

# The differing responses to prolonged drought in the Murray-Darling Basin and California

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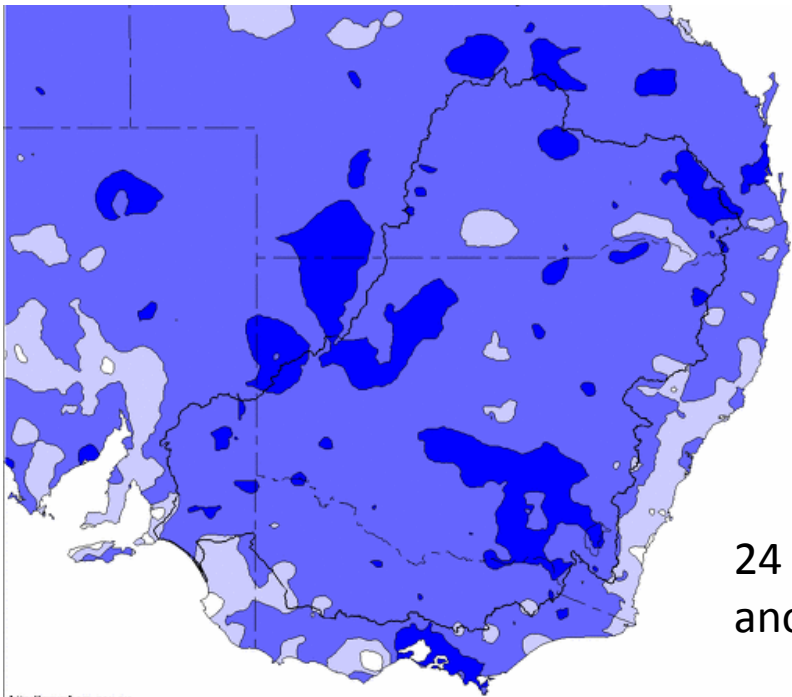
Presentation at 2017  
Conference of Economists,  
Sydney

# Received wisdom: Australia is a world leader in water management

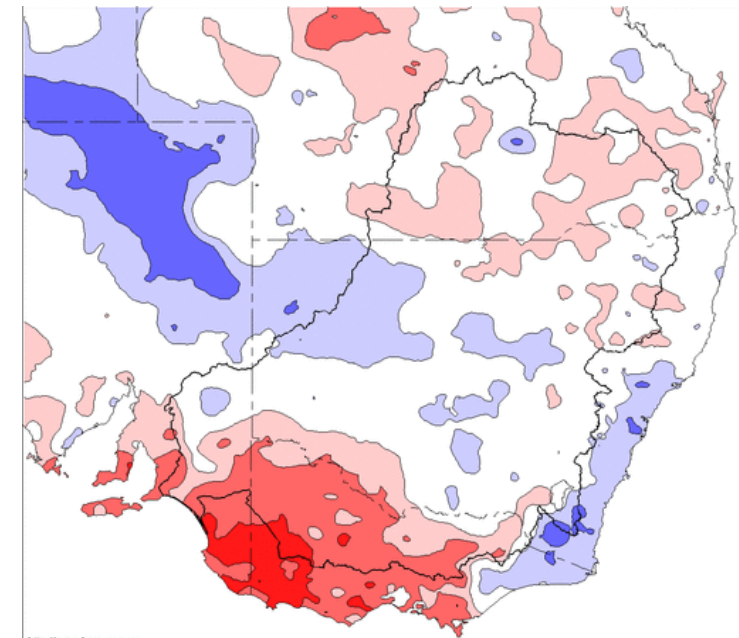
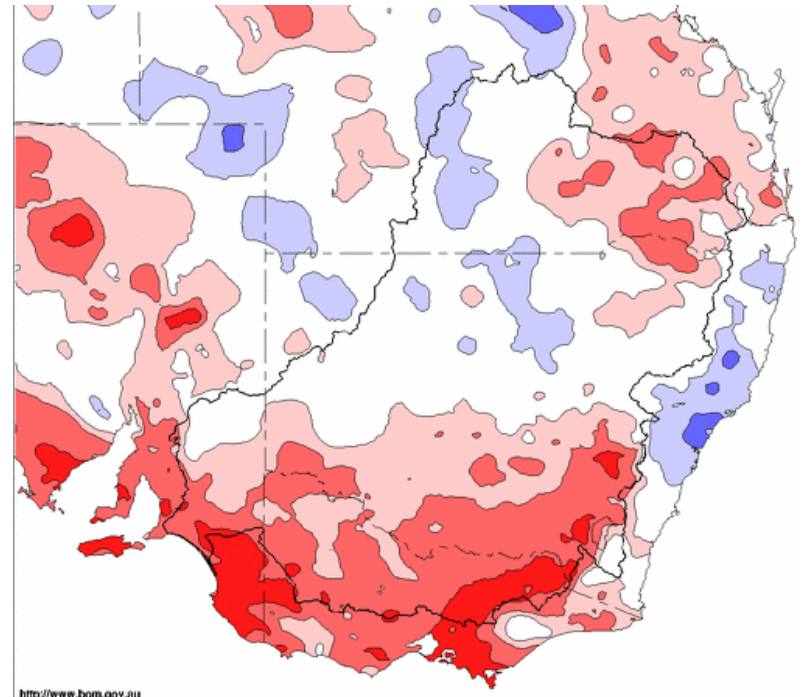
- Water markets in southern MDB are relatively mature. Tempering this:
- The buyback process under the 2007 Water Act has been hindered by the reluctance of policy makers to let markets work
- And it started in drought

# The good news: let the audience decide

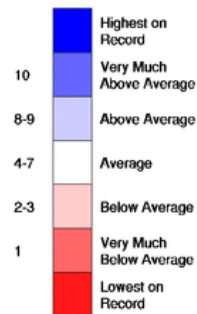
- Fit the price to the map
- Weighted average annual water trading prices in southern MDB



24 month anomalies



Rainfall Decile Ranges

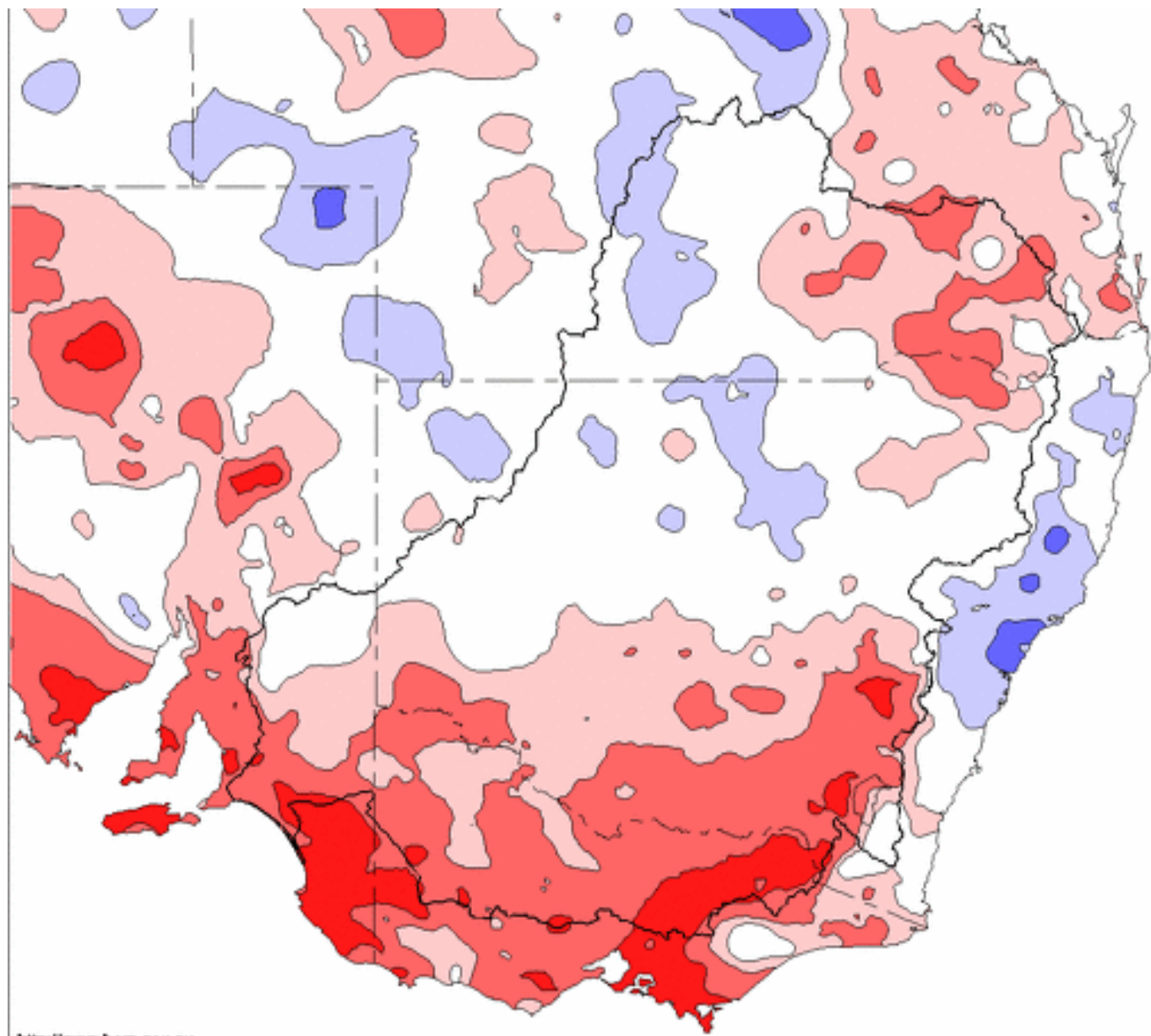


**Puzzle – match water price to rainfall:**

**\$680/ML**

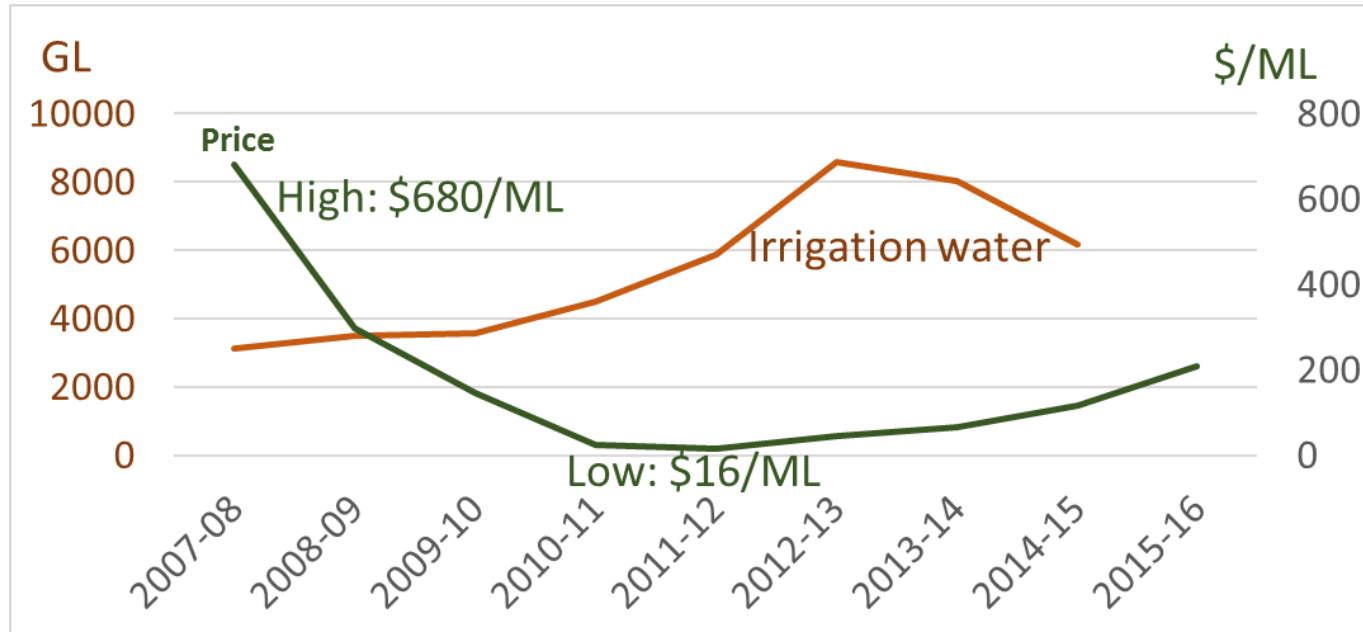
**\$16/ML**

**\$208/ML**



<http://www.bom.gov.au>

# Murray-Darling Basin irrigation

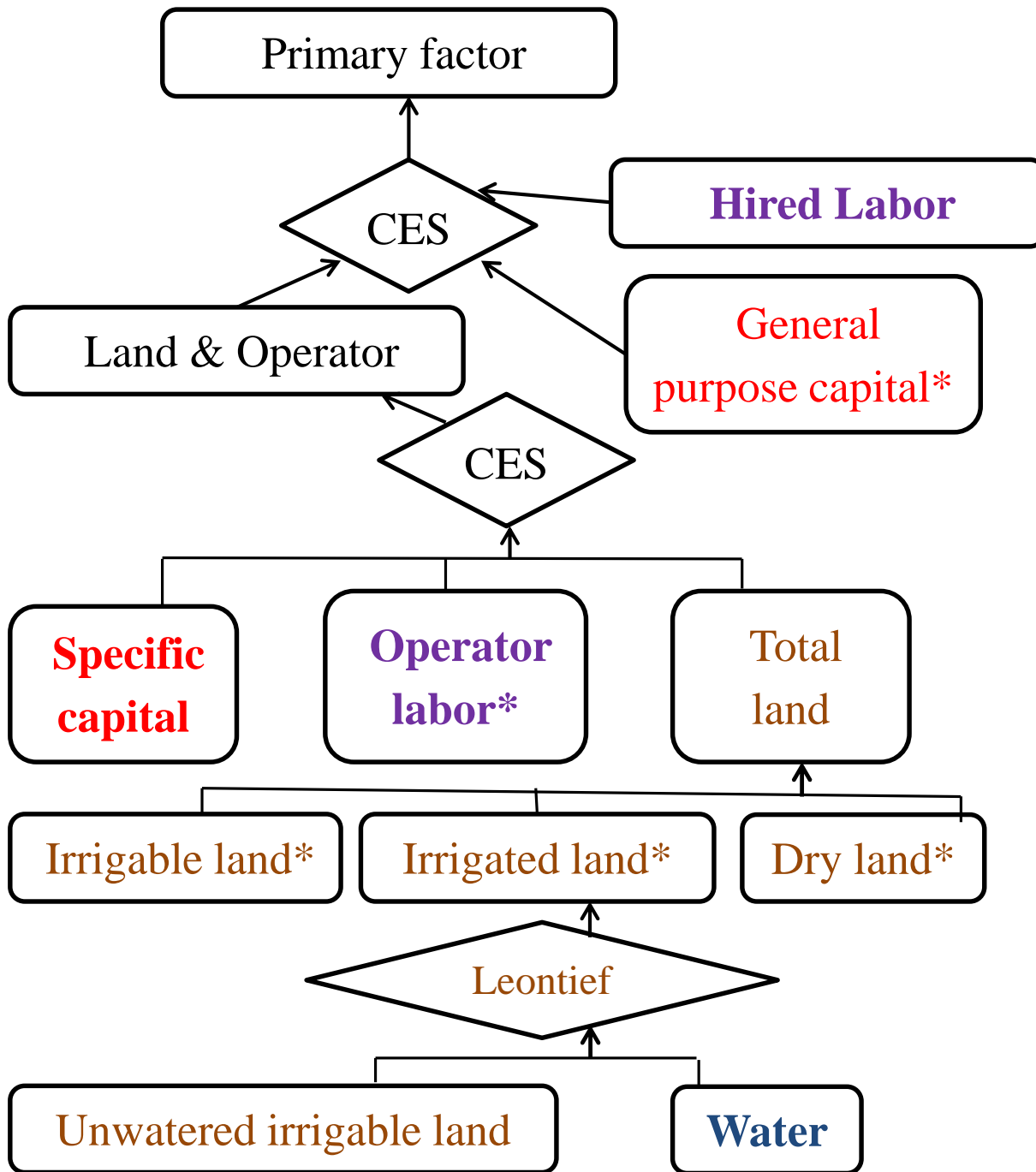


Water price is influenced by:

1. Rainfall
2. Volume of irrigation water available
3. Output prices

# Capturing farm input movements in CGE model

- Modifications to production function
- TERM-H2O: dynamic CGE model of southern MDB



\*=CET between different farm activities

# Distinguishing annuals from perennials

- We model annuals with **mobile** capital that can switch to other activities
- If the average product of water in rice production falls below the price of water, it is better for rice growers to sell their water allocation
- Land normally used for rice in TERM-H2O based models can switch to dryland activity with greatly reduced inputs per hectare
- Perennials include **specific** capital: this reduces the flexibility so they become buyers of water when it is scarce

# Modelling note: pitfalls in water trading

- Do not allow water trading between regions where it is not feasible

No trading between far-flung tributaries

Southern basin is more like a trading grid -- feasible



# Response to drought

- Rice production must almost cease when water prices are high (average product of water in rice production is well under \$300/ML)
- In real life, rice production in southern MDB dropped 98% between 2005-06 and 2007-08
- In TERM-H2O we managed to get a 90% drop in rice output in depiction of drought
- We couldn't do this without the distinction between annuals and perennials built into the database and theory of the model

# What about livestock? How do we match observed water usage in drought?

- The fixed capital in livestock is the herd
- We allow substitution between irrigated pasture and cereals
- Irrigated pasture is an on-farm input but cereals/hay are substitutable
- So in drought when water rises many-fold, there is substitution into cereal/hay inputs

# Californian drought from 2012-2016

- This has coincided with soaring almond prices ...
- And a booming Californian economy

# What trading possibilities are there in California?

- Let us start by looking at **agricultural census data** county by county
- We will assume that within counties, it is physically possible to trade water between farmers
- The aim is to move water from annuals to perennials
- I know alfalfa is a perennial, but it is drought-tolerant so it is a deep-rooted “honorary annual”
- Perennials: almonds, citrus orchards, vineyards, other fruit and nuts

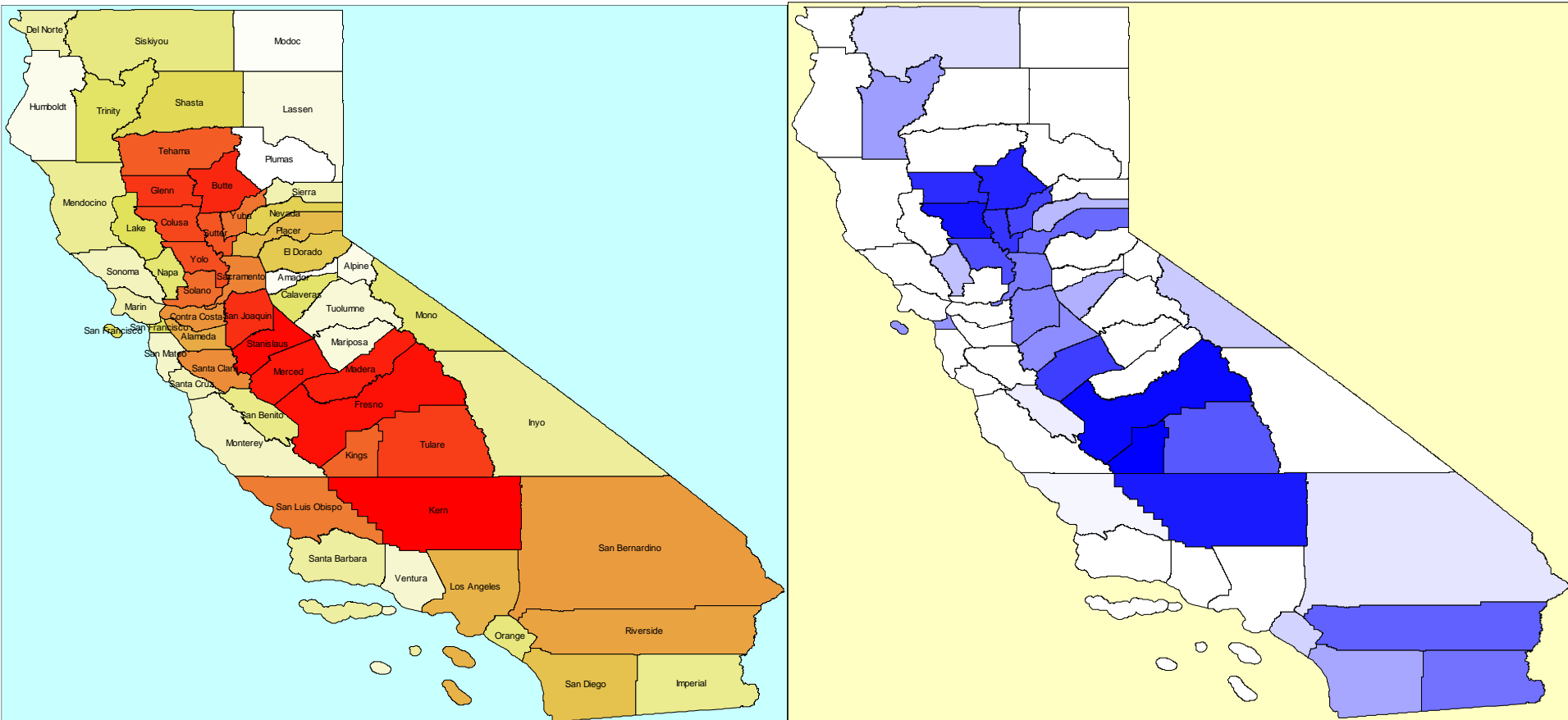
# Almond production

red = max.,  
white = min.

# Cotton + rice

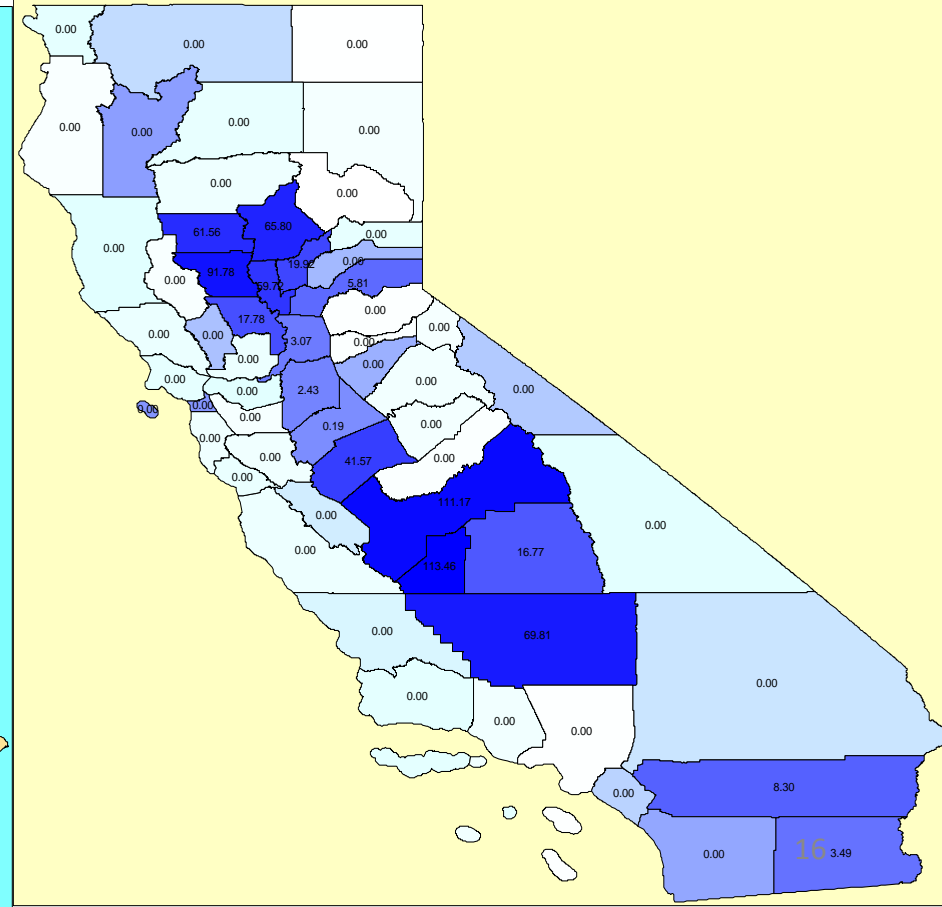
production

blue = max.



All tree crops,  
vineyards  
red = max.,  
white = min.

Livestock +  
forage production  
blue = max.



# Regions in USAGE- TERM- H2O



# Rainfall matters

|              | Average<br>(inches) | Effective<br>(inches) |
|--------------|---------------------|-----------------------|
| ButteCA      | 40                  | 25                    |
| ColusaCA     | 18                  | 10                    |
| FresnoCA     | 13                  | 7                     |
| GlennCA      | 23                  | 13                    |
| MercedCA     | 12                  | 6                     |
| KernCA       | 7                   | 1                     |
| KingsCA      | 8                   | 2                     |
| TulareCA     | 11                  | 5                     |
| YoloCA       | 32                  | 17                    |
| SanJoaquinCA | 18                  | 10                    |
| StanislausCA | 13                  | 7                     |
| MaderaCA     | 12                  | 6                     |

A given crop in Butte on average will require 15 inches less irrigation per annum than in Colusa

Source: <http://www.usclimatedata.com>.  
Effective rainfall based on author's judgment.

# The scenario: more a model test than attempt to replicate Californian drought

- Cut irrigation water allocations by 40%
- At this stage, no substitution towards groundwater: could model by increasing pumping costs (assume \$100 per acre-foot)
- Rainfall unaffected in this test scenario

# Hypothetical water trading rules

- Full water trading within each region between users
- Inter-regional trading between Kings and Kern counties
- Could alter inter-regional trading in response to better information

# Impact with full trading within regions

| 12 counties macro outcomes |       | Terms of trade |      |
|----------------------------|-------|----------------|------|
| Aggregate cons             | -0.97 | ButteCA        | 0.0  |
| Real Inv                   | -0.04 | ColusaCA       | 2.2  |
| Real GDP                   | -0.78 | FresnoCA       | -0.1 |
| Agg Employ                 | -0.51 | GlennCA        | -0.9 |
| averealwage                | 0     | MercedCA       | -1.0 |
| GDPPI                      | -0.80 | KernCA         | -0.2 |
| CPI                        | -0.62 | KingsCA        | 0.3  |
|                            |       | TulareCA       | 0.5  |
|                            |       | YoloCA         | -0.1 |
|                            |       | SanJoaquinCA   | 0.1  |
|                            |       | StanislausCA   | -0.6 |
|                            |       | MaderaCA       | -0.3 |

# Terms-of-trade loss

- This arises from increased inter-regional imports of livestock feed
- Colusa is an exception: small livestock activity

# Water trades (acre-feet\*10<sup>3</sup>)

|              | Hay&forage | Almonds      | Oth fruit & nuts | Vegetables | OthAgri     | Cotton     | Grapes     | Rice       | Tomatoes    | Total    | \$/acre-foot |
|--------------|------------|--------------|------------------|------------|-------------|------------|------------|------------|-------------|----------|--------------|
| ButteCA      | 3          | -35          | -8               | 0          | -10         | 0          | 0          | 50         | 0           | 0        | 146          |
| ColusaCA     | 6          | 0            | -17              | -6         | -2          | 0          | 0          | 29         | -11         | 0        | 130          |
| FresnoCA     | 117        | -248         | 47               | 23         | -29         | 98         | 63         | 0          | -70         | 0        | 405          |
| GlennCA      | 21         | -65          | -10              | -2         | -3          | 0          | 0          | 59         | 0           | 0        | 208          |
| MercedCA     | 180        | -176         | -17              | -7         | -17         | 40         | 3          | 6          | -12         | 0        | 383          |
| KernCA       | 114        | -274         | 47               | -3         | -66         | 48         | 16         | 0          | -11         | -129     | 387          |
| KingsCA      | 144        | -46          | 7                | -7         | -5          | 69         | 0          | 0          | -32         | 129      | 387          |
| TulareCA     | 148        | -42          | 5                | -1         | -97         | 6          | -17        | 0          | 0           | 0        | 169          |
| YoloCA       | 36         | -18          | -1               | -14        | -5          | 0          | -3         | 18         | -13         | 0        | 165          |
| SanJoaquinCA | 95         | -93          | 35               | 1          | -48         | 0          | 17         | 6          | -14         | 0        | 343          |
| StanislausCA | 91         | -96          | 5                | 10         | -6          | 0          | 5          | 0          | -8          | 0        | 713          |
| MaderaCA     | 34         | -104         | 27               | 3          | 0           | 2          | 41         | 0          | -3          | 0        | 528          |
| <b>Total</b> | <b>988</b> | <b>-1197</b> | <b>120</b>       | <b>-3</b>  | <b>-288</b> | <b>263</b> | <b>125</b> | <b>168</b> | <b>-174</b> | <b>0</b> | <b>290</b>   |

# Identity

- If the Australian dollar is worth US \$0.81:

AUS\$/ML is the same as US\$/acre-foot

# Now impose restrictions on water trading

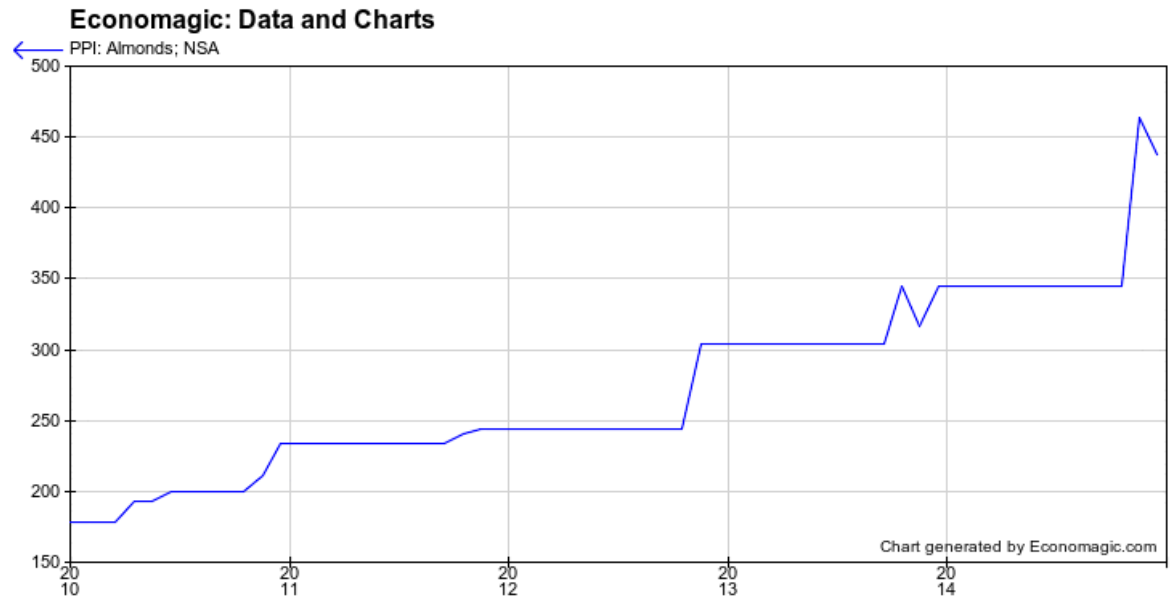
- No water sales from Hay & forage sector in main almond producing counties: Fresno, Glenn, Merced or Stanislaus

# Summarize differences

- Real GDP in the 12 counties: -1.07% instead of -0.78%
- Employment: -0.64% instead of -0.51%
- GDP deflator: +0.59% instead of -0.80%
- Almond price rises 17% relative to full trading scenario
- Terms-of-trade gain: counties with almonds have gains of 4% or more relative to more-trade scenario
- Aggregate consumption does better due to terms-of-trade gain: ? equity, fewer jobs, more well investment
- Water trading price shoots up: \$1080/acre-foot in Merced, \$1121/acre-foot in Stanislaus

# GTAP 2016: In this world, almonds are the new OPEC cartel

- California accounts for 80% of global production
- Drought has reduced Californian and global almond supply
- This has pushed prices up



- Almond price rises alone raise aggregate consumption by 0.27% across the 12 counties
- But there will be a substantial supply response in the rest of the world
- High almond prices will not persist for too many years

# Establishing a water market

- All groundwater and surface water use should be metered
- To steal a line from Richard Howitt who's trying to retire at UC Davis, California leads the world in IT technology and therefore should find it straightforward to meter water
- The groundwater crisis is worsening in California

# Environmental consequences

## Groundwater & Land Subsidence in California

In an average year, groundwater provides about **40%** of California's water supply.

In the current drought, groundwater may account for **65%** or more of the state's groundwater supply.

Subsidence in Santa Clara Valley has required various infrastructure construction & repairs, totaling more than **\$756 million**



Subsidence from groundwater pumping in the San Joaquin Valley has been called the **greatest human alteration of the Earth's surface.**

Today, land subsidence is occurring at almost **1 ft/yr**

By 1970, subsidence of more than 1 foot had affected more than half of the San Joaquin Valley – in some areas as much as **28 feet**