Changing climate/weather (?) and future wheatbelt farming

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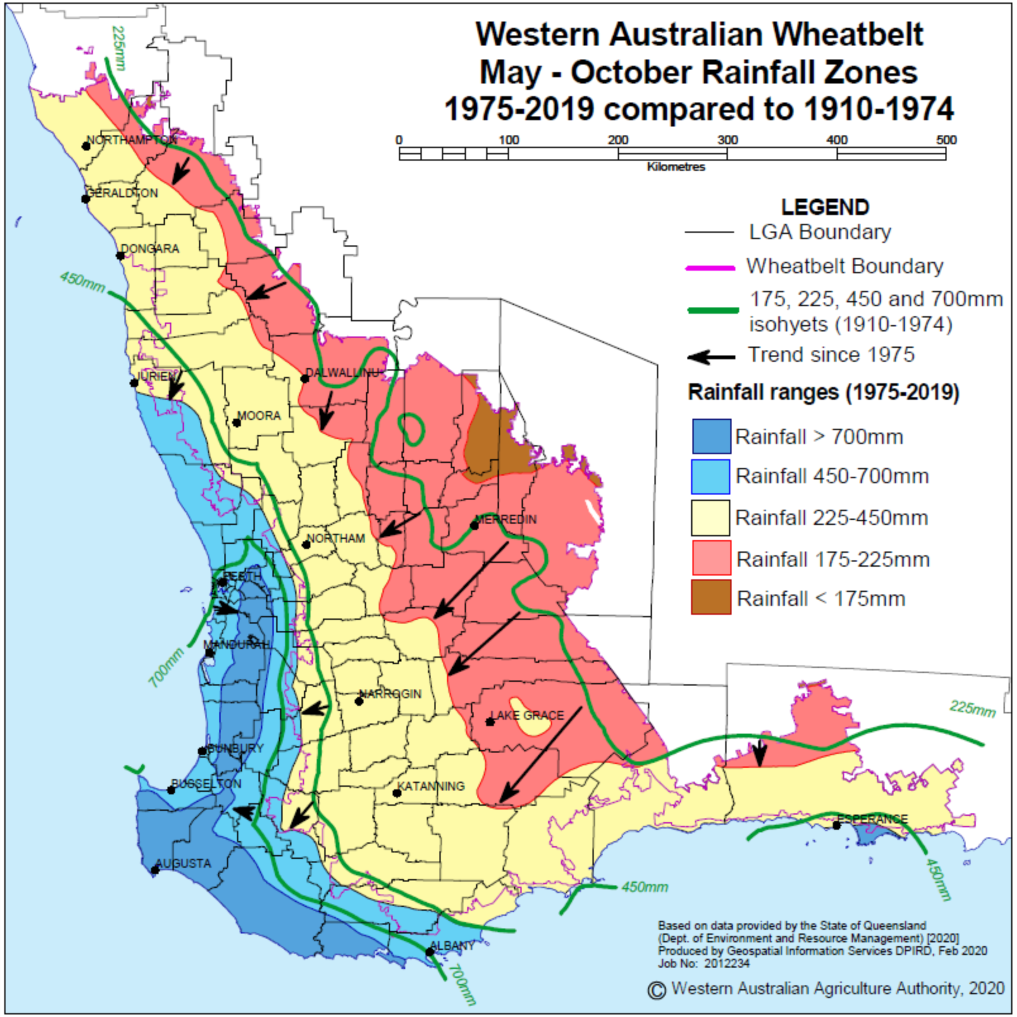
GRDC for Crop Updates

Overview

- Climate shift in the South West Land Division in 1975 and 2000
- Standardized Precipitation Evapotranspiration Index (SPEI)
- Rain days / Days between rain in winter
- Temperature and Growing Degree Days
- Future Predictions
- Impacts on farming systems
- Impacts on natural ecosystems
- Innovation

CLIMATE SHIFT IN 1975

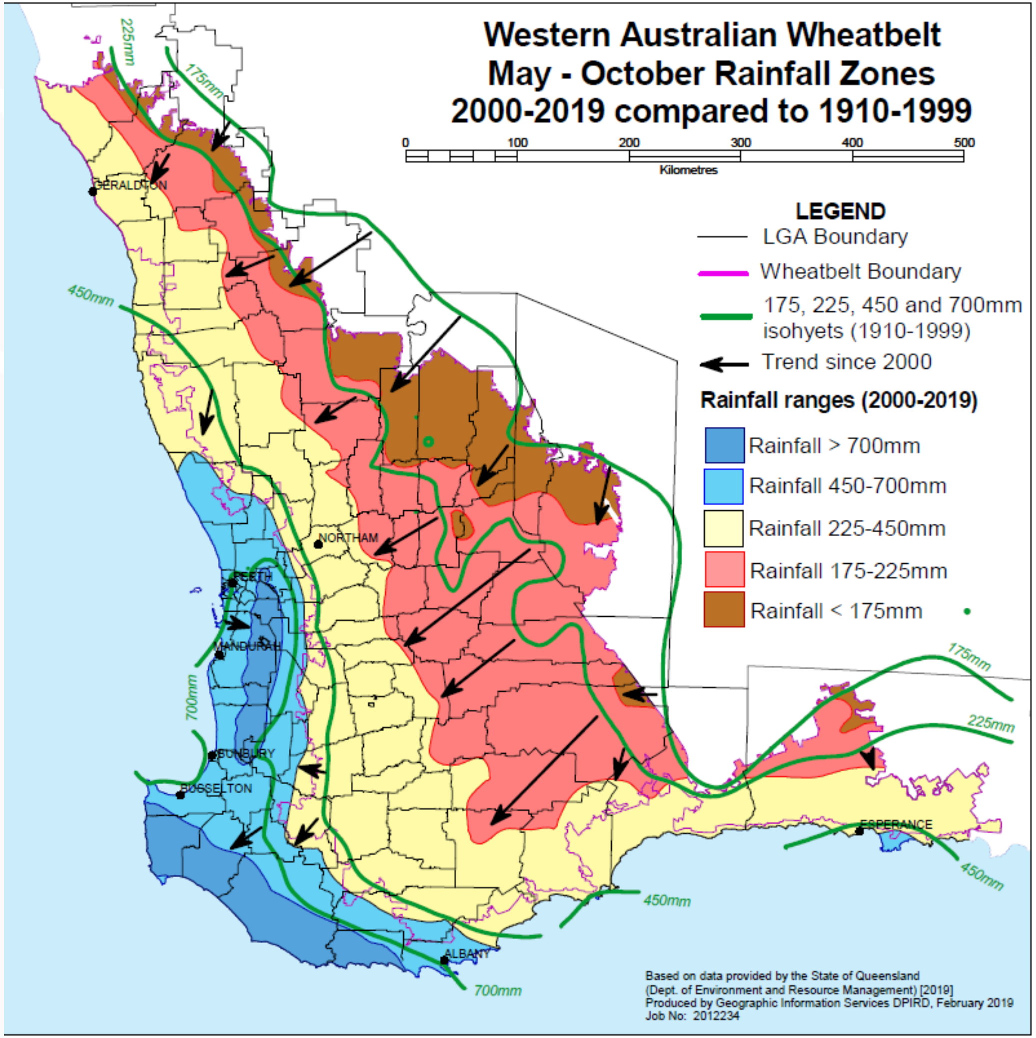
Due to:
southward shift of low pressure systems and westerly frontal systems



Hope, P.K., Drosdowsky, W. & Nicholls, N. Shifts in the synoptic systems influencing southwest Western Australia. *Clim Dyn* **26,** 751–764 (2006).

AGAIN IN 2000

17 of the last 20 years April to October rainfall in Southern Australia has been below average



Bureau and CSIRO
State of Climate Report 2020

Natural Variability

- The natural variability in temperature and rainfall continues to dominate weather systems – El Nino/La Nina pattern, IOD phases, SAM remain key determinants of Australian weather
- Any climate signal from human GHG induced warming is often hard to detect (IPCC 5th and 6th reports) at local and sub regional level
- Temperature can be lower even when global temperatures are rising. Must consider synoptic pattern changes
- There can be winners and losers even within regions – eg previous high rainfall zones are now better cropping and highly productive with less waterlogging

- The natural variability in rainfall for SWWA has been shown to be a long standing occurrence
- O’Donnell et al have used tree ring data as proxies for rainfall from Lake Deborah East to look at how this has changed over nearly 700 years
- Runs of dry years (>10 yrs) with up to 25% reductions in average rainfall were found, while the most extreme individual dry years were close to 50%.
- An extreme dry year was not necessarily present in a long run of dry years

Climate Dynamics
https://doi.org/10.1007/s00382-021-05782-0

Megadroughts and pluvials in southwest Australia: 1350–2017 CE

Alison J. O'Donnell[1] · W. Lachlan McCaw[2] · Edward R. Cook[3] · Pauline F. Grierson[1]

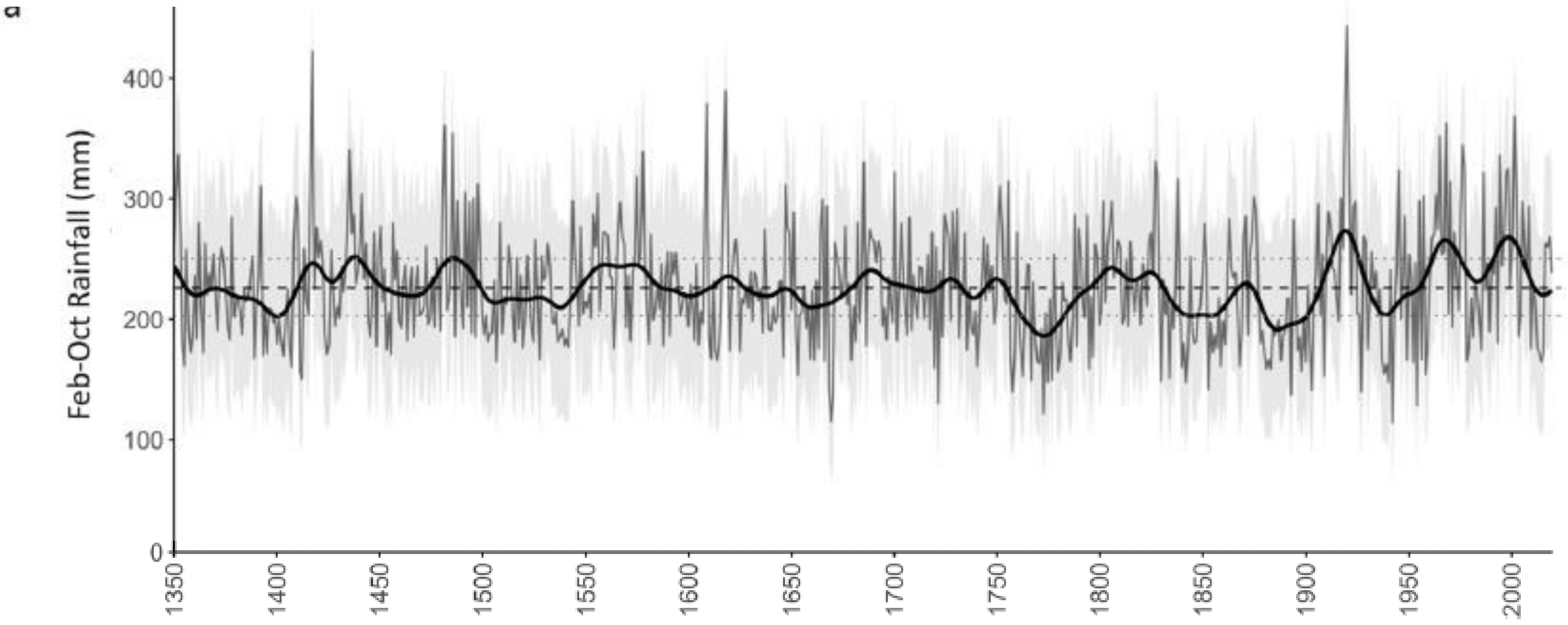
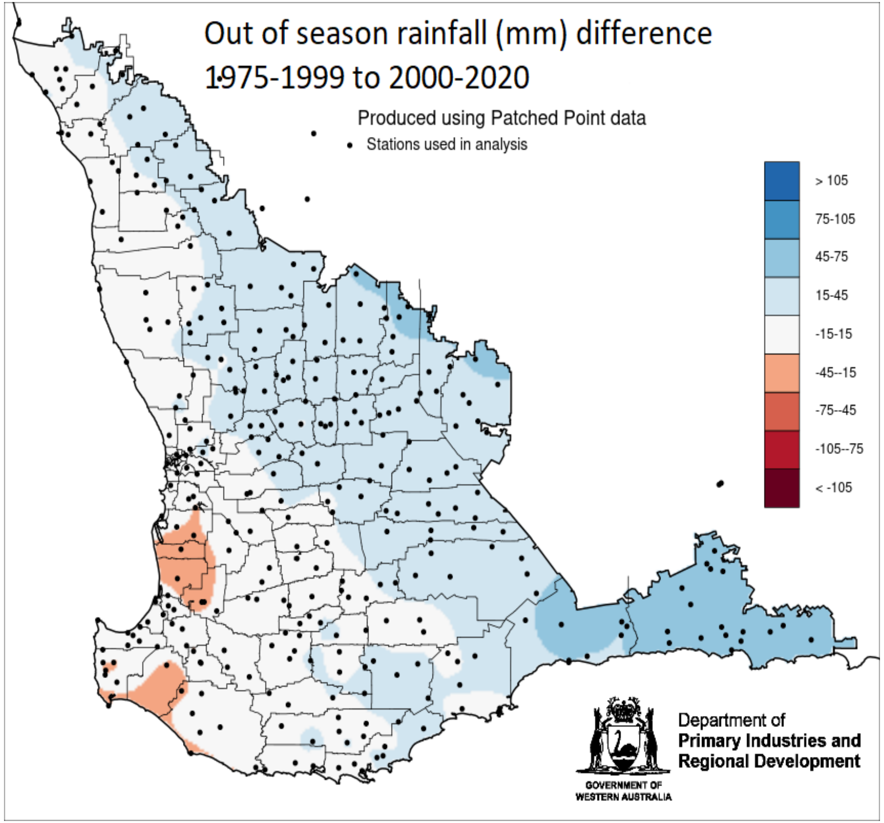
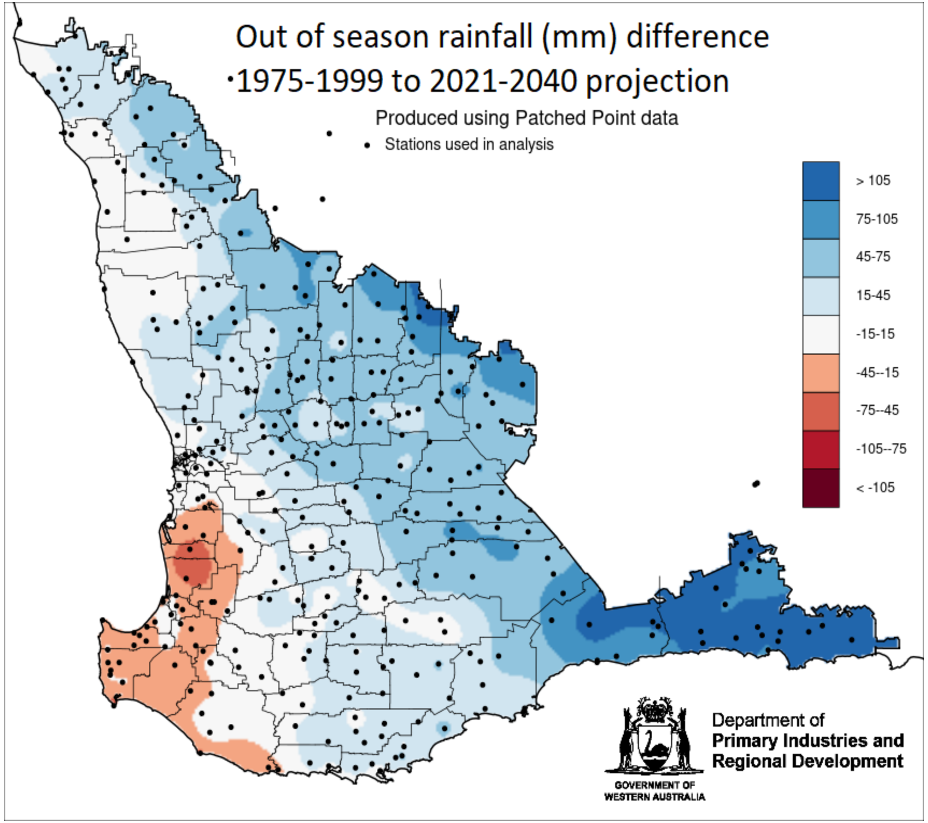


Fig. 4 The 668-year reconstruction of autumn–winter (Feb-Oct) rainfall for inland southwest Australia showing **a** inter-annual and ~ decadal variability y with a ~ 15-year Gaussian filter;

Out of season rainfall

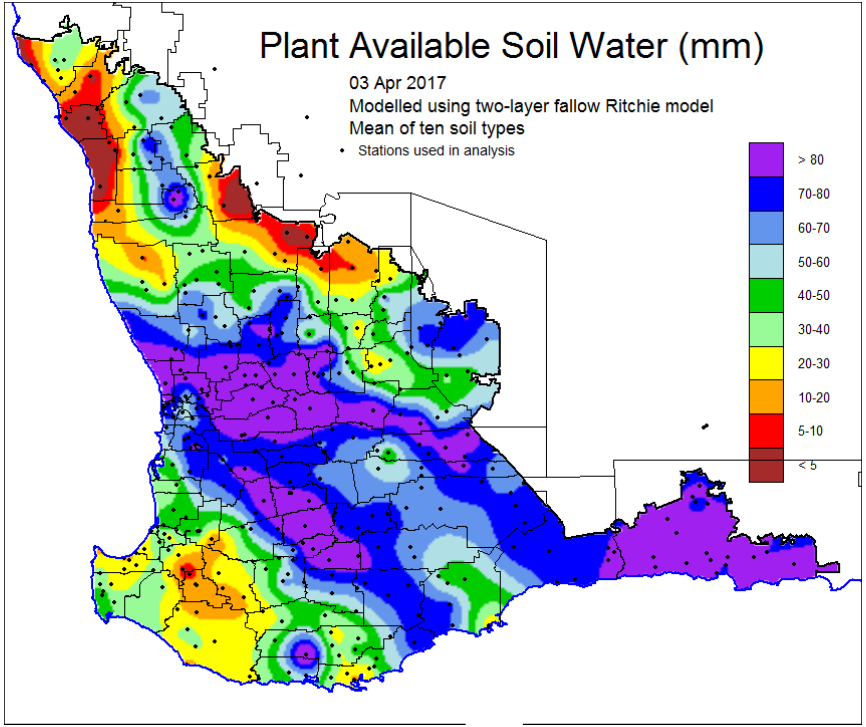


Observed

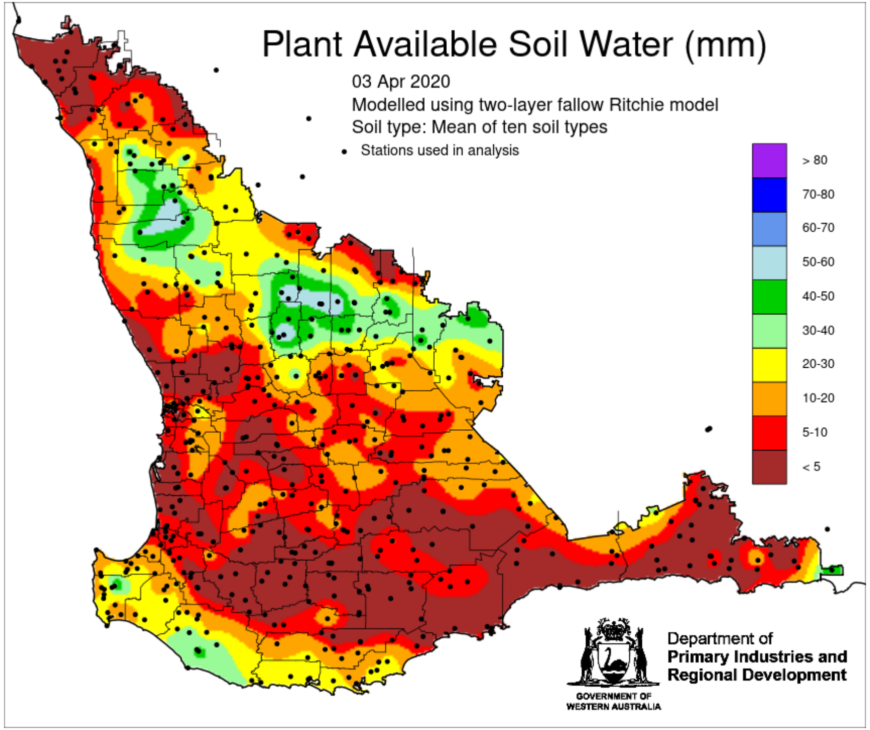


Simple projection

Soil moisture- highly variable

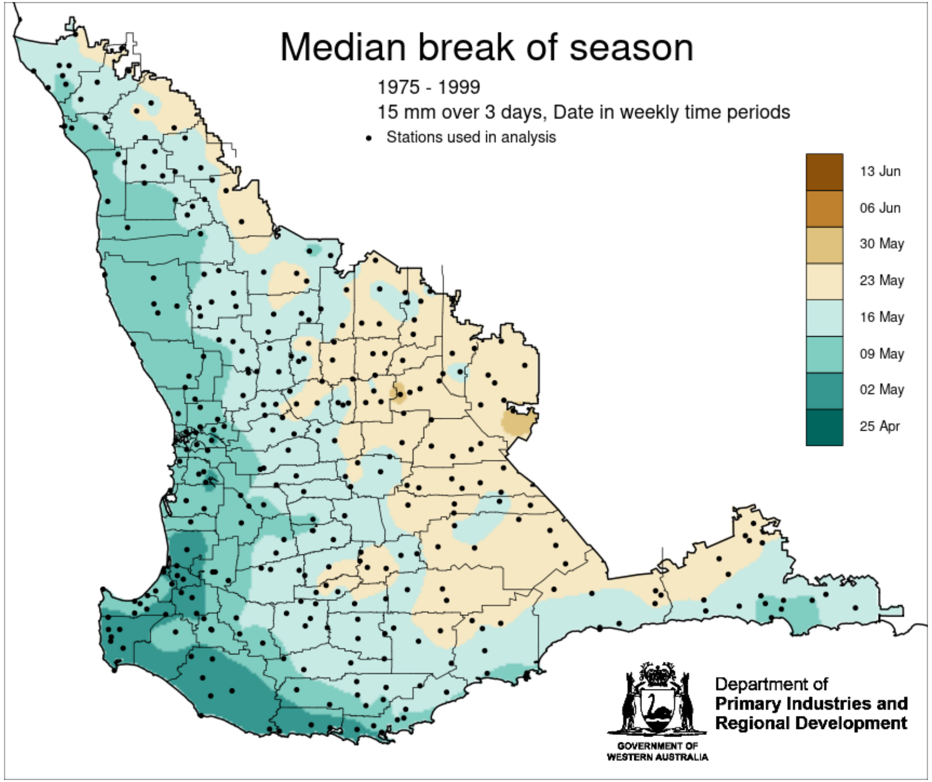


3 April 2017

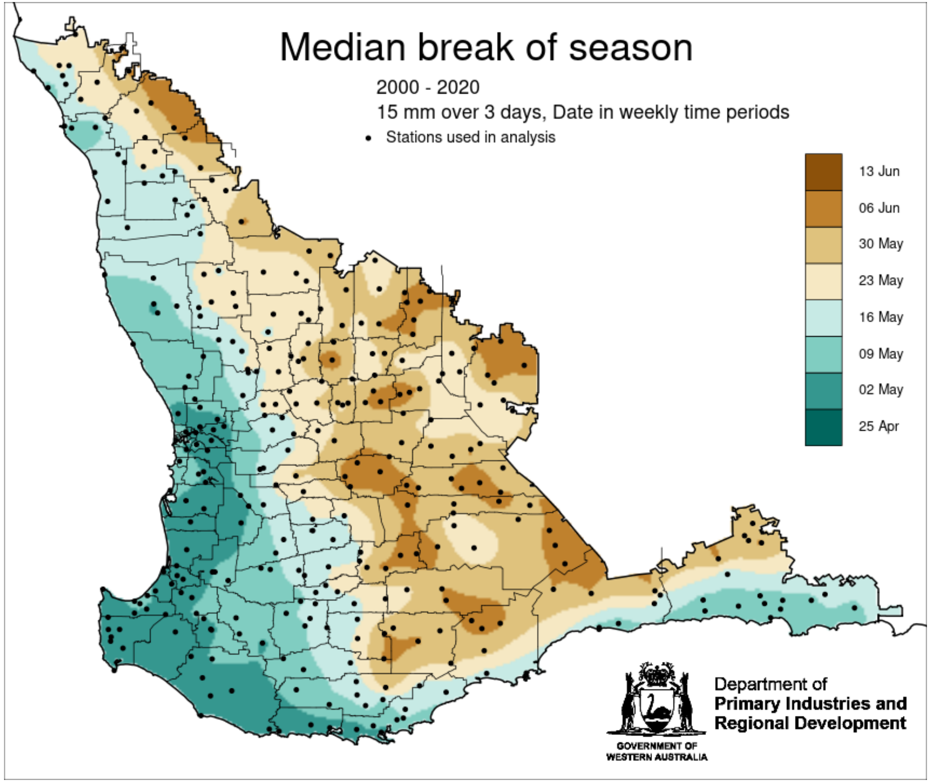


3 April 2020

Later break



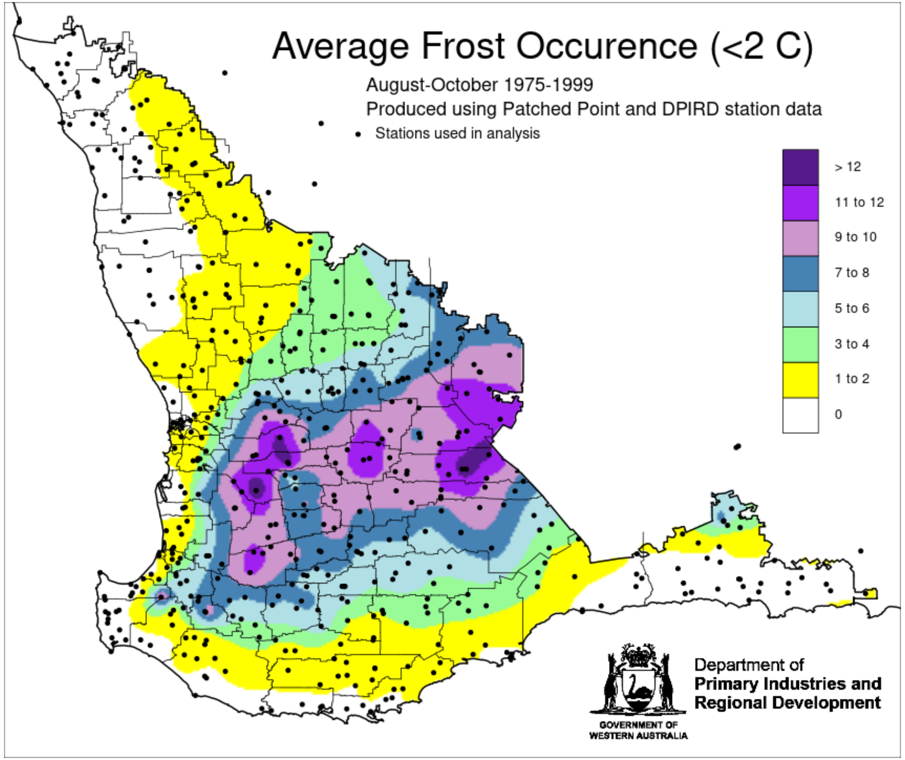
1975-1999



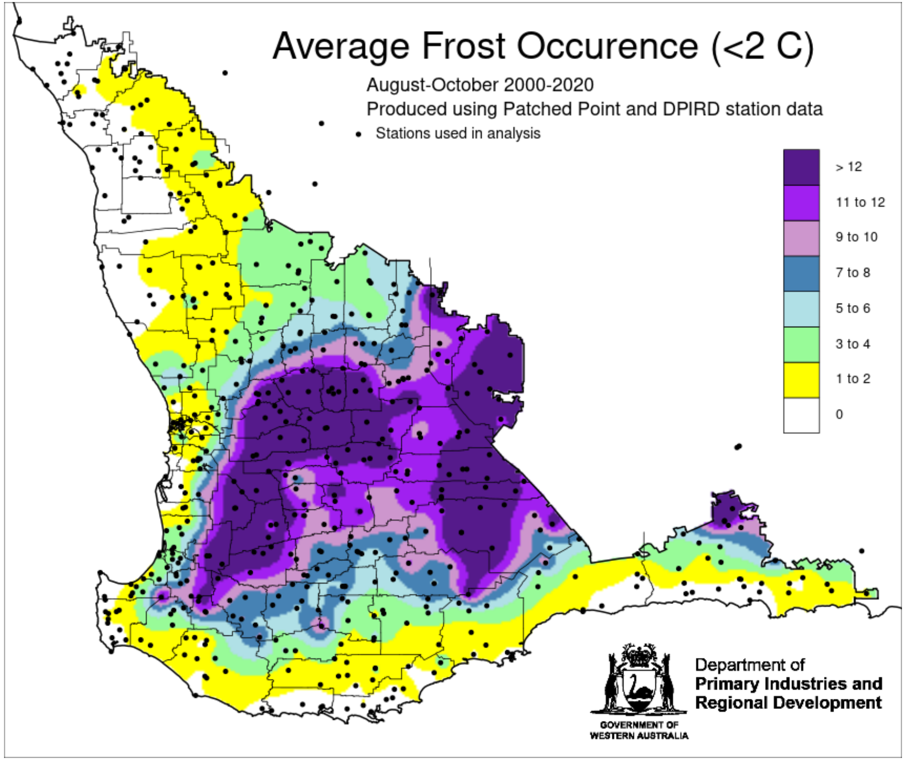
2000-2020

Aug-Oct frost occurrence

Average number of days below 2°C August to October



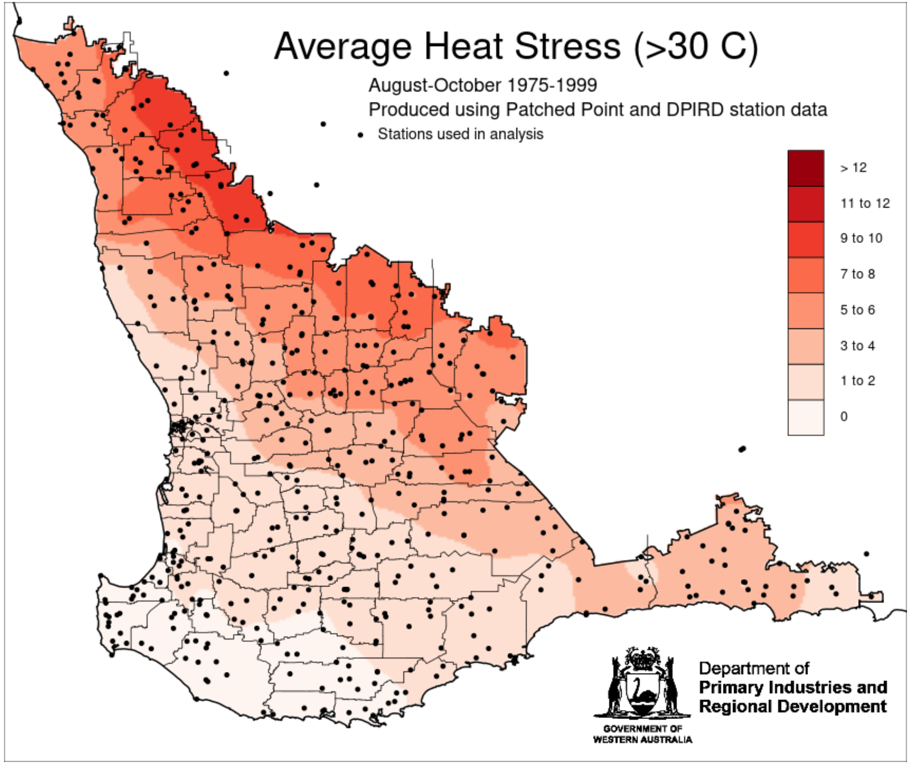
1975-1999



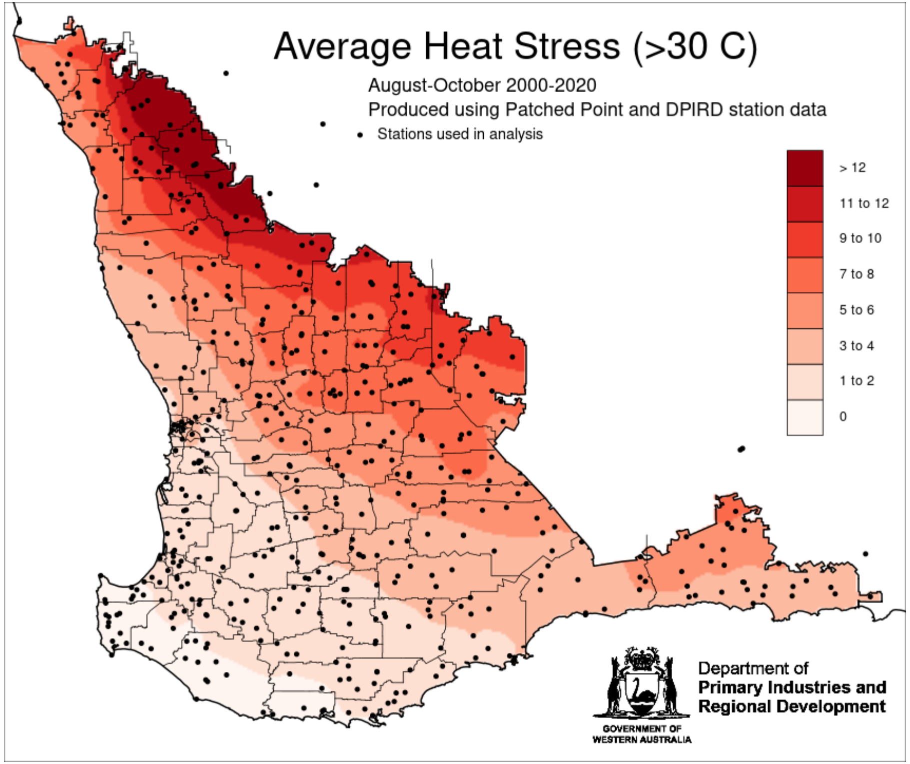
2000-2020

Aug-Oct heat stress

Average number of days above 30°C August to October



1975-1999



2000-2020

Standardized Precipitation Evapotranspiration Index (SPEI)

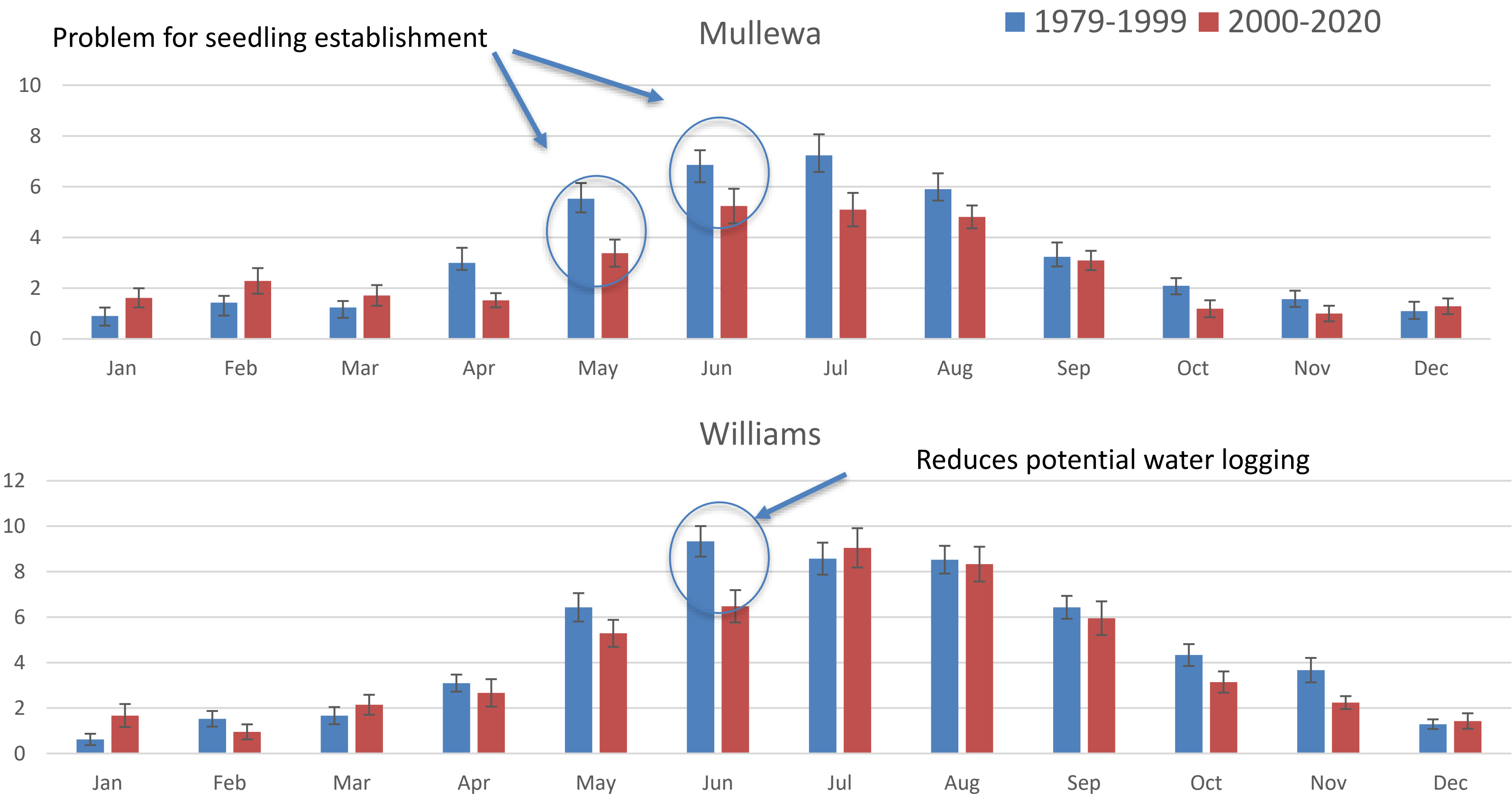
- Combines rainfall and temperature effects in one drought index
- SPEI - intensity scale in which both positive and negative values are calculated identifying wet and dry events
- Lower SPEI – less rainfall
- Lower SPEI – higher temperatures
- Values of SPEI <-1 during the growing season of a crop are often indicative of drought stress and have been shown to be positively correlated with yield loss.

Vicente-Serrano S.M., Begueria S, Lopez-Moreno J.I. 2010. A multi-scalar drought index sensitive to global warming: the Standardised Precipitation Evapotranspiration Index. Journal of Climate 23:1696-1718

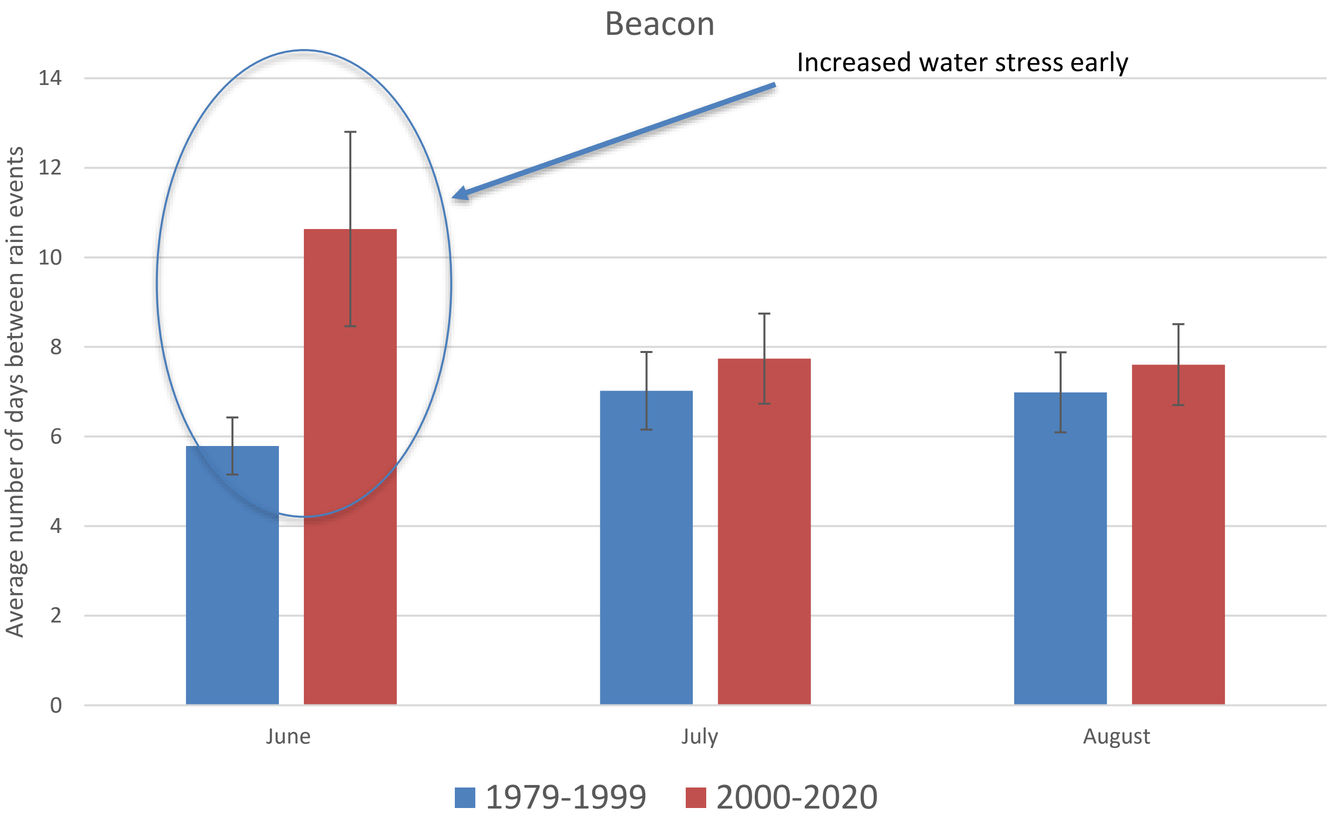
SPEI

	Out of season		Winter	
	1975-1999	2000-2018	1975-1999	2000-2018
Mullewa	0.07	-0.29	0.14	-1.04
Beacon	0.43	-1.38	-0.16	-0.45
Kondinin	-0.52	-1.03	0.08	-1.06
Ravensthorpe	-0.74	-0.08	-0.07	-0.40
Mingenew	0.11	-1.53	0.12	-1.10
Goomalling	-0.28	-0.48	-0.12	-0.48
Williams	-0.42	-0.83	-0.21	-0.45*
Gnowangerup	-1.03	-0.64	-0.02	-0.92
Katanning	-0.63	-0.51	-0.20	-0.50 *
Newdegate	-0.11	0.01	-0.10	-0.44

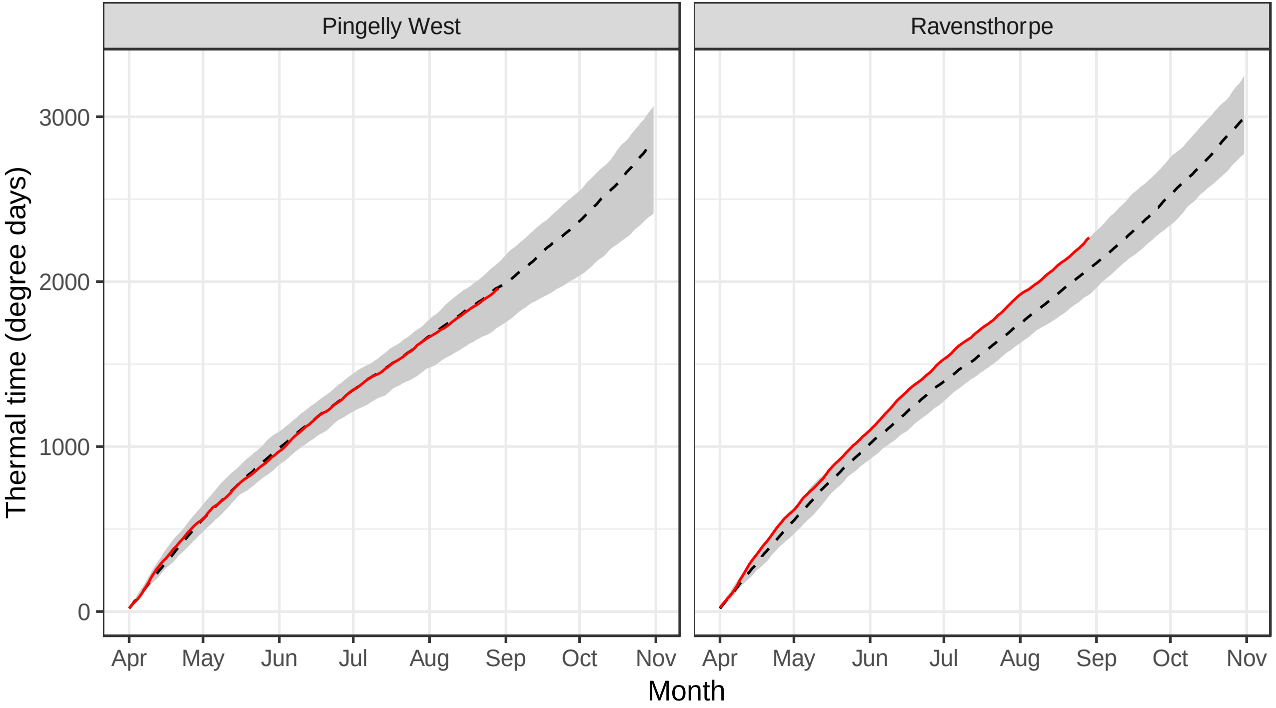
Rain days then and now



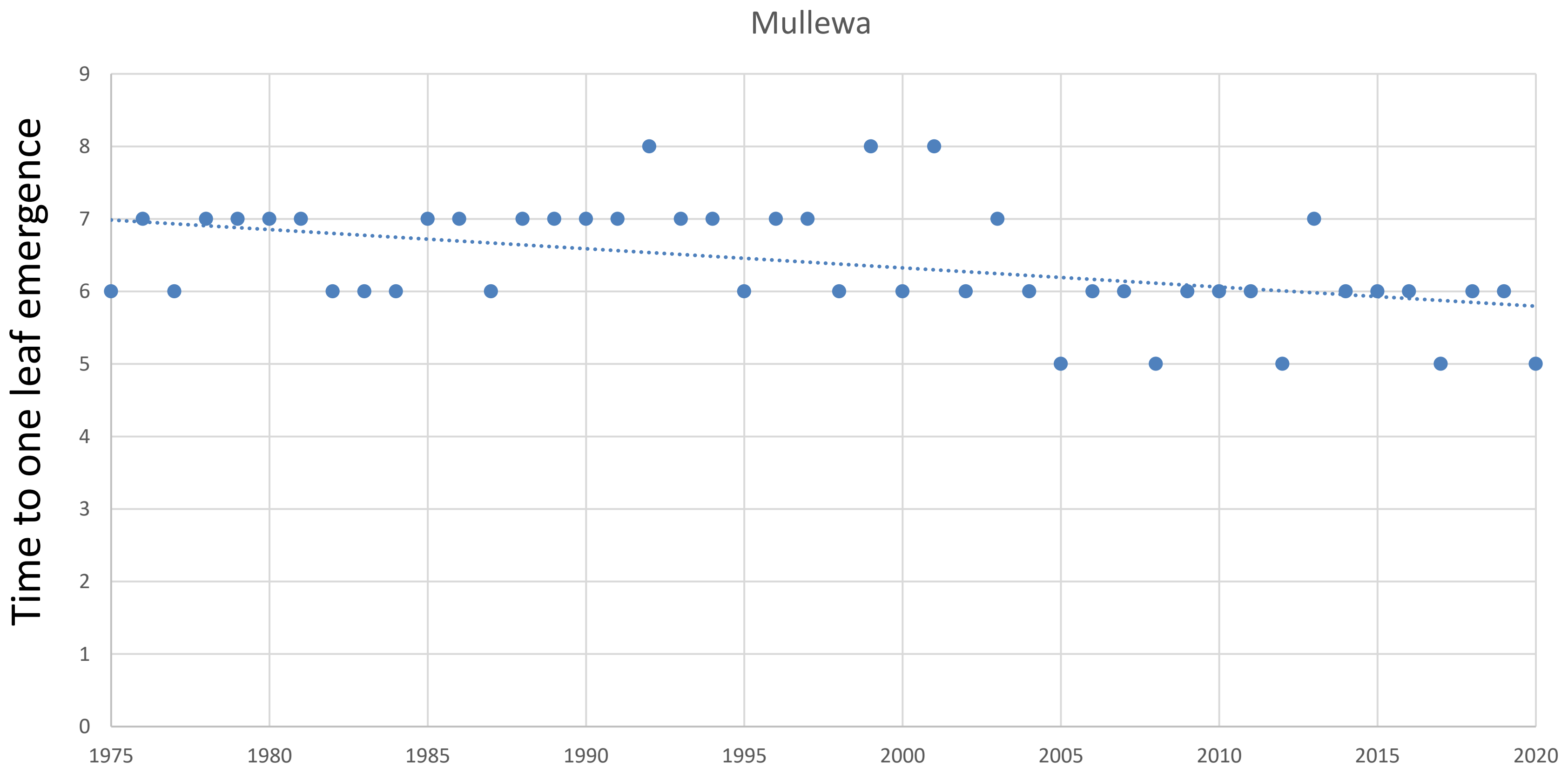
Number of days between rain days



Thermal time graphs



Growing degree days - time to 90



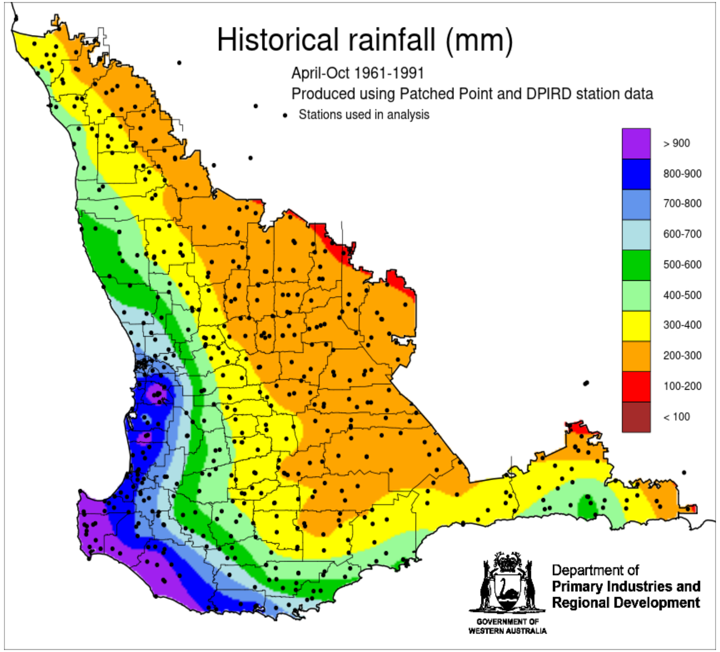
Future predictions

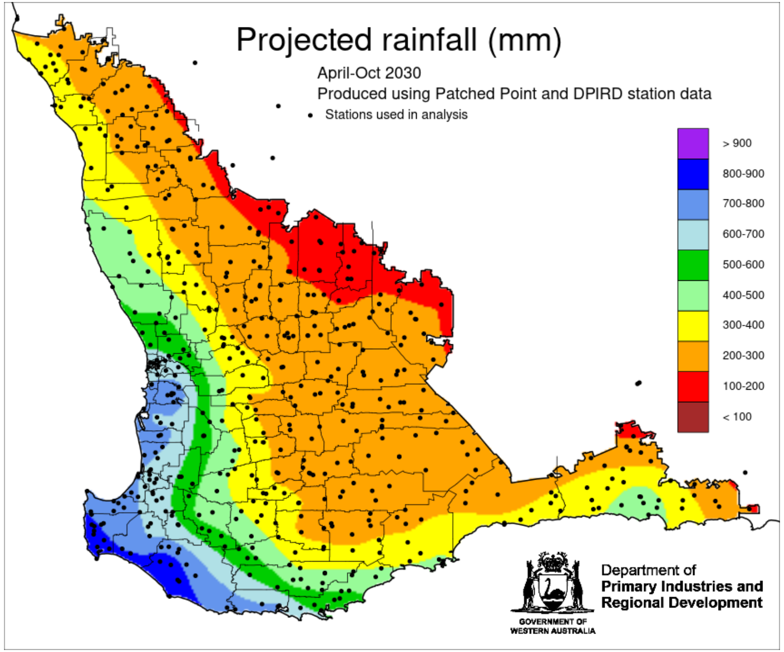
Climate Models predict

- Temperatures will slowly continue to rise, and yet chilling incidence may increase in one third of the grain-belt
- Further decrease in winter rainfall with crops having more time under water stress – considerable variability in this
- Increase in intense heavy (out of season) rainfall. These may still only occur once every 3-4 years
- An increase in the frequency of low rainfall years often back to back – more water scarcity over parts of grain-belt (eg 2018 to 2020 – 250 to 500 mm deficit over 3 yrs)
- Extreme dry-year frequency# (once in a century drought) will increase in Australia once the rise in global average temperature exceeds 1.5°C

#Takeshima A., Kim H., Shiogama H., Lierhammer L., Scinocca J.F., Seland O., Mitchell D. 2020 Global aridity changes due to differences in surface energy and water balance between 1.5°C and 2°C warming. *Environ. Res. Lett.* 15

Winter rainfall futures?

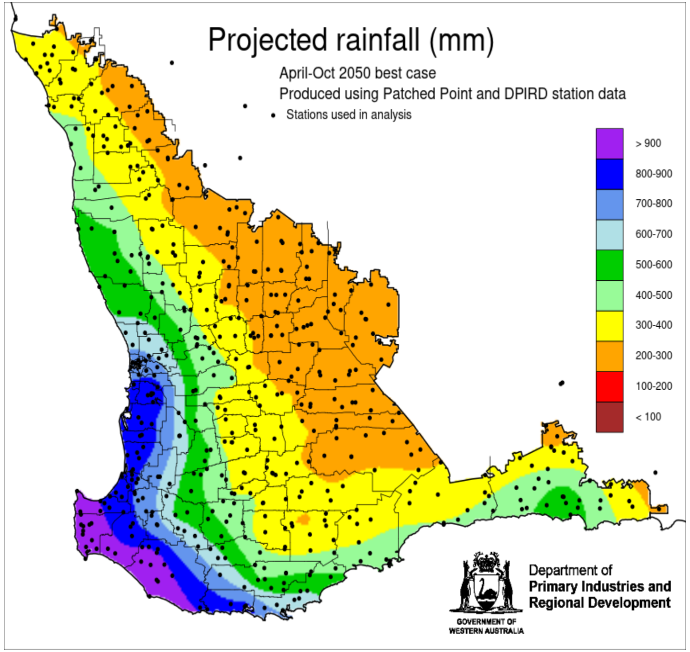




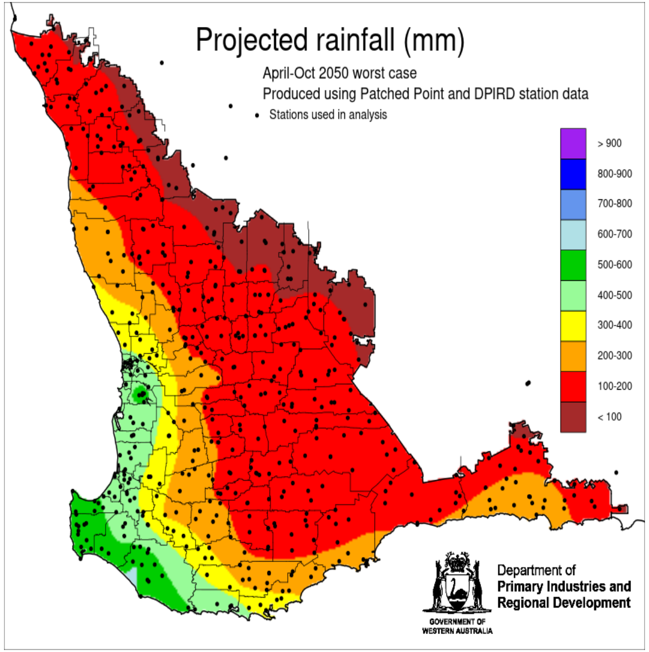
Average Rainfall
1961-1991

Median rainfall from 100+
climate model runs for 2030

Winter rainfall futures?



Best case scenario for 2050 individual year



Worst case scenario for 2050 individual year

Impacts - agriculture

- Delayed break of season, earlier onset heat stress
  - shorter growing season
- Drier winters
  - Increased chance of drought stress, less biomass
  - Less waterlogging in HRZ
- Wetter summers
  - Increased ground water recharge
- Warmer winters
  - Less efficient water use, more heat stress during grain fill, greater soil carbon loss
  - Flowering and grain fill earlier when winter is at its coldest

Impacts - agriculture

- Clear skies
  - Some climate models have more frost due to change in high pressure cell location
- Delayed break of season
  - Less chance for pre-season weed control
- Drier/warmer winters

  More disease/pests in crops
  - Fire season risk earlier
- Wetter summers
  - Increased summer weeds, potential for more perennial weeds eg skeleton weed, green bridge for pests eg locusts, mice, stem rust

Impacts – natural systems

- More years with sustained water deficits in winter. Does this lead to more tree/ shrub death or will summer rainfall increases offset
- What effects will higher extreme summer temperatures have – do our long lived species have adaptations that allow them to survive
- Will higher temperatures/summer rainfall lead to higher risk of disease establishment eg myrtle rust in eucalypts
- Water availability to animals – natives vs ferals
- Summer recharge leading to more salinisation
- Reduced establishment of natural regenerating species, planted trees. Introduced grasses are well adapted to lower rainfall and are highly competitive, fire promoting

A few Innovations!

- Soil amelioration (i.e claying, strategic deep tillage, amendments) improves availability and supply of soil water
- Narrow furrow sowing works for now – but later? Need to improve water harvesting technology. What are trade offs?
- Long coleoptile wheat for early sowing after summer rain
- Better genetics for heat stress/ drought tolerance
- Integrated livestock/cropping/silvicultural systems eg dehesa of Spain
- Improved seasonal forecasting tools up to 2-3 years in advance
- Modelling to optimise systems response to any changed weather patterns

Final Points

- Inter annual and decadal variability in weather is a constant for WA
- Some weather/climate indicators shows signs of the GHG warming signals
- Future rainfall patterns are well within ranges where the majority of farms can still operate for another 30 years
- There are good innovations being adopted or which will be available to offset the potential weather impacts of any warming
- We need good models/modellers and political commitment to understand the consequences for current and future farming systems