# 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 widely adopted or remain ahead of their time.**

# Precision Agriculture and Site-Specific Crop Management

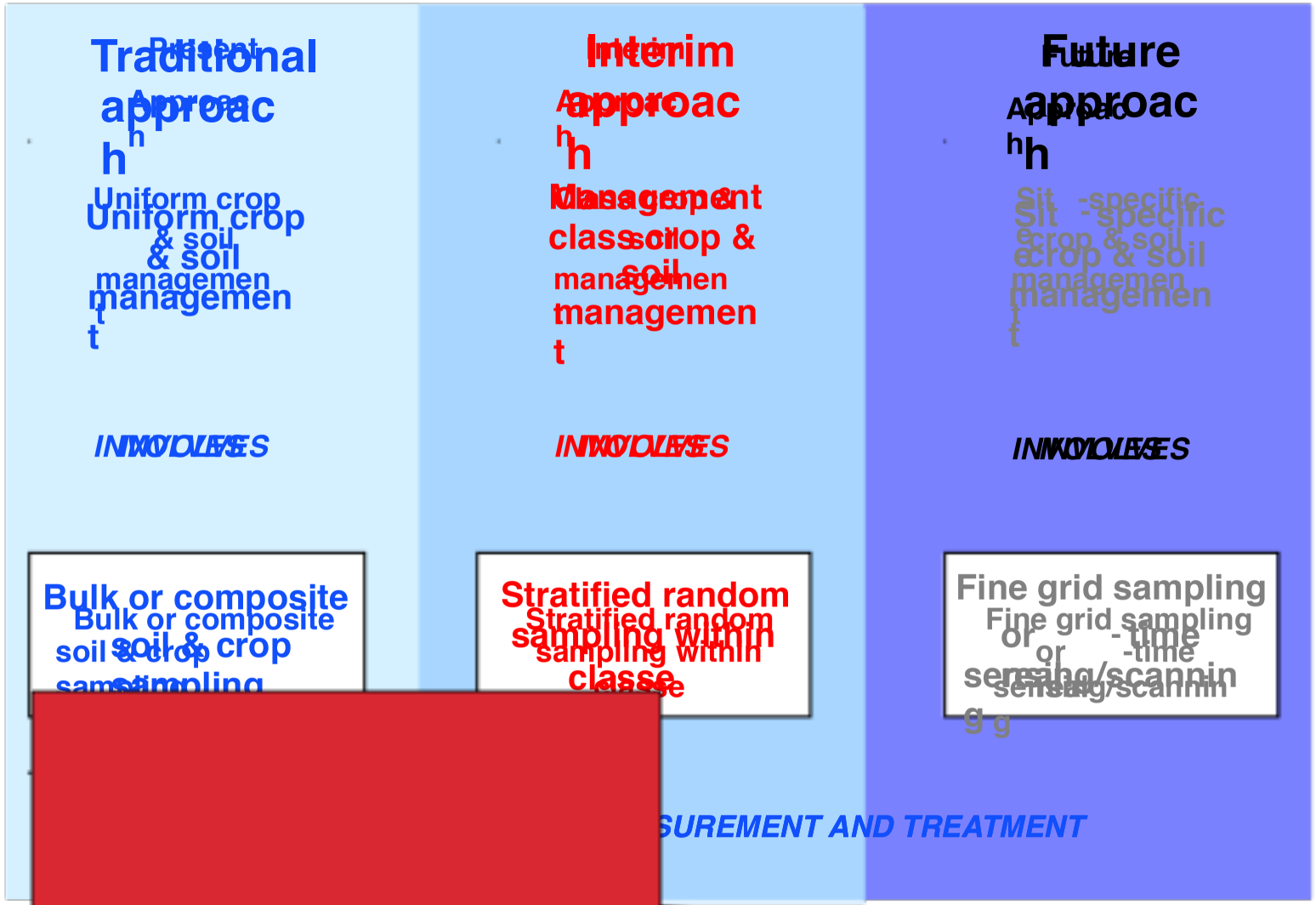
## *Main messages:*

**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*

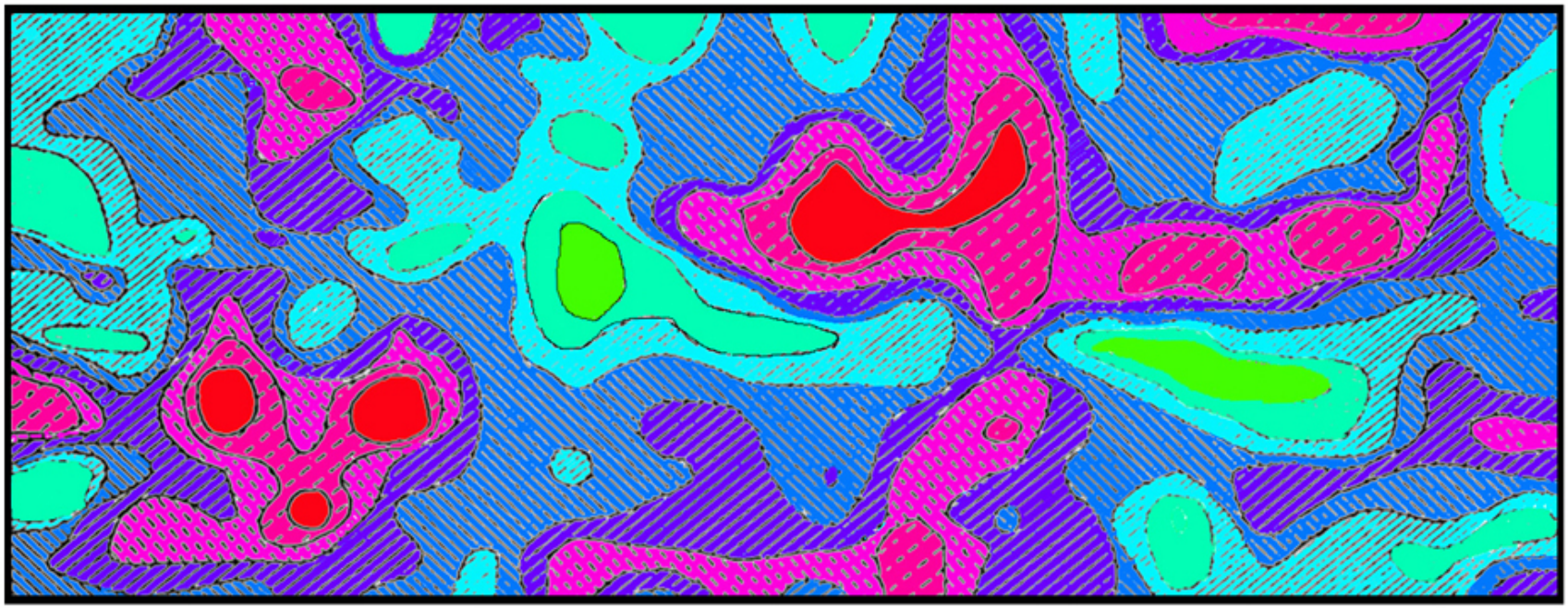
**Henry Dodd: culling uneconomic production areas in 1788/9.**

**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.

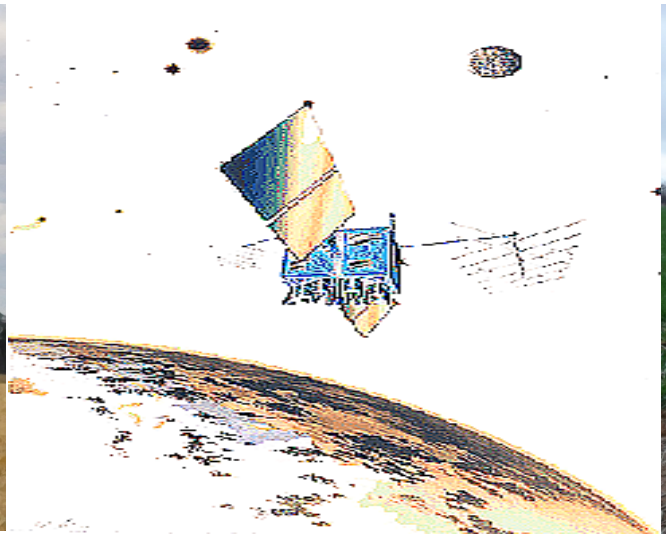
# PA History in Australia

## *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.

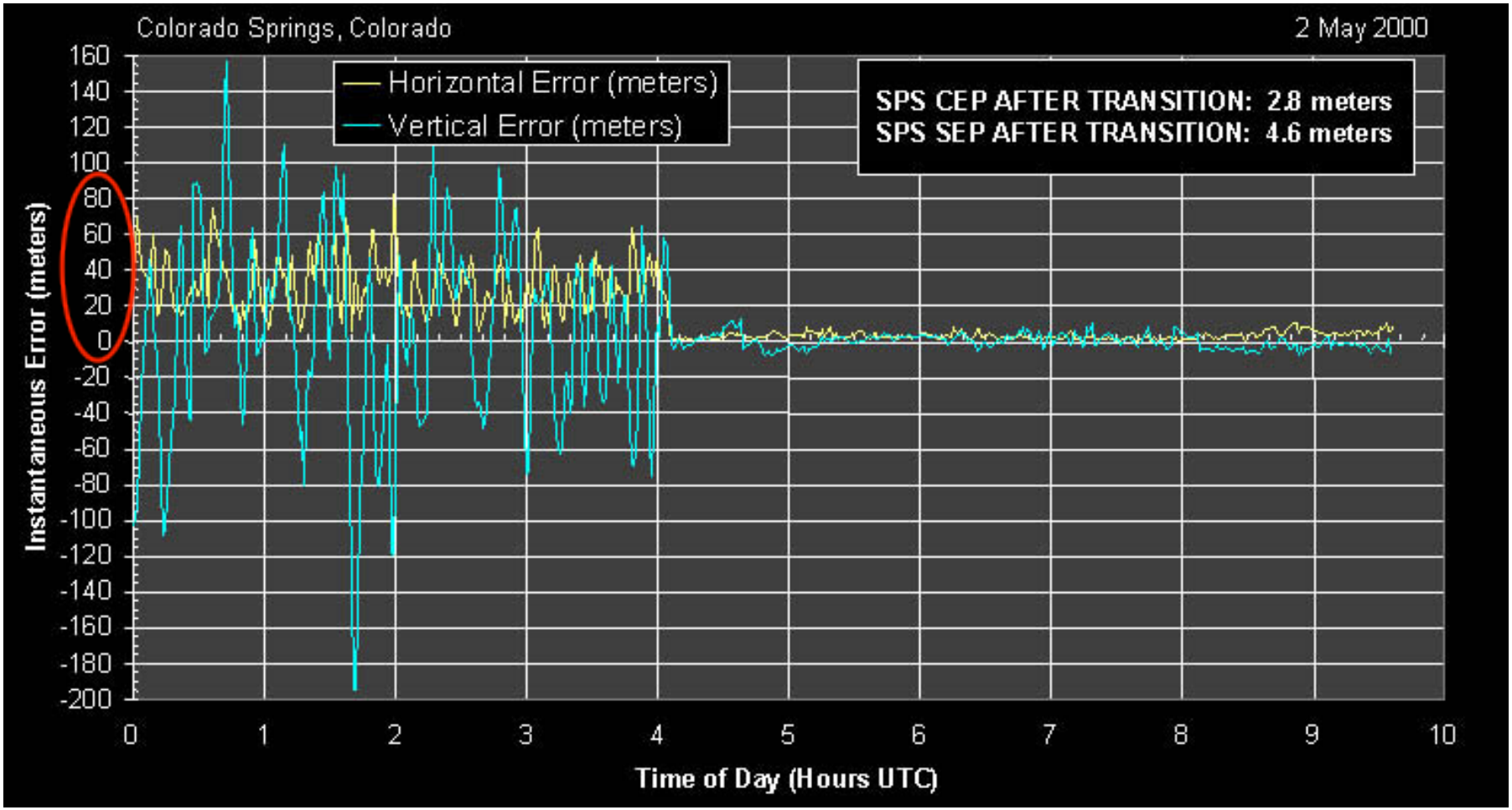
# PA History in Australia

## *The arrival of civilian access to the GPS in 1993*



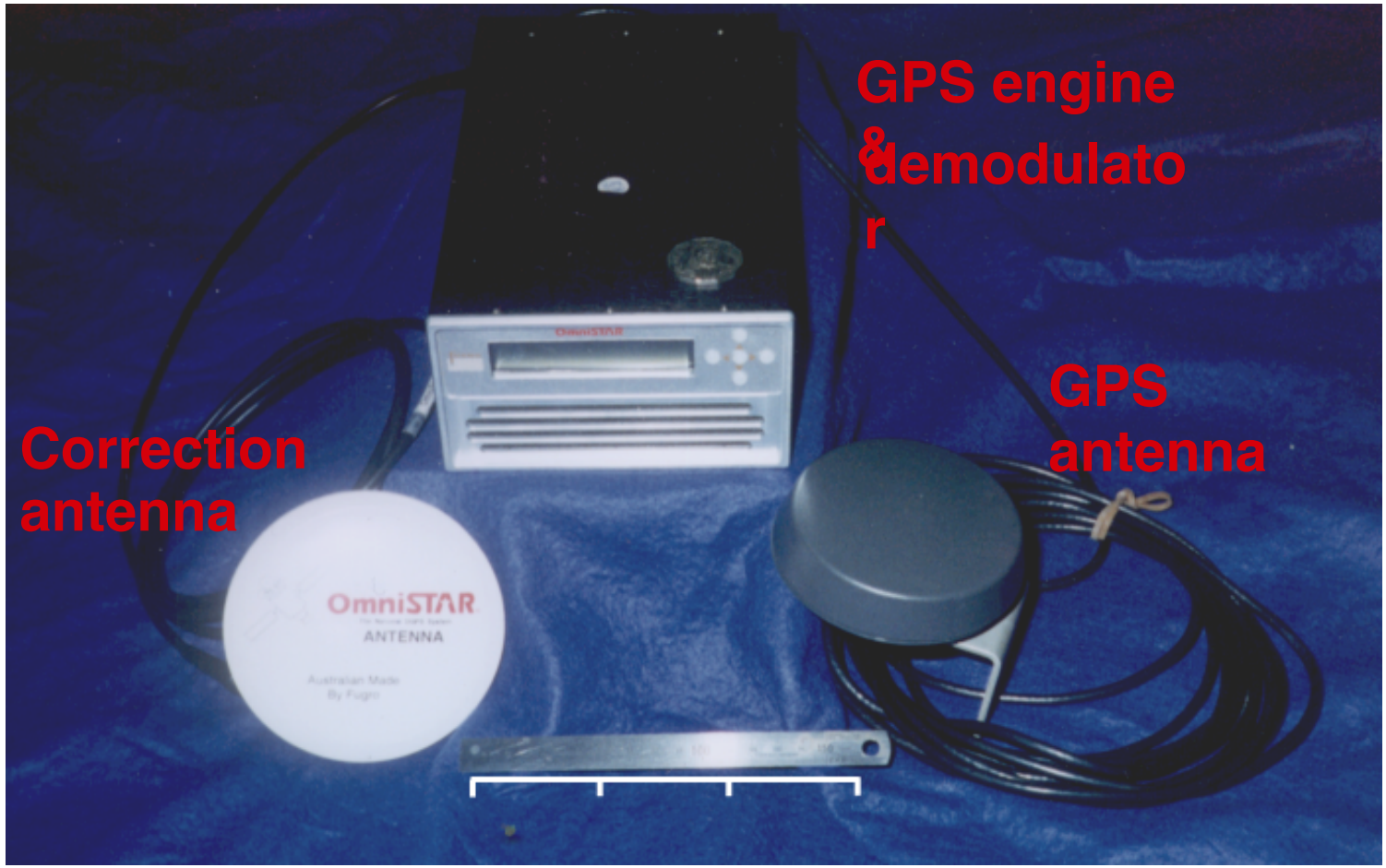
# GPS history in Australia

## *Selective availability active until 2/5/2000*



# GPS history in Australia

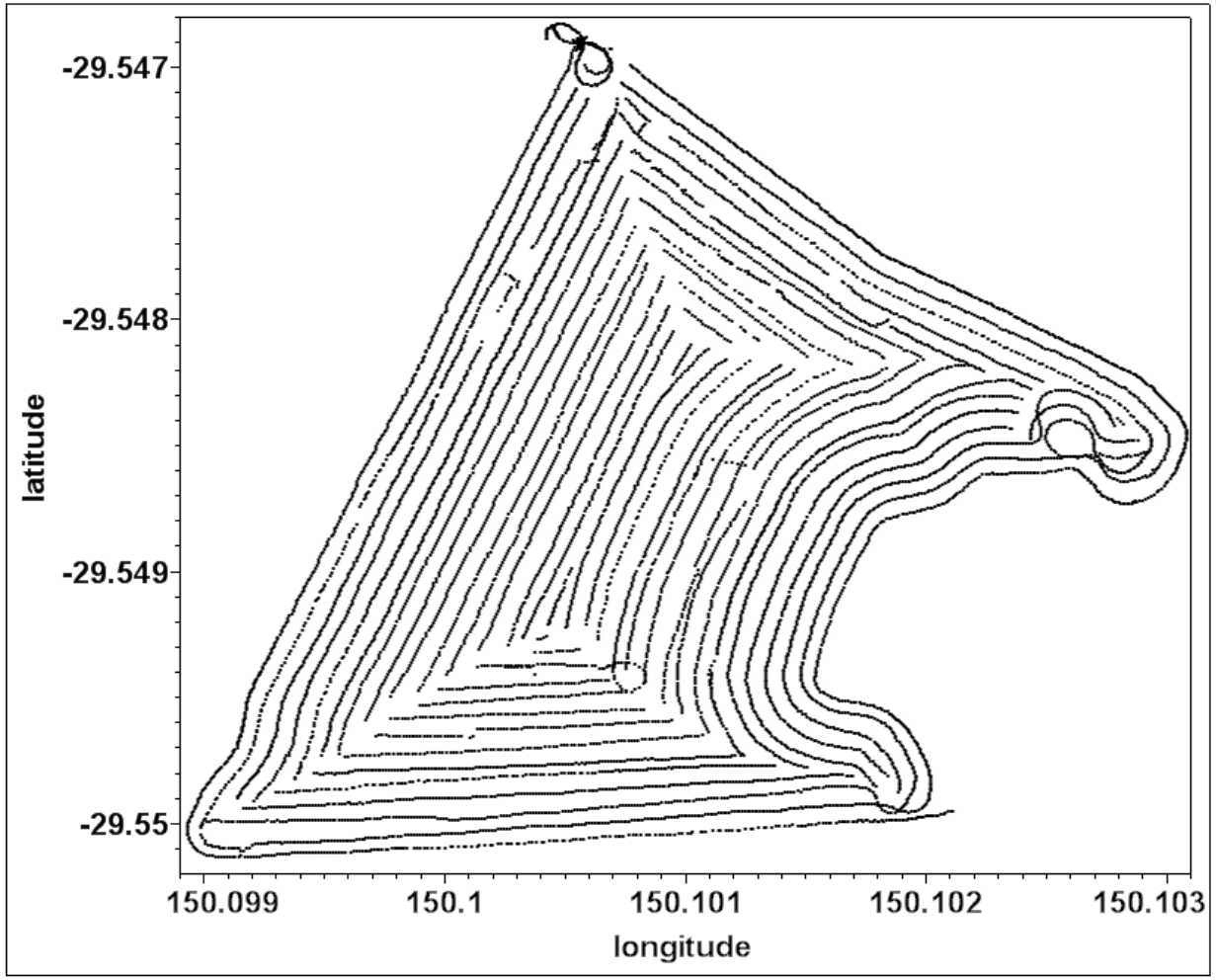
## *Fugro Starfix/OmniStar WADGPS : (1994/5)*




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

# GPS history in Australia

## *Harvester track data: (December 1995)*



# GPS history in Australia

## *Beeline Navigator: late 1990's*

**A GPS and inertial guidance system for agricultural machinery.**

Courier Mail - Saturday 18th October, 1997

THE LAND Thursday, October 23, 1997 29

Grains & Cropping

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.

completely automates steering of the tractor, turning the farmer from a driver into a machine operator.

Robert, 30, said: "Having grown up on the land and gone off and done engineering and been interested in physics and all that sort of thing, the opportunity to come back and bring that engineering know-

supporters.

"Farmers these days, if they haven't got a computer or have access to one, they're really starting to fall behind," Mr Macfarlane said.

When Robert Mailler was looking at building a system for the family farm, he looked at off-the-shelf American systems. Those systems use the Satloc signal which, for the

directions on the dashboard display.

They then went the extra step, adding the self-steering component that completed the Beeline system.

Tests done on fields with fixed tractor tracks have found up to 20 percent increases in yield from the paddock. Control traffic eliminates overlap or underlap in spraying, fertilising or seeding.


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

Australian Centre for Precision Agriculture

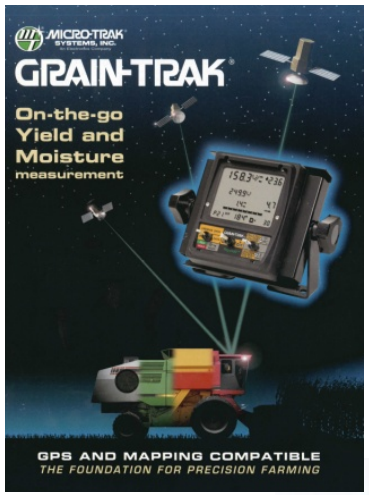
# GPS history in Australia

## *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 monitor

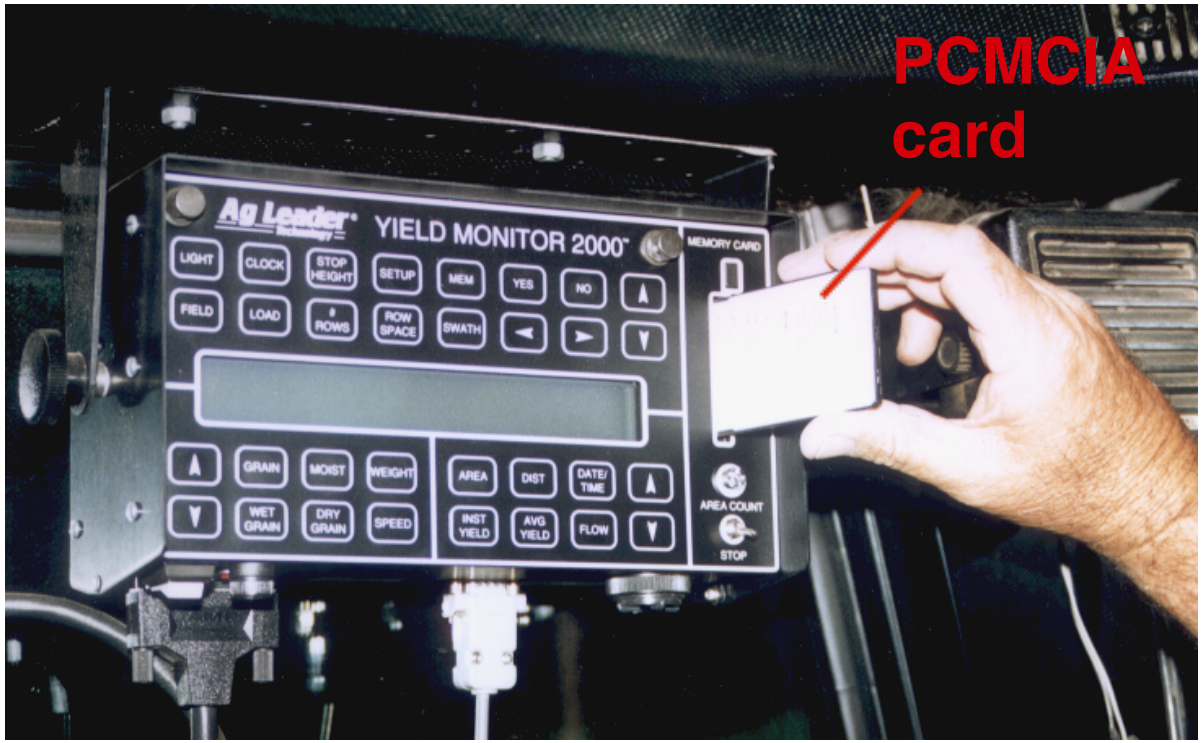

yield sensor

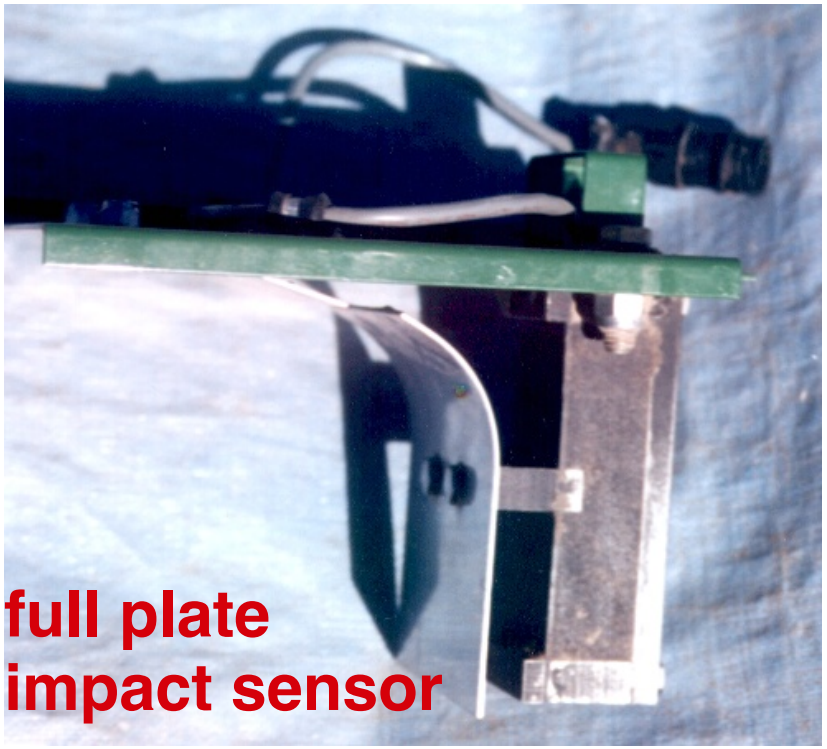
moisture sensor


**Distributed in Australia in 1993 by Croplands: A$ 8500**

# Yield monitor history in Australia

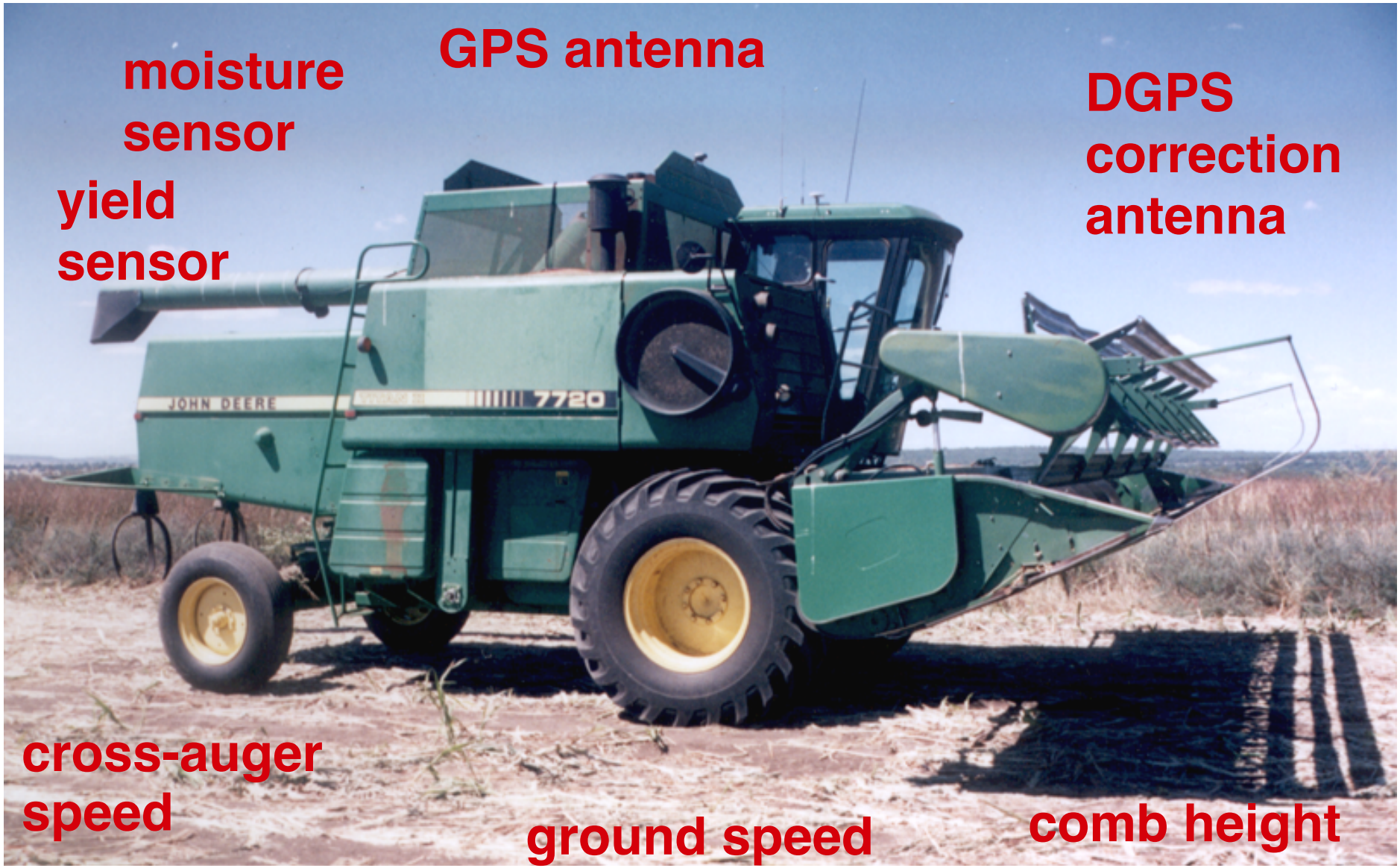
## *AgLeader: 1995*




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

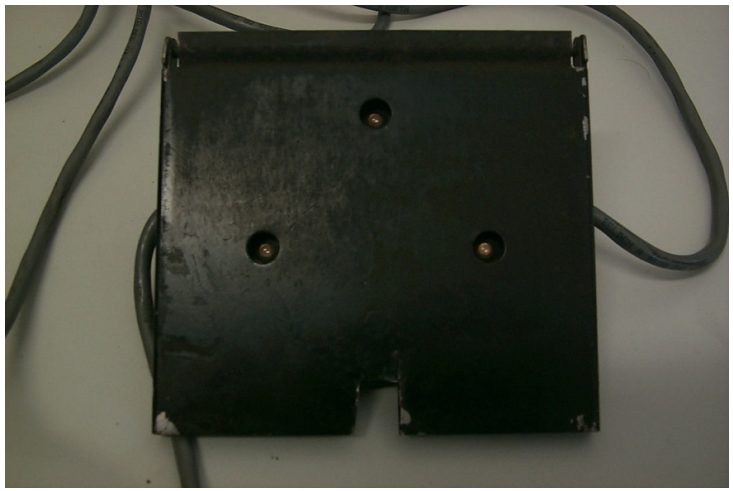
# Yield monitor history in Australia



# Yield monitor history in Australia

## *Cotton yield monitors: from 1997*

Zycom



AgLeader

Farmscan

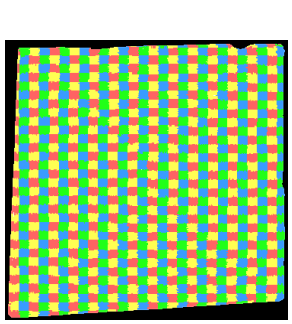
# Yield monitor history in Australia

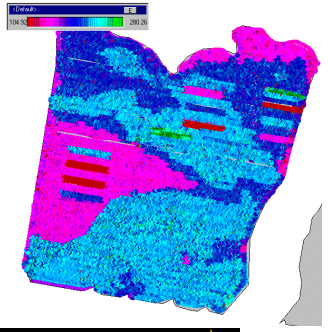
## *Grape yield monitors: from 1995/6*

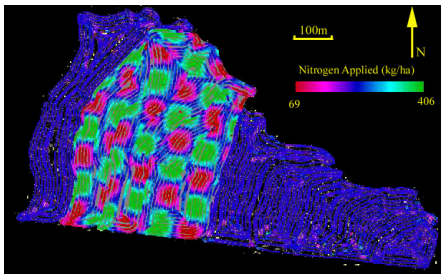
**Much successful utilisation and developments in PV has come from Australia**

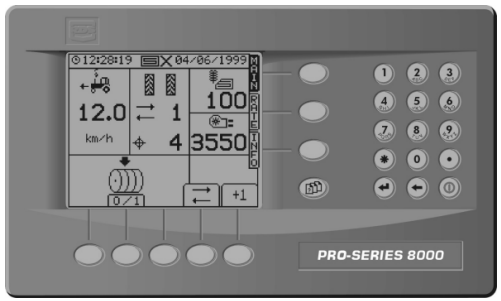
# PA hardware history in Australia

## *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

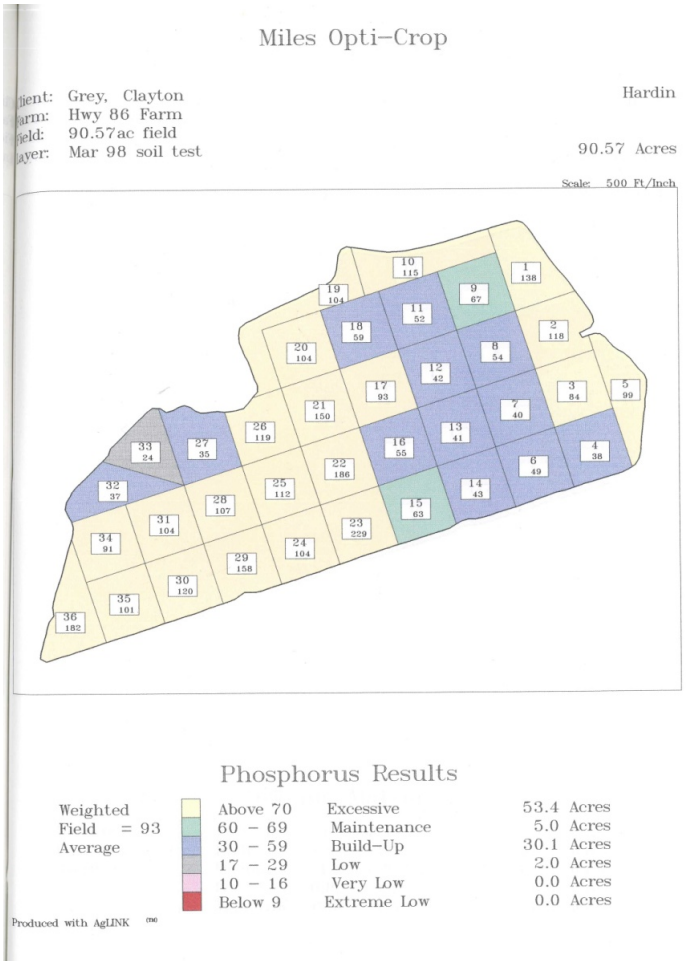
## *Grid soil sampling: the USA approach*

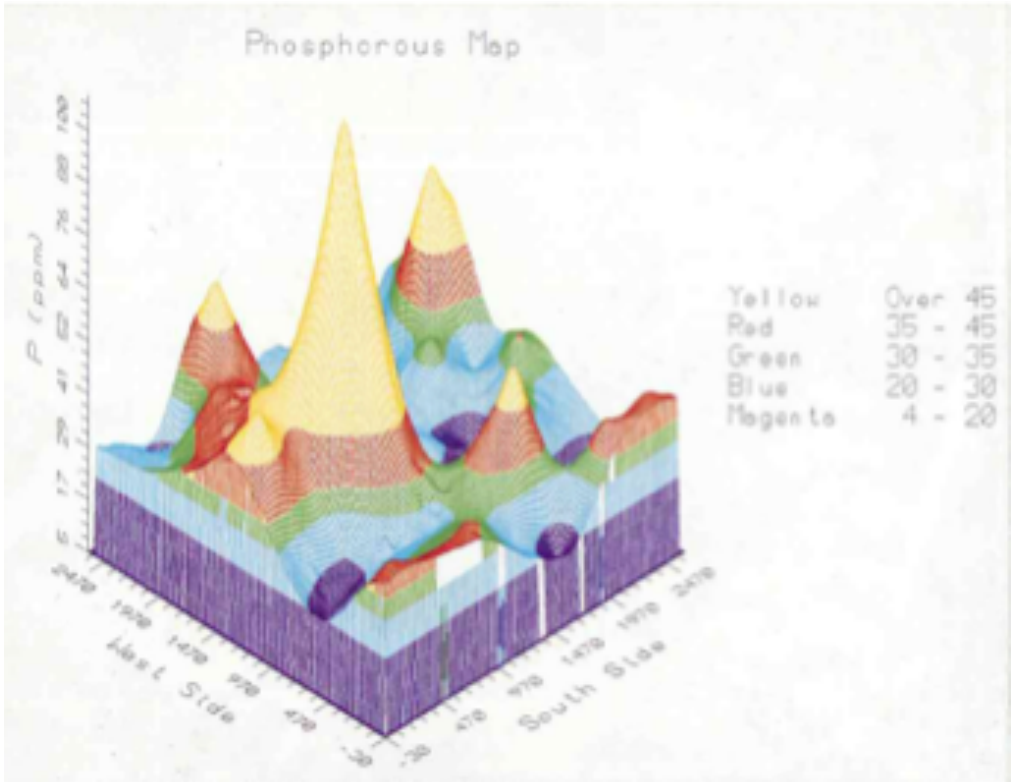
MORE PRECISION…MORE PROFIT

Opti-Crop

# The American approach to investigation

## *Grid soil sampling*

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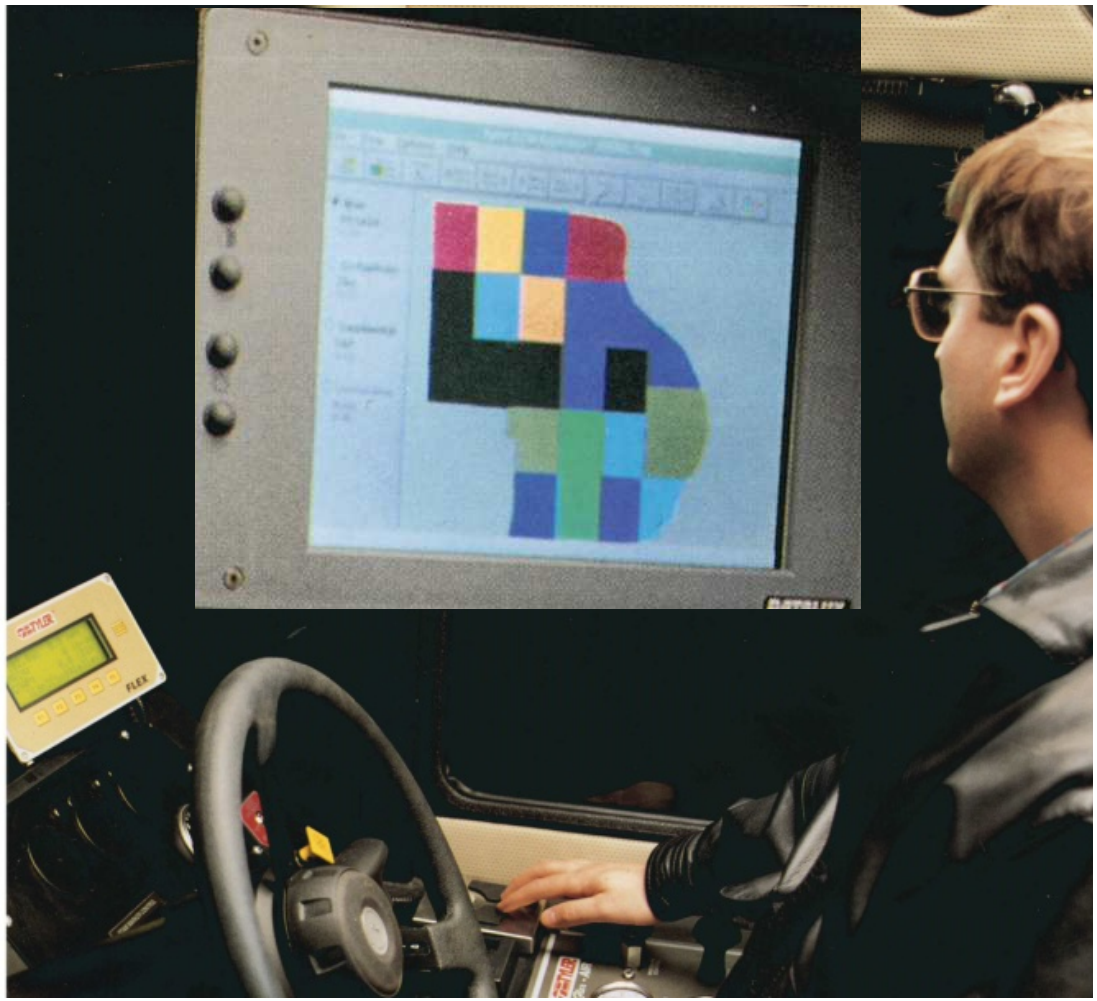
# The American approach to investigation

## *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

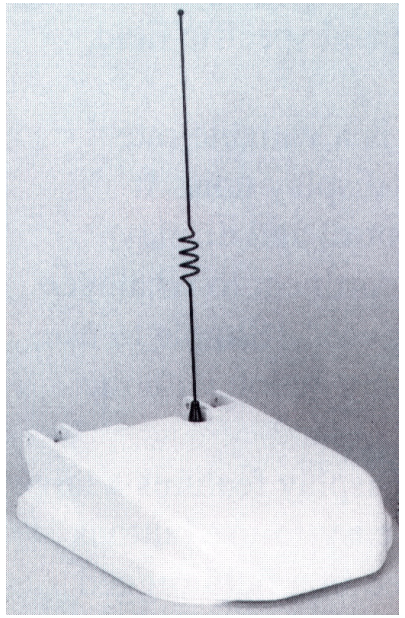
## *Rockwell Vision System: 1996*



Monitor and controller


GIS software

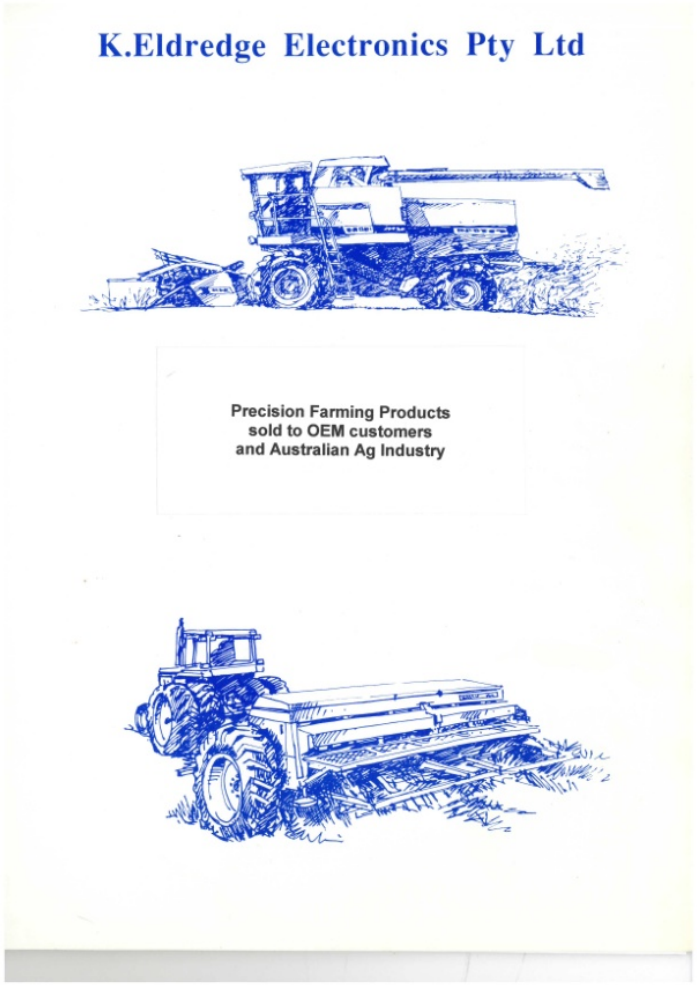
**A$ 18,000**



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

**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.**

**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 Bryceson & 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.**

**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.**

**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*

EM38

Veris pH sensor

Omnistar HP GPS

Veris 3100 EC Cart

Gamma Radiometer

CPU

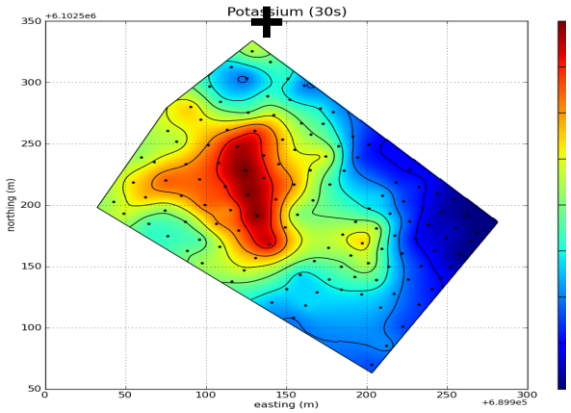
EM31

Australian Centre for Precision Agriculture

# Soil nutrient measurement

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

**K**

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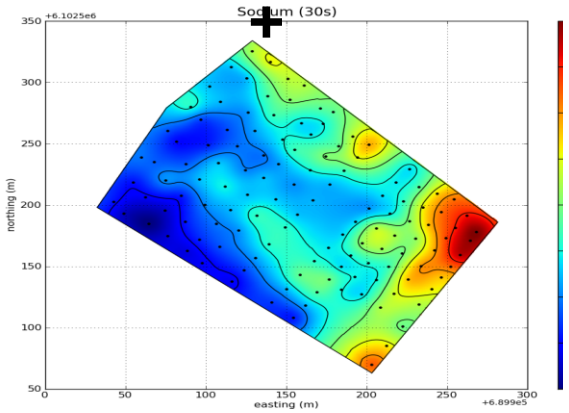
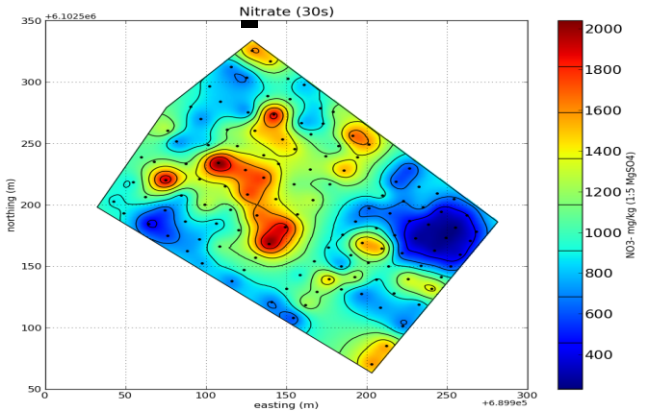



**NO3**

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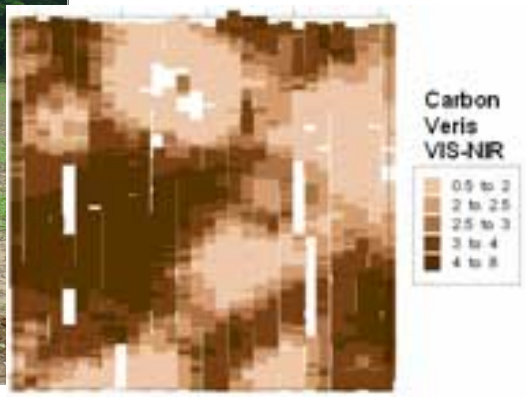
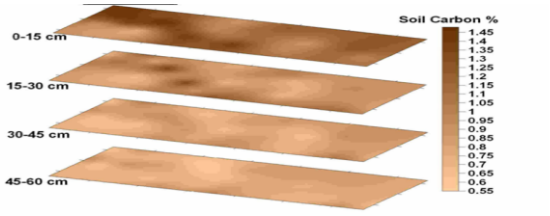
CSIRO

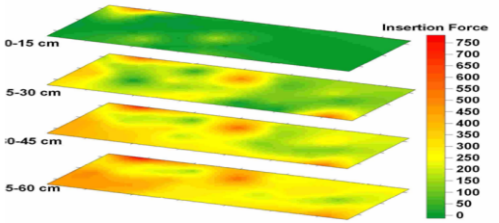
# New techniques for nutrient measurement

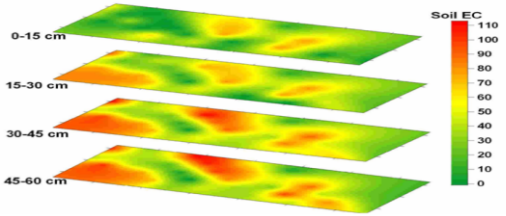
## Spectroscopy

surface




profiler

# *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;**

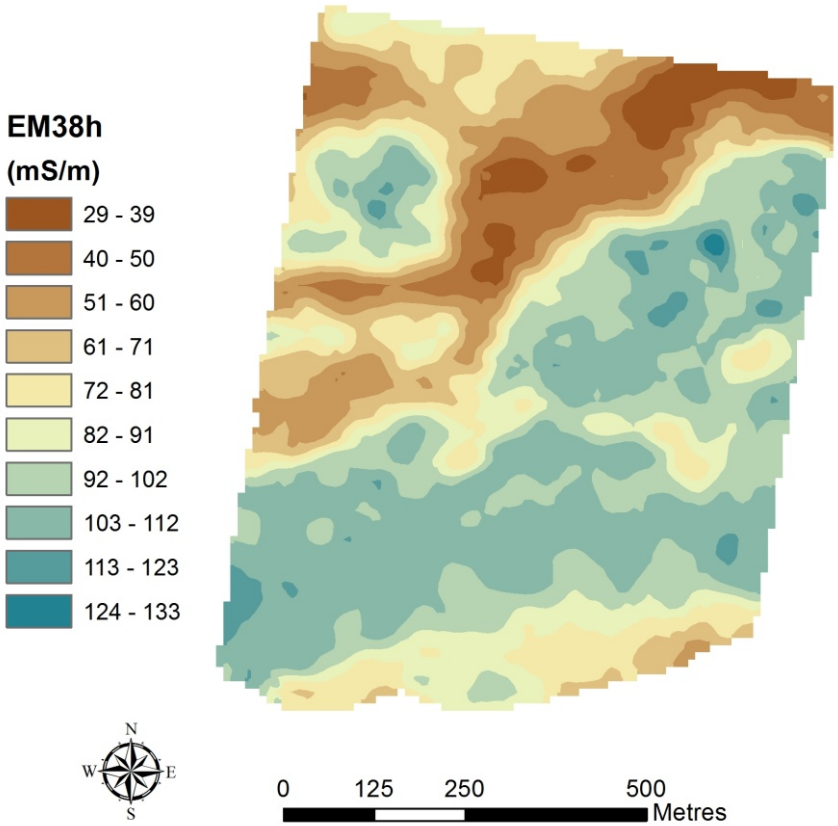
# *Future opportunities in cropping*

**autonomous weeding;**

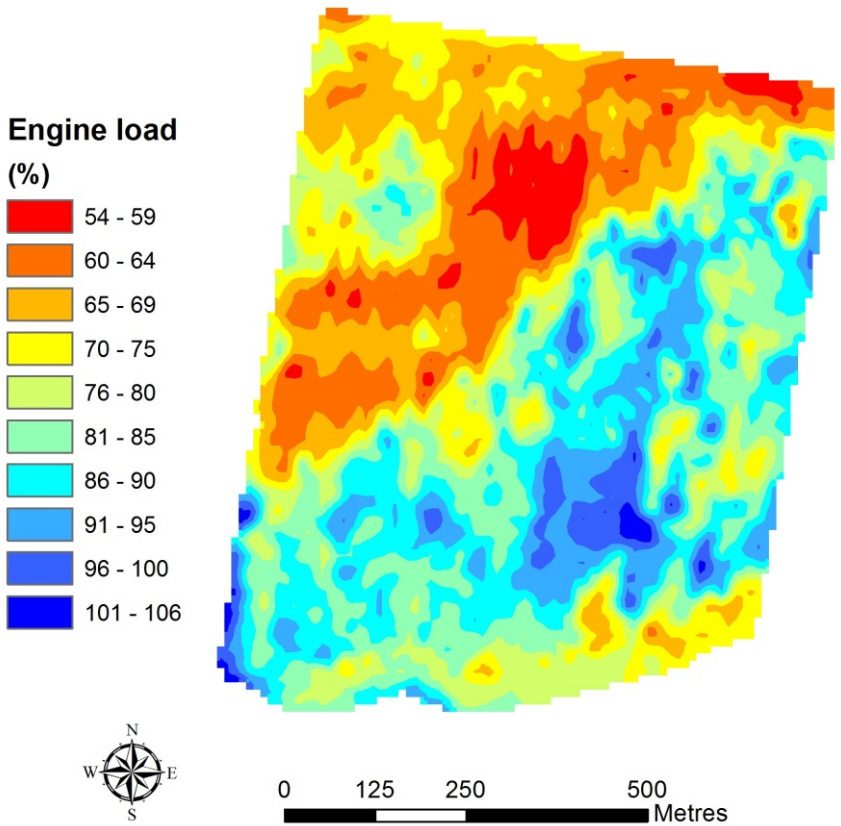
**public-funded research targeting PA for increased water-use efficiency and improved farm C and N emission management;**

# Gathering soil/crop information during common operations

## *Vehicle engine load during sowing*




**Soil ECa measured using EM38h**



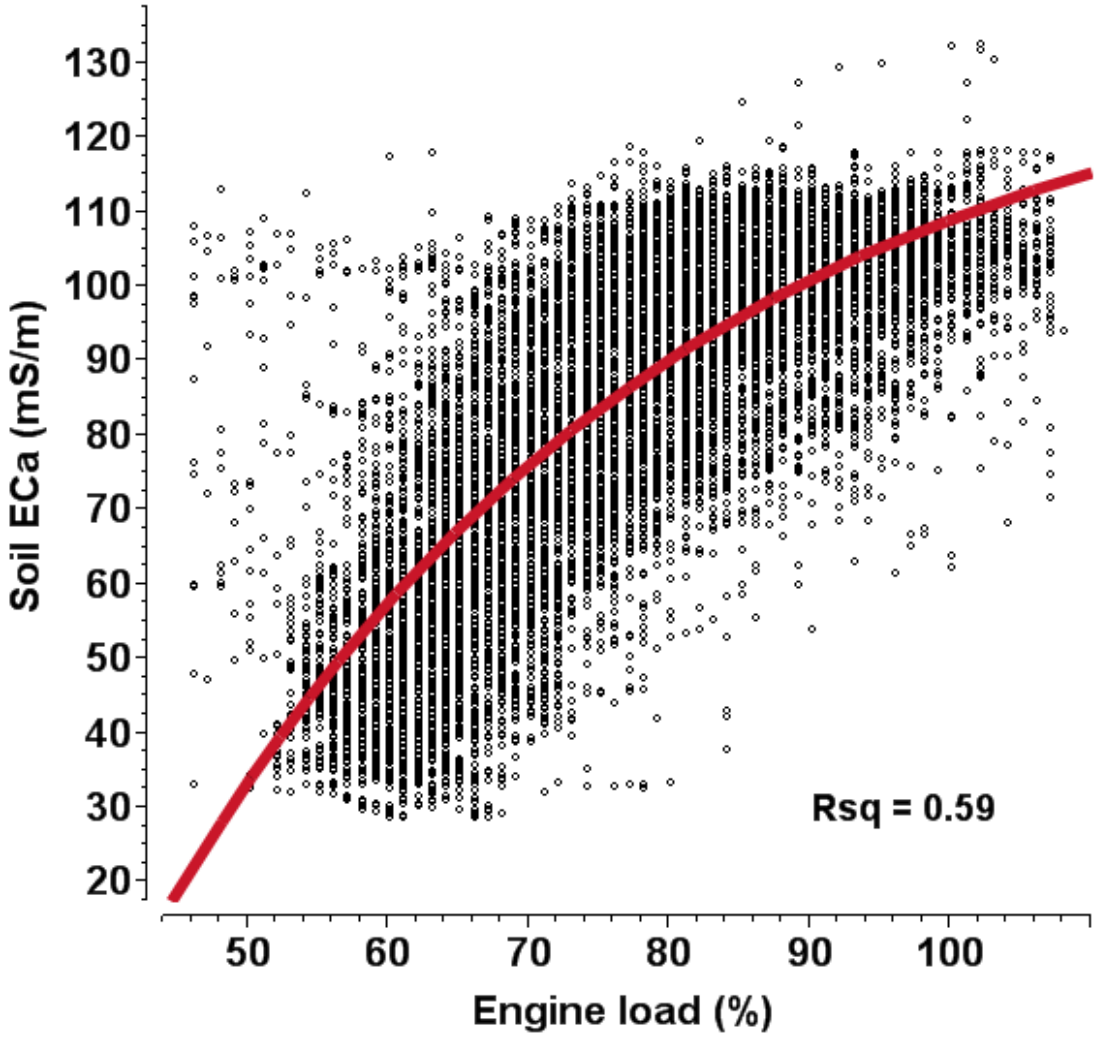

**Engine load (% of total power rating)**

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

Australian Centre for Precision Agriculture

# Gathering soil/crop information during common operations

## *Vehicle engine load during sowing*

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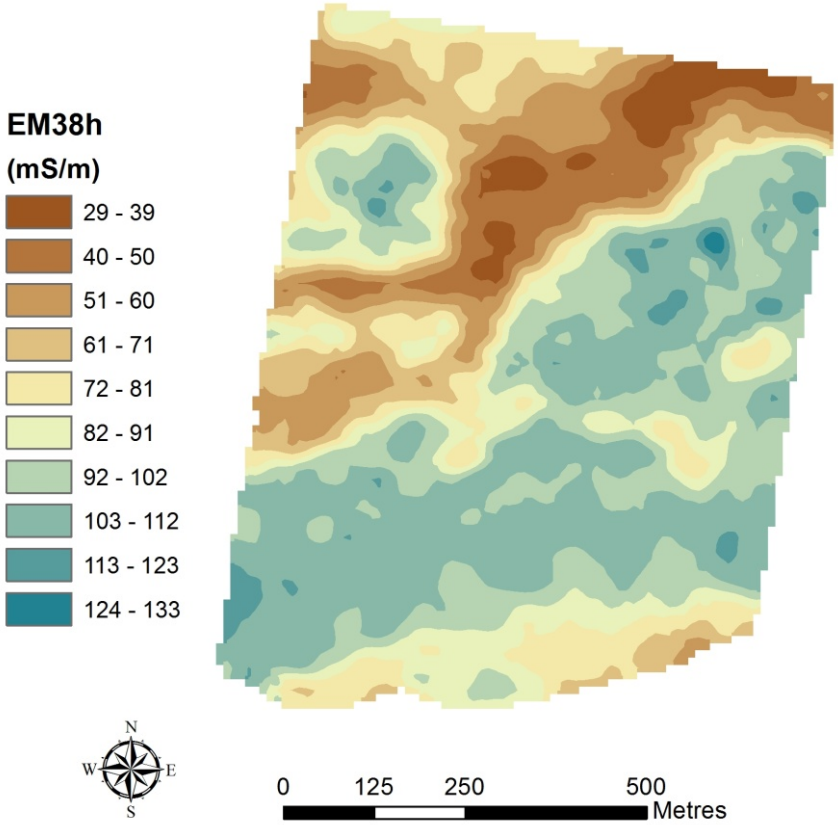
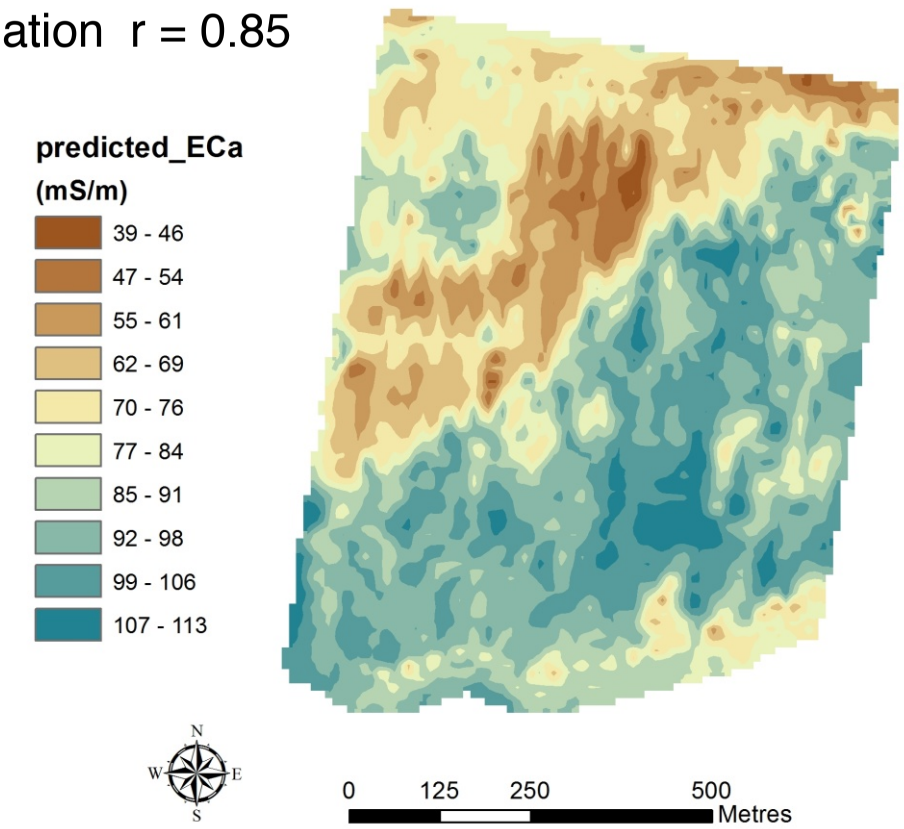



Soil ECa measured using EM38h

Correlation r = 0.85

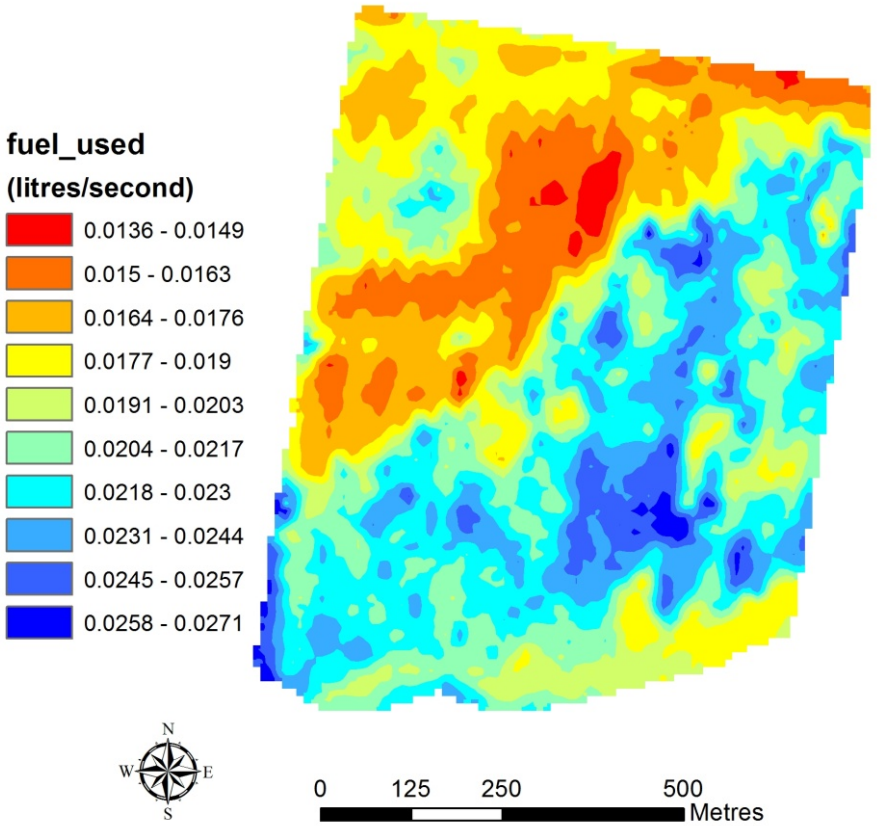



Soil ECa predicted from engine load

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

Australian Centre for Precision Agriculture

# 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.**