CSIRO’s Agricultural Sustainability R&D
Outline

• CSIRO’s Agricultural Sustainability Initiative
  • Looking back
  • Current R&D activities
  • Looking forward
Looking back ... 80 years of agricultural R&D
In 2007, Internal Drivers

- Eight Divisions investing $43M p.a. on Agricultural Sustainability
- Large numbers of small projects
- Co-investing with diverse range of partners
- Was CSIRO maximising its national impact?
- Were we using science capability most effectively?
- Did we have a CSIRO strategy or eight competing strategies?
External Drivers

• Evolving challenges / opportunities for Australian agriculture
  • Climate change
  • Greenhouse mitigation
  • Global competitiveness
  • Environmental degradation
  • Social and economic change

• Need for more integrated R&D capability to address contemporary challenges
Agricultural Sustainability – Core Focus

- Reduce ecological footprint of Australian agriculture
- Increase economic value to Australia from agricultural landscapes
- Increase resilience of Australian rural and regional communities

ASI Focus
1. **Australian Agriculture Transformed**
   - New industries, regions, cross-sectoral integration, resilient design
   - Adapting, responding, anticipation of change drivers

2. **Economic and Environmental Performance of Australian Agriculture**
   - Enhanced economic and environmental performance and risk management of agricultural enterprises and agricultural value chains

3. **Agro-ecosystem Function and Prediction**
   - Knowledge based tools for agro-ecosystem management
   - Quantifying functional processes and ecosystem services
Theme: Transforming Australian Agriculture

Focus Areas

- **Agriculture in a Carbon Constrained World**
  - Reducing GHG emissions from agriculture
  - Increasing carbon storage in the Australian landscape.

- **High Rainfall Zone Agricultural Futures**
  - For sustainable food production and environmental outcomes

- **Northern Australia Agricultural Futures**
  - Supporting decisions on agricultural development in the major water basins (partnership with WfHC)
Focus Areas

• Fostering smart farming at the frontiers of technology
  • “precision” technologies, information technologies

• Driving farm-level adaptation to reduced irrigation water availability through
  • New technology, management, locations

• Reducing the environmental impact of food and fibre value chains
  • energy, water and GHG emissions
Theme: Agro-ecosystem Function & Prediction

Focus Areas

- Environmental stewardship initiatives for biodiversity conservation & ecosystem function in agricultural landscapes
- Advancing soil health as a foundation for sustainable agriculture
- Integrated capacity to model land use systems at the enterprise & landscape scale
ASI External Investment (07/08)

ASI: External Investors by Category (Approximate)

- Commonwealth Govt
- CRC
- Other
- NRM
- State Govt
- RDC

ASI: External Investments by Product (RDCs & CRCs Only)

- Grains
- Grapes
- Cotton
- Sugar cane
- Cattle and calves
- Wool
- Dairy
- Sheep and lambs
- Other

Non-product-related work (L&WA, CRC Dryland Salinity/FFI, CRC Irrigation Futures, RIRDC, some forestry CRC)
Investment by Geographic Region (07/08)

ASI: Approximate Investment by State

Australian Agriculture: Value by State
ASI Research by Agricultural Zone (07/08)

ASI: Approximate Investment by ABARE Zone

- Pastoral
- High Rainfall
- Irrigation
- Cereal-Livestock

Australian Agriculture: Value by ABARE region

- Pastoral
- High Rainfall
- Cereal-Livestock
- Irrigation
Recent developments

• Portfolio expanded ca. 30% via inclusion of ……

  • Managing Australia’s Soil and Land Assets (MASaLA)

  • Sustaining Australia’s Forest Ecosystem Resources (SAFER)
Current CSIRO Divisions currently involved

ASI PORTFOLIO - 2008/09

$52M p.a., 40% external

21% 16% 13% 11% 34% 2% 3%

Cento CLI CLW CPI CSE ICT CMSE

16th Nov 2008
Theme Leaders

Pete Thrall
Agro-ecosystem function and prediction

Peter Carberry
Economic and Environmental Performance

Michael Battaglia
SAFER

Mike Grundy
MASaLA

16th Nov 2008
Some current activities
Carbon measurement and modelling

• Underpinning science for National Carbon Accounting System (NCAS)
  • FullCAM model and the National Carbon Accounting Toolbox (NCAT) for carbon accounting in agriculture and forests at project and national scales
    • Current expansion to include N₂O and methane

• Soil carbon measurement
  • A new rapid and inexpensive analytical methods using MIR spectroscopy
LCA of Forest Production Systems

- Life Cycle Assessment (LCA)
  - Cradle-to-grave (i.e. seed to sawmill) assessment and inventory for forest products.
  - Inform industry practice on emissions mitigation.
  - Will also inform Government policy and international negotiations on carbon sequestration in long-lived forest products.
Assessing “biochar” as a carbon store

• Examining the potential of biochar as in soil for both net sequestration of atmospheric CO$_2$ as well as secondary agronomic benefits
  • in collaboration with Rothhamsted
Impact of defoliation on carbon stocks

1. Model pest distribution now and under climate change

2. Link changes in climate to seasonality of pest activity

<table>
<thead>
<tr>
<th>Site</th>
<th>Climate</th>
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3. Establish relationship between climatic suitability and damage levels

4. Use damage probabilities and future climates to predict impact on production and carbon stocks, including interactions with site

- Under 2030 and 2070 climates pests will have a greater impact on forest production and carbon stocks
- In some situations (e.g. low fertility sites) up to a 40% decrease may result
Measuring forest carbon stocks

• Extending the development of the CSIRO-designed ECHIDNA® instrument, to help develop new methods of measuring forest carbon stores on a large scale.

• Collaboration with NASA funded project in the USA

Hemispherical projection of the ECHIDNA™ data.
Australian Tree Seed Centre

- Australian Tree Seed Centre priority climate change research
  - Producing new germplasm with adaptive traits for future climates or future industries
  - Plotting Genotype x Environmental interactions
  - Second generation bioenergy production
Australia’s Soil Resources

• Digital soil mapping and online delivery – the Australian Soil Resource Information System (ASRIS)

• developed for a broad range of users including natural resource managers, educational institutions, planners, researchers and community groups.

• recent addition of Acid Sulphate Soils module helping in the management of this significant issue
Global Soils Information

- **Global Soil Map initiative (GlobalSoilMap.net)**
  - being developed by a consortium of agencies around the world, to support the rapidly growing issues around food production, security and poverty, land degradation and climate change impacts and mitigation.
Information systems for farm management

• Pastures from Space
  • Enhancing efficiency of feed resource use to improve farm profitability.
  • Weekly pasture growth rate data for drought assessment in southern Australia (via NAMS)

• Spatial Information CRC project
  • Clever Cattle and Cropping Systems
    • integrating remote and ground-based near-real-time paddock and infrastructure data into a farm management system.
Reforestation Decision Support

- **Scenario Planning and Investment Framework “SPIF”**
  - Decision support in reforestation projects for multiple environmental and economics outcomes.
  - A recent application has evaluated the entire continent of Australia on a hectare scale for the use of woody vegetation as carbon sinks.
Improving N fertiliser use efficiency

• Nitrogen fertiliser management in the sugar industry enhanced via in-mill N analysis

• prevents excessive loss of nitrogen fertiliser to the sensitive GBR environment (reduced by 40%)
• Significantly reduced fertiliser input costs for farmers
• maintained cane sugar yields similar to conventional systems
Integration of cropping and grazing

- Crop and livestock management systems in NSW which:
  - Provides 1000-2000 sheep grazing days/ha on wheat crops
  - Almost double gross margins ($350 to $700/ha) via increased livestock production with minimal impact on crop yields
  - Involves Mg / Na mineral supplements to balance nutrients in wheat high K stubble
Optimising supply chain operations

- Optimal sugar harvesting plans increase profitability across the supply chain
  - Generating up to a 10% increase in sugar production

- Tasmanian pea harvest modelling delivering industry and consumer benefits
  - Neural network developed to better forecast when peas are at their optimal maturity
  - Provides greater lead time in their harvest planning activities
Modelling land use systems - enterprise scale

Recent progress

- Soil-crop-pasture-livestock models used extensively in Grain & Graze programme
- CSIRO forestry model (CABALA) brought into common framework
- Way clear to incorporate vine growth model
- Workshop held to consolidate water balance models

An example: NRM-profit tradeoffs

- Mixed farming systems at 3 locations
- Large simulation experiment coupled with MIDAS model
- Different natural resources respond differently to shifts in land use
International agricultural R&D partnerships

- Indonesian livestock production and economic wellbeing
  - Research, supported by ACIAR since 2001, improving Indonesian self-sufficiency in livestock production
  - Results show quantifiable gains in production, household income and labour saving.
International forests research

• The Planted Forests Project in Borneo
  • CSIRO is providing technical expertise in support of what US science magazine, Discover, has described as one of ‘the six most important experiments in the world’. CSIRO is providing support in tree improvement, forest health, silviculture and forest management.

Photo by: Grand Perfect, Malaysia
Disease risk assessment

- **Foot & Mouth Disease outbreak model** takes shape
  - first stage of development work on a comprehensive model of the spread of Foot and Mouth Disease (FMD) in cattle
  - Modelling will improve our ability to prepare for and manage such threats.
Creating a focus moving forward?

• Global drivers
  • What forces do we need to consider?

• National drivers
  • What are the big drivers reshaping Australian agriculture?

• R&D Response
  • Where can R&D make a difference?
We live in interesting times …..

Global crisis on our plate

Global food crisis: biofuels threaten hunger

Call for a drop in carbon

Farming under threat
Global context
Food security – the emerging international issue

- Rapid rises in food prices (times two to three over the last 2 years)
Food supply and demand

- Production increase < consumption increase in 5 of the last 8 years

Reproduced from Stoeckel (2008)
Drivers of demand increases

- Increased protein consumption in Asia a significant driver of increasing grain demand

**Annual meat consumption in kg per head**

- **United States**
- **China (RHS)**
- **European Union**
- **India (RHS)**

Data source: GMI Statistical database

Reproduced from Stoeckel (2008)
Growth in “high value” production

- Production and consumption shifts in developing countries are broadly based

**Figure 3—Annual growth rate of high-value agriculture production, 2004–2006 (percent)**

<table>
<thead>
<tr>
<th>Product</th>
<th>Developed countries</th>
<th>Developing countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetables</td>
<td>0.2</td>
<td>2.9</td>
</tr>
<tr>
<td>Fruits</td>
<td>0.2</td>
<td>3.0</td>
</tr>
<tr>
<td>Meat</td>
<td>0.6</td>
<td>4.0</td>
</tr>
<tr>
<td>Milk</td>
<td>0.3</td>
<td>4.0</td>
</tr>
</tbody>
</table>

Source: Data from FAO 2007a.

Reproduced from: von Braun (2007) - IFPRI
Declining rates of productivity growth

- Annual growth in yields has declined from around 2% p.a. to 1% p.a. over the last 30 years

**Trends in global yields (tonnes per hectare) for the major food crops — annual percentage changes**

*Data source: OECD-FAO Statistical database*

Reproduced from Stoeckel (2008)
Impacts on food stocks

- Global food stocks at their lowest levels for over 50 years (less than 25% of annual consumption of staples)

12 Major food stocks as a ratio of annual consumption

- Rice
- Wheat
- Coarse grains (a)

Percent


Data source: OECD-FAO Agricultural Outlook - Database

Reproduced from Stoeckel (2008)
Biofuels and food security

- Biofuels - one of many drivers influencing global food security
  - Account for around 6% of wheat, and coarse grains in 2007
  - 60% of the INCREASE in grain production between 2005 and 2007 was diverted to biofuels

- Far from the sole cause
  - Has given us a “heads-up” on the challenges ahead

Data source: OECD-FAO Agricultural Outlook - Database
Reproduced from Stoeckel (2008)
A “blip” or a new order?

• Most forecasts are for soft commodity prices to remain above historic levels in real terms.

Figure 6: Historical and projected real prices of selected food and feed commodities.
Income and price elasticity in food markets

• 20% rise in incomes → 10% rise in food demand ($E_i = 0.5$)

• 100% rise in price → 10% decrease in food demand ($E_p = 0.1$)

• Therefore, if supply stays constant, a 20% rise in incomes will lead to a doubling of world food prices*

• In recent years
  • the rate of increase in food supply has been reduced
    • Seasons, biofuels, energy costs etc.
  • Incomes have risen (esp. Asia)
  • i.e., “perfect storm” for food prices

* After Paul Collier, 2008
Global drivers - synopsis

• Facing a complex environment of supply and demand drivers
  • Small shifts on the demand or supply side will drive price volatility

• Likely to be continuing strong demand for Australia’s food products
  • Domestically and internationally
  • Shorter term volatility with world economic down-turn

• Quality and differentiation will remain important but incentives to maintain or grow production volume.
Australian context
Challenges facing Australian agriculture

- Climate Change / Water Availability
  - Temperature, elevated CO2
  - Rainfall and irrigation supplies

- Greenhouse Gas Mitigation
  - A “cost” on carbon emissions

- Environmental degradation
  - Production soils and landscapes
  - Biodiversity and ecosystem assets

- Input costs
  - Energy, fertiliser, agro-chemicals, labour

- Productivity
  - A problem and a solution
Australian agricultural productivity

- After initial “run-down”, series of technology and management driven advances and plateaux
4-fold increase in nitrogen inputs

Source: FAO (2004), FAOSTAT data; FIFA; OECD Environment Directorate.
3-fold increase in water diversions (MDB)

Actual diversions

Annual diversion (GL/year)

14,000
12,000
10,000
8,000
6,000
4,000
2,000
0

1920 1940 1960 1980 2000 2020

Average natural flow to sea

a) Average modelled values. Diversions from Queensland and ACT are smaller than those from South Australia.
b) The decrease in diversions in recent years reflects mainly drought conditions.
Source: Murray-Darling Basin Commission.
... but an emerging productivity plateau?

Total factor productivity growth in Australia’s cropping industries (ABARE)

- 1977-78 to 2005-06: 2.3%
- 1977-78 to 1993-94: 4.1%
- 1994-95 to 2005-06: 0.9%
Figure 7.15  Emissions attributable to Australian industry by sector, 2006

- Agriculture, forestry & fishing – 29.3%
- Mining – 13.8%
- Manufacturing – 27.7%
- Electricity, gas & water – 8.0%
- Construction – 0.4%
- Commercial services – 12.2%
- Transport & storage – 8.7%

Sources: DCC (2008b); ABS (2007).
Australian agriculture highly greenhouse gas emissions intensive
Australia well endowed with land and “forests”

Figure 7.14  Per capita area of forested and wooded land, 2005

- Australia
- OECD average
- World average

Key greenhouse gas sources – Australian agriculture (under current accounts)

- Agricultural soil: 19%
- Savanna burning: 10%
- Methane from livestock: 66%
- Other: 5%

Farm level Impacts of ETS / CPRS

% reduction in farm cash margins

ETS covered
ETS covered - EITE

EITE = 90% free emissions permits for “Emissions Intensive – Trade Exposed” industries

From Keogh and Thompson (Aug 2008) – Australian Farm Institute. Based on ABARE Farm Survey data, 2001-2006
Future greenhouse accounts

• MAY depart from current assumptions around carbon at equilibrium in agricultural systems

• MAY be less arbitrary in terms of land use change and forestry

• MAY move to be more “seamless” in terms of “all gases, all activities, all lands”

• Our R&D has to inform these developments
Is there a Flagship here somewhere?
Flagship Selection Criteria

1. Focus on a large-scale national problem or opportunity
2. Outcome cannot be delivered through existing initiatives and structures
3. Stakeholder commitment
4. The potential benefits (triple bottom line) compared with other R&D investment options
5. Science capability in a national and international context
6. The quality of the multidisciplinary R&D program (not business as usual)
7. The importance of science and technology-based outcomes to the achievement of the goal
8. Scale of investment to achieve critical mass
The challenge for land use in 2050

Internationally
1. Double food production
2. Develop new production systems to provide industrial feedstocks to replace petrochemicals
3. Sustain per capita ecosystem services
4. Protect biodiversity
5. With 80% less greenhouse gas emissions

Nationally
1. Provide the food and bio-feedstocks for Australia while maintaining our ecosystems resources
2. Maintain our contribution to world supplies
3. With demonstrated long term sustainability
4. With (at least) 80% less greenhouse gas emissions
High-level “Stretch” Goals – work in progress

• **Productivity:** Food production needs to double by 2050, target a 50% increase by 2030
  - via 25% more output with 25% less inputs?

• **Greenhouse Emissions:** By 2030, Australian agriculture and forestry needs to reduce emissions by 80%
  - 40% less emissions, 40% offset via carbon storage?

• **Ecosystem Health and Environmental Stewardship:** Natural assets sustain productivity and new markets develop for environmental services

• **Global Food Security:** Leveraging Australian expertise and technologies to help address global challenges in food security and greenhouse gas mitigation.
More than a “trade-off problem” …

- The science challenge here …..
  - Exists because we need to simultaneously pursue all three outputs
    - Food/fibre products, greenhouse mitigation and carbon storage, environmental services
  - Can’t be solved with markets or prices alone
    - These only change the distribution amongst these outputs, won’t give us more of all three
    - In addition, the social and environmental cost of any unplanned and unsupported transition would be high
  - We need to open new pathways to secure these outputs
    - Technologies, practices, services and policies informed by integrative science
The challenge unfolds at different scales...

• Within enterprises,

• Within and between regions and

• At national scale in terms of Australia’s comparative advantage in global marketplaces
The greenhouse mitigation challenge

- Exists irrespective of agriculture’s ultimate inclusion or exclusion from “emissions trading scheme” (ETS)

- One signal will come via higher costs for energy intensive inputs

- If excluded from ETS, then other means of sending a “cost on carbon” will need to be found for agriculture
  - Important that our research does not get “over-focused” on the ETS question
  - Also important that we don’t get locked into the current Kyoto accounting paradigm
Could carbon neutrality be achieved in Australia’s rural landscapes?

<table>
<thead>
<tr>
<th>Source</th>
<th>Current (Mt Co2-e p.a.)</th>
<th>2030 Target (Mt Co2-e p.a.)</th>
<th>Strategy</th>
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<tr>
<td>Direct agricultural emissions</td>
<td>90</td>
<td>50 ??</td>
<td>New practices and technologies</td>
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<td>More intensive production from reduced land footprint</td>
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<td>Shifts out of emissions intensive industries</td>
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<td>Indirect agricultural emissions</td>
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<td>20 ??</td>
<td>Efficiencies in energy use</td>
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<td>Net forest change</td>
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<td>-50 ??</td>
<td>New forest plantings</td>
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<td>Soil carbon change</td>
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<td>-20 ??</td>
<td>Agricultural management</td>
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<td>New technologies such as “biochar”</td>
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<tr>
<td>Total</td>
<td>165</td>
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Could the land use and management sector cost-effectively offset emissions from elsewhere in the economy?
A conceptual framework - ASI

Natural Assets - Land - Ecosystems

- Food and Fibre Products
  - $40B agricultural outputs
  - $18B forest outputs
- Greenhouse Gases and Carbon Bio-sequestration
  - Net 160 M tonnes CO$_2$e p.a.
  - $7B cost liability
- Ecosystem Services
  - Biodiversity, water flows, amenity values etc (outside formal markets)

Outcomes

- Food Security
  - 93% domestic needs
  - 3% of global food trade
- Rural Livelihoods
  - 30% of Australians living in rural regions
- Economic Activity along Value Chains
  - 3% of GDP directly
  - 12% of GDP value added
- Healthy Ecosystems

Outputs

- Productivity
- Mitigation
- Environmental Stewardship

Science-based Interventions
- Technologies
- Practices
- Services
- Policy support

Flagship Research

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National Research Flagships

• Food Futures
  • on value adding in the agri-food sector via frontier technologies

• Water for Healthy Country
  • on rural and urban water technologies, management and policy support

• Energy Transformed
  • on greenhouse gas mitigation in the energy generation and transport sectors

• Climate Adaptation
  • on adaptation responses to climate change in primary industries and communities, natural ecosystems and cities and coasts

• ?? Agricultural Sustainability ??
  • on raising agricultural and forest productivity whilst reducing greenhouse emissions and improving agri-ecosystem health
The missing piece in the jigsaw?

- Minerals
- Health
- Oceans
- Energy
- Food (FFF)
- Water (WfHC)
- Climate (CAF)
- Land-use ASI

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Opportunities for UWA – CSIRO links

1. Dialogue as we shape the case

2. Existing collaborations in CRCs, RDC projects, DAFF/DCC initiatives etc.

3. Partnerships around international agricultural development / human and institutional capability building

4. Strategic partnerships under the Collaboration Fund and/or other University initiatives
Agricultural Sustainability Initiative
Dr Brian Keating
Director, Agricultural Sustainability Initiative

Phone: 07 3214 2261
Email: brian.keating@csiro.au

Thank you