A review of the history of Precision Agriculture in Australia and some future opportunities

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THE UNIVERSITY OF SYDNEY

GRDC
Grains Research & Development Corporation

Australian Centre for Precision Agriculture

Precision Agriculture and Site-Specific Crop Management

Precision Agriculture:

A philosophy aimed at increasing long term, site-specific and whole farm production efficiency, productivity and profitability while minimising unintended impacts on the environment.

Site-specific crop management (SSCM)

A form of PA whereby decisions on resource application and agronomic practices are improved to better match soil and crop requirements as they vary in the field.

Precision Agriculture and Site-Specific Crop Management

Main messages:

- **Precision Agriculture (PA), in its current SSCM form, has a long history of innovators and pioneers with a single aim of improving agricultural management. Australia remains at the forefront of the development of PA tools and practical applications, not the least because of our unique range of production conditions.**

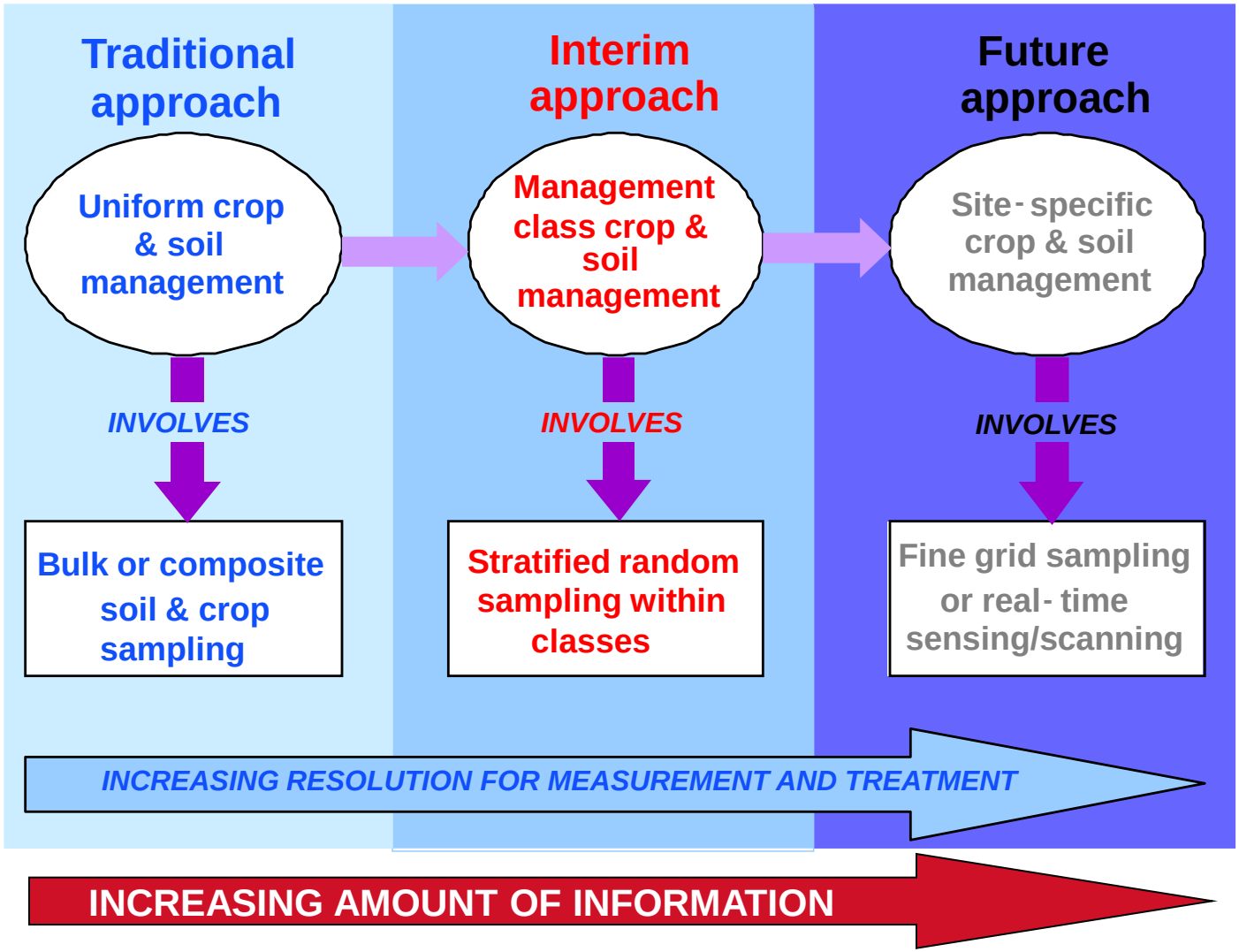
- **Undoubtedly the application of PA continues to be a general success in Australia despite the fact that some products or techniques have not been adopted or remain ahead of their time.**

Precision Agriculture and Site-Specific Crop Management

Main messages:

- **Development opportunities are naturally opening in areas which better quantify small-scale variation and allow such information to be usefully integrated into management decisions.**
- **Important areas for PA to continue the transformation of agricultural management into an increasingly resource efficient, less risky, societal endeavour are:**
  - **sensing systems**
  - **analytical procedures**
  - **software**
  - **agronomic understanding**
  - **robotics**
  - **human resources**

The Development of SSCM



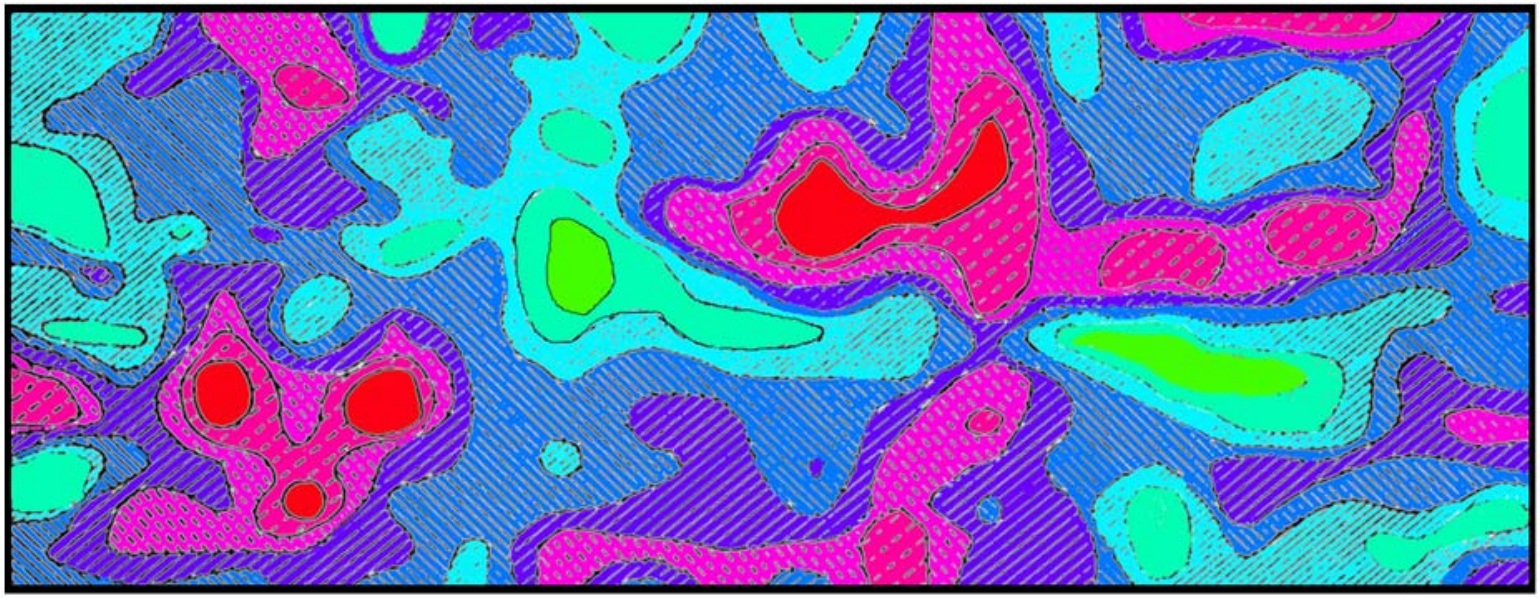
Precision Agriculture and Site-Specific Crop Management

PA evolving in Australia since 1788

- **Henry Dodd: culling uneconomic production areas in 1788/9.**
- **Since then: farmers, scientists and agribusiness have been learning about, modifying and redesigning management systems to suit the spatial and temporal variability in agricultural production conditions presented across the country.**
- **PA is a logical part of this process.**

PA History in Australia

Wheat yield map: Canberra 1934



Fairfield Smith, H. 1938. An empirical law describing heterogeneity in the yields of agricultural crops. Journ. Agric. Sci. 28:1-23.

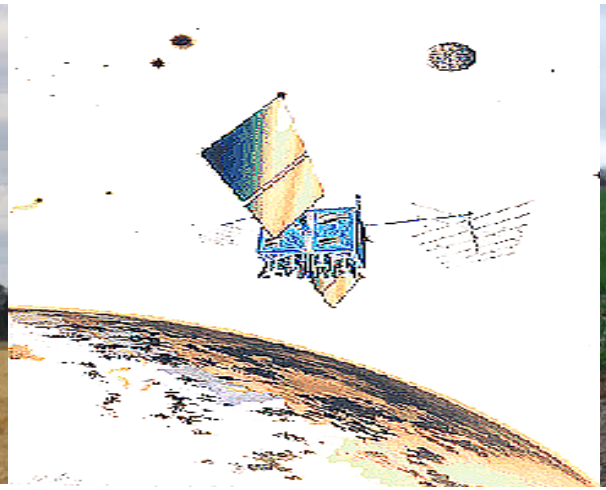
PA History in Australia

Reflectance activated spot spraying:
commercialised O/S from work in Tamworth in mid 1980's

Felton, W.L. and K.R. McCloy. 1992. Spot spraying. Agricultural Engineering 73(6):9-12.

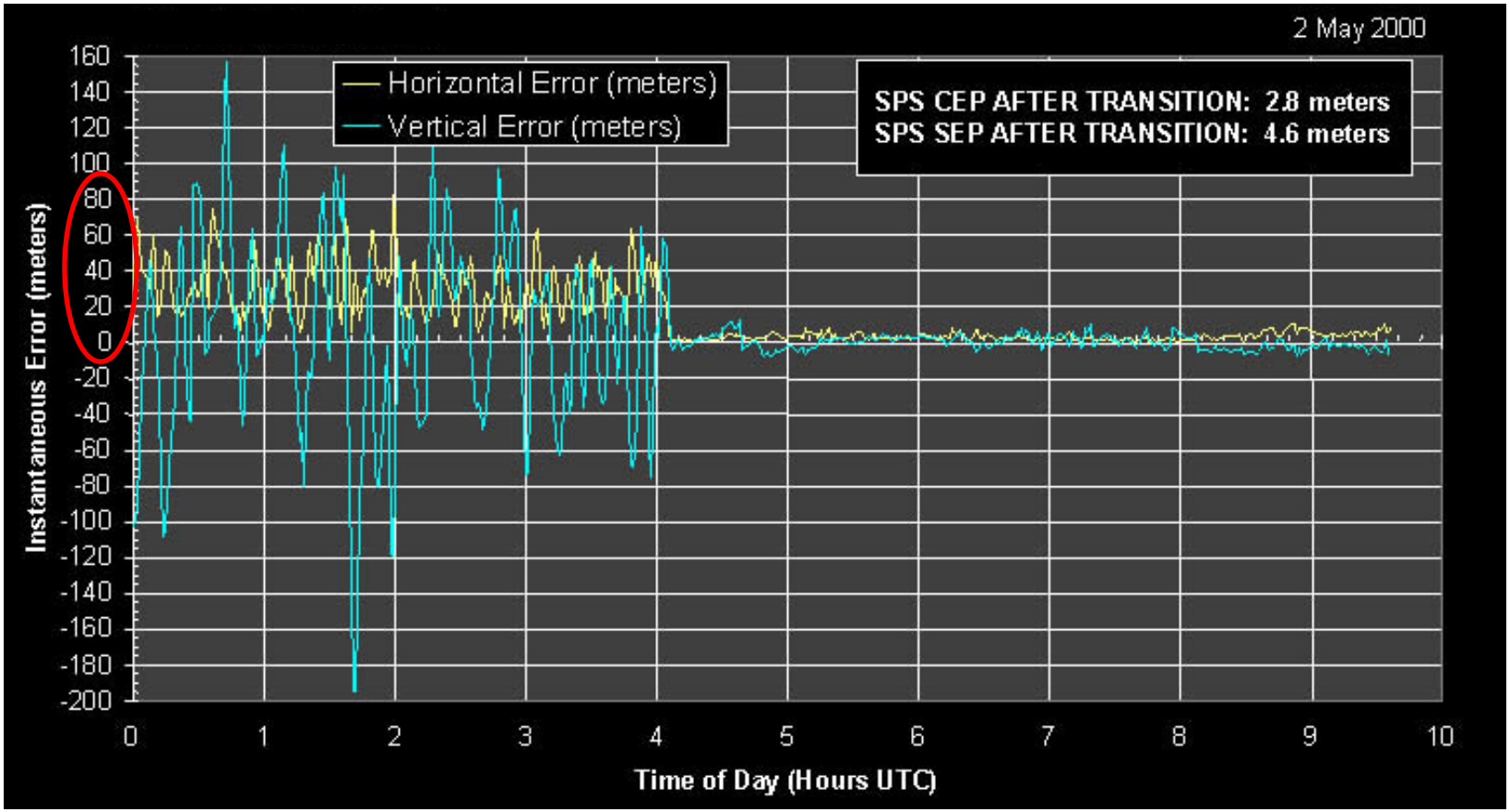
PA History in Australia

The arrival of civilian access to the GPS in 1993



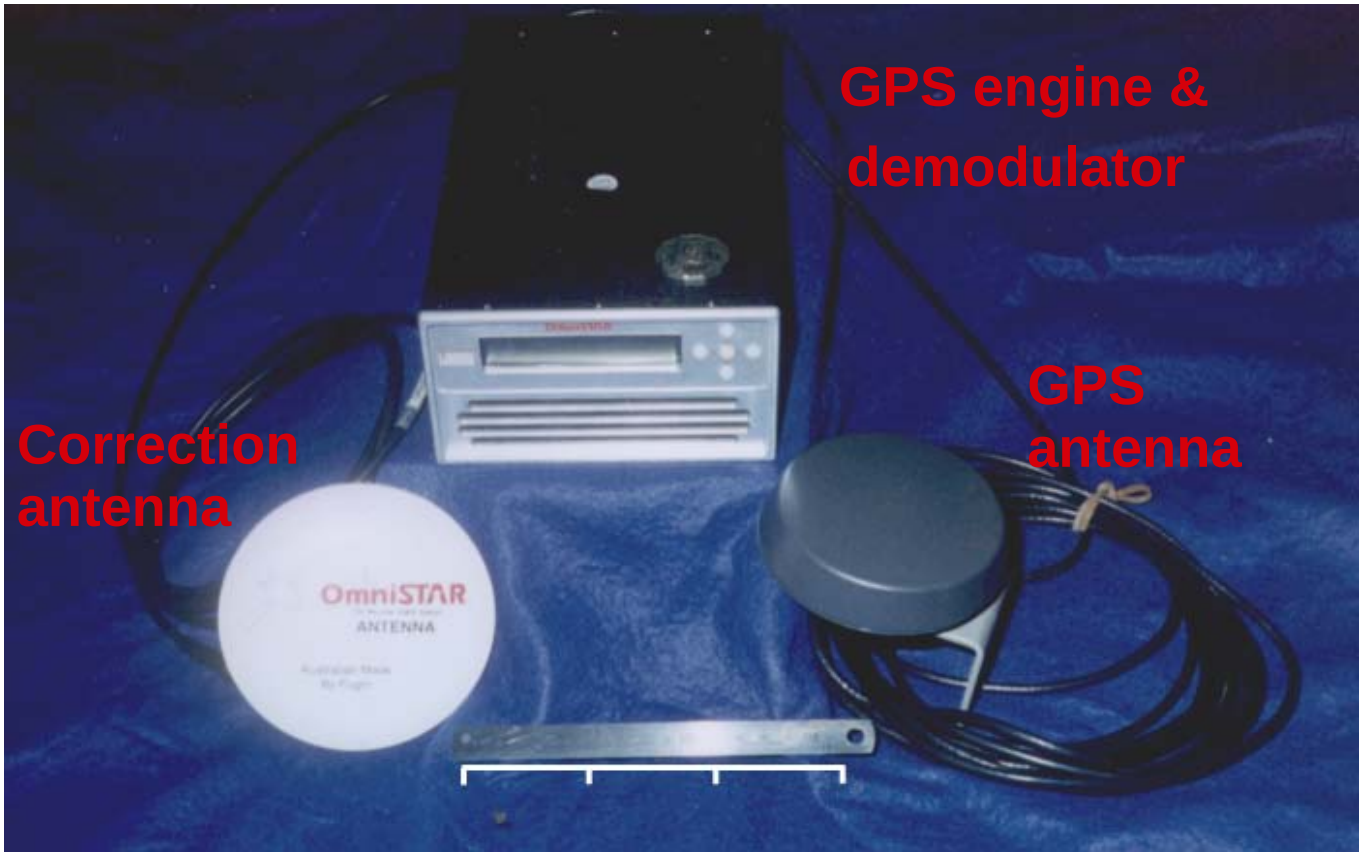
GPS history in Australia

Selective availability active until 2/5/2000



GPS history in Australia

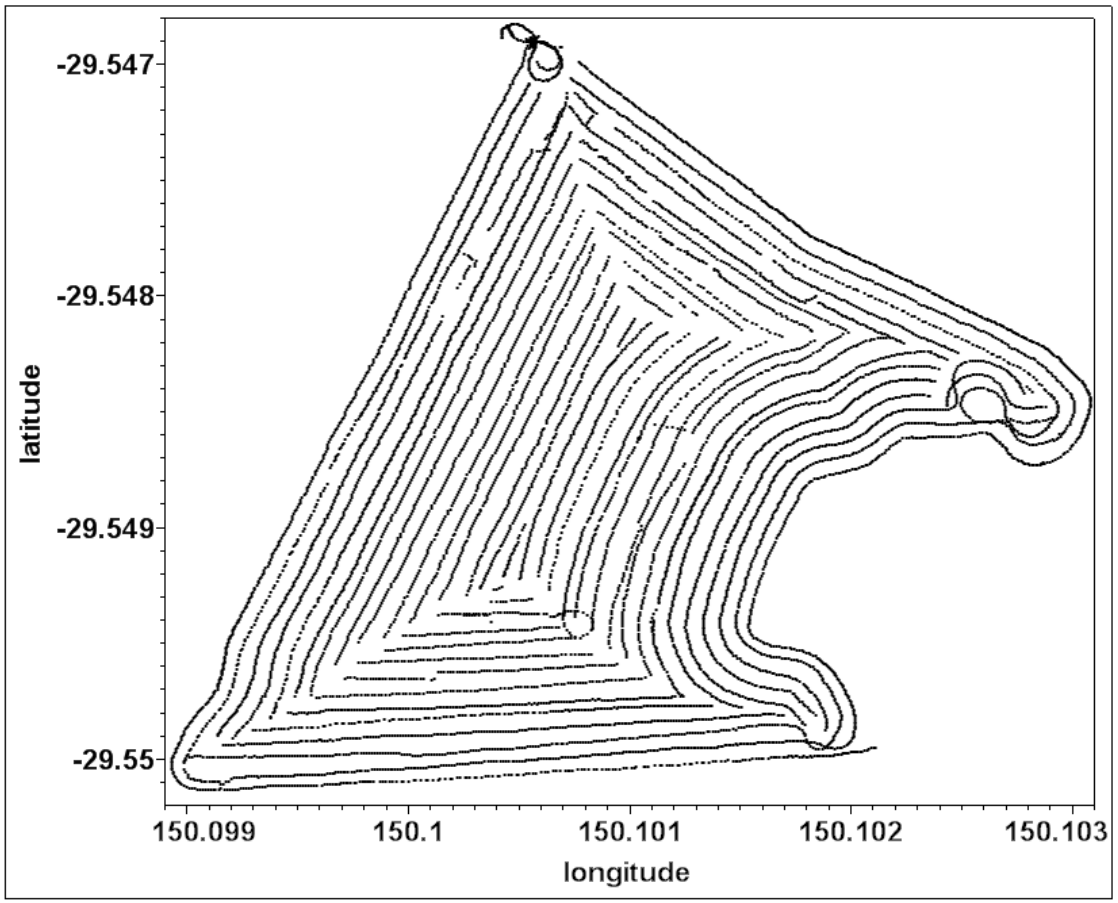
Fugro Starfix/OmniStar WADGPS : (1994/5)



~ A$6500 plus A$3000 licensing (1-3m WADGPS)

GPS history in Australia

Harvester track data: (December 1995)



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GPS history in Australia

Beeline Navigator: late 1990's

A GPS and inertial guidance system for agricultural machinery.


Courier Mail - Saturday 18th October, 1997

NORTH West NSW farmer Doug Cush believes it will take just one season to pay for his recent purchase of two "top of the line" $80,000 Beeline Navigator Pro 2 tractor guidance systems — now at work on his Bellata property.

With two tractors capable of "self steering" to within centimetres of a designated path, he has been planting dryland cotton day and night on "Saltwell" with two machines in the one paddock.

Beeline Navigator , Agsystems P/L - Design award at 2001 Australian International design awards, Heavy machinery

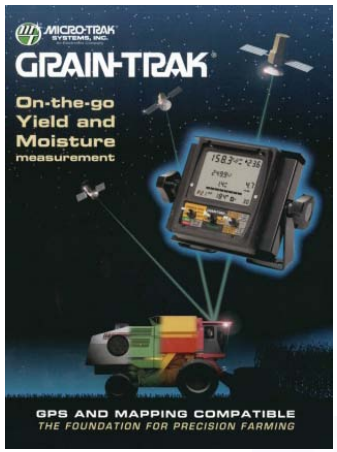
GPS history in Australia

More recent:

- **Wide area corrections increase in accuracy from sub-metre to sub-decimetre by 2005.**
- **Corrections and diagnostics via internet and mobile communications.**
- **High accuracy CORS networks available to agriculture from 2009.**

Yield monitor history in Australia

Micro-Trak: 1993



yield sensor

yield monitor

moisture sensor

Distributed in Australia in 1993 by Croplands: A$ 8500

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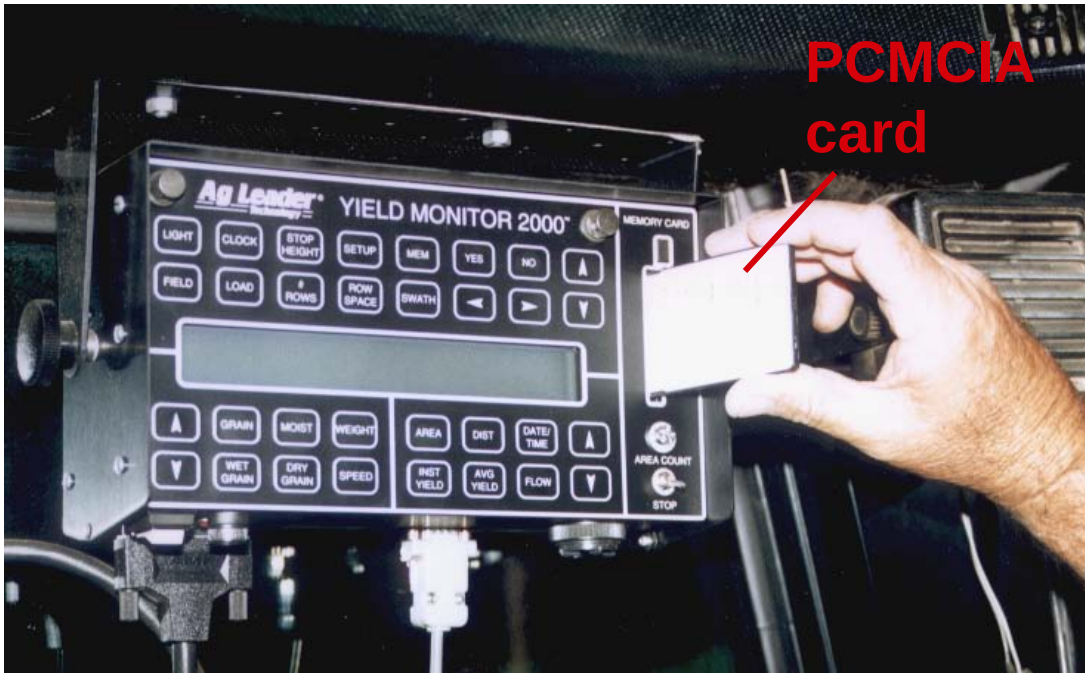
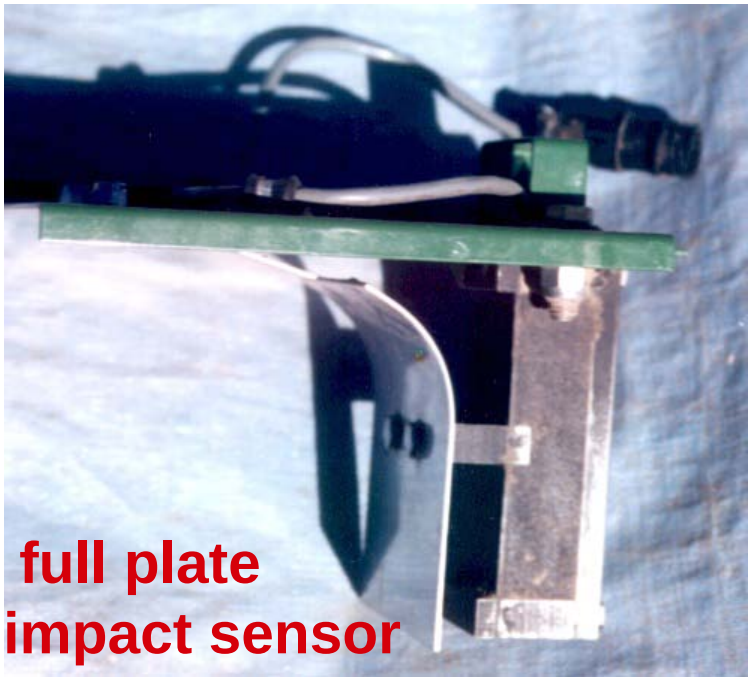
Yield monitor history in Australia

AgLeader: 1995





Imported direct from AgLeader (eventually distributed by Pathways): A$ 6000

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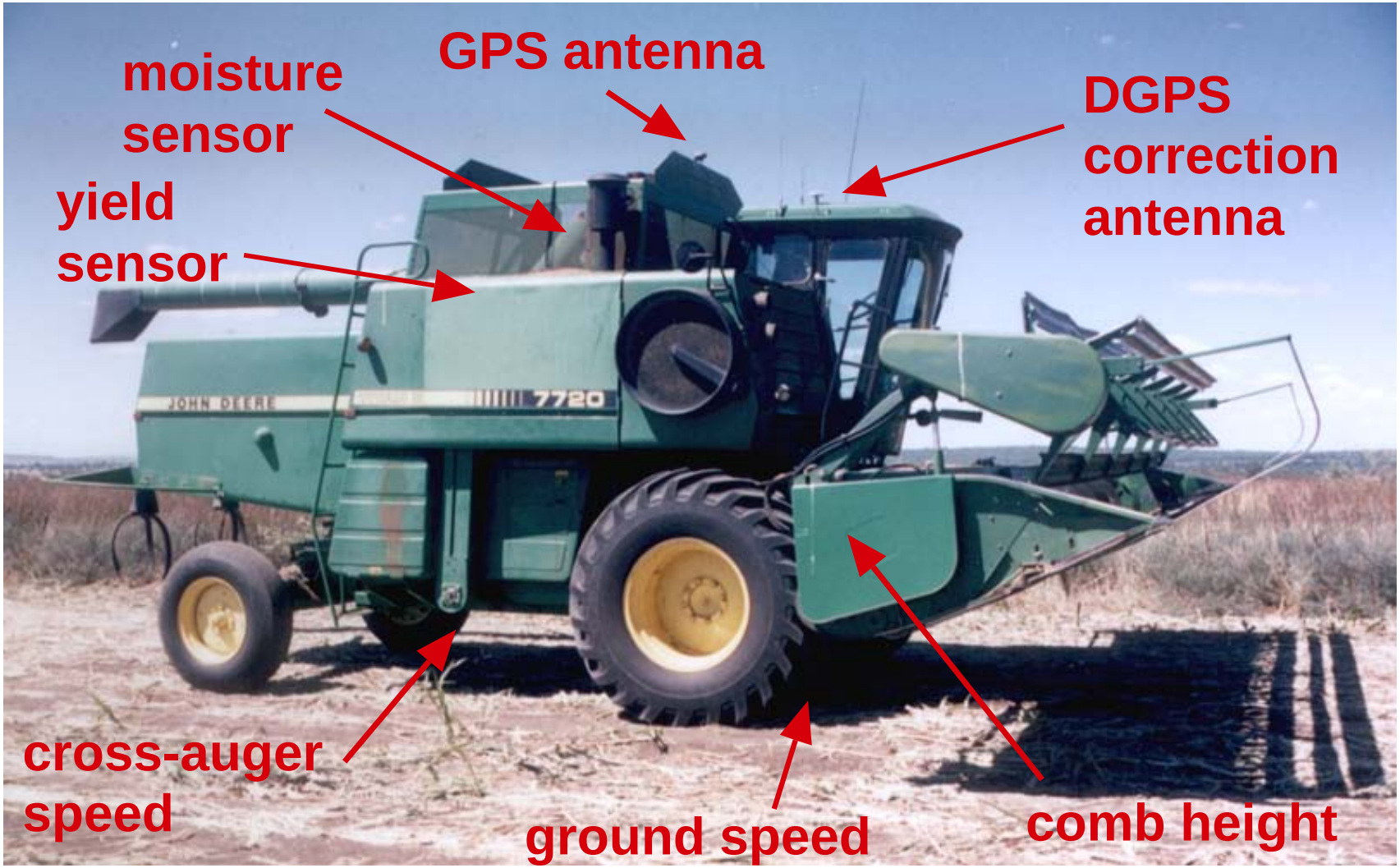
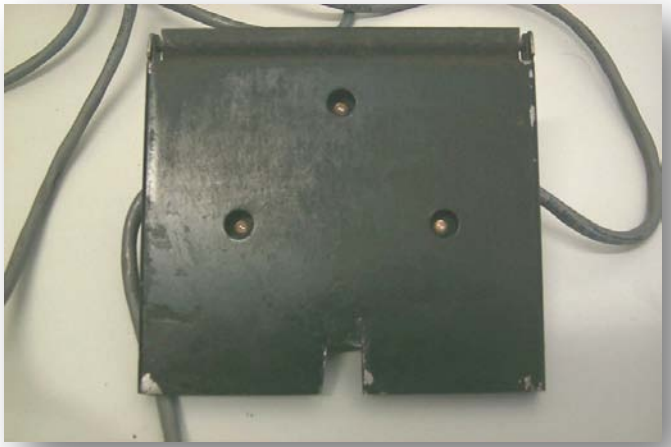
Yield monitor history in Australia



Yield monitor history in Australia

Cotton yield monitors: from 1997

Zycom



AgLeader

Farmscan

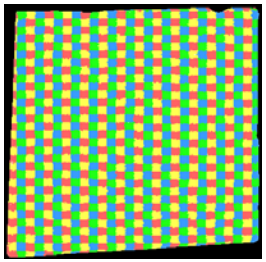
Yield monitor history in Australia

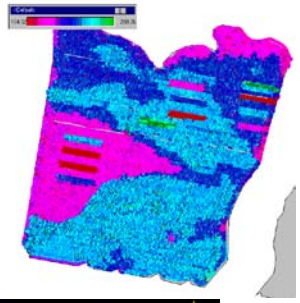
Grape yield monitors: from 1995/6

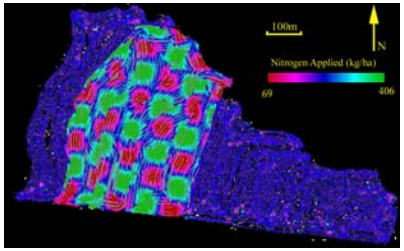
Much successful utilisation and developments in PV has come from Australia

PA hardware history in Australia

Variable-rate controllers: available before GPS







Mid-late 90's sees some 'extravagant' Australian experimentation with nutrients.

- **Late 90's sees initial commercial use of variable-rate controllers.**
- **Importantly, led to the substantiation of savings/efficiencies to be gained.**

PA hardware history in Australia

Other important developments

- **Late 1990's: Soil ECa field instruments mobilised and applied in Australia to PA. Gamma-radiometrics around 2000.**
- **Late 1990's: on-harvester protein sensors first trialed in Australia.**
- **Broad-acre spot spraying systems using plant reflectance commercially available in the early 1990's but not considered widely in Australia till 2005/6.**
- **2005: Boom and planter section control arrives.**
- **Crop reflectance sensors available for nutrient management in 2003/4, but not widely available in Australia until 2006.**
- **2009: Implement steering available.**

PA hardware history in Australia

The major early issue: combining hardware

PA software history in Australia

PA software history in Australia

Further developments

- **1994: Basic software with manufacturer's yield monitors allows yield map construction;**
- **1995/6: Independent spatial farm management software;**
- **1996: Hand-held computer mapping/scouting software available;**
- **1996/7: Farmstar ~A$3400 plus licensing fee;**
- **2000: PA software with intuitive GUI and GIS capabilities;**
- **2000: PA-specific mobile mapping software; and**
- **Since then: explosion in developments and capabilities from Australian and International independent and aligned companies.**

History of PA management in Australia

- **1995/6: yield mapping sparks wider interest in dealing with production variability across large paddocks.**
- **1995/6: Grid soil sampling concept to drive variable-rate input application brought to Australia.**

History of PA management in Australia

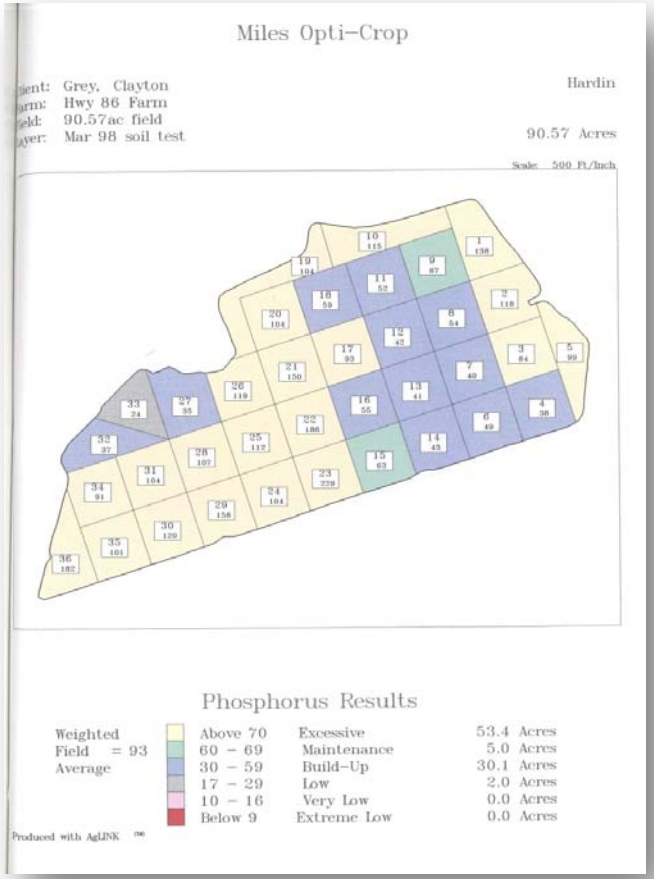
Grid soil sampling: the USA approach

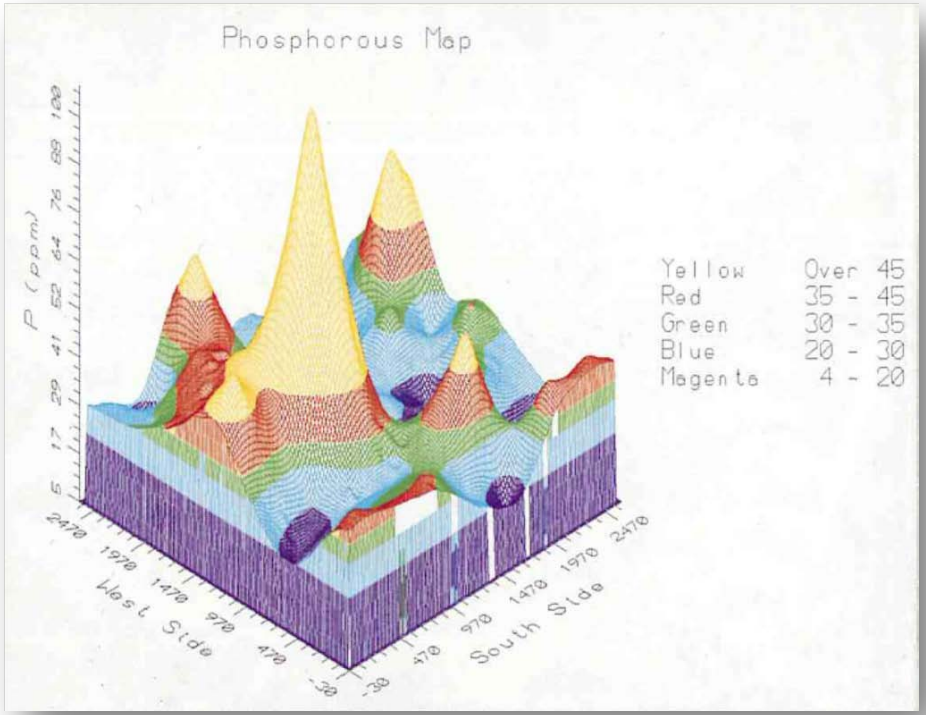
MORE PRECISION...MORE PROFIT

Opti-Crop

The American approach to investigation

Grid soil sampling





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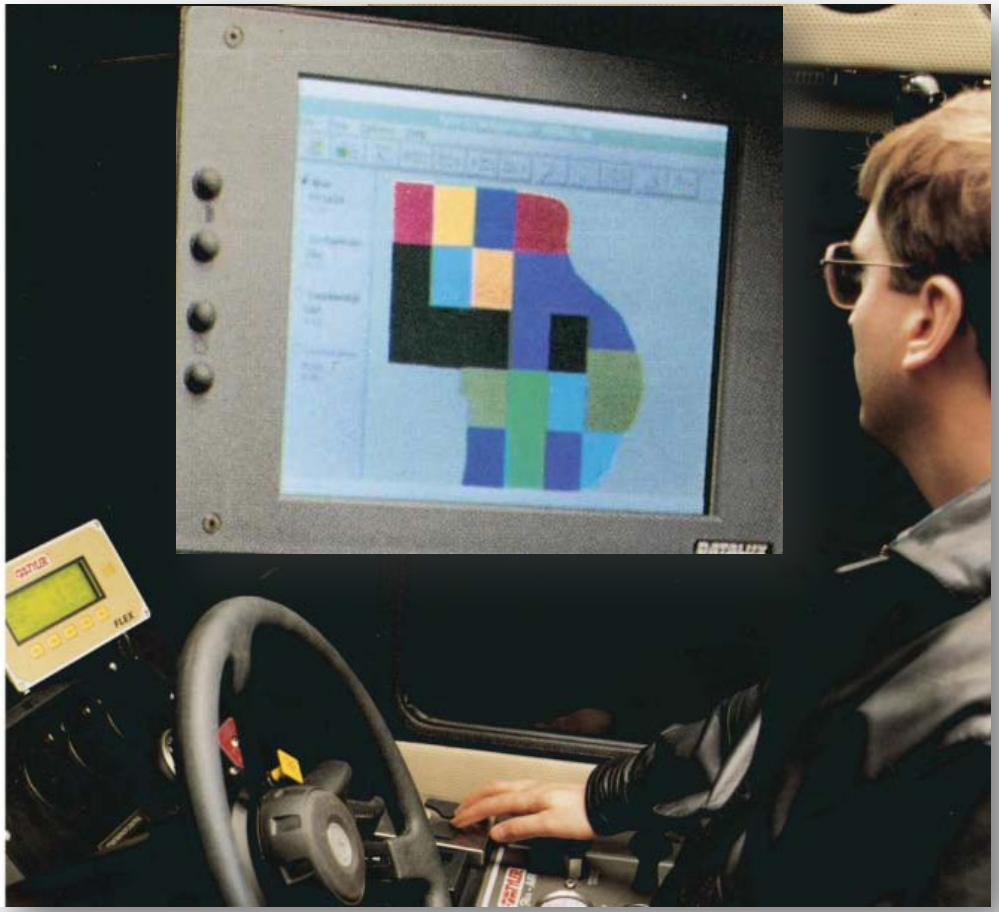
The American approach to investigation

Grid soil sampling: input application decisions



History of PA management in Australia

- **1995/6: yield mapping sparks wider interest in dealing with production variability across large paddocks.**
- **1995/6: Grid soil sampling concept to drive variable-rate input application brought to Australia.**
- **1996: first all-in one hardware and software solution for yield mapping, field navigation for scouting and variable-rate control.**

PA hardware history in Australia

Rockwell Vision System: 1996

Monitor and controller

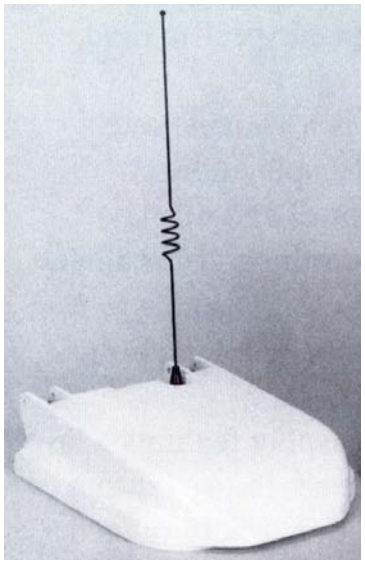
SYSTEM REQUIREMENTS:

- An 80486 computer (Pentium 150MHz or faster recommended).
- At least 8 Mb of RAM (32 Mb recommended).
- Video Card -2 Mb VRAM capable of 16 bit HiColor mode.
- A minimum of 10 Mb of free hard disk space to install; additional space required for processing data.
- Microsoft Windows95 or Windows NT 4.0 operating system.
- Floppy disk drive.

Rockwell

GIS software

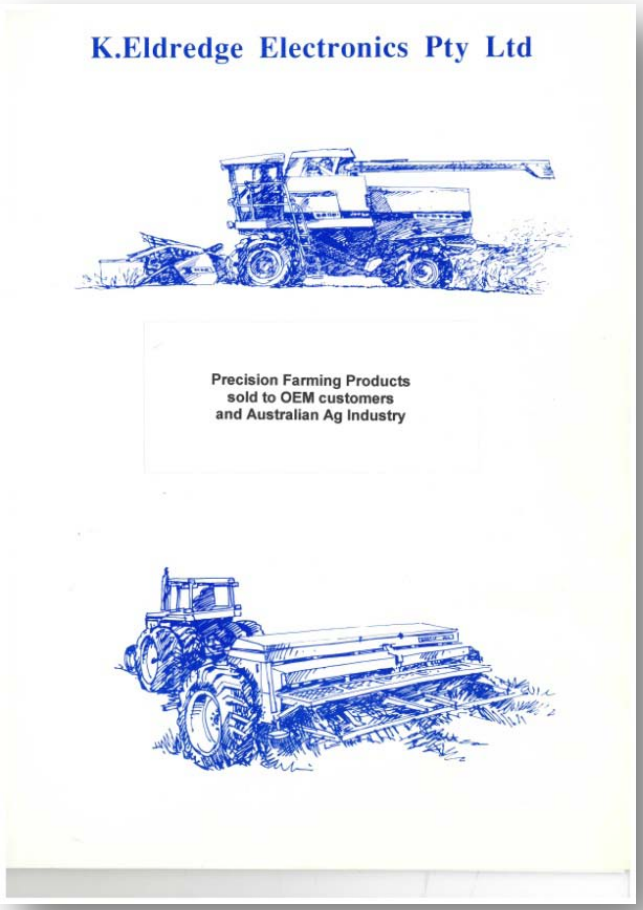
A$ 18,000



GPS & demodulator

PA hardware history in Australia

KEE Lynx/Zynx X10: ~ 2000



Added:

- **Guidance system**
- **Boom leveler**
- **Header height control**
- **Depth control**
- **PC operating system**

History of PA management in Australia

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- **1997: first national PA conference in Australia.**

PA History in Australia

First national PA conference: 1997

Presentation Program

The program format has been structured to highlight research within the basic components of a Site-Specific Management System.

9.00 am Symposium Introduction and Opening
Professor Don Napper, Pro-Vice Chancellor, College of Sciences & Technology, University of Sydney.
9.10 am Welcome and introduction to Pierre Robert
Alex McBratney, ACPA, University of Sydney.

Chairman: Alex McBratney
9.30 am Grid sampling and crop monitoring-measuring crop variability.
Jon Medway, Charles Sturt University.
9.50 am Rice yield mapping.
Brendan Williams, University of Melbourne.
10.10 am Adoption of site-specific technology at the farm gate.
Nigel Bodinnar & Robert Christie, Pivot.
10.30 am Remote sensing applications in pasture nutrition
Martin Williams, Incitec Fertilisers.
Morning Tea

Chairman: Simon Cook
11.20 am An investigation of barley grain protein variation.
Richard Lowe, Graham Moore, Marc Nicolas & Brendan Williams, University of Melbourne.
11.40 am Precision Agriculture: what are the implications for wheat quality?
John Skerritt, CSIRO Division of Plant Industry.
12.00 noon Preliminary real-time cotton yield monitoring.
Broughton Boydell, ACPA, University of Sydney / CRC for Sustainable Cotton Production.
12.20 pm Precision Agriculture for sugar cane.
Graeme Cox, Harry Harris & Randolph Pax, University of Southern Queensland.
12.40 pm Towards a real-time soil pH sensor.
Raphael Viscarra Rossel, ACPA, University of Sydney.
Lunch

Chairman: Tom Cowlrick
13.50 pm Spatial prediction and mapping precision.
Brett Whelan & Alex McBratney, ACPA, University of Sydney.
14.10 pm Modelling sorghum response to fine-scale soil variation.
Tamara Shatar, ACPA, University of Sydney.
14.30 pm Potential role of Precision Agriculture techniques in property management planning.
Kim Brycseon & Steve Marvenek, CRC for Soil and Land Management.
14.50 pm Designing and implementing on-farm experimentation for Precision Agriculture.
Simon Cook, CSIRO Land and Water.
15.10 pm Designing and implementing on-farm experimentation for Precision Agriculture.
David Mills, Precision Farming Australia.
Afternoon Tea

Chairman: Brett Whelan
15.50 pm Determining variable-rate Nitrogen requirements.
Tony Good, Incitec Fertilisers.
16.10 pm Progress on variable-rate control equipment.
David Sharp, Computronics.
16.30 pm Precision Agriculture-putting the concept into practice:a demonstration project.
Geoffrey Hamilton, Kondinin Group.
16.50 pm International perspective and local review.
Pierre Robert, Centre for Precision Agriculture, University of Minnesota
17.20 pm Discussion
17.30 pm Close

History of PA management in Australia

- 1995/6: yield mapping sparks wider interest in dealing with production variability across large paddocks.
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- 1996: first all-in one hardware and software solution for yield mapping, field navigation for scouting and variable-rate control.
- 1997: first national PA conference in Australia.
- Late 1990's: management class/zone concept introduced to direct investigative sampling and manage inputs.
- Early 2000's: High accuracy elevation, soil ECa and yield maps to make management classes proves useful across much of Australia.
- Mid-2000's: variable-rate nutrient and ameliorant application within management classes is used in numerous agricultural industries.

History of PA management in Australia

- From 2001: vehicle navigation accuracy continues to improve and controlled traffic/swathing takes off by 2006. Reduced input application from boom section control by 2007, interrow sowing by 2009 and automated implement control by 2010.
- 2003: First general conference for PA in livestock management is held in Europe and signals the beginning of fine scale spatial management to join precision feeding and animal handling operations.
- 2007: plant reflectance sensors more widely applied to manage in-fallow weeds and brings significant reductions in herbicide applications.
- 2008: plant reflectance sensors used to monitor crop vigour/health/nutrition begin to be used by innovators for fine-scale N management.

Future opportunities in cropping

- **fine scale, real-time, cost-effective estimation of crop/soil nutrient levels;**
- **fine scale, real-time, cost-effective estimation of profile soil moisture content;**

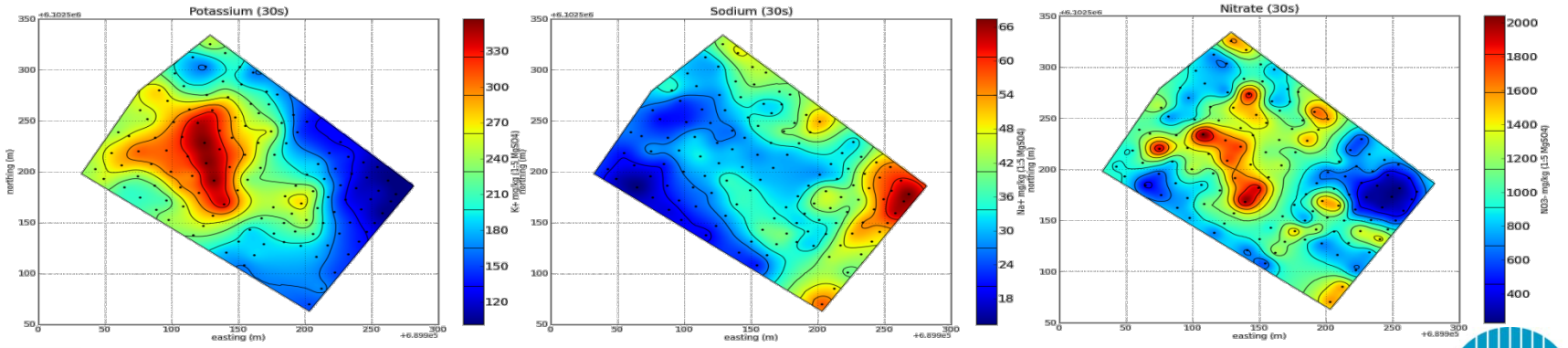
Mapping soil variability

Multi-sensor platforms

Soil nutrient measurement

An automated multi ion measuring system (MIMS) for rapid in–field soil nutrient testing

K^+ Na^+ NO_3^-



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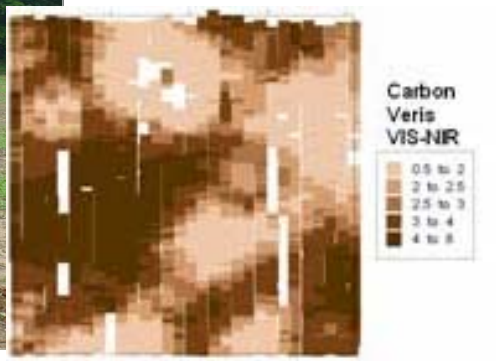
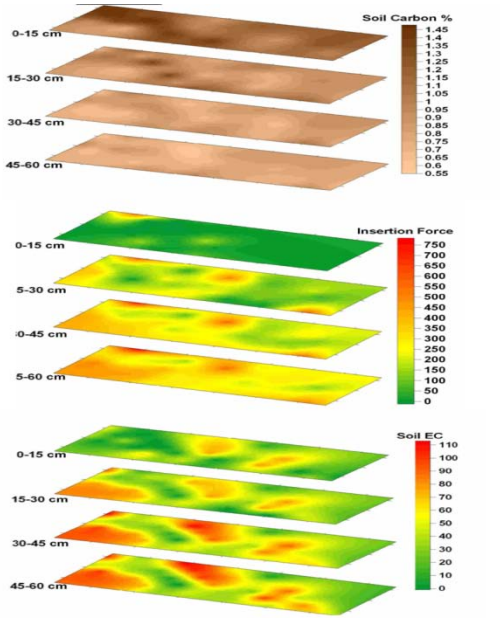
CSIRO

New techniques for nutrient measurement

Spectroscopy

surface





profiler

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Future opportunities in cropping

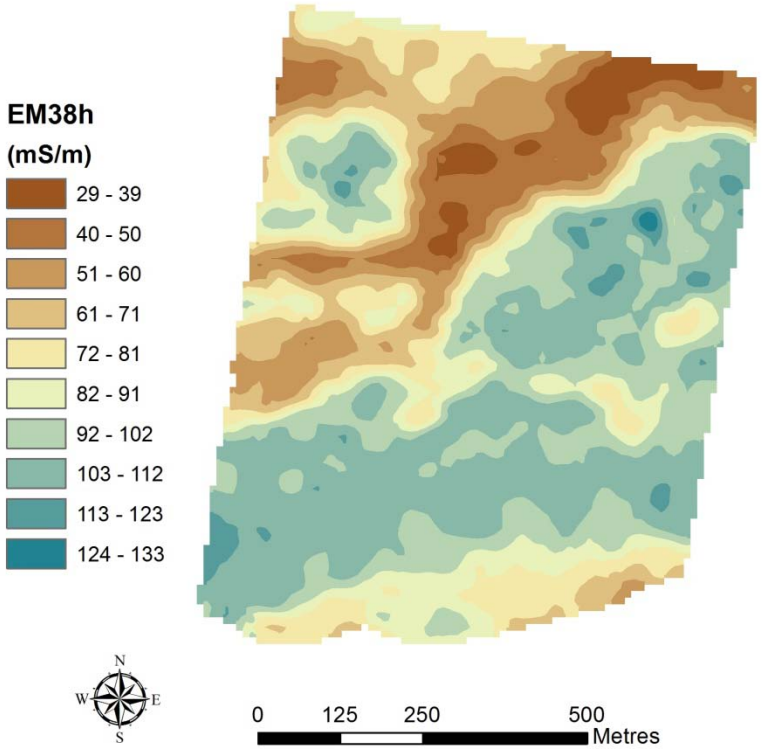
- **fine scale, real-time, cost-effective estimation of crop/soil nutrient levels;**
- **fine scale, real-time, cost-effective estimation of profile soil moisture content;**
- **localised weather predictions;**
- **crop yield monitors for more crops;**
- **efficient, integrated crop quality monitors;**
- **spatial yield prediction/simulation models;**
- **combining crop reflectance sensors with an independent biomass sensor;**
- **understanding agronomic impact of fine-scale resource variability and interactions;**

Future opportunities in cropping

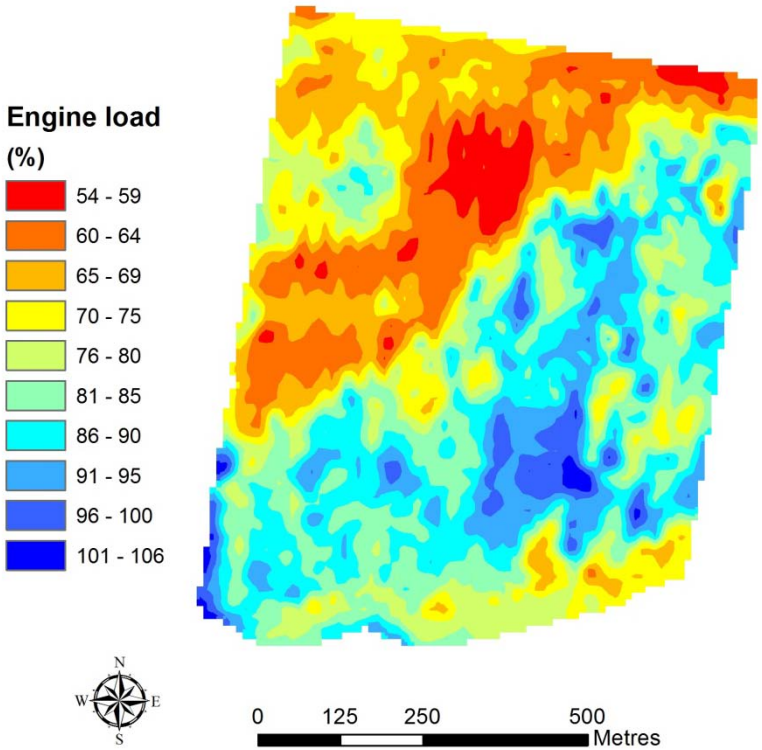
- **autonomous weeding;**
- **public-funded research targeting PA for increased water-use efficiency and improved farm C and N emission management;**

Gathering soil/crop information during common operations

Vehicle engine load during sowing



Soil ECa measured using EM38h



Engine load (% of total power rating)

Data supplied by Rupert McLaren, McLaren Farms 'Glenmore', Barmedman, NSW

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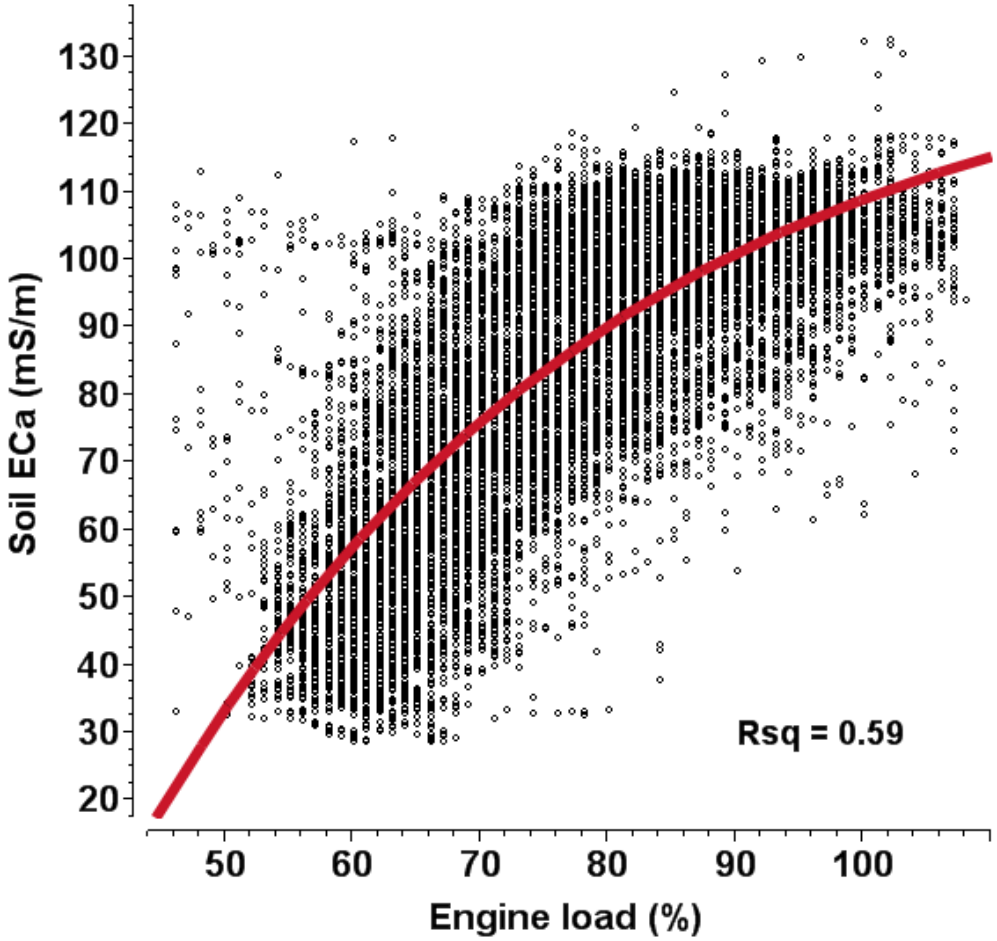
Gathering soil/crop information during common operations

Vehicle engine load during sowing



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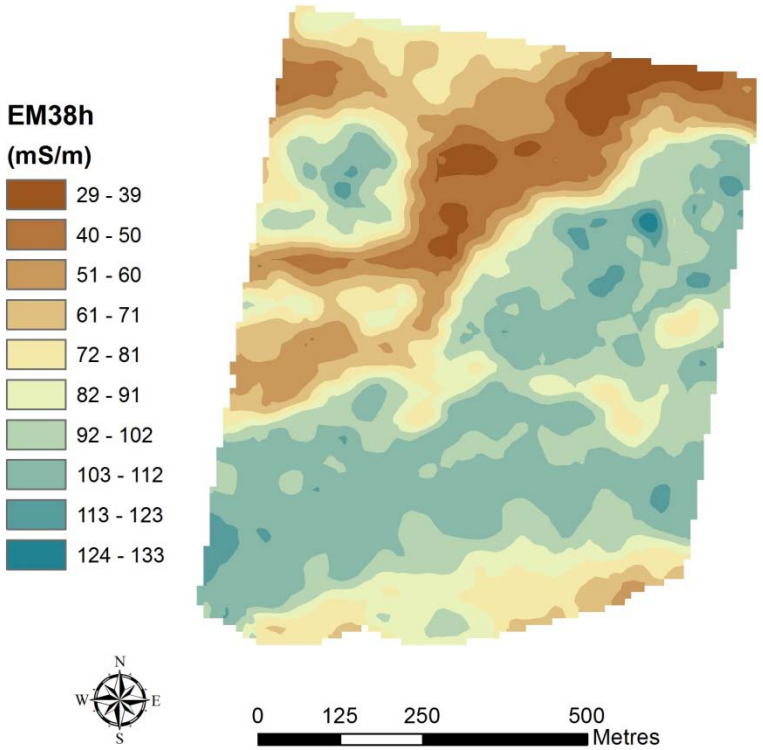
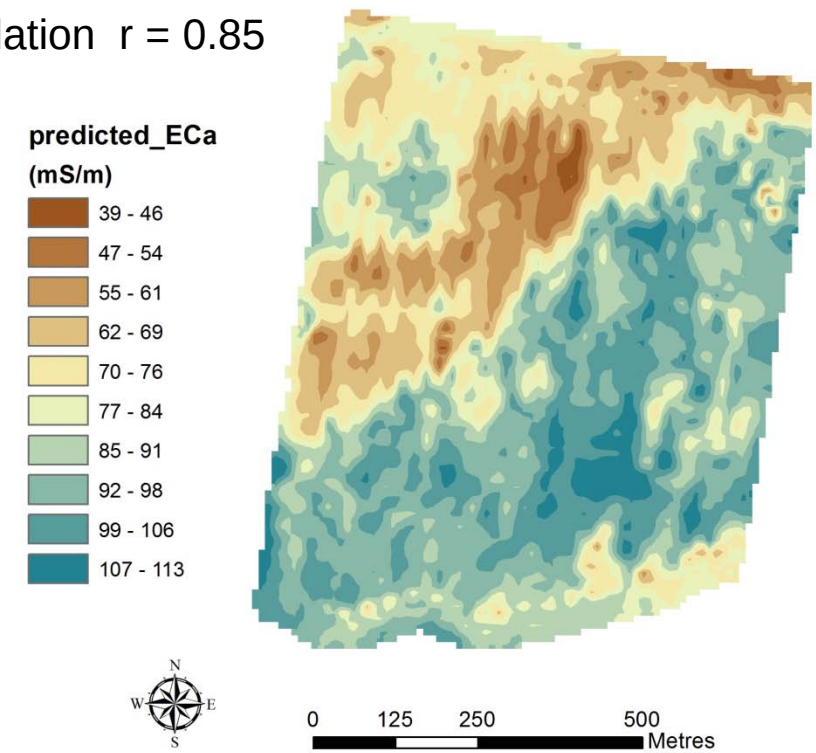


Soil ECa measured using EM38h

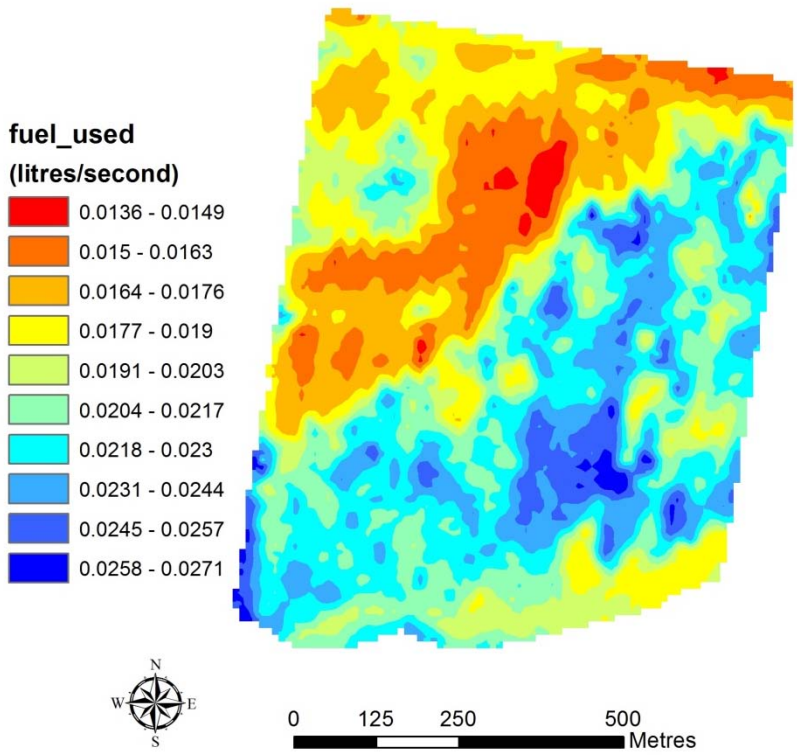
Correlation r = 0.85



Soil ECa predicted from engine load

Data supplied by Rupert McLaren, McLaren Farms 'Glenmore', Barmedman, NSW

Spatil C and N dynamics and balance



+ as-applied fertiliser map

+ yield map or imagery to estimate biomass

= spatial estimates of C and N dynamics which could be used to support balance calculations.

Future opportunities in cropping

- **autonomous weeding;**
- **public-funded research targeting PA for increased water-use efficiency and improved farm C and N emission management;**
- **secondary and tertiary education;**
- **improving PA GIS capabilities;**
- **integrating multiple data layers for real-time decision making for nutrient/irrigation applications;**
- **product tracking and production information traceability; and**
- **more plug and prosper.**

Summary

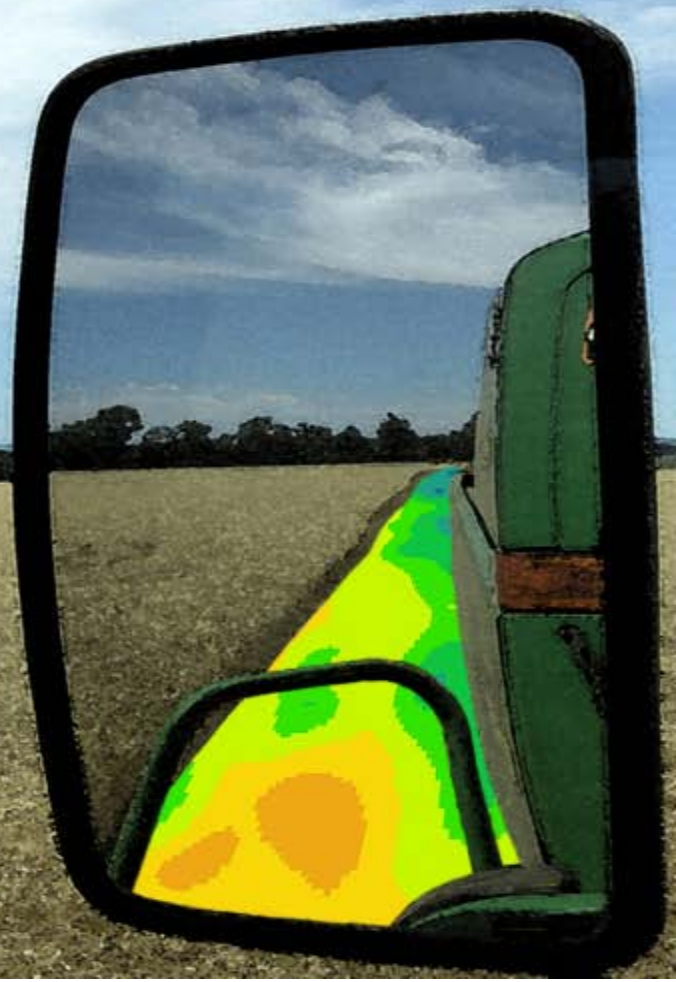
Looking back:

Australians have been hugely influential in the development of PA tools and techniques that increase the efficiency of crop management

By any measure, PA has improved Australian agricultural management over the past 10 years.

Looking forward:

Given continued pressure on production efficiency, it is no time to back off the innovation and practical application of PA by and for Australians.



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