcare investment to overall economic impacts (in economics often termed as the concept of 'with' and 'without');
- The flow-on benefits of practice adoption (impact on rural suppliers, improved trade) can be estimated as additional impacts of economic value once each individual practice is estimated.

Whilst the approach conceived was robust in terms of theory, several practical problems had to be overcome and required some simplification. A more detailed description of the theoretical approach and the development of a practical modelling approach (based on an adoption curve and assessment of the private net financial benefits, in both cases 'with' and 'without' Landcare investment) is outlined in Appendix 3. The practical approach also relied on the use of expert knowledge to populate the model where published data were not available.

The project team had assumed (correctly) that most of the information required to estimate the adoption curve with and without Landcare of individual practices would not emerge from the available literature and would need to be collected from experts who had local and contextual specific knowledge.

A deliberate decision was also made to use gross margin¹⁸ analysis through time, using scenarios of with and without Landcare investment as the basis of assessing private on-farm net financial benefits and hence on-farm economic impacts of the practice adoption through time. Off-farm economic impacts of each practice were very simply captured by estimating the various inputs and services required by the landholder to adopt each practice and multiplying these costs by a profit margin (assumed to be 30% across all industries).

The scope of the model in addressing the project brief requirements is summarised in Table 4 and the model can be requested from the Department of the Environment and Energy.

¹⁸ Gross margins were used to estimate financial impacts as they are commonly accepted form of measuring economic benefits and widely used by industry as well as being the most practical approach in the project timeframe. Gross margins have limitations in that they do not capture the extent to which practices with markedly different up-front and ongoing costs differ in their attractiveness for farmers to adopt.

Table 4. Elements of the systems model to enable evidence-based assessment of economic impacts of Landcare investment.

Project brief required elements for the systems model	Systems model capability
Descriptions of key activities under Landcare (sustainable land management practices).	The model is capable of assessing any land management practice that can be specified. It does not cover enabling activities such as extension/education/capacity building activities directly, but rather the impacts that result from these, namely practice adoption.
Analysis and descriptions of the relevant environmental, social and economic impacts of such activities.	The model is based on well- grounded economic and social (landholder behaviour) theory. In the time-frame of the project it was not possible to quantify social and environmental impacts. This would require additional work and time to attempt.
Descriptions, including visual and mathematical depictions of relationships and interactions between and within relevant activities and impacts (including at multiple scales).	The systems model is spreadsheet based and relies on mathematical descriptions depicted in graphs embedded within the model. The model inputs are per hectare and it reports at the scale to which the land management is relevant (local/regional scale). There is not the evidence-base to report at higher scales, and the confidence in results would be extremely low due to much larger impacts than Landcare investment affecting larger scales.
Evidence underpinning determination of impacts, relationships and interactions within the model	The literature review revealed an extremely limited evidence-base for assessing economic impacts. Sensitivity analysis has been conducted on the important model inputs and ranges of values are reported. The model diagrams in the results section of this report and text about the confidence in results are clearly stated.
Transparency about the scope and limitations of the model	A deliberate decision was taken to build a spreadsheet model. Reasons included that the project time-frame was limited, spreadsheets are able to be used by non-modellers to use, are easy to adapt and allows assumptions to be transparent. The scope and limitations of the model are outlined in this report.
Selection of clusters that are key representative examples of investment in the Landcare	The three case studies represent some of Australia's key agricultural and export industries (grains, cotton, dairy) and cover four states (Western Australia, Queensland, NSW and Victoria). The clusters were selected in consultation with NLAC and the Department. The model is capable of covering any agricultural industry on privately held and leased land used for primary production. Considerations regarding scaling up are outlined in this report.

4.3 Comments on estimating social and environmental benefits

The premise of sustainable land management practices is that there are often benefits that are more than simply financial. These are often termed as non-market benefits or impacts. For example, a particular practice could also protect soil resources, provide habitat for wildlife or provide other ecosystem and/or social benefits.

The systems model has a strong emphasis on financial impacts (market rather than non-market economic impacts) rather than on non-market benefits. This was a considered and deliberate decision, because of known complexities and contestability in non-market valuation techniques as well as the more practical issue that the project time-frame could not allow it to be done in a

meaningful way. Members of the project team have expertise in this area which informed the project design (see Pannell discussions 218-221 for an overview)¹⁹.

4.4 Scaling up from case studies (clusters)

For this project the systems model was applied to select Landcare practices in three case studies (termed 'clusters' in the project brief). These were:

- Grains and mixed grains/livestock industry in Western Australia (WA);
- Cotton industry in Queensland (QLD) and New South Wales (NSW);
- Dairy industry in Gippsland, Victoria.

Within the spreadsheet model, each sheet represents a Landcare practice within an industry. A total of 10 practices (four for the grains and mixed grains/ livestock zone, three for cotton and three for dairy) were assessed in this project. Depending upon the number of practices and industries, development of a non-spreadsheet based model might be preferred in future because there will be limitations in spreadsheet modelling approaches (speed and number of worksheets required may become cumbersome). The model could be readily programmed using a different approach. For example there are likely to be better approaches to enhance the spatial capabilities of the model and/or to link more directly with MERIT.

Fundamental units as the basis of model conceptualisation and scaling up are:

- Some form of plant-soil-climatic based unit which can also be integrated with other administrative reporting units of interest;
- Industries within these units;
- Sustainable land management practices within industries.

Some concepts regarding how the model might be scaled up are outlined below.

Plant-soil-climatic units

If the model were to be scaled up across Australia this would require use of a consistent and nation-wide classification framework. Agricultural industries across Australia have used a myriad of different classification systems to represent the climatic diversity in which industries operate²⁰ and current industry systems are therefore unlikely to be useful in developing a consistent national approach.

MERIT uses the Interim Biogeographic Regionalisation for Australia (IBRA) zones (see Figure 2). This or some other form of national classification would be suitable units as the basis for scaling up. The 89 IBRA regions would be unwieldy to name as individual units for the spreadsheet model, but it would make sense to use them or another reporting unit in MERIT as the basis for scaling up.

¹⁹ <http://www.pannelldiscussions.net/2012/07/221-valuing-environmental-intangibles-part-4-the-upshot>

²⁰ For example the Grains Research and Development Corporation has developed 14 major agro-ecological zones; Dairy Australia has uses eight major dairy farming regions; Meat and Livestock Australia has identified 12 major climatic zones; Cotton is grown in eight regions across NSW and Queensland; Sugarcane is grown in a number of regions in Qld and northern NSW across a range of climatic zones.

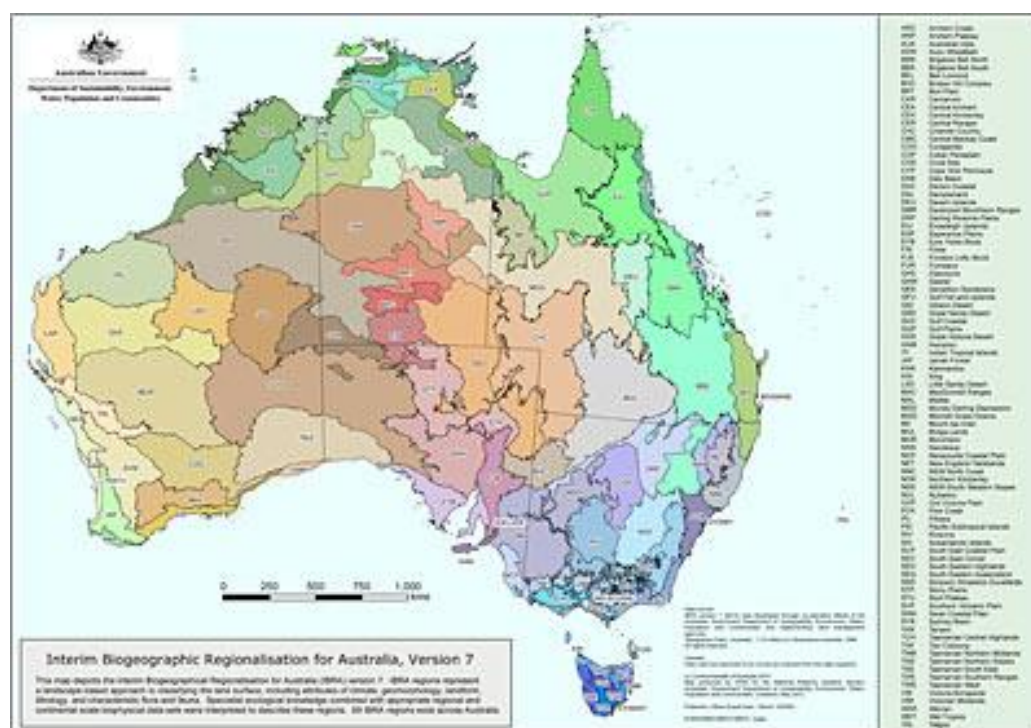


Figure 2. Interim biogeographic regionalisation units for Australia.

Industries

MERIT uses nine industry groupings²¹ which fitted well with the selection of the case studies used in this project. Financial data (such as gross margins) are commonly available on an industry by geographic or climatic region basis.

Sustainable land management practices

Sustainable land management practices vary across industries. Some, such as the grains industry²² and cotton²³ have consolidated lists which could be used in relevant regions across Australia, although it is likely that not all sustainable land management practices developed within industries are of significance from a Landcare perspective. Other industries have not developed such agreed practice lists. The relevance of sustainable land management practices varies within industries because different natural resource management (NRM) issues are faced in different regions.

It was not readily possible to ascertain a list of sustainable farming practices from MERIT. MERIT uses 'public good outcomes' and 'change facilitation strategy' fields to show the flow on impacts from the farm management practice change. A further challenge is that sustainable farming practices have varied between Australian government programs and will continue to vary over time.

²¹ Aquaculture; Cotton; Dairy; Fruit trees; Grains; Grazing; Sugarcane; Vegetables; Other.

²² Matching land use to land capabilities; Reduced or no-tillage; Stubble retention; Crop rotation with pastures, oilseeds and pulses; Controlled traffic and precision agriculture; Integrated weed / pest / disease management in crops and pastures; Nutrient budgeting and soil testing; Use of perennials in systems (can include pastures and trees); Stocking rate and intensity; Managing biodiversity; Water budgeting

²³ <https://www.mybmp.com.au/>

The conclusions from this project were that it was necessary to ask local experts to identify the most important sustainable land management practices from Landcare economic impact perspective as practices and their economic impact are likely to differ between regions.

4.5 Process to populate the model

The process to populate the model was:

- Identification of key people with history and local, context-specific knowledge of relevant industries, practices and perspectives. Identifying and working with local champions was key to finding a good mix of people covering both production and environmental perspectives;
- Running a facilitated workshop to specifically seek out expert knowledge of the specific questions and quantification needed to develop inputs for the model. The workshop elements included;
 - Development of a list of candidate practices to be considered;
 - Agreement on several practices which were to be used to conduct more analysis for population of the model;
 - Discussion about off-farm impacts, both direct economic impacts and broader indirect environmental and social impacts which were known to be important but which could not be used in the systems model ;
- Follow up with reference and other sources of evidence to develop as strong and transparent and evidence-base as possible;
- Population of templates with the information required to be used as model inputs;
- Adaptive management making changes to the model to enable the economic benefits of all practices to be estimated as well as possible in the time-frame;
- Review of model inputs, assumptions and results by selected experts who had participated in the process
- Writing up of results.

Overall the process worked extremely well. Participants were actively engaged and have shown strong interest in the results generated. The process was constructive and could be readily replicated in other regions. Table 5, taken from the dairy workshop, illustrates how the list of agreed candidate practices were filtered to decide which ones would become the focus of the project. Box 1 illustrates some the initial data collected at the expert workshop which formed the basis of follow up with specific people. Reviewers of information were also nominated at the expert workshop.

Table 5. Characteristics of candidate dairy practices for the purposes shortlisting three practices.

Practice	Region/Scale applicable	Scale of adoption (2015)	Baseline adoption	Max scale adoption/time	Without Aust Govt investment
Better nutrient* management	Australia wide	Y	Y	Y	Y
Farm layout and management	Australia wide	?	?	N	?
Improved effluent management*	Australia wide	Y	Y	Y	Y
Improved grazing management	Australia wide	N	N	?	?
Managing stock density, groundcover and rotations	Decided to combine with improved grazing management				
Riparian management - revegetation and fencing*	Australia wide	Y	Y	Y	?
Revegetation for shade and shelter	Australia wide	Y?	Y	Y?	?
Revegetation in sensitive areas (wet areas, gullies, biodiversity)	Gippsland and other areas – (features vary –e.g. not many gullies in some regions)	Discussion about whether to combine with riparian management, then decided better for focus only on riparian management as it applies Australia wide			
Installation of re-use systems and irrigation	Reuse systems – relevant mostly to irrigation regions but Australia wide in these areas	Y	Y	Y	Y
Flood irrigation to spray conversion	Dominantly MID relevant and some other areas	Ended up deciding that the practice was limited in overall area			

*Indicates practice that was agreed as one of the top three to progress for detailed analysis.

Box 1. Template illustrating data collected for a Landcare practice from the dairy workshop.

Practice: Improved nutrient management

Baseline (pre-Landcare) practice: Apply nutrients at a rate that was based on ‘as much as you could afford’. Some soil testing (limited), but not used to inform fertiliser requirements. Aiming for high Olsen P. Fertiliser wasn’t expensive enough to stop putting it out.

Current best practice: Soil testing, applying fertiliser according to results and farm production requirements. More targeted fertiliser application (timing through the year and pasture requirements). Nutrient budgets (all sources on farm including sources brought in). Independent consultants are a major source of advice for landholders. Integration of effluent into the nutrient mix has been a big change since the 90s.

Farming System: Applies across both dryland and irrigated and also intensive feedlot systems.

Region/ Scale: National but questions regarding adoption to be answered based on knowledge of Gippsland and then we will assess the extent to which we handle national extrapolation.

Mechanism by which Landcare has had impact:

Sheets were handed out and filled out for this practice. Major mechanisms were listed as:

- Increased knowledge of how to implement practices (extension and field days, increased skills in nutrient budgeting);
- Receipt of payment through Landcare (e.g. subsidised soil testing, through Fert\$mart courses);
- Encouraged soil testing;
- Encouraged cooperation with others;
- Changed farm goals to put more emphasis on environmental outcomes.

Overall both extension and incentives are important mechanisms.

Adoption of the practice

2015	2000	Max / When	Without Aust. Govt. funding - current adoption
30-40% of farm area	<10%	85% farm area by 2025	10 -15% None/few farmers would sign up without funding

Profitability comments:

Broader benefits:

Other notes and follow up leads:

Direct off-farm benefits:

Reviewers of information once we have compiled:

5. Case study results - Grains and mixed livestock zone, Western Australia

5.1 Geographic area and farming system

Grains and livestock production on private land in the Western Australian (WA) wheatbelt and mixed livestock zones are critical to Australia's agricultural export success. The WA grains industry is export-oriented with more than 80% of annual grain production exported to more than 50 countries worldwide²⁴. Western Australia is also a world leader in live exports, super fine wool production and dryland sheep and grain systems. Both cattle and sheep systems are focused on export markets to Asia and the Middle East.

The grains industry is the largest agricultural sector in WA delivering more than \$4.5 billion to the State economy each year, the majority of this coming from cereal production (\$3.5 billion). WA produces approximately 10 million tonnes of grain each year from around 4000 rain-fed farms ranging in size from 1000 to 15,000 hectares.

While some farms only produce grain, livestock (sheep or beef production, depending upon rainfall) is an important part of the farming system on many farms. A significant portion of the 26% of the state's agriculture (worth approximately \$2 billion at the farm gate in 2011/12) comes from grains and mixed livestock zones.

The area of privately owned land broadly described as the WA wheatbelt is approximately 19.7 million ha (Anonymous 2015a). For the purposes of our study we have assumed the overall relevant area to be 16.9 million ha of privately owned land and where grain only or mixed grains-livestock are important.

5.2 Practices selected

Australian government investment through the Landcare has been important for a range of practices. At the expert workshop held in Perth a long list of practices²⁵ was initially developed. Practices could be lumped or split in various ways and the following were agreed as a short list at the meeting:

- No till/reduce till/direct drilling and retained stubble;
- Perennial pastures which could potentially include forage shrubs;
- Liming (managing soil pH, soil testing and liming);
- Managing water/salt in the landscape (remnant veg, contour banks etc.);
- Tree planting/agroforestry – potentially for biodiversity, shade and shelter or revegetation.

²⁴ www.agric.wa.gov.au/crops/grains

²⁵ Perennial pastures (kikuyu pasture, Lucerne and other perennial species); forage shrubs; drainage; mouldboard ploughing; revegetation for restoration; claying/mould boarding – ameliorants for non-wetting soils; overcoming soil constraints; biological farming – move to organic fertilisers – timing and application of fertilisers; agroforestry systems; fit for purpose land use; soil testing to depth; controlled traffic; managing water in the landscape (remnant vegetation planning, contour banks)

Following further discussion and follow up from the workshop to assess areas, as well as assessment about availability of information, four practices were selected, one of which had a strong environmental focus involving native vegetation. The following four practices are described as:

- **Liming:** The use of lime to manage soil pH (surface or subsoil) to enable yields to be maintained and prevent soil acidification. The potential area of land assessed as requiring liming is in excess of 11 million ha, and 2015 adoption was assumed as 1.6 million ha;
- **No-till:** No-tillage is a way of growing crops or pasture from year to year without disturbing the soil through tillage. Technically, it is one pass seeding with narrow or knife points with less than full cut-out (<20% soil disturbance). It is sometimes also called zero tillage or direct seeding. At 2015 we have assumed that 8 million ha is under no-till management;
- **Kikuyu pasture:** Kikuyu is a sub-tropical perennial (meaning it lives for 2 years or more) grass typically grown with subterranean clover in pastures. It is the most widely adoptable perennial pasture species in suitable areas. The area suitable for kikuyu is estimated to be approximately 300,000 ha and at 2015 adoption levels are assumed as 180,000 ha;
- **Revegetation of marginal cropping land for biodiversity outcomes:** This is strategic revegetation of very low productivity cropping land. This land has limited agricultural productivity due to significant soil constraints, consistently produces low yields, and as a result landholders can be receptive to removing it from production. The area of marginal land was assessed to be 825,000 ha (but it could be much higher as estimates were based on soils with 3 or more soil constraints) and 2015 adoption was only 40,900 ha.

A number of other practices associated with Australian government investment into Landcare will also have economic and other benefits beyond these four practices; however these are likely to be amongst those of most importance.

5.3 How Landcare has had impact

The mechanisms by which Landcare investment was assessed to have impact have been summarised for each practice below, based on input at an expert workshop. The impact of investment on the area of adoption for each practice is shown in Figures 3-6.

Liming

The mechanism by which Landcare investment affected adoption of liming was assessed by expert workshop participants as:

- Increased landholder knowledge of how to implement practices through extension;
- Influenced the awareness of funders of the issues and influence of the success of on-going funding;
- Encouraged soil testing;
- Incentive payments from Landcare (soil testing for acidity below the traditional top 10 cm);
- Helped to change landholder's goals to put more emphasis on environmental outcomes
- Encouraged co-operation with neighbours and other landholders.

The estimates of liming adoption (by area of land) are shown in Figure 3, showing estimated adoption 'with Landcare' (total of all investments, industry, state and federal governments, the green curve in Figure 3). The 'with Landcare' curve was based on actual lime sales data supplied by Chris Gazey. The adoption that was estimated if the Australian government funding through

Landcare had not been made (the red 'without' Landcare curve) was based on expert opinion. Adoption was estimated to have increased even without Landcare funded research and development, but at significantly lower rates. There is early divergence (1996) as a major liming program set the groundwork for increased sales.

A critical point is the adoption rate in 2005 which was low due to cessation of Landcare extension activities and a poor season. Adoption without Landcare was estimated significantly lower. The dips in the 'with Landcare' adoption curve around 2005 and 2011 corresponded with dips in Landcare extension funding. Landholders dis-adopted lime without extension despite economic benefits because of the requirement of relatively large upfront expense and the benefits of ameliorating subsoil acidity occur over a long time horizon (more than 10-20 years).

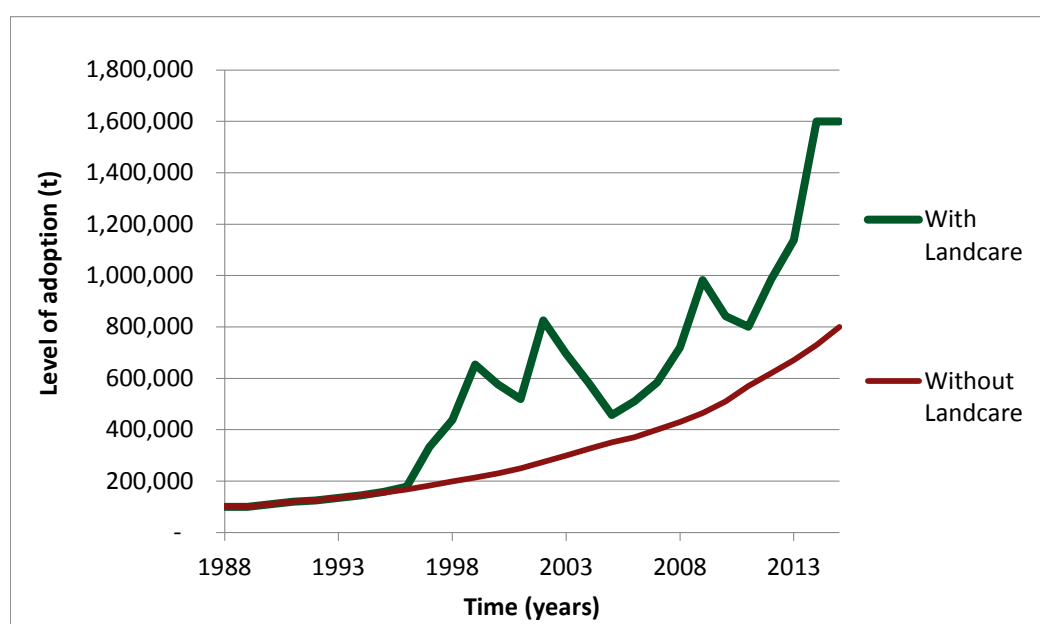


Figure 3. Estimated adoption of liming with and without Landcare funding.

Overall, Landcare funding was estimated to increase the scale and speed of adoption of liming. However lime tonnages applied (based on lime sales) still fall well short of what is required. Over 11 million ha require lime and lime needs to be re-applied on a regular basis to counteract the acidifying effect of agricultural production.

No-till

Experts suggested that the mechanism by which Landcare investment affected adoption of no-till were:

- Development of early practice research (through early investment through Australian Government funding – Landcare and precursor programs);
- Encouraged cooperation with neighbours or other landholders;
- Increased knowledge of how to implement practices;
- Change in landholder goals to put more emphasis on environmental outcomes;
- Encouragement of soil testing.

The impact of investment in the area adopted under the no-till practice is illustrated in Figure 4.

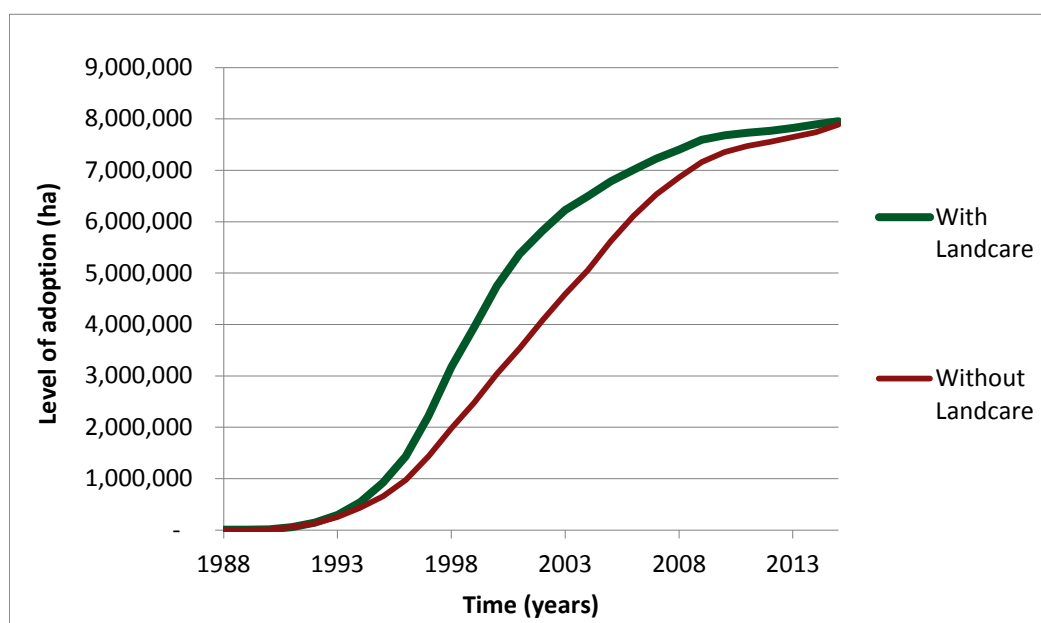


Figure 4. Estimated adoption of no-till with and without Landcare funding.

Investment attributed to pre-cursor Landcare started with a project called the National Soil Conservation Program (NSCP) from 1982-93. This project determined that no-till provided yield benefits to landholders and started the extension activities. This project was seminal in the establishing the Western Australian No-Tillage Farmer's Association (WANTFA). Formed in 1992, WANTFA was built on the ethic of growers helping growers.

Reflections regarding the success of no-till farming in the WA grains and mixed livestock zone suggest that a combination of factors have been involved in the success of no-till. These are a combination of:

- A large natural resource management problem (soil erosion);
- Innovative developments (machinery improvements such as tungsten tips as well as new herbicides in glyphosate and paraquat/diquat) that appealed to grain producers;
- Innovative grain producers willing to work together collaboratively;
- Passionate advocates who believed in the technology;
- A collective desire to gain new knowledge and overcome resistance to change.

The early investment through the NSCP and early Australian government funding has been a major contributor to the success of no-till farming in WA. Maximum adoption is estimated to have been reached.

Kikuyu pasture

The mechanism by which Landcare investment affected adoption of kikuyu pasture was assessed as:

- Incentive payments to help with establishment of kikuyu pasture;
- Support for community and grower groups to encourage adoption;

- Increased knowledge of how to implement practices;
- Change in goals to put more emphasis on environmental outcomes;
- Encouraged co-operation with neighbours or other landholders (peer learning).

The estimated adoption of area under kikuyu pasture is shown in Figure 5. Australian Government funding in the form of incentives to establish kikuyu through the NAP/NHT only occurred in WA around 2005. Although Australian Government funding since 2007 has declined significantly, the adoption was estimated to continue due to the attractiveness of kikuyu and support from other state and industry extension programs.

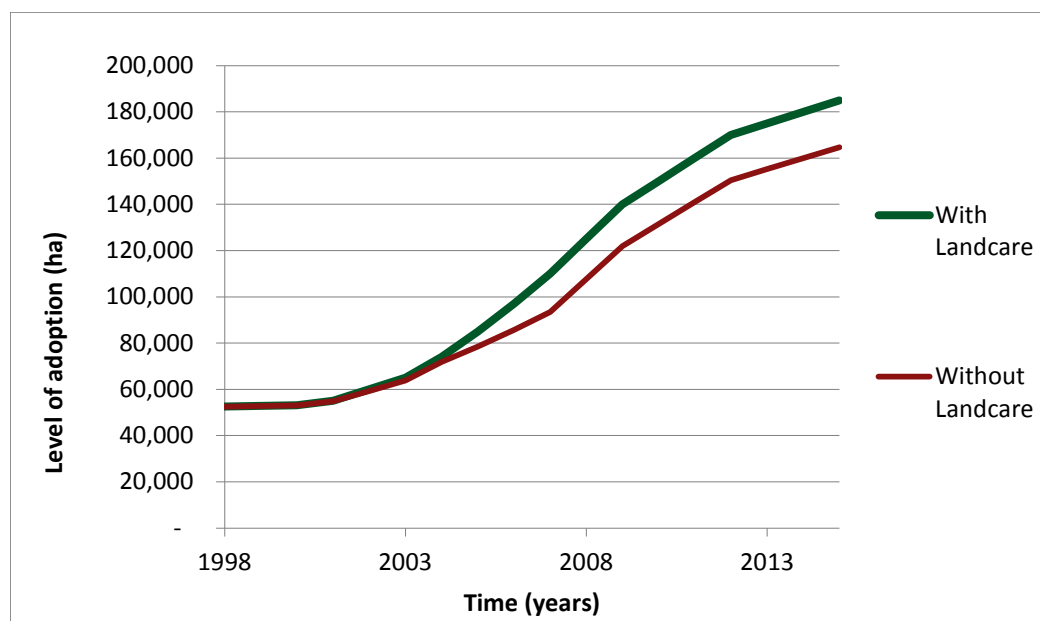


Figure 5. Estimated adoption of kikuyu with and without Landcare funding.

Overall Landcare investment for a relatively short period (2005-2007) was assumed to help spur the speed and scale of adoption of kikuyu pastures.

Revegetation on marginal land

Revegetation on marginal land for biodiversity outcomes was selected as an important and strongly environmentally focussed practice. The mechanisms by which Landcare investment affected adoption of revegetation on marginal land were assessed by experts to be:

- Receipt of payments from Landcare;
- Change in landholder goals to put more emphasis on environmental outcomes;
- Increased knowledge of how to implement the practices;
- Encouraged cooperation with neighbours or other landholders;
- Favouring of a collaborative approach between growers and groups to foster strategically valuable placement of plantings for soil erosion mitigation, corridors and/or for water protection.

The area of estimated adoption is shown in Figure 6. In contrast to the three other practices, only very small levels of adoption without Landcare investment are estimated to occur, because of the costs associated with changing land use, even though the land is of limited productivity. The costs of

revegetation are estimated to be very high and without significant incentives, landholders cannot afford to adopt such practices at scale. Even with the incentives offered (50:50 cost share) the 2015 level of adoption of 40,900 ha is only a portion of the area estimated (825,000 ha) as having potential for revegetation. Unlike the other three practices, continued investment at high levels is crucial for continued adoption.

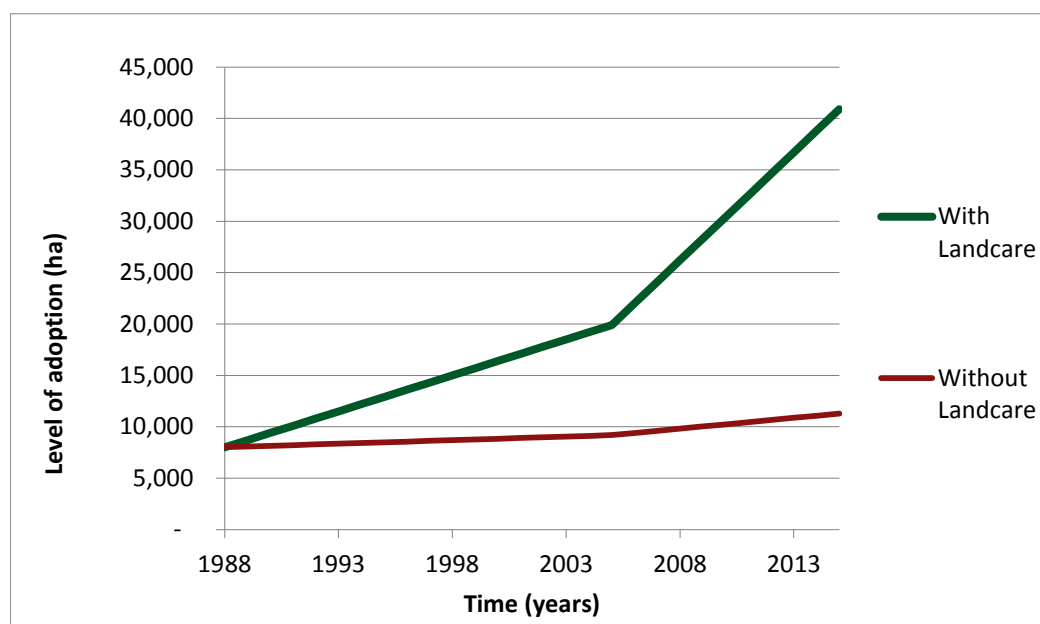


Figure 6. Estimated adoption of revegetation on marginal land with and without Landcare.

5.4 Benefits – direct on-farm, direct off-farm and indirect off-farm

Australian government investment through the Landcare is one of a number of factors influencing the amount and scale of adoption. Development of an evidence-based model to assess the economic impacts requires clear assumptions about the cause and effect relationships between adoption of practices and impacts. Three types of impacts were considered:

- Direct on-farm economic benefits (the systems model captures impacts assessed in \$ values due to increased yields, improved profitability and/or reduced costs, but does not capture biodiversity and broader outcomes because \$ values were not able to be assessed);
- Direct off-farm economic benefits (the systems model captures \$ value impacts associated with direct impacts on rural industries resulting from practice adoption through simple assumptions about changes to profitability and differences in inputs and/or outputs);
- Broader indirect off-farm social and environmental benefits (these impacts were unable to be quantified in this project but could be as part of additional work).

Adoption of improved practices (liming, no-till, kikuyu pasture and revegetation on marginal land) leads to direct on-farm benefits. Figure 7 shows the links between practices and positive direct on-farm and off-farm benefits (the bold arrow shows the link of greatest economic significance). Note

that the model only captured direct economic benefits and it is well known that practices have additional environmental and social benefits (both direct and indirect) which the model has not captured.

For the WA grains and livestock work the benefits that have been assessed are:

Direct on-farm benefits:

- Improved yields: Liming, no-till, kikuyu pastures;
- Increased farm income: Liming, no-till, kikuyu pastures;
- Diversified farm income: kikuyu pastures.

Direct off-farm benefits:

- Increased sales: Lime suppliers for liming;
- Increased sales: Seed merchants for kikuyu pastures and revegetation;
- Increased sales: Input suppliers for revegetation plantings;
- Increased services: Planting contractors for revegetation and kikuyu pastures.

Note that benefits to increased transport of agricultural produce were identified as an additional direct off-farm benefit from practice adoption, however the costs associated with road maintenance are likely to more than off-set the benefits and thus transport impacts have not been considered.

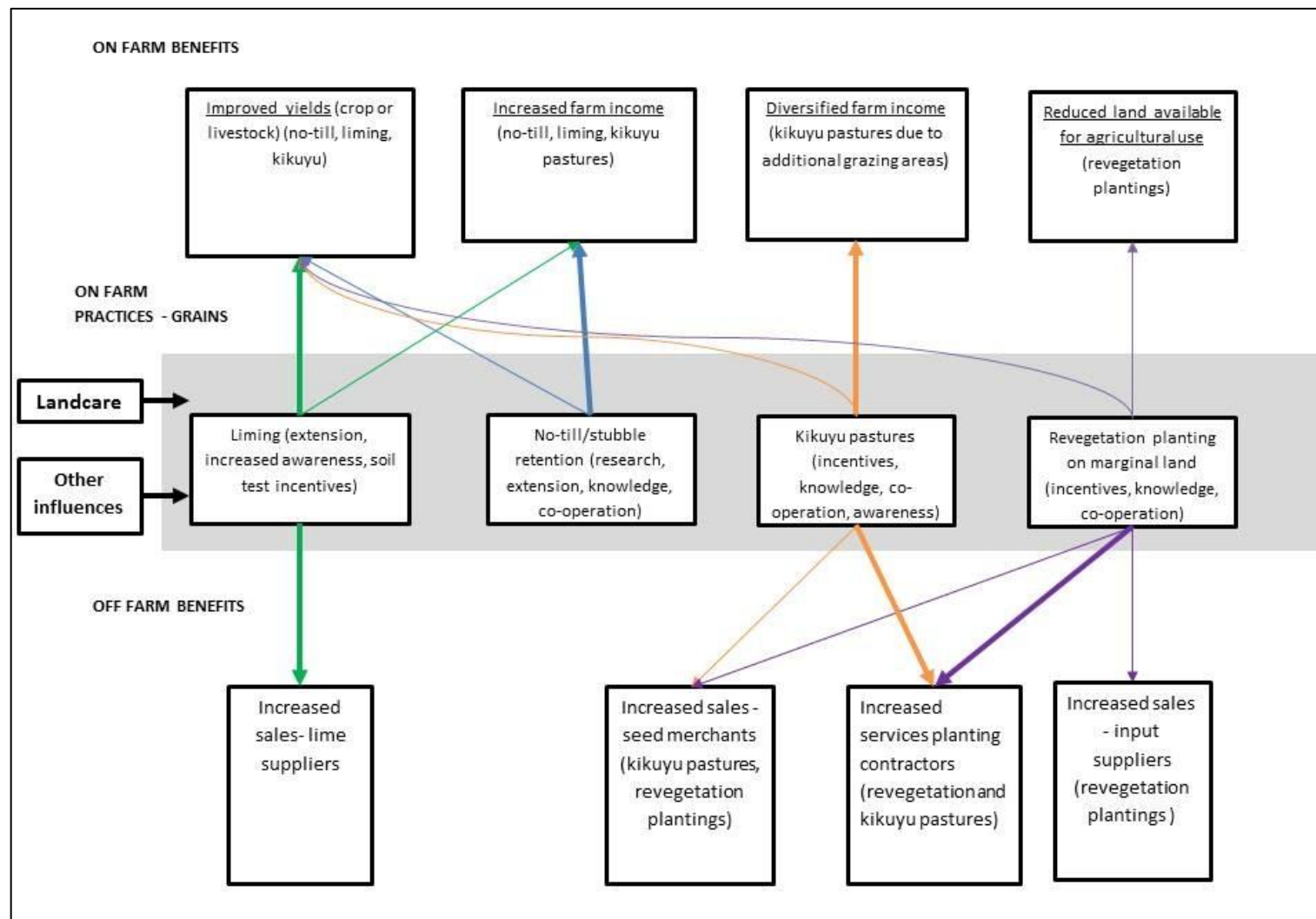


Figure 7. Direct on-farm and direct off-farm benefits of practice adoption in the grains and mixed grains/livestock zone in Western Australia

5.5 Direct economic benefits of WA practices

The 'headline' results are presented in Table 6 for each of the four practices analysed (liming, no-till, kikuyu pasture and biodiversity revegetation on marginal land). More detail is presented below and details of all major assumptions are further outlined in Appendix 4. The spreadsheet model can also be requested from the Department of the Environment and Energy.

Table 6. Estimated direct economic benefits (on-farm and off-farm) from 'Landcare' from 1988-2015 for grains and mixed grains/livestock in Western Australia.

	\$ millions of economic benefits (present value, 1988 – 2015)			
Direct benefits	Liming	No-tillage	Kikuyu	Biodiversity revegetation on marginal land, grain farm ²⁶
On-farm value	131	790	8.8	-99
Off-farm value	48	0	0.6	25
Total measured economic value	179	790	9.4	-74
Range	124-254	395-1580	4.2-18.3	-17 to - 115

Direct on-farm benefits

By far the greatest value has resulted from more rapid adoption of no-till (Table 6) which was attributed to early Landcare funding for a practice that is economically attractive to landholders. The direct on-farm value of no-till was estimated to be \$790 million over 27 years (1988-2015). Direct on-farm economic value of liming was next (\$131 million), followed by kikuyu pasture (\$8.8 million over the life of Landcare).

The measurable direct on-farm economic benefits from revegetation for biodiversity on marginal agricultural land always had negative values. Six scenarios were analysed, one of which is shown in Table 6. On-farm losses were \$99 million on grain only farms and even higher (\$123 million on mixed grains/livestock enterprises. The large up front establishment costs (including fencing on mixed grains/livestock farms) are the major reason for the result.

Brief details for each practice are outlined below and the timeframe for all practices was 1988-2015.

Liming

The on-farm value of liming (\$131 million) has been estimated by multiplying the on-farm marginal benefit of lime by the adoption rates of lime through time attributable to Landcare. The Optlime model was used to assess equivalent annual profit. Optlime represents the essential biological, physical and economic factors related to soil acidity management in WA. The estimated on-farm benefit of liming (expressed as present value) from 1988 to 2015 that was attributable to Landcare was \$131 million (subtracting the 'without Landcare' present value of \$185 million from the 'with Landcare' value of \$316 million). Details of calculations are outlined in Appendix 4.

No-till

No-till was estimated to have a \$790 million economic benefit (Table 6). The estimated marginal value of no-till in grains and mixed grains/livestock was calculated based on an estimated 10% yield

²⁶ Grain farms, no fencing required for revegetation and the landholder outsources establishment

boost on grain yields over time, multiplied by the grain price, and minus an additional 10% cost in fertilisers. It was acknowledged at the expert workshop that while there would be some reduction in fuel use at seeding due to no-till, this would be off-set by an increase in fuel use at harvest due to larger crops. It was also acknowledged that while no-till can have some higher input costs than conventional tillage, the advantages in other technologies such as large air-seeders/herbicide advancements/precision agriculture/GPS have resulted in a much more efficient system overall regardless of tillage system used; thus for this analysis we have not assumed additional costs of new technologies added on to no-till. Further details are contained in Appendix 4.

Kikuyu pasture

The on-farm economic benefit of kikuyu pasture was estimated to be \$8.8 million. This was based on a summary of gross margin analysis provided by Paul Sanford (see Appendix 4) and no change through time (i.e. gross margins of livestock grazing kikuyu pasture have remained constant in real terms over this time period and Landcare impacts do not change this, only contribute to the speed of adoption). The calculation of the on-farm economic impact was developed from summary figures using Grassgro modelling²⁷ where simulations were run for 40 years (average of prime lamb and wool enterprises for a whole farm analysis) and suggesting an increase on kikuyu pastures of 5-10%.

Biodiversity revegetation on marginal land

Revegetation of marginal land for biodiversity purposes was estimated to have an economic loss on farms (a loss of \$99 million for grain farms and \$123 million for mixed grains livestock farms, see Appendix 4). The results were driven by large upfront costs to landholders associated with establishment of vegetation and fencing where required. For periods prior to 2005 incentives were not available and establishment costs were assumed to be \$2,500/ha. With Landcare 50% cost share funding, establishment costs were still very large (\$1,250/ha). Even though it was assumed that there was a \$100/ha savings through reduced crop losses, the establishment costs were the over-riding challenge for adoption and economic benefit.

Direct off-farm benefits

Off-farm benefits were estimated to differ markedly depending upon the practice. Minimal off-farm benefits were estimated for both no-tillage and kikuyu pasture. The off-farm benefits from liming were significant (\$48 million or 27% of total economic impact) compared with no-tillage (no off-farm benefit estimated) and kikuyu pasture (\$0.6 million). The value of off-farm benefits of revegetation of marginal land was \$25 million (Table 6), the extent depending upon the level of contracting labour used.

The direct off-farm economic benefits of all practices included increased profits to the transport industries. However, these benefits are likely to be at least offset by additional infrastructure costs for maintaining roads and associated infrastructure and were therefore not included in the analysis.

Liming

Landcare has increased lime sales with an estimated value of \$48 million. The current price of lime from different lime sources was estimated to be a weighted average price of \$15/t and it was assumed that lime retailers make a 30% profit margin. The marginal off-farm value of liming was

²⁷ Grassgro modelling sourced from P.Sanford (Department of Food and Agriculture Western Australia)

calculated by summing the marginal benefits to the lime industry for the period of 1988 to 2015 (marginal value multiplied by level of adoption, Appendix 4).

No-till

No-till caused a change to the type of machinery bought – the substitution of wide points with narrow points. While wide points are cheaper than narrow points, the wear-and-tear on the wide points causes them to be replaced more often than the narrow points. Hence, it was estimated that no-till has had no net economic impact on the machinery industry.

Kikuyu pasture

Direct off farm benefits (total of \$625,000) were identified for three industry sectors; seed producers, seeding contractors and shearing contractors. Assumptions on seed prices (which have reduced over time), a 30% profit margin and seeding rates generated benefits ranging from \$14-26/ha over time. Seeding contractor rates of \$55/ha, a 30% profit margin and assuming that 50% of kikuyu pasture is seeded by contractors, generated an estimated increased profitability to seeding contractors of \$8/ha. Impacts on shearing contractors were too small to be considered.

Biodiversity revegetation on marginal land

The value of direct off-farm economic benefits of revegetation on marginal land was estimated as \$25 million where no fencing was required and where landholders used revegetation contractors. Where fencing was required (on farms containing livestock the value of off-farm impacts increased to \$30 million. Calculations are outlined in Appendix 4 and involved assumptions about seedling costs, establishment costs, fencing costs (if required) and the amount of land being revegetated.

5.6 Confidence levels in the systems model results

The results presented are considered as a first attempt to assess economic impacts of Landcare investment. Sensitivity to model inputs is outlined in Appendix 4 and the model itself can be scrutinised. The model method is simple, transparent and based on adoption theory from Australia's leading economists and social researchers. The approach developed worked well using expert opinion.

Comments on each of the major model inputs are presented below:

- Level of overall adoption (moderate confidence for no-till, liming and kikuyu adoption, low confidence for revegetation on marginal land);
- Level of adoption attributable to Landcare investment (low confidence for all practices);
- On-farm economic benefits and costs (moderate confidence, albeit that the heterogeneity experienced on farms has not been captured);
- Direct on-farm benefits (moderate-low confidence because of strong dependence on adoption attributable to Landcare);
- Direct off-farm impacts (low confidence as this has been captured very simply and is based on on-farm benefits).

5.7 Broader indirect off-farm benefits

As outlined earlier, only direct economic impacts have been captured in the systems model. It is known that there are other important benefits from adoption of sustainable land management practices, however it has not been possible to put a value on these associated environmental and social impacts. Through the expert workshops a number of important additional broader off-farm impacts associated with Landcare investment were identified.

Economic benefits: Landcare has created jobs in some local communities, and every job in a small WA town is important. Across the WA grains and mixed livestock zone it was estimated that approximately 12 local Landcare facilitators were employed during the first round of the National Heritage Trust (NHT 1) and Landcare jobs have declined since then. The rough estimate was that there has only been one regional facilitator for each WA NRM since NHT1. Some people have moved to local governments because of lack of job security but the extent to which employment has reduced was not possible to quantify.

Even if the number of jobs created by Landcare had been able to be quantified, this wouldn't give a robust estimate of overall impacts on the economy. Whether a job in a local community is associated with Landcare or another job (for example nurses or teachers), what matters to local towns is maintaining employment levels. Increased funding for Landcare might mean reduced services in other parts of the economy. To do a robust analysis would require assessing other impacts as well as the benefits from employment due to the program.

Environmental benefits: To recognise the importance of some of the broader impacts that Landcare investment has had, for each of the practices assessed, a simple qualitative assessment of additional impacts from practice adoption is presented in Table 7. These impacts were mentioned through interactions with stakeholders. The table indicates an assessment of whether the impact is high, medium or low. If the impact is believed to be minimal or was not mentioned in discussion with stakeholders the cell has been left blank.

Table 7. Additional impacts associated with practice adoption not captured in the systems model.

Additional impacts associated with practice adoption	Liming	No-till	Kikuyu pasture	Biodiversity revegetation on marginal land
On farm environmental impacts				
Soil structure	Low	High	High	High
Soil biology	High			
Carbon storage	Low	Medium	Medium	High
Reduced erosion	Low			
Improved crop pest management		Low		Low
Shade/shelter for livestock				Low
Off-farm impacts				
Water quality (eutrophication)	Low ²⁸	High	High	High
Water quality (salinity)			Low	High
Air quality (dust)		High	High	High

²⁸ There is no evidence in WA and no published evidence elsewhere in Australia, however if acidification continues it may have potential to change pH in waters.

Improved aesthetics, mental health, women staying on farms		Low	Low	High
Additional employment				High ²⁹

5.8 Discussion

The results show that investment in Landcare has had an estimated economic impact on adoption of sustainable farm management practices. It is believed that this is the first time in Australia that the economic impact of investment into Landcare has been assessed through development of a systems model (or indeed even without this and with transparent assumptions). The results are highly sensitive to assumptions used and there limited hard evidence in terms of the scale of adoption and/or the impact of Landcare compared with other sources of investment. The figures are not measures of the cost-effectiveness, nor measures of the overall impact, efficiency or effectiveness of Landcare.

The large estimated impact of no-till in the grains and mixed grains/livestock zone in WA is due in part to a relatively favourable set of circumstances – a pressing natural resource management problem (loss of soil from farms), technology that was available and adoptable at scale and the vigour of early passionate advocates (scientists, machinery developers and growers). Early investment from Landcare was assumed to increase the adoption of this technology. It is important to note also that given the overall on-farm attractiveness of no-till, it is likely that adoption in the absence of the programme would have eventually reached the same level, albeit more slowly.

Adoption of liming and kikuyu in the grains and mixed grains/livestock zone have at least some characteristics similar to no-till. Both practices can be attractive to landholders and there are passionate advocates of the practice who experimented over a long period of time to show that the practice worked on farms and acted as strong advocates to encourage funding support to help practice adoption.

The adoption of liming also presents an interesting challenge. Landcare has been assessed as increasing the speed and scale of adoption. Liming is essential to maintain productivity in the WA grains and mixed livestock zone (and many other areas in Australia also). Of the economic impacts evaluated in this study the benefits were estimated to mostly accrue to landholders from liming, however the upfront costs can present serious adoption barriers to some and incentives have been shown to encourage adoption. This has potential to create a subsidy mentality for practices that are in landholders' direct economic interests to address. Considered decisions about when to use particular policy tools (extension, incentives etc.) need to be made and use of the public:private benefits framework (Pannell 2008) is useful to provide guidance.

Revegetation on marginal land is a typical 'environmental' or 'Landcare' practice, and one of the practices that is important to genuinely develop Australia's reputation in sustainable agriculture. Unlike the first three practices, adoption is extremely unlikely to occur without public funding. The scale of the challenge is large as is the expense of addressing it. The adoption of this practice has

²⁹ Employment of Landcare facilitators is more likely to be required for practices with environmental tree-planting and land use change practices than for more conventional farm management. This has also been found in at least one international study in the Philippines (Newby & Cramb 2011)

been modest overall in the WA grains and mixed livestock zone (approximately 600 ha/year in the South Coast NRM region estimated with 50:50 cost share incentives). Results suggest that landholders simply cannot afford to revegetate land at scale given the substantial upfront costs and on-farm losses incurred, but those that do demonstrate excellent environmental stewardship.

The challenges faced for WA agriculture are large. The WA grains and mixed livestock zone has very fragile soils and very important biodiverse ecosystems. Dryland salinity, declining water quality, soil acidification and loss of biodiversity all pose large challenges (Morrell 2010)(Pannell & Roberts 2010), in addition to serious climate related challenges. WA farmers are known for their innovation and early adoption of practices both for production and environmental purposes. Evidence of this is that 5.5 million ha of existing native vegetation was protected by fencing, covenanting and other treatments to protect biodiversity values during the NAP/NHT. During the same time period only 9,872 ha of land was revegetated for Landcare purposes (Morrell 2010).

The results are strongly dependent upon the assumptions used and due to the poor levels of hard data available are based largely on best-estimates using local experts. The economic values should be considered as a first attempt to quantify economic impacts, under conditions of limited available data and strong reliance on expert opinion. Nevertheless they provide the strongest evidence to date of the economic value Landcare investment has generated.

5.9 Conclusions from the WA case study

Investment by the Australian government through Landcare from 1988-2015 in four sustainable land management practices in the WA grains and mixed grains/livestock zone has generated economic value in the order of \$978 million expressed as present values. By far the largest value has occurred for no-till (\$790 million), followed by liming (\$179 million). Kikuyu generated a much smaller but still positive value (over \$9 million). The majority of impacts for each of these three practices were on-farm (100% for no-till, 94% for kikuyu pasture, 73% for liming), with smaller positive impacts on agricultural service industries.

Revegetation on marginal agricultural land presents challenging results. Impacts from revegetation for biodiversity on marginal agricultural land were always estimated as strongly negative for on-farm impacts. For grain farms (if it was assumed fencing was not required) on-farm losses were approximately \$99 million and higher (\$123 million) for mixed grains livestock farms. There was always estimated positive off-farm economic value (up to \$30 million), the extent depending upon the level of contracting labour used. The ranges, both for on-farm and off-farm values, is potentially even larger in the real (rather than modelled) world farm situation.

The systems model has only estimated direct economic impacts on selected practices and there will be other important social and environmental benefits from adoption of sustainable land management practices. These have not been captured given the time and resources available.

The results are strongly dependent upon the assumptions used and due to the poor levels of hard data available are based largely on best-estimates using local experts. As such they should be considered as a first attempt. The figures are not measures of the cost-effectiveness, nor measures of the overall impact, efficiency or effectiveness of Landcare. Non-market social and environmental impacts have also not been monetised.

6. Case study results – Cotton in Queensland and NSW

6.1 Geographic area and farming system

The cotton industry is an integral part of the Australian economy, worth more than \$2 billion per annum in export earnings and helping to underpin more than 50 rural communities. Australia produces three percent of the world's cotton but is the third largest exporter, behind the US and India. More than 99 percent of Australia's cotton is exported³⁰. For Australia's growers to compete in a heavily subsidised world market (where governments essentially pay their growers to produce cotton) they must be extremely efficient, grow high yields and keep their costs as low as possible.

Cotton farms in the major cotton growing areas of Queensland and New South Wales are typically located in floodplain areas associated with major river systems and their tributaries. Major cotton growing regions shown in Table 8.

Table 8. Major cotton growing areas in Australia and associated geography.

Cotton Growing region	Main Rivers	Valley, towns or region
Central Queensland (QLD)	Fitzroy	Emerald, Biloela, Theodore
Condamine Balonne (QLD)	Condamine	Darling Downs
Border Rivers Maranoa Balonne (QLD)	Maranoa, Condamine, Balonne, Culgoa, McIntyre	St. George, Dirranbandi
Border Rivers (NSW)	Macintyre	Goondiwindi, Mungindi,
Gwydir (NSW)	Gwydir, McIntyre	Moree
Namoi (NSW)	Namoi	Wee Waa, Narrabri, Walgett, Gunnedah
Macquarie (NSW)	Macquarie	Warren, Trangie, Narromine
Western (NSW)	Darling	Tandou, Bourke
Lachlan	Lachlan	Hillston
Murrumbidgee (NSW)	Murrumbidgee	Riverina - Griffith

Areas sown to cotton since 1989/90 vary between approximately 68,000-600,000 ha³¹. Cotton is grown dominantly under irrigation, but dryland cotton is also increasingly been grown and the trend is likely to increase in future (G. Hamilton, pers. comm.). The area of cotton grown is dependent upon season (dryland cotton) and water availability (irrigated cotton).

Along with other crops (such as wheat, sorghum and millet) grown as part of the cotton rotation, beef cattle and to a much lesser extent sheep, are often part of a cotton growing enterprise. Livestock are typically a small part of the operation and used in areas that are not suitable for cropping, such as riparian zones. Waterways and riparian areas have significant conservation and ecosystem function values which are sensitive to disturbance and overgrazing by stock.

³⁰ Globally, cotton is produced in more than 70 countries in the world, but six of them - China, India, Pakistan, USA, Brazil and Uzbekistan - contribute about 80 percent of production. On average 33-34 million hectares are planted to cotton annually around the world, producing about 26 million tonnes of lint.

³¹ <http://cottonaustralia.com.au/cotton-library/statistics>

The cotton industry is extremely progressive due in large part to having faced some very difficult environmental issues associated with pesticide usage and water extraction. The industry has collectively faced these issues and as a result has made remarkable progress in improving its water use efficiency, reducing off-site impacts and protecting remaining riparian zones. Sustainable land management is seen as crucial for the cotton industry to maintain its social licence to farm as well as to compete globally as part of a 'clean and green' economy.

6.2 Practices selected

Australian government investment through Landcare has been important for a range of practices. At the expert workshop held in Dalby Queensland the following list of eight practices were identified for consideration within this project:

1. Genetically modified cotton and Integrated Pest Management (IPM) combined;
2. The IPM component itself;
3. Groundwater extraction;
4. Water Use Efficiency (irrigated cotton);
5. Manuring;
6. Reduced till/stubble/controlled traffic (dryland cotton);
7. Riparian management;
8. Reuse systems for irrigated cotton.

Following discussion about both the significance of these practices overall and the importance of Australian government investment through Landcare, three practices were selected, including one that was highly environmentally focussed (native vegetation). The practices are described briefly below in terms of the baseline (or pre-investment practice) and post-investment, the differences which are the basis of the estimates of adoption used in this project:

Water Use Efficiency (WUE for irrigated cotton)

- **Baseline (pre-Landcare) practice:** In the early 1990s, cotton growers were generally not concerned with WUE. WUE figures varied between 40-90%. Siphon pipes would run all night with the excess water ponding and/or flowing down natural water courses. Yields were depressed due to waterlogging;
- **Current best practice:** There are a number of components to the WUE practice. Paddocks are laser levelled to improve irrigation uniformity and speed of watering (irrigation time is commonly halved, as is the time the crop is waterlogged). Water application is fine-tuned (irrigation scheduling). Crop consultants and use of in-field assessment help assess the level of crop stress and water needs. Water re-use systems result in less nitrogen being lost in water and greater overall water use. Overhead irrigation systems are used where suitable.

Most elements of the practice are suitable for all irrigated cotton growing regions, the area of which has varied from approximately 61,000 in 2007/08 and 450,000 ha in 2011/12³².

³² Data supplied by Graham Harris, Principal Economist, Queensland Department of Agriculture and Fisheries.

Reduced tillage

- **Baseline (pre Landcare) practice:** When dryland cotton first was grown it involved multiple passes, solid tynes and a very fine seed bed;
- **Current best practice:** The practice involves markedly reduced tillage compared with the pre-investment practice. The practice is a combination of as few tillage operations as are possible, stubble retention and controlled traffic. For cotton production some tillage (pupae busting) is required for cotton growing as part of the regulatory requirement for growing genetically modified crops, which is why zero-tillage is not possible. The practice is suitable for all dryland cotton growing regions, the area of which has varied from approximately 4,500 in 2002/03 and over 206,000 ha in 2010/11³³.

Riparian management

- **Baseline (pre-Landcare) practice:** Stock were grazed with minimal management. Riparian areas were commonly over-grazed, and in some cases also cropped, reducing the biodiversity values of the vegetation. River banks were often eroded or sensitive to erosion.
- **Current best practice:** The practice involves the installation of stock-proof fencing to manage grazing pressure on riparian areas, with width of which varies enormously on farms. In many cases this involves stock exclusion although controlled or 'crash' grazing is often used to control weeds, or to provide drought fodder in times of need. Off-stream watering systems are usually a component of this management practice. The length of riparian vegetation in cotton growing areas was estimated to be 4787km (1352 in Qld and 3,435 in NSW), with the assumptions outlined in Appendix 5.

A number of other practices have also been funded through Australian government investment into Landcare, including investment into overall improved best practice management education and assessment. These investments will also have economic and other benefits beyond those outlined for the three practices in this project.

6.3 How Landcare has had impact

The mechanisms by which Landcare investment was assessed to have impact have been summarised for each practice below, based on input at an expert workshop held in Dalby. The impact of investment on the area of adoption for each practice is shown in Figures 8-10.

Water Use Efficiency (irrigated cotton)

The major mechanisms by which Landcare has encouraged adoption were summarised from the expert workshop as being:

- Receipt of payments from Landcare for incentives;
- Change in goals to put more emphasis on environmental outcomes;
- Increased knowledge of how to implement the practices;
- Encouraged cooperation with neighbours or other landholders;

³³ Data supplied by Graham Harris, Principal Economist, Queensland Department of Agriculture and Fisheries.

- Favouring of a collaborative approach between growers and groups, including use of facilitators, to foster strategically valuable placement of plantings for soil erosion mitigation, corridors and/or for water protection.

The estimate of improved WUE practice adoption (by area of land) is shown in Figure 8. It shows estimated adoption 'with Landcare' (total of all investments, industry, state and federal governments, the green curve) and that which has been estimated if the Australian government funding through Landcare has not been made (the red 'without' Landcare curve).

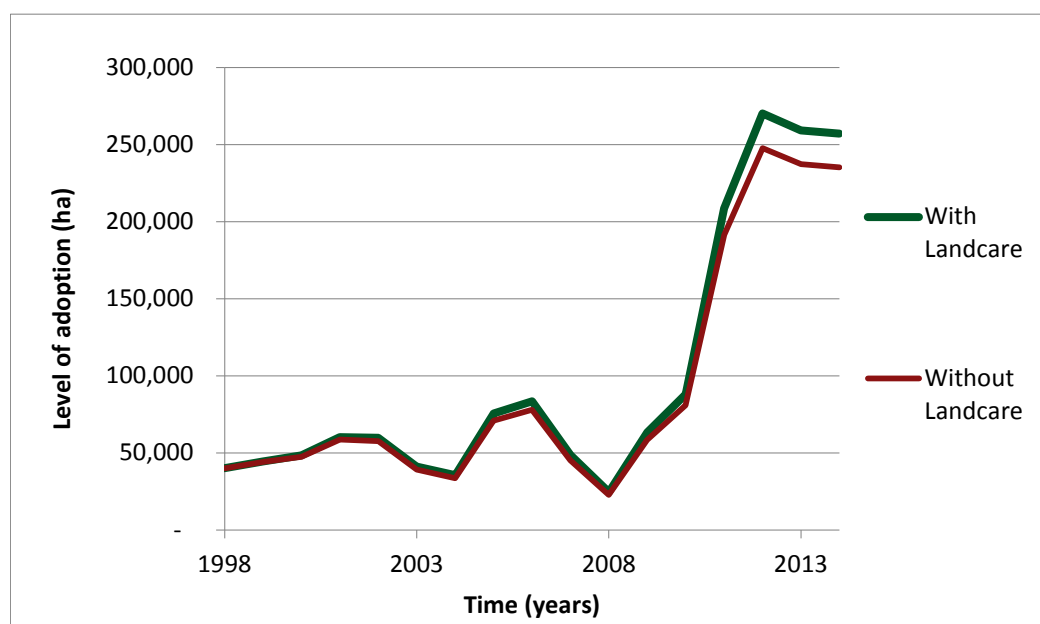


Figure 8. Estimated adoption of improved water use efficiency in irrigated cotton (NSW and QLD) with and without Landcare funding.

Overall whilst there has been some investment in WUE by Australian Government through 'Landcare', the majority has come from other sources - State programs and associated Australian government programs concerned more directly with water funding. The quantum of Australian Government funding for WUE through Landcare has declined markedly since NAP/NHT days and thus the impact has been due to early funding and time-lags in adoption and overwhelming contribution from other government and non-government sources other than Landcare. The large variation in estimated adoption for both curves is due to the large impact of water availability on the area of irrigated cotton grown.

Reduced tillage (dryland cotton)

Once the technology was developed, adoption was assumed to be rapid because of the overall profitability of the practice (better yields due to water conservation) and less time involved and possibly costs in tillage (herbicides are relatively cheap). Much of the success of rapid adoption is due to industry (research and development corporations, growers, agri-chemical and machinery advances). Early research projects, in Queensland under the National Soil Conservation Program

(NSCP) were also very influential in terms of increasing awareness about the soil erosion losses from cultivated systems.

The main mechanisms by which Landcare has had direct influence were summarised as:

- Faster adoption and higher adoption because of increased knowledge about the importance of increased soil moisture storage (this was the most important aspect for landholder adoption);
- Incentive funding from NHT for tillage and planting machinery incentives ;
- Landcare funding for spray technologies;
- Reduced soil erosion and this increased emphasis on environmental outcomes were important but secondary considerations.

Figure 9 shows the differences in adoption of reduced tillage in cotton with and without Landcare. Only a 5% difference between 'with' and 'without' Landcare was estimated and thus the differences in area of adoption are barely detectable in the figure. Overall higher levels of early adoption due to NSCP funding for research and extension, incentive funding combined with an attractiveness of the practice itself have led to rapid adoption. The widely varying areas grown under dryland cotton have a much greater influence on area of adoption in a particular year than Landcare funding.

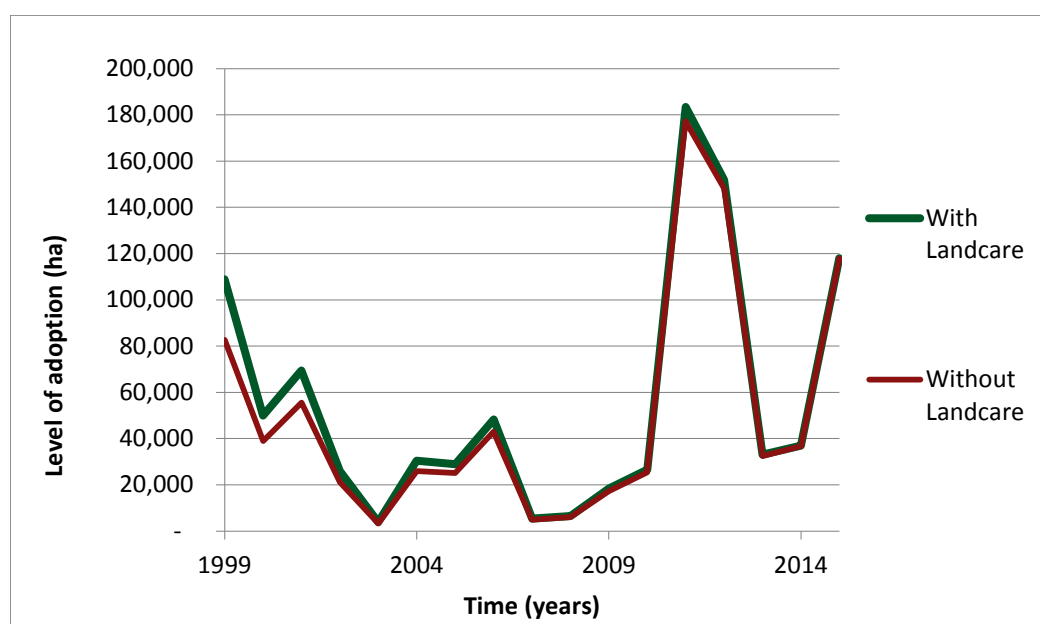


Figure 9. Estimated adoption curve for reduced tillage in dryland cotton (NSW and QLD) with and without Landcare funding (ha/year).

Riparian management

Prior to 1998, with the advent of NHT funding, there was virtually no funding available for riparian management activities. From 1998 numerous projects have been undertaken in the major cotton growing areas, with significant Australian government and state funding in both QLD and NSW over since then to support improved riparian management. These have included:

- Direct grants to landholders to fund the costs associated with riparian management activities, especially a financial contribution towards the cost of fencing and off-stream watering materials;
- Extension and awareness raising activities to encourage cotton growers to undertake riparian management (both improving values of riparian ecosystems and also helping to prevent cropping right to the edge of the river).

These projects have significantly accelerated adoption of improved riparian management practices, especially where targeted extension and incentive projects have been implemented.

Major mechanisms by which Landcare has encouraged adoption were summarised from the expert workshop as being:

- Receipt of payments from Landcare;
- Change in goals to put more emphasis on environmental outcomes;
- Increased knowledge of how to implement the practices;
- Encouraged cooperation with neighbours or other landholders;
- Favouring of a collaborative approach between growers and groups to foster strategically valuable placement of plantings for soil erosion mitigation, corridors and/or for water protection.

The estimated level of adoption based on fencing and off-stream watering (expressed as km) occurring for riparian management is shown in Figure 10.

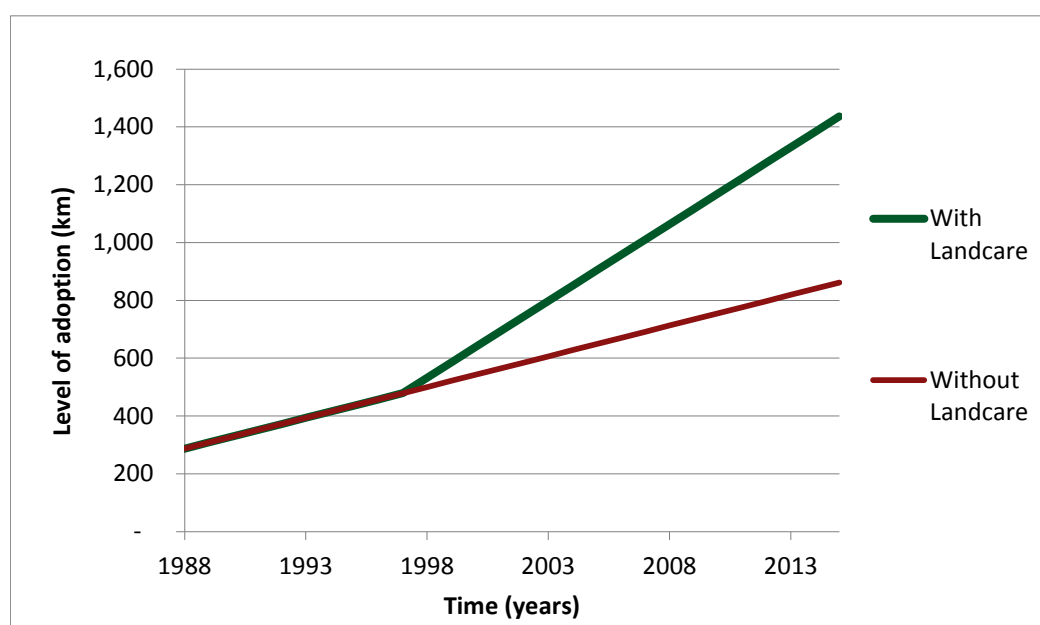


Figure 10. Estimated adoption of riparian management with and without Landcare funding in cotton growing areas (NSW and QLD).

Estimated small and positive adoption in the absence of Landcare funding has been shown, attributed to the increase in awareness about the importance of riparian areas and the increasing 'social licence' pressures on the cotton industry overall. The marked increase in adoption with Landcare funding since 1998 has been estimated as a result of increased Landcare funding.

With this funding an estimated total of 1,436³⁴ km of riparian areas have been fenced compared with 862 km in the absence of funding. The total estimated area is 4787 km and thus even with this strong progress there is still a long way to go.

Without funding, total de-stocking would be the only option (other than continued grazing and direct access of stock to rivers) for many landholders.

6.4 Benefits – direct on-farm, direct off-farm and indirect off-farm

Australian Government investment through Landcare is one of a number of factors influencing the amount and scale of adoption in the cotton industry in NSW and QLD. Development of an evidence-based model to assess the economic benefits requires clear assumptions about the cause and effect relationships between adoption of practices and benefits. Three types of benefits were considered:

- Direct on-farm economic benefits (the systems model captures impacts assessed in \$ values due to increased yields, improved profitability and/or reduced costs, but does not capture biodiversity and broader outcomes because \$ values were not able to be assessed);
- Direct off-farm economic benefits (the systems model captures \$ value impacts associated with direct impacts on rural industries resulting from practice adoption);
- Broader indirect off-farm social and environmental benefits (these impacts were unable to be quantified in this project).

Adoption of improved practices (WUE, reduced tillage, riparian management) leads to direct on-farm benefits. Figure 11 shows links between practices and direct on-farm and off-farm benefits that have been captured in the systems model. For the cotton industry in QLD and NSW the economic impacts that have been assessed are:

Direct on-farm benefits:

- Improved yields: WUE and reduced tillage;
- Increased farm income: WUE and reduced tillage.

Direct off-farm benefits:

- Increased sales: Equipment for farm redesign for WUE, rural input suppliers for all practices;
- Increased services: Contractors for picking (WUE and reduced tillage), contractors for fencing and off-stream watering (riparian management).

Note that benefits to increased transport of agricultural produce were identified as an additional direct off-farm benefit from practice adoption, however the costs associated with road maintenance are likely to more than off-set the benefits and thus transport impacts have not been considered.

³⁴ The assumptions used have been outlined in Appendix 4 and fairly simplistic due to limited data availability in the time. Increased level of monitoring and recording in future programs is very important.

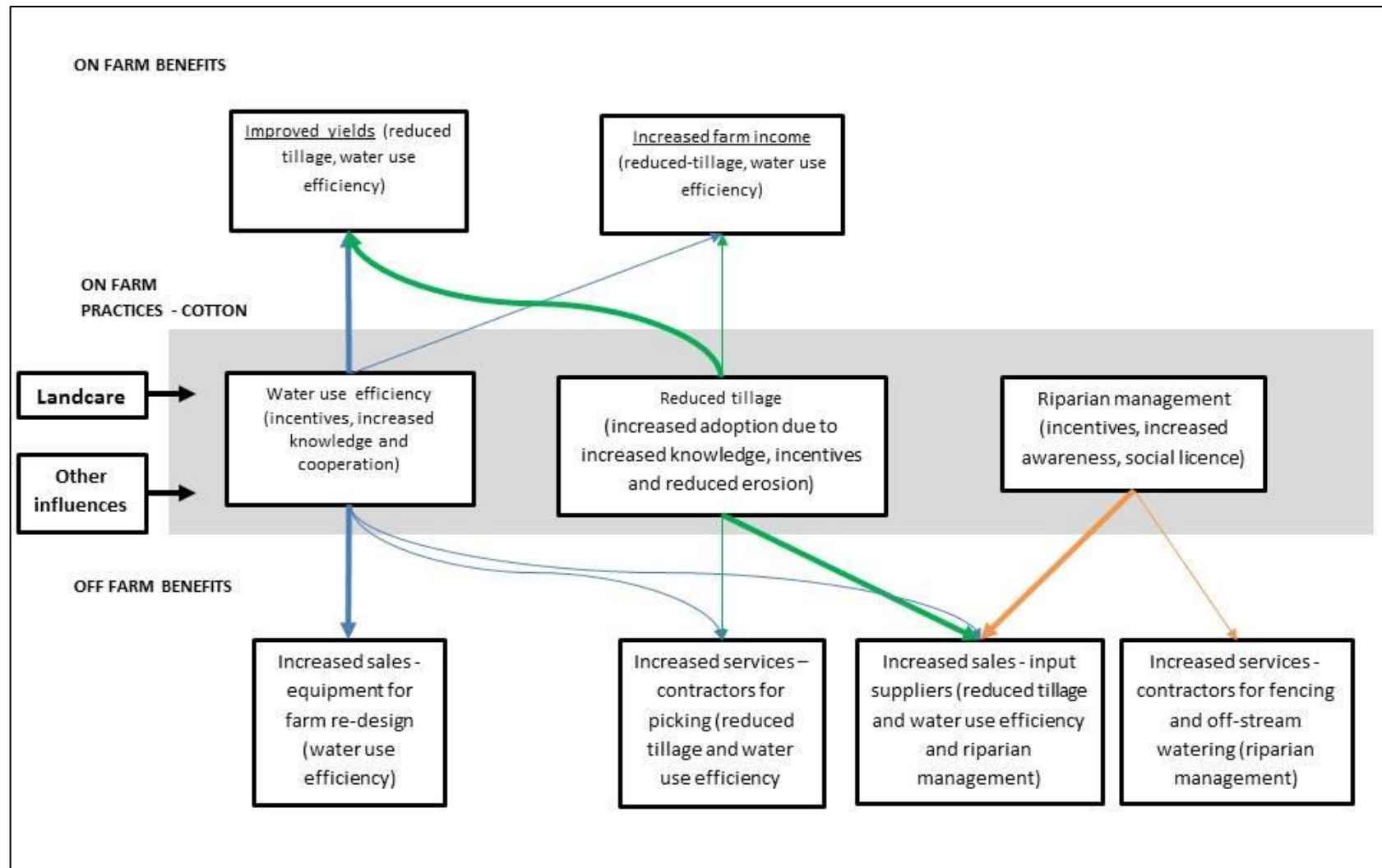


Figure 11. Direct on-farm and direct off-farm benefits of practice adoption in the cotton industry (NSW and QLD).

6.5 Direct economic benefits of cotton practices

The 'headline' results are presented in Table 9 for each of the three practices analysed (WUE, reduced tillage, riparian management). More detail is presented below and details of all major assumptions are further outlined in Appendix 5.

Table 9. Estimated direct economic benefits (on-farm and off-farm) from 'Landcare' from 1988-2015 for the Australian cotton industry (NSW and QLD).

\$ millions of economic benefit (present value, 1988 – 2015)			
Direct benefits	Water use efficiency	Reduced tillage	Riparian management
On-farm value	37	30.6	-6.2
Off-farm value	9.8	3.4	1.5
Total measured economic value	46.8	34.0	-4.7
Range	23-94	17 to 81	-3.4 to -5.9

Direct on-farm benefits

The largest direct on-farm economic value (\$37 million) was estimated to come from WUE adoption (Table 9). This practice is attractive to landholders anyway and Landcare funding has simply sped up adoption in the early years. Investment in reduced tillage was estimated to generate \$30.6 million in direct on-farm benefits over the life of Landcare.

Quantifiable on-farm economic benefits from riparian management were negative (loss of \$6.2 million). When off-farm benefits were considered the total measured economic value was reduced to -\$4.7 million.

Brief details for each practice are outlined below.

Water use efficiency (WUE)

The on-farm value of WUE (estimated as \$37 million, Table 9) was estimated by multiplying this marginal value of WUE by the adoption area of WUE and subtracting the 'with Landcare' from 'without Landcare'. Details of calculations are outlined in Appendix 5.

Reduced tillage

The on-farm value of reduced tillage was estimated to be \$30.6 million (Table 9). The net marginal benefit of reduced tillage was assumed to be the gross value of the increase in yield minus the costs of extra fertiliser (\$125/ha which were scaled for fertiliser price indices through time) and additional picking costs (estimated to be \$62/ha and assumed to be the same whether the landholder uses own or contracted labour orange line). It was also assumed that growers are opportunistic and therefore had one third of the farm area in cotton at any one time, and therefore the marginal net value of reduced tillage has been multiplied by one third. Additional details and figures can be found in Appendix 5.

Riparian management

Overall the on-farm economic value (expressed in present value terms) attributed to Landcare from riparian management over the 1998-2015 period is estimated to be a \$6.2 million loss to landholders from 1988-2015 (Table 9). This marginal value is the cost of establishment multiplied by the proportion of land that is being managed plus the cost of maintenance multiplied by the proportion of land that is being maintained.

The loss was estimated because of the assumed lack of production gains (the value of additional grazing is assumed to be zero and landholders have incurred large costs in erecting fencing and off-stream watering). While Landcare incentives have reduced the cost of riparian management, this has led to a significant increase in riparian areas managed, which in turn has led to a significant increase in farm costs (landholders still incur establishment and on-going maintenance costs for pest weeds, animals and fence replacement when flooding occurs) compared with what would have been expected in the absence of Landcare. Periodic loss of fences from flood damage results in landholders having to pay high costs in rebuilding fences (some landholders have paid up to \$500,000, G. Ringwood, pers. comm.) and thus it is likely that the losses estimated here are conservative. This analysis has not taken into account avoided costs to landholders (such as the loss of riverbanks from previously over-grazed riparian areas).

Direct off-farm benefits

Off-farm benefits were estimated to differ between practices. There were significant off-farm benefits from WUE (21% or \$9.8 million of the \$47 million of total economic impact). Lower off-farm value was estimated for reduced-tillage (\$3.4 million). Unlike the negative on-farm impacts for riparian management there were positive economic off-farm values (\$1.5 million, Table 9).

The direct off-farm economic benefit for all practices included increased profits to the transport industries. However, these benefits are likely to be at least offset by additional infrastructure costs for maintaining roads and associated infrastructure and were therefore not included in the analysis.

Water use efficiency

Overall the off-farm economic benefit (expressed as present value) attributed to Landcare from WUE over the 1988-2015 period was estimated to be a \$9.8 million. The economic benefit was estimated to be \$7.6 million for contracting services (picking industry), \$1.9 million for input suppliers and \$0.3 million for equipment associated with WUE farm re-design. The assumptions, further outlined in Appendix 5, were:

- **Contract picking industry:** Assumed 50% of the irrigated area used a contract picker. Additional picking costs were assumed to be \$62/ha crops) but only over 50% area of the crop;
- **Input suppliers:** Fertilisers: Assumed an increased cost of \$42/ha for increased fertilisers;
- **Equipment associated with WUE farm re-design:** Assumed farm redesign costs \$600/ha.

Reduced tillage

The total marginal off-farm economic benefit (expressed as present value) attributed to Landcare from reduced tillage over the 1998-2015 period was estimated to be a \$3.4 million (see Appendix 5 for details) for contract picking (\$0.4 million) and input suppliers for fertilisers (\$3.0 million). The assumptions used were:

- **Contract picking industry:** It was assumed that 50% of the dryland cotton area used a contract picker. Additional picking costs assumed to be \$62/ha but only over 50% area of the crop (assumed overall as \$31/ha for all areas). Assumed estimates are based on \$225/ha for a 5 bale per hectare crop includes \$25/ha for the plastic wrap for the round bale. For a 2.5 bale/ha hectare crop charge \$163/ha, i.e. \$150 per hectare plus \$13 for the wrap (G. Hamilton, pers. comm);
- **Input suppliers:** Fertilisers: The increased yield (5.5 bales/ha compared with 2.5/bales/ha) has an assumed increased fertiliser cost of around \$125/ha (G. Hamilton pers. comm).

Riparian management

Overall the off-farm economic benefit (expressed as present value) attributed to Landcare from riparian management over the 1998-2015 period was estimated to be a \$1.5 million. This was estimated as \$0.8 million for input suppliers (fencing), \$0.55million for input suppliers (off-stream watering) and \$0.07 million each for fencing contractors and off-stream watering contractors.

Assumptions included that fencing costs \$6,909/km, off-stream watering cost \$16,682/unit and one unit was required every 3.5 km. Contract labour was assumed as \$1143/km for fencing and \$4,500/unit for off-stream watering contractors. Also assumed is that 50% of installation costs for fencing and off-stream water systems has involved local/regional contractors and that there was a 30% profit margin on all off-farm impacts.

6.6 Confidence levels in the systems model results

The results presented are considered as a first attempt to assess economic value of Landcare investment. Sensitivity to model inputs is outlined in Appendix 5 and the model itself can be scrutinised. The model method is simple, transparent and based on adoption theory from Australia's leading economists and social researchers. The approach developed worked well using expert opinion.

Comments on each of the major model inputs are presented below:

- Level of overall adoption (moderate confidence for reduced tillage and WUE, low confidence for riparian management);
- Level of adoption attributable to Landcare investment (low confidence for all practices);
- On-farm economic benefits and costs (moderate confidence, albeit that the heterogeneity experienced on farms has not been captured);
- Direct on-farm benefits (moderate-low confidence because of strong dependence on adoption attributable to Landcare);

- Direct off-farm impacts (low confidence as this has been captured very simply and is based on on-farm benefits).

6.7 Broader indirect off-farm benefits

As outlined earlier, only direct economic benefits have been captured in the systems model. There are other very important benefits from adoption of sustainable land management practices, however it has not been possible to put a value on these associated environmental and social impacts. Through the expert workshops a number of important additional broader off-farm benefits associated with Landcare investment were identified.

Economic benefits: There would be some increased rural employment in rural towns supporting the cotton industry, as a result of employment of Landcare facilitators and the flow-on effect from contracting services and rural suppliers. This effect might be less important than in WA because the size of towns in NSW and QLD around cotton growing areas are larger overall and sustaining of towns is more attributable to industry and sources of funding other than Landcare.

Another important economic value not accounted for is the value of recreational fishing which has been estimated to have a direct value of \$152 million in Queensland and \$530 million in NSW in the Murray-Darling Basin (Ernst & Young 2011), a portion of which could be attributed to improved practices in cotton.

Social and cultural benefits: The cotton industry has faced some very large issues around ‘social licence to farm’. The rapid adoption of many sustainable land management practices, helped significantly by early Australian Government investment into development of Environmental Management Systems and ultimately to the ‘my BMP’³⁵ program have been pivotal in helping improve cotton’s image.

Environmental benefits: Adoption of sustainable land management practices have environmental benefits which have not been able to be quantified in the systems model.

The practice of reduced tillage which has increased groundcover has markedly reduced erosion. Reduced sediment loads improve surface water quality. This is important for all cotton growing regions, but of immediate importance are for cotton growing regions in the Fitzroy Basin which flow into the Great Barrier Reef. A potential emerging dis-benefit was also raised at the expert workshop, which was that cleaner water which runs off paddocks with higher groundcover has greater erodibility when it hits susceptible fallow paddocks (G. Hamilton, pers. comm.). The extent of the issue is unclear and overall the benefits are likely to markedly outweigh the dis-benefits.

The greatest environmental benefits will come from improved riparian land management. These have been outlined (Lovett et al, 2003) as being:

- sediment trapping (e.g. soil), nutrients and other contaminants (e.g. attached pesticides and herbicides) before they reach the waterway;
- reducing rates of bank erosion and loss of valuable land;
- control of nuisance in-stream plants through shading;

³⁵ <https://www.mybmp.com.au>

- reducing water temperatures and help ensure healthy in-stream life;
- providing a source of food and habitat for stream animals;
- providing an important location for conservation and movement of wildlife;
- connecting fragmented habitats for wildlife;
- helping to maintain agricultural productivity;
- providing recreation and aesthetically-pleasing landscapes;
- improving water quality for human and stock consumption, as well as the environment; and,
- supporting beneficial insects and animals that prey on pest species (e.g. bats preying on *Heliothis* moth).
- Reducing the impacts of extreme weather events (flood damage, storm damage to crop, stock protection etc.).

Well managed riparian zones help prevent flood damage (sheet erosion/scalping and gully erosion) by up to 66% on floodplains due to slower water velocities along waterways and reduced water velocities exiting the waterway onto the floodplain and reduced water velocities re-entering the waterway from the flood plain (G. Ringwood pers. comm.). Riparian vegetation helps reduce erosion along the waterway (bank slumping and gully erosion) by binding the soil together, reducing the water velocity and creating a buffer adjacent to the soil.

Riparian management stabilises soils and increases soil carbon. The lack of a carbon market means that carbon benefits are of minimal value currently, but could provide opportunity for landholders to participate in future markets. A study by Smith and Reid (2013) illustrated the value of native vegetation and the soil beneath for storing large amounts of carbon in floodplain environments associated with cotton growing areas.

There are also a range of beneficial insects that utilise riparian zones and play an important role in controlling agriculture pests (Schelhoern 2012). Riparian management improves water quality, native fish populations and communities increase, habitat and food webs increase and food webs increase and also the impacts of 'black water' events are reduced. If a 'black water' event occurs then this impacts on fisheries through fish kills. There are a number of positive off-farm impacts associated with improved riparian management including: social aspects – recreational use, fishing clubs, improved picnic areas for landholders and others, regional benefits to do with increased fishing and tourists (e.g. reduced algal blooms including blue green algae).

An important point for the cotton industry is maintaining a 'social licence to farm'. The cotton industry has faced huge challenges in this area. Management of riparian land is highly visual and provides a strong form of evidence that landholders are responsible managers of water and also protect biodiversity. When viewed in this light, and also given that there are values associated with environmental benefits that the systems model has not taken into account, the overall on-farm losses of \$6.2 million over from 1988-2015 do not look large in comparison to the environmental benefits outlined above and the value of cotton losing its social licence.

To recognise the importance of some of the broader impacts that Landcare investment has had, for each of the practices assessed, a simple qualitative assessment of additional impacts from practice adoption is presented in Table 10. These impacts were mentioned through interactions with

stakeholders. The qualitative assessment of the impact is high, medium or low. If the impact is believed to be minimal or was not mentioned in discussion with stakeholders the cell has been left blank.

Table 10. Additional impacts associated with practice adoption in the cotton industry not captured in the systems model.

Additional impacts associated with practice adoption	Water Use Efficiency	Reduced till	Riparian management
On-farm environmental benefits			
Soil Structure	Low	High	High
Soil biology			
Carbon storage	Low	Medium	High
Reduced erosion		Medium	High
Improved crop pest management		Low	Low
Shade/shelter for livestock			Low
Off-farm benefits			
Biodiversity benefits			High
Flood prevention		Low	High
Water quality (eutrophication)	Low	High	High
Water quality (salinity)			Low
Air quality (dust)		High	High
Improved aesthetics, mental health, women staying on farms		Low	High
Additional employment			High ³⁶

6.8 Discussion

The results show that investment in Landcare is estimated to have modest positive economic impacts on adoption of sustainable farm management practices of WUE and reduced tillage (total measured economic value of \$47 and \$34 million respectively). The impact of Landcare investment accelerated adoption of these practices which helped the cotton industry increase its competitiveness in a very tough global market. It needs to be noted that adoption of WUE and reduced tillage would have been expected to occur anyway, but occurred more rapidly with Landcare and other sources of funding (industry, state and Australian Government from other sources) were the dominant causes of increased adoption.

Improved riparian management is where Australian government investment through Landcare has made the biggest difference. Although improved riparian management created an estimated \$6.2 million direct on-farm loss (and an overall economic impact of -\$4.7 million), these impacts could be viewed as relatively small when compared with the positive benefits in terms of increased social licence and major unquantified environmental benefits. Improved riparian management would not have occurred at the levels it has without Landcare investment. Viewed in terms of Australia's global reputation, investment in practices which require high up-front costs (revegetation and fencing) for landholders simply could not occur without public investment.

³⁶ Employment of Landcare facilitators is more likely to be required for practices with environmental tree-planting and land use change practices than for more conventional farm management. This has also been found in at least one international study in the Philippines (Newby & Cramb 2011)

The results are highly sensitive to assumptions used and there limited hard evidence in terms of the scale of adoption and/or the impact of Landcare compared with other sources of investment. They should be viewed as a first attempt rather than a definitive analysis.

6.9 Conclusions from the cotton case study

Investment through Landcare from 1998-2015 in WUE and reduced tillage in the Australian cotton industry was estimated to generate positive economic benefits totalling \$81 million from 1988-2015. The majority of benefits were on-farm (21% for WUE and 10% for reduced tillage).

Riparian management generated an estimated \$6.2 million direct on-farm loss but positive direct off-farm benefit of \$1.5 million (overall total economic benefit of -\$4.7 million). Viewed in terms of maintaining the cotton industry's global competitiveness and maintaining its social licence to farm, investment in riparian management is very important.

The systems model has not been able to capture the full range of important environmental and social benefits generated particularly by riparian management, and overall results should be should be viewed as a first attempt to estimate economic value from Landcare investment. The figures presented are not measures of the cost-effectiveness, nor measures of the overall impact, efficiency or effectiveness of Landcare.

7. Case study results – Dairy in Gippsland, Victoria

7.1 Geographic area and farming system

Australia-wide dairying is Australia's third largest rural industry, valued at \$13 billion/year (farm, manufacturing and exports). In 2013/14 38% of Australia's dairy production was exported, totalling \$3.21 billion and 7% of the global dairy export trade³⁷.

Owner-operated farms dominate the Australian dairy industry, with corporate farms comprising 3% of the total. Farm numbers continue to fall, having declined by two-thirds over the last three decades from 20,060 in 1983 to 6,314 in mid-2014³⁸.

Victoria is the largest dairy producing state, with 4,268 licenced dairy farms in 2013/2014, spread across the three dairy regions of northern Victoria (mostly irrigated), south west (mostly dryland) and Gippsland (about two thirds of which are dryland and one third irrigated). In 2013-14, there were 1.1 million dairy cows in Victoria, accounting for two thirds of the national dairy herd and milk production. Victoria accounts for approximately 85 per cent of Australia's dairy product exports, worth around \$2.3 billion in 2013-14 (an increase from \$1.87 billion in 2012-13)³⁹.

The number of dairy farms in Gippsland (includes areas within the Port Phillip and Westernport and East Gippsland CMAs in addition to West Gippsland CMA) is estimated to be 1430⁴⁰ Dairying is spread across Gippsland, with the Baw Baw, Wellington and South Gippsland shires home to more

³⁷ <http://www.dairyaustralia.com.au/Markets-and-statistics/Farm-facts/Dairy-at-a-glance.aspx>

³⁸ <http://www.dairyaustralia.com.au/Markets-and-statistics/Farm-facts/Cows-and-Farms.aspx>

³⁹ <http://www.depi.vic.gov.au/agriculture-and-food/dairy>

⁴⁰ <http://www.gippsdairy.com.au/GippslandFacts/DairyinGippsland.aspx>

than 75% of the region's dairy farms (a total of 1430 dairy farms). Dairying is biggest agricultural contributor to the Gippsland economy.

The average dairy farm size in Gippsland is estimated to be 186ha⁴¹. Using this and the 1430 dairy farms in Gippsland gives an estimated total area of dairy farm land in Gippsland 265,980 hectares. Of this area, approximately 183,000 ha is used as the milking area, with the remainder being used as 'run-off' areas where dry stock (non-milking), young stock and bulls are grazed.

7.2 Practices selected

A local expert workshop was held in Traralgon, Gippsland. The results developed are relevant to Gippsland, but participants were mindful of selecting the practices for study which were nationally applicable.

At the expert workshop the following list of eight practices were identified for consideration within this project:

- Better nutrient management;
- Farm layout and management;
- Improved effluent management;
- Improved grazing management;
- Managing stock density, groundcover and rotations;
- Riparian management, revegetation and fencing;
- Revegetation for shade and shelter;
- Revegetation in sensitive areas (wet areas, gullies, biodiversity plantings);
- Installation of re-use systems and irrigation;
- Flood irrigation to spray conversion.

Following discussion about both the significance of these practices overall and the importance of Landcare investment, three practices were selected one of which was environmentally focussed. The practices are described briefly in terms of the baseline (or pre-investment) and post-investment practices, the difference between which were the basis of the estimates of adoption:

Improved effluent management

- **Baseline (pre Landcare) practice:** There was no regulation in 1970s and in the 1990s containment and treatment started. The baseline practice was described at the workshop as 'open slather', with effluent draining directly into paddocks;
- **Current best practice:** Utilisation of effluent in the dairy. Effluent is fully contained and re-used strategically to grow fodder. The practice is linked to better nutrient management. Note that this practice is above and beyond current regulatory requirements – costs have not included effluent containment on-farm as this is a legal requirement.

Improved nutrient management

- **Baseline (pre-Landcare) practice:** High nutrient application rates that aimed to maximise the historically low Olsen P level in the soil. Landholders put on as much as they felt they could afford. Once landholders commenced high nutrient application rates they were slow

⁴¹ <http://www.depi.vic.gov.au/agriculture-and-food/dairy/business-management/farm-monitoring-dairy>

to review change in soil P levels. There was limited soil testing, but this was not always used to inform fertiliser requirements;

- **Current best practice:** Targeted fertiliser application (timing through the year and pasture requirements). Regular soil testing with fertilisers applied according to results and farm production requirements. Nutrient budgets (all sources including brought in feed) are commonly prepared using independent consultants being used as a major source of advice.

Riparian management

- **Baseline (pre- Landcare) practice:** No fences and access to waterways by all stock;
- **Current best-practice:** Waterways (designated and small streams) fenced and revegetated to local native species according to guidelines and to a minimum of 10 m plantable ground each side and maintained. Off-stream watering is provided. Long-term weed control maintenance in the defined best practice was not included because the adoption rates would be likely to be much lower.

7.3 How Landcare has had impact

Improved effluent management

The following mechanisms were identified at the expert workshop as key drivers of practice uptake:

- Increased knowledge of how to implement practices (extension and field days, increased skills in management of system, nutrient management plans);
- Receipt of payment through Landcare programs for the installation and management of effluent storage, reuse and distribution systems;
- An increasing awareness of regulatory requirements has been driven by both the Victorian Government and milk companies which is linked to an increased environmental awareness of off-farm nutrient impacts (e.g. water quality).

Estimates of adoption of improved effluent management are shown in Figure 12. The 'with Landcare' curve shows the estimated increase in adoption of improved effluent management. The increase in adoption resulted largely from Landcare funded extension and incentive program in the Upper Latrobe and Corner Inlet catchments (Core 4). Under the 'without Landcare' adoption increased at a slow and steady rate.

Overall Landcare funding has increased both the speed and scale of adoption and has achieved good results in the upper Latrobe and Corner Inlet catchments in particular. Adoption levels of improved effluent management as defined in 2015 were still very low (total of 27,360 ha out of 183,000 available) driven largely by the large upfront costs associated with best practice and the geographically targeted nature of the incentives.

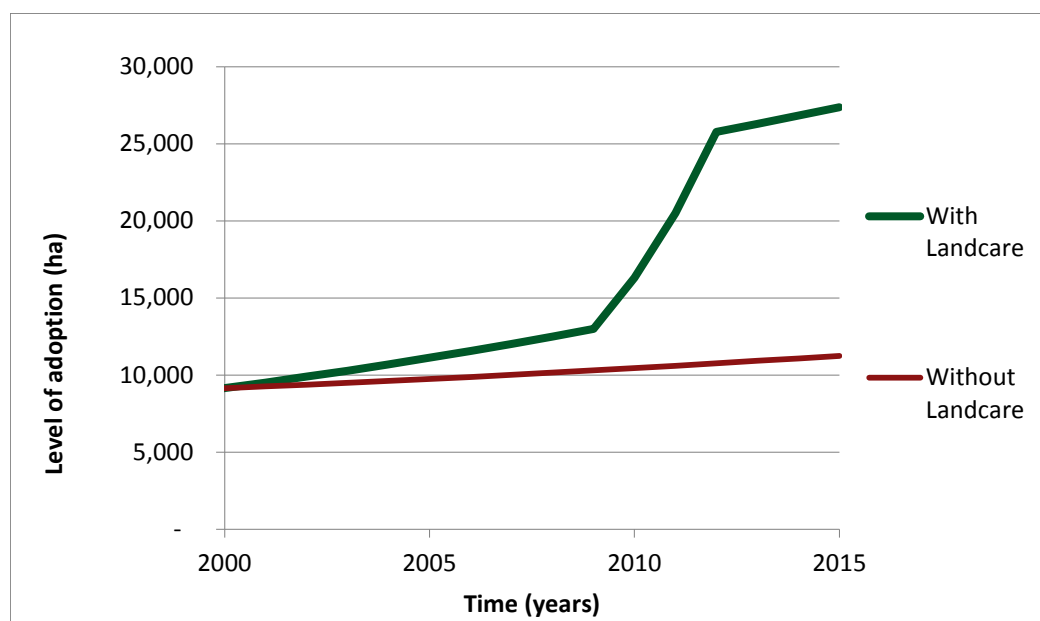


Figure 12. Estimated adoption of improved dairy effluent management (Gippsland VIC) with and without Landcare.

Improved nutrient management

Landcare has been instrumental in the understanding and adoption of improved nutrient management practices as summarised:

- Increased knowledge of how to implement practices (extension and field days, increased skills in nutrient budgeting);
- Receipt of payment through Landcare (e.g. workshops for activities and plan development associated with Fert\$mart courses, with other partners pays providing incentives for soil tests);
- Encouraged soil testing;
- Encouraged cooperation with others;
- Changed farm goals to put more emphasis on environmental outcomes.

Estimated adoption of improved nutrient management is shown in Figure 13. Increased adoption with Landcare is assumed to be the results of earlier soil testing due to extension efforts under the NHT/NAP period and increased nutrient budgeting and the Fert\$mart participation thereafter.

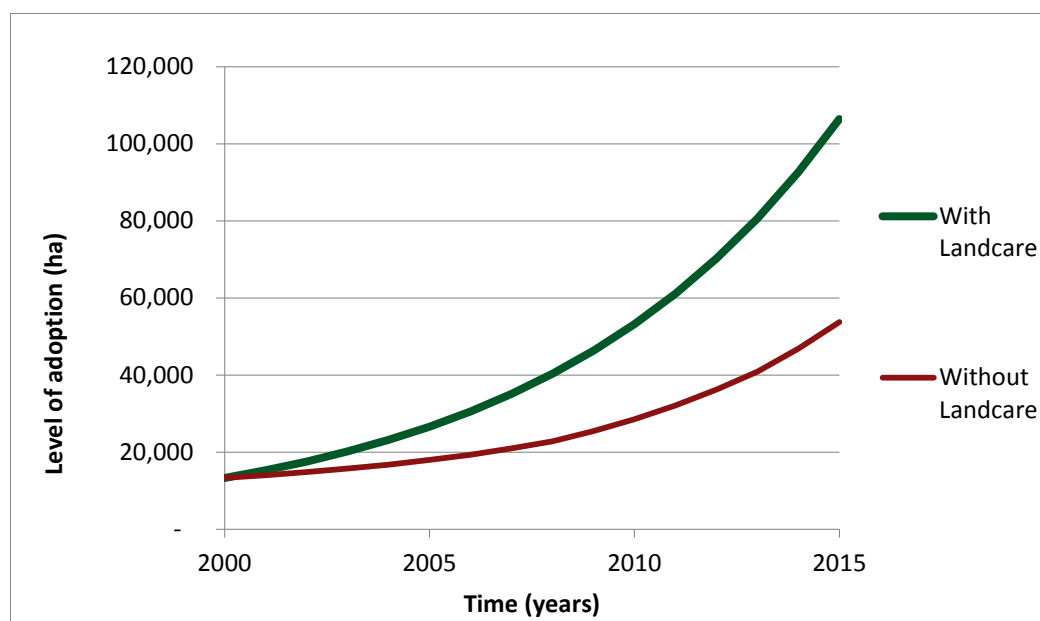


Figure 13. Estimated adoption of improved nutrient management on dairy farms (Gippsland VIC) with and without Landcare funding.

Riparian management

From 2000 onwards projects have been undertaken to support improved riparian management. The mechanisms of practice change have been:

- Incentives (funding) towards materials and direct works coordinated by the CMA and Melbourne Water;
- Change in goals to put more emphasis on environmental outcomes;
- Increased knowledge of potential offsite impact from stock in waterways;
- Encouraged cooperation with neighbours or other landholders.

State government funding has been the dominant source of public funding in riparian management. Extension and awareness raising activities and incentives funded by Landcare in the early 2000s as well as state government incentive programs to encourage dairy farmers to undertake riparian management have been instrumental in helping them to understand the importance of riparian management and have contributed to all the mechanisms outlined above.

Figure 14 shows the level of adoption expressed as km managed riparian zone. Incentives for riparian management were available between 2002 and 2007, however increased funding for incentives occurred from 2008 whereby landholders were only required to pay in the order of 20% upfront costs (prior to this landholders were paying approximately 50%). The increase in funding was reported to be related to a change in the practice with an increased emphasis on achieving a 10m setback of the fence.

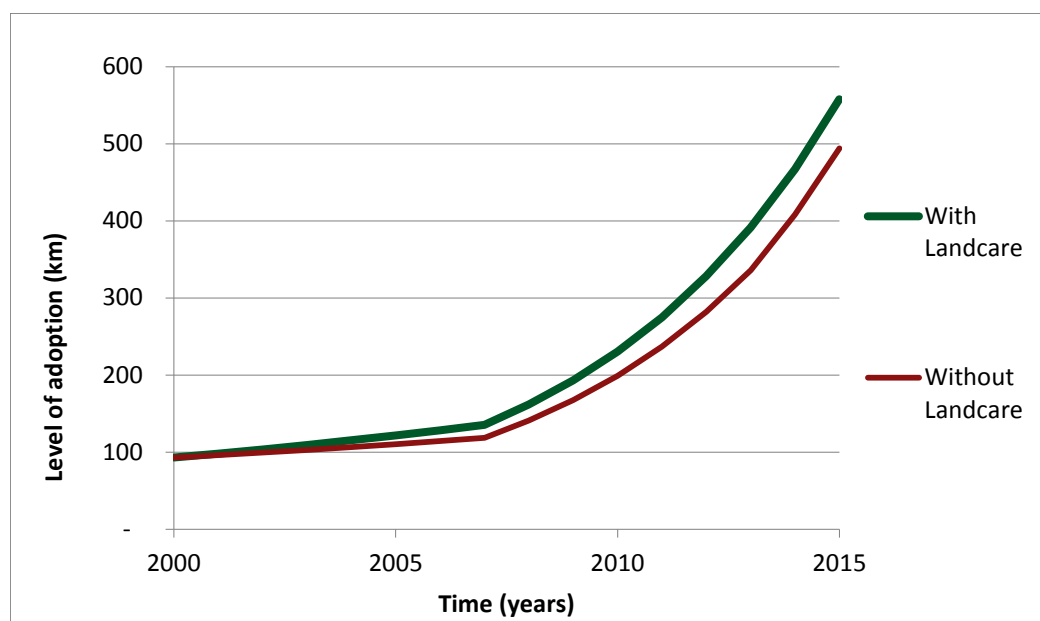


Figure 14. Estimated adoption of riparian management on dairy farms (Gippsland VIC) with and without Landcare funding.

7.4 Benefits – direct on-farm, direct off-farm and indirect off-farm

Development of the systems model to assess the economic benefits required clear assumptions about the cause and effect relationships between adoption of practices and benefits. Three types of benefits were considered:

- Direct on-farm economic benefits (the systems model captures impacts assessed in \$ values due to increased yields, improved profitability and/or reduced costs, but does not capture biodiversity and broader outcomes because \$ values were not able to be assessed);
- Direct off-farm economic benefits (the systems model captures \$ value benefits associated with direct impacts on rural industries resulting from practice adoption);
- Broader indirect off-farm social and environmental benefits (these impacts were unable to be quantified in this project).

Adoption of improved practices (improved effluent, nutrient and riparian management) leads to direct on-farm benefits. Figure 15 shows links between practices and direct on-farm and off-farm benefits that were able to be captured in the systems model.

For the dairy practices the benefits were assessed are:

Direct on-farm benefits:

- Improved yields: Effluent and nutrient management;
- Increased farm income: Effluent and nutrient management;
- Reduced farm costs: Effluent⁴² and nutrient management.

⁴² Although upfront costs can be significant and highly variable

Direct off-farm benefits:

- Increased sales: Input suppliers for all selected practices;
- Increased sales: Nurseries for riparian management;
- Increased services: Agricultural consultants for both effluent and nutrient management;
- Increased services: Soil testing laboratories for nutrient management;
- Increased services: Rural contractors for effluent and riparian management.

7.5 Direct economic benefits of dairy practices

The 'headline' results are presented in Table 11 for each of the three practices analysed (improved effluent management, nutrient management, riparian management). More detail is presented below and details of all major assumptions are further outlined in Appendix 6. The spreadsheet model developed for the project can also be requested from the Department of the Environment and Energy.

Table 11. Estimated direct economic benefits (on-farm and off-farm) from 'Landcare' from 1988-2015 for dairy industry (Gippsland VIC).

\$ millions of economic benefit (present value, 1988 – 2015)			
Direct benefit	Effluent management	Nutrient management	Riparian management
On-farm value	0.2	17.0	-2.1
Off-farm value	0.5	1.2	0.3
Total measured economic value	0.7	18.2	-1.8
Range	0.4 to 0.9	12.3 to 20.6	-1.0 to – 2.9

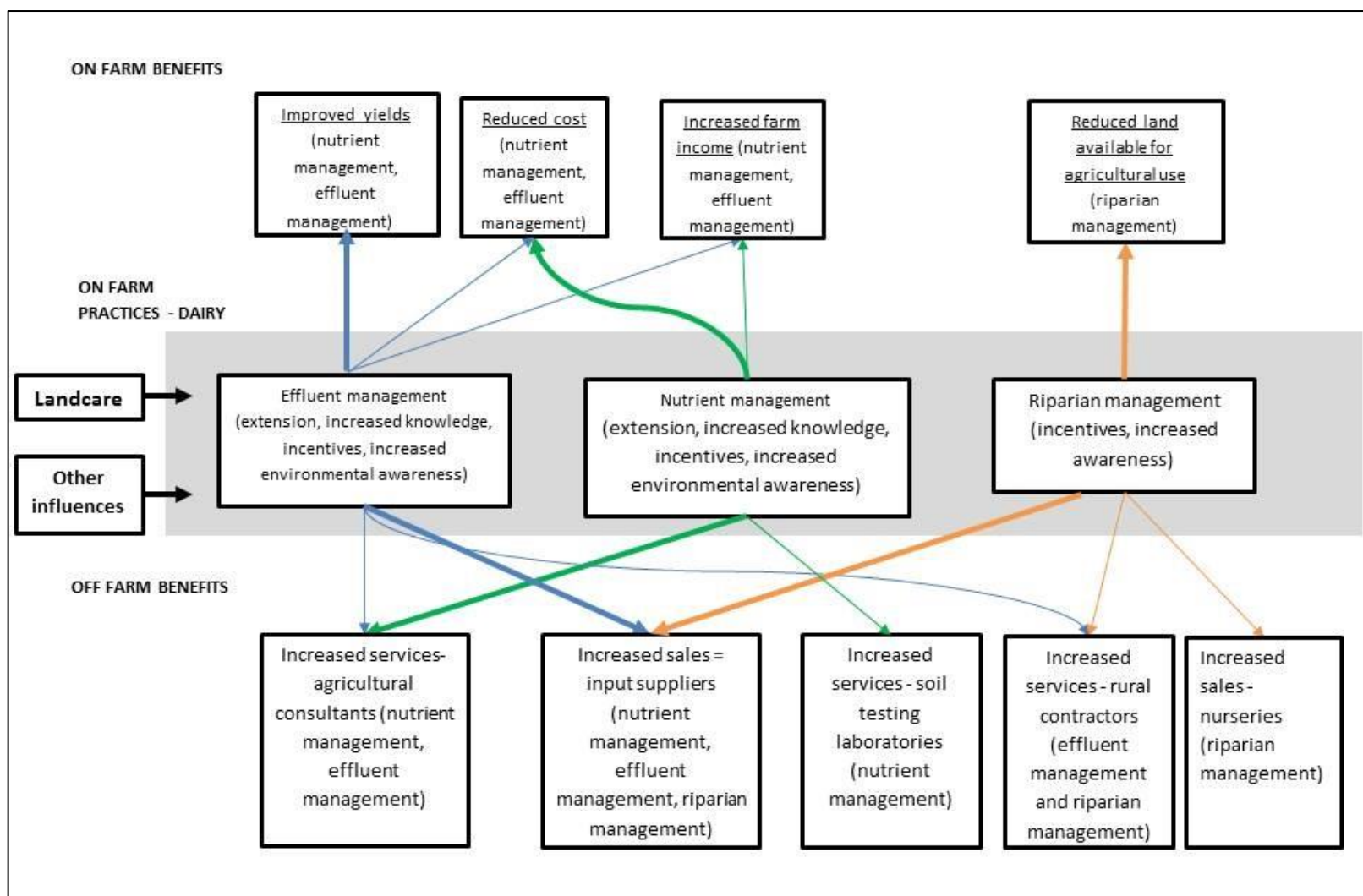


Figure 15. Direct on-farm and direct off-farm benefits of practice adoption in the dairy industry, Gippsland VIC.

Direct on-farm benefits

Modest positive on-farm economic value (total of \$17 million) was estimated from improved nutrient management (Table 11) and small value (\$0.2 million) from improved effluent management. On-farm economic value of riparian management was negative (loss of \$2.1 million). For both effluent and riparian management large upfront costs were the major challenge and even with incentives adoption is likely to continue to be constrained because of costs and management complexity.

Brief details for each practice are outlined below.

Improved effluent management

Improved effluent management was estimated to generate an on-farm value of \$0.2 million. This was derived from assuming an annual increase in profitability of \$25/ha/year (benefit of \$47/ha/year and additional costs of \$22/ha/year). Of all the practices assessed in the project, improved effluent management can have extremely variable costs. Results estimated here were estimated to be slightly positive, however in reality they could range from negative to positive and it was difficult to define an 'average' on-farm situation.

Financial incentives to help off-set some of the upfront costs have proved instrumental in 'getting people over the line' through programs such as Core 4. Upfront costs vary widely amongst farms (associated with as pipes and pumps to get effluent to wider areas on-farm) and the best-bet estimate was an average of \$20,000/farm. Effluent management, particularly management beyond compliance will increasingly be viewed as a social licence to farm issue and milk companies are increasingly requiring improved management of landholders to protect the reputation of the industry. Details of calculations are outlined in Appendix 6.

Improved nutrient management

On-farm economic value of \$17.0 million was estimated from improved nutrient management. This was based on assumptions of a modest increase in profit of \$55/ha, and a small increase in costs of \$10/ha, leading to an overall assumed benefit of \$45/ha/year. Unlike improved effluent management, nutrient management does not have high upfront costs. It does however require more active management including increased soil testing and use of farm consultants.

Riparian management

Riparian management was estimated to result in an on-farm loss of \$2.1 million. If landholders have to pay full costs, the upfront cost for riparian management was estimated to be \$21,142/km. Even when government programs have been available, noting that the majority is state-driven, landholder contributions have been in the order of 20-50% of upfront costs. Although there are benefits to dairy farmers in terms of reduced mastitis and stock losses, and improved management of stock they also bear substantial additional annual costs. Annual costs were estimated for this project to be lost productivity equivalent to \$1,744/ha/year (50% of the average gross margin of \$3,488/ha) and maintenance costs (calculated as 5% of upfront costs) equating to \$1057/km/year. Benefits were not able to be quantified in the time-frame of the project.

Direct off-farm benefits

Modest direct off-farm benefits were estimated, ranging from \$0.3 million for riparian management to \$1.2 million for nutrient management. A 30% profit margin on increased sales and services was assumed as the basis for assessment of off-farm impacts.

Improved effluent management

Total marginal off-farm value for improved effluent management was estimated at \$0.5 million or \$54/ha/year. Per hectare benefits for rural consultants were \$7, rural suppliers \$35 and contract labour \$12.

Improved nutrient management

The total marginal benefit for improved nutrient management was estimated to be \$3.15/ha/year, which resulted in an off-farm benefit of \$1.2 million. This is calculated by multiplying \$3.15 by the number of ha adopted (313,068 ha) over the time period 2001-15, and accounting for adjusting figures to represent the value in today's dollars. Two thirds of the benefit was for rural consultants and one third for laboratories as a result of increased soil testing.

Riparian management

The major rural service industries that were assessed as benefiting from riparian management were rural input suppliers (2,250/km), contractors for site preparation (\$108/km), nurseries (\$450/km) and revegetation contractors (\$1,680/km) which gave an estimated overall off-farm benefit of \$ 0.3 million over the life of Landcare.

7.6 Confidence levels in the systems model results

The results presented are considered as a first attempt to assess economic impacts of Landcare investment. Sensitivity to model inputs is outlined in Appendix 6 and the model itself can be scrutinised. Comments on each of the major model inputs are presented below:

- Level of overall adoption (moderate confidence for all practices);
- Level of adoption attributable to Landcare investment (low confidence for all practices);
- On-farm economic benefits and costs (moderate confidence, albeit that the heterogeneity experienced on farms has not been captured);
- Direct on-farm benefits (moderate-low confidence because of strong dependence on adoption attributable to Landcare);
- Direct off-farm impacts (low confidence as this has been captured very simply and is based on on-farm benefits).

7.7 Broader indirect off-farm benefits

Other very important benefits occur from adoption of sustainable land management practices, however it has not been possible to put a value on these associated environmental and social impacts. Through the expert workshops a number of important additional broader off-farm impacts associated with Landcare investment.

Economic benefits: The greatest economic benefits not accounted for in the systems model are associated with tourism. The Gippsland Lakes have been reported to generate in excess of \$250

million/year in tourism income to the regional economy (Roberts et al. 2012) and more recent work puts the value of the total net impact of the recreational boating industry in Gippsland to be estimated at \$163.0 million, which comprises a direct economic impact of \$51.4 million and a flow on or indirect economic benefit of \$111.6 million (AECOM 2014). The Corner Inlet RAMSAR site, located in close proximity to Wilson's Promontory has potential to generate significant additional tourism value. Tourism is critically dependent upon clean water and these sites are highly threatened by eutrophication from agriculture (Roberts et al. 2012, Dickson et al. 2013).

Social and cultural benefits: The dairy industry continues to intensify in Victoria. As mentioned tourism is important to the regional economy and the region also faces increasing demand for lifestyle 'sea' and 'tree' changers as it is close to Melbourne. The dairy industry is likely to face increasing issues around 'social licence to farm'. Improved nutrient and effluent management will be particularly important to address for dairy to maintain and improve a 'clean and green' image.

Environmental benefits: Along with the importance of improving water quality for freshwater rivers and the marine ecosystems of the Gippsland Lakes and Corner Inlet, additional environmental benefits will come from improved riparian land management. These have been outlined (Lovett et al. 2003) as being:

- sediment trapping (e.g. soil), nutrients and other contaminants (e.g. attached pesticides and herbicides) before they reach the waterway;
- reducing rates of bank erosion and loss of valuable land;
- control of nuisance in-stream plants through shading;
- reducing water temperatures and help ensure healthy in-stream life;
- providing a source of food and habitat for stream animals;
- providing an important location for conservation and movement of wildlife;
- connecting fragmented habitats for wildlife;
- helping to maintain agricultural productivity;
- providing recreation and aesthetically-pleasing landscapes;
- improving water quality for human and stock consumption, as well as the environment; and,
- supporting beneficial insects and animals that prey on pest species;
- Reducing the impacts of extreme weather events (flood damage, storm damage to crop, stock protection etc.).

To recognise the importance of some broader impacts that Landcare investment, a simple qualitative assessment of additional impacts from practice adoption is presented in Table 12. The table indicates simply whether the impact is high, medium or low. If the impact is minimal, or was not mentioned in discussion with stakeholders, the cell has been left blank.

Table 12. Additional impacts associated with practice adoption in the dairy industry (Gippsland VIC) not captured in the systems model.

Additional impacts associated with practice adoption	Improved effluent management	Improved nutrient management	Riparian management
On-farm environmental benefits			
Soil Structure			High
Soil biology	Low	Low	
Carbon storage			High
Reduced erosion			High
Improved crop pest management			Low
Shade/shelter for livestock			Low
Off-farm benefits			
Biodiversity benefits	Low	Low	High
Flood prevention			High
Water quality (eutrophication)	Medium	Medium	High
Water quality (salinity)			Low

7.8 Discussion

The dairy industry has been very proactive in addressing eutrophication from excess nutrients. Strong improvements have been made over the past 25 years. Eutrophication will continue to be a threat because of continued intensification and structural adjustment pressures. Dairy production is becoming increasingly concentrated around higher rainfall, coastal areas. Many of these areas including Gippsland, as well as dairy areas in other states are desirable for 'sea' and 'tree changers' as well as having highly valued freshwater and marine assets. International experience with intensifying industries suggests that increased regulation results if industries cannot adapt to meet increasing demands for maintaining clean water (Craig & Roberts 2015).

Maintaining the social licence to farm is critically important for the dairy industry both domestically and increasingly for positioning to expand export opportunities as a supplier or 'clean and green' produce. Viewed in this way the losses from riparian management can be interpreted more favourably if viewed from the perspective of industry as a whole. Milk companies are acutely aware of the social licence to farm issues and are increasingly requiring farmers to improve effluent management, nutrient management overall and fence off riparian areas.

Results presented cover the approximately 1,430 dairy farms in Gippsland. Registered dairy farms in 2013/14 in Victoria totalled 4,268, and 6,314 Australia-wide⁴³. Overall Gippsland represents approximately 22% of dairy farms in Australia. Whilst the results presented here are specific to the Gippsland context, the practices selected are relevant nationally. Overall benefits and costs could be in the order of four or five times larger than reported here if assumptions made for Gippsland are broadly applicable elsewhere.

7.9 Conclusions from the dairy case study

Investment by the Australian Government through Landcare from 2000-2015 in the dairy region of Gippsland Victoria generated an estimated economic impacts of \$18.2 million for the practice of nutrient management of which 93% of the benefit accrued to landholders due to increased income

⁴³ <http://www.dairyaustralia.com.au/Markets-and-statistics/Farm-facts/Cows-and-Farms.aspx>

resulting from increased yields and reduced costs. Effluent management generated smaller benefits (\$0.7 million), and in the heterogeneity of the real world situation value is likely to range from negative to positive.

Riparian management generated negative on-farm impacts (loss of \$2.1 million) due to high value dairy land being taken out of production. Modest positive off-farm impacts (\$0.3 million) were estimated due to increased use of rural contractors and nursery sales.

The systems model estimated direct economic benefits and it is well known that there are other important benefits from adoption of sustainable land management practices. These have not been captured given the time and resources available.

The results are strongly dependent upon the assumptions used and due to the poor levels of hard data available are based largely on best-estimates using local experts. As such they should be considered as a first attempt. It is important to note that the work has not considered the costs of Landcare and therefore does not assess overall impact, cost-effectiveness or value for money from the investment.

8. Analysis across industries

The results presented here represent only a proportion of Australian agriculture and the following principles can be drawn both for the three industries studied and also more broadly:

- For practices which have positive economic impacts, Landcare investment has generally contributed to an increased speed of adoption and in some cases the extent also;
- For practices which have high upfront costs and/or which generate large environmental benefits, Landcare investment was always critical to increase both the scale and speed of adoption;
- Maintaining agriculture's social licence to farm will become increasingly important and increased scale of adoption of sustainable land management will become even more important in future (this conclusion is not drawn from the systems modelling results, but on the basis of our own experience and judgement).

Recognising that there was insufficient time to cover all agricultural industries and regions, the project team were asked to pick out some of the economic value 'gems' of Landcare. Of the approximately \$1 billion economic value across the three industries, that \$790 million occurred from just one practice, namely zero-tillage in grains and mixed grains/livestock zone, represents a major 'gem'. The reason this practice represents such impressive economic value was due to the combined issues of scale (the WA grains and mixed grains/livestock zone estimated to be 16.9 million ha was much larger than either of the cotton or dairy case studies), an economically attractive practice, a pressing environmental problem (erosion of fragile soils) and strong champions who promoted the technology early. It would be expected that practices in other industries with these features would also generate positive economic returns. Water use efficiency and reduced tillage in cotton have similar features, but the area of cotton overall is much lower than for the grains and mixed grains/livestock zone.

The three environmental practices, which involved revegetation and/or vegetation management incurred on-farm losses. In all cases the upfront costs of revegetation, fencing and off-stream watering presented challenges to landholders. In the case of Victoria there was an additional issue for dairy land that the productive capacity of land used for riparian management was very high and therefore in addition to upfront costs, landholders also suffered the on-going opportunity cost of lost production. The lower production value of marginal land in WA and remaining riparian frontage in cotton did not incur such large opportunity costs. Overall however, the fact that landholders are willing to engage in adoption of environmentally oriented practices shows commitment to land stewardship, and investment into Landcare has made a significant contribution to such commitment. Investment is crucial if adoption is to occur at the scale required to achieve measurable outcomes.

The issue of social licence to farm will become increasingly important, particularly in intensive industries. The rapid adoption of many sustainable land management practices, helped significantly by Landcare investment into development of Environmental Management Systems and ultimately to cotton's 'my BMP'⁴⁴ program have been pivotal in helping improve cotton's image. Continued development of independent evaluation systems to show that landholders are adopting more sustainable practices is also becoming increasingly important in the dairy industry.

The dairy industry continues to intensify and often in areas which also face increasing demand for lifestyle 'sea' and 'tree' changers. The three dairy practices analysed in this project are all important to improve water quality. Using the assumptions made here, none of the practices are highly attractive in terms of large increased profitability but all are very important to help dairy maintain its social licence to farm and potentially to maintain and improve a 'clean and green' image.

9. Opportunities for future work

Until this project was commissioned there has not been a way to assess the economic impacts of Landcare investment. This project developed and tested a practical and evidence-based approach to do so. Whilst there are many potential areas for future work, some of the most important are outlined below. These work areas could be conducted as separate projects or more ideally as inter-linked activities because there will be dependencies between elements which could affect the way particular areas are tackled:

- **Improvements in monitoring and reporting:** While MERIT provides a strong basis on which to record activities, there will be ways to improve reporting to better assess programme outcomes. Currently economic outcomes are not considered. Linkages between MERIT and other data sources is critical (or developing increased capacity within MERIT itself) if economic impacts are to be assessed. Without this, the current problem of lack of ability to assess economic outcomes will remain. Other data being collected by the Australian Government also need to be considered in this piece of work. The specificity of definition of sustainable land management practices within MERIT requires attention for economic impacts of practice adoption to be assessed. Separating out the impacts of Australian

⁴⁴ <https://www.mybmp.com.au>

Government investment (the ‘with’ and ‘without’ issue) from that which would have occurred anyway is also critical;

- **Additional case studies:** The model developed can readily be expanded to other industries and geographic areas;
- **Further model development:** Further development of the systems model would be useful to enable it to be used nationally. Linkage of the model itself to MERIT reporting would be useful as would considering linkages with other information sources. If the model were to be used more broadly then moving from a spreadsheet based model would be useful, particularly to include a more spatial component;
- **Valuing of other benefits:** Assessing non-market impacts of sustainable land management practice adoption would be very beneficial and important in developing a more holistic view of the economic impacts.

10. Conclusions

Investment into Landcare over the past 25 years has changed the mindset of landholders to become more environmentally conscious and engender a greater stewardship ethic as concluded from the literature review. This finding (although not able to be tested in this study) will help position Australian agriculture globally in marketing ‘clean and green’ credentials because landholder are more aware and willing to adopt sustainable management practices. For industries such as cotton, dairying and other intensive industries, helping maintain agriculture’s social licence to farm is likely to become increasingly important element of maintaining export competitiveness (although could not be tested in this study). Continued investment in Landcare along with independent evaluation of practice adoption, as is occurring in the cotton and dairy industries might help brand Australian agriculture and improve global competitiveness in future.

There has not previously been a credible evidence-base to assess the economic impacts of Landcare investment and this is the first time such an assessment has been attempted. The economic benefits estimated only covered three industries within specific regions (grains and mixed livestock in WA, cotton in NSW and Queensland and dairy in Gippsland, Victoria). In aggregate, direct economic impacts in excess of \$1 billion were estimated from 1988-2015 using the systems model developed, 94% of which were estimated to accrue directly to landholders. National economic impact could not be estimated from the study but would be much higher as the regions studied were only a sliver of Australian agriculture and have not included additional social and environmental benefits.

Through adoption of practices that protect biodiversity and water quality (revegetation, fencing and off-stream watering) landholders are demonstrating strong environmental stewardship even though they face considerable on-farm costs as estimated in this study. Adoption of such practices is critical and provides tangible evidence of the long-term stewardship ethic of Australian farmers and landholders. Without continued financial support landholders are unlikely to be able to adopt these practices at scale.

This is the first time the economic benefits of investment into Landcare has been estimated and results are a first attempt. The work provides an important piece of evidence supporting Australia’s global agricultural reputation and competitiveness. The model developed is simple and transparent.

Further development plus refinements in assessing the adoption of sustainable land management practices provide a powerful basis for further work.

This work has not considered the costs of implementing the Landcare programme and therefore does not assess overall impact, cost-effectiveness or value for money from the investment.

11. References

- AECOM, 2014. *The economic value of boating and marine industries associated with the use of Gippsland Lakes. AECOM report for Boating Industry Association of Victoria,*
- Alexander, F. et al., 2000. Landcare and farm forestry: Providing a basis for better resource management on Australian farms. *Forestry*, (November), p.88.
- Anonymous, 2015a. *Agriculture Fisheries and Forestry in the Wheatbelt Region of Western Australia,*
- Anonymous, 1999. *Consideration Of Cumulative Impacts In EPA Review of NEPA Documents,*
- Anonymous, 2015b. *MERIT Activity Family Tree,*
- Anonymous, 2014. merit-ready-reckoner.
- Anonymous, UNICEF M&E Training Resource.
- Austin, P., 2015. *Landcare contributions to human wellbeing: a case study. Prepared by the Upper Barwon Landcare Network. January 2015.,*
- Austin, P., 2014. *The Economic Benefits of Native Shelter Belts Report 01/14. Basalt to Bay Landcare Network.,*
- Bathgate, A. et al., 2009. Managing catchments for multiple objectives: The implications of land use change for salinity, biodiversity and economics. *Animal Production Science*, 49(10), pp.852–859.
- Byron, I. & Curtis, A., 2001. Landcare in Australia: Burned out and browned off. *Local Environment*, 6(3), pp.311–326.
- Byron, I., Curtis, A. & Mackay, J., 2004. *Exploring the effectiveness of Landcare in the Brigalow Jimbour Floodplains Group area October 2004,*
- Byron, Allan Curtis, Michael Lockwood, I., 2001. Exploring Burnout in Australia's Landcare Program: A Case Study in the Shepparton Region. *Society & Natural Resources*, 14(10), pp.901–910.
- Cary, A.J., 2000. Social Perspectives on Technology Transfer to Meet Economic and. , (July), pp.1–8.
- Cary, J., 2010. Changing behavior to more sustainable practice: Australian resource management experience. In *Human dimensions of soil and water conservation.*
- Cary, J. & Roberts, A., 2011. The limitations of environmental management systems in Australian agriculture. *Journal of Environmental Management*, 92(3), pp.878–885.
- Cary, J.W., 1994. The Adoption of Conservation Practices in Australia : An Exploration of Commercial and Environmental Orientations The Adoption of Conservation Practices in Australia : An Exploration of Commercial and Environmental Orientations.
- Craig, RK; Roberts, A., 2015. When will governments regulate nonpoint source pollution? *Boston College Environmental Affairs Law Review*, 42, pp.1–64.

- Cullen, P., Williams, J. & Curtis, A., 2003. LandcareFarming Securing the Future for Australian Agriculture. , (August), p.28.
- Curtis, A., 2003. *Reflecting on the Landcare experience A report based on information held within ABARE and BRS*,
- Curtis, A. et al., 2014. The great experiment with devolved NRM governance: lessons from community engagement in Australia and New Zealand since the 1980s. *Australasian Journal of Environmental Management*, 21(2), pp.175–199.
- Curtis, A. & de Lacy, T., 1995. Examining the assumptions underlying Landcare. *Rural Society*, 5(2-3), pp.44–55.
- Curtis, A. & De Lacy, T., 1996. Landcare in Australia: Does it Make a Difference? *Journal of Environmental Management*, 46(2), pp.119–137.
- Curtis, A. & Sample, R., 2010. *Report No . 55 CBNRM in Victoria : Contributing to dialogue , learning and action A report to the Victorian Department of Sustainability and Environment*
- Dickson, M; Park, G; Roberts, A., 2013. *Corner Inlet Water Quality Improvement Plan 2013*. West Gippsland Catchment Management Authority,
- DSE, 2008. 2008 Victorian Landcare Forum. Landcare Victoria. Department of Sustainability and Environment. In *Shaping our Future Proceedings 29-30 May 2008*.
- Ernst & Young, 2011. *Economic Contribution of Recreational Fishing in the Murray Darling Basin*. Department of Primary Industries.,
- GHD, 2013. *Multiple benefits of Landcare and Natural Resource Management - GHD Final Report*,
- Hodges, A. & Goesch, T., 2006. Australian Farms: Natural Resource Management in 2004-05. , (september).
- Kancans, R, Ecker, S, Duncan, A, Stenekes N and Zobel-Zubrzycka, H., 2014. *Drivers of practice change in land management in Australia - synthesis report*,
- Love, C., 2012. *Evolution of Landcare in Australia: In the context of Australian Government natural resource management policy and programs*,
- Lovett, S; Price, P; Lovett, J., 2003. *Managing riparian lands in the cotton industry*,
- McVay, P., Pike, L. & Crossley, D., 2004. *The Administration of the National Action Plan for Salinity and Water Quality*. The Auditor-General Audit Report No. 17 2004-2005.,
- Morrell, B., 2010. *National Action Plan for Salinity and Water Quality Natural Heritage Trust*,
- Mues, C., Chapman, L. & Hilst, R. Van, 1998. Promoting improved land management practices on Australian farms: A survey of Landcare and land management related programs. *ABARE Research Report 98.4*.

- Mulder, J, Brent, C., 2006. Selection of sustainable rural agriculture Projects in South Africa: Case studies in the LandCare Programme. *Journal of Sustainable Agriculture*, 28, pp.55–84.
- Newby, J.C. & Cramb, R. a., 2011. Economic impacts of conservation farming in a marginal environment: the case of “Landcare” in the Philippines. *International Journal of Agricultural Sustainability*, 9(3), pp.456–470.
- Nicholson, C., 2012. *Woody Yallock Catchment Group Annual Report*,
- Nordblom, T.L. et al., 2010. Least cost land-use changes for targeted catchment salt load and water yield impacts in south eastern Australia. *Agricultural Water Management*, 97(6), pp.811–823.
- Pannell, D., 2008. Public benefits, private benefits, and policy intervention for land-use change for environmental benefits. *Land Economics*, 84(2), pp.225–240.
- Pannell, D.J. et al., 2006. Understanding and promoting adoption of conservation practices by rural landholders. *Australian Journal of Experimental Agriculture*, 46(11), pp.1407–1424.
- Pannell, D.J., 2003. What is the value of a sustainability indicator? Economic issues in monitoring and management for sustainability. *Australian Journal of Experimental Agriculture*, 43(3), pp.239–243.
- Pannell, D.J. & Glenn, N. a., 2000. A framework for the economic evaluation and selection of sustainability indicators in agriculture. *Ecological Economics*, 33(1), pp.135–149.
- Pannell, D.J. & Roberts, A.M., 2010. Australia’s National Action Plan for Salinity and Water Quality: A retrospective assessment. *Australian Journal of Agricultural and Resource Economics*, 54(4), pp.437–456.
- Patrick, I., Barclay, E. & Reeve, I., 2009. If the price is right: farmer attitudes to producing environmental services. *Australasian Journal of Environmental Management*, 16(1), pp.36–46.
- Race, D. & Curtis, a., 2007. Adoption of farm forestry in Victoria: linking policy with practice. *Australasian Journal of Environmental Management*, 14(3), pp.166–178.
- Read, V; Petersen, L., 2008. *Grain and Graze Evaluation Report*,
- Ridley, A. et al., 2007. Priority environmental issues for monitoring—mismatch between farmers and catchment management perspectives. *Animal Production Science*, 47(1), pp.356–366.
- Roberts, A. et al., 2012. Agricultural land management strategies to reduce phosphorus loads in the Gippsland Lakes, Australia. *Agricultural Systems*, 106, pp.11–22.
- Robins, L., 2004. A Case for Rethinking Policy and Research Directions for the Rehabilitation of Riparian Lands in Australia. *Australasian Journal of Environmental Management*, 11(3), pp.190–200.
- Robins, L. & Kanowski, P., 2011. “Crying for our Country”: eight ways in which “Caring for our Country” has undermined Australia’s regional model for natural resource management. *Australasian Journal of Environmental Management*, 18(2), pp.88–108.

- Schelhoern, N., 2012. *Keeping Pest Populations Lower for Longer: Capturing the Benefits of Native Vegetation, Cotton Catchment Communities CRC Project Number: 5.10.03.41*,
- Simpson, G. & Clifton, J., 2010. Funding and Facilitation: implications of changing government policy for the future of voluntary Landcare groups in Western Australia. *Australian Geographer*, 41(3), pp.403–423.
- Smith, R. & Reid, N., 2013. Carbon storage value of native vegetation on a subhumid–semi-arid floodplain. *Crop & Pasture Science*, 64, pp.1209–1216.
- Sobels, J., Curtis, A. & Lockie, S., 2001. The role of landcare group networks in rural Australia: Exploring the contribution of social capital. *Journal of Rural Studies*, 17(3), pp.265–276.
- Tennent, R. & Lockie, S., 2012. Vale Landcare: the rise and decline of community-based natural resource management in rural Australia. *Journal of Environmental Planning and Management*, 56(4), pp.1–16.
- Youl, R., Marriott, S. & Thabben, N., 2006. *Landcare in Australia founded on local action.*,

Appendices

Appendix 1 – List of stakeholders who participated in expert workshops and reviewers of the modelling results.

Appendix 2 – Timeline of phases of the Landcare movement and comments on implications from the literature.

Appendix 3 – Systems model conceptual thinking and methodology

Appendix 4 – Grains and mixed livestock, WA results

Appendix 5 – Cotton Queensland and NSW results

Appendix 6 – Dairy, Gippsland Victoria results