Investing in RD&E for the world-leading Australian cotton industry
Emerald cotton consultant Jamie Iker is one of two cotton industry leaders who took part in the Australian Rural Leadership Program in 2015–16. He and fellow participant Sean Boland of Moree received support from CRDC, Cotton Australia and Auscott Ltd. Jamie is also part of the CRDC-supported *Strengthening the Central Highlands Cotton Production System* project, led by QDAF’s Paul Grundy. Under this project, researchers have been trialling growing cotton under biodegradable plastic film to take better advantage of the region’s climate. Jamie is pictured here at the trial site at ‘Orana’ Emerald, owned by Cowal Agricultural Operations. Photo courtesy researcher, Paul Grundy.
About CRDC

The Cotton Research and Development Corporation (CRDC) has been delivering outcomes in cotton research, development and extension (RD&E) on behalf of Australia’s cotton growers and the Australian Government for 25 years.

Established in October 1990 and operating under the Primary Industries Research and Development Act 1989 (PIRD Act), CRDC exists to enhance the performance of the Australian cotton industry through investment in, and delivery of, cotton RD&E. CRDC is based in Narrabri, NSW: the heart of one of Australia’s major cotton-growing regions and home to the Australian Cotton Research Institute.

Cotton is a major contributor to the economy, environment and social fabric of rural Australia. Grown in New South Wales, Queensland, and recently expanding into northern Victoria, cotton is a major employer and contributor to the local, state and national economy. Over the past five years, the industry has generated an average of $1.9 billion in export revenue per annum.

CRDC’s role is to invest in RD&E on behalf of cotton growers and the government, with the outcomes boosting the productivity and profitability of our industry. RD&E, and its resulting innovations, are a key driving force behind the cotton industry’s continued success.

In 2015–16, CRDC invested $21 million into 290 RD&E projects in collaboration with 92 research partners and growers who conducted on-farm trials, across five key program areas: farmers, industry, customers, people and performance.

The findings from these research projects continue to be extended through a range of methods, including the industry’s joint extension program CottonInfo. The adoption of best management practices is also encouraged via the industry program myBMP. CRDC is a founding partner of both programs.

This report outlines CRDC’s investments and impact across these five program areas during 2015–16.

**Vision:** A globally competitive and responsible cotton industry.

**Mission:** To invest in RD&E for the world-leading Australian cotton industry.

**Purpose:** Enhancing the performance of the Australian cotton industry and community through investing in research and development, and its application.
The Australian cotton industry is one of the success stories of Australian agriculture. A culture of innovation within the industry, supported by and embracing a well-organised RD&E framework, has been a major contributor to this success.

From small beginnings in the 1970s, Australia’s cotton industry is now a valuable agricultural export commodity. Cotton is currently the major agricultural crop grown in many rural and remote regions of Queensland (QLD) and New South Wales (NSW).

Australian cotton is the highest yielding, finest, cleanest and greenest cotton in the world. On a global scale, Australia is not a large cotton producer—only around three per cent of the global crop is grown within Australia, by some 900 cotton growers on 1250 farms in QLD and NSW, with commercial trials in Victoria (VIC).

However, Australia is one of the largest exporters of cotton, with nearly 100 per cent of the national crop exported, generating an average of $1.9 billion in export revenue annually. The industry generates significant wealth and provides an economic foundation to many regional and remote rural economies, employing up to 10,000 people.

Improved practices driven by RD&E over the past 15 years have reduced insecticide use by 92 per cent and improved water-use efficiency by 40 per cent, while improvements in fertiliser and energy use are driving an ongoing reduction in nitrous oxide emissions.

The best cotton producers now achieve more than two bales of cotton per megalitre (ML) of water—almost double the industry average of just a decade ago. The industry is at the forefront of environmental management systems, and climate variability mitigation and adaptation.

Importantly, cotton is an industry taking responsibility for itself by changing practices to meet societal expectations. The introduction of the industry’s best management practice program myBMP, the uptake of biotechnology to help reduce pesticide use, and the implementation of the industry’s environmental assessment and resulting actions, are all examples of the cotton industry recognising the need for change, and working with the RD&E system to enact it.

In recent years, new cotton varieties, new farming technologies, and favourable weather and market conditions have facilitated an expansion in southern NSW cotton-growing regions, reaching as far south as the Victorian border. The industry has also historically invested in developing cotton production practices for northern Australia, in preparation for any future commercial developments.
Executive Summary

Report from the Chair and Executive Director

Progress against CRDC Strategic R&D Plan 2013–18

Year in Review: RD&E Achievements

Organisational Highlights

2015–16 Investment and Impact
Executive Summary
REPORT FROM THE CHAIR AND EXECUTIVE DIRECTOR

The Australian cotton industry is one of the success stories of Australian agriculture. Australian cotton is the highest yielding, finest, cleanest and greenest cotton in the world.

We’re an industry taking responsibility for ourselves by changing our practices to meet our own expectations and those of contemporary society. Australia’s best cotton producers now achieve more than two bales of cotton per megalitre of water—almost double the industry average of just a decade ago. Our industry is at the forefront of environmental management systems, climate change preparedness and climate change adaptation.

It’s an extraordinary story of achievement, thanks primarily to the continued support of the industry and the Australian Government for RD&E over the past 25 years.

CRDC’s strategic leadership and collaboration in RD&E investment has been—and continues to be—a driving force behind the industry’s continuous improvement and transformation.

From 1990 to 2015, CRDC invested more than $280 million into RD&E on behalf of the industry, delivering billions of dollars in benefit back to Australian cotton growers on their farms. One project alone—CRDC’s investment in plant breeding—is estimated to have contributed $5 billion to the industry and the Australian agricultural economy.

In terms of the impact of R&D, our world-leading cotton yields and quality are easy to see and quantify. Efficiency gains in water use and reductions in pesticide use are also evident.

But arguably, cotton production would not have been possible for the last 20 years—during which time growers have collectively contributed to producing more than $27 billion in exports—if it wasn’t for R&D and the industry’s commitment to improving its practices for controlling insects and managing diseases such as Fusarium.

CRDC invested in some 2100 projects over these 25 years—moving from a response-oriented approach of specifically addressing the industry issues of the 1990s to a more proactive approach of collaboratively identifying potential future threats and opportunities, and strategically investing in them to ensure the industry’s continued success.

As 2015 marked 25 years of CRDC-led cotton RD&E, in 2015–16, we took time to look back on these 25 years, to acknowledge the major RD&E achievements and the individuals and organisations who contributed to this success.

The foundations of the early Australian cotton industry—of forward-looking leadership, tenacity, RD&E and its resulting innovation—continue to be fundamental to the industry today. And, as it was back then, success requires a combined and collaborative effort.

The three cornerstones of CRDC have always been investment, innovation and impact. Our role is to invest in targeted and strategic research that delivers real benefits to Australian cotton growers and the wider industry, and that underpins a strong, profitable, sustainable and competitive future for cotton.

That is why, in 2015–16, CRDC invested $21 million into 290 RD&E projects in collaboration with 92 research partners and growers who conducted on-farm trials, across five key program areas: farmers, industry, customers, people and performance.

In this report, we outline the investment we have made in these projects on behalf of growers and the government, along with the resulting innovations and impacts.
Take these, for example: the world’s first facility into cotton climate change research, which will help cotton growers prepare for future climate variability; the industry’s first resilience assessment, which will help the industry adapt to change; and the industry’s first workforce development strategy, which will help growers attract, retain and develop their staff—but three of CRDC’s investments in 2015–16.

On behalf of our fellow Directors, we invite you to read the CRDC Annual Report for 2015–16.

Dr MARY CORBETT finished her tenure as CRDC’s Chair on 12 August 2016. Mary served as a Director of CRDC from 2008, and as Chair from 2013.

On behalf of the CRDC Board, we thank Dr Corbett for her contribution to CRDC during this period. CRDC Director and Deputy Chair Cleave Rogan served in the role of Acting Chair until the appointment of the incoming CRDC Chair Richard Haire on 29 August 2016 by the Minister for Agriculture and Water Resources.

As Dr Corbett was the Chair during the 2015–16 year, she remains as a signatory to this Annual Report.
**Executive Summary**

**PROGRESS AGAINST CRDC STRATEGIC R&D PLAN 2013–18**

CRDC’s RD&E investments are governed by the Strategic R&D Plan 2013–18, which outlines five key investment programs—farmers, industry, customers, people and performance. Each year CRDC completes an analysis of performance against the Strategic Plan measures.

2015–16 marked CRDC’s third year of operation under the Strategic Plan. The following table shows CRDC achievements and progress against the Strategic Plan programs as of 30 June 2016.

Progress is measured through the CRDC monitoring and evaluation framework. Each of the measures of success outlined in the Strategic Plan have corresponding metrics, against which performance is measured through annual quantitative and qualitative surveys.

The red, amber and green traffic light system is used in CRDC’s monitoring and evaluation to track overall performance against the CRDC Strategic Plan.

### Key:
- The specific measure has been achieved.
- On target to deliver against the measure.
- Not on target to deliver against the measure.

<table>
<thead>
<tr>
<th>Strategic Plan Measures</th>
<th>Result</th>
<th>Comments</th>
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<tbody>
<tr>
<td><strong>Farmers:</strong> Cotton is profitable and consistently farmers’ crop of choice</td>
<td>Estimated achievement of 3.1 per cent average growth in yield per hectare per annum since 2013. According to CSIRO, these yield increases can be attributed to management and the interaction of management and genetics (52 per cent); and genetic improvements (48 per cent). CRDC invests predominately in the areas of management and the interaction of management and genetics, and data from our monitoring and evaluation program has demonstrated a resulting increase in crop yield, resource-use efficiencies, and profitability.</td>
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<td>Farmers increase productivity by 3 per cent per hectare per year</td>
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<td><strong>Industry:</strong> The Australian cotton industry is the global leader in sustainable agriculture</td>
<td>The Australian cotton industry was the first agricultural industry in Australia to develop and document its performance against specific environmental, economic and social sustainability indicators. Developed in response to the industry’s Third Environmental Assessment, the 2014 Australian Grown Cotton Sustainability Report developed and benchmarked 45 key sustainability indicators for the Australian cotton industry. Since undertaking this effort, the Australian Dairy Industry Council has also reported on its industry’s sustainability (with eight target areas and 50 indicators), indicating a strong alignment between cotton and other agricultural industries.</td>
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<td>Industry can report against recognised sustainability indicators</td>
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<td><strong>Customers:</strong> The Australian cotton industry captures the full value of its products</td>
<td>While the industry receives a premium for its product (at times double the premium paid for cotton from other countries) this is not a consistent trend. Competition with man-made fibres will continue to exert downward pressure on the value of cotton. As such, CRDC’s RD&amp;E focus is on new uses for cotton and disrupting the supply chain to make cotton more competitive with man-made fibres.</td>
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<td>Double the premium for Australian cotton</td>
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<td><strong>People:</strong> Capable and connected people driving the cotton industry</td>
<td>CRDC continues to fund 10 leadership and development programs, run two scholarship programs for emerging researchers, and run the Grassroots Grants program to encourage local innovation. CRDC is the foundation sponsor for both the Australian Cotton Conference and the Association of Australian Cotton Scientists research conference. In 2015–16, CRDC and Cotton Australia developed the industry’s first Workforce Development Strategy. Educational attainment in cotton is commensurate with regional Australia, with 28 per cent of the population possessing post-school qualifications, up from 24 per cent in 2006.</td>
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<td>A skilled, educated and progressive workforce</td>
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<td><strong>Performance:</strong> Measured performance of the Australian cotton industry and its RD&amp;E drives continuous improvement</td>
<td>A monitoring and evaluation framework has been developed for CRDC’s investments, enabling performance reporting. CRDC’s RD&amp;E underpins the industry’s best management practices program, myBMP, with industry participation in the program now at 70 per cent.</td>
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<tr>
<td>Measured performance of the Australian cotton industry and its RD&amp;E drives continuous improvement</td>
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Executive Summary
YEAR IN REVIEW: CRDC RD&E ACHIEVEMENTS

The future of cotton irrigation—irrigation automation

The CRDC-led Smarter Irrigation for Profit project is a large-scale, ambitious project designed to achieve a 10–20 per cent improvement in water productivity, efficiency and farmer profitability across the cotton, dairy, rice and sugar industries. Within cotton, one of the major focuses is irrigation automation, and in 2015–16, CRDC supported the CottonInfo Irrigation Automation Tour, which took 40 cotton growers to the southern irrigation industry to see surface irrigation automation technologies in action. Participants of the tour were impressed with the technology; 95 per cent said they would do something differently on-farm as a result of what they had learnt on the tour.

Taking research to the field: nutrition researchers tour

The CRDC-supported CottonInfo nutrition tour delivered a series of five nutrition field days to growers across five cotton-growing valleys in February 2016, taking the latest developments in nutrition research to 360 cotton growers and consultants. The tour involved 10 leading CRDC-supported industry researchers who presented on and discussed a range of important cotton nutrition topics, helping growers realise optimal yields and fibre quality, reduce costs and emissions, and increase margins. The tour resulted in a 35 per cent increase in understanding of soil health and nitrogen-use efficiency among attendees, and a 52 per cent increase in understanding of loss pathways and greenhouse gas emissions.

World’s first facility into cotton climate change research

In a first for the cotton industry globally, a national facility for cotton climate change research has been co-established by CRDC and CSIRO at the Australian Cotton Research Institute (ACRI) at Narrabri to investigate the impacts of climate change on cotton production, and to evaluate the likely effectiveness of adaptation strategies. Over three cotton-growing seasons, CSIRO will be measuring cotton growth, production and resource-use efficiency in detail, with new in-field poly-tunnels established at ACRI maintaining elevated CO₂, temperature and variable soil water availability.

Best practice for managing cotton’s riparian vegetation

A CRDC-supported project to identify the critical thresholds for riparian vegetation, run by Griffith University, has found that managing riparian lands under best practice makes an important contribution to the conservation of natural assets. The project found that canopy cover and litter loads are particularly significant drivers of riparian vegetation, and as a result, any land management activities that impact these, such as clearing and grazing, have the potential to adversely affect vegetation regeneration. The findings are important as they may inform future cotton industry’s natural resource management positions.

Cotton RiverCare Champion demonstrates river stewardship

To demonstrate the best practice management of rivers and riparian areas, CRDC has appointed a cotton grower, Mark Palfreyman, as the Cotton RiverCare Champion under the National Cotton RiverCare Champion project. The champion will demonstrate to cotton growers and the general public how best management practice leads to good condition riparian areas. Under the program, long-term monitoring sites will be established on the Palfreyman family farm to look at water quality, the condition of native vegetation and the diversity of local fauna, with results shared in real time via social media.

CRDC commissions first-ever resilience assessment

CRDC commissioned the Australian cotton industry’s first resilience assessment to better understand how to help the industry best adapt to change and to identify critical threats and opportunities for future investment. The assessment looked at three levels of cotton production: the farm, the region and the whole...
of industry. It found that there are key drivers and shocks acting across the industry, and that industry leaders and growers need to be aware of the impact of those drivers, and of the changing nature, frequency or severity of shocks to better prepare and respond to them.

**Do round modules have a shelf life?**

A CRDC-supported project with CSIRO, *Determining the shelf life of round modules and impact on cotton quality*, aims to address fibre-quality issues in round modules that could be caused by the storage duration and conditions prior to ginning. There is a concern that the plastic wrap on round modules can create favourable conditions for microbial degradation of the cotton, which can weaken the fibre and cause quality deterioration, resulting in price discounts and yield loss for growers. Findings to date indicate that the orientation of the module during storage can influence its temperature and moisture levels, and that covering modules with a tarp can significantly reduce temperature and relative humidity fluctuations.

**Measuring cotton’s greenhouse gas emissions**

A CRDC-supported project led by NSW DPI to review the emission methodologies of cotton has used a life-cycle assessment to produce a clear picture of the greenhouse gas (GHG) emissions profile for a representative cotton production system in North West NSW. The project found that 1 tonne of cotton lint at port had a carbon dioxide equivalent (CO₂e) of 1601 kg. The impact of the pre-farm, on-farm and post-farm stages were 407kg CO₂e; 775 CO₂e; and 419 CO₂e respectively. Six emission reduction options were developed by the researchers—optimum nitrogen (N) application rate, controlled-release N fertilisers, solar-powered irrigation pumps, biofuel-powered machinery, legume crops, and fertigation—for consideration by industry.

**Can cotton be used for 3D printing?**

The CRDC-supported *Cotton rapid customisation feasibility study* project, conducted by QUT, aimed to assess the feasibility of using cotton as a feedstock in rapid customisation processes, such as 3D printing. The project identified areas within the broad range of rapid customisations where cotton has a clear advantage due to its inherent material qualities. The project found five areas for future research and investigation: on-site fabrication of cotton-based filtration products; on-demand manufacture of bespoke furniture; next-generation lifestyle garments and accessories; 3D printing of children’s toys; and patient-specific smart wound dressings using cotton-derived cellulose and rapid customisation.

**CRDC supports new cotton innovation: an ever-dry self-cooling fabric**

The CRDC-supported, Deakin University-led *Ever-dry self-cooling cotton fabrics* project has successfully developed a new coating technique that gives cotton fabrics added functionality: the ability to regulate moisture, breathability and surface temperature. This important innovation has the potential to considerably increase the use of cotton in clothing ranges, including sportswear, summer clothing and defence force uniforms. Work is now underway on the development of a commercialisation plan.

**Cotton’s first Workforce Development Strategy**

CRDC and Cotton Australia collaborated to deliver the industry’s first *Workforce Development Strategy*. The strategy is focused on delivering workforce outcomes for growers on-farm, and ultimately will ensure that the cotton industry is able to attract, retain and develop people who will drive industry competitiveness. The strategy provides a shared and focused plan to ensure the cotton industry’s organisations’ investments in workforce strategies target key priorities, are well coordinated and deliver maximum outcomes.
Developing skills through education
CRDC supported or led eight educational initiatives during the year to help increase the skills and knowledge of current and future cotton workforces. Over 1000 students participated in the Cotton industry young professionals project over the course of the program; 76 students enrolled in the UNE Cotton Production Course in this year; and CRDC supported 46 undergraduate and postgraduate students through the CRDC summer, honours and PhD and RIRDC Horizon scholarships. In addition, this year marked 12 years of investment by CRDC in the Aboriginal Employment Strategy, and supported two Indigenous students under this program.

Encouraging future leaders
CRDC invested in four leadership programs during 2015–16, designed to build a network of informed and experienced leaders. Two emerging industry leaders, Jamie Iker and Sean Boland, participated in the Australian Rural Leadership Program during 2015–16; two cotton growers, Matthew McVeigh and Tom Quigley, continued their Nuffield Scholarships; an irrigator, Adam Harris, participated in the Peter Cullen Trust program; and CSIRO research assistant, Yvonne Chang, was awarded the Science and Innovation Award for Young People in Agriculture.

Investing in grower-led grassroots research
CRDC’s Grassroots Grants program encourages Cotton Grower Associations to apply for funding to support capacity-building projects in their region. Up to $10,000 in funding is available for CGAs to help fund a project aimed at increasing the engagement of growers in the industry, solving specific regional issues and improving their skills, knowledge base and networks. Since the Grassroots Grants program commenced in 2011, it has supported 44 projects across the cotton-growing valleys, including 11 projects in 2015–16.

Demonstrating best practice in cotton production
The CRDC-supported Australian cotton production and best practice documentaries project, delivered by QDAF, aims to communicate scientifically based crop production, protection and best practice principles to a diverse audience through a series of short, easily accessible videos. To date, 85 short videos have been produced, ranging from pre-season planter maintenance and planting tips through to overcoming challenges for new growers in the southern districts. The videos, which are published on the CottonInfo YouTube channel, have collectively received 15,000 views.
Executive Summary
YEAR IN REVIEW: ORGANISATIONAL HIGHLIGHTS

25 years of cotton RD&E, led by CRDC
October 2015 marked 25 years of CRDC: 25 years of cotton RD&E, invested in by cotton growers and the Australian Government and led by CRDC. The milestone was marked through the release of a special edition of the CRDC Spotlight magazine, and a subsequent publication CRDC: 25 years of RD&E, which outlined the 25 key RD&E achievements in the cotton industry over 25 years.

20 years of GM cotton: CRDC R&D underpins stewardship
2016 marked 20 years of GM cotton in Australia, with the introduction of the industry’s first Bt cotton, Ingard, in 1996. CRDC has played an instrumental role in ensuring the enduring efficiency of GM cotton through stewardship. Australia is now recognised as having the most pre-emptive, rigorous and successful resistance management system for transgenic cotton in the world.

Strong support for CRDC investments among growers
For the first time in 2015–16, the Grower Practices Survey sought feedback from growers about their perceptions of CRDC and support for our RD&E investments. The survey found that 99.6 per cent of growers are aware of CRDC, 88 per cent of growers are supportive of CRDC’s research and investments, and 74 per cent of growers have input into CRDC about research.

Final RD&E reports now online
Over 1100 final reports of RD&E projects invested in by CRDC are now available via the CRDC online digital library, Inside Cotton. The reports range from 1986 to 2015, including those invested in by CRDC’s predecessor, the Cotton Research Council. The reports join a host of other important cotton industry materials on Inside Cotton, including previous editions of the CRDC Spotlight magazine, CRDC corporate publications, papers and presentations from the Australian Cotton Conferences and archived materials from the former cotton CRCs.

Second annual Strategy Forum identifies cotton RD&E priorities
CRDC hosted its second annual Strategy Forum in Brisbane in May 2016, bringing together cotton growers on Cotton Australia’s grower advisory panels to help determine the industry’s future research priorities. The Forum is part of CRDC’s procurement process, which was revised in 2015–16 to improve efficiency, streamline the RD&E investment process and provide greater clarity to researchers.

$11.3 million for Rural R&D for Profit: CRDC leading three collaborative projects
The CRDC-led collaborative Smarter Irrigation for Profit project commenced in 2015–16 under round one of the Australian Government’s Rural R&D for Profit programme. The Minister for Agriculture and Water Resources announced another two CRDC-led collaborative projects in 2016 under round two: More Profit from Nitrogen and Accelerating precision agriculture to decision agriculture, commencing in 2016–17. Collectively, these projects will contribute up to a combined $11.3 million into RD&E funding across their respective terms.

Collaboration: a key to cotton RD&E
CRDC works in partnership with other industry bodies and other rural research and development corporations (RDCs) to achieve strategic outcomes for the industry, and to leverage higher returns for our investments. This underpins our investment strategy, with CRDC partnering in over 80 per cent of RD&E projects conducted in the cotton sector. Almost 25 per cent of CRDC investments are in cross-sectoral RD&E. The collaboration extends from national to cotton industry-specific and local initiatives—from national cross-sectorial partnerships on water and soils; to the industry-specific extension joint venture, CottonInfo; and at the local level, partnerships with Cotton Grower Associations on CRDC Grassroots Grants.
International research collaboration

Australia is well recognised as a global leader in cotton RD&E and, in addition to building strong partnerships and collaborations with Australian research partners, CRDC also builds mutually beneficial relationships abroad. In 2015–16, CRDC representatives visited Cotton Incorporated, the US cotton research, development and marketing organisation, to discuss areas for RD&E collaboration. CRDC and the Association of Australian Cotton Scientists also jointly supported 14 Australian cotton researchers to attend the World Cotton Conference in Brazil in May 2016.

CRDC RD&E showcased at industry events

CRDC-supported RD&E projects have been showcased at a number of events during 2015–16, including the grower-focused Cotton Collective, held in Narrabri in August 2015 with 250 growers in attendance; and the researcher-focused Association of Australian Cotton Scientists’ Australian Cotton Research Conference, held in Toowoomba in September 2015 with 200 researchers in attendance. CRDC also supported the 18th Australian Cotton Conference, at the Gold Coast in August 2016. Of the 150 speakers on the Cotton Conference agenda, 75 per cent of presentations about research were supported by CRDC.

Cotton Australia Director Bob Dall’Alba, CRDC Chair Dr Mary Corbett, Deputy Prime Minister Barnaby Joyce, Cotton Australia Director Stuart Armitage, and CRDC Executive Director Bruce Finney at the announcement of the Rural R&D for Profit programme project, More profit from nitrogen, at Dalby in May 2016.
Commitment to sustainability: response to the Third Environmental Assessment

The Australian cotton industry has a 24-year history of independent environmental assessments, demonstrating our commitment to monitoring and improving our environmental performance. In 2012, the Third Environmental Assessment was conducted and in February 2016, CRDC and Cotton Australia officially responded, outlining the high-level outcomes that have been delivered on behalf of the industry. These outcomes include the *Australian Grown Cotton Sustainability Report* and the establishment of 45 key sustainability indicators.

Cotton Futures: investing in blue-sky, transformational cotton RD&E

Cotton Futures provide a clear framework for CRDC to invest in long-term, transformational innovations to ensure the industry remains profitable, sustainable and competitive in the future. In 2015–16, CRDC invested in 11 innovative blue-sky projects under the three Cotton Futures themes.

CottonInfo: three years of connecting growers with CRDC-led R&D

2015–16 marked three years of the industry’s joint extension program, CottonInfo, supported by CRDC, Cotton Australia and CSD Ltd. Studies conducted in 2014–15 have shown that 82 per cent of growers and 90 per cent of consultants are aware of CottonInfo; 78 per cent of growers and 90 per cent of consultants source information from CottonInfo; and 89 per cent of growers and 90 per cent of consultants believe CottonInfo has helped improve practices.

CRDC Deputy Chair awarded major industry award

CRDC Deputy Chair and St George cotton grower Cleave Rogan was awarded the prestigious 2015 Incitec Pivot Fertilisers Service to Industry Award at the Cotton Industry Awards presentation in August 2015.

First year of funding agreement partnership

2015–16 was the first year of operation under the CRDC and Commonwealth Government Funding Agreement. This agreement recognises the importance of the partnership between growers and the government as co-investors in RD&E through CRDC. The agreement sets out expectations about CRDC’s performance, transparency and accountability, and runs until 2018–19.

Cotton and the agricultural innovation inquiry

In 2015–16, the House of Representatives Standing Committee on Agriculture and Industry conducted an Inquiry into Agricultural Innovation, investigating the role of technology in increasing agricultural productivity in Australia. CRDC and other industry partners made submissions and presented to the Inquiry’s hearings, focusing on the industry’s innovation, adaptiveness and support for technology. Submissions to the committee highlighted the Australian cotton industry’s international recognition as innovative and dynamic, largely due to industry investment in RD&E.

CRDC research published in leading journals

CRDC-supported research is achieving worldwide recognition with publication in high-impact international journals. The CRDC-supported project to evaluate the extent of hydraulic connectivity between the Condamine Alluvium, the Great Artesian Basin and the Walloon Coal Measures, led by UNSW researcher Dr Bryce Kelly, was published in *Nature Scientific Reports* and has ranked in the top three per cent of research articles published worldwide. Additionally, CSIRO’s Dr Nancy Shellhorn and Dr Vesna Gagic’s paper on ecosystem services was published in *Trends in Ecology and Evolution*, the international ecology journal.
Executive Summary
2015–16 INVESTMENT AND IMPACT

THE AUSTRALIAN COTTON INDUSTRY IN 2015-16:

- **2.5 million bales** produced by the Australian cotton industry
- **Increase of $1200** per hectare profit: the increase achieved by the top 20 per cent of growers against the five-year average (source: Australian Cotton Comparative Analysis 2015)

CRDC’S INVESTMENT IN 2015-16:

- **$21 million**: CRDC’s investment in cotton RD&E on behalf of cotton growers and the Government
- 290 RD&E projects
- 92 research partners
- 5 key program areas: farmers, industry, customers, people and performance

CRDC’S IMPACT IN 2015-16:

- **3.1% average** growth in yield per hectare: the estimated increase in productivity each year since 2013. CRDC’s goal is 3 per cent per hectare per annum.
- 95% of participants in the 2015 Irrigation Automation Tour said they would do something differently on their farm as a result of the tour.
- 73% of attendees at the 2016 Nutrition Researchers Tour said they were likely to adopt new practices around irrigation deficits and nitrogen rates to improve crop gross margins as a result of the tour.
World-leading research

Cotton climate change facility is the first for the cotton industry globally.

First-ever resilience assessment
outlines the cotton industry’s resilience and preparedness.

Cotton in 3D printing
feasibility study outlines five areas for further investigation.

New coating technique developed

to give cotton fabrics added functionality – the ability to regulate moisture, breathability and surface temperature.

The industry’s first Workforce Development Strategy
developed by CRDC and Cotton Australia.

12 years of investment

BY CRDC IN THE ABORIGINAL EMPLOYMENT STRATEGY.

15,000 YouTube views:
achieved by CottonInfo’s 78 CottonInfo best practice videos.

11 grassroots grants:
supported this year, taking the total number since the program commenced in 2011 to 44.

Over 1000 high school and undergraduate students: participated in the cotton industry young professionals program over the course of the program.

70% of growers: estimated to now be participating in myBMP.

1st Cotton RiverCare Champion:
appointed to demonstrate best practice management of riparian areas.

12

1st Cotton RiverCare Champion: appointed to demonstrate best practice management of riparian areas.

1st Cotton RiverCare Champion: appointed to demonstrate best practice management of riparian areas.

14 Researchers
attended the World Cotton Research Conference in Brazil, co-supported by CRDC and the Association of Australian Cotton Scientists.

200 Researchers
attended the Association of Australian Cotton Scientists Conference in September 2015, with CRDC as a foundation sponsor.

89% of growers and 90% of consultants believe CottonInfo has helped to improve practices.
Corporate Operations

Business Financials

Our Investments in RD&E
CRDC’s investment in RD&E is funded through an industry levy and matching Commonwealth contributions. In 2015–16, CRDC invested $21 million in cotton RD&E throughout the industry supply chain. In 2016–17, CRDC estimates cotton RD&E expenditure will be $20 million.

Cotton production for the 2015–16 year is estimated to be 567,500 tonnes or 2.5 million bales of ginned cotton, which is below the previous five-year average of 4.0 million bales. Forward estimates by industry and ABARES are for continued below-average cotton production.

The lower levels of cotton production over the past two seasons has resulted in a decline in revenues. To sustain the current level of RD&E expenditure, CRDC has budgeted to draw on financial reserves.

To achieve the strategic priorities of the 2013–18 R&D Plan, the CRDC is budgeting for $100 million of expenditure during the five-year Strategic Plan.

Revenue
Cotton farmers pay a levy of $2.25 for each 227 kilogram bale of cotton. Cotton levy revenue is collected at the point of ginning, that is, when cotton has been picked and delivered to cotton gins. This occurs from March to September of each calendar year, therefore cotton levy revenue in any financial year is drawn from two consecutive cotton crops.

The Australian Government provides a contribution that matches levy revenue. The maximum contribution is generally capped at 0.5 per cent of a three-year rolling average of gross value of production. Within this cap, the government reimburses up to 50 per cent of the cumulative total eligible expenditure on RD&E.

The setting and collection of the industry levy is enabled by the Primary Industries (Excise) Levies Act 1999 and the Primary Industries Levies and Charges Collection Act 1991 respectively. The Australian Government matching contributions in 2015–16 were capped at the value of levies collected, as it was lower than the 0.5 per cent of the three-year average gross value of production.

### Revenue (actuals) 2015–16 ($m)

<table>
<thead>
<tr>
<th>Revenue Type</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industry levies</td>
<td>6.054</td>
</tr>
<tr>
<td>Australian Government</td>
<td>6.053</td>
</tr>
<tr>
<td>Royalties</td>
<td>0.745</td>
</tr>
<tr>
<td>Interest</td>
<td>1.282</td>
</tr>
<tr>
<td>Research grants</td>
<td>4.127</td>
</tr>
<tr>
<td>Other</td>
<td>0.674</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>18.935</strong></td>
</tr>
</tbody>
</table>

Total revenue for 2015–16 of $18.935 million was $8.079 million (74.4 per cent) above budget of $10.856 million. Total 2015–16 revenue is comprised:

- Industry levy revenue of $6.054 million, which includes $3.176 million (62 per cent) from the 2014–15 crop and $2.878 million (51 per cent) from the 2015–16 estimated crop.
- Australian Government matching contribution of $6.053 million was capped at the value of levies collected.
- $0.745 million in royalties from the sale of CRDC-funded CSIRO seed varieties.
- Interest revenue of $1.282 million was 55.4 per cent above budget, due to the higher level of cash reserves under CRDC management generated by above-budget revenues in the current and prior years.
- External grants of $4.127 million included unbudgeted Rural R&D for Profit $3.522 million, Carbon Farming Initiative $0.300 million, Action on the Ground $0.170 million, Filling the Research Gap $0.050 million, third party project contributions of $0.085 million.
- Other revenue of $0.674 million, which includes project refunds.
Expenditure and investment

Actual expenditure for 2015–16 was $20.555 million, a decrease of $0.024 million over the budgeted expenditure of $20.579 million.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cotton crop size (millions of bales)</td>
<td>5.28</td>
<td>4.49</td>
<td>3.90</td>
<td>2.31</td>
<td>2.50*</td>
</tr>
<tr>
<td>Total Revenue</td>
<td>25.353</td>
<td>30.915</td>
<td>27.479</td>
<td>20.073</td>
<td>18.935</td>
</tr>
<tr>
<td>Royalties</td>
<td>3.145</td>
<td>3.971</td>
<td>1.830</td>
<td>1.707</td>
<td>0.745</td>
</tr>
<tr>
<td>Interest</td>
<td>1.401</td>
<td>1.726</td>
<td>1.779</td>
<td>1.596</td>
<td>1.282</td>
</tr>
<tr>
<td>National Program for Sustainable Irrigation**</td>
<td>1.293</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Research grants</td>
<td>0.426</td>
<td>1.356</td>
<td>1.243</td>
<td>0.925</td>
<td>4.127</td>
</tr>
<tr>
<td>Other***</td>
<td>0.027</td>
<td>0.538</td>
<td>0.411</td>
<td>1.252</td>
<td>0.674</td>
</tr>
<tr>
<td>Cotton RD&amp;E activities</td>
<td>10.682</td>
<td>15.632</td>
<td>18.203</td>
<td>19.244</td>
<td>17.052</td>
</tr>
<tr>
<td>Total equity position</td>
<td>27.317</td>
<td>38.931</td>
<td>44.488</td>
<td>41.645</td>
<td>40.025</td>
</tr>
</tbody>
</table>

* ABARES estimate, Agricultural Commodities March 2016.
** The National Program for Sustainable Irrigation (NPSI) concluded 30 June 2012.
*** Includes project refunds.

Cost Allocation Policy

CRDC has a Cost Allocation Policy for allocating direct and indirect costs to activities across its program. Expenditure in 2015–16 was allocated to the following activities:

<table>
<thead>
<tr>
<th>Cost allocation activity</th>
<th>2015–16</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct R&amp;D expenditure (project costs)</td>
<td>$15,829,535</td>
</tr>
<tr>
<td>Indirect R&amp;D expenditure (administration costs)</td>
<td>$3,503,525</td>
</tr>
<tr>
<td>Grant-funded expenditure (R&amp;D not eligible for Commonwealth Matching)</td>
<td>$1,222,075</td>
</tr>
<tr>
<td>Total expenditure</td>
<td>$20,555,135</td>
</tr>
</tbody>
</table>

Portfolio Budget Statement

Outcomes and outputs 2015–16

CRDC has one government outcome: Adoption of innovation that leads to increased productivity, competitiveness and environmental sustainability through investment in research and development that benefits the Australian cotton industry and the wider community.

<table>
<thead>
<tr>
<th>Outcome</th>
<th>2015–16</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOTAL budgeted revenue</td>
<td>$10,856,000</td>
</tr>
<tr>
<td>TOTAL actual revenue</td>
<td>$18,935,202</td>
</tr>
<tr>
<td>TOTAL budgeted cost of outputs</td>
<td>$20,579,000</td>
</tr>
<tr>
<td>TOTAL actual cost of outputs*</td>
<td>$20,555,135</td>
</tr>
</tbody>
</table>

*Total cost is shown rather than total price because CRDC is primarily funded through industry levies rather than on the basis of the price of its outputs. Each research project and its funding contributes to the outcome. Total research expenditure for the outcome is calculated, with the remaining expenditure attributed to the outcome on a pro rata basis.

The variation between the budgeted and the actual revenue of $8.079 million is a result of the 2015–16 crop being 0.5 million bales above budgeted crop of 2.0 million bales. The larger crop has provided additional levies, Commonwealth contributions and royalties of $3.745 million. In addition, CRDC had an increase in research grants of $3.554 million, interest revenue, project refunds, and other income of $0.780 million.

Forecast revenue

Future revenue from levies, Commonwealth-matching contributions and royalties are directly impacted by cotton production. Water availability and commodity prices are significant factors in forthcoming cropping decisions. ABARES June 2016 Agricultural Commodities report estimated the average storage level of public irrigation dams serving the Australian cotton growing region was 31 per cent of capacity in June 2016, down from 35 per cent at the same time in 2015 but still above the 10-year average of 28 per cent.

Seasonal inflows into the main cotton irrigation dams can be expected before November 2016. Similarly, soil moisture profiles have improved, which may increase the planting of rain-grown cotton.

CRDC has budgeted for a $7.228 million operating deficit for 2016–17. This reflects revenue of $13.173 million and expenditure of $20.401 million. Industry levy revenue and Commonwealth contributions will continue to be drawn from two crop seasons, 2015–16 and 2016–17.

The size of industry levies and Commonwealth contributions is heavily reliant upon crop production, which is budgeted to be 2.5 million bales for 2016–17. CRDC expects that the Australian Government matching contributions will be based on matching industry levy revenue in 2016–17.

Forecast expenditure

Budgeted expenditure for 2016–17 is $20.401 million, a decrease of $0.154 million below the 2015–16 actual expenditure. The forecast expenditure for the next two years for RD&E is budgeted at $17.916 million in 2017–18 and $14.974 million in 2018–19.

Forecast deficits

CRDC is a statutory body enabled by the PIRD Act with the rights of a body corporate and has the right to retain surplus funds. However, as a corporate Commonwealth entity, CRDC must seek approval from the Minister of Finance for a deficit in any year. CRDC has sought and received approval for deficits of $7.228 million in 2016–17 and $4.118 million in 2017–18.
CRDC used the Strategic R&D Plan 2013–18 to guide its program investments in 2015–16. The plan was developed with extensive industry, government and stakeholder consultation and was evaluated in the preparation of the Annual Operational Plan 2015–16.

CRDC's investments addressed the Australian Government priorities (the Science and Research Priorities and the Rural RD&E Priorities), the cotton industry priorities and the collective Cotton Sector RD&E Strategy.

As established in the Strategic R&D Plan, the CRDC actively seeks to achieve a balanced RD&E portfolio that considers the distribution of investment across:

- The RD&E strategies.
- The type of research, including basic, applied, blue-sky, development and delivery.
- In-project risks.
- Researcher experience and capacity.
- Research providers.
- Timeframe to outcomes.
- The likely return on investment for projects and programs.
- R&D management.

The portfolio includes RD&E that seeks to 'protect and defend' the production base from pest threats; increase productivity while ensuring resource-use efficiency; enhance product value through the supply chain; build a capable industry; and create an element of research discovery.

CRDC invests in applied RD&E that improves productivity, biosecurity, and natural resource management, and manages climate variability concurrently given the interrelationships between the issues.
Projects by CRDC program area:

<table>
<thead>
<tr>
<th>CRDC program</th>
<th>Farmers</th>
<th>Industry</th>
<th>Customers</th>
<th>People</th>
<th>Performance</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of projects</td>
<td>98</td>
<td>42</td>
<td>25</td>
<td>111</td>
<td>14</td>
<td>290</td>
</tr>
<tr>
<td>Program expenditure ($m)*</td>
<td>9.4</td>
<td>3.6</td>
<td>2.0</td>
<td>1.5</td>
<td>0.5</td>
<td>17</td>
</tr>
<tr>
<td>Program percentage (of expenditure)</td>
<td>55%</td>
<td>21%</td>
<td>12%</td>
<td>9%</td>
<td>3%</td>
<td>100%</td>
</tr>
</tbody>
</table>

* Excludes budgeted employee and supplier expenditure, contingency provisions for research and corporate research activities that support R&D planning and adoption. Some percentages have been rounded up or down.

Total number of CRDC projects:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Active projects</td>
<td>42</td>
<td>50</td>
<td>61</td>
<td>118</td>
<td>150</td>
</tr>
<tr>
<td>New projects funded</td>
<td>125</td>
<td>153</td>
<td>142</td>
<td>162</td>
<td>141</td>
</tr>
<tr>
<td>Projects completed</td>
<td>117</td>
<td>142</td>
<td>85</td>
<td>130</td>
<td>136</td>
</tr>
<tr>
<td>Continuing projects</td>
<td>50</td>
<td>61</td>
<td>118</td>
<td>150</td>
<td>155</td>
</tr>
</tbody>
</table>
RD&E Portfolio

Program 1: Farmers
Program 2: Industry
Program 3: Customers
Program 4: People
Program 5: Performance
## Program 1: Farmers

<table>
<thead>
<tr>
<th>Program</th>
<th>Farmers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outcome</td>
<td>Cotton is profitable and consistently farmers’ crop of choice.</td>
</tr>
<tr>
<td>Measure</td>
<td>Farmers increase productivity by three per cent per hectare per year.</td>
</tr>
</tbody>
</table>

### Theme

<table>
<thead>
<tr>
<th>1.1 Successful Crop Protection</th>
<th>1.2 Productive Resource Efficiencies</th>
<th>1.3 Profitable Futures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cotton crops protected from pest, weed and disease threats.</td>
<td>Inputs for cotton production are optimised.</td>
<td>Innovations in cotton production.</td>
</tr>
</tbody>
</table>

#### Will be achieved by

<table>
<thead>
<tr>
<th>1.1.1 Monitoring and investigating the ecological behaviours and responses of cotton pest, weeds and diseases.</th>
<th>1.2.1 Delivering benchmarks of on-farm resource-use efficiencies.</th>
<th>1.3.1 Investigating the application of new technologies and different scientific approaches which have the potential to deliver significant improvements and economic returns to the cotton farming system.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1.2 Testing practices that deliver improved management of insect pests, weeds and diseases.</td>
<td>1.2.2 Developing and proving decision systems and practices that deliver optimal resource efficiencies on cotton farms.</td>
<td>1.2.3 Developing new systems and tools to support farm decision-making processes.</td>
</tr>
<tr>
<td>1.1.3 Improving capacity, knowledge and adoption of techniques to successfully protect the cotton crop.</td>
<td>1.2.4 Improving capacity, knowledge and adoption of techniques to optimise resource uses.</td>
<td></td>
</tr>
</tbody>
</table>

#### Measure of success

- Farmers are able to improve their crop management practices based on sound science:
  - 85 per cent of farmers adopting improved practices that reduce the reliance on pesticide inputs.
  - 50 per cent of farmers adopting improved practices that reduce the incidence of insect pests, weeds and diseases affecting cotton on their farm.
  - World-class science foundations for managing ecological adaptations in cotton insect pests, weeds and diseases.

- Farmers are able to increase their productivity:
  - per hectare of land.
  - per unit of nitrogen fertiliser.
  - per ML water.
  - per unit of CO₂ equivalent emitted.

- Farmers are profitable:
  - Improving gross margins for Australian cotton production systems.
  - On-farm innovations and partnerships established to drive profitability.
A collaborative project involving researchers, extension officers and cotton growers is helping to identify and tackle disease in northern NSW through on-farm trials.

The CRDC-supported trials, which are being conducted by QDAF Senior Plant Pathologist Dr Linda Smith and CottonInfo’s Regional Extension Officer for the Namoi Geoff Hunter, build on the disease surveys conducted through the Diseases of Cotton XI and the Fusarium wilt management in cotton projects.

The surveys have identified Verticillium wilt as a major issue in the Upper and Lower Namoi and Gwydir Valleys, and the trials aim to help researchers and growers better understand, diagnose and manage the disease.

Six growers who have been heavily affected by Verticillium are actively involved in the trials, across six sites at Wee Waa, Narrabri, Boggabri and Moree.

The three-year trials involve different rotation crops for cotton, to field test the understanding of the Verticillium pathogens, their inoculation levels and hosts, and the impact of nutrition and soil on the disease.

‘Verticillium is costing us in terms of both yield and dollars,’ says Boggabri cotton grower Andrew Watson—one of the six growers participating in the trials.

‘These trials will provide critical information to me, the researchers and importantly, other growers, about how to best manage vert. Being involved in a trial is significant in terms of both time and money. I have estimated that my direct costs and my opportunity costs, in terms of a crop I could have grown on the 18 hectares I have dedicated to this trial, equal around $11,000 per annum.

‘But these costs are far outweighed by the knowledge I will gain from these trials—the knowledge is far more valuable to me,’ Andrew said.
**Key program investments**

This section provides a snapshot of some of CRDC’s investments during 2015–16 in this program area. The full list of CRDC’s investments for this period can be found at Appendix 4: the RD&E portfolio.

**Successful Crop Protection:**

- Monitoring and investigating the ecological behaviours and responses of cotton pest, weeds and diseases;
- Testing practices that deliver improved management of insect pests, weeds and diseases;
- Improving capacity, knowledge and adoption of techniques to successfully protect the cotton crop.

Significant advancements have been made in protecting cotton from insect pests, weeds and diseases, but new threats and challenges continue to emerge. The RD&E focus is on developing strategies and practices that support farmers in addressing these challenges.

CRDC’s 2015–16 investment in this area included the following projects:

- **Identification of beneficials attacking silverleaf whitefly and green vegetable bug**, with CSIRO;
- **Diseases of Cotton XI**, with NSW DPI;
- **Fusarium wilt management in cotton**, with QDAF;
- **Multiple host use and gene-flow in green vegetable bug relative to cotton crop** (PhD project), with UQ;
- **Quantifying and mapping the impacts of herbicide drift on cotton (non-target crop)** (PhD project), with USQ; and
- **Regional weed management workshops for growers and advisors**, with ICAN.

The **Identification of beneficials attacking silverleaf whitefly and green vegetable bug** project aims to identify the key predators of silverleaf whitefly and green vegetable bug in cotton systems. This information will allow more-targeted sampling for these species and the development of guidelines for their conservation within the crop.

Further, it provides the basis from which to develop further studies of beneficials focusing on species that are likely to have greatest impact.

The project has developed and used molecular techniques to identify predators, enabling the regular sampling of a range of predatory species through the season, quantifying the abundance of the prey and predators, and conducting analysis of the collected predators to determine if they contain DNA from either silverleaf whitefly or green vegetable bug. Testing of potential predator species is underway with several thousand samples processed. The results to date highlight the importance of early season predators for suppression of silverleaf whitefly populations. The project is due for completion in 2016–17.

The **Diseases of Cotton XI** project and the **Fusarium wilt management in cotton** project provided pathology diagnostic services, biosecurity preparedness and surveillance capacity for the cotton industry. These projects collaborated to conduct annual disease surveillance on commercial cotton farms, recording the presence or absence of exotic cotton diseases, as well as recording the incidence and severity of endemic disease and other pathology-related issues. While both of these projects concluded in 2015–16, CRDC will continue to invest in this important area of research from 2016–17.

The **Multiple host use and gene-flow in green vegetable bug relative to cotton crop** PhD project focuses on green vegetable bug (**Nezara viridula**), which has re-emerged as a cotton pest with the adoption of Bt cotton varieties. This project aims to investigate the genetic origin of **N. viridula**, in order to understand the movement of the bug from different hosts across and between cotton-growing regions. This will allow growers to prioritise weed control before a growing season, and help manage and prepare for outbreaks of green vegetable bug.

Regional variation in the bug may signify the presence of different host-related species (eg. on cotton, variegated thistle). If species limits do exist and are found within green vegetable bug, understanding their differential host use and
potential to interbreed is critical to understanding which crops they will affect, which weeds they are likely to persist on between seasons, which control methods are suitable for them, and how resistance genes spread between populations.

Sampling of *N. viridula* has confirmed that Australian populations originated from two locations, Asia and Europe, with extensive gene-flow between these two lineages of *N. viridula* along the east coast of Australia. However, there are still two genetically distinct populations of *N. viridula* in Australia: one along the east coast and one in the Northern Territory and north-eastern Western Australia. Their current independent geographical distributions keep them genetically distinct. The project is due for completion in 2016–17.

The *Quantifying and mapping the impacts of herbicide drift on cotton (non-target crop)* PhD project recognises that quantifying and mapping the impacts of herbicide drift on cotton is important for a number of reasons: cotton crop management, scientific understanding, documenting the damage for loss compensation, and improving environmental management.

As such, this project seeks to understand the responses of cotton plants that are affected by herbicides, and to assess the accuracy of remotely sensed imagery to detect and map herbicide drift damage to cotton crops. The project will develop a framework and a set of procedures or protocols that will optimise the use of sensing technology to assess and monitor herbicide drift damage. The project is due for completion in 2016–17.

The *Regional weed management workshops for growers and advisors* project, which commenced in 2015–16, aims to increase the industry’s capacity to manage weeds in the cotton system, particularly with increasing herbicide resistance and species shift. The project will deliver 21 regionally adapted training workshops for growers and their advisors to address weed-management issues specific to the cotton industry. The workshops will assist participants to identify the risk to the industry and their business from herbicide resistance and/ or species shift. The impact that increasing levels of weed resistance to glyphosate have on cotton farming systems will be a focal issue, with time devoted to the identification and use of strategies to delay or manage the onset of resistance.

The project will also build consultant capacity through three cotton agronomy weed management masterclasses. The project is due for completion in 2016–17.

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**Productive Resource Efficiencies:**

**Developing and proving decision systems and practices that deliver optimal resource efficiencies on cotton farms; Developing new systems and tools to support farm decision-making processes.**

Ensuring growers can achieve optimal resource efficiencies of key input resources is a key focus for the cotton industry’s R&D. CRDC’s investment focuses on developing, identifying and testing decision systems and practices to help growers improve their efficiencies.

CRDC’s 2015–16 investment in this area included the following key projects:

- *Optimising management of manure in southern NSW cotton production*, with CSIRO; and
- *Smarter Irrigation for Profit*, with various research partners, including: National Centre for Engineering in Agriculture (NCEA), Sugar Research Australia (SRA), Gwydir Valley Irrigators Association (GVIA), University of Tasmania (UTAS), CSIRO, NSW DPI, Dairy Australia, Roth Rural and Regional, and the Victorian Department of Economic Development, Jobs, Transport and Resources (DEDJTR).

The *Optimising management of manure in southern NSW cotton production* project, which commenced in 2015–16, recognises that manure from local beef and poultry producers in the southern region of NSW is becoming an economical soil amendment and nutrient source option for new cotton producers in the area, and is showing benefits for soil fertility.

Given that the region is still relatively new to cotton production, there is limited research available on
regionally specific nutrient response for less-fertile southern soil types. As such, this project involves three-year replicated cotton field trials on two soil types (vertosol, chromosol) with a range of manure and cotton-trash compost amendment rates, which will be used to evaluate nitrogen balance and nitrogen-use efficiency.

An important outcome from the trials will be the evaluation of manure application as a more rapid method of improving soil fertility. The datasets will provide regionally specific information that can be used to refine existing general manure management guidelines developed for broadacre cereals, which may assist cotton growers to better estimate how manure may be applied to reduce synthetic fertiliser inputs without compromising yield and quality outcomes. The project is due for completion in 2017–18.

The Smarter Irrigation for Profit project, which commenced in 2015–16, is a cross-sectoral project under the Australian Government’s Rural R&D for Profit programme (round one), administered by the Department of Agriculture and Water Resources. It is led by CRDC in conjunction with fellow RDCs, Dairy Australia, RIRDC, Sugar Research Australia and other research partners.

The project is a large-scale, ambitious project designed to achieve a 10–20 per cent improvement in water productivity, efficiency and farmer profitability across the cotton, dairy, rice and sugar industries, while also improving cross-sector industry research collaborations. It is designed to increase on-farm profitability by integrating new irrigation scheduling and delivery technologies into good irrigation practice.

The project comprises a series of 11 sub-projects, including cotton-specific projects around irrigation automation, grower-led irrigation systems comparisons, and maximising on-farm irrigation profitability.

One such sub-project, the Irrigation Automation Tour short project, ran during November and December 2015. The tour, hosted by CottonInfo with support from CRDC, took a group of 40 cotton growers, irrigators and consultants from the northern cotton-growing valleys to visit the southern irrigation industry to see surface irrigation automation technologies in action.

The four-day tour covered working irrigation systems across the Goulburn-Murray, Coleambally and Murrumbidgee irrigation areas, including pasture, maize, silage and cotton production systems. The group visited six farms, including cotton, dairy, cropping and sheep; the IREC field station and regional trial site; and irrigation automation retailers Rubicon and Padman Stops, to gain an understanding of alternative irrigation designs and the potential for automation.

Feedback from the tour found that 95 per cent of participants would do something differently on-farm as a result of what they had learnt on the tour.

Strong demand for further irrigation automation information resulted in two related events: a field walk at Wee Waa to showcase irrigation automation in use on a cotton farm; and a replica of the Irrigation Tour hosted by IREC for southern irrigators who couldn’t attend the original event.

For more, see The future of irrigation: automation technology case study.

Productive Resource Efficiencies: Improving capacity, knowledge and adoption of techniques to optimise resource uses.

Ensuring that information on improved resource efficiency is extended to growers is a key focus for the industry’s RD&E effort. CRDC’s 2015–16 investment in this area included the following key projects:

- Carbon farming in the Australian cotton industry, with Jon Welsh; and
- CottonInfo nutrition tour, with Jon Welsh.

The Carbon farming in the Australian cotton industry project, due for completion in 2016–17, is funded under the Australian Government’s Carbon Farming Futures Extension and Outreach program, and administered by the Department of Agriculture and Water Resources.
Case study: The future of irrigation: automation technology

It takes just one person and a mobile phone to fully irrigate a 100-hectare cotton field set up with automated irrigation at Steve Carolan’s property ‘Waverley’ near Wee Waa, North West NSW.

Steve has 2478 hectares of irrigation at ‘Waverley’ with both river and bore allocations.

Last year Steve and farm manager Andrew Greste (pictured) converted 100 hectares from traditional siphons to a fully automated system, consisting of pipes through the bank and a series of gates in the channel-delivery system that can be remotely opened and closed—by mobile phone. Steve says the advantages are labour savings, improved uniformity, and water-use efficiency.

Steve and Andrew first saw the automated configuration at the CRDC-supported CottonInfo 2015 Irrigation Technology Tour at Australian Food and Fibre’s ‘Redmill’ Moree, where CRDC and the National Centre for Engineering in Agriculture were conducting automation trials.

Steve and Andrew were so impressed with the idea of automation that they went home and began to work on converting some of their own fields. They, in turn, hosted a field day with CottonInfo, CRDC and NCEA at ‘Waverley’ in March 2016 to showcase their system.

Steve says ideally he would like to expand the automation system across the whole farm, and while cost is a limiting factor, with the help of the NSW DPI’s Sustaining the Basin Irrigated Farm Modernisation program, further expansion of the system has begun.

CRDC-supported CottonInfo Technical Specialist Janelle Montgomery was the key organiser of the Irrigation Technology Tour, and the specific automated irrigation events at Moree and in Southern NSW that followed, including the 2016 Irrigation Automation Tour.

Janelle says the field days and tours have directly resulted in a number of growers investigating irrigation automation and conducting feasibility trials on their own farms.

The project integrates the latest information on carbon, climate variability and emissions management into the cotton industry’s extension efforts, with the aim of improving resource-use efficiency and reducing land-sector emissions in the cotton industry.

Through the appointment of a carbon technical specialist, Jon Welsh, within the cotton industry’s extension team CottonInfo, the project focuses on:

- increasing the cotton industry’s understanding of emissions reduction possibilities and sequestration; the opportunities, benefits and trade-offs under the Emissions Reduction Fund;
- upskilling cotton and grain industry advisors, extension networks and key influences; and
- consolidating current, cross-sectoral science and providing a clear direction for future research.

Of late, the project has delivered the CottonInfo nutrition tour, Emissions Reduction Fund webinars, energy efficiency workshops, revisions to the myBMP modules for natural assets and energy and input efficiency (underpinned by CRDC-supported research) and extension of these modules to growers, and presentations regarding cotton climate risk management.

Under this project, the CottonInfo technical specialist is also working with an industry economist to conduct economic costings and carbon emissions profiling with growers. For more, see The economic and environmental rewards of solar pumping case study.

The tour took ten leading CRDC-supported industry researchers to growers to present and discuss a range of important cotton nutrition topics, including:

- nutrient budgeting;
- improving nitrogen-use efficiency;
- mineralised nitrogen in-crop;
- nitrogen losses from irrigated cotton;
- phosphorus considerations in irrigated and raingrown cotton;
- soil health and crop rotations; and
- optimising nitrogen and irrigation application and nitrous oxide emissions.

The tour also hosted cotton grower and CRDC-supported Nuffield scholar Nigel Corish, who spoke about putting industry research along with his own into practice on his farm at Goondiwindi.

Some 360 cotton growers and consultants attended the field days, representing approximately 140,000 hectares of irrigation land, providing valuable feedback on nutrition research. The post-event surveys indicated that there was a 35 per cent increase in understanding of soil health and nitrogen-use efficiency, and a 52 per cent increase in understanding of loss pathways and greenhouse gas emissions, among attendees as a result of the field days. In addition, 76 per cent of attendees said that they would consider mineralised nitrogen calculations in more detail when developing their nutrient budgets as a result of the event.
Case study: The economic and environmental rewards of solar pumping

Energy is one of the fastest growing on-farm costs. The CRDC-funded Improving energy efficiency on irrigated cotton farms project, which concluded in 2015, found that the average direct energy cost was $298 per hectare, with diesel counting for at least 85 per cent.

But not for cotton grower Andrew Gill of Narromine.

The installation of a solar-diesel hybrid irrigation bore pump on his Central West NSW farm has led to substantial cuts in fuel costs, greater irrigation efficiencies and a massive reduction in greenhouse gas emissions.

Attracted by the drop in the price of solar panels in recent years and the prospect of the system paying for itself in less than four years, Andrew decided to install a solar-diesel hybrid system at one of the pump sites on his Narromine farm at the end of last year. Andrew said while the environmental achievements were important, the deciding factor was the economic viability of the project that promised a quick return on investment.

The move has cut pumping costs from $76/ML to $41/ML, and slashed diesel use by between 45,000 and 55,000 litres a year. Over 25 years, that equates to a saving of more than 1 million litres of fuel and a reduction of over 3000 tonnes in carbon emissions.

CottonInfo Technical Specialist Jon Welsh and research economist Janine Powell worked through project economics costings and carbon emissions profiling with the Gill family during feasibility as part of the CRDC and Australian Government Carbon farming in the Australian cotton industry project.

The Gills run sheep and cattle, and grow summer and winter dryland and irrigation crops, including 300 hectares of cotton each year. They have no access to river water, only bore water. Their irrigation pumping system has traditionally been run exclusively by diesel pumps.

For the past few years, they have been trying to improve the fuel efficiency of these pumps.

However, with their turbines already operating at peak efficiency, they decided to install the solar-diesel hybrid system at one of their bore sites that provides year-round pumping into a large irrigation reservoir.

Mr Gill’s focus now is on fine-tuning the system and improving its efficiency. He plans to introduce more solar pump stations throughout the farm.

For Andrew’s full case study, please visit: www.cottoninfo.com.au/publication-type/case-studies.
Cotton nutrition remains an important topic for growers and consultants as they strive to realise optimal yields and fibre quality, reduce costs and increase margins.

Too little nutrition will reduce cotton’s yield potential, while too much fertiliser can reduce profitability through increased costs, contamination of groundwater, excessive vegetative growth in the crop, and related insect, disease and harvest problems.

Too much fertiliser—particularly nitrogen (N)—can be lost to the environment in certain climatic conditions. Carefully monitoring soil N stocks is critical for informing fertiliser management decisions to increase yield and reduce the carbon footprint of the fibre.

To share the latest research, CRDC supported the 2016 Cotton Nutrition Tour, hosted by CottonInfo. The tour took 10 CRDC-funded researchers to farms in the Upper Namoi, Macquarie, Southern NSW, Central QLD and Gwydir valleys in February 2016. About 360 growers and consultants attended the event over the five days.

The tour focused on a range of topics, from reducing inputs and improving nitrogen-use efficiency to the role of irrigation, soil health, phosphorus and crop rotations.

Researchers included Dr Oliver Knox and Dr Brendan Griffiths (UNE), Dr Ben MacDonald and Dr Gupta Vadakattu (CSIRO), Dr Graeme Schwenke and Jon Baird (NSW DPI), Dr Chris Dowling (Back Paddock), Dr Dio Antille (USQ) and Dr Francois Visser (UQ).

CRDC and Cotton Australia-supported Nuffield scholar and cotton grower Nigel Corish also joined the tour to share his learnings from Nuffield and how he has put nutrition research to the test on his Goondiwindi farm.

The tour was run with support from UNE, USQ, UQ, CSIRO, NSW DPI, and sponsors Yara, Fertilizer Australia, Koch Fertilizer, SST Software and Incitec Pivot. The Moree event was held in conjunction with the Gwydir Valley Irrigators Association. The tour was also supported by funding from the Australian Government.

PROGRAM 1: FARMERS

Profitable Futures: Investigating the application of new technologies and different scientific approaches which have the potential to deliver significant improvements and economic returns to the cotton farming system.

Cotton growing will continue to evolve. Whether change is driven by productivity constraints, environmental, economic or regulatory factors, the long-term profitability of farmers relies on finding innovation and strategies that allow the cotton farming system to adapt. This theme looks to initiate RD&E efforts to deliver these innovations and build the longer-term profitability of cotton production.

In 2015–16, CRDC’s support for this important research area included the following key projects:

- **Future Farm: Intelligent decisions—improving farmer confidence in targeted N management through automated decisions**, with GRDC;
- **Integrated program to deliver automated, adaptive, precision irrigation system**, with USQ;
- **National regulatory framework governing big data in primary production** (PhD project), with UNE.

The Future Farm: Intelligent decisions—improving farmer confidence in targeted N management through automated decisions project, which commenced in 2015–16, is a joint collaboration between GRDC and CRDC. Collectively, the organisations have been focusing on the challenges of increasing cotton and grain profitability and by optimising the use of inputs, enabling new farming practices and the automation of routine decision and implementation processes.

As part of the analysis, both industries have identified that further improvement in the nitrogen (N) application process is required to better manage the crop canopy at the within-field scale to optimise the use of available soil water, increase N-use efficiency, and maximise product yield and quality.

The project recognises that one effective way of optimising N use is to use the tools of precision agriculture to deliver on the 4 Rs—putting the right amount of the right product in the right place at the right time. However, such strategies can require a substantial investment in time spent processing and analysing data, and may require several steps that are not necessarily well integrated, while farmer confidence in these tools as decision aids is low given some of the assumptions that underpin them. This project will therefore re-examine and improve the way in which soil and crop sensors are used to inform decisions about N management, and to provide a way of automating the process from data acquisition, through analysis, to the formulation and implementation of decision options. This project is due for completion in 2017–18.

The Integrated program to deliver automated, adaptive, precision irrigation system project, which commenced in 2015–16, fits within the wider Smarter Irrigation for Profit project, outlined above. The aim of this sub-project is the delivery of a smart, automated precision irrigation management system, tested and validated at the field scale, and demonstrated to growers and potential commercial providers to encourage future industry adoption.

This project will deliver, demonstrate and evaluate smart automated, precision irrigation systems for the cotton (pivot and furrow), dairy (centre pivot) and sugar (furrow) industries. The prototype surface and overhead systems will be developed in close consultation with irrigators, technology suppliers and commercial suppliers, providing opportunities to develop a pathway for future commercialisation.

This project goes beyond the singular development of a novel technology, experimental trials of a particular crop trait, or simple collation of information from different monitoring technologies. Instead, the work focuses on the integration of a wide range of new and proven individual technologies that can monitor and interpret crop production response to irrigation, and manage all aspects of the irrigation
system—hence its fit within the Cotton Futures’ Profitable futures theme. This project is due for completion in 2019–20.

The National regulatory framework governing big data in primary production project, which commenced in 2015–16, recognises that primary industry production now requires a significant increase in the use of data, but that little governance exists concerning how such data is generated, gathered, managed, analysed, accessed, and distributed. The lack of a national framework or code of practice concerning data used in primary production, combined with the economic benefit accruing to entities involved in the value chain, implies a gap in the precision agriculture infrastructure being developed to enhance farm-level decision making.

As such, this project intends to develop a model identifying systems of governance, and advance an approach for better management of primary production data. This PhD project aims to investigate these questions: How might an integrated model consisting of the production value chains described by data inputs for primary industries describe a national regulatory framework for big data?; How might the regulatory framework be constructed and implemented in Australia?; and How would this ensure productivity gains and reduction in production costs for food and income security? The project is due for completion in 2019–20.
### Program 2: Industry

<table>
<thead>
<tr>
<th>Program</th>
<th>Industry</th>
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<tbody>
<tr>
<td>Outcome</td>
<td>The Australian cotton industry is the global leader in sustainable agriculture.</td>
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<tr>
<td>Measure</td>
<td>Industry can report against recognised sustainability indicators.</td>
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#### Theme 2.1 Respected Stewardship

- 2.1.1 Monitoring for and investigating changes in pest and weed susceptibility to biotechnologies and crop-protection products used by the cotton industry.
- 2.1.2 Exploring tactics and strategies that lower the risks of pesticides to the environment and resistance evolution in populations of key insect pests and weeds.
- 2.1.3 Developing and supporting the industry's capacity to effectively steward key technologies and products.
- 2.1.4 Supporting the industry's preparedness and ability to deal with biosecurity threats.

#### Theme 2.2 Responsible Landscape Management

- 2.2.1 Defining the values and drivers relating to the management of natural landscapes and systems in cotton-growing regions.
- 2.2.2 Recording and demonstrating improved environmental performance of the cotton industry.
- 2.2.3 Identifying and proving integrated management strategies which deliver environmental and productivity gains.
- 2.2.4 Researching the connectivity between cotton farms and natural systems in the landscape.
- 2.2.5 Supporting initiatives and partnerships to improve the knowledge and capacity to manage natural landscapes and systems in cotton regions.

#### Theme 2.3 Sustainable Futures

- 2.3.1 Scoping and investigating critical threats and opportunities which may influence the long-term sustainability of the Australian cotton industry.
- 2.3.2 Supporting innovative approaches to solve traditional industry issues and drive future sustainability.

### Strategy Outcomes

- Industry protects its production technologies and its biosecurity.
- Industry leads in managing natural assets.
- An industry achieving its vision.
## Program 2: Industry

<table>
<thead>
<tr>
<th>Measure of success</th>
<th>Industry is able to maintain its access to, and the effectiveness of, biotechnologies and crop protection products.</th>
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<tbody>
<tr>
<td></td>
<td>- 100 per cent of cotton farmers are aware of the underlying risks of trait and agricultural chemical resistance.</td>
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<td>- 100 per cent of insecticide use decisions are consistent with the Insecticide Resistance Management Strategy (IRMS).</td>
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<td>- The cotton industry has the necessary science to provide informed input into the development of resistance management plans for biotech traits.</td>
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<td></td>
<td>- The cotton industry demonstrates pesticide management practices that lower the risks posed to the environment and the evolution of resistance in target insect pest and weed populations.</td>
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<tr>
<td>Industry is capable of managing its biosecurity responsibilities.</td>
<td>- The cotton industry is able to meets its biosecurity obligations.</td>
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<td></td>
<td>- The cotton industry is prepared to effectively respond to biosecurity incursions.</td>
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<tr>
<td>Industry participation in the collective management of natural landscapes.</td>
<td>- Regional delivery partnerships for every major cotton-growing region.</td>
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<td>- Industry recognised for its leadership in environmental performance.</td>
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<td>- Recognition by national and global initiatives for biodiversity management.</td>
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<td>- 1000 km of riparian lands managed under best practice.</td>
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<td></td>
<td>- One million hectares of floodplain vegetation managed under best practice.</td>
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<tr>
<td>Industry contributes to the improvement of landscape systems knowledge and science.</td>
<td>- A comprehensive database documenting the extent and condition of the natural assets the industry utilises and manages.</td>
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<td></td>
<td>- Two national science-based collaborations for the industry to inform surface and groundwater management.</td>
</tr>
<tr>
<td>Industry is capable of leading and adapting to change.</td>
<td>- Innovations and partnerships established to drive cotton industry sustainability.</td>
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Key program investments

This section provides a snapshot of some of CRDC's investments during 2015–16 in this program area. The full list of CRDC's investments for this period can be found at Appendix 4: the RD&E portfolio.

Respected Stewardship:

Monitoring for and investigating changes in pest and weed susceptibility to biotechnologies and crop-protection products used by the cotton industry;

Exploring tactics and strategies that lower the risks of pesticides to the environment and resistance evolution in populations of key insect pests and weeds.

Stewardship refers to protecting the long-term effectiveness of the chemicals and technology used to control pests and weeds in the Australian cotton industry. Resistance is an outcome of exposing pest or weed populations to a strong selection pressure, such as an insecticide or herbicide. Genes for resistance naturally occur at low frequencies in most populations.

Once a selection pressure is applied, such as an insecticide or from a biotechnology trait, resistance genes can increase in frequency because resistant individuals are more likely to survive and produce offspring. If selection continues, the proportion of resistant individuals may increase in the population until reduced effectiveness of the toxin is observed in the field.

Ensuring that key insect pests and weeds do not become resistant to biotechnology or crop-protection products is of critical importance to the industry.

In 2015–16, CRDC continued its support of this important research area through key projects, including:

- Can genetic diversity predict the potential for emergent glyphosate resistance? with the University of QLD;
- Economic risk assessment of resistance management strategies for Bt cotton, with CSIRO;
- Managing Bt resistance and induced tolerance in Bollgard 3® using refuge crops, with CSIRO; and
- Silverleaf whitefly resistance monitoring 2013-16, with QDAF.

The Can genetic diversity predict the potential for emergent glyphosate resistance? project, which concluded in 2015–16, aimed to increase genetic understanding of targeted weed species, particularly the potential risk of cross-resistance.

Resistance to herbicides can happen by changes to the target gene (target site resistance) or other genetic changes (non-target site resistance, or NTSR). NTSR is particularly difficult to decipher as it is usually polygenic and can be constitutive, stress-induced, or possibly both. Cross-resistance between different herbicide groups is not possible with target site resistance; however, since NTSR is the result of both regulatory processes (signal production, reception, and response) and protective processes of several kinds, they have the potential to interact together and accumulate, and possibly provide resistance across herbicide groups.

This project examined four weed species from cotton-growing regions: Feathertop Rhodes grass, fleabane, barnyard grass and windmill grass. The project found that the only species (of those investigated) that had a fixed target site mutation was Feathertop Rhodes grass. Fleabane, barnyard grass and windmill grass all have glyphosate resistance by NTSR mechanisms.

The genomic data generated during this project is now being used in the Staying ahead of weed evolution in changing cotton systems project (under the Farmers program area) to help address the issue of glyphosate resistance. For more on this project, download the full final report from CRDC's online library of final reports at Inside Cotton: www.insidecotton.com.

The Economic risk assessment of resistance management strategies for Bt cotton project, which concluded in 2015–16, aimed to inform the cotton industry about the economic benefits of developing resistance management plans (RMPs), and to improve the capacity of the cotton industry to base resistance management strategies/plans on
rigorous analysis of the relative effectiveness, costs, and economic risks of the options available.

Evaluating an RMP for Bt cotton involves comparing the costs to landholders today (e.g., from refuge crops, planting windows, pupae busting) with uncertain future benefits from delayed resistance (e.g., reduced cost of spraying, loss of yield, health and wellbeing benefits to farmers and communities). The project developed a model that provides a basis for detailed analysis and effective communication of the value of the RMP.

The Managing Bt resistance and induced tolerance in Bollgard 3® using refuge crops project, which commenced in 2015–16, aims to improve the ability of refuges to counter the threat of resistance. This project builds on previous CRDC-supported research, which found unexpectedly high numbers of Helicoverpa moths emerging from Bt cotton fields, suggesting that about half the moths emerging from the cotton/refuge system could be originating from Bt cotton.

Comparing the number of moths emerging from Bt cotton to those emerging from structured and unstructured refuges (unstructured refuges are non-mandatory refuges, including natural systems and other crops), will improve the estimates of the proportion of Helicoverpa in cotton ecosystems exposed to Bt toxins. This will provide the industry with an understanding as to how well refuges, both mandatory and unstructured, are working in practice to dilute any resistant individuals that may emerge from Bt crops. The project is due for completion in 2017–18.

The Silverleaf whitefly resistance monitoring 2013–16 project aimed to provide early and rapid detection of resistance in silverleaf whitefly from Australian cotton fields while still at low frequencies. This would allow the industry to take corrective management actions before levels become problematic for control, and help maintain the industry’s reputation as a producer of high-quality fibre. This project has identified early indications of resistance to one of the cornerstone silverleaf whitefly products, Pyriproxyfen, and provided recommendations to industry for the 2016–17 Insecticide Resistance Management Strategy (IRMS).

This project concluded in 2015–16, however another project, Monitoring silverleaf whitefly insecticide resistance, commences in 2016–17 with the same aim and lead researcher.

Respected Stewardship: Supporting the industry’s preparedness and ability to deal with biosecurity threats.

Biosecurity plays a critically important role in ensuring the sustainability of the Australian cotton industry—managing the risk of pests and diseases entering, emerging, establishing or spreading to avoid production losses, management and eradication costs, and potentially the loss of important overseas markets.

CRDC’s 2015–16 investment in the area of biosecurity included these key projects:

- Plant Biosecurity RD&E Strategy, with Plant Health Australia; and
- Surveillance and studies for endemic and exotic virus diseases of cotton, with QDAF.

The Plant Biosecurity RD&E Strategy is a component of the National Primary Industries RD&E Framework, an initiative of the Standing Committee on Primary Industries (SCoPI). The Strategy is a cross-sectoral strategy that establishes the future direction for improving biosecurity RD&E for Australia’s plant industries. CRDC and the other RDCs help to co-fund the strategy, as an important collaborative effort to ensure Australia has world-leading science-based systems and capability for safeguarding our plant sector, including cotton, from biosecurity threats.

The Surveillance and studies for endemic and exotic virus diseases of cotton project, which commenced in 2015–16, focuses on viral diseases that are serious biosecurity and economic threats to Australian cotton, including cotton leaf curl disease, cotton leaf roll dwarf virus (causing cotton blue disease) and cotton leaf crumple virus.
The project aims to enhance and support the sustainability of the Australian cotton industry by providing continued capacity in plant virology expertise and diagnostics, building industry awareness of viral disease threats, and developing preparedness for viral diseases that pose serious biosecurity threats to the Australian cotton industry.

Under the project, researchers conduct surveillance and provide diagnostic support as required for endemic and exotic viral diseases of cotton in order to help protect and support a sustainable Australian cotton industry. This project collaborates closely with the Northern Australian Quarantine Strategy, participating in surveillance and monitoring activities in neighbouring countries for early signs of targeted viruses. Regular surveillance provides valuable information on the seasonal distribution and damage caused by the endemic cotton bunchy top disease and tobacco streak virus.

**Responsible Landscape Management:**
Defining the values and drivers relating to the management of natural landscapes and systems in cotton-growing regions.

The Australian cotton industry recognises the need for sustainable and responsible landscape management, and over the past decade has made significant gains in improving its environmental management. Industry research has shown the mutual benefits that can be gained from managing natural assets for both production and environmental outcomes.

CRDC’s 2015–16 investment in this area includes the following key project:

- **Critical thresholds for riparian vegetation regeneration in the northern Murray-Darling Basin,** with Griffith University.

This project, which concluded in 2015–16, aimed to address major knowledge gaps concerning the dynamics and resilience of riparian vegetation in cotton-growing catchments of the northern Murray-Darling Basin. The project sought to predict the outcome on riparian vegetation in this region of various land and water management and climate scenarios, and to identify robust management interventions for maintaining biodiversity and key ecosystem functions and services.

The project has found that canopy cover and litter loads are particularly significant drivers of riparian vegetation dynamics at local scales, and that consequently, any land management activities that affect these, including clearing and grazing, have the potential to impair vegetation regeneration.

Conversely, these findings demonstrate that managing riparian lands under best practice makes an important contribution to the conservation of natural assets on cotton farms. The findings are important because they may inform future natural resource management positions.

For more information on the project, see the Revealing riparian value case study.
Australia’s inland riverine and floodplain environments are among the most variable, unpredictable and dynamic ecosystems on the planet, says cotton industry researcher Dr Sam Capon.

‘There are areas of amazing natural vegetation on cotton farms, especially in their riparian zones. We found more than 200 plant species in studies in the central and northern regions of the Murray–Darling Basin. This incredible biodiversity makes riparian zones the most important part of these landscapes,’ said Sam.

As a Research Fellow at Griffith University’s Australian Rivers Institute, Sam undertook a riparian regeneration research project with support from CRDC. The research sought to inform best practice for managing riparian lands on farms in the northern Murray–Darling Basin’s cotton-growing regions, and she says each region has specific characteristics and needs.

She believes good management of riparian lands has important benefits for the health of vegetation (particularly tall eucalypt species like the river red gums, along the river banks on cotton farms in the northern Murray–Darling Basin), and that riparian vegetation also plays a really important role in terms of its ecological function in providing habitat for animals, its effect on nutrient cycling and water filtration.

Sam’s parents were teachers, and most of her earlier life was spent on Queensland’s eastern seaboard, which could be considered one of the most desirable places in the country. However, these days Sam has found what she describes as the most amazing ecosystems in these riparian zones and floodplains of arid and semi-arid Australia. Her admiration for these systems began in earnest while she worked along one of the most famous rivers in Australia, Coopers Creek—infamous as the site of the death of the explorers Burke and Wills in 1861.

At 1300 kilometres, the Cooper is the second longest inland river system in Australia after the Murray–Darling system.

While studying for her Honours degree, Sam took her first trip west to Coopers Creek, and was surprised by how stunningly beautiful and welcoming the landscape was. She continues to be fascinated by the resilience of the floodplain landscapes and their ecology, particularly how they can cope with long periods of drought then severe flooding, and their ability to survive and regenerate.

The resilience and toughness of floodplains and their riparian zones—identifying the vulnerable elements in these systems and how best to maintain them—formed the basis of Sam’s PhD study. Having been involved in community engagement, Sam had found landholders to be very aware of their environments. With this in mind and to harness this knowledge, Sam’s project has documented local knowledge of riparian, floodplain and wetland vegetation change, and the major factors driving this change, among farmers of the northern Murray–Darling Basin.

As part of the project, Sam has compiled an oral history of vegetation dynamics and change across the northern Basin by recording stories of local land managers. The information will be used to prepare an oral history document for use in local communities and to inform management agencies with an interest in the region.

For more on this project, see the CottonInfo focus on NRM research fact sheet ‘Riparian vegetation and land management’ at www.cottoninfo.com.au/publications.
PROGRAM 2: INDUSTRY

Responsible Landscape Management: Researching the connectivity between cotton farms and natural systems in the landscape.

The connectivity between cotton farms and the natural landscapes within which they operate is an area that CRDC invests in to help improve the available knowledge and science.

In 2015–16, CRDC’s investment in this area included the following key projects:

- **Quantifying the uncertainty associated with predicting coal seam gas (CSG) production impacts**, with UNSW;
- **Baselining lower Namoi groundwater and evaluating Pilliga coal seam gas developments**, with UNSW; and
- **National facility for cotton climate change research**, with CSIRO.

The **Quantifying the uncertainty associated with predicting coal seam gas (CSG) production impacts** project, which concluded in 2015–16, examined the impact of CSG production in the Surat Basin on groundwater levels in the upper Condamine Alluvium and the eastern portion of the Great Artesian Basin. The research aimed to highlight any potential concerns that would impinge upon the future availability of groundwater to the irrigation sector, and benchmark the groundwater quality, major ion chemistry, and groundwater and air methane concentrations in priority areas in the Condamine Alluvium.

A combination of groundwater and degassing air samples (methane (CH4) concentration and isotopic composition, dissolved organic carbon (DOC) isotopes and tritium (3H) were collected from irrigation bores and government groundwater monitoring boreholes, while a mobile methane survey took continuous air samples in and around areas of agricultural and unconventional gas production.

The study has found that the chemistry of groundwater from irrigation bores throughout the Condamine catchment indicates that recharge to aquifer depths from which groundwater is pumped occurs only following rainfall of at least 400 millimetres per month—yet this occurs on average once every four years. Such rainfall is usually associated with extra-tropical lows in spring and autumn, and the remnants of tropical cyclones in summer. Floodwater is the primary, and in some places only, source of groundwater recharge.

For more on this project, see the CottonInfo focus on NRM research fact sheet ‘Evaluating the extent of hydraulic connectivity’ at www.cottoninfo.com.au/publications.

The **Baselining lower Namoi groundwater and evaluating Pilliga coal seam gas developments** project, which commenced in 2015–16, follows on from the above project.

Under the project, the research team will conduct an extensive study of groundwater conditions throughout the lower Namoi. This project aims to assess the impact of the groundwater sharing plans, provide insights into groundwater recharge pathways and the age of the groundwater being used by irrigators, map connectivity between the Great Artesian Basin and lower Namoi Alluvium, and highlight any risks associated with the expansion of the coal seam gas projects in the Pilliga region. The project is due for completion in 2017–18.

The **National facility for cotton climate change research** project recognises that the increased focus on climate change by government and media has meant that balanced research on the potential impacts of climate change on cotton production in Australia is essential. This project seeks to develop a credible capacity within the industry to investigate the impacts of climate change on cotton production, and therefore evaluate the likely effectiveness of adaptation strategies, such as varietal selection, sowing date, nutritional management, irrigation strategy, and industry expansion.

Under this project, a national facility for cotton climate change research has been co-established by CRDC and CSIRO at the Australian Cotton Research Institute at Narrabri to create new knowledge about the interactive effects of projected climate change.
Over three cotton-growing seasons, researchers are imposing fully irrigated and water-stressed treatments in both high CO₂ and temperature environments similar to those conducted in the glasshouse on individual plants in recent thesis experiments by a CRDC PhD student. Cotton growth, production (yield and quality), and resource-use efficiency (e.g., water and nutrition) are being measured in detail with new in-field poly-tunnels established at ACRI maintaining elevated CO₂, temperature, and variable soil-water availability for research purposes.

For more, see the Leading the world in cotton's future climate studies case study.

Responsible Landscape Management: Supporting initiatives and partnerships to improve the knowledge and capacity to manage natural landscapes and systems in cotton regions.

CRDC also invests in initiatives and partnerships to improve the knowledge and build the capacity of growers and the wider industry in managing natural resources.

Natural resource management (NRM) extension can be challenging: although cotton growers are by their very nature stewards of the land, encouraging interest in NRM can be difficult as it does not have a direct production or profitability correlation. The impact of NRM, of ecosystem services, is not measured in terms of bales per hectare or dollars per megalitre, but rather a holistic improvement in the farm’s natural environment, in carbon sequestration, in green gas emissions, and in natural pest suppression—among other benefits.

As a result, extending this critical topic area to growers, their families and the wider community remains a key priority. CRDC’s investment in this area for 2015–16 included the following key projects:

- National Cotton NRM Technical Specialist, with Stacey Vogel Consulting; and
- National Cotton RiverCare Champion, with Capricorn North Pty Ltd.

The National Cotton NRM Technical Specialist sits with the industry’s extension team, CottonInfo, and provides the technical NRM skills and knowledge required to assist industry to meet CRDC’s NRM goals.

The specialist’s role under this project includes supporting and demonstrating the cotton industry’s best practice management of riparian lands and floodplain vegetation; implementing an innovative approach using social networks to increase the engagement of cotton growers in NRM; and leading the continuous improvement of the industry’s best practice recommendations for NRM. The technical specialist is using innovative and diverse methods to reach the target audience, including the development of an app about birds on cotton farms as a form of pest control.

The National Cotton RiverCare Champion project, which commenced in 2015–16, is managed by the NRM technical specialist and aims to support the responsible management of riverine areas within Australia’s cotton-growing regions. The project recognises that in an increasing environmentally conscious global community, the industry needs to demonstrate its good stewardship of rivers and riparian areas. As such, a cotton grower has been appointed as the Cotton RiverCare Champion to establish a long-term riparian condition-monitoring site on his cotton farm, and demonstrate to cotton growers and the general public how best management practice leads to good condition riparian areas.

For more information on the project and the RiverCare Champion, see the Zoologist-turned-cotton grower case study.
Case study: Leading the world in cotton’s future climate studies

CRDC and CSIRO have jointly invested in a new climate change facility at the Australian Cotton Research Institute.

The climate change facility, established under the CRDC-funded project National facility for cotton climate change research, consists of dedicated in-crop chambers that modify atmospheric carbon dioxide concentration CO₂ and higher temperatures on cotton grown in the field.

A major part of this investment is supporting Katie Broughton (pictured), a postdoctoral fellow in crop physiology to undertake these experiments, a first for the cotton industry globally.

The research continues on from Katie’s PhD studies, also supported by CRDC, to study the physiology and growth of cotton in elevated CO₂ and temperature scenarios.

Now in its second year, the climate change facility project has involved the construction of four chambers that control temperature and CO₂ in a field at ACRI, to replicate potential future scenarios of different CO₂ and temperature levels.

With current CO₂ air levels at around 400 parts per million (ppm), the treatment with the most ‘extreme’ levels is injecting 550 ppm CO₂ into the chamber, and temperature is set to between two and four degrees higher than the ambient temperature compared with the conditions in the control plots outside the chambers. With current rates of CO₂ and warming increases, it is expected that the levels replicated in the trial will be realised in around 30 to 50 years. The effects on the plants are immediately visible, due to their increased growth.

Under the project, Katie is attempting to take the experiment through to yield to ascertain whether the increased growth is translated into higher yields and to quantify the effect on fibre quality.

Previous studies have shown positive effects on yield, but Katie is particularly interested in crop water use. She believes that the larger plants could use more water early in the season, leaving less water for fruit growth: a concern if water is limited.

As a result, once the effects are determined, the researchers will look at management strategies such as irrigation and growth management in next season’s trials, so as to provide key information on how to manage crops in a changing climate.

Case study: Zoologist-turned-cotton grower tracks river health

A zoology degree is not a traditional qualification for a cotton grower, but for Southern QLD grower Mark Palfreyman it provides an ideal grounding for his new role as national Cotton RiverCare Champion.

The CRDC-led Cotton RiverCare Champion project aims to support the responsible management of riverine areas within Australia’s cotton-growing regions.

Under the project, cotton growers and the wider cotton community can follow the progress of Mark and his family as they care for their farm and its natural environment. Mark, his wife Anne and their four children Edward, Finn, Wilson and Elsie (pictured) will be discovering what biodiversity lives on their farm, how their management decisions impact on the condition of their riverine areas, and the benefits healthy riverine areas can provide to their farming business.

Mark’s passion for maintaining healthy ecosystems on his farm and keen interest in native fauna make him the ideal Cotton RiverCare Champion.

Under the program, long-term monitoring sites will be established on the Palfreyman family farm to look at water quality, the condition of native vegetation and the diversity of local fauna.

Water monitoring assessments will be conducted, and photo points established to accurately capture snapshots of riparian conditions over time. Visual and technological assessments of fauna will take place through such methods as sightings, scats, tracks, camera surveillance and burrow monitoring, and an ecologist will perform a microbat and fauna survey.

CRDC-supported CottonInfo Technical Specialist Stacey Vogel says the program provides a unique way for the cotton industry to see first-hand how on-farm best management practice leads to healthy riparian areas.

Results of the project will be shared in real time via social media, including Facebook, Twitter and YouTube.

For more information, and to access the Cotton RiverCare social media accounts, visit www.cottoninfo.com.au/cotton-rivercare.
PROGRAM 2: INDUSTRY

Sustainable Futures: Scoping and investigating critical threats and opportunities that may influence the long-term sustainability of the Australian cotton industry; Supporting innovative approaches to solve traditional industry issues and drive future sustainability.

Agricultural production, including cotton production, is becoming an increasingly complex business. Major uncertainties about global economics and international markets, shifting national policies and social values, demographic changes, competition for key resources, rapid technological change and the impact of an increasingly variable climate dominated by extreme events mean agricultural industries must continually adapt to changing circumstances.

In 2015–16, CRDC invested in the following key project to help scope and investigate critical threats and opportunities:

- Resilience assessment of the Australian cotton industry at multiple scales, with Bel Tempo.

CRDC commissioned the resilience assessment to better understand how to help the cotton industry best adapt to change and to identify critical threats and opportunities in order to strategically target investment and resources. The assessment is structured around three scales of cotton production: the farm, the region, and the whole of industry.

The assessment found that there are five key drivers of change acting across the Australian cotton industry: demand, policy, climate change, climate variability, and cotton price. Potential shocks, which are a sudden spike in one of these drivers, relate to climate change and variability, biosecurity, policy, price and social licence. The report identifies that industry leaders and growers need to be aware of the impact of these drivers, and of the changing nature, frequency or severity of shocks to better prepare and respond to them.

The researchers believe that these drivers and shocks have the potential to push the Australian cotton industry towards identified tipping points, or critical thresholds, which, if crossed, lead to significant changes in system dynamics.

At the farm scale, the critical thresholds identified are water quality and quantity, soil health, farm profitability, and habitat proximity. Network connectivity and function, infrastructure investment, native vegetation cover, water quantity, and land availability are critical thresholds at the regional scale. At the whole-of-industry scale, the critical thresholds are social licence, network connectivity and function, and research and development investment.

The report recommends that national R&D, regional water availability and infrastructure, farm profitability, and farm-water availability thresholds should be the highest priority for interventions from a specified resilience perspective.

The full resilience assessment is available to download from the CRDC website: www.crdc.com.au/publications.
**Program 3: Customers**

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<th>Program</th>
<th>Customers</th>
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<tbody>
<tr>
<td><strong>Outcome</strong></td>
<td>The Australian cotton industry captures the full value of its products.</td>
</tr>
<tr>
<td><strong>Measure</strong></td>
<td>Double the premium for Australian cotton.</td>
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</table>

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<thead>
<tr>
<th>Theme</th>
<th>3.1 Assured Cotton</th>
<th>3.2 Differential Products</th>
<th>3.3 Competitive Futures</th>
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<tbody>
<tr>
<td><strong>Strategy Outcomes</strong></td>
<td>The integrity and qualities of Australian cotton set global benchmarks for customers.</td>
<td>Customers recognise the differentiated value of Australian cotton products.</td>
<td>The demand for Australian cotton products is positively transformed.</td>
</tr>
<tr>
<td><strong>Will be achieved by</strong></td>
<td>3.1.1 Improving Australian fibre quality testing standards and procedures and the capacity to measure and manage contamination. 3.1.2 Supporting the development and implementation of post-farmgate BMPs. 3.1.3 Developing and implementing a standardised reporting system for Australian cotton product quality and traceability. 3.1.4 Benchmarking Australian cotton against key international programs for product stewardship and sustainability.</td>
<td>3.2.1 Identifying opportunities for improvements in fibre quality and cotton products. 3.2.2 Demonstrating the value of different fibre classes and defining fibre quality parameters that secure a premium market. 3.2.3 Developing customer-based partnerships for the development of higher value and novel products, which differentiate Australian cotton.</td>
<td>3.3.1 Investigating existing and future markets for Australian cotton and communicating these findings to the Australian cotton industry. 3.3.2 Facilitating the development of new technologies and systems to improve the competitiveness of Australian cotton.</td>
</tr>
</tbody>
</table>

| Measure of success | Customers have confidence in the integrity of Australian cotton:  - Australia has the best ranking for non-contamination in the International Textile Manufacturers Federation (ITMF) survey.  - Customers recognise and use Australia’s BMP standards as their guarantee of quality assurance.  - Australia uses standardised reporting systems for product quality and traceability for farmers, industry and customers.  - Australia can respond to customer needs for reporting sustainability indicators. | Customers value the qualities of Australian cotton:  - New fibre classification systems established.  - Partnerships established to demonstrate the potential for differentiating Australian cotton. | Customers continue to demand Australian cotton products:  - Provide the Australian cotton industry with knowledge of fabric innovations and future market opportunities.  - Develop alternative and high-value cotton products. |
Key program investments

This section provides a snapshot of some of CRDC’s investments during 2015–16 in this program area. The full list of CRDC’s investments for this period can be found at Appendix 4: the RD&E portfolio.

Assured Cotton: Improving Australian fibre quality testing standards and procedures and the capacity to measure and manage contamination; Benchmarking Australian cotton against key international programs for product stewardship and sustainability.

CRDC’s investment in this area aims to ensure that Australia maintains its global reputation for high-quality cotton, so as to help the industry capture the full value of its products. Programs that help to maintain and improve Australian cotton’s fibre quality, and demonstrate the sustainability, transparency and traceability of the Australian cotton industry, are part of this investment program.

In 2015–16, CRDC continued its support of assured cotton through key projects, including:

- Determining the shelf life of round modules and impact on cotton quality, with CSIRO; and
- A review of emission methodologies for the Australian cotton industry and development of a detailed study for north west NSW, with NSW DPI.

The **Determining the shelf life of round modules and impact on cotton quality** project aims to address fibre quality issues in round modules that could be caused by the storage duration and conditions prior to ginning. There is a concern that the plastic wrap on round modules can create favourable conditions for microbial degradation of the cotton (as a result of solar radiation, the impermeable wrapper, and when the moisture content of the cotton is too high), which can weaken the fibre and cause fibre quality deterioration, resulting in price discounts and yield loss for growers.

As a result, this project aims to establish the threshold of conditions that can cause damage, and propose potential solutions and risk-management guidelines for eliminating and reducing fibre damage during round module storage. Findings of the project to date indicate that the orientation of the module during storage can influence its temperature and moisture levels, and that covering modules with a tarpaulin can significantly reduce temperature and relative humidity fluctuations. The project is due for completion in 2016–17.

The **Review of emission methodologies for the Australian cotton industry and development of a detailed study for north west NSW** project, which concluded in 2015–16, aimed to use a life-cycle assessment to produce a clear picture of the greenhouse gas (GHG) emissions profile for a representative cotton production system in North West NSW.

The project also aimed to identify the most plausible set of emission-reduction opportunities; create a platform to routinely test emission mitigation options or the consequences of new productivity-based technologies; and undertake a sensitivity analysis to check whether the case study region was representative of other regions.

The project found that 1 tonne of cotton lint at port had a carbon dioxide equivalent (CO\textsubscript{2}e) of 1601 kg. The impact of the pre-farm, on-farm and post-farm stages were 407kg CO\textsubscript{2}e; 775 CO\textsubscript{2}e; and 419 CO\textsubscript{2}e respectively. The GHG emission profile of the representative cotton production system indicated that approximately 45 per cent of the total GHG emission was related to the production of nitrogen (N) fertiliser (17 per cent), and the use of fertiliser (28 per cent). The processes of drying seed cotton at the gin, and the ginning process itself, contributed 12 per cent and 9 per cent respectively. Among farming practices, diesel used in farm machinery, and electricity and diesel used in irrigation pumps contributed 8 per cent and 7 per cent of the total GHG emissions.

Six emission-reduction options were developed by the researchers: optimum N application rate; controlled-release and stabilised N fertilisers; solar-powered irrigation pumps; biofuel-powered machinery; legume crops; and fertigation. Once released, the final report will be available from CRDC’s online library at Inside Cotton: www.insidecotton.com.
Differentiated Products:
Identifying opportunities for improvements in fibre quality and cotton products;
Demonstrating the value of different fibre classes and defining fibre quality parameters that secure a premium market;
Developing customer-based partnerships for the development of higher value and novel products, which differentiate Australian cotton.

Australian cotton growers are competing in a complex global market, with challenges coming from both within the global cotton industry (with Australian growers competing against subsidised overseas growers) and the wider global textile industry (where cotton’s market share is diminishing against the ever-growing man-made fibre industry).

As a result, investments in this area look to fully exploit current advantages of Australian cotton, while also opening up other opportunities for Australian cotton to be differentiated on the world market.

In 2015–16, CRDC continued its support of the differentiated products theme through key projects, including:

- **Ever-dry self-cooling cotton fabrics**, with Deakin University;
- **Novel spinning technologies for fine and high-quality Australian cotton yarns**, with Deakin University; and
- **Smart cotton/cotton fabrics for electromagnetic interference shielding**, with Deakin University.

The **Ever-dry self-cooling cotton fabrics** project, which concluded in December 2015, successfully developed a new coating technique that gives cotton fabrics added functionality: the ability to regulate moisture, breathability and surface temperature.

Under the project, the research team developed a technique to give single-layer cotton fabrics ‘ever-dry’ and ‘self-cooling’ properties, which eliminate the wet and clinging feeling of cotton on the skin and ensure that the fabrics maintain their permeability, even at an over-saturated state. This technique has the potential to considerably increase the use of cotton in the next generation of sportswear, summer clothing, defence force uniforms, work wear and functional fabric products for healthcare.

With the project now complete, CRDC is working with the research team on the development of a commercialisation plan for the technology.

The **Novel spinning technologies for fine and high-quality Australian cotton yarns** project is exploring novel spinning technologies to improve the overall quality of yarn made from long-staple Australian cotton. It focuses on ways of making cotton yarns less hairy and more abrasion resistant, to reduce the cost of yarn sizing and improve weaving efficiency. The project aims to increase the demand for Australian cotton and the subsequent premiums offered to growers.

The research undertaken to date has had promising results, with further testing of techniques underway. The project is due for completion in 2016–17.

The **Smart cotton/carbon fabrics for electromagnetic interference shielding** project aims to create a novel type of electromagnetic interference (EMI) shielding cotton fabric that provides protection against electromagnetic radiation, with the additional value of enhanced comfort.

EMI is the name given to unwanted radiated signals that cause unacceptable degradation of systems and equipment and that can impact on human health. Exposure to electromagnetic waves is believed to have effects on immune function and neurological behaviour. As such, researchers and industrial companies have a keen interest in providing solutions to overcome the EMI problem by using advanced textile technology.

The project will use a wrap-spun yarn technique to create new cotton EMI shielding fabrics with carbon fibres as the conductive filament. The lightweight, flexible cotton/carbon technical textiles created with high EMI shielding effectiveness will be ideal for human protection and comfort. Such textiles will have the feel of normal cotton textiles, with the added advantage of providing effective EMI shielding. The project is due for completion in 2017–18. For more on this project, see the Cottoning on to smart fabrics case study.
With developments in computer technology and interactive devices advancing at a breathtaking pace, CRDC is working to position cotton at the forefront of ‘smart fabric’ innovation.

Interactive electronic functionality is set to invade every aspect of our lives, including our wardrobe. Indeed, international research is already underway into shirt pockets that can charge your phone, and the integration of touch screen-style controls in denim jeans.

Unfortunately, the unwanted electromagnetic interference (EMI) emitted from electronic and digital devices, and from cables carrying high-volume electric currents, is an ever-increasing hazard of modern life. Headaches, anxiety, and compromised immune function have all been reported as symptoms associated with the constant bombardment of the human body from electromagnetic signals.

There is now a growing market for ‘functional’ textiles and clothing capable of shielding against harmful electromagnetic radiation. Tapping into this demand, CRDC has launched the Smart cotton/carbon fabrics for electromagnetic interference shielding project to develop a cloth, incorporating cotton fibres, that can protect the wearer against electromagnetic emissions, while also being light weight and comfortable.

Leading the Smart Cotton project is Dr Jin Zhang (pictured), a researcher at Deakin University in Geelong, Victoria, with extensive experience in working with composites and natural fibres for use in automotive and aerospace industries. According to Jin, some manufacturers are already making composite cloths with electromagnetic shielding properties, but they’ve tended to use heavy-metal fibres. She is working on a fabric that combines lightweight carbon fibres with high-quality, long-staple Australian cotton to create a far higher level of comfort for the wearer.

The electrostatic discharge, electromagnetic protection and radio frequency interference protection qualities of carbon fibre, combined with the hypoallergenic, excellent moisture control and comfort characteristics of Australian cotton, will give rise to a new type of shielding fabric.

The Smart Cotton project is targeting the development of a range of ‘electronically functional’ products, such as internal pocket liners designed to protect the wearer against mobile phone radiation. They’re also researching ‘next to skin’ clothing for the maternity market, such as an apron expectant mothers could wear under their clothing to shield their unborn child from the radiation emitted by electronic devices.

Lightweight composite cotton-shielding fabrics could be used in everything from anti-radiation pyjamas and bedding, to curtains, ground sheets and tents.

According to CRDC R&D Manager, Allan Williams, this research project will undoubtedly add value to Australian cotton, given the scope for innovation in the rapidly evolving ‘smart fabric’ field. A report by the Global Industry Analysts (GIA) forecasts the global market for EMI shielding materials and technologies will reach US$7.9 billion by 2020 in a booming worldwide electronics industry.

**Competitive Futures:**
Investigating existing and future markets for Australian cotton and communicating these findings to the Australian cotton industry; Facilitating the development of new technologies and systems to improve the competitiveness of Australian cotton.

Continued innovation is necessary to maintain the competitiveness of Australian cotton in traditional markets, and to open up new market opportunities. Investments in this area, under the CRDC Cotton Futures banner, are designed to transform the way in which consumers demand Australian cotton products, in order to continue to ensure cotton’s competitiveness.

In 2015–16, CRDC’s support for the Competitive futures theme took place through key projects, including:

- Cotton rapid customisation feasibility study, with QUT; and
- Regenerated cotton to carbon fibre, with CSIRO.

The Cotton rapid customisation feasibility study project, which concluded in March 2016, aimed to assess the technical and economic feasibility of using cotton-derived materials as a feedstock in rapid customisation processes. Rapid customisation is a way of creating physical products directly from digital design files through computer-controlled manufacturing, the best known of which is 3D printing. It is likely to allow new forms of manufacturing, including novel combinations of materials, which have not been possible or economically feasible to achieve previously.

A particular focus of this project was to identify application areas within the broad range of rapid customisations where cotton has a clear advantage due to its inherent material qualities. Rapid customisation encompasses many different possible approaches, techniques and technologies. There are many possible ways to process cotton as a feedstock and there are diverse possibilities for end-user applications.

The emphasis of the project was on mapping out the potential approaches and assessing their feasibility with the goal to identify the most promising areas for further targeted research. The project found five areas for future research:

- on-site fabrication of cotton-based filtration products;
- on-demand manufacture of bespoke furniture using cotton-derived feedstocks and rapid customisation;
- next-generation lifestyle garments and accessories that used cotton-derived material, smart sensing material and rapid customisation;
- 3D printing of children’s toys using cotton-derived feedstocks; and
- patient-specific smart wound dressings using cotton-derived cellulose and rapid customisation.

The Regenerated cotton to carbon fibre project, which concluded in June 2016, was a feasibility study focusing on the potential for virgin cotton (e.g. cotton slivers) and/or regenerated cotton fibre to be used as an alternate feedstock in carbon fibre production. Carbon fibres are becoming essential in the fabrication of composites, and they find many uses in the creation of advanced lightweight high-strength structures for defence, aerospace, automotive and sports industries.

One of the major issues in carbon fibre fabrication is that the precursor materials such as polyacrylonitrile (PAN) are expensive. While cotton’s relative purity makes it easier to work with as a potential carbon fibre feedstock, a limitation on its use as a precursor material is that the theoretical carbon yield is in the mid 40 per cent by weight range, compared to over 50 per cent for PAN. CSIRO is therefore investigating whether the use of novel ionic liquids to dissolve cotton cellulose can increase the carbon percentage for use as a carbon fibre precursor.
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<th>Program 4: People</th>
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<tbody>
<tr>
<td><strong>Outcome</strong></td>
<td>Capable and connected people driving the cotton industry.</td>
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<tr>
<td><strong>Theme</strong></td>
<td><strong>4.1 Workforce Capacity</strong></td>
<td><strong>4.2 Networks</strong></td>
</tr>
<tr>
<td><strong>Strategy</strong></td>
<td>A skilled, educated and progressive industry workforce.</td>
<td>An industry connected by dynamic networks.</td>
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<tr>
<td><strong>Outcomes</strong></td>
<td><strong>Will be achieved by</strong></td>
<td><strong>Will be achieved by</strong></td>
</tr>
<tr>
<td><strong>4.1.1</strong></td>
<td>Investigating effective strategies for attracting, developing and retaining people in the cotton industry.</td>
<td>4.2.1 Establishing and empowering creative forums and initiatives which build relationships.</td>
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<tr>
<td><strong>4.1.2</strong></td>
<td>Supporting initiatives which lead to the continuous improvement of human resource management, including on-farm Workplace Health and Safety.</td>
<td>4.2.2 Supporting and participating in collaborative cross-sectoral RD&amp;E initiatives.</td>
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<td><strong>4.1.3</strong></td>
<td>Understanding opportunities for greater Aboriginal participation in cotton and partnering with organisations to support the development of a culturally aware cotton workforce.</td>
<td>4.2.3 Creating and facilitating opportunities for national and international RD&amp;E exchange.</td>
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<td><strong>4.1.4</strong></td>
<td>Supporting educational opportunities which increase the skills and knowledge of current workforces and will meet the needs of future workforces.</td>
<td>4.2.4 Facilitating engagement with stakeholders for prioritising and capturing advice on RD&amp;E issues.</td>
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<tr>
<td><strong>4.1.5</strong></td>
<td>Creating opportunities for, and supporting the development of, leadership skills.</td>
<td>4.2.5 Honing research expertise and the application of science from core research disciplines.</td>
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<tr>
<td>Measure of success</td>
<td>Opportunities for learning are demanded by industry:</td>
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<td></td>
<td>▪ A 10-fold increase in school visits to promote careers in cotton by 2018.</td>
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<td>▪ A student gap year internship program.</td>
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<td></td>
<td>▪ 50 Horizon students by 2018.</td>
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<td></td>
<td>▪ 30 completed summer scholarships by 2018.</td>
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<td></td>
<td>▪ 300 students having completed the UNE Cotton Course by 2018.</td>
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<tr>
<td>People and industry are connected through effective networks:</td>
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<td></td>
<td>▪ 10 conferences and forums are coordinated which promote industry, cross-sectoral and community knowledge sharing.</td>
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<td></td>
<td>▪ CRDC is an active member of key industry and government initiatives.</td>
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<td></td>
<td>▪ Primary Industry Standing Committee (PISC) cotton and cross-sectoral RD&amp;E strategies.</td>
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<tr>
<td></td>
<td>▪ 50 travel scholarships are supported.</td>
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<td></td>
<td>▪ The cotton industry has effective collaborative structures for prioritising RD&amp;E.</td>
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<tr>
<td>People have ready access to industry information:</td>
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<tr>
<td></td>
<td>▪ Communication systems for all CRDC stakeholders are meeting their communication needs.</td>
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<tr>
<td></td>
<td>▪ The information and services derived from CRDC investments are in demand and the technologies are adopted.</td>
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Key program investments

This section provides a snapshot of some of CRDC’s investments during 2015–16 in this program area. The full list of CRDC’s investments for this period can be found at Appendix 4: the RD&E portfolio.

Workforce Capacity: Investigating effective strategies for attracting, developing and retaining people in the cotton industry.

People are the cotton industry’s most important resource, and ensuring the industry continues to have a network of capable and connected people is a key priority. CRDC’s investments in this area aim to provide critical supporting information for the industry, helping to inform the industry’s wider workforce development strategy.

In 2015–16, CRDC continued its investment into workforce development through a number of key projects:

- PhD: Career motivational factors of cotton growers (attraction and retention), with USQ;
- PhD: Investigating cotton farm workers’ experiences of job satisfaction using social cognitive career theory, with USQ;
- PhD: Skills profile and labour supply structure on cotton farms, with UNE;
- The impact of farm workforce turnover in the cotton sector, with the University of Melbourne; and
- Workforce Development Strategy, with Cotton Australia and Agrifood Skills Solutions.

The Career motivational factors of cotton growers (attraction and retention) PhD project looks at the psychological drivers and characteristics that impact on cotton grower motivation and work/life satisfaction. Previous research into the psychology of farming was conducted in the 1970s, but despite the cotton-growing profession changing markedly over the past four decades with the advancement of technology, there have been no major advances in this research. This research project aims to fill this gap, and will look at such factors as risk tolerance, optimism and entrepreneurship in cotton growers, and how the motivations of growers impacts on their attraction and retention strategies. The project is due for completion in 2016–17.

The Investigating cotton farm workers’ experiences of job satisfaction using social cognitive career theory PhD project aims to identify the key personal motivational factors that attract and retain farm employees of the cotton industry. The knowledge generated from this research project may be used to guide future cotton policy, inform employers’ decision making, and underpin the production of educational resources for attracting new employees into the cotton industry. The project will conclude in 2016–17.

The Skills profile and labour supply structure on cotton farms project is investigating the workforce needs of cotton farms and comparing them with supply sources and structures to assess the effectiveness of employee-retention practices. The project is developing an inventory of current and future labour needs, to identify the gaps and to outline the strategies to address these needs for the industry. The project is due for completion in 2017–18.

The impact of farm workforce turnover in the cotton sector project, which concluded in 2015–16, aimed to establish meaningful measures of turnover that could be used to assess changes in human resource management performance, and track progress over time; examine the real costs and impacts of staff turnover on a sample of cotton farms; identify the practices most strongly linked to low turnover; and explore the relationship between turnover performance and farm profit.

The project found that while workforce turnover was likely to increase costs and reduce profit, it was difficult to identify the impact on whole farm profitability. Workforce strategies deployed were linked to the remoteness and isolation of farms, the location of farms, and the farms’ water security, which included the influence of climate and weather. Three different workforce structures were found: core contract; core casuals (skilled) and core casuals (inexperienced). Growers’ ‘worldviews’ around people management fell into three categories: a focus on efficiency; a focus on looking
after people; and a focus on getting the best people, which resulted in differing management practices relating to turnover.

This project provided valuable information on the impact of farm turnover and best management practices for human resource management, and fed into the development of the Workforce Development Strategy.

The Workforce Development Strategy project, which concluded in 2015–16, was a collaboration between CRDC and Cotton Australia, with the assistance of Agrifood Skills Solutions (AFSS)—part of Agrifood Skills Australia, the key body on skills and workforce development for the Australian agrifood industry and regional Australia. The cotton industry workforce development strategy is focused on delivering workforce outcomes for growers on-farm, and ultimately, will ensure that the cotton industry is able to attract, retain and develop people who will drive industry competitiveness. The strategy provides a shared and focused plan to ensure the cotton industry’s organisations investments in workforce target key priorities are well coordinated and deliver maximum outcomes. The strategy is available to download from the CRDC website: www.crdc.com.au/publications.

Workforce Capacity: Supporting initiatives which lead to the continuous improvement of human resource management, including on-farm Workplace Health and Safety.

Health and safety continues to be a major concern for cotton growers and cotton industry employers. The goal for the industry is to reduce cotton farm-related injuries by 10 per cent by 2018. CRDC contributes to the achievement of this industry goal by investing in on-farm safety, and monitoring and evaluation projects.

In 2015–16, CRDC continued its investment into workplace health and safety through two key projects:

- **Primary Industries Health and Safety**, a joint partnership with RIRDC; and
- **Smart technology for best practice work health and safety by cotton growers**, with the University of Sydney.

The ongoing Primary Industries Health and Safety project aims to improve the health and safety of farm workers and their families. A jointly funded project involving six of the Rural Research and Development Corporations (RDCs), it undertakes RD&E activities to improve the physical and mental health of farmers and the safety of the farm work environment.

The project targets its health and safety information at business owners, managers and employees involved with farming, including cotton growers, as well as health professionals and researchers in the field of rural health and safety.

The Smart technology for best practice work health and safety by cotton growers project, which concluded in 2015–16, supported the development of two sets of communications materials specifically for cotton industry Work Health and Safety (WHS)—YouTube videos to provide best practice hazard control for the common scenarios and risks that are known on cotton farms; and a mobile website and app for cotton-specific worker induction. The induction platform allows growers to induct any number of workers simultaneously, simplifying the induction and resulting record-keeping process.

Workforce Capacity: Supporting educational opportunities which increase the skills and knowledge of current workforces and will meet the needs of future workforces.

The cotton industry recognises the need for passionate, skilled and innovative people to shape its future in a rapidly changing and growing world. To ensure the industry is able to attract talented young people, CRDC continues to invest in a number of initiatives focused on developing students at the school, undergraduate and postgraduate levels.
In 2015–16, CRDC continued its investment into educational opportunities for current and future workforces through a number of key projects:

- **Aboriginal Employment Strategy student scholarships**, with the Aboriginal Employment Strategy;
- **Cotton industry young professionals program**, with USQ;
- **Cotton Production Course**, with UNE;
- **CRDC Summer and Honours Scholarships program**, funded by CRDC;
- **CRDC PhD Scholarship program**, funded by CRDC;
- **Developing education capacity in the Australian cotton industry project**, with CSIRO;
- **Horizon Scholarship program**, with RIRDC; and
- **Primary Industries Education Foundation**, co-funded with Cotton Australia.

The ongoing **Aboriginal Employment Strategy** program, supported by CRDC and the Aboriginal Employment Strategy, is a school-based traineeship for Indigenous students. Running for 12 years, the program provides an opportunity for local Indigenous students enrolled in Years 11 and 12 at Wee Waa and Narrabri High Schools to gain paid work experience, a nationally recognised qualification, credit towards their Higher School Certificate and exposure to the different career opportunities available in the cotton industry. The program increases the skills, experience and capacity of the young Indigenous students; exposes them to range of vocations available through the cotton industry; presents a possible source of future employment; and breaks down the barriers between non-Indigenous employees and Indigenous students. In 2015–16, CRDC supported two students through this program.

The ongoing **Cotton Production Course** provides a tertiary-level course on cotton production for those interested in, and working in, cotton. It also provides the wider benefit of mentoring prospective industry researchers and conducting applied systems research. The number of students participating in the course continues to increase, with 76 students enrolled in 2015–16.

The **CRDC Summer and Honours Scholarships** are available to university students completing the senior years of an undergraduate degree or enrolled in an honours program. The scholarships provide them with the opportunity to work on real research, extension or industry projects in a working environment as part of their professional development. In 2015–16, CRDC supported 13 summer/honours scholarships for students to work with existing researchers or research organisations.

The **CRDC PhD Scholarship** program funds researchers undertaking their PhDs. In 2015–16, CRDC helped fund 18 new or ongoing PhD scholars across all five of the CRDC's program areas.

The ongoing **Developing education capacity in the Australian cotton industry** project provides a full-time education officer, who implements a range of activities and programs in schools to boost knowledge of the industry and its varied career options. The office is based at the Australian Cotton Research Institute and forms part of the industry’s extension program, CottonInfo.
The ongoing Horizon Scholarship program is an initiative of RIRDC that, in partnership with other RDCs and industry sponsors, supports undergraduates studying agriculture at university by providing a bursary, professional development workshop and work experience. In 2015–16, CRDC supported three new Horizon Scholarships for undergraduate students: Scott Nevison and Camilla a’Beckett (2015) and Sam Knight (2016). Overall, CRDC has supported 15 Horizon scholars throughout the 2015–16 year.

The Primary Industries Education Foundation is focused on encouraging primary industries education in schools, through providing national leadership and coordination of activities; resources for students and teachers; and encouraging interest in primary industry careers. CRDC and Cotton Australia jointly contribute to the Foundation on behalf of the cotton industry.

Workforce Capacity: Creating opportunities for, and supporting the development of, leadership skills

The cotton industry, like many other industries, is facing a period of change and uncertainty. Faced with variability in climate, competition for skilled labour, changes in land use and access to water, the industry requires a network of informed and experienced leaders that can work together to develop resilient and sustainable farming systems and communities.

In 2015–16, CRDC continued its investment into leadership through a number of key projects:

- **Cotton industry leadership development strategy**, with the Australian Rural Leadership Foundation;
- **Nuffield Farming Scholarships program**, with Nuffield Australia;
- **Peter Cullen Trust: Science to Policy Leadership Program**, with the Peter Cullen Trust; and
- **Science and Innovation Award for Young People in Agriculture**, with ABARES and the Department of Agriculture and Water Resources.

The Cotton industry leadership development strategy includes funding of the Australian Rural Leadership Program, which is focused on producing a network of informed, capable and ethical leaders who can work collaboratively to advance the interests of their industries, communities and rural Australia. In 2015–16, CRDC co-sponsored two participants with Auscott and Cotton Australia: cotton consultant Jamie Iker and farm manager Sean Boland.

The Nuffield Farming Scholarships program is the leading agricultural study program for primary producers in Australia. It provides farmers with the opportunity to pursue an area of agricultural-related study overseas, to the benefit of both the individual grower and their wider industry. In 2015–16, CRDC continued its support for two cotton growers undertaking the Nuffield Scholarship program: Matthew McVeigh and Thomas Quigley.

The Peter Cullen Trust: Science to Policy Leadership Program aims to enhance the role of science in policy development and bring about positive change in water and catchment management in Australia. It is intended to build the leadership and communication skills of people actively involved in water systems management—be it river or catchment, rural water or environmental science or policy. In 2015–16, CRDC supported one participant in the program: irrigator Adam Harris.

The Science and Innovation Award for Young People in Agriculture program recognises big ideas from young rural innovators who contribute to the success of Australia’s agricultural industries. For CRDC, the awards provide an opportunity to help develop the technical and leadership skills of young cotton researchers, and reward them for their commitment to innovation. The 2016 recipient of the CRDC-supported cotton Science and Innovation Award is Yvonne Chang.
Ten young Australians with a love of agriculture and the capacity to be future leaders have each been awarded the RIRDC Horizon Scholarship for 2016, including one CRDC-funded scholar, Sam Knight.

The Horizon Scholarship program was developed to help address the shortage of trained professionals entering primary industries and to promote the diverse career pathways that agriculture offers.

Horizon Scholarships are open to students entering their first year of university and studying a degree related to agriculture, such as agricultural science or agribusiness.

Sam Knight (pictured) is from a family cotton farm at Wee Waa, and is studying a Bachelor of Agriculture and Business at UNE. After getting more involved on the farm during high school, he discovered a passion for cotton, which has set his career path. Sam aims to not just make an impact on his own farm, but more broadly on the industry. He particularly wants to get involved with research and development and trials. Sam believes that through research, cotton growers can continue to increase yield and profit while reducing costs and not degrading the land.

The Horizon Scholarship provides $5000 per year for the duration of the scholar’s university degree. It also offers students annual industry work placements that give them first-hand exposure to agriculture, access to industry leaders, professional development workshops and opportunities to network and gain knowledge at a range of industry events.

Scholarship recipients are selected on the basis of their commitment to a career in agriculture, as well as their leadership potential and high school academic record.

CRDC remains a strong supporter of the Horizon program, recognising that people are cotton’s most valuable resource. In the 2015–16 year, CRDC supported a total of 15 Horizon scholars under RIRDC Horizon Scholarship projects.
Case study: Award for cotton’s young science innovator

Yvonne Chang, a cotton research assistant with CSIRO in Narrabri, was awarded an ABARES Science and Innovation Award by the Minister for Agriculture and Water Resources in Canberra in March 2016.

Yvonne (pictured) was selected as the recipient of the award, which is proudly supported by CRDC under the 2016 ABARES Science and Innovation Awards for Young People project, for her novel approach to the issue of soil organic carbon. Yvonne’s project will look at the use of melanised root-associated fungi to increase long-lived soil organic carbon.

As part of the Award, Yvonne will receive a grant of $22,000 to undertake this research project, which looks at three things: improving the soil; increasing cotton yields; and reducing the impact of greenhouse gases.

Yvonne will use the grant to undertake a glasshouse or field project to examine the effect of the fungi on soil organic carbon under irrigated cotton. If the result is a significant increase in soil organic carbon, then this could help to address the long-standing issue of declining carbon in soil, and as a result, enable increased production and sustainability for cotton growers.

Yvonne, who grew up in Sydney and studied science at the University of Sydney, says her career in the fields of plant ecology and plant-soil microbe interactions was driven by an interest in understanding how living systems function.

CRDC Executive Director Bruce Finney believes Yvonne’s research project has the potential to make a real, tangible contribution to the field of cotton research, and help growers improve their productivity and sustainability.

CRDC continues to be a strong supporter of the ABARES Science and Innovation Awards as a pathway to developing future research leaders, such as Yvonne.
Networks: Establishing and empowering creative forums and initiatives which build relationships; Creating and facilitating opportunities for national and international RD&E exchange.

The cotton industry is well known for its collaborative and inclusive nature, and CRDC’s investment in this area is designed to ensure the industry continues to stay connected via dynamic networks.

In 2015–16, CRDC continued its investment into networks through a number of key projects:

- **CRDC Grassroots Grants program**, funded by CRDC;
- **Sponsorship of the Association of Australian Cotton Scientists 2015 Conference**;
- **Sponsorship of the 17th and 18th Australian Cotton Conferences**, with Cotton Australia; and
- **Travel and scientific exchange: World Cotton Research Conference, Brazil**, co-funded by CRDC and the Association of Australian Cotton Scientists.

CRDC’s **Grassroots Grants** program encourages Cotton Grower Associations to apply for funding to support capacity-building projects in their region. Up to $10,000 in funding is available for CGAs to help fund a project aimed at increasing the engagement of growers in the industry, solving specific regional issues and improving their skills, knowledge base and networks. Since the Grassroots Grants program commenced in 2011, it has supported 44 projects across the cotton-growing valleys, including 11 projects in 2015–16.

CRDC’s **Sponsorship of the Association of Australian Cotton Scientists 2015 Conference** provided an opportunity to showcase CRDC’s investments in RD&E to the research community, and to assist the community to further develop their relationships. 200 cotton researchers and scientists attended the Conference in September 2015, with over 130 research presentations on the agenda, covering the research fields of plants, soils and systems, cotton breeding, weeds, entomology, energy, carbon and climate, nutrition, NRM, pathology, irrigation, fibre and processing, and social science.

CRDC’s **Sponsorship of the 17th and 18th Australian Cotton Conferences** provide a platform to showcase the Australian cotton industry and enhance the outputs of CRDC-funded R&D and extension activities to the industry at large. The August 2014 conference saw the largest gathering of industry participants since the event commenced, with some 1800 registered attendees, including 600 cotton growers representing every cotton-growing region. The 2016 conference is expected to attract 1600 attendees, with the agenda featuring CRDC-supported research projects.

The **Travel and scientific exchange: World Cotton Research Conference, Brazil** project involved CRDC and the Association of Australian Cotton Scientists partnering to ensure Australian cotton research was well represented at the conference. Together, the two organisations supported 14 Australian cotton researchers to attend the conference, encouraging international research collaboration and showcasing Australian cotton research on the world stage. CRDC representatives were among the Australian delegation, with CRDC director and grower Cleave Rogan, General Manager of R&D Dr Ian Taylor and R&D Manager Susan Maas also attending.

Communication: Providing information for demand-driven communication strategies and performance reporting; Applying innovative communication methods.

CRDC’s investment in the area of communication aims to ensure that stakeholders’ information needs are met. In 2015–16, CRDC continued its investment into communication through two key projects:

- **Australian cotton production and best practice documentaries**, with QDAF; and
- **Stimulating private-sector extension in Australian agriculture to increase returns from R&D**, with Dairy Australia.
The ongoing *Australian cotton production and best practice documentaries* project aims to communicate scientifically based crop production, protection and best practice principles to a diverse audience through a series of short, easily accessible videos. To date, 85 short videos have been produced, ranging from pre-season planter maintenance and planting tips through to overcoming challenges for new growers in the southern districts. The videos have collectively received 15,000 views. They are accessible via the CottonInfo YouTube channel: www.youtube.com/CottonInfoAust.

The *Stimulating private-sector extension in Australian agriculture to increase returns from R&D* project recognises the opportunity for the private sector to play a greater role in extending existing and future research outcomes to growers. As such, it aims to increase the capacity of commercial and private-sector extension services in delivering R&D outputs on-farm. The project is due for completion in 2017–18.
Dr Sharna Holman recently began work as the CRDC-supported CottonInfo Technical Specialist for diseases, volunteers and ratoons and QDAF Development Extension Officer, based in Emerald. The University of Sydney Honours graduate says it was exposure to the cotton industry while studying that attracted her to a world she’d barely heard of. Recently completing a Bachelor of Science in Agriculture, Sharna says she was fortunate to receive a scholarship to attend the Australian Cotton Conference in 2014, which sparked her love of the industry.

The same year through a CRDC Summer Scholarship, Sharna (pictured) furthered her involvement with the industry by researching her honours project on Bt tolerance in Helicoverpa with Dr Mary Whitehouse and Dr Sharon Downes at the Australian Cotton Research Institute near Narrabri.

A PICSE cotton internship from CRDC followed, giving Sharna the chance to complete work placements with different researchers and commercial cotton industry organisations. She says that without these opportunities, she may never have thought of the cotton industry as a career.

For now, Sharna’s role is communicating research to growers, but there are plans for further study, with a PhD in either agronomy or entomology. She would like her PhD to be research that growers can put straight into action on their farms, and believes her current role gives her a good grounding for that.

Sharna believes some of the most important challenges faced in the future are related to agriculture, such as improving and finding new ways to feed and clothe a growing population with limited resources.
## Program 5: Performance

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### Will be achieved by

#### 5.1.1 Supporting a best practice framework as the primary integrated planning, risk management, benchmarking, knowledge development and delivery system.

5.1.2 Promoting best practices through the development and delivery Joint Venture.

#### 5.2.1 Developing and implementing an internal M&E framework for evaluating CRDC’s investment portfolio balance and its RD&E performance.

5.2.2 Conducting annual industry surveys to capture practice change.

5.2.3 Establishing a framework through which industry performance can be nationally and internationally reported.

#### 5.3.1 Undertaking scientific discipline reviews of the industry’s RD&E.

5.3.2 Commissioning and participating in independent reviews of CRDC’s RD&E and organisational performance.

5.3.3 Commissioning independent reviews of the social, environmental and economic performance of the industry.

5.3.4 Participating in cross-sectoral RD&E impact evaluations and reviews.

### Measure of success

#### Industry is able to demonstrate best practice:

- The cotton industry’s myBMP program is the primary resource for farmers accessing best practice knowledge and tools.

- The cotton industry’s myBMP program is nationally recognised and integrated with other agricultural sector best management practice programs.

- An 80 per cent coverage of Best Management Practice systems across the Australian cotton industry.

#### Industry and CRDC are able to capture and demonstrate performance:

- A rigorous monitoring and evaluation platform which measures and reports on the performance of CRDC’s research and development investments.

- An industry performance monitoring and evaluation framework that is consistent with national and international standards.

- Providing the industry with cotton sustainability indicators and supporting its capacity to report against these indicators.

#### Industry and CRDC are able to continually review and improve performance:

- Independent reviews of the social, environmental and economic performance of the industry’s performance.

- Independent reviews.
Key program investments

This section provides a snapshot of some of CRDC’s investments during 2015–16 in this program area. The full list of CRDC’s investments for this period can be found at Appendix 4: the RD&E portfolio.

Best Practice: Promoting best practices through the development and delivery Joint Venture.

CRDC’s support for the industry’s joint venture extension program, CottonInfo, includes investment in key CottonInfo personnel (including the CottonInfo program manager and communications manager); support for the myBMP program; and investment in the CottonInfo technical specialists via research projects under their specific topic areas.

In 2015–16, this investment from CRDC includes a technical specialist that fits within the Performance category, under the project:
- Science into best practice, linking research with CottonInfo, with CSIRO.

The role of the CottonInfo technical specialist includes: developing new information and strategies to help the industry respond to current issues and pre-empt future issues; ensuring myBMP is linked to and updated with the latest best practice messages from research results; validating best practice guidelines using field experiments; supporting the development of key industry publications; and exploring opportunities for the development of new decision-making tools to support the uptake of research outcomes and best practices.

Monitoring and Evaluation:
Conducting annual industry surveys to capture practice change;
Establishing a framework through which industry performance can be nationally and internationally reported.

Measuring the performance of the Australian cotton industry over time is critically important: in helping the industry to continuously improve; in helping to tell the story of the industry to customers; and in helping to secure overseas markets through the demonstration of the industry’s social, economic and environmental sustainability.

In 2015–16, CRDC continued its commitment to industry monitoring and evaluation through three key projects:
- Annual Cotton Grower Practices Survey, with Roth Rural and Regional;
- Annual qualitative and quantitative surveys for the Australian cotton industry, with Crop Consultants Australia; and
- Australian Cotton Comparative Analysis, with Boyce Chartered Accountants.

The Annual Cotton Grower Practices Survey gathers valuable information about cotton farming practices to give a greater understanding of the industry’s performance. Each year, data is collected on the industry’s yields, fibre quality and grower perspectives on RD&E. In addition, the survey monitors practices and performance over specific topic areas, including nutrition, soils, biotechnology stewardship, weed management, irrigation, energy, workforce, harvesting and riparian areas.
Sandra Williams is a highly dedicated experimental scientist with CSIRO. She is also a member of the industry’s extension program, CottonInfo, a joint venture supported by CRDC, Cotton Australia and CSD.

Within CSIRO, Sandra’s primary focus is on developing and delivering research to improve cotton crop decisions for sustainable cotton production. Within CottonInfo, under the CRDC-led Science into best practice, linking research with CottonInfo project, Sandra (pictured) takes this research and development focus one step further into extension.

Her role, like that of the other CottonInfo Technical Specialists, is to be the conduit of information from cotton researchers to the industry, ensuring that growers and consultants know of the latest research outcomes and best practice.

Sandra’s focus throughout her 20-year career in cotton RD&E has been integrated pest management (IPM), which forms her speciality within CottonInfo. Her role is to provide IPM expertise into CottonInfo extension campaigns, and to play a linking role with the industry’s best management practices program, myBMP.

Sandra believes that at the heart of IPM is the conservation of natural enemies. Her message to the industry regarding IPM is that beneficial species such as predatory insects, spiders, bats and birds can help control pests and reduce the reliance on insecticides for their management. Cotton growers who use IPM have shown that with optimal crop growth, a healthy population of beneficials and a plant-monitoring approach, it’s possible to grow a Bollgard II® crop without (or with significantly reduced reliance on) insecticides.

She believes IPM is a win-win for both your crop and your bottom line.


Case study: Converting science into best practice via CottonInfo

The Annual qualitative and quantitative surveys for the Australian cotton industry project consists of two separate data sets/reports. The qualitative report is a survey of cotton consultants, which provides information on the practices and attitudes of consultants and their cotton grower clients. The quantitative data provides hard data as to practices on-farm, such as chemical use, and tracks how this has improved over time. The information provided by both surveys forms a critical data set for benchmarking, trending and research purposes.

In 2015–16, two surveys were released: the 2013–14 and 2014–15 editions, with 92 consultants participating across the two surveys, representing a collective 890 growers. The reports are available at the CRDC website: www.crdc.com.au/publications.

The Australian Cotton Comparative Analysis report provides the industry benchmark for the economics of cotton growing in Australia. The 2015 crop report, published in March 2016, focuses on the economics of the 2015 crop from growers across the different cotton-growing valleys. It also presents trends that have been measured against more than 10 years of data. For more on the report and its key findings, read the case study titled Latest analysis reveals stellar season.

Reviews:
Commissioning and participating in independent reviews of CRDC’s RD&E and organisational performance.

Ensuring continuous improvement is a key goal of the organisation, and as such, CRDC commissions independent reviews of RD&E investments and organisational performance as required.

In 2015–16, CRDC continued its investment into reviews through a number of key projects:

- CRDC leadership program review, with Inner Compass Pty Ltd; and
- Impact assessment of selected clusters of projects, with Agrtrans Research and Consulting.

The CRDC leadership program review project, which concluded on 30 June 2016, involved a strategic review of all CRDC’s investments into leadership development, to identify gaps, determine whether the current investments are resulting in strong leadership capacity, and to ascertain how to maximise leadership development potential. The review recommended the implementation of key performance metrics for each investment in order to better measure program impacts.

The Impact assessment of selected clusters of projects review, which commenced in May 2016, will undertake qualitative and quantitative impact assessments of CRDC investments into nutrition and water-use efficiency projects. The purpose of the evaluation is to determine the success of CRDC’s investments against the stated Strategic Plan goals, and to inform future investments. The project will report in 2016–17.
In 2015, the top 20 per cent of cotton growers in the industry’s major benchmarking study showed an increase of $1200 per hectare profit against the five-year average.

The 2015 Australian Cotton Comparative Analysis, produced by Boyce Chartered Accountants and CRDC, shows that although 2015 was a relatively small season in terms of hectares grown, it was a stellar season for yield and price.

The analysis, conducted annually by Boyce under a CRDC-supported project, provides a benchmark for the economics of growing cotton in Australia. The 2015 report is based on figures from growers who produced 340,000 bales, or 15 per cent of total cotton production.

The study found that 2015 was generally an ideal irrigated cotton season in terms of weather, with enough heat, rainfall at ideal times, and low levels of prolonged cloud and cold shock days all contributing to a good season for growers.

And, as a result, the report reveals that the average group of cotton growers achieved a profit per hectare of $1899—greater than both the 2014 result of $711, and the five-year average.

The top 20 per cent of growers had an outstanding season, with a profit of $3388 per hectare, against the five-year average of $2190.

Report co-author Paul Fisher of Boyce Moree noted that yield was the distinguishing factor between the two groups. He says increased yield has two impacts: increased income and reduced cost per bale. As a result, he believes the focus for growers wishing to increase their profitability should be on increasing yield as cheaply as possible.

According to Paul, the long-term average figures for the top producers prove that it is possible to achieve a benchmark cost of production in the range of $281 to $326 per bale in a ‘normal’ year.