

How Has a Changing Climate Recently Affected Western Australia's Capacity to Increase Crop Productivity and Water Use Efficiency

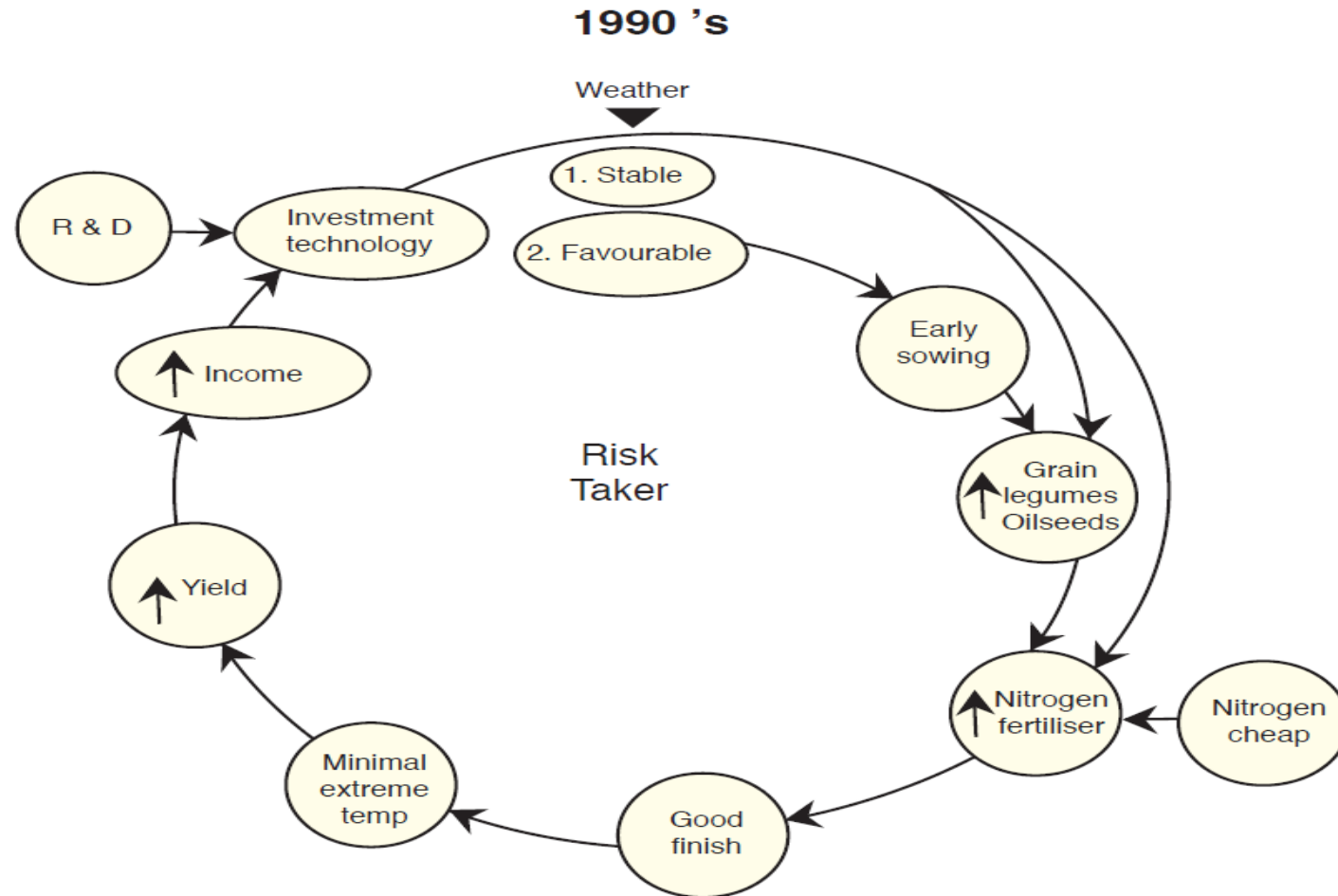
Dr David Stephens

Climate and Modelling Science

Department of Agriculture and Food, WA

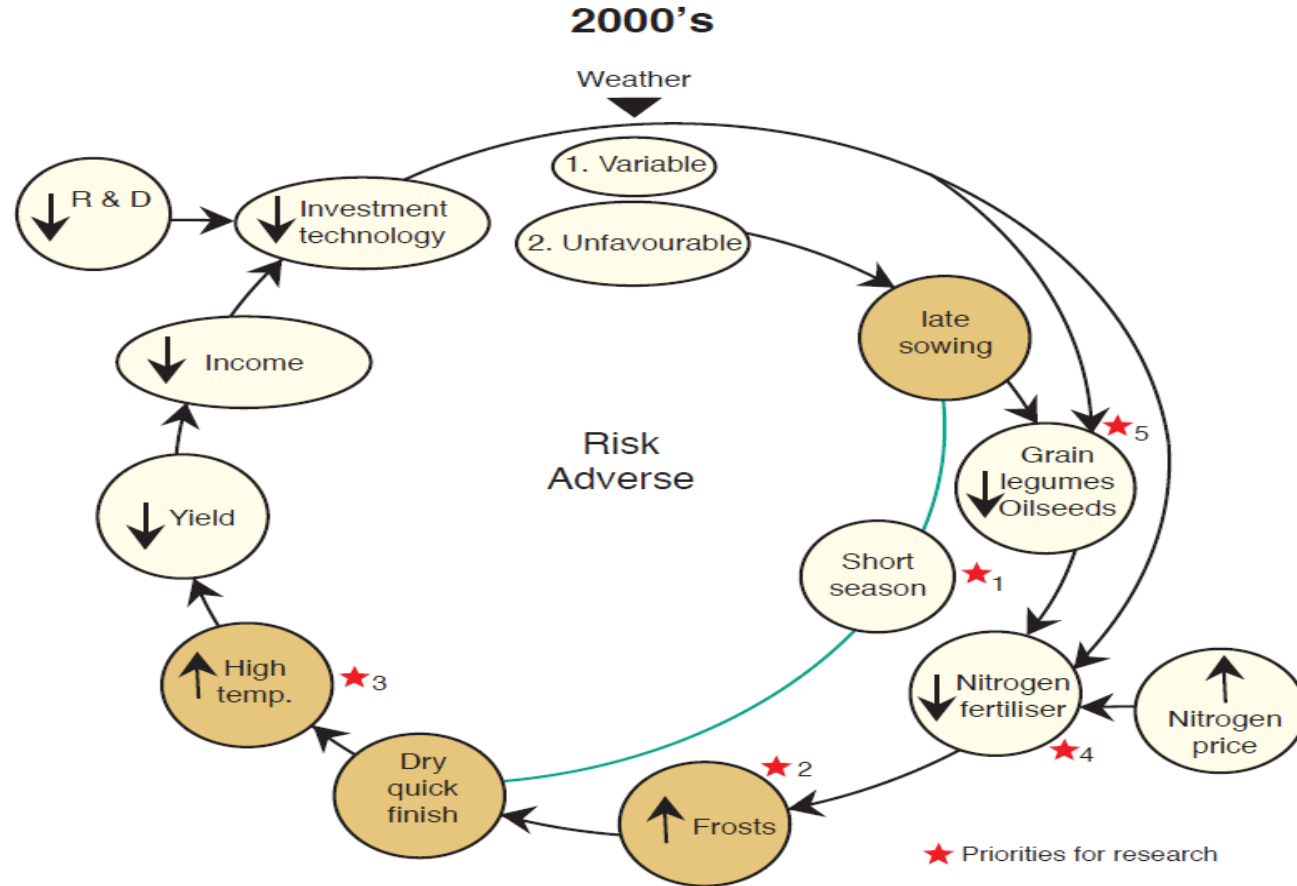


CONCLUSION 1 – A change to a high yielding package based on higher inputs was unhindered by climate in the 1980s and 1990s – Farmers maximized yields+profits

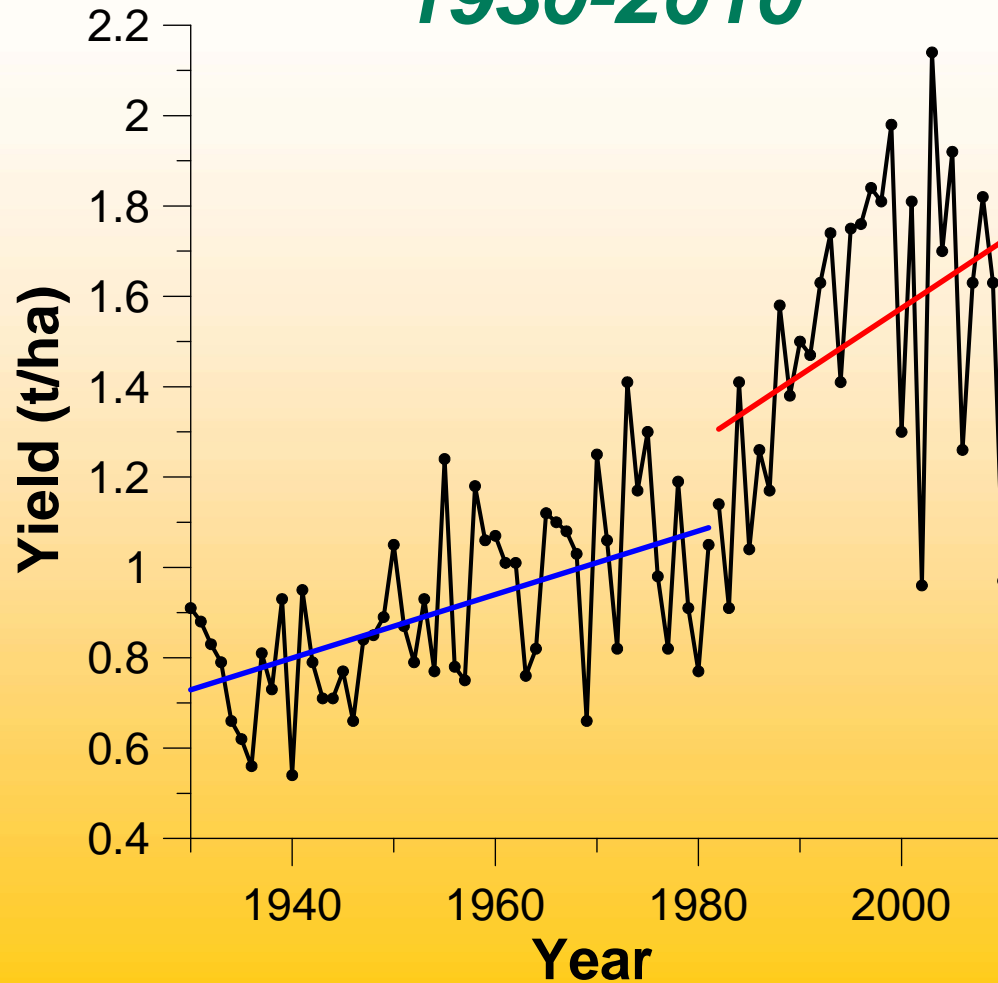


CONCLUSION 2 – Climate change in the 2000s has severely impacted on WA's capacity to increase productivity by:

- (1) Directly - ↓ yields
- (2) Indirectly - 1990s technology ↓ yields further when used in drought/frost
- (3) Indirectly - farmers ↓ inputs/costs to reduce (2) and maximise profits.



1. *Productivity : Average WA Wheat Yields* *1930-2010*



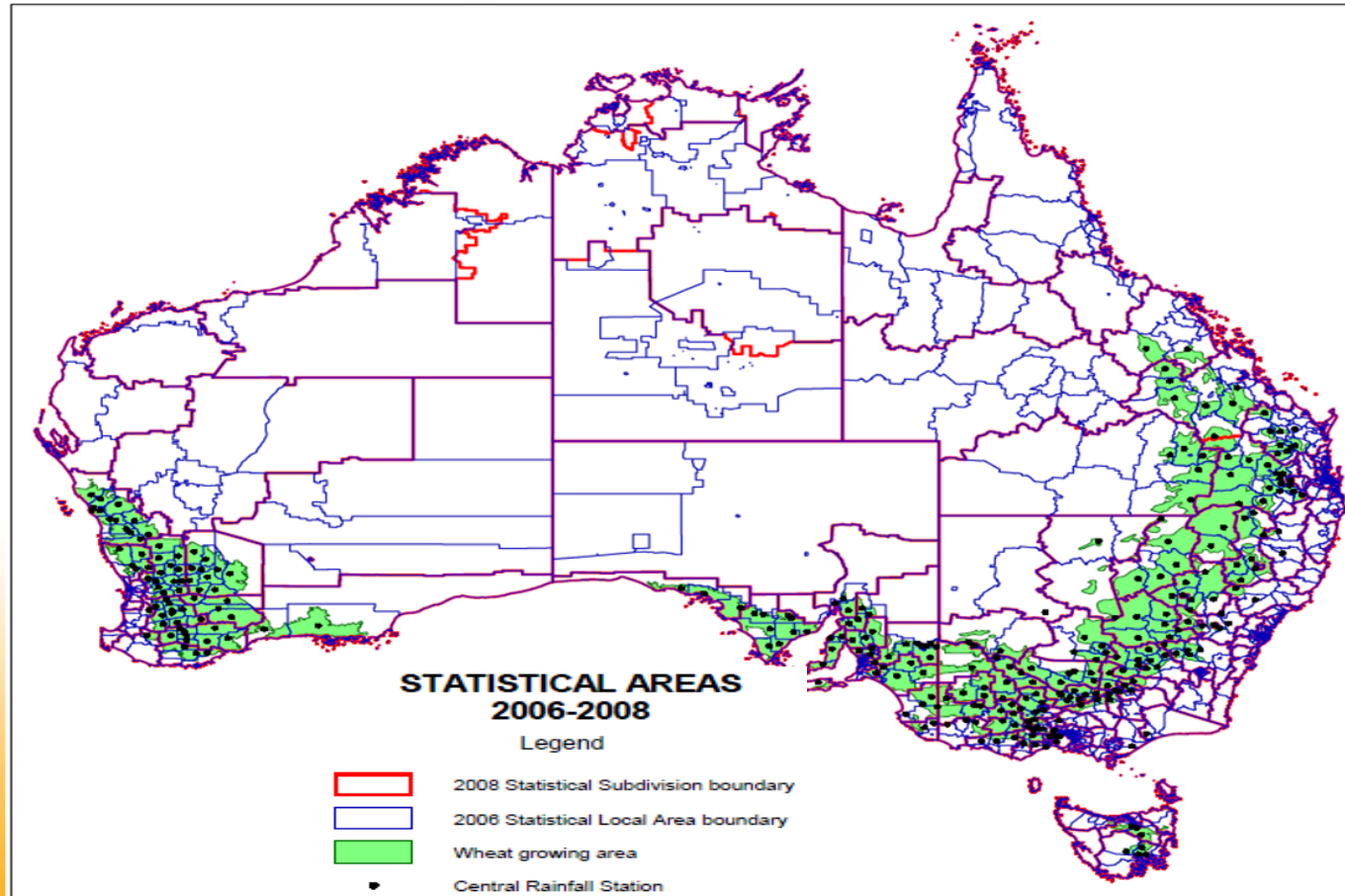
DAFWA Crop Forecasting System–STIN (STress INdex)



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1. Water balance – soil moisture, moisture stress index – correlated with yields



Modelling Approach

- Yield = **a** + **b**(Stress Index) + **c**(Year)
- **c** = technological increase in yields from genetics + management, but also changes in soil condition and extreme events

Yield Trend in rolling 20-year periods



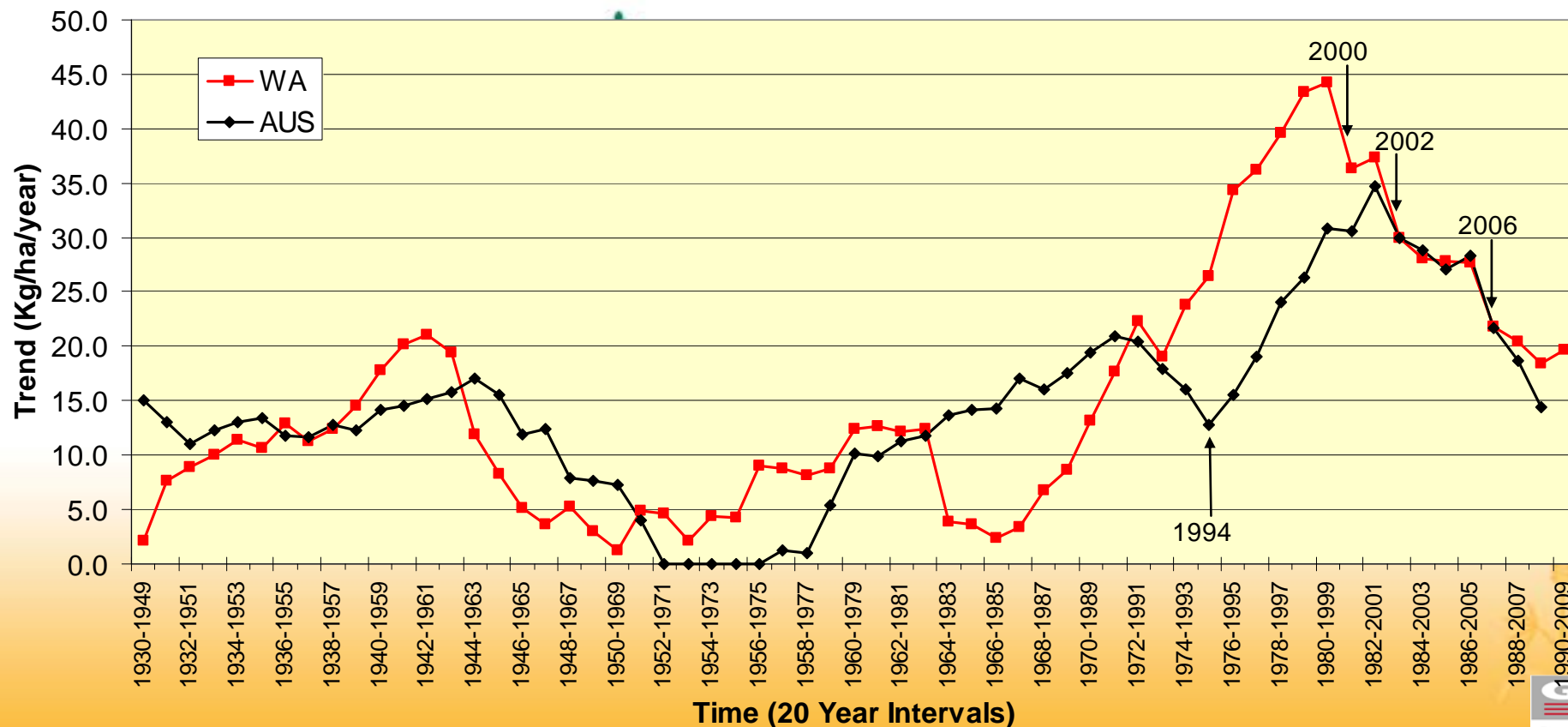
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$$\text{Yield} = a + b(\text{SI}) + c(\text{year})$$

National Wheat Yield Trends 1930-2009

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Trend in Wheat Yields: 1982-2000

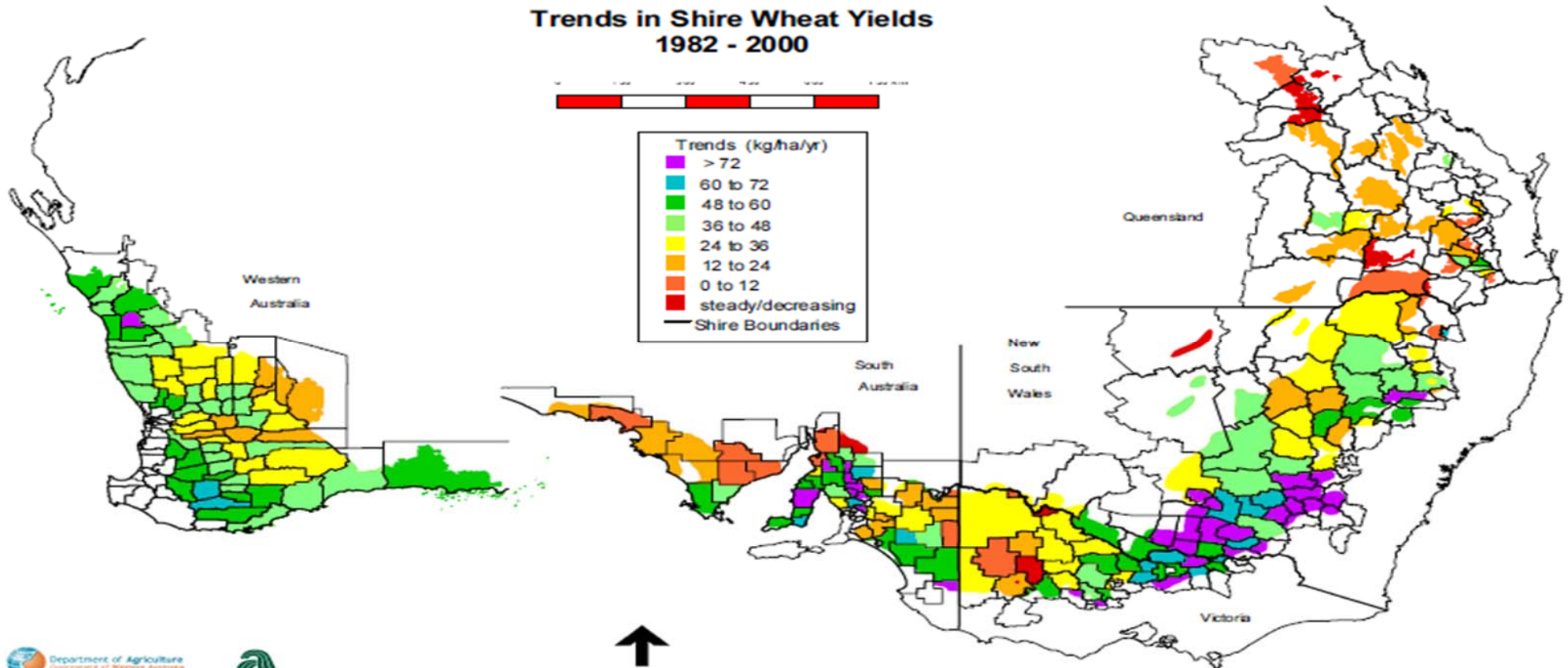


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**Trends in Shire Wheat Yields
1982 - 2000**



Trend in Wheat Yields

WA: 1990-2009



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Western Austral
Trend in Shire Wheat
1990 - 2009

Trend kg/ha/yr

> 72

60 - 72

48 - 60

36 - 48

24 - 36

12 - 24

0 - 12

Steady/decrea

Shire Boundar

Wheatbelt Bound

Average frost risk for September
for 1990 - 2005

0 75 150 225 300 375
Kilometres

LEGEND
Shire Boundary
Agricultural Region Boundary
Weather Station

Average number of days with minimum
temperature of 2 degrees C or less

0
1
2
3
4
5

Data from Bureau of Meteorology,
Patches from GRDC and
Department of Agriculture and Food

Average frost risk for October
for 1990 - 2005

0 75 150 225 300 375
Kilometres

LEGEND
Shire Boundary
Agricultural Region Boundary
Weather Station

Average number of days with minimum
temperature of 2 degrees C or less

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Data from Bureau of Meteorology,
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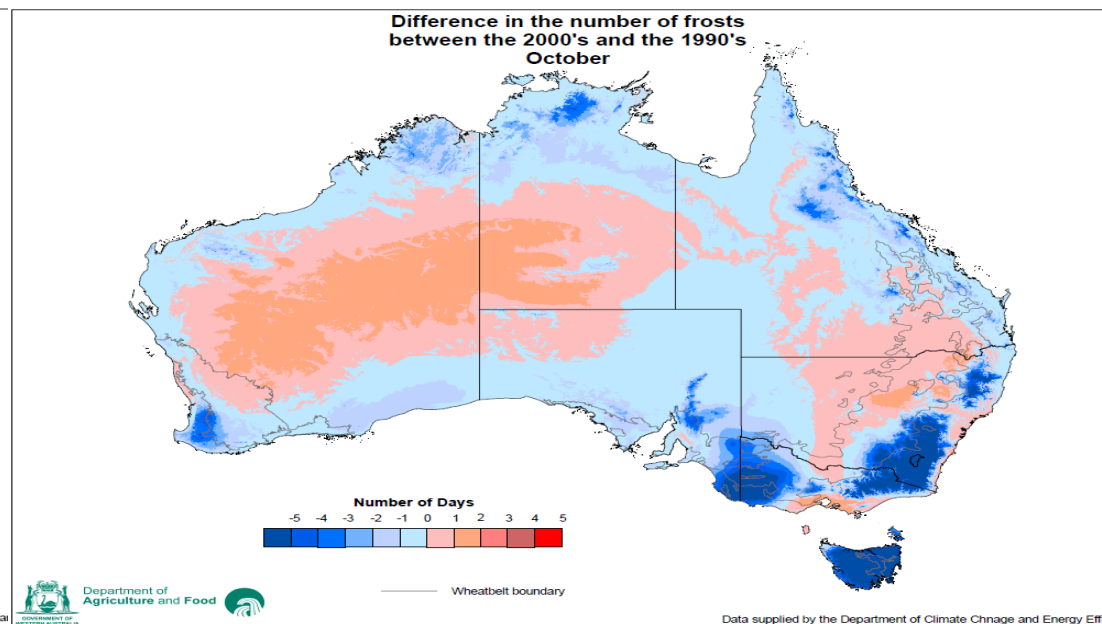
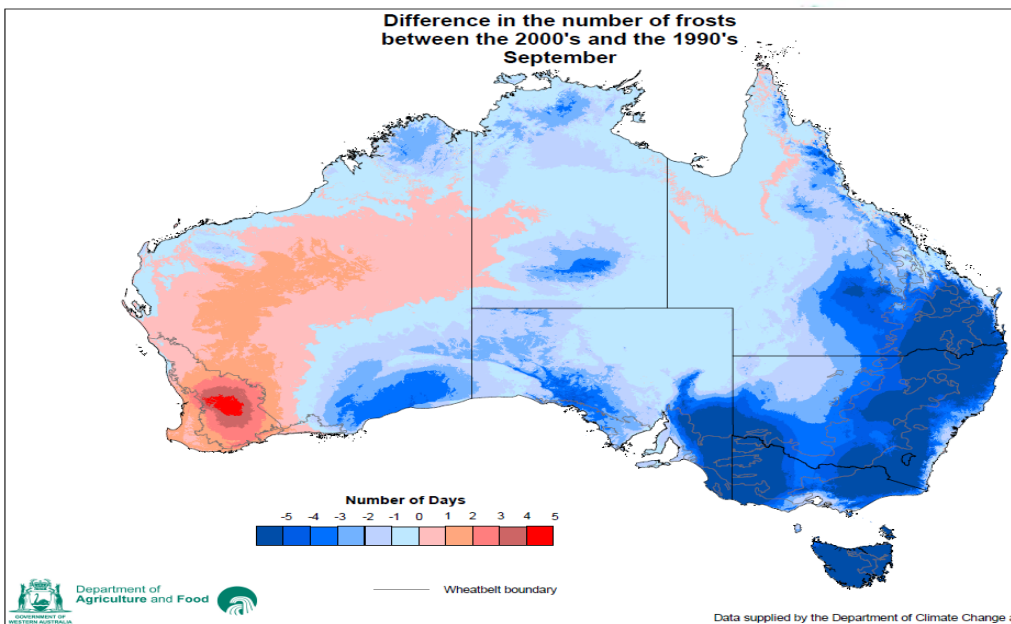
Change in Frost Frequency 2000s compared to 1990s



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1990s



Data analysis by Nicki Fitzgerald, Department of Climate Change and Energy Efficiency;
Data source- Fenner School, ANU



Variability in State Yields – Rolling 15-year periods

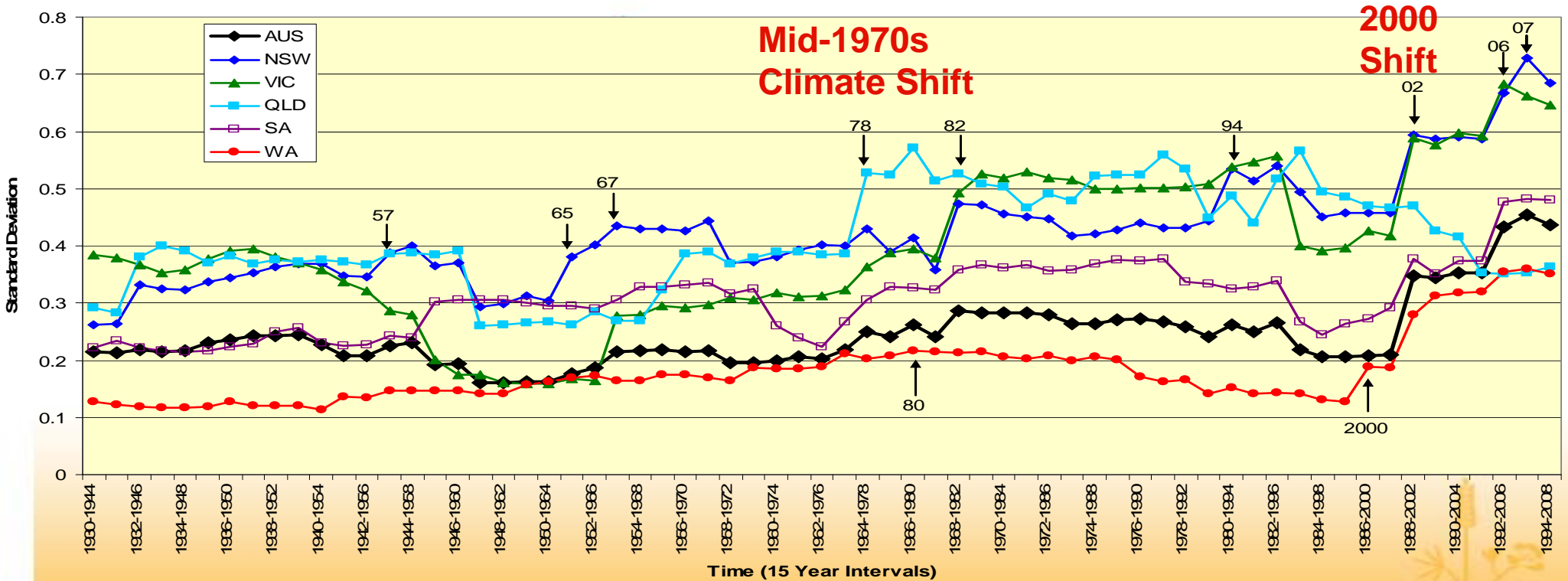


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Variability in State and National Wheat Yields 1930-2008

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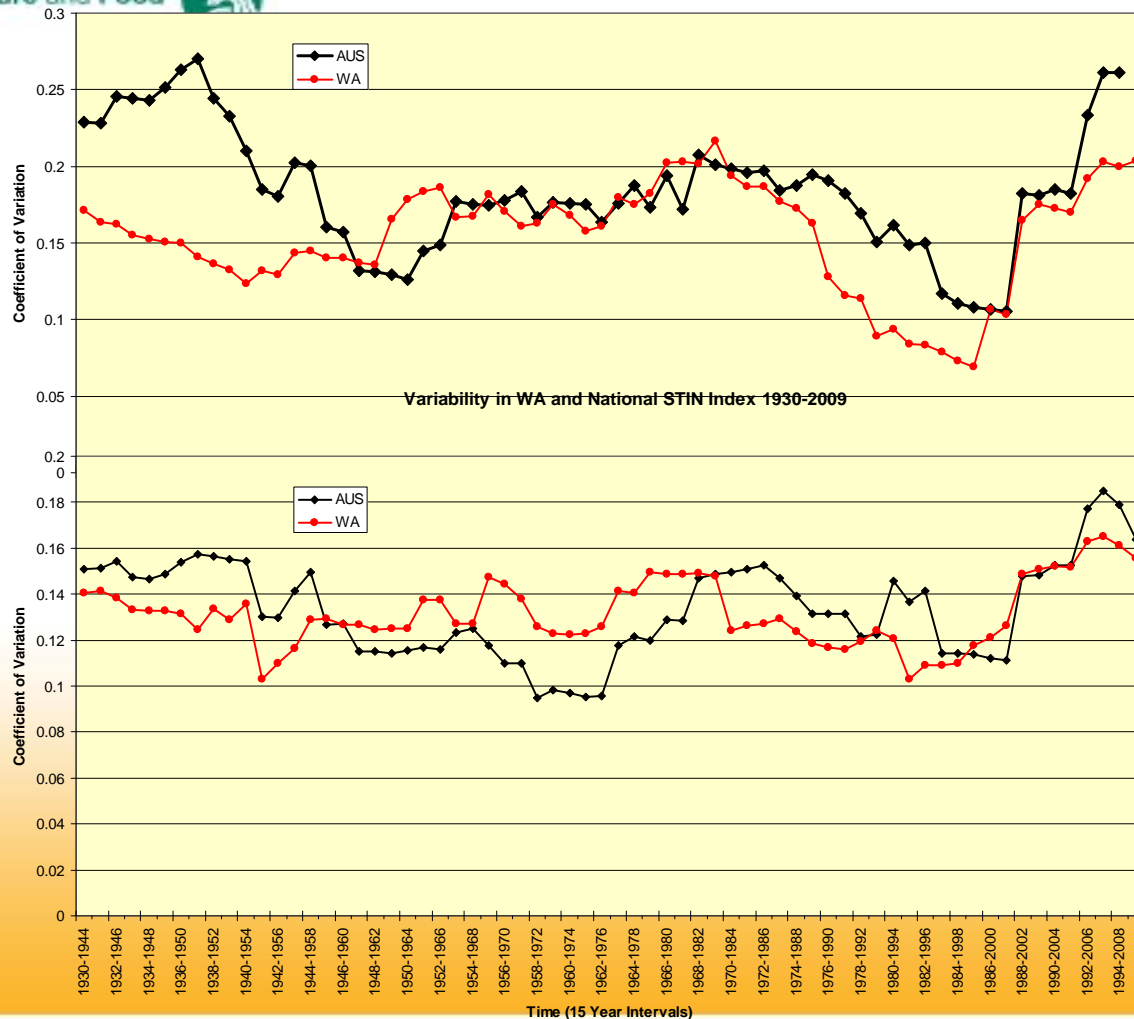
Variability in State Yields v STIN model SI (15-years)



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Variability in WA and National Wheat Yields 1930-2009



**Yield variability
increased above
moisture index
variability in 2000s**

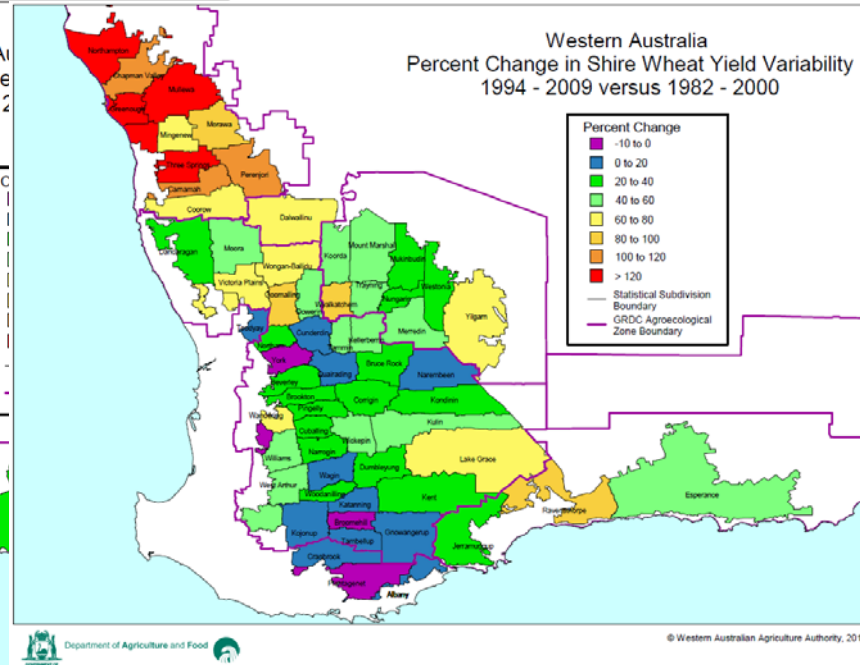
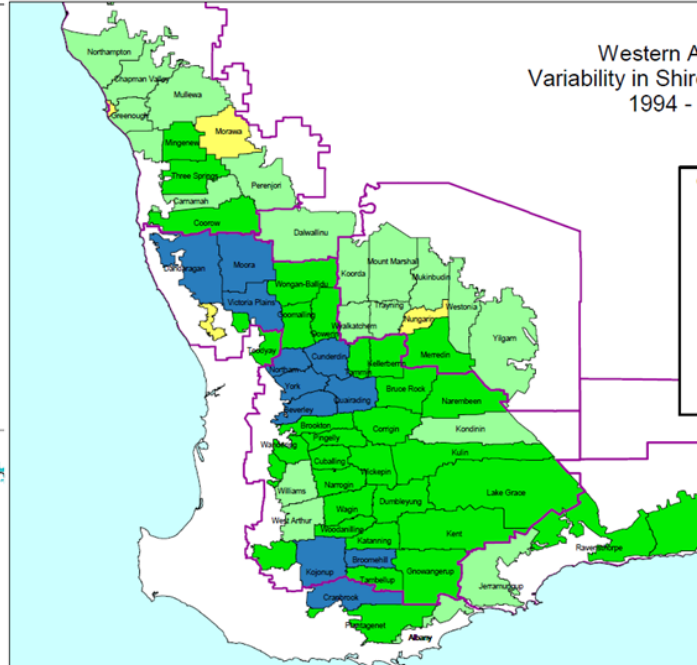
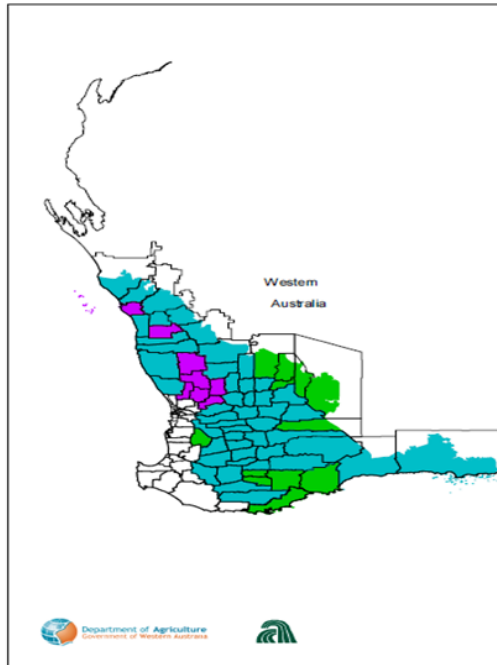


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Variability in wheat yields 1994-09 v 1982-00



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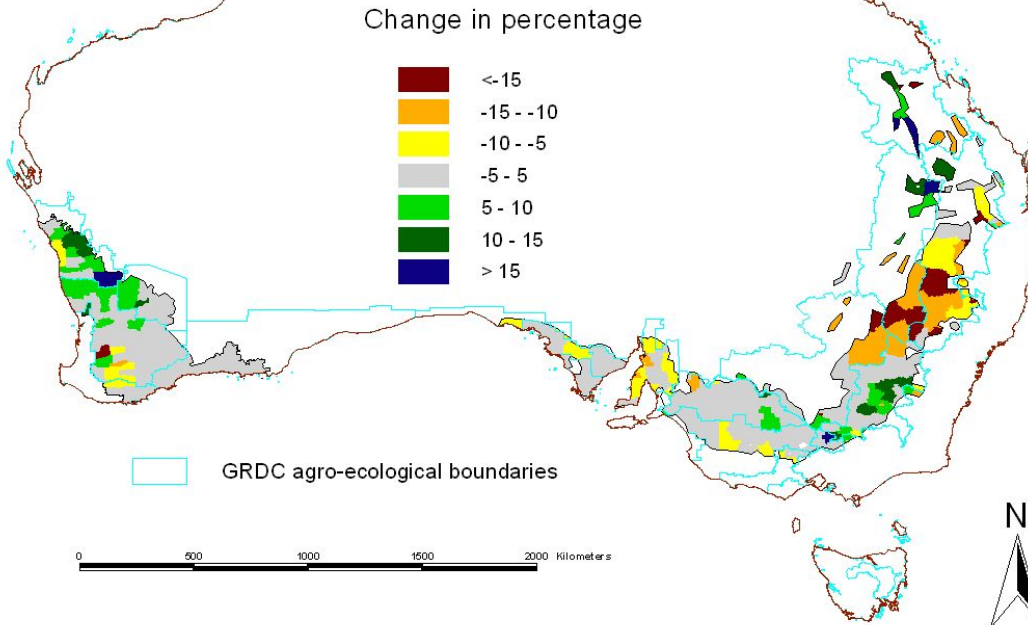


Large increase in variability in northern wheatbelt

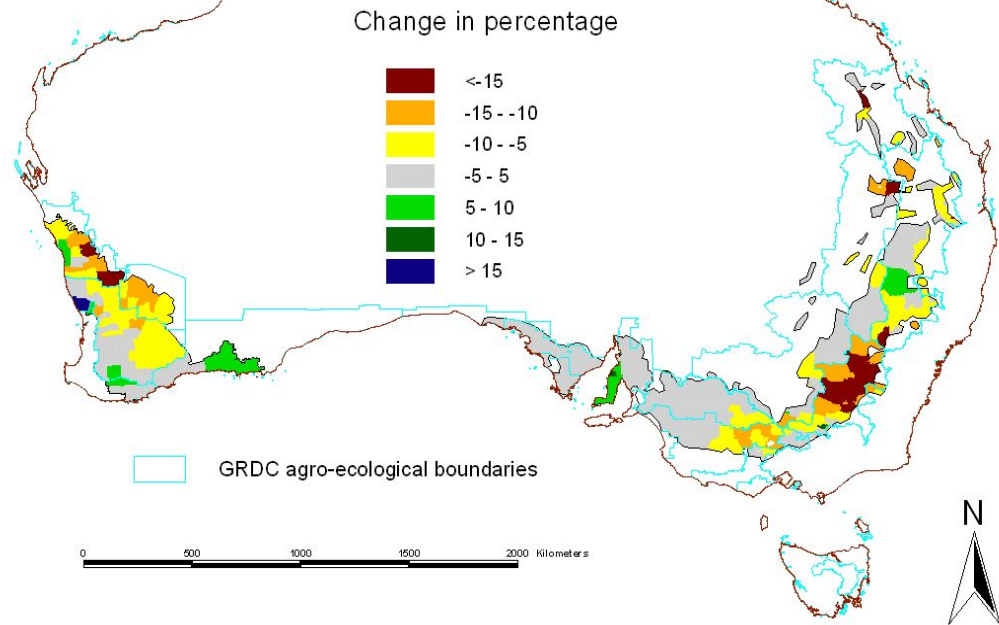
Change in Cropping 2000/01 to 2005/06



Change in the proportion of grains sown to wheat between 2001 and 2006



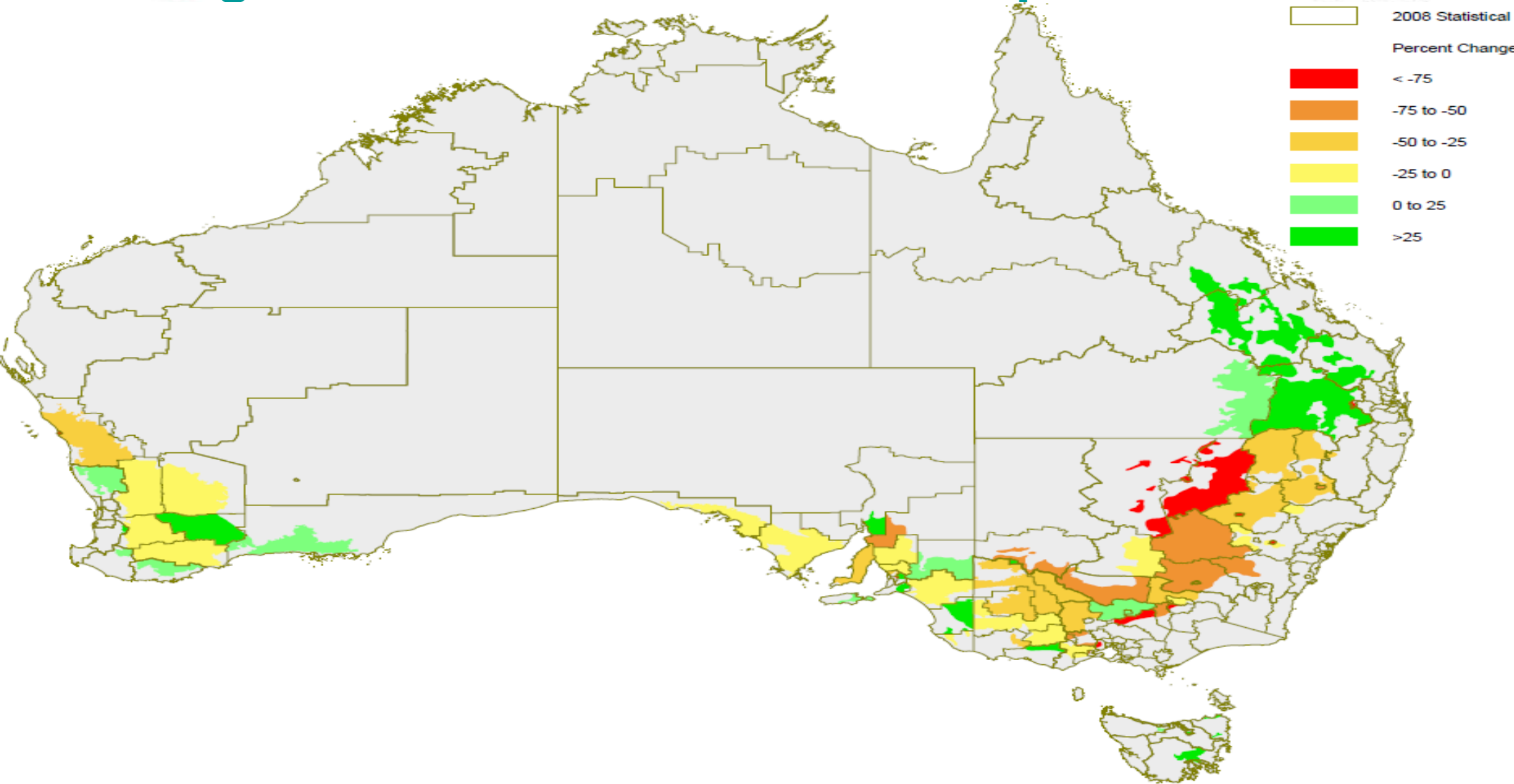
Change in Non-cereal proportion of grains cropped between 2001 and 2006



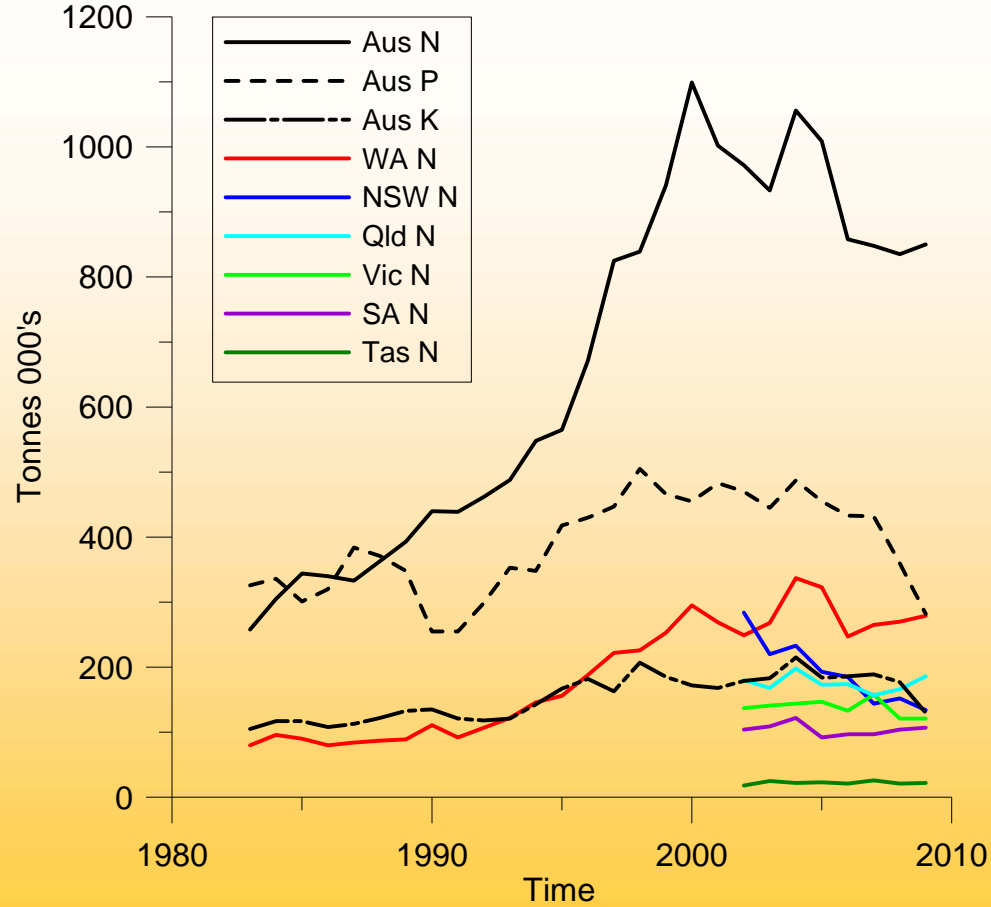
Maps produced by Jim Walcott (ABARES)



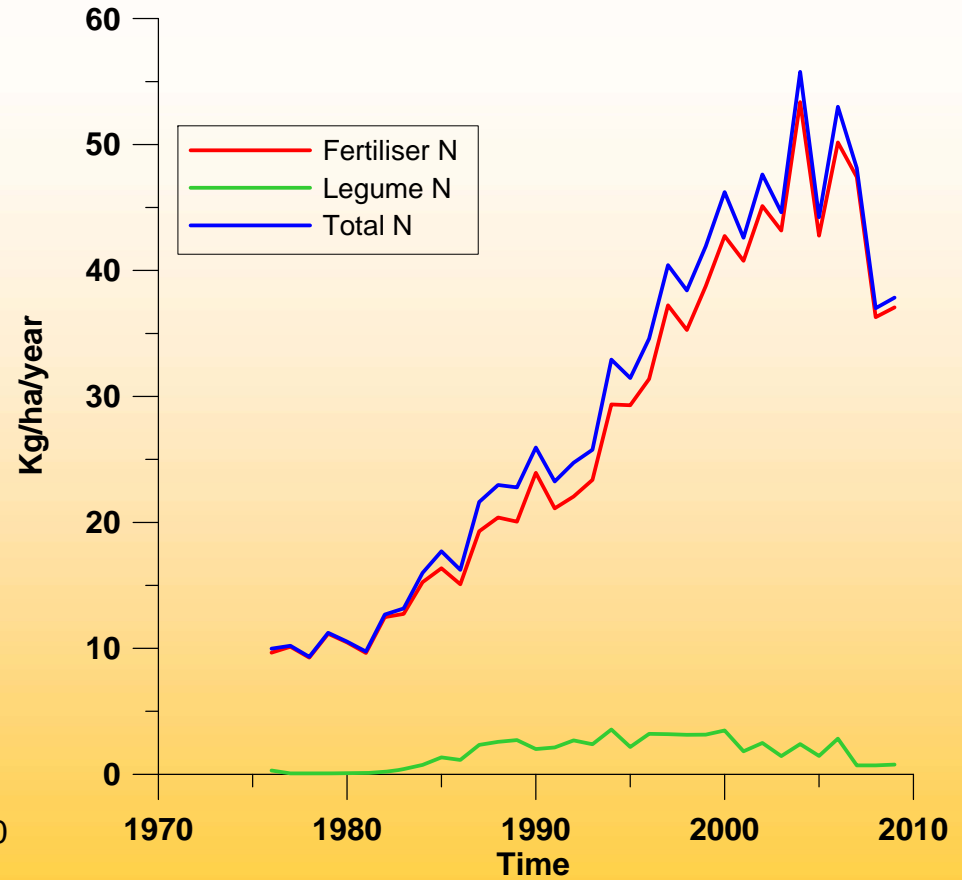
Change in N Fertiliser 2007/08 compared to 2000/01



N,P,K fertiliser amount – WA rate N fertiliser/legume



Decrease in N,P,K fertiliser since mid-2000s



Legume N (Bill Bowden)

Change in Farm Income 1996-00 v 2005-09 (ABARES)



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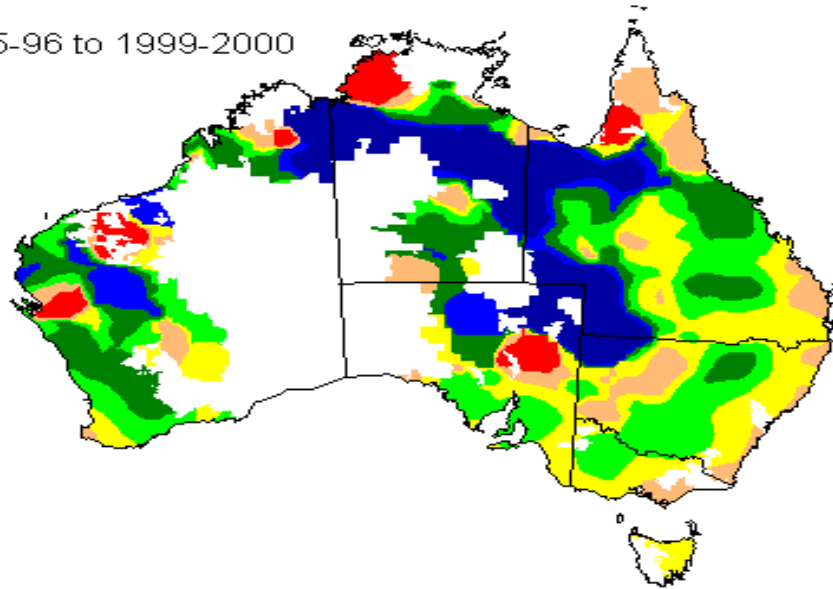


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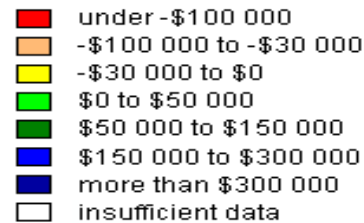
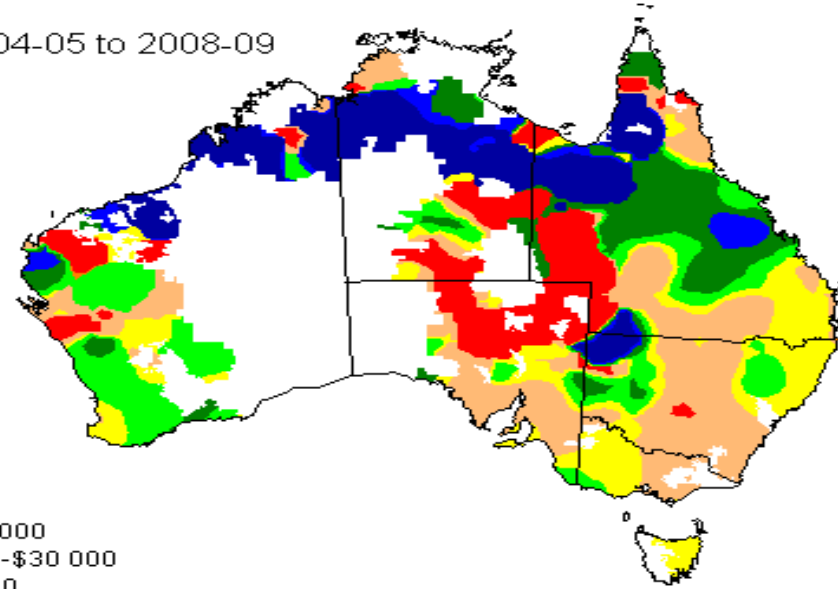
Farm performance - Farm business profit: 5 year average

2008-09 dollars

1995-96 to 1999-2000



2004-05 to 2008-09



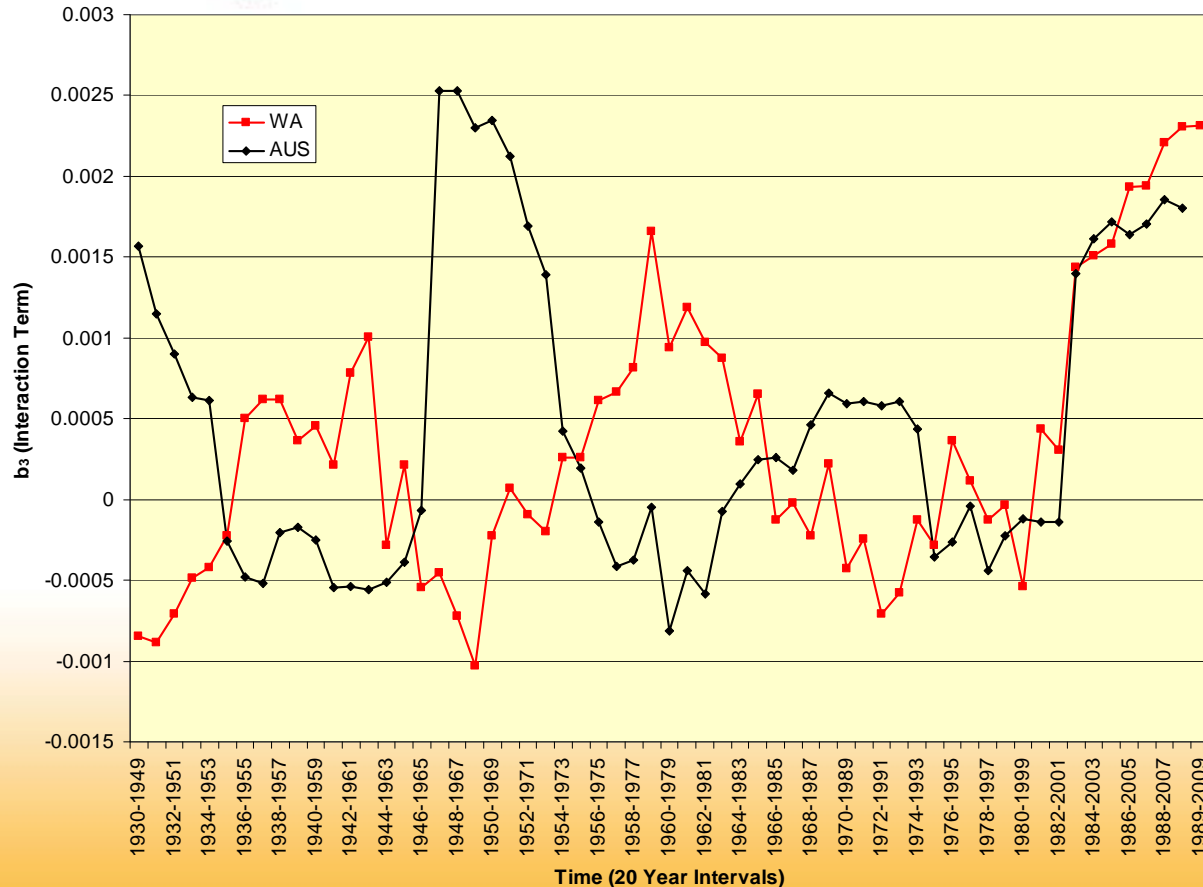
$$\text{Yield} = a + b_1(\text{SI}) + b_2(\text{year}) + b_3(\text{SI} * \text{year})$$



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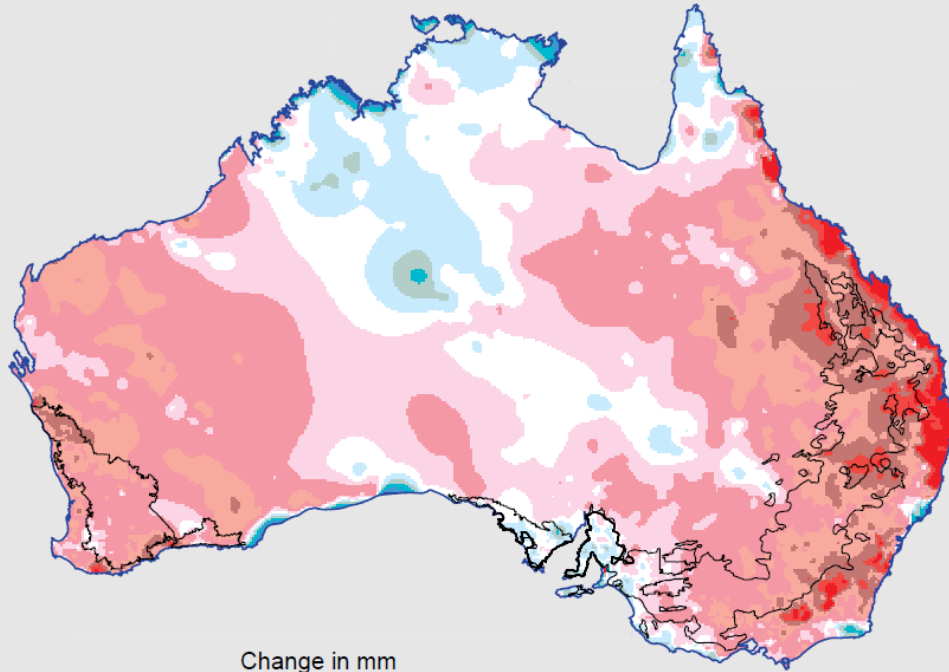


Large interaction between climate and technology in 2000s



Change in May, May-October rain 2000s v 1980s+1990s

Change in Average May Rainfall:
2000-2009 compared to 1980-1999



Change in mm
-50 -40 -30 -20 -10 -5 0 5 10 20 30 40 50



Data Supplied by the Department of
Natural Resources - Queensland



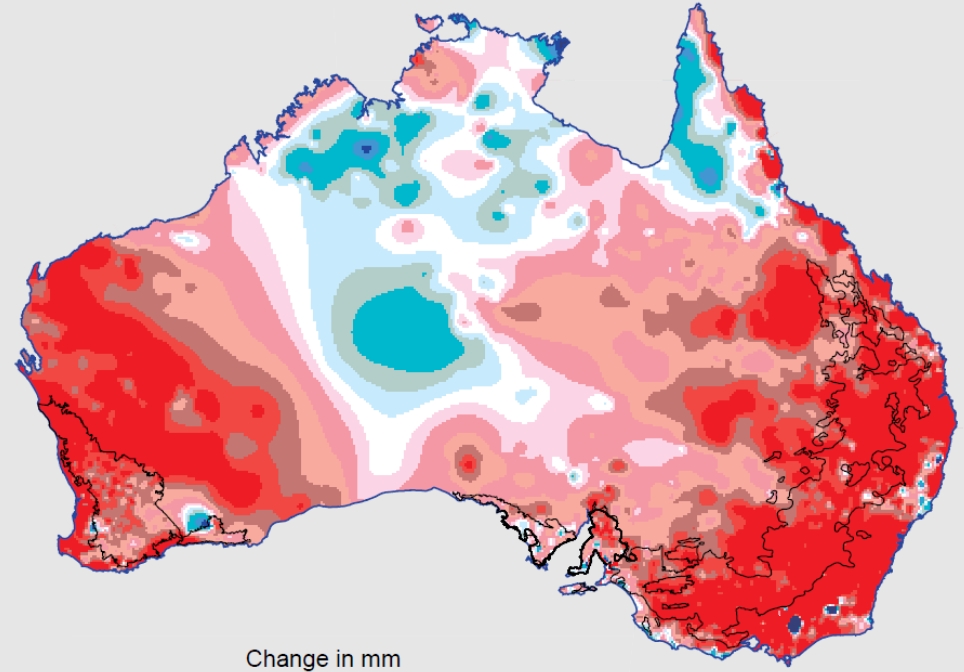
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— Wheatbelt boundary

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Change in Average May-October Rainfall:
2000-2009 compared to 1980-1999



Change in mm
-50 -40 -30 -20 -10 -5 0 5 10 20 30 40 50



Data Supplied by the Department of
Natural Resources - Queensland



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— Wheatbelt boundary

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Rate of Change in Yield Trend: rolling 30-year periods

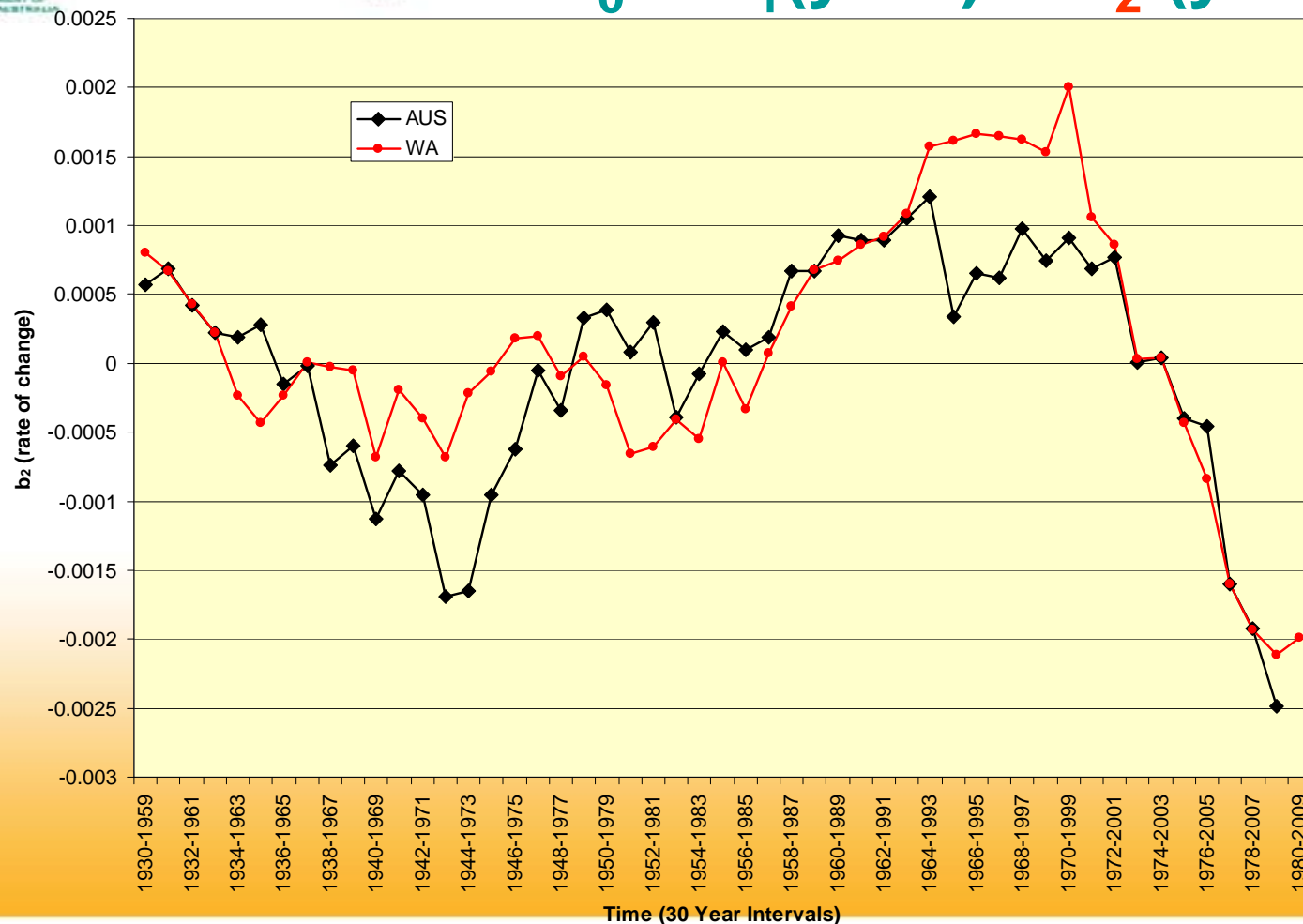


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$$Y = b_0 + b_1(\text{year}) + b_2(\text{year})^2$$

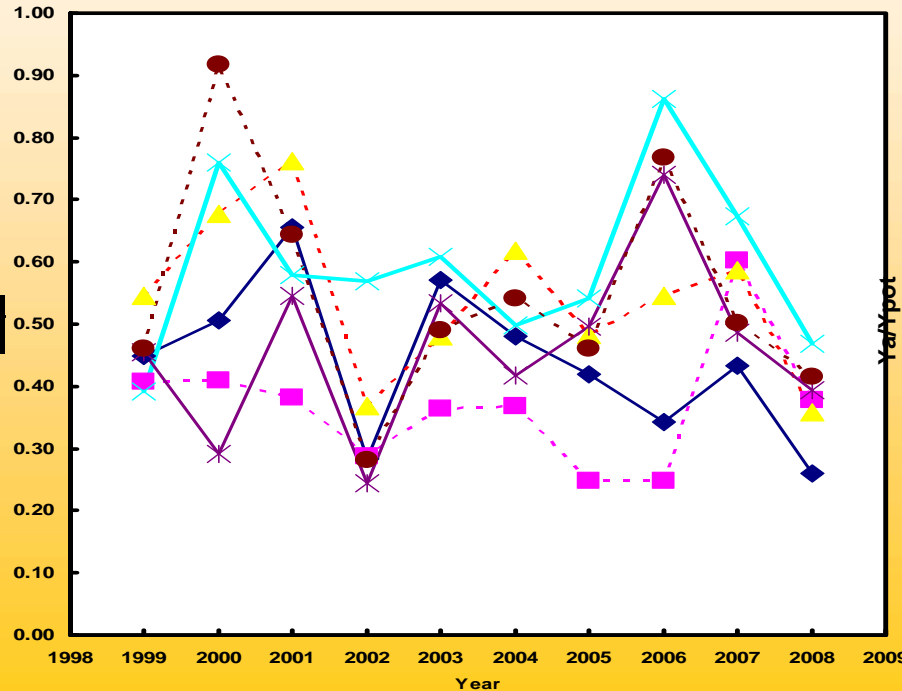
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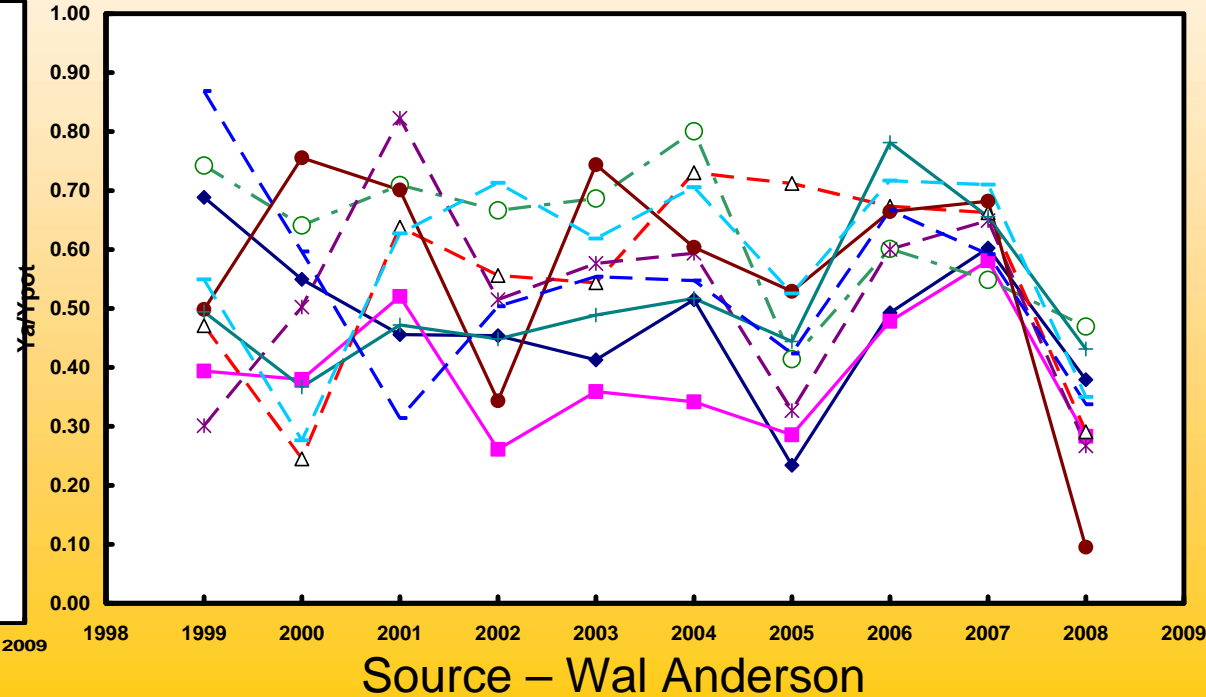
2. WUE (Production) Efficiency

- $WUE = Y_{actual} / Y_{potential}$
- $Y_{potential} = \text{Water used} * 20 \text{ kg/ha/mm}$
- $= (SM_{sow} + GSR) - (0.33 * GSR) * 20$

Management efficiency, low rainfall south, 6 farms



Management efficiency, MRF South



Source – Wal Anderson

Change in WUE: 1996-2000 to 2005-2009

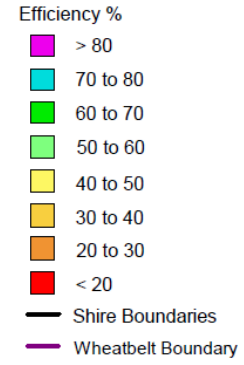
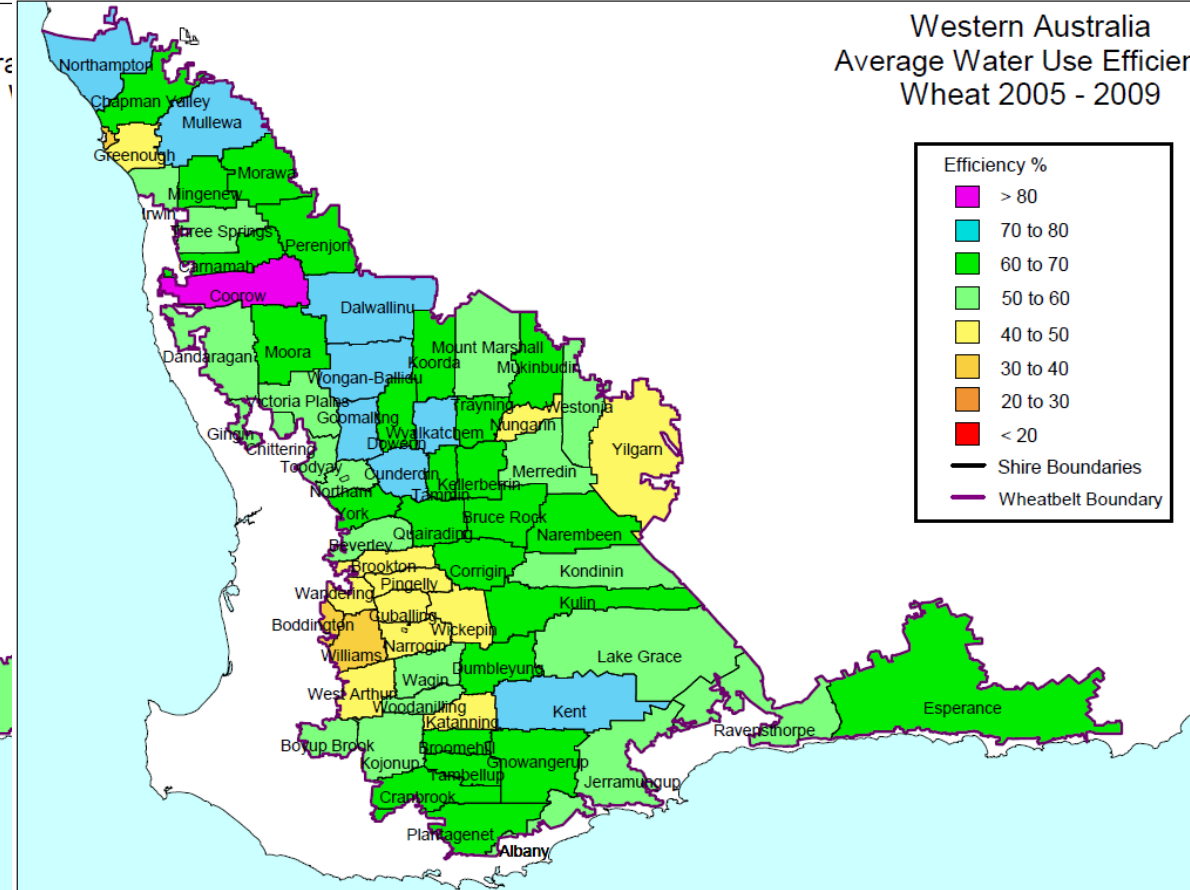
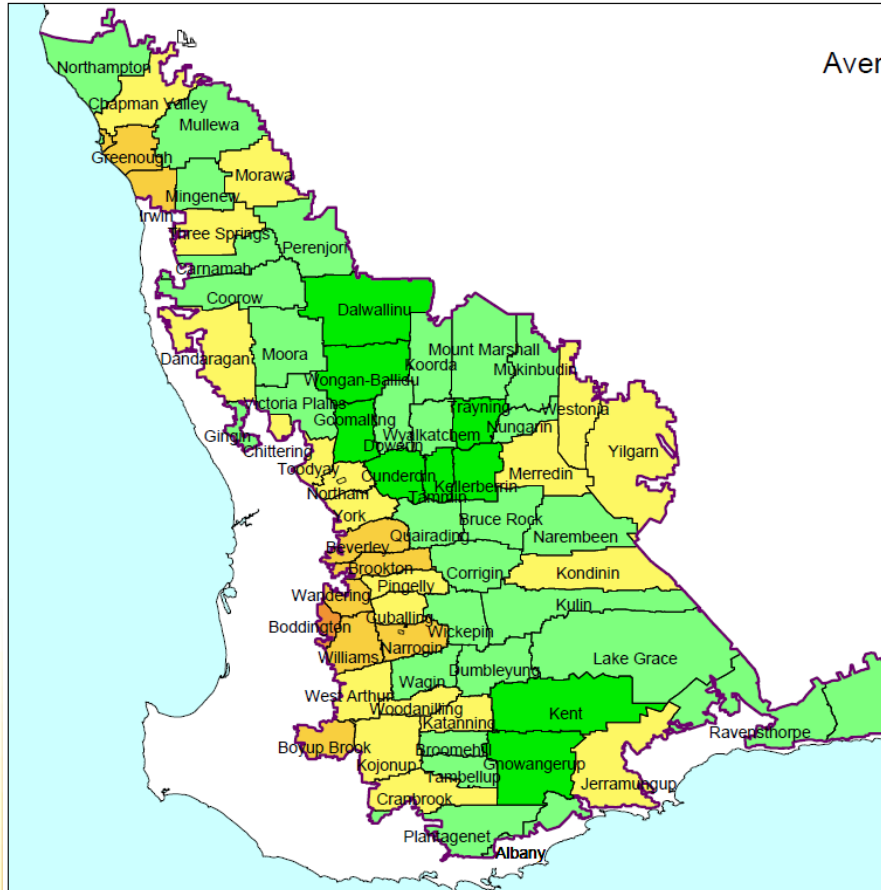


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Western Australia
Average Water Use Efficiency
Wheat 2005 - 2009



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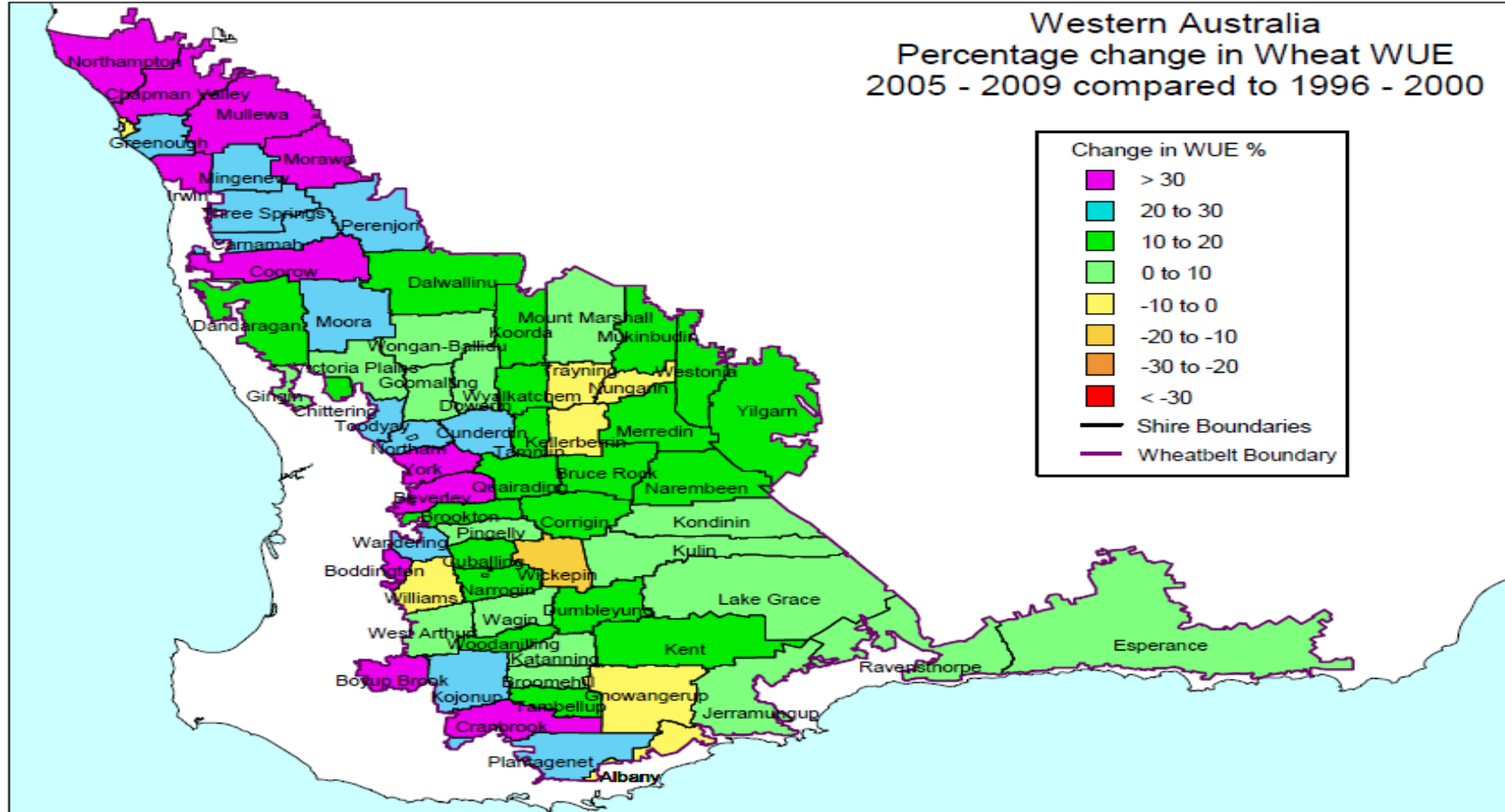
% Change in WUE: 1996-2000 to 2005-2009



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CONCLUSIONS

- Western Australian farmers have dramatically increased the WUE of crops over the last decade.
- However, an abrupt change to a more variable and dry climate, and more September frosts in the south, have severely impacted Western Australia's crop productivity growth.
- Aspects of the high yield package that underpinned productivity growth were not advantageous in the 2000s and this exposed a frailty in our cropping systems not observed before.
- The fact that the “rate of change in yield trend” has reached an all time minimum suggests that this is not the time to be decreasing our R&D!



Thanks GRDC for funding
Wal Anderson, Bill Bowden - analysis
Phil Goulding (CRIS) maps
Helpful discussions with Doug Abrecht

A faint, stylized illustration of a plant with a wheat head and a clover-like flower, similar to the one in the CROP updates logo, is positioned to the right of the text.