R&D Review: Responsible Landscape Management 5th-6th May 2016 Brisbane

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15 May 2016

Acknowledgements

The 2016 Responsible Landscape Management R&D review was undertaken by the Cotton Research and Development Corporation (CRDC) and Cotton Australia with support from CottonInfo.

CRDC R&D Manager Jane Trindall provided extensive experience and expertise to chair the forum.

Cotton Australia's Research direction and Stewardship policy officer Nicola Cottee, CottonInfo's Warwick Waters & the University of New England Brendan Griffith provided input into the agenda.

We would like to especially thank our sustainability panel members, Greg Kauter (CRDC board), Ross Burnett (Grower panel rep), Graeme Scheu (Mayor Goondiwindi Regional Council), Simon Corish (CA board) & Chris Cosgrove (Sustenance Asia) for their time and insights into what sustainability means to their business. Thankyou to Brendan Griffith (UNE) for chairing this session.

We would like to thank all of the presenters and all of our participants for their contributions to the forum especially in the workshop sessions.

Stacey Vogel
NRM Technical Specialist
CottonInfo
May 2016

Forum background

Cotton Australia (CA) and Cotton Research and Development Corporation (CRDC) partnered to hold a R&D review of the Responsible Landscape Management Theme, on the 5-6 May 2016 in Brisbane. CRDC invests in research and development in this Theme (via the Strategic Plan 2013-18) for the Australian cotton industry to manage natural resources responsibly and become a global leader in sustainable agriculture.

The review was held to discuss the cotton industry's R&D needs specifically in this Theme and to refine the direction of investments to meet future challenges and make a difference. The outcomes of the forum will be used to advise the Panel Strategy meeting in late May and the Sustainability stakeholder forum to be held later this year

The two day forum was deigned around 2 themes
Day 1: Science to impact: Future & innovation
Day 2: Sustainability: Creating sustainable value to cotton businesses and identifying pathways to impact

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Contents

Responsible Landscape Management Forum – Day 1

Presentations : What is the latest research saying about sustainable cotton production in 2030?

A copy of these presentations can be found in Appendix 1.

Presenter	Topic	Key messages
Bryce Kelly, UNSW	Groundwater chemistry and connectivity lower Namoi	Need to review impact of water sharing plans. Managed Aquifer recharge – use natures dams-replenish the system during floods- many barriers to overcome. BIG DATA at catchment scale: optimise catchment water use. Soil microbes pop. have declined in density and complexity impacting on plant growth, nutrient use, disease resistance & greenhouse gas emissions.
Francesca Andreoni, Bel Tempo	Resilience assessment of cotton industry	R&D desicions critical to future sustainability, key drives of sustainability for the industry are Social Licence, L&W availability and Profitability. Cotton industry stands out against others in its past ability to adapt to "shocks' – take R&D seriously & communicate it well, younger demographic & growers don't just see themselves as 'cotton growers'.
Kathryn Korbel, Macquarie Uni	Groundwater health and sustainability	Landuses show different microbial footprints. Healthy groundwater ecosystems aid water flow and Water quality. Also play role in surface water health. Developing a groundwater health index with aim to provide tools for industry to monitor groundwater health. Microbes potentially important role in nitrogen cycle, specifically in aiding

		nitrate removal. What are hydrological factors influencing GW organisms and how are they responding to surface-GW changes?
Yvonne Chang, CSIRO	Nitrogen losses & Indirect N2O emissions in irrigated cotton	More fertiliser N lost than we might expect. The soil provides more then half of the plant N. Indirect N2O emissions from irrig. Cotton may be larger than IPCC EF5r estimates. There is no clear relationship between indirect N2O emissions and other water chemistry parameters *Looking to the future:* How does N balance change at different N rates? What is the fate of N that enters the irrigation system? Are we reducing soil N over time? And What controls indirect N2O emissions?

Keynote Speaker: How do we navigate a path to sustainable cotton industry in 2030? Steven Cork, Futurist

See Appendix 4 for presentation summary.

Presentations: Shaping factors – Drivers

A copy of these presentations can be found in Appendix 2.

Presenter	Topic	Key messages
Cathy Phelps, DA	Dairy perspective	2 key drivers – Cost and accessibility of natural resources & Market, investor and community expectations. Developed a Dairy Industry Sustainability Framework, achieving change through integration into mainstream D&E. Challenges are biodiversity and reporting – enter data only once to achieve multiple outcomes. Future direction - maintain focus on efficiency and integration into mainstream programs, continue to engage with market, investors and community and Incorporate climate risk.
Alice Payne, QUT	Sustainability & fashion	Increased consumer scrutiny and demand for transparency. Greener, cleaner and with less waste. More recycling and closing the loop. Sustainability as a baseline?
Michael Murray, CA	Policy context	Access to water will continue to be driven by policy. MDBC will move focus to other catchments. Reef catchment program will increase scrutiny of cotton industry practices. More focus on nitrogen use efficiency. Need to increase myBMP adoption to provide evidence of good stewardship so we have more control over

		regulatory process e.g. Vegetation Leg. Development of energy efficiency tools to help descions on investment into new technology. More scrutiny into pesticides – bee, spray drift, health impacts. Climate change what does it collectively mean to the industry and how to we mediate impacts. How can Ag. and the resource sector co-exist.
Steve Ainsworth, CSD	What NRM means to a Cotton business	NRM is a customer enabler. Long term importance – provides FTO to grower & industry per se. Commercially, growers are able to reliably grow cotton and therefore purchase CSD products & services for long term. Enables CSD to continue R,D &E investment, business viability to growers and hence CSD, aids social license to industry. Efficient NRM = Better productivity =Win Win

Futuring Workshop – facilitated by Steven Cork

Future Scenario 1: Global Sustainability (M. Anderson)

Assumptions:

this scenario would be the global government scenario or the UN government. However, it would be the functioning version rather than the dystrophic version – so a positive scenario. It is therefore consultative (bottom-up), community driven, transparent and harmonious (socialist utopia ?). Decisions are driven by analysis of the balance between overall societal needs and efficiency on one side and environmental and social cost on the other. So marked driven mechanisms are no longer in effect or much subdued and free enterprise is limited. Decisions are mainly based on logic reasoning requiring much information. So it is also technocratic and data collection and monitoring is pervasive qua the need for information driven decisions.

Challenges and opportunities:

In this context the cotton industry (is this a nationalised state owned industry? or production collectives ? or still individual farmers but heavily regulated ? we were

not sure) would have to produce the best fiber (measured against a holistic matrix including water, environment and social factors besides the technical aspects of fiber quality economic measures) or document that there are niche areas where cotton cannot be replaced. So assuming that cotton as an industry would exist, then there would be global specifications and standards in place and the industry would have to be on the top of the list of sustainable indicators/indexes. The need for information driven decisions would mean that cotton farms and production would be highly metered and monitored (water, nutrients, pesticides in air soil and water – continuously in space and time), so technically advanced. I.e. on farm recycling, on farm energy production, bio-indicator monitoring (bees flying around with GPS tracker and pesticide sensors ?).

Time-frames:
In this scenario the cotton would have to be very proactive. So no dragging of feet waiting to be regulated (or dictated from above). Anticipating this future, the cotton industry would have to head out on this path within the next few years to become sustainable (or at least a leader in sustainability relative to other fiber producing industries).

Future Scenario 2: World Markets

In this scenario we see the dilution of national sovereignty as global trade based agreements reach further behind traditional domestic borders in the regulation of everyday life. The United Nations is replaced by the World Trade Organisation as the peak forum for global engagement between nation states, trading blocs, corporations, and civil society.

Powerful nations, trading blocs, and corporations are expanding their ownership of resources globally and setting product specifications to supply into their marketplace. Further unification of currency by emerging national economies like Brazil/Argentina/Mexico and India/Pakistan/China, which influences the profitability of cotton growing in Australia.

Future Scenario 3: Local Stewardship

In 2030:

- Through consistent investment in real time on-farm and system monitoring, research undertaken to understand and avoid potential environmental impacts, and widespread adoption of cotton *my*BMP, cotton farmers have avoided the severe restrictions placed on other industries limiting their ability

to farm. (regulation and capped access to inputs esp.)

- Cotton has become a valued crop by communities and avoided resource use conflict due to its multiple purposes: fuelling, feeding, healing and clothing
- While society is heavily regulated and taxed in general, regional communities are happy and desirable places to live due to their clean air and water. Individuals are not as wealthy but capital is spread more evenly throughout the regions.
- Cotton is still a national exporting industry but has aligned itself to meet community desires around localism by:
- Marketing cotton locally that is differentiated by regional characteristics (eg Macquarie Valley Jeanswest Homespun, Reef friendly Dawson t-shirts)
- Developing novel localised, modular processing techniques which can be established at low cost in each region
- Establishing collaborative, industry hubs in each region to reduce the environmental footprint of all products (eg a gin, oil processing plant, feedlot, chemical plant, solar plant, water recycling plant are co-located together to share and utilise every part of every input)
- Robust virtual cotton innovation and research networks have been maintained despite the move towards regional systems

Future Scenario 4: National Enterprise

This future is characterised by a protectionist outlook with reduction in free trade between countries and the need to increase internal productive capacity. For the cotton industry, this would mean a shift from a purely export economy to more manufacturing in Australia. We also considered the specific impact of the increase in re-cycled cotton in this context.

Timeline

For Australia to develop its own manufacturing capacity, it would need to consider the markets it could develop in and the changes to the current marketing arrangements. We thought that Australia was well positioned to capitalise on the recycled clothing market as we produce a long fiber product suited to blending with a ground recycled fiber. We also thought the Australian clothing market could support the increased cost and value the environmental benefits of recycled clothing. In the mid term, we would want to develop cellulose dissolving and reconstitution technology to further enhance the opportunity that recycled cotton presented. This could link to future 3D printing technology to enable the production of cellulose based products. In the longer term, the development of expanded on

shore manufacturing would decrease our reliance on overseas products, which would probably have high tariffs imposed.

Assumptions

We assume that market mechanisms shape individual behavior regarding the purchase of locally manufactured clothing using recycled materials. We assumed that clothing will remain the main use of locally grown cotton. We assume that the international holders of GM licenses will continue to allow their use in Australia, even in a National Enterprise environment.

Challenges

What will the impact of continuing low oil prices be on the fiber market?
If we are early developers of recycled technology, we have the opportunity to shape and influence the market.
Will the market bear any increase cost for the use of recycled fabric?

P A R K

P: protect our own supply chain
A: need to develop new processing technology
R: need to remove uncertainty about water access as the local manufacturing industry will require a consistent supply of cotton
K: to develop local manufacturing, we need to keep out overseas dumping of recycled material

Responsible Landscape Management Forum – Day 2

Keynote Speaker: Creating Sustainable value: Wagner's as a case study

Key Messages:

- Wagner's is a family company based in Toowoomba employing over 500 people. It operates in Australia and Malaysia and provides cement, contract quarrying, contract and precast concrete, bulk haulage, steel reinforcing, composite fiber technology, properties & development and the Brisbane West Wellcamp Airport.
- Invested in development of new technologies, which are more sustainable such as EFC. EFC binder has 80-90% reduction in CO2 emissions compared to Portland cement. EFC being used in sustainable building construction e.g. Global Change Institute building UQ.
- Wellcamp airport services Toowoomba and region providing passenger services and cargo freight (regional & International). Built, owned and operated by Wagner's. Regional access to international freight service can potentially stimulate growth of regional businesses.
- Use our new technologies in all our own constructions
- Sustainable building construction largely being driven by Architects.
- Many organisations get paralysed by indecision, need to manage your risk but not be afraid to try new things
- Our business has some diversity which allows us to weather shocks/impacts e.g. downturn in mining sector

Sustainability Panel: Creating sustainable value to cotton businesses, what does sustainability mean to your business?

Panel members left to right: Greg Kauter, Ross Burnett, Graeme Scheu, Simon Corish and Chris Cosgrover, panel facilitated by Brendan Griffith (UNE)

Panel member	Key messages
Greg Kauter, Grower/CRDC Board	Boggabilla Area Wide Management group example – 90's Product and profit under pressure – high pesticide application costs & ineffectiveness in controlling pests Community concerns about social and environmental health from spray drift A consultant and chemical company control at time showed in an unsprayed site 1.8km from any sprayed site deceased and dying insects due to natural pest control. As a group saw that what was happening on one farm was impacting neighbours and community so needed to mange on an area wide basis and build our social capital to manage the problem. Area wide management groups were developed across the industry. Funded comparative analysis amongst the group emerged that the most profitable crops weren't the most sprayed. Gave confidence and quickened adoption of a more integrated approach to pest management. Summary Clear driver that we responded too. Built on social capital, added value without setting out too. Added human capital to

	industry by being more proactive
Ross Burnett, Grower/Grower Panel rep	Emerald grower part of reef catchment. Nutrient runoff concerns in reef catchments making it difficult for other industries to operate, risk that cotton will be lumped into any future regulation. Competing resource industries for water and land on-going issue for community. Social licence to farm impacts myBMP will continue to be a platform which enhances how we operate and increases our sustainability Part of pilot project "Value farm habitat" to provide a platform that links cropping farms to improve and monitor native vegetation condition and water quality in reef catchments and extend that to the public and offer opportunities for the pubic to recognise and buy into farm sustainability.
Graeme Scheu, Mayor Goondiwindi	Pop. 6000, highly liveable (12 doctors & 7 dentists), supply hub for the area, low growth approximately 1%. Agricultural main industry. Wagners inland airport potential growth for area especially in horticulture in the east of shire. Viability of community underpinned by access to productive water. Need more evaluation and investment into the social and economic impacts from the loss of productive water on the community.
Simon Corish, Grower/CA Board/BCI Board	Pressure from government in the 90's to improve the industry environmental performance or be shut down was the catalyst for myBMP. Fantastic program that has helped us address our environmental performance as well as opened opportunities e.g. allowed to try new technology like GM cotton. As industry under myBMP increased environmental performance and yields growers began to question the need for it even though governments and community continued to love it. A sustainability review of the industry identified man made fibres as biggest threat. CA started to focus on connecting with end user to get good news stories out. Worked with Better Cotton Initiative (BCI) global Initiative which links to the supply chain.

	Big retailers increasingly want sustainability evidence in supply chain – however won't pay extra for it BCI very powerful for having discussions with environmental groups and being proactive rather then reactive to bad press. Need to challenge ourselves to keep moving forward Our aim is to pass onto our kids a farm that is in a better condition without impacting on anyone else.
Chris Cosgrove, Sustenance Asia	Sustainability is about resilience and adaptation – turning liabilities into assets e.g. Wagner's & OBE Organics (using geographic remoteness to sell organic credentials) Using unappreciated assets e.g. Sundrop Farms (Port Augusta SA) use solar panels to desalinate seawater to grow hydroponic tomatoes – just signed with Coles. 3 Themes of sustainability Inclusivity – leading organisations including all internal and external stakeholders in decision making processes. More likely to be successful if include the people who influence you getting there. Integrated Reporting- integrated nature of 6 capitals (financial, nature, manufacturing & 3 human) and articulating the real impact of these. Science based targets – Use more global goals, don't set targets in isolation. More effective at regional scale, regional NRM bodies great framework for gauging what happens in industries and on farms. How can we as an industry meet regional NRM targets?

Discussion

Spray drift is an enduring challenge across sectors, not just cotton. Big social licence risk. New technologies such as bio pesticides & targeted pesticides may help reduce impact and risk. Trial work looking at ground rig application shown potentially reduced risk.

Need for more social economic research to better understand the impact of resource loss and the resilience/adaptability of communities to this loss. It is communities that really loose out, more so then the farmer.

Inclusivity is essential for the industries social licence to farm, Cotton Australia work with BCI great example of how new alliances with environmental groups are helping open dialogue and moving the industry forward but we need to do this better and apply inclusivity at a local/regional not just global scale. Inclusivity takes a long time to achieve 10-30 years and over that time governments, CEO's etc. change. But if the industry and community have real ownership of targets and are working together towards achieving those targets very difficult for a government to derail that.

What does sustainability mean? It means different things to different people, industries, organisations and sectors. To a farmer it means surviving economically, having a reasonable lifestyle and passing the farm onto your kids in a better shape without impacting on anyone else.

The big retailers (15-20% market) are not getting worldwide pressure to be sustainable they just see this is the pathway the world is going. The rest of the retailers are sitting back and watching to see how consumers respond, because essentially the majority of consumers will not pay an extra cent for a sustainable product. The idea that a sustainable product has more value is not being reflected by consumer consumption.

Workshop: Pathways to Impact

Five key themes emerged from the Futures workshop held on day 1, they were:

1. Agricultural (N) impacts on the REEF : *"Our canary in the mine?"*
2. Managing spray drift (bees) : *"Lifting the lid"*
3. Sustainable fashion : *"Apple v Kodak moment"*
4. Inclusivity : "*Playing our part"*
5. Water "*Where's our watershed?"*

Using a futures thinking process called the Futures Triangle, participants mapped the *Weight* of the past, *Push* of the present and *Pull* of the future to explore 5 plausible futures using the themes listed above.

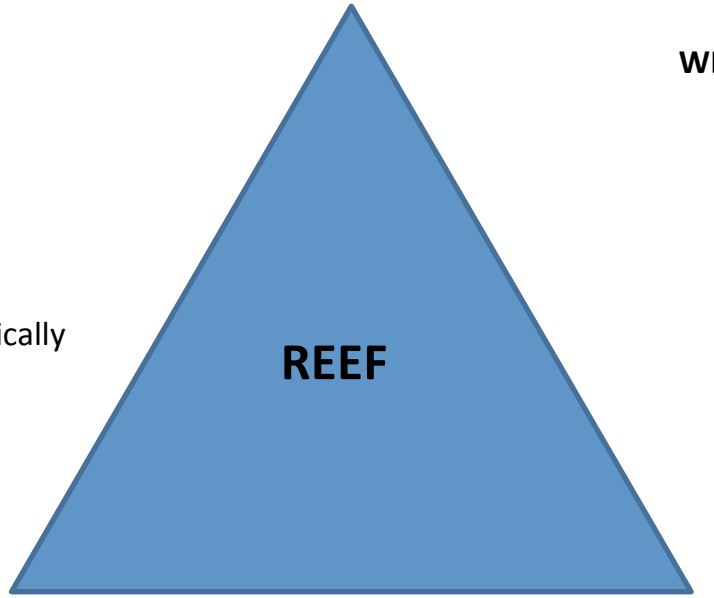
A summary of the 5 plausible futures are provided below.

PULL

- Cotton industry being the catalyst
- Healthy reef – enhancing the reef / ecosystem / no off-farm impact : Is this possible?
- Able to identify the impacts
- Relationship between good tourism & strong local economy
- Inclusivity – local & national stewardship ; NGOs increasing credibility
- Climate Change
- Good regulation – self regulating industry – myBMP & promotion of good practices. Are these good enough? – need for innovation

PUSH

- Strength of cotton in Aust i.e. yields, economy = HIGH VALUE
- Using new technology to monitor environment
- Aids in making informed decisions
- Aids in demonstrating proof
- Govt regulation on production specifically proof.



WEIGHT

- Sediment run-off
- Public image – ag is damaging the reef; especially sugarcane however cotton is being drawn into it
- Reef is already battling!
- We are applying more pressure Difficulty in demonstrating improvement due to the image of other industry

R&D

Research Q/ Ability to monitor impacts specific factors they can control.
Innovation – reducing sediment P/N release & pesticides.

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PULL

- Eliminate/minimise drift – no spray?
- New technology e.g. weather /inversion conditions
- Self regulation more ideal than the stick
- Conserving biodiversity
- Opp. In moving into new areas eg Northern Australia

PUSH

- Consumer expectations
- Social licence – consumers, other growers, neighbours, media
- Bee kills – transparency
- EPA – regulation
- Animal rights environmental protection

Managing spray drift

WEIGHT

- GM tech – slow rate of change + current tech (either improves or removes weight eg round up ready)
- How to regulate. Who's responsible
- Communication
- Education – realising the problem
- Knowledge – do we understand impacts?

RDE GAPS – RISK MANAGEMENT

Managing drift: Extension, education; compliance – what are the main issues influencing spray draft? Logistics
Who's responsible. How large is the potential impact?
Alternatives eg biocontrol
Move to a no-spray future
Productivity optimisation - $/bale (not just yield)

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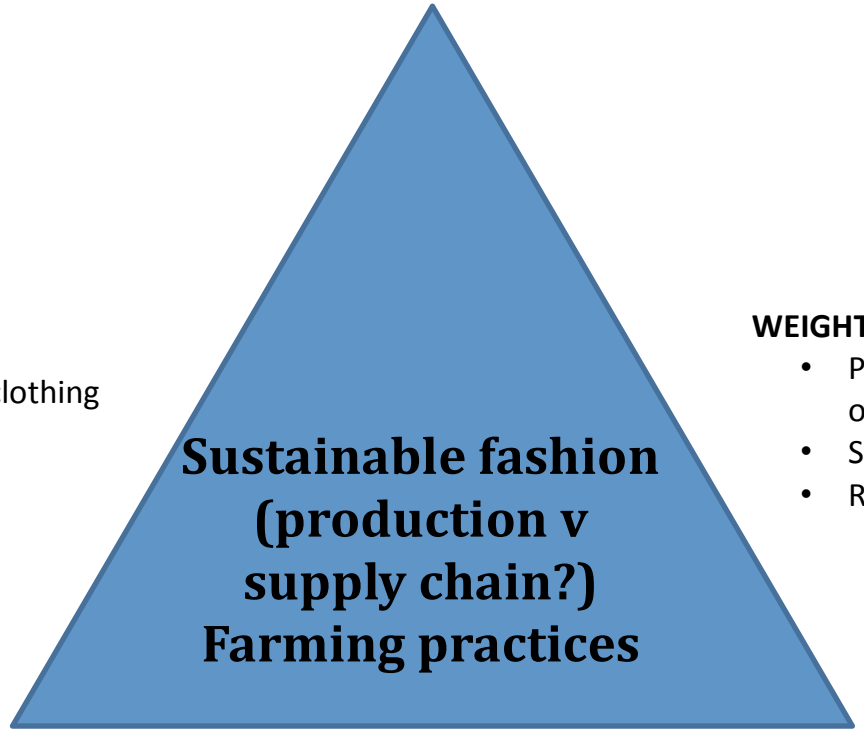
PULL

- Traceability (social & Economic)
- C neutral clothing
- Regulation (govt) +/-

PUSH

- Increasing efficiency & recycle cotton clothing
- Regulation (govt) +/-



WEIGHT

- Perception that cotton production uses lots of water
- Supply chain perception
- Regulation (govt) +/-

R&D

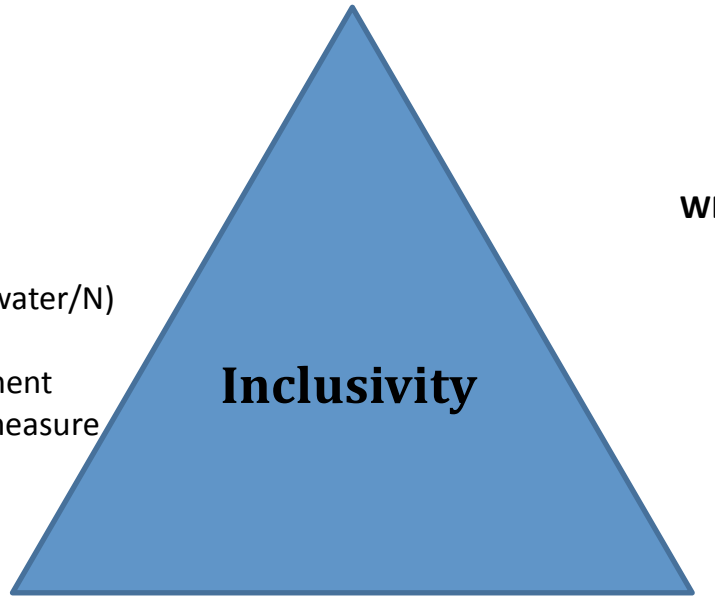
How to achieve C neutral clothing?
Agro-ecosystem health monitoring & measures
Adopting the myBMP to align practise with product outcome
Market cotton into the sustainable fashion industry by the way it is produced

PULL

- "Playing our part"
- Valued partner in communities / Australia/agriculture
- Shared resources & political support for joint goals
- "A better path/way"
- Shared understanding of assets
- Shared goals based on science – water, veg, fauna

PUSH

- Legislative change -operation caps (water/N) + vegetation management
- Technologies that facilitates engagement
- Provides accurate/ rigorous impact measure



WEIGHT

- Water sharing plans
- Polarisation – emotive & lacking dialogue
- Lack of usable ecosystem resources
- Fear / ignorance or not knowing
- Barriers – fear & data "loss of cream" - language

R&D

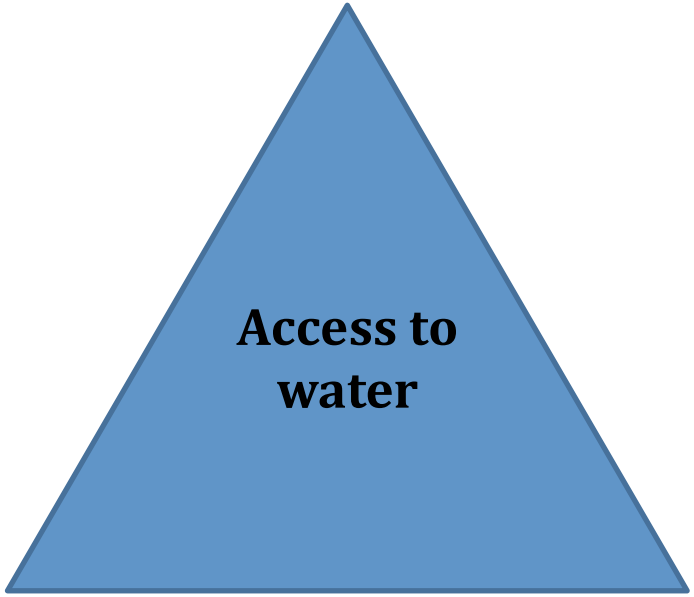
Regional survey of barriers/assets + economic and social impact of cotton+ understand value/s regionally & by groups/sectors eg ecosystem/land use / water

PULL

- Move to higher reliance on water
- Towards highest return per megalitre
- Move to increase productivity of the system
- More efficient nutrient management

PUSH

- Climate change
- Driver of legislation
- Impact of cotton industry on water quality



WEIGHT

- How do we allocate water between stakeholders
- Political views
- Existing water sharing plans

R&D

Research Q/ Can the industry exist in the absence of limited water availability?

Forum outcomes and feedback

The outcomes from the forum were presented in late May by Jane Trindall to the Cotton grower panels considering CRDC R&D annual investments. Post forum we also asked participants to provide feedback on What you really enjoyed, what you though we could of done better and if you had any post forum light bulb moments. Your responses are summarized below.

1. What you really enjoyed ?

- The culture of the group and these meetings, which are collaborative and open, leads to great conversations and a safe space to challenge, test and stretch thinking. Always a great bunch to catch up with.
- I thought it was most interesting. Particularly enjoyed Steven Corks input. Well done on organising it. Good job.
- Really enjoyed the diversity of conversations and speakers – and I particularly found the panel session valuable.
- I really enjoyed the workshops – learning new skills and listening from others. Was also great to hear from the growers, researchers and other 'experts' in sustainability.
- I really enjoyed the workshops – learning new skills and listening from others. Was also great to hear from the growers, researchers and other 'experts' in sustainability.
- Overall I got a lot from the workshop, mostly from the various conversations at lunch and dinner.
- The future planning workshop was really interesting, and I think the framework is helpful to thinking about the direction of a number of fields in the coming years.
- I also really loved the range of presentations and it was really helpful to get a broad coverage of sustainability issues from the field all the way to the consumer.
- The whole idea of sharing info between researchers is great. I enjoyed hearing about other peoples projects and what they are researching, especially as some of the research is directly related to my research .
- -It was great to have such a diverse array of industry representatives in the room, and to be able to talk to growers regarding issues that affect them

2. What you thought we could have done better ?

- Sustainability panel discussion on the 2nd day - nnly at the very end did it really

get into the nitty gritty of what the panel discussion was about. Perhaps more directed facilitation could have helped get us there sooner - so the conversation could then have gone further potentially.

- I would have liked a little more time to explore the ideas generated in the workshops
- I think it was a little rushed but understand how travel impacts the agenda and time.
- I think you would have got a lot more ideas had you let the panel session on day 2 run longer.
- The future planning workshop – just in terms of having a bit more clarity as to the end point after the hour of each groups' discussion (just to direct the conversation about more)
- I think the panel should have had a NRM type person on it, and i would have like to been able to discuss the actual implementation of MyBMP, and how any environmental monitoring actually occurs in the industry, The cotton industry is really pro-active in research, but I'm not sure how this translates into actual environmental monitoring. It seems like lots of thought is given to research and looking at future scenarios. However on-going long-term monitoring of environmental impacts and change, and how these may be impacting on ecosystem services and water quality seem to be overlooked?
- The panel was really rushed, there were many questions from the room that couldn't be answered.
- I felt that the last day was too rushed, there wasn't enough time to really debate within our groups and get ideas down on paper.

3. *Any post workshop lightbulb moments ?*

- Follow up meeting with Cotton Info network the following week was really interesting and potentially productive in terms of what the industry might do with the resilience assessment.
- I was struck by the system-wide focus coming through - cotton's place within the landscape but also within the social, cultural landscape etc - and into the future.
- One of the things I've been musing over is what the future will look like as climatic patterns change (and given the news yesterday about the CO2 levels measured at Cape Grim, I'd say this is a sure possibility). A few people brought this up at a conference I was at, in particular the possibility of climatic patterns moving 'down' Australia, how that interacts with the soils we have and (together) how the combination of these things might influence how we manage the use of our soils. So will this change the geographical spread of the cotton

region? Or will business go on as usual?

- After the workshop a few of us had a quick think about the different ways in which different people understand sustainability, and really what motivates and drives people to 'become more sustainable' and how we fit this into our current system (largely driven by finance). (Alice's talk was really interesting in thinking about how consumer choices can have an impact on production of clothes and as a consequence influence social and environmental change). One thing that comes from this is how these views influence the way we manage some of our resources like soils.

Appendix 1 AGENDA

R&D Review: Responsible Landscape Management
5th-6th May 2016
Riverlife, Kangaroo Point, Brisbane

Purpose:

- Review CRDC's R&D investments
- Discuss the cotton industry's R&D needs
- Identify future directions for R&D and pathways to impact

Thursday 5th May 2016

12 noon	Arrive & lunch	
12.45pm-1.15pm	**Overview & purpose & R&D Plan obligations** 5mins **What will sustainability mean to the cotton industry in 2030?** 20 mins Q&A 5mins @ end	Jane Trindall CRDC R&D manager
1.15-1.45pm	**What is the latest research saying about sustainable cotton production in 2030?** • Bryce Kelly, UNSW • Francesca Andreoni, Bel Tempo • Kathryn Korbel, Macquarie Uni • Yvonne Chang, CSIRO	Presentation 5mins Q&A 10mins @ end
1.45-2.30pm	**Keynote speaker: How do we navigate a path to sustainable cotton industry in 2030?** Q/ What are future trends we should be aware of? Q/ What does this look like in 2030?	Steven Cork Futurist
2.30-3.20pm	**SHAPING FACTORS - DRIVERS** Cathy Phelps (DA) – *Dairy perspective* Alice Payne (QUT) – *Sustainability & fashion* Michael Murray (CA) – *Policy context* Steve Ainsworth (CSD) – *What NRM means to a cotton business*	10 mins Q&A 10 mins @ end
3.20-3.40pm	AFTERNOON TEA	
3.40 – 5pm	**FUTURING WORKSHOP**	Facilitator Stephen Cork
5pm	Thanks & close	

Dinner – Pony Restaurant

Friday 6th May 2016

8.45am	Welcome & overview	Jane Trindall CRDC R&D Manager
9.00am	**Keynote speaker:** **Creating sustainable value: Wagner's as a case study** 45mins (30mins talk 15mins discussion)	Tom Glasby Development Manager Wagner's
9.45am	**Sustainability Panel: Creating sustainable value to cotton businesses** What does sustainability mean to your business?	Facilitator: Brendan Griffiths, UNE **PANEL MEMBERS:** Simon Corish CA Board member Greg Kauter CRDC Board Ross Burnett Industry grower panel rep) Mark Palfreyman, Rivercare Champion Graeme Scheu, Mayor Goondiwindi Regional Council Chris Cosgrove Sustenance Asia
10.45am	MORNING TEA	
11.15am	**Workshop:** **PATHWAY TO IMPACT** – what does responsible landscape management look like to you? **R&D GAPS & DIRECTION**	Facilitators: Warwick Waters Jane Trindall
12.30pm	Thanks, close & lunch	

Appendix 2 Presentations : What is the latest research saying about sustainable cotton production in 2030?

UNSW AUSTRALIA

R&D Review: Responsible Landscape Management
5th-6th May 2016
Riverlife, Kangaroo Point, Brisbane

Never Stand Still | Connected Waters Initiative Research Centre

Lower Namoi Catchment / Gunnedah Basin
Condamine Catchment / Surat Basin

UNSW
A/Prof. Bryce Kelly (Project Leader)
Prof. Andy Baker
A/Prof Mike Manefield
Dr. Martin Andersen
Dr. Sabrina Beckman
Charlotte Iverach
Elisa Ginty
Mark Hocking

ANSTO
Dr. Dioni Cendón (Leader Groundwater Chemistry)
Stuart Hankin

Royal Holloway, University of London
Prof. Euan Nisbet
Dr. Dave Lowry
Dr. Rebecca Fisher
Dr. James France (now East Anglia)
Giulia Zazzeri

ansto | ROYAL HOLLOWAY | UEA University of East Anglia | Australian Government Cotton Research and Development Corporation | UNSW

Lower Namoi Catchment Groundwater Chemistry

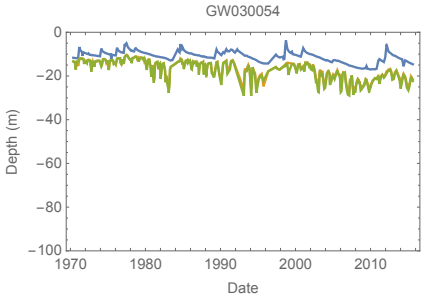
UNSW Australia Bryce Kelly, Charlotte Iverach, Elisa Ginty, Mike Manefield, Sabrina Beckman, Martin Andersen
ANSTO Dioni Cendon, Stuart Hankin

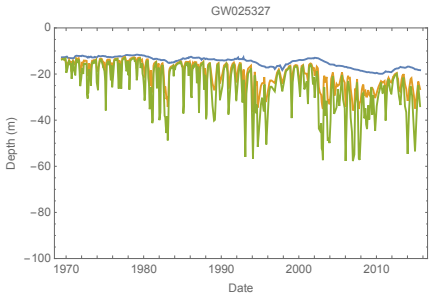
- 30 sampling points in Narrabri, Wee Waa and Pilliga regions: shallow and deep alluvial aquifers, plus Great Artesian Basin and NSW Government coal bores.
- Monitoring bores (wells) fully pumped before sampling. No use of passive samplers, which will yield distorted results under low flow conditions.
- Summer and Winter surveys (1st summer done)
  - Summer: aquifer stressed due to irrigation pumping season
  - Winter: the groundwater levels have recovered
- Major ion chemistry
- Trace element chemistry
- Age dating (isotopes)
- Microbiological analyses
- Analysis of dissolved gases in groundwater: methane plus other hydrocarbons
- UNSW has the only LGR dissolved gas extraction unit in Australia.

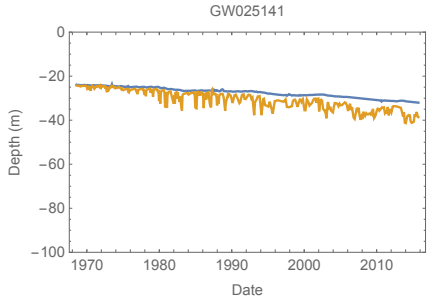
ansto | UNSW

CottonInfo Information when you need it

Groundwater Levels







- Review the impact of the water sharing plans
- Managed Aquifer Recharge – use Nature's Dams – replenish the system during floods
- BIG DATA at the catchment scale: optimised catchment water use

UNSW

Soil beneficial bacteria and archaea

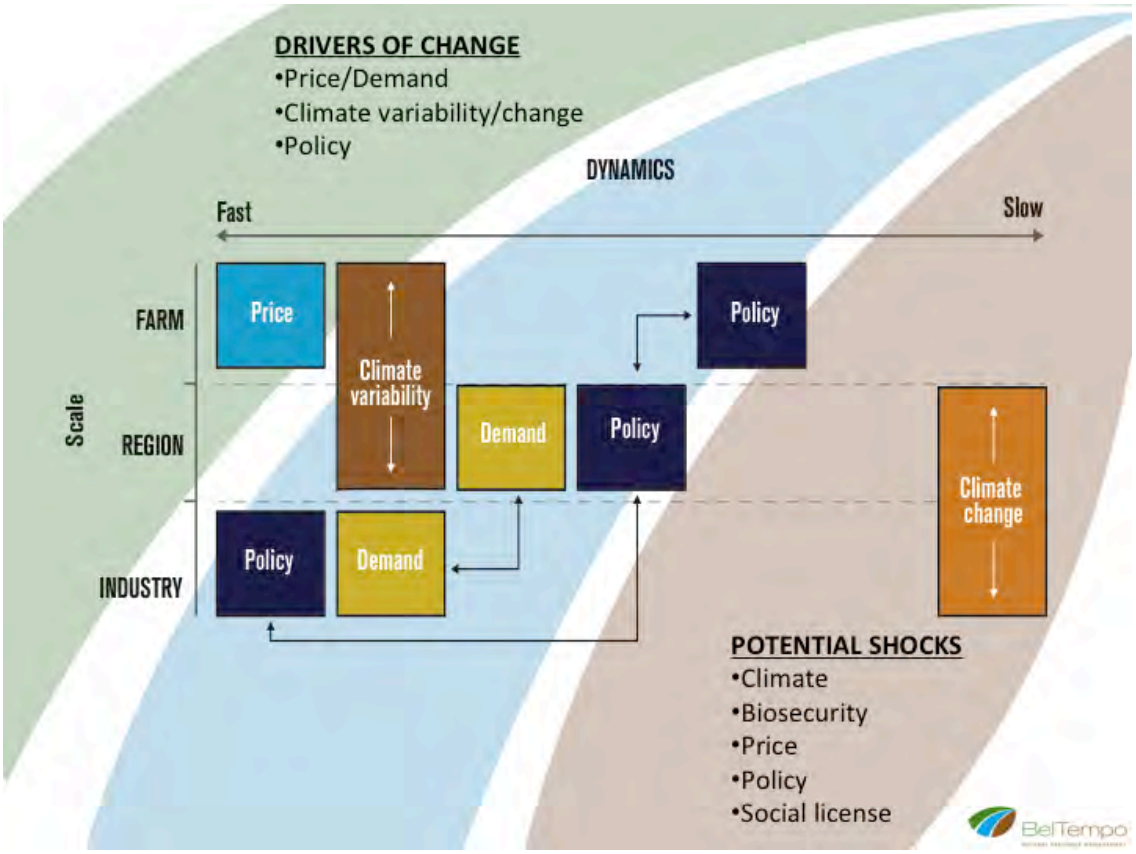
- To help address some of our questions when examining methane data we started looking at the microbiology of soils and groundwater.
- Farming has dramatically altered the microbiological ecological community. Soil microbiological populations have declined in both density and complexity.
- Ivan Kennedy was right on the money a decade ago:
  - Plant growth promoting rhizobacteria
    - Stimulate plant growth through the production of hormones
    - Efficient nutrient use (N and P)
    - Improved disease resistance
    - Greenhouse gas reduction

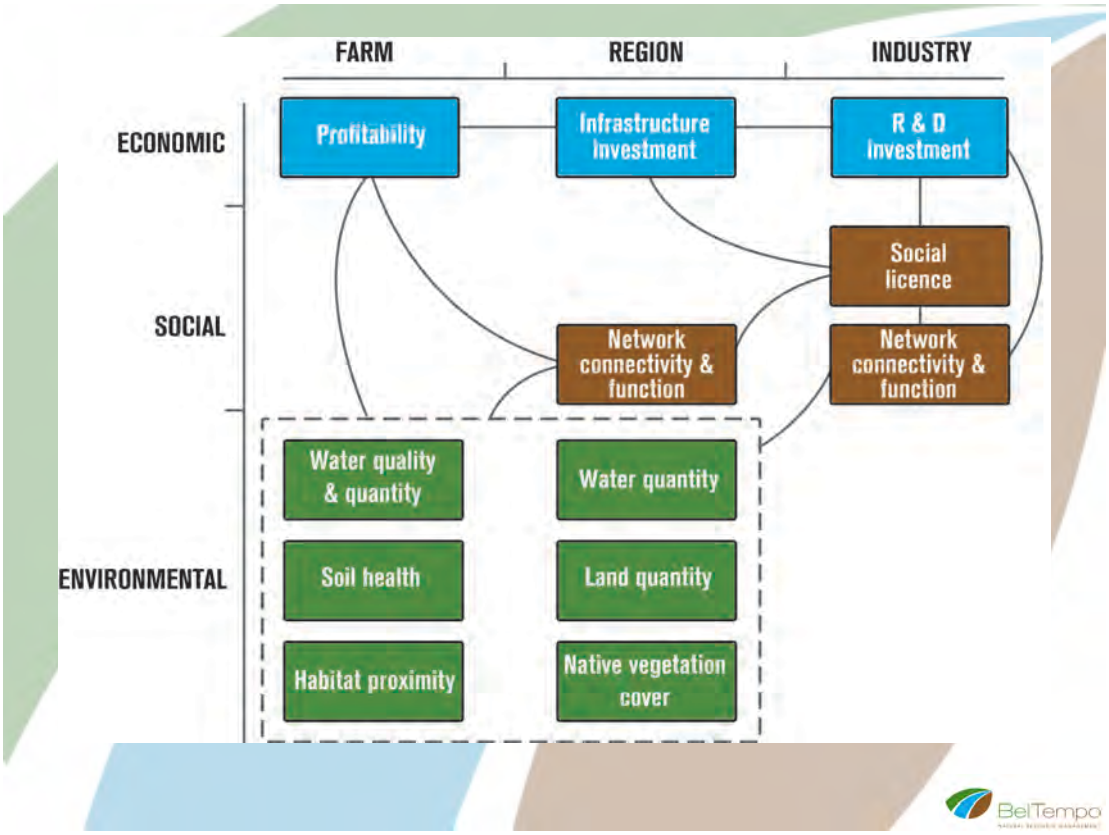
UNSW

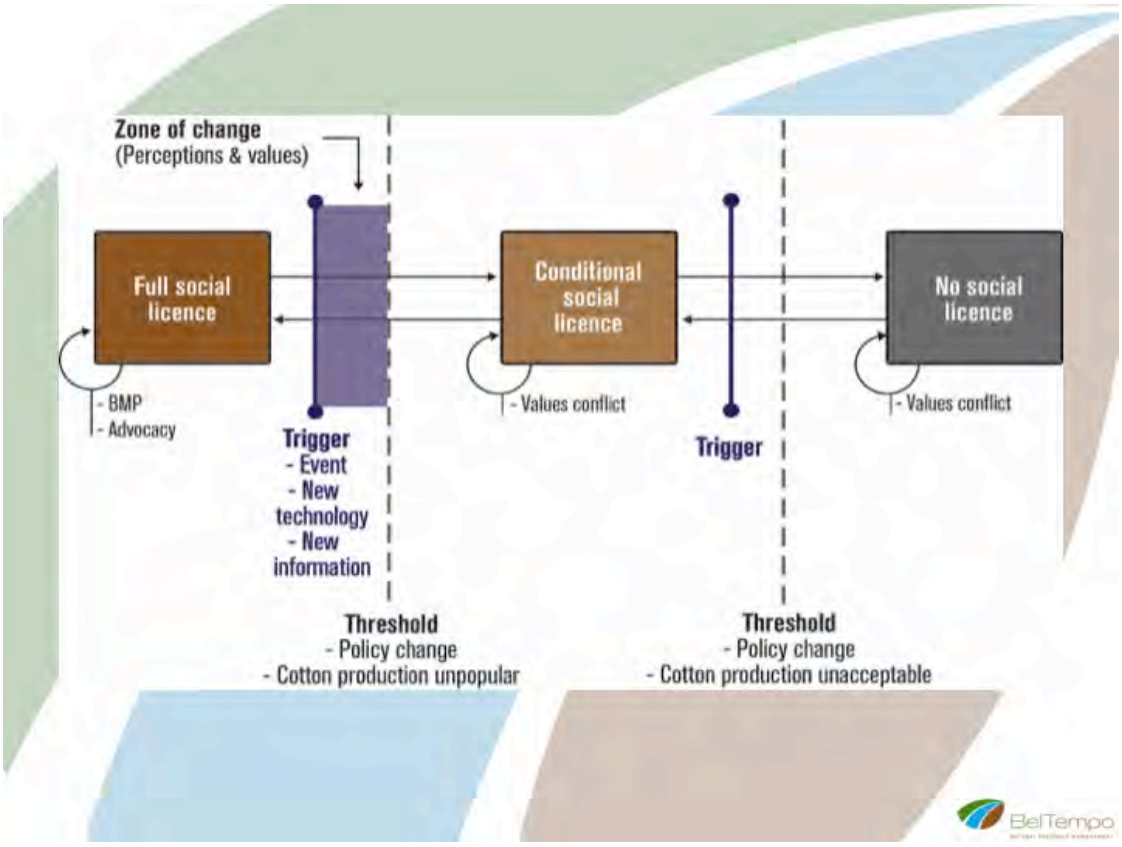
Resilience Assessment of the Australian Cotton Industry at Multiple Scales

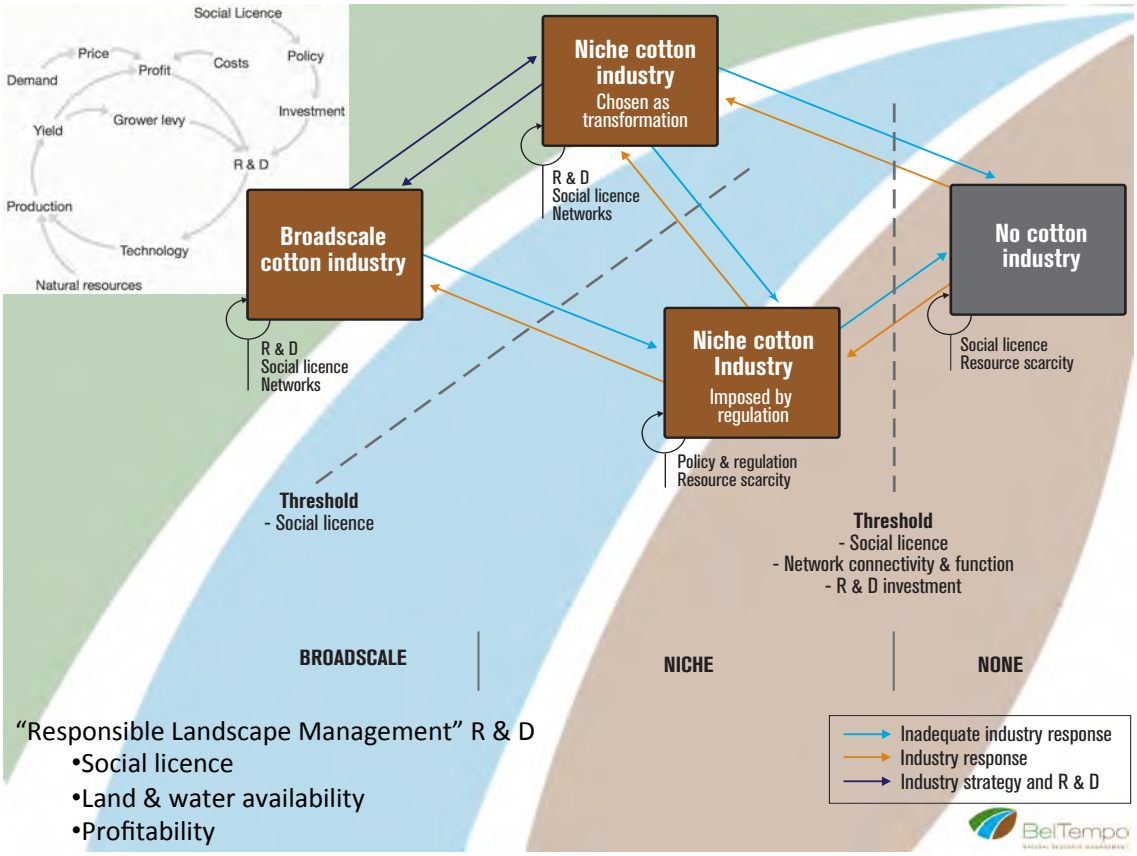
Insights for sustainable cotton production in 2030

Francesca Andreoni
Bel Tempo NRM




FARM
REGION
INDUSTRY
ECONOMIC
SOCIAL
ENVIRONMENTAL
Profitability
Infrastructure Investment
R & D Investment
Social licence
Network connectivity & function
Network connectivity & function
Water quality & quantity
Water quantity
Soil health
Land quantity
Habitat proximity
Native vegetation cover
BelTempo


Zone of change
(Perceptions & values)
Full social licence
- BMP
- Advocacy
Trigger
- Event
- New technology
- New information
Threshold
- Policy change
- Cotton production unpopular
Conditional social licence
- Values conflict
Trigger
Threshold
- Policy change
- Cotton production unacceptable
No social licence
- Values conflict
BelTempo



"Responsible Landscape Management" R & D
- Social licence
- Land & water availability
- Profitability

Why are groundwater ecosystems important?

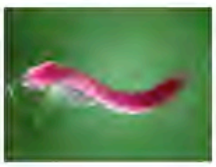
MACQUARIE University

Water flow

- Stygofauna burrowing creates channels
- Microfauna grazing reduces bacterial clogging

Water quality

- Microbes breakdown organic matter (incl pesticides /fertilisers)
- We have detected denitrifying bacteria in groundwaters



Role in surface river health

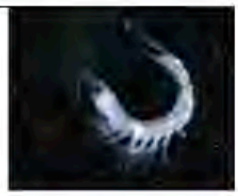
→ Ecological & ecosystem service values

Measuring groundwater health

MACQUARIE University

Biological indicators

- Stygofauna
- Microbes: metagenomics

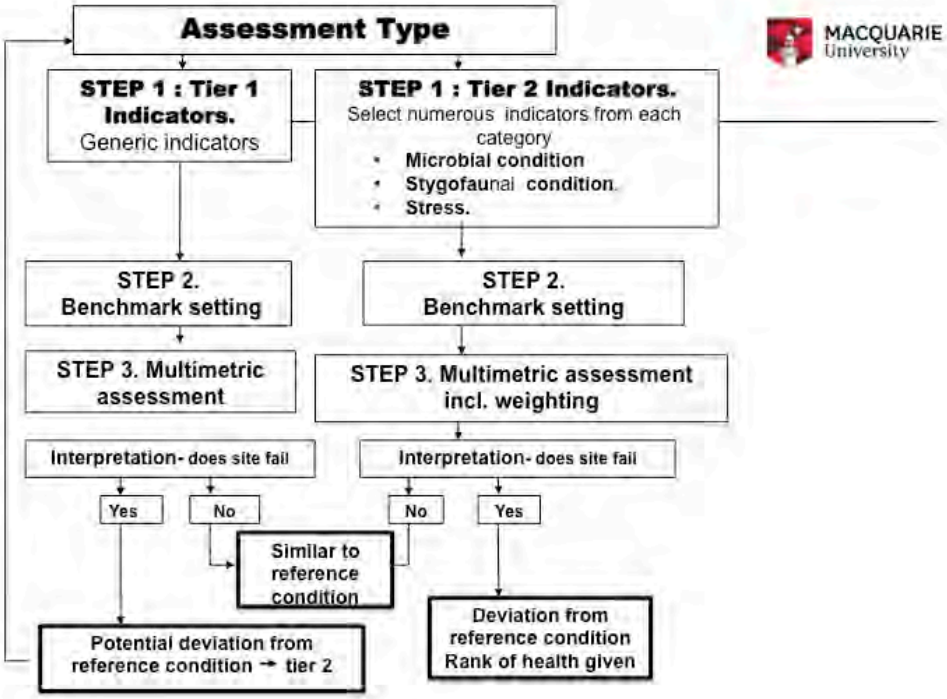


Water chemistry indicators

- Nitrates
- Dissolved oxygen

Indicators of stress

- Evidence of pesticides
- Biotic stress indicators



MACQUARIE University

Outcomes

Collaboration with UNSW Connected Waters team

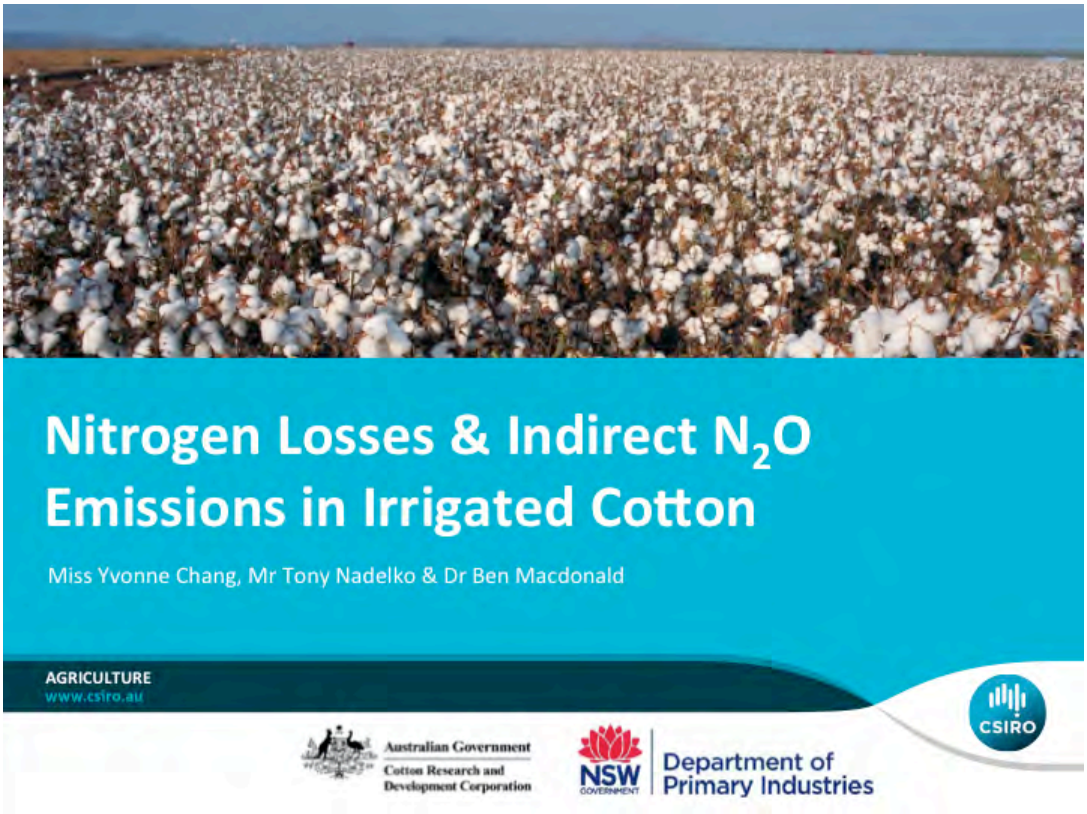
- Hydrological factors influencing GW organisms
- How stygofauna & microbes respond to surface-groundwater changes

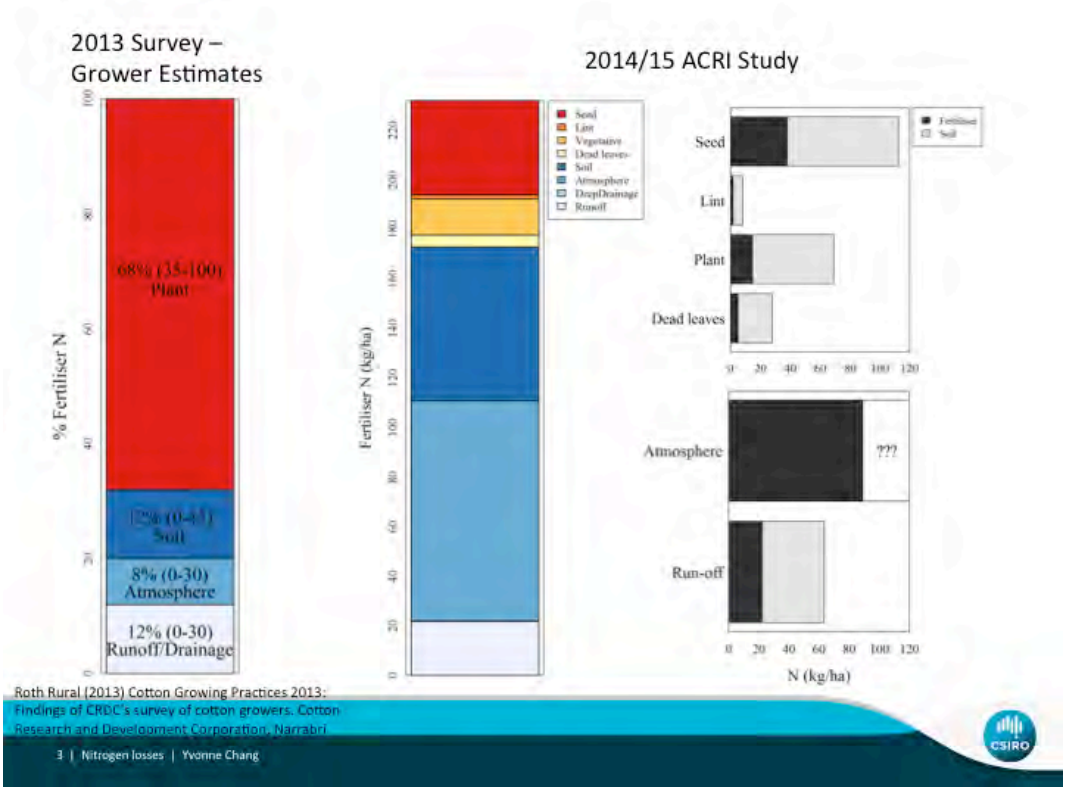
DNA analysis shows microbial diversity & function

- Results indicate a potentially important role in nitrogen cycle, specifically in aiding nitrate removal.

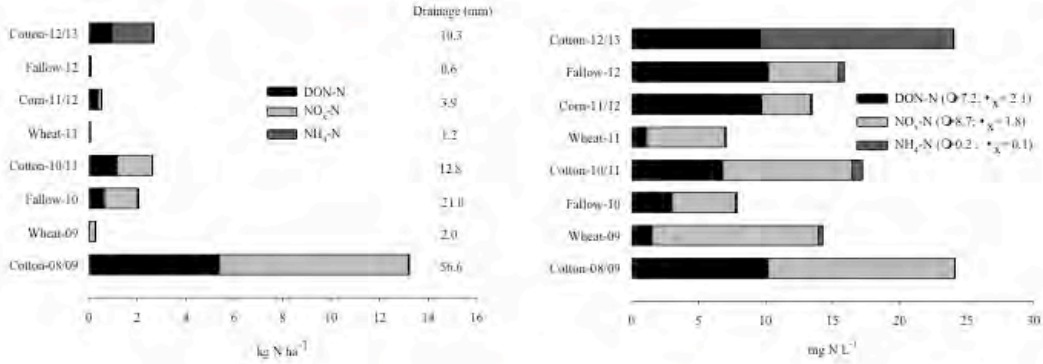
The groundwater health index

- Provide the industry with a tool to monitor groundwater health.
- Identify causality?


Nitrogen Losses & Indirect N_2O Emissions in Irrigated Cotton
Miss Yvonne Chang, Mr Tony Nadelko & Dr Ben Macdonald
AGRICULTURE
www.csiro.au
Australian Government
Cotton Research and Development Corporation
NSW GOVERNMENT
Department of Primary Industries
CSIRO


2013 Survey – Grower Estimates
% Fertiliser N
68% (35-100) Plant
12% (0-43) Soil
8% (0-30) Atmosphere
12% (0-30) Runoff/Drainage
2014/15 ACRI Study
Fertiliser N (kg/ha)
Seed
Lint
Vegetative
Dead leaves
Soil
Atmosphere
DeepDrainage
Runoff
Seed
Lint
Plant
Dead leaves
Atmosphere
???
Run-off
N (kg/ha)
Roth Rural (2013) Cotton Growing Practices 2013: Findings of CRDC's survey of cotton growers. Cotton Research and Development Corporation, Narrabri
3 | Nitrogen losses | Yvonne Chang
CSIRO

Deep Drainage

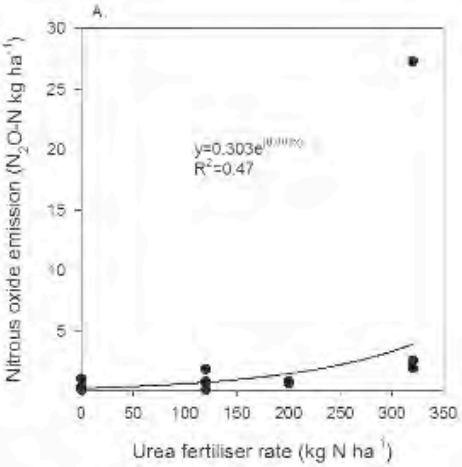


Atmospheric Emissions

N2O/N2 mole fraction = 0.024 (Rochester, 2003)

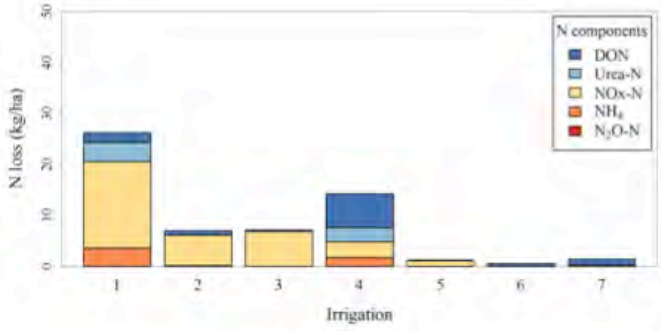
This means that of the 89kg lost from our plot approximately 2.09 kg was lost as N2O-N.

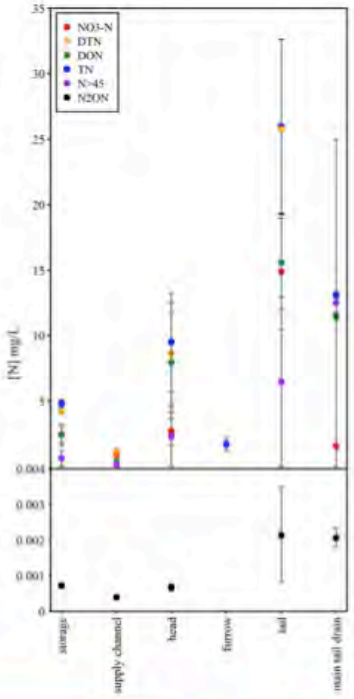
Under higher N rates, emissions of N2O-N are greater.



Macdonald BCT, Rochester IJ & Nadelko A (2015) High yielding cotton produced without excessive nitrous oxide emissions. Agronomy Journal. 107: 1673-1681

The Irrigation Network.





Indirect N_2O Emissions

IPCC = EF_5 x TN lost

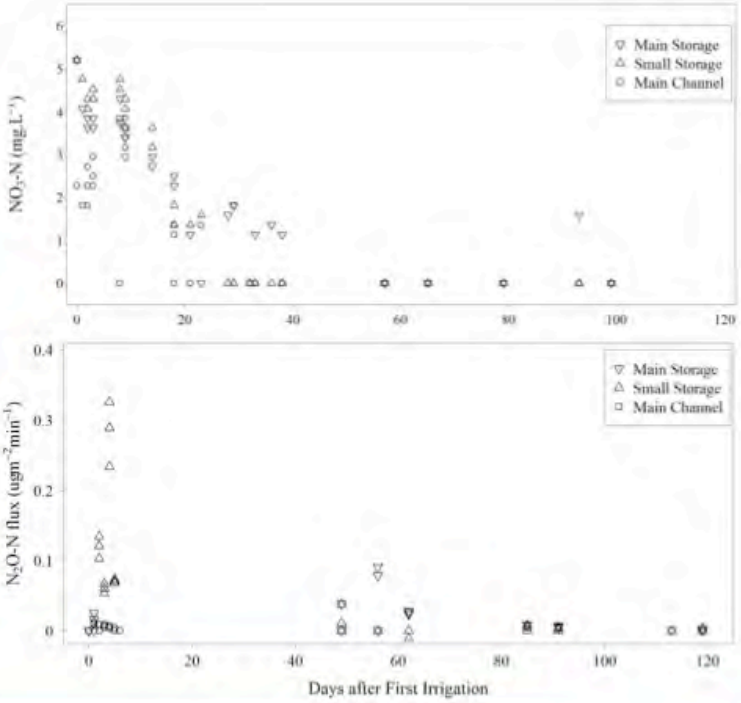
Rough Calc. assuming 10% loss from 250N plot.

0.0025 x (0.1*250N) = 0.063 kg N_2O-N

Estimate based on storage flux

Rough Calc. assuming mean rate of emissions is constant between sample points.

~ 0.25 kg N_2O-N



CottonInfo Information when you need it

Take home messages

- More fertiliser N is lost than we might expect.
- The soil provides more than half of the plant N.
- Indirect N2O emissions from irrigated cotton may be larger than IPCC EF5r estimates

  BUT the are no clear relationship between indirect N2O emissions and other water chemistry parameters.

Where to now?

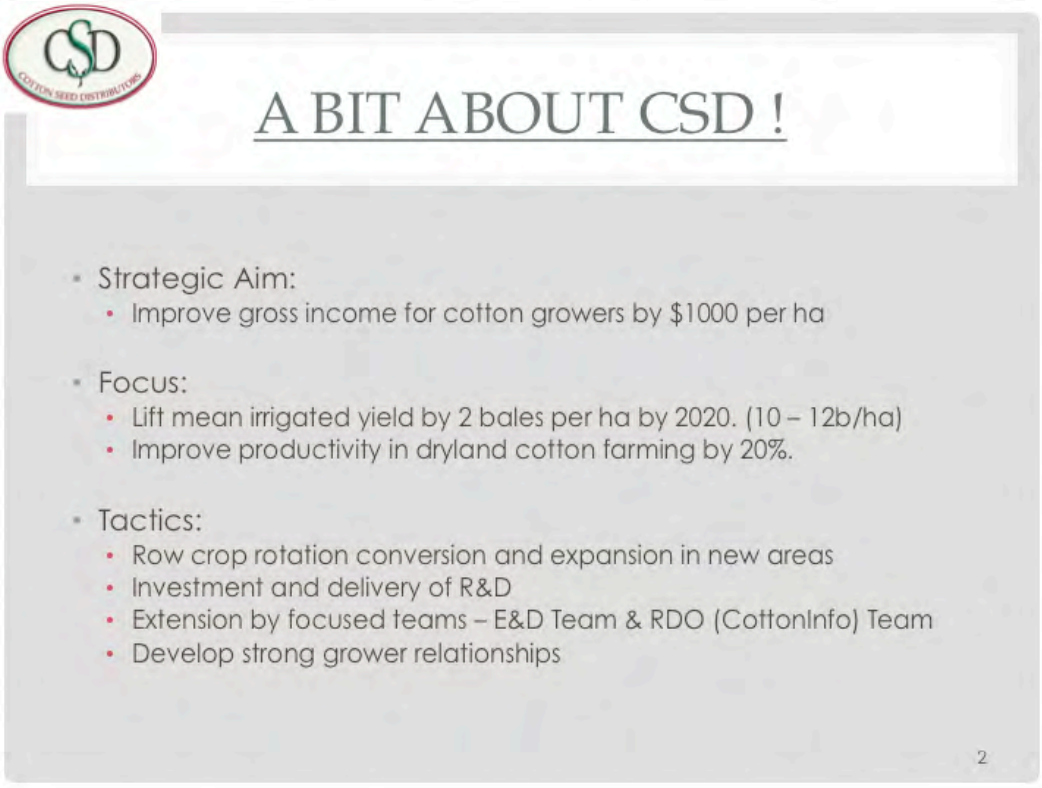
- How does the N balance change at higher (or lower) N rates?
- What is the fate of N that enters the irrigation system?
- Are we reducing soil N over time?
- What does controls indirect N_2O emissions?

Appendix 3 Presentations - Shaping Factors – Drivers

'A Business Perspective on Natural Resource Management'

Responsible Landscape Forum
Brisbane – 5th May 2016

Stephen Ainsworth
sainsworth@csd.net.au



A BIT ABOUT CSD !

- Strategic Aim:
  - Improve gross income for cotton growers by $1000 per ha
- Focus:
  - Lift mean irrigated yield by 2 bales per ha by 2020. (10 – 12b/ha)
  - Improve productivity in dryland cotton farming by 20%.
- Tactics:
  - Row crop rotation conversion and expansion in new areas
  - Investment and delivery of R&D
  - Extension by focused teams – E&D Team & RDO (CottonInfo) Team
  - Develop strong grower relationships

2

THE PRODUCTIVITY LENS

- NRM is a Customer Enabler
- Long term importance – provides FTO to grower and industry per se.
- Commercially, growers are able to reliably grow cotton and therefore purchase CSD's products and services for the long term.
- Enables CSD to continue to invest in R,D&E for the industry.
- Business viability for growers and hence CSD.
- Aids social license to industry.

Efficient NRM = Better Productivity = Win:Win

WHAT ROLE DOES CSD PLAY ?

'Our products, technologies and services contribute to practical NRM outcomes from 3 perspectives'

Products – principally cotton germplasm / cultivars and chemistry.
- The breeding pipeline is aligned to deliver against primary needs Yield, Fibre Quality, Disease Tolerance & Adaptation.
- Chemistry – crop protection & enhancement from biotic stresses (early season)

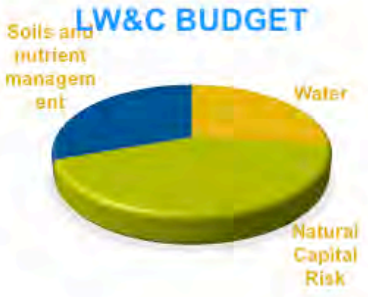
Technologies – protect and enhance yield.
- CSD is positioned to deliver future biotech solutions from in house and licensed third party organizations.

Extension – engage with growers and advisor.
- Ensure our products and services are leveraged to generate value for growers and the industry.

RD&E priorities

Dairy Australia
Your Levy at Work

- Natural Capital Risk and Climate Change
  - Climate risk
  - Sustainability assessment
  - Regional support
  - Biodiversity
  - Energy
- Soils and nutrient management
- Water



Two key drivers

Cost and accessibility of natural resources

Market, investor and community expectations

...."the Australian dairy industry is the first industry to be deemed a sustainable supplier at a country level by Unilever"

Social license to operate

Dairy Australia
Your Levy at Work

Australian Dairy Industry Sustainability Framework

Australian Dairy Industry Sustainability Framework Progress Report 2013

Summary

Enhancing livelihoods

1. Creating industry prosperity
2. Supporting communities
3. Investing in dairy people

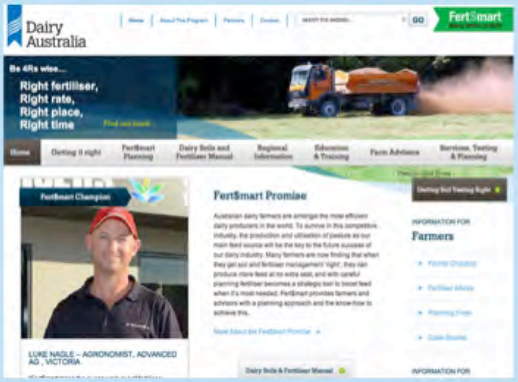
Improving wellbeing

4. Ensuring health and safety
5. Maximising nutrition
6. Caring for our animals

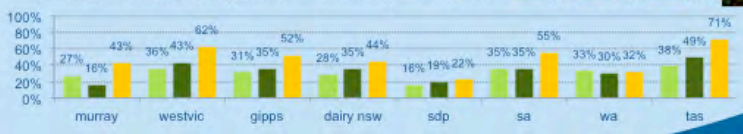
Reducing environmental impact

7. Minimising our environmental footprint

Achieving change through integration into mainstream D&E



Percentage of farms using a fertiliser management plan

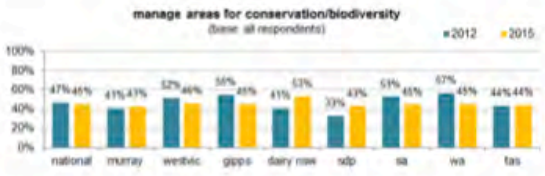


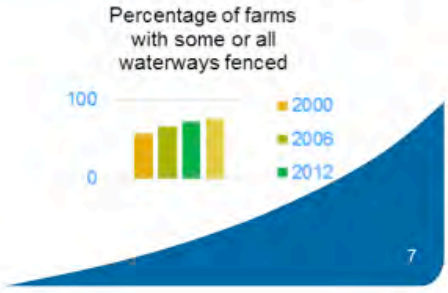
6

Dairy Australia
Your Levy at Work

Challenges

Biodiversity



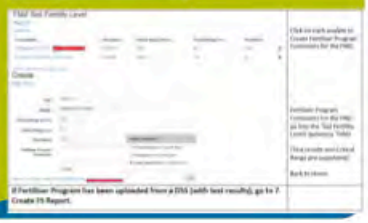


Dairy Australia

Reporting

Aim:
Enter data only once for multiple outcomes:

- **Carbon**
- Water use efficiency
- Fertiliser recommended/ applied
- Natural Capital Risk assessment



CottonInfo **Information** when you need it

Where next?

Maintain focus on efficiency and integration into mainstream programs

Continue to engage with market, investor and community expectations

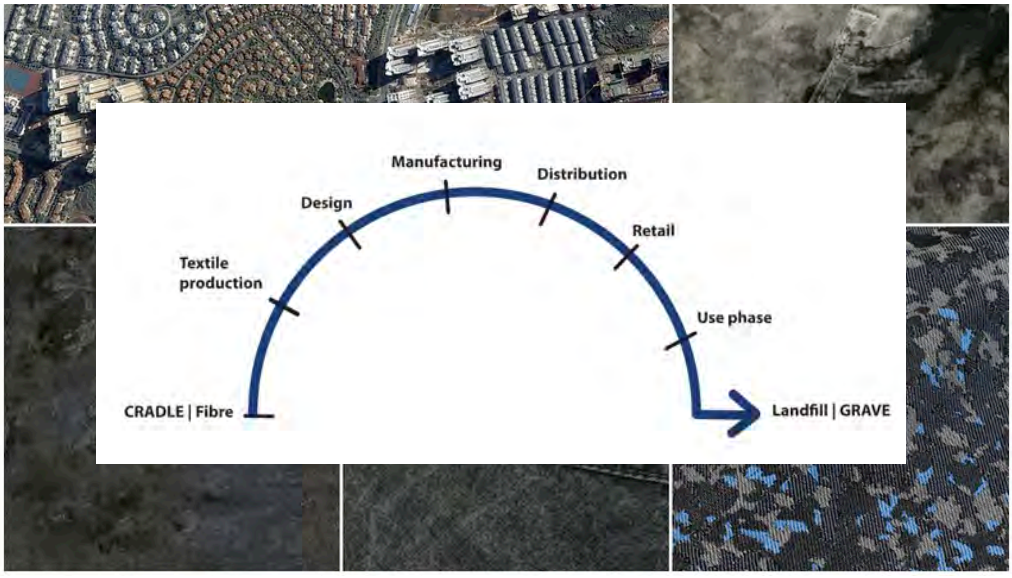
Incorporate Climate risk: estimated 1% annual productivity increase required to stay still

9

Sustainability and Fashion
May 2016
Dr Alice Payne - - Fashion, School of Design, CI QUT

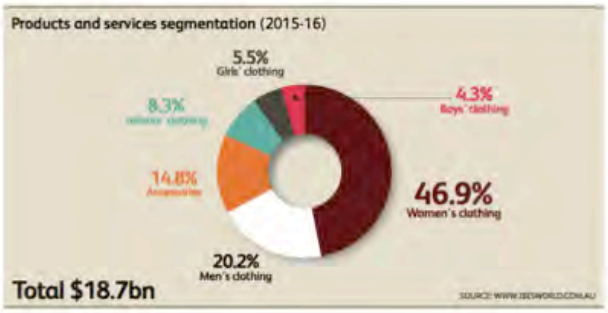
Above: Fashion Revolution Day promotional material, April 24 2016

Context – the fashion paradox



Above: WGSN S/S 2016 Material forecast: Eco-Active; Payne, garment life cycle

Clothing retail in Australia – 2015-16

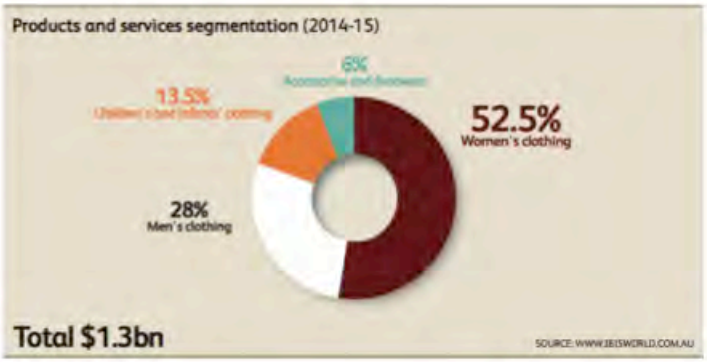


Revenue	Annual Growth 11-16	Annual Growth 16-21
$18.7bn	3.3%	1.2%
Profit	**Wages**	**Businesses**
$709.3m	$3.5bn	12,785

1.2 billion items of apparel imported from China annually (2012 figures)

IBISWorld report

Fast Fashion in Australia 2014-15



Market Share

Cotton On Clothing Pty Ltd 32.4%

Fast Future Brands Limited 23.1%

Group Zara Australia Pty Limited 18.4%

Revenue	Annual Growth 10-15	Annual Growth 15-20
$1.3bn	10.1%	11.0%
Profit	**Wages**	**Businesses**
$173.2m	$260.4m	24

IBISWorld report

2007: world apparel fibre consumption 67.7 million tons, cotton 36.3%, cellulosic fibres: 4.6%; synthetic fibres 55.5% / 2015: world fibre consumption 95.6 million tons, cotton: 25.2%; cellulosic fibres, 6.4%, synthetic fibres 62.1% (Source: ICAC 2013, Lenzing 2015)

1. Increased consumer scrutiny and demand for transparency

2013: Rana Plaza collapse, Bangladesh

http://graphics8.nytimes.com/images/2013/05/02/opinion/burial/burial-sfSpan.jpg

- 1127 deaths in Dhaka factory collapse
- The Bangladesh Accord on Fire and Building Safety signed by over 200 global brands
- Annual Fashion Revolution Day movement via social media – 'Who Made Your Clothes' – in 2016, engagement from consumers in 89 countries petitioning brands for greater transparency and accountability.
- Australian Fashion Report published annually since 2013 with wide media exposure

Baptist World Aid Australia: The Australian Fashion Report 2013 - 2016

Download the report: http://www.baptistworldaid.org.au/assets/Be-Fair-Section/FashionReport.pdf

Child and forced labour in cotton production, 2015 report

http://www.baptistworldaid.org.au/assets/Be-Fair-Section/FashionReport.pdf

CottonInfo **Information** when you need it

Cotton On Group | Traceability
(Cotton On, Cotton On Body, Cotton On Kids, Factorie, Rubi, Supre, T-Bar)

Traceability is a significant challenge for most apparel companies, with very few managing to trace the origins of their cotton. The Cotton On Group has taken an innovative approach in tackling this challenge, by partnering with the Business for Development to invest in cotton farming in Kenya. This new, sustainable cotton initiative aims to deliver significant financial and environmental benefits to farming communities in Kenya. It is also an important move towards full traceability for the Cotton on Group supply chain, as it provides confidence in the knowledge that the cotton has been sustainably sourced.

The initiative provides hundreds of farmers with support to setup or progress to set up cotton farms, as well as training and education on sustainable and environmentally-friendly farming techniques. The Cotton on Group has committed to purchasing sustainable cotton from the farmers to integrate into its supply chain.

As part of the initiative, the Cotton on Group is also utilising independent third party auditors to conduct raw materials specific audits on the farms. These audits will underpin further training and education in areas including (but not limited to) workplace safety, minimum wage and fair working hours.

With more than 500 farmers expected to be involved in the initiative by the end of this year, the Cotton on Group is working towards a goal of 10,000 farmers by 2020; eventually integrating sustainable cotton across each of its six apparel brands.

COTTON:ON®
KIDS
T Bar
rubi
BODY
factorie
Typo
supré

Download the report: http://www.baptistworldaid.org.au/assets/Be-Fair-Section/FashionReport.pdf

The True Cost (2015)

Launched worldwide with multiple public screenings and panel discussions in Sydney, Melbourne and Brisbane

Highlights waste, overconsumption and labour abuses in industry

Reviews and features in major international papers e.g. Guardian, New York Times

Now showing on Netflix, available ITunes

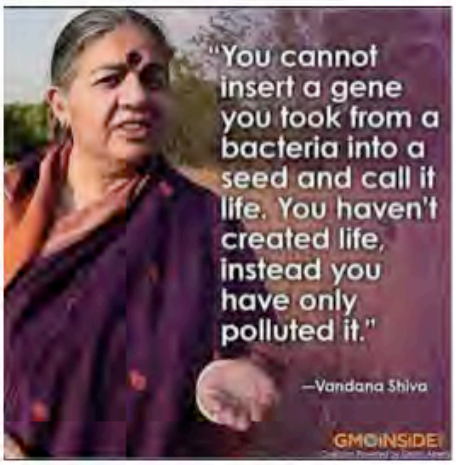
Included statements such as:

- 250,000 Indian cotton farmers have committed suicide in the past 15 years due to going into debt to purchase genetically modified cotton seeds, with Vandana Shiva Indian environmental activist interviewed
- Interview with US organic cotton farmer who links her husband's death from cancer to cotton pesticides

"THE TRUE COST IS A STUNNING AND ILLUMINATING FILM. THIS MOVIE IS GOING TO SHOCK THE FASHION WORLD!"

- HARVEY WEINSTEIN

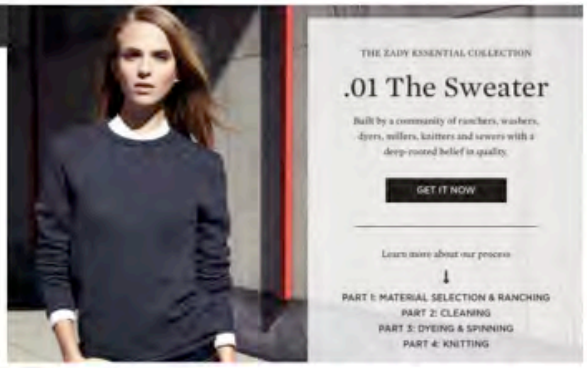
THE TRUE COST



Traceability as brand story

Left: Zady – traceable, allowing customers to follow every aspect of production from fibre to textile to manufacturing

Below: Premium brand Nudie jeans production guide



- Nike – lists suppliers on website, 692 factories in 42 countries
- H&M – direct & 2nd tier suppliers' names and addresses
- Honest By – shows *everything* from listing all suppliers to price calculations
- Patagonia – Footprint Chronicles
- Rapanui – traceability through supply chain

2. Reducing waste, promoting transparency: Trends in fibre and textiles for fashion

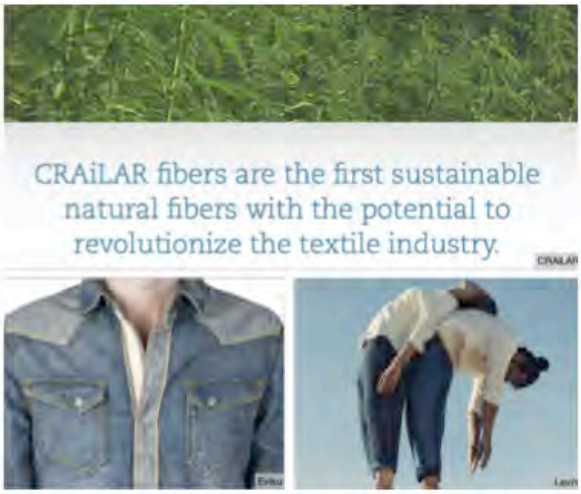
CottonInfo **Information** when you need it

Materials sustainability index

50 point scale, higher the better: Lyocell, 30.2; silk, 29.7; RPET 28.7; **organic cotton fabric, 28.2**; **cotton knit, 26.6**; Polyester 23.3, hemp 22.5; **cotton woven 20.4**, acrylic, 19.7, wool fabric, 18.8; rayon/viscose bamboo, 18.3; rayon/viscose wood, 17.3

http://msi.apparelcoalition.org/#/materials/478

- Raw for the oceans – Gstar Raw and Bionic Yarn's collection using 10 tons recycled plastic
- Crailar fibres in denim – flax – company claims 99% less water used than cotton and better wicking
- Increased use of Tencel and recycled MMF fibres in denim
- Organic cotton and sustainable cotton (e3) a focus for premium denim brands
- Cottoned on UK initiative partnering with Marks and Spencers
- Sustainable Cotton Project (US)



Sustainable denim trends

- Return to Made in America branding for premium denim
- Transparency of production at Cone Mills denim, one of the last remaining makers of selvedge denim in the US
- Cone Mills and Sustainblue denim comprised of recycled polyester and recycled cotton.

New localism – 'Made in America' and trends in premium denim

Cone denim: https://www.conedenim.com/sustainblue/

New localism – 'Made in Australia'

"More and more we know our customers want transparency around where our collections are made." – Adam Lloyd, Jeanswest GM of Product
Designed, sourced and made in Australia, the collection consists of denim jeans, 100% cotton tees and fleece sweaters, merino wool beanies and scarves, socks, leather belts and suede desert boots. **Cotton knitted and dyed in Melton, Victoria**

H&M and the sustainable fashion paradox

3900 stores in 61 countries

Plans to open 55 new stores in Aus in next 5 years

Aim to have all cotton from sustainable sources: organic, recycled & BCI by 2020

Sells 500 million items of clothing per year

World's biggest buyer of organic cotton

Promotes Conscious range

Recycling promoted with in house collection scheme

Publishing suppliers' names

Sells $3 t-shirts

Founding member of Sustainable Apparel Coalition

H&M launches recycled denim collection in 2014, using material from in-store donations

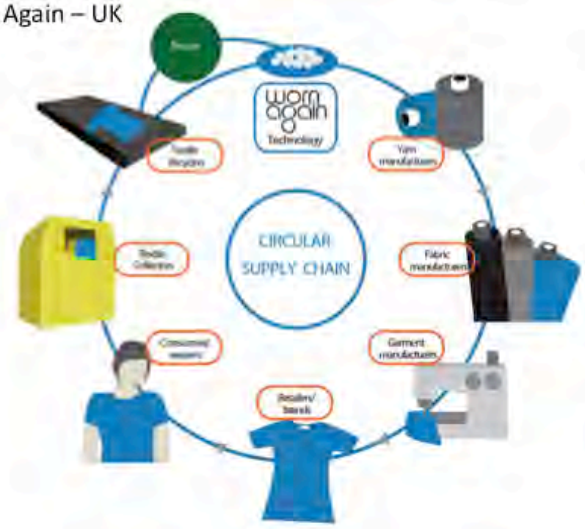
Collection uses max 20% recycled cotton fibres to preserve quality

2015: launches $1 million euro prize seeking textile recycling innovations

H&M's recycling initiatives: https://youtu.be/N3QYJuu2vy0

Looking ahead: recycling and closing the loop

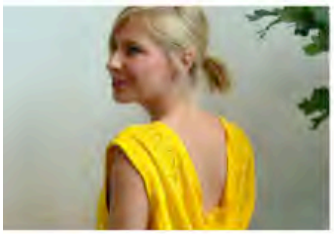
Worn Again – UK

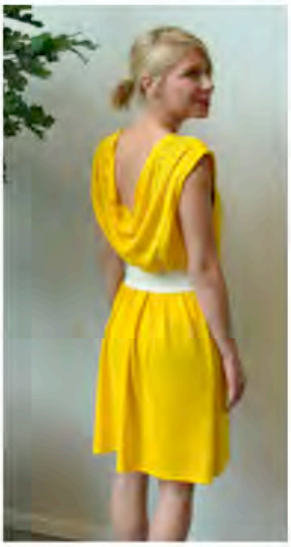


- Textile to textile chemical recycling technology
- Technology reportedly overcomes barriers such as how to separate blended fibre garments; and how to separate dyes and other contaminants from polyester and cellulose
- Partnering with Kering (second biggest luxury conglomerate) and fast fashion giant H&M

Worn Again founder, Cyndi Rhoades: "I don't think cotton will be obsolete, but I see it becoming a luxury item... Our vision for the future would be to recycle everything that already exists into new clothing so we don't need to generate any more waste" (WGSN Futures 2030 report, 2015, 9)

CottonInfo Information when you need it





- Swedish company Re:newcell can recycle textiles with a 95% + cellulosic content such as cotton or viscose.
- The material is then dissolved in a solution which doesn't destroy the cellulosic chains, and the non-cellulosic material is removed.
- New lyocell fibre can then be produced from what remains.

100% recycled cotton using the Lyocell process

WGSN: http://www.wgsn.com.ezp01.library.qut.edu.au/content/board_viewer/#/54655/page/1 , http://renewcell.se/

The future of fashion?

Greener, cleaner, with less waste
Greater brand scrutiny
Sustainability as a baseline?

Aboce: Fashion Transparency Index report, 2016:

Appendix 4 How do we navigate a path to sustainable cotton industry in 2030? Steven Cork, Futurist

CRDC NRM Research Summaries, May 2016

River red gums in cotton landscapes

Dr Rhiannon Smith, University of New England, Armidale

What are you researching?

Over the past ten years, we have illustrated the value of river red gums in providing a range of ecosystem services, including carbon sequestration and storage, erosion mitigation and biodiversity conservation. River red gums also capture the hearts and minds of Australians, inspiring art and poetry and playing an important spiritual role for indigenous cultures. As such, river red gums are an easily identifiable icon species and an important focal point for monitoring riparian health and condition. However, dieback of river red gums in a number of cotton catchments has become a concern for cotton growers and the wider community, with the cause of this dieback remaining uncertain. Tree dieback impacts biodiversity conservation value and carbon sequestration rates. As such, this project is investigating the causes of river red gum dieback and management strategies to improve tree health to maximise ecosystem service provision.

What have you found?

Our research has shown that well-managed, good condition river red gum ecosystems on cotton farms provide important habitat for threatened and declining woodland birds. Riparian areas provide biodiverse, structurally complex, well-connected habitat and are therefore home to species that are not found elsewhere on the floodplain. Important species found in riparian areas on cotton farms include black-chinned honeyeater, crested bellbird, rufous whistler, red-capped and eastern yellow robins, jackie winter and brown treecreeper. In addition, riparian areas are highly productive and sequester and store large amounts of carbon. We found 300 tonnes of carbon per hectare stored in river red gum woodland near Narrabri, and sequestration rates during La Niña conditions of 2.5 tonnes of carbon per hectare each yr. This carbon stabilises soils and riverbanks, stopping slaking and dispersion of soil aggregates, and reduces sediment yields into river systems.

We are currently measuring tree water use and water potential (stress) under a range of conditions, including different restoration scenarios commonly employed in riparian zones on cotton farms. This investigation will provide information on how trees in different situations respond to environmental conditions (e.g. temperature changes, rainfall, river flows, changes in groundwater levels) and determine if restoration has any impact on tree health. We have recently completed a study into circumferential variation in water use rates on different axes of large old trees to get a better handle on overall tree water use.

Why is it important?

Ecosystem services are vital for sustainable agriculture and general well-being of rural communities. Many ecosystem services provided by river red gum vegetation communities contribute directly to agricultural productivity, such as nutrient cycling, water filtration, breakdown of chemicals, natural pest control and pollination. In addition, cotton growers can illustrate good environmental management and stewardship by conserving biodiversity on farms. Environmentally conscious consumers demand sustainably produced products, and minimising carbon footprints is one way growers can illustrate their commitment to this goal.

How can I apply/what should I do about it?
Well-managed, good condition riparian areas are an integral part of healthy catchments and sustainable agricultural landscapes. Growers who can maintain healthy trees, good groundcover, diversity of native plant species, complex habitat structure and connectivity will benefit from the services provided by riparian ecosystems.

Where to go for more information
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Riparian vegetation and land management

Dr Sam Capon & Dr Stephen Balcombe (Griffith University)

What are you researching?
We are investigating where, when and how riparian vegetation regeneration occurs across the northern Murray-Darling Basin. We are examining spatial patterns in plant dispersal, germination, seedling establishment and reproduction at sites across the MacIntyre/Weir Rivers, the Balonne River and its tributaries, and the Barwon-Darling. Our research aims to identify which factors are important in driving these patterns including hydrology, tree canopy cover, ground cover, grazing etc.

What have you found?
Very few seedlings of river red gum (Eucalyptus camaldulensis), coolibah (E. coolabah) or lignum (Duma florulenta) have been recorded during our surveys. In contrast, river cooba (Acacia stenophylla) seedlings have been abundant and widespread. Significant numbers of whitewood (Atalaya hemiglauca), creek wilga (Eremophila bignoniiflora) and weeping myall (Acacia pendula) seedlings have also been observed. Our research indicates that soils, surface litter and animal droppings all provide important sources of propagules for vegetation regeneration in these habitats. Litter appears to be a particularly significant source for woody species, including eucalypts. Our experiments highlight canopy cover and litter load as key drivers of local vegetation dynamics. Shade, for example, appears to enhance the diversity and abundance of understorey vegetation under drier conditions while, under wetter conditions, leaf litter inhibits seedling emergence from riparian soil seed banks that, according to our experiments, are dominated by weed species.

Why is it important?
In comparison to many other ecosystems, riparian systems provide a disproportionately high number of ecosystem functions, goods and services with respect to the area they cover, e.g. provision of habitat to terrestrial and aquatic wildlife, riverbank stabilisation, water filtration etc.. Our research seeks to inform both water resources management and riparian land management so that these benefits can be best protected and enhanced.

Our results indicate that riparian vegetation in the northern Murray-Darling Basin has the potential to change considerably and may already be undergoing a shift. Relatively narrow bands of taller and more open Eucalypt dominated riparian woodland that fringe many channels in the

region, for example, may be encroached upon by shrubby, fast-growing and more terrestrial woody species. Woody thickening is currently a global phenomenon that has been observed in a wide range of ecosystems, especially in dryland regions, and is often attributed to increasing concentrations of atmospheric carbon dioxide. Our research suggests that the scope for such vegetation change can also be strongly influenced by local factors, particularly canopy and litter cover.

How can I apply it/what should I do about it?

Our results indicate that canopy cover and litter loads are particularly significant drivers of riparian vegetation dynamics at local scales. Consequently any land management activities that impact on these, including clearing and grazing, have the potential to affect vegetation regeneration. Declines in the abundance and diversity of understorey plants, including grasses and forbs, for example, are likely to occur during drier periods as a result of clearing. Additionally, disruptions to litter, either through clearing or grazing, may promote the establishment of riparian weeds. Activities associated with grazing, such as the intentional planting or movement of fodder shrubs (and propagules), may also exacerbate any woody thickening of riparian woodlands that may be occurring.

Where to go for more information?

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How can trees intercept salinity?
Dr Andrew Biggs (QDNR)

What are you researching?
We are researching the role of native vegetation buffers in 'soaking up' ground water recharge. We have a number of study sites in the lower Border Rivers and Lower Balonne where we are measuring the water use patterns of common floodplain trees (poplar box, coolabah, brigalow, belah, myall). At the same time, we are undertaking background investigations into groundwater chemistry and hydrogeology to better understand the risks posed by excess groundwater recharge. We will also be establishing a rehabilitation trial to deal with lateral dam seepage in the Border Rivers. In the Condamine and Border Rivers catchments we have also re-sampled the historical deep drainage study sites established by the late Des McGarry.

What have you found?
Our initial results confirm that whether trees use groundwater depends on the salinity and pH of the groundwater and local variations in the depth to groundwater. We have DNA analysis of tree roots that confirm that myall trees are accessing 30-40 000 uS/cm groundwater at a depth of 13 m. There appears to be a trend of acidification in some groundwater in the Border Rivers (which is not good). In some irrigated areas, groundwater is rising rapidly while in other areas it is relatively steady. It is generally steady under native vegetation. The native vegetation will use more water if it is supplied with more water (and the trees will grow bigger). A strip of about 50 m of poplar box is successfully soaking up leakage from a ring tank on one farm but bare ground is a critical factor determining how successful vegetation strips are.

Why is it important?
Many irrigation areas currently or will suffer from shallow groundwater. Whether it causes a problem on- or off-farm will vary locally. In the Border Rivers and Lower Balonne/Moonie (and across the Border) the issue is exacerbated by the fact that the naturally present shallow groundwater is extremely saline and often acidic.

How can I apply it/what should I do about it?
Understand the water balance on your farm and know where your water goes. Access relevant data about groundwater in your district and understand what the risks might be. Ensure you maintain any remnant vegetation on farm. Where possible (and relevant), increase the vegetation strips around structures and paddocks. Establishment of permanent improved pastures (e.g bambatsi) in un-used bare areas can create a positive benefit both from a salinity perspective but also economically (as a grazing resource or harvesting for seed).

Where do I go for more information?
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Local NRM groups can assist with re-vegetation options.

How quickly do floods recharge aquifers?

Dr Martin Anderson /Calvin Li University of New South Wales

What are you researching?

After prolonged drought, wet periods between 2010 and 2013 provided opportunities for replenishing groundwater resources. Yet observations reported around the country shows the extent of groundwater level recovery varies from site to site. This research studies the rate of recovery of a depleted aquifer under variable climatic conditions. Fundamentally, it is aimed at quantifying the relative importance of stream recharge via stream channels and diffuse recharge over the land surface and to identify the governing processes and suitable conditions for recharge.

What have you found?

Groundwater level record shows recovery across the study area, which has confirmed that intra-annual recharge events provide replenishments of the groundwater resources. Moreover, groundwater abstraction in the preceding years had caused large cones of depression that created a thicker unsaturated zone by 1-4 m. This zone allowed for additional river recharge and thus encouraged flood capturing. However, semi-confined aquifers at greater depth receive less recharge than shallow aquifers. Carbon dating shows natural replenishment in those deeper aquifers takes much longer than human lifetime.

Why is it important?

Water storage in aquifers beyond the root zone does not incur evapotranspiration losses and has no space requirements on the surface. Developed river valleys have the potential for managed aquifer recharge of flood waters, since pumping encourages groundwater capture. Yet, the dominating recharge processes, pathways and aquifer stratigraphy determine the efficiency and sustainability of underground storage, which need to be refined before the economics of managed aquifer recharge can be examined.

How can I apply it/what should I do about it?

The preliminary results suggest more vertical flow into the deeper aquifer need to be promoted perhaps by engineered solutions. Furthermore, land management need to facilitate focused recharge through natural groundwater recharge zones, such as oxbow lakes and wetland near river channels.

Where to go for more information?

Dr Martin Andersen and Mr Calvin Li, Connected Waters Initiative, University of NSW.

Groundwater ecosystem functioning and potential impacts

Dr Kathryn Korbel (University of Macquarie)

What are you researching?

Our current project aims to establish a database of groundwater biota within the Condamine, Gwydir, Maules Creek and Macquarie catchments, allowing for a comparison of impacts on groundwater between competing landuses. We will also test new methods devised to monitor groundwater health for the purpose of groundwater management.

What have you found?

A stygofauna and microbial species inventory is currently being compiled, with a number of microbes and stygofauna entirely new to science. Evidence indicates structural and functional differences in groundwater communities under differing landuses, however the implications of these findings in terms of groundwater health and quality are unclear at this stage.

Using molecular techniques to sequence microbial DNA, a large number of microbes have been identified in groundwater. The functional roles of these microbes are believed to be important in influencing water quality e.g. nitrate concentrations.

A framework to measure groundwater health is currently being refined and tested. This framework will combine ecological, environmental and water chemistry measurements to monitor groundwater health.

Why is it important?

Stygofauna and microbes contribute to the maintenance of water quality and flow in aquifers. Thus understanding factors that influence their distribution and contribution to ecosystem health is important to ensure groundwater remains suitable for drinking and agricultural purposes. Overall this research will benchmark groundwater health in 4 catchments and provide of a tool by which groundwater health can be evaluated and monitored in a quick, cheap and robust way.

How can I apply it/what should I do about it?

In these early stages of the project, the Groundwater Health Index is still being refined, and alternative techniques trialed, to produce practical and affordable tools for use by industry.

Where to go for more information?

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Connecting farms and natural systems

Dr Nancy Schellhorn

What are you researching?

The control of insect pests by beneficial arthropods (i.e. insects, spiders and mites). Many beneficial are highly mobile, live long time (often longer than the life of the crop), and require different habits and shelter to survive.

What have you found?

- We must think beyond the crop to capture pest control services from beneficial arthropods;
- Native remnant vegetation in good condition (e.g. few weeds, and different plant types) provides habitat for beneificials, especially out-of-cropping season;
- Weeds harbour pests and in much higher numbers than beneficials;
- Perennial pasture and Lucerne play key role in landscapes for beneficials AND for pests if pasture is degraded and weedy;
- Beneficials move from remnant veg to crops and back again;

Why is it important?

Beneficial insects suppress pests and can keep pests below economic injury thresholds. To capture these pest control services we must conserve and support beneficial populations.

We can **conserve** them by:

- eliminating broad-spectrum insecticides – choose chemistry soft on beneficials,
- monitoring before and after spraying,
- spraying if a threshold is reached – not before;
- Developing targeted measures that secure resources throughout the life cycle of service providing organisms is required.

We can **support** beneficial populations by:

- providing habitat for them to live -especially out-of-cropping season, and habitat nearby so that they can quickly colonize an emerging crop. On-going research is determining the link between on-farm habitat interventions (e.g. wind breaks, diverse crops, managed remnant native veg) and getting beneficials into crops early to keep pest populations lower for longer.

How can I apply it/what should I do about it?

1. Start by taking actions to conserve beneficials (above).
2. Control weeds and volunteer crop plants on-farm (i.e. in crops, ditches, remnants).
3. Maintain and manage native remnant vegetation. Stay tuned for results from on-going research investigating the type of local interventions needed to support beneficials throughout the year, and how these interventions may link to additional production benefits.

Where to go for more information?

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Evaluating the Extent of Hydraulic Connectivity Between the Condamine Alluvium, the Great Artesian Basin and the Walloon Coal Measures

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Ms. Charlotte Iverach – School of Biological, Earth and Environmental Sciences, UNSW Australia
Mr. Mark Hocking – School of Biological, Earth and Environmental Sciences, UNSW Australia
Dr. Dioni Cendon – Institute for Environmental Research, ANSTO
Mr. Stuart Hankin – Institute for Environmental Research, ANSTO
Ms. Lucienne Martel – School of Biological, Earth and Environmental Sciences, UNSW Australia
Prof. Euan Nisbet – Royal Holloway University of London, UK
Dr. Dave Lowry – Royal Holloway University of London, UK
Dr. Rebecca Fisher – Royal Holloway University of London, UK
Dr. James France – University of East Anglia, Norwich, Norfolk, UK
Prof. Andy Baker – School of Biological, Earth and Environmental Sciences, UNSW Australia

What are you researching?

We recently completed a project evaluating the extent of hydraulic connectivity between the Condamine Alluvium, the great Artesian Basin and the Walloon Coal Measures. The project analysed the chemistry of the groundwater from 30 boreholes throughout the Condamine Alluvium, near Cecil Plains, to see if there was a geochemical signature that would indicate natural groundwater movement between the Walloon Coal Measures (WCM), the overlying sedimentary rock layers of the Great Artesian Basin (GAB), and the Condamine Alluvium (CA). We measured the major ion chemistry, isotopes to determine sources and age of the groundwater, the dissolved organic content, and the concentration and chemical signature of the methane emitted from the boreholes. We also mapped pathways of recharge and assessed the impact of abandoned leaky wells. As an addition to the project we studied the microbiology of the groundwater and soil under different land uses and farming practices (refer to the separate project description for further details on the microbiological investigations).

What have you found?

Connectivity

Throughout the Cecil Plains portion of the CA the concentration of methane in the groundwater is low. At four sites the chemical signature of the methane indicated that it was probably sourced from the WCM. These four sites were isolated from each other. The combination of this spatial information and the low concentration of methane measured throughout the CA indicate that the extent of natural connectivity between the WCM and the CA is low. Comprehensive details have been published in:

Iverach CP; Cendon DI; Hankin SI; Lowry D; Fisher RE; France JL; Nisbet EG; Baker A; Kelly BFJ, 2015, 'Assessing Connectivity Between an Overlying Aquifer and a Coal Seam Gas Resource Using Methane Isotopes, Dissolved Organic Carbon and Tritium', Scientific Reports, vol. 5, http://dx.doi.org/10.1038/srep15996

Recharge

It is clear from our research that ongoing access to groundwater will be related primarily to flood frequency. 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. Contributions to groundwater recharge from irrigation deep drainage, rainfall over the wider landscape or river leakage under normal streamflow conditions are small and recharge from hard rock aquifer systems, in particular the Great Artesian Basin, is small. Floodwater is the primary, and in some places only, source of groundwater recharge.

Abandoned Leaky Wells

Throughout the Condamine catchment there are thousands of abandoned coal exploration wells. Many of these wells have either never been sealed or have failed due to aging infrastructure (eg. casing corrosion, subsidence, etc.). The environmental impact of leaky decommissioned wells has been the subject of much speculation. To assess this we modeled the impact that a leaky well may have on inter-aquifer flux. In the Condamine Catchment of southern Queensland we used the steady-state Analytic Element Method. We showed that a single leaky well significantly contributes to inter aquifer water movement. Under pre-development head there is a natural upwards hydraulic gradient from the Walloon Coal Measures (WCM) to the Condamine Alluvium (CA), and a single leaky well (radius of 100 mm) is predicted to transfer 40 ML/a between the formations. If the post-development head in the WCM is 50 metres below the CA (a conservative estimate based on CSG production modelling), then a single leaky well is predicted to transfer 263 ML/a from the CA to the WCM. Our modelling highlights the need to: 1) Investigate the potential impact of partly penetrating wells; 2) locate and remediate leaky abandon wells to prevent the movement of fluids between strata in areas of CSG developments.

New mobile methane surveys are being undertaken in April 2016 to extend the mapping of abandoned leaky wells throughout the Condamine Catchment.

Why is it important?

Each day tens to hundreds of mega-litres of co-produced groundwater will be extracted from the WCM associated with the production of gas. Over the next few decades this will lower the groundwater head (the water level measured in monitoring boreholes) firstly in the WCM, then in the adjacent formations of the GAB and then, depending on the extent of hydraulic connectivity, possibly in the CA.

To correctly model the potential impact of CSG developments on groundwater levels in the CA we need a good conceptual geological model of the region. In particular, we need to know where and to what extent there is hydraulic connectivity between the WCM and the CA. Groundwater geochemistry provides insights on the extent of this hydraulic connectivity.

Research outreach and impact

Our research is providing independent baseline information for the groundwater irrigation community. The project team has presented the information to relevant government departments, to the wider scientific community involved in coal seam gas investigations, and to key staff in CRDC and Cotton Australia. Farmers involved in the project received a report on the quality of their groundwater, and comprehensive details on the water chemistry. This has provided many farmers in the region valuable baseline data.

Where do I go for more information?
Contact the project leader:
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Evaluating the Extent of Hydraulic Connectivity Between the Great Artesian Basin and the Lower Namoi Alluvium

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Mr. Stuart Hankin – Institute for Environmental Research, ANSTO
Dr. Martin Andersen – School of Civil and Environmental Engineering, UNSW Australia

What are you researching?
CRDC in partnership with UNSW and ANSTO are funding 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 GAB and lower Namoi alluvium and highlight any risks associated with the expansion of the coal seam gas projects in the Pilliga region.

We are sampling the groundwater at 30 points in the Narrabri, Wee Waa and Pilliga regions. These samples are from shallow and deep alluvial aquifers, the Great Artesian Basin, and NSW Government coal bores. At each of these locations we are measuring the major ion chemistry, trace elements, isotopes to age date the water, and dissolved gases. We are also conducting extensive microbiological analyses (refer to the separate project description).

We are conducting mobile methane surveys to detect leaky wells, which sometimes leak gas. There are many abandoned coal and GAB exploration wells throughout the lower Namoi. If the abandoned wells are poorly sealed they provide a pathway for the upward movement of water and gas from the Great Artesian Basin to the fresh water alluvial aquifers used to supply irrigation water. Decades of CSG production will result in the depressurisation of the coal measures. If an abandoned leaky well connects the alluvium to the GAB, then once the coal measures are depressurised groundwater will move downwards out of the alluvial aquifer used for irrigation towards the CSG production formation.

Why is it important?
To have sustainable access to groundwater we need to know where and how much groundwater is recharging the lower Namoi Aquifers. By mapping groundwater recharge pathways in the lower Namoi we will gain insights into where, when, and how much groundwater can be used to support agriculture.

Groundwater is also critical for ecosystem health, and there are now many regions throughout the Namoi catchment where many trees are in poor health. The groundwater data being collected in this study will assist with groundwater-dependent ecosystems investigations currently being undertaken by Dr Rhiannon Smith at UNE.

Both the groundwater chemistry and ground level greenhouse gas surveys will help with assessing the impacts associated the expansion of coal seam gas throughout the region.

Where do I go for more information?

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Microbiological Communities in Vertosol Soils and Aquifers

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A/Prof. Mike Manefield – School of Biotechnology and Biomolecular Sciences, UNSW Australia
A/Prof. Bryce Kelly – School of Biological, Earth and Environmental Sciences, UNSW Australia

What are you researching?
We are studying soil microbiological communities in the upper cotton soil ecosystem (Vertosol soil) from different agricultural fields and areas of native vegetation. Plus we are analysing the microbiological ecosystems in aquifers. The primary emphasis of the project is on determining the abundance and diversity of microbes involved in methane oxidation and production.

We started analysing the soil and groundwater microbiology to enable better interpretation of the air and groundwater methane surveys in the Condamine Catchment. Our preliminary results have shown that soil bacterial and archaea populations under native vegetation, traditionally fertilised irrigated cotton crops, and bio-fertilised soils are all significantly different. This raises many questions relating to soil health, disease resistance under climate variability and change, optimal nutrient uptake, and greenhouse gas production from agricultural soils.

Why is it important?
Little is known about how farming practices have altered the bacterial and archaea populations in Vertosol soil. Yet the microbiological community controls soil health, plant disease resistance, nutrient uptake, and the production and consumption of greenhouse gases.

Preliminary Findings
A high diversity of aerobic methanotrophic bacteria belonging to Type 1 (*Gammaproteobacteria,* 2-6% relative abundance to the overall microbial community) and Type II methanotrophs (*Alphaproteobacteria*, 4-18% relative abundance) were observed in all soil samples. The relative abundances of single methanotrophic species were significantly different between soil samples, whereas the composition of the overall methanotrophic community was quite similar. Furthermore, methane-producing archaea (methanogens) were detected in almost all soil samples in very low abundance (0-0.5% relative abundance) suggesting biogenic methane production is a negligible process in the agricultural cotton soil. Interestingly, most of these sequences were recovered within the order *Methanosarcinales* and could potentially be affiliated with anaerobic methanotrophic archaea oxidising methane using e.g. nitrate, iron, or sulfate as electron acceptors. A higher abundance (7% relative abundance) and diversity of methanogenic archaea, mainly associated with hydrogenotrophic methanogens, were observed in the bio-fertilised soil that would contribute of methane formation and methane cycling in that soil habitat. The

irrigation water samples from every borehole sampled harboured a low-diversity methanotrophic community only associated with the order *Rhizobiales* with a relative high abundance of 4-12% to the overall microbial community. No methane-producing archaea were observed.

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Resilience Assessment of the Australian Cotton Industry at multiple scales

Dr Francesca Andreoni, Bel Tempo NRM, Armidale

What are you researching?
I am completing a resilience assessment of the Australian Cotton industry at multiple scales (farm, region and industry), to better understand how to best adapt to change and identify critical threats and opportunities for the industry, and strategically target investment and resources.

This project uses a resilience assessment approach to develop a whole-of-system perspective that incorporates the economic, social and ecological dimensions of the industry, how these interact and influence each other over time. The key assets, inputs, outputs, alternate states and dynamics have been identified for each scale, with particular emphasis on identifying the major thresholds or tipping points that are potential risks the industry may need to manage in the future (specified resilience). The attributes of general resilience (capacity to cope with unknown and unpredicted changes) have also been assessed and the linkages between scales and the potential for cross-scale interactions are identified.

What have you found?
There are five key drivers of change acting across the Australian cotton industry. These are **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**. Industry leaders and growers need to be aware of the impact of those drivers, and of the changing nature, frequency or severity of shocks so as to better prepare and respond.

These drivers and shocks have the potential to push the Australian cotton Industry towards identified "tipping points" critical thresholds which if crossed lead to significant changes in the 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 **R&D investment**. A case study based on an analysis of two cotton growing regions over the decade of the "millennium" drought demonstrates the way in which growers and cotton growing regions respond to these drivers and thresholds in practice.

Based on this assessment and an initial review of potential intervention points, addressing **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. **Modularity** (the degree of connected/disconnectedness across the system) emerges as the priority general resilience attribute for the industry as a whole. A review of the existing sustainability indicators reveals the extent to which some of these can also be used as resilience indicators at

various scales.

Why is it important?
Cotton production in Australia is an increasingly complex business requiring continuous adaptation to changing circumstances. Resilience assessments are undertaken to identify risks, opportunities and strategies in ways that are often not addressed by conventional management approaches. The CRDC is using this approach to better understand how to best adapt to change and identify critical threats and opportunities for the industry, and strategically target investment and resources.

The process of undertaking a resilience assessment in collaboration with stakeholders has led to a greater shared understanding of the cotton industry from a multiple-scale systems perspective (farm, region and industry). This is another important objective of resilience assessment. Working with cotton growers and industry leaders this assessment has collaboratively:

- defined focal scales;
- developed timelines based on past shocks and changes;
- identified key assets, inputs, outputs, drivers, dynamics and critical thresholds;
- understood the status and trend of general resilience attributes; and
- considered cross-scale interactions.

This has developed the industries capacity to understand their industry as a complex adaptive system. This in itself is proven to enhance the resilience of social-ecological systems and is a positive outcome for the future of the cotton industry

Understanding the industry's capacity to cope with uncertainty and manage critical tipping points - where that capacity is well developed and where it is weakest - will allow the industry to target future research and development, planning, capacity building and extension activities to ensure all facets of the industry are best placed to cope with an uncertain future.

How can I apply/what should I do about it?
The process of resilience assessment involves six phases as outlined below in Figure 1:

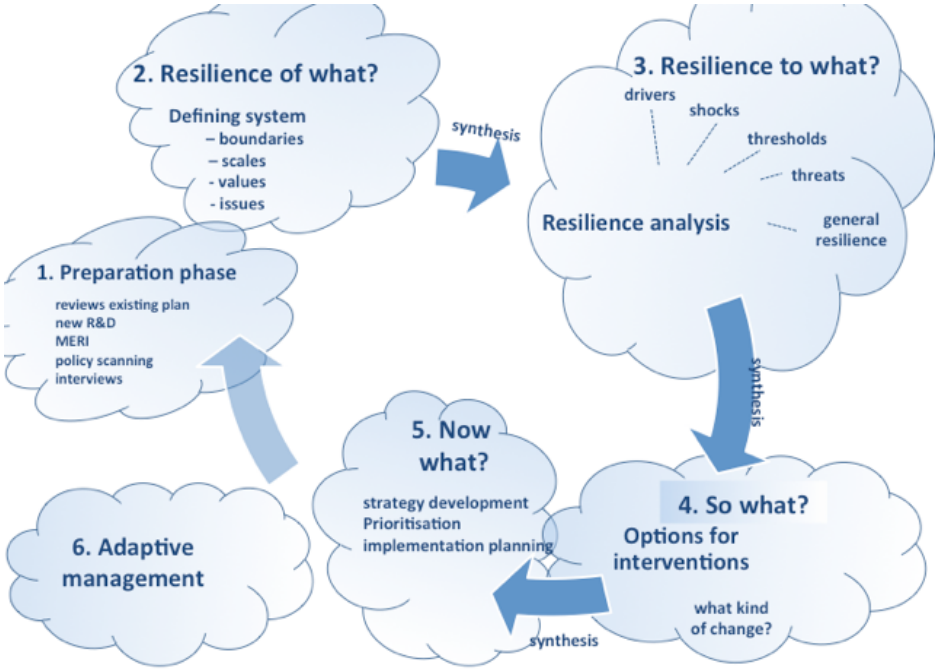

Figure 1. The resilience assessment process

Where to go for more information

- Contact principal researcher: Dr Francesca Andreoni (Bel Tempo NRM).
  Email: Francesca@beltempo.com.au
  Mob: 0447 530 299
  Web: www.beltempo.com.au
- Read the Report: *Resilience Assessment of the Australian Cotton Industry at Multiple Scales* (available on the CRDC website after June '16)
- Participate in the next Cotton Industry Resilience Workshop (to be held at the Australian Cotton Conference in August 2016).
- Check out the Australian Resilience Centre online at www.ausresilience.com.au. Director Paul Ryan is part of the team involved in this research with the cotton industry.
- For an international perspective on resilience assessments in general check out the Resilience Alliance online at www.resalliance.org

Nitrogen losses & Indirect Nitrous Oxide Emissions

Dr Ben Macdonald & Yvonne Chang (CSIRO)

What are you researching?

Application of nitrogen (N) fertiliser in irrigated cotton is necessary to maintain the quality and quantity of yield. Excess N may remain stored in the soil, or may be lost. Losses of N can occur as gaseous emissions of N_2 and N_2O from the soil surface or via tail water run-off and deep drainage. Subsequent transformations of N in run-off water or deep drainage may result in indirect N_2O emissions.

We are interested in N losses from irrigated cotton, with a particular focus on nitrous oxide emissions. Using 15-N labelled urea, we quantified the movement of fertiliser N to different pools (plant, soil, atmospheric losses, run-off and deep-drainage) over the 2014-15 cotton season. We also measured indirect nitrous oxide (N_2O) emissions from farm irrigation systems over three cotton seasons and are beginning to develop a better understanding of the magnitude of and potential controls on indirect N_2O emissions.

Why is it important?

Nitrogen losses should be concerning for a number of reasons. Excessive N losses may affect environmental systems (e.g. eutrophication and biodiversity losses), contribute to changing climatic conditions and present potential risks to human health (e.g. elevated concentrations of nitrate in drinking water). N_2O emissions are of particular interest because of its role as a greenhouse gas (100 year global warming potential 298 times that of carbon dioxide) and as a key causal agent in the depletion of stratospheric ozone. Agricultural N_2O emissions resulting from fertiliser or manure use represent 56-70% of total global N_2O sources. Much of the work on N_2O emissions from irrigated cotton has focused on direct emissions from the soil surface, however the magnitude of and controls on indirect emissions resulting from N leaching and runoff remain uncertain.

What have you found?

Nitrogen losses: Under a rate of 220N, 25.5% of the N fertiliser applied was taken up by the plant, 27% remained in the soil, 9.5% was lost via run-off and deep drainage, and 38% was lost to the atmosphere. Under these conditions, nitrogen concentrations in tail water run-off ranged

between 0 - 346 mgL^{-1}, with most of the N lost early in the season with irrigations following fertiliser application. Greater concentrations of N were found in water sampled from skip vs irrigation furrows, suggesting that N is leached from the beds as water moves through the beds from irrigated to skip furrows. Within the storages, concentrations of nitrate did not change significantly during the 10 days following the first irrigation, where movement of irrigation water in or out of the storages had paused.

Indirect Emissions: Our estimates of N_2O flux, using chambers and dissolved N_2O concentrations, ranged between 0 to 0.28 $ugm^{-2}min^{-1}$ (in storages), and -0.3 to 2 $ugm^{-2}min^{-1}$ (in tail water). Cumulative emissions from irrigation tail drains were approximately 2.4-4% the magnitude of direct land emissions.

How can I apply/what should I do about it?

Increasing both nitrogen and water use efficiency will help minimise N losses via runoff. Reductions in N run off may also be achieved through altering the timing and placement of N (e.g. using split applications, changing the placement of N in hills relative to water furrows). Re-use of N rich tail water may also provide an opportunity for N lost in run-off to be returned to the system. The use of nitrate test strips also provides an inexpensive method for growers to better monitor run-off losses.

Where to go for more information

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How do we navigate a path to a sustainable cotton industry in 2030?

Steven Cork
Adjunct Professor, Crawford School of Public Policy, ANU
Director, Australia21
Principal, Ecoinsights

futures thinking:

- best done ***by those who have a stake in it***
- ***strategic conversations*** - speaking *and* listening
- little value in ***predicting***
- exploring ***multiple plausible futures*** (including unlikely ones) systematically

Outline

- Why humans struggle with the future
- How can we do it better?
- Drivers of change
- Assumptions, certainties and uncertainties
- Four stylized futures
- Implications

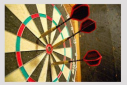
Research:

- 20-year study (1985-2005)
- 28,000 predictions
- 284 experts

Philip E. Tetlock
Professor of Psychology
University of Pennsylvania

Conclusions:

- only slightly more accurate than chance (guessing)



Black swan thinking
= Imagining only what we have seen before

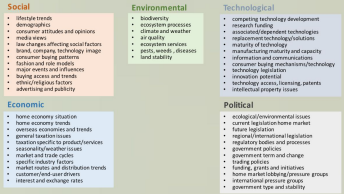
thinking challenges

- filtering
- imagining only what we have experienced already
- false assumptions
- and many more ...

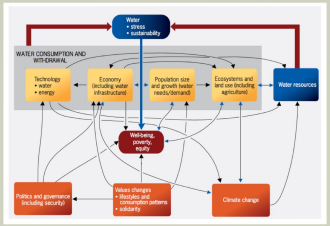
deliberate effort

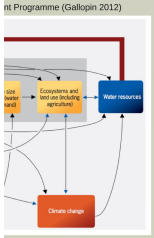
...less a deliberate effort is made, organisations and society ...nd to have low capability to consider multiple futures
(Slaughter 1996)

some drivers/ influencers of change



United Nations World Water Assessment Programme (Gallopin 2012)





Megatrends

urbanisation
ageing
localism
anxiety
individualism
personalisation
digitialisation
extinctions

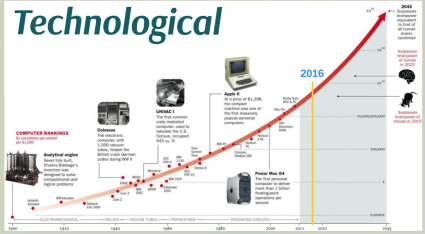
resource depletion
environmental change
sustainability
economic shifts (west to east)
debt
consumerism
globalisation
volatility

Social

- High employment
- High social capital
- High uptake of technologies

Questions:
- Suitable workforce?
- Adaptability of regional communities?
- Urbanisation?
- Government/ governance trends?
- Generational trends?

Technological



Fourteen technologies expected to change the world by 2020

- The 'humanised' internet
- The end of the 19th-century grid
- The end of scarcity
- Fewer fancy phones, more fulfilment
- Cheaper, more widespread solar power
- Internet of things no longer about things
- New cures from the bacteria that live in the human body
- The beginning of the end for cancer
- Data-driven healthcare
- Printable organs
- The 'Internet of everywhere'
- Renewables will power mobile networks
- Learning on the job will never stop
- Wastewater is an asset, not a liability

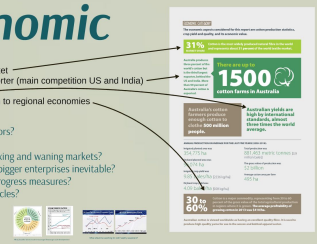
Agricultural technologies
- Biotechnology
- Genetically modified (GM) agricultural technologies
- Second- or third-generation products
- Decarbonising agriculture
- New farming approaches
- Convergence of nanotechnologies, genomics and microelectronics
- Smart sensors

How might we operate if most challenges are removed?

Economic

- Large global market
- Third largest exporter (main competition US and India)
- High yields
- Large contribution to regional economies

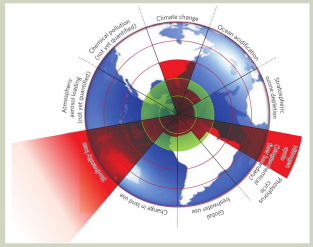
Questions:
- Other competitors?
- Trade policy?
- Adapting to waxing and waning markets?
- Are bigger and bigger enterprises inevitable?
- New national progress measures?
- Influences of cycles?

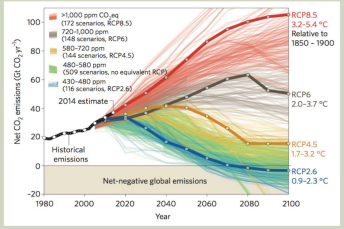


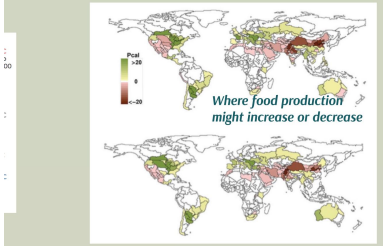
Environmental

- Increasing focus on soil health
- Increasing water productivity
- Biodiversity trends/ significance?
- Decreasing use of chemicals

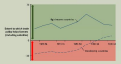
Questions:
- droughts?
- rate of improvement in soil health?
- acceleration/ deceleration of efficiency gains?
- economy, markets and competing uses of water?
- role of biodiversity?
- ability to turn alternative fertilizers, insecticides etc into competitive advantage?







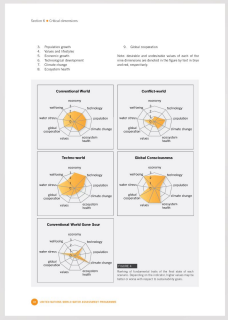
Political/ legal



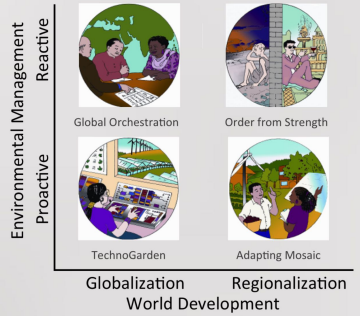
end of democracy?
abolish the states?
regional government?
susbsidiarity/ adaptive governance

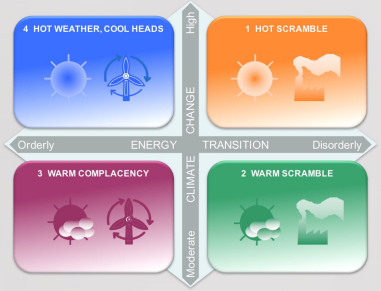
Royal Dutch Shell
in the 1960s

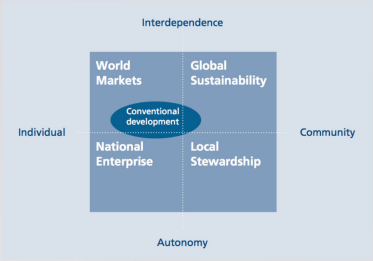
- Developed scenario planning in 1960's
- Conventional view: oil prices will stay low
- Shell's strategists questioned this assumption, identifying oil prices as a critical uncertainty
  - 'imagined' increases in oil prices
  - 'emotionally prepared' for 1973 energy crisis



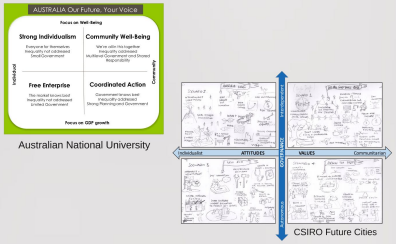
Global Water Scenarios

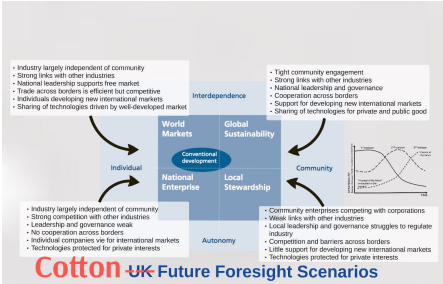






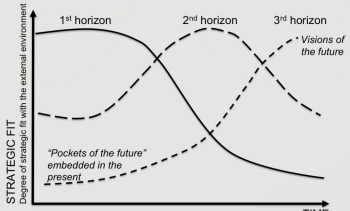
UK Future Foresight Scenarios



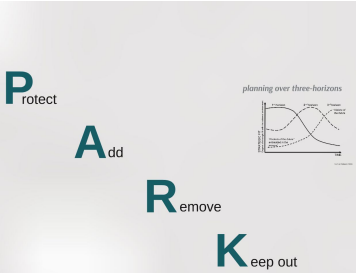


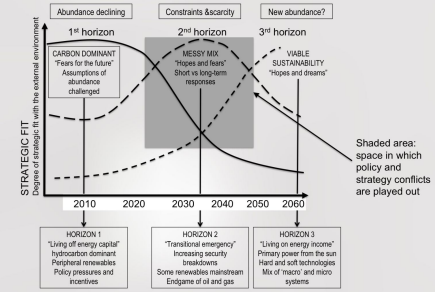
Cotton ~~UK~~ Future Foresight Scenarios

planning over three-horizons



Curry & Hodgson (2008)





Curry & Hodgson (2008)

1900s Decade Events

A new century, Australia begins life as federated nation. It touts itself as the 'social laboratory' of the world, and a progressive nation that will try out new programs and policies before any other country. However it still finds time to loudly declare itself faithful to the British throne. The new parliament, its politicians and various opinion-makers embark on 'nation building' exercises – choosing the site for a new capital, debating and passing laws that lead to a fair and reasonable wage, unemployment benefits and a universal pension - universal, that is, unless you're Indigenous. The new Parliament of a new nation sets the political and economic trajectory, for good and ill that Australia will follow until the 1970s and 1980s.

Perhaps the most crucial change in white Australia is the slowly evolving sense of connection and identity with the land. Dorothea McKellar, homesick in London, writes a poem declaring Australia to be 'core of my heart, my country!'

1910s Decade Events

World War 1, a global catastrophe becomes Australia's famous 'baptism of blood'. The nation is initiated first at Gallipoli in 1915, and then proves itself by forming one of the elite fighting forces on the fields and in the trenches of France. Yet the losses involved are almost incalculable, not just in a generation of young men on the battlefield but also on the home front. Triggered by the furore surrounding two conscription referenda a visceral hostility emerges between Irish Catholic and British Protestant Australians splits the Labor government. The war is won and a reputation on the national stage is made, but the sectarian divisions will last more than a generation.

World War 1 (1914-1919)

1920s Decade Events

With war's end, this is a time of hope and optimistic renewal. But returned soldiers find it difficult to adjust to peacetime, and families and workplaces struggle to incorporate these men into 'normal life'. Meanwhile, governments and newspapers take up the dream of E.J. Brady's *Australia Unlimited* – that a country with a continent at its disposal should develop its resources and population at breakneck speed. As a consequence, state and federal governments create massive public debt (to go with pre-existing war debts) as they embark on ambitious nation-building projects. In an era of at times frenzied expansion, Prime Minister Stanley Bruce wins elections with slogans about getting more 'men, money and markets' into the country.

Actor Felicity Price as Florence Broadhurst

1930s Decade Events

Stock market collapse on Wall Street leads to British banks calling in its loans to Australia. The decade is swallowed in a great global depression. Successive governments have to decide whether to assist Australians in economic hardship, or maintain the integrity of international contractual obligations by repaying foreign loans. While America has its 'New Deal' under Roosevelt, as a kind of social and economic crusade to produce more work for more people, Australian leaders - Labor's James Scullin, Labor defector Joseph Lyons, then a newly emergent and conservative Robert Menzies, rely on cutting the minimum wage and slash government expenditure in order to meet the requirements laid down by the British banking sector. By 1932 almost a third of Australians are out of work.

Builders, Sydney Harbour Bridge

1940s Decade Events

With another World War and Japanese forces sweeping south, Australia's direct safety is threatened. Australia realises it can no longer blithely rely on Britain protection. Enter America, and General Douglas MacArthur. Prime Minister Curtin declares in a newspaper article in a New Year's message at the end of 1941 that 'Without any inhibitions of any kind, I make it clear that Australia looks to America, free of any pangs as to our traditional links or kinship with the United Kingdom.' There are many who criticise this new tone but a new course has been set.

Unemployment becomes a thing of the past, as a generation of women discover the possibilities of life outside the home. Australia begins to transform itself with visions of reconstructing a whole society not just from the consequences of war but also the previous decade's economic depression. The policy of encouraging an exclusively British migration is thrown out the window. Arrivals from across post-war Europe are welcomed as new industries are created and vast new construction schemes begun.

Australian soldiers in Tobruk, Libya

1950s Decade Events

The decade sees the birth of the ‘prosperous society’ and a boom in babies and marriages. This is a time of full (male) employment as Australians enjoy the fruits of long economic growth overseen by the man who will become the longest-ever serving Prime Minister Robert Menzies. But this is also the first decade of the Cold War which sees spies, defections, and profound nuclear threat, making for particular undercurrents of fear.

Britain sees outback Australia as mostly empty and the ideal place to test nuclear weapons, and the Australian government agrees. Irish Catholic Australians, who have been staunch Labor supporters since the controversies of the First World War, are troubled by the threat of atheist Communism in the Labor movement, and begin to shift their allegiances to the Conservatives. For his part, Labor leader ‘Doc’ Evatt, a touch paranoid, decides the Catholic ‘Movement’ in his party is part of a conspiracy against him. Another cataclysmic Labor split occurs.

In the midst of all this, a quiet demographic revolution is underway. The great immigration project continues unabated. The Governor General, William McKell, calls it ‘undoubtedly one of the most constructive and notable events in the history of Australia.’

Queen and Prince Philip, Australian tour 1954

1960s Decade Events

The post-war baby boomers reach adulthood in a time of plenty and inject their new mood of subversive rebellion. Their music, tastes, fashions and philosophies have a profound impact on Australian culture. The large-scale protests against Vietnam War conscription is one sign, but the urge for change galvanises other, long-standing campaigns as well – equal rights for women, and Indigenous Australians will become key issues of the decade.

Meanwhile, the first ever tour of Australia by an incumbent American President, Lyndon Baines Johnson represents the culmination of the American alliance. New Liberal Prime Minister Harold Holt happily declares Australia will go 'all the way with LBJ', and a large majority of voters agree with him.

Parkes Radio Telescope

1970s Decade Events

With the slogan ‘It’s Time’ Gough Whitlam leads the Labor Party into power for the first time in 23 years. A large series of reforms soon follows, conscription is abolished and Australian troops are withdrawn from Vietnam. But a crash-through or crash approach to governance and policy-making does not make for long-term stability.

Simultaneously, the long economic boom, which has powered Australian prosperity for thirty years, begins to crack. Global crises bring a dramatic upward spike in the price of oil, and inflation climbs to 17%. A parliamentary deadlock threatens to halt monetary supply before Governor-General John Kerr dismisses the Whitlam government.

The new Liberal Prime Minister, Malcolm Fraser, takes the reins. His comment that “Life wasn’t meant to be easy”, suggests a leader of unsympathetic austerity, but with the end of the Vietnam War and the mass-arrival of the first Vietnamese ‘Boat People’, Fraser has no hesitation in letting in the refugees.

Australian troops return from Vietnam

1980s Decade Events

This is a brash decade of excess, opportunism and expansion. Many old restrictions and regulations are disbanded, allowing new banks and entrepreneurs to flourish briefly, although many meet a catastrophic fate. Australia emerges as a confident nation, as pleased with beating its new dominant trade and security partner – America – in the America's Cup yacht race as the colonies had been a century earlier in claiming the Ashes from England. On the morning of the final race victory, new Prime Minister Bob Hawke gleefully declares that any boss who doesn't give their workers a day off work to celebrate "is a bum!"

The Labor government begins dismantling much of the Protectionist legislation and tariffs to free up the economy and remove artificial barriers, which have kept out imported goods. The great policy shift is broadly speaking a success, although the decade closes in the midst of what the Treasurer, Paul Keating, describes as "the recession we had to have" with unemployment exceeding a million and many families losing homes and businesses.

Parliament House, Canberra ACT

1990s Decade Events

The landmark Mabo judgement by the High Court finds Australia was never *terra nullius* (empty land) and inserts the legal doctrine of native title into Australia law. Questions of immigration levels and what sort of cultural mix is suitable for Australia become a national debate when a dis-endorsed Liberal Party candidate in Queensland, Pauline Hanson, founds the One Nation Party. She briefly gathers a constituency challenging support for refugees and Indigenous Australians. The mandatory detention of asylum seekers becomes a 'hot issue'.

In the midst of all this controversy, the economy recovers strongly from recession under first the Keating Labor government and then John Howard's Liberal-National Coalition. Prime Minister Howard cuts government spending in response to large-scale public debt. An Asian financial crisis has little effect, and, although rejecting the idea of a Republic at a referendum, Australia enters the new millennium on an upward note, determined to 'punch above its weight' as a global player.

Bondi Beach, NSW

2000s Decade Events

A spectacular Olympics in Sydney is followed by a decade of long drought in many parts of Australia. The terrorist strike on the World Trade Centre of New York is followed a year later by terrorist bombing in Bali nightclubs where many of the killed and injured are Australian.

For most of the decade, Australia experiences a baby boom, a property boom and a consumer boom as unemployment drops to levels not seen since the early 1970s. Despite growing concerns about global warming and energy supplies, a golden 15-year cycle of economic growth and high commodity prices brings growing affluence and spending power to many especially in the resource-rich states. But 2008 heralds a global financial crisis and in early 2009 a catastrophic series of bushfires rage throughout Victoria. They cause the greatest loss of life from any natural disaster in recorded Australian history.

Sydney Olympics, 2000