Climate Change Impacts and adaptation considerations for Alexandrina

Climate & Agricultural Support PTY LTD

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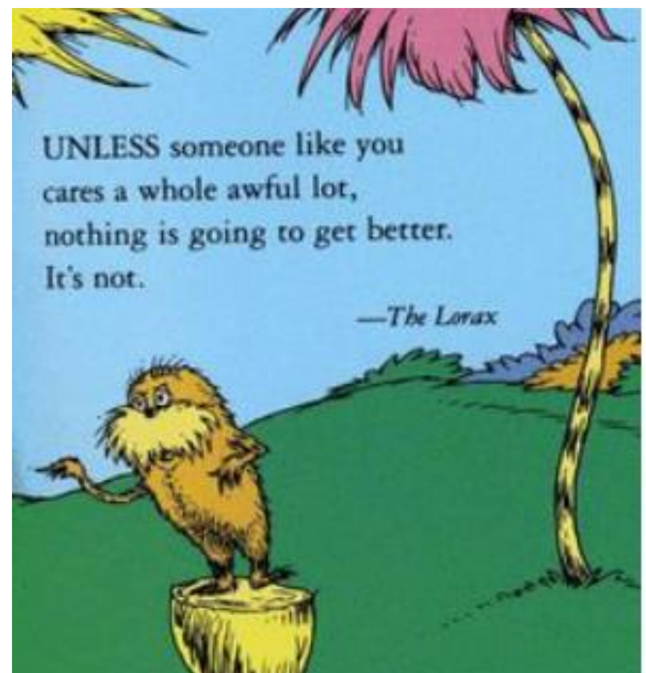


Climate Trends – Alexandrina

Greenhouse emissions

Climate projections

Impacts

Adaptation and mitigation for agriculture

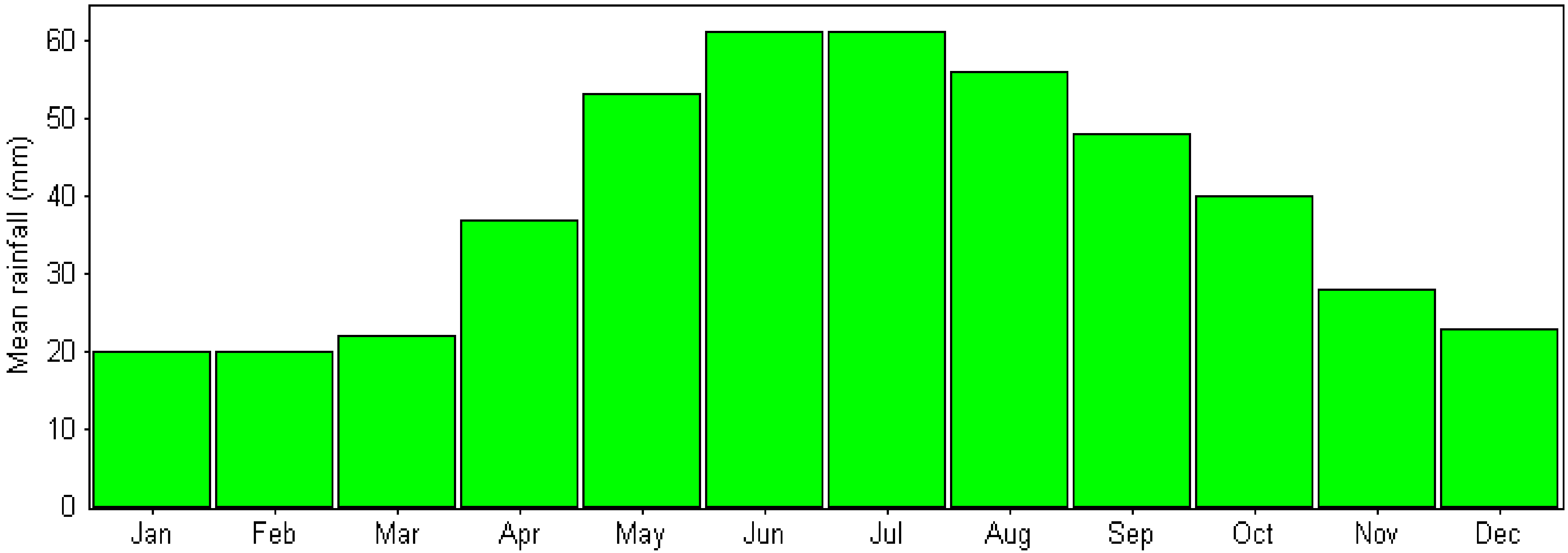
Policy for agriculture

What can Cittaslow do?

Monthly Rainfall at Goolwa

Monthly rainfall (mm) recorded at GOOLWA POST OFFICE

Mean monthly rainfall (mm)



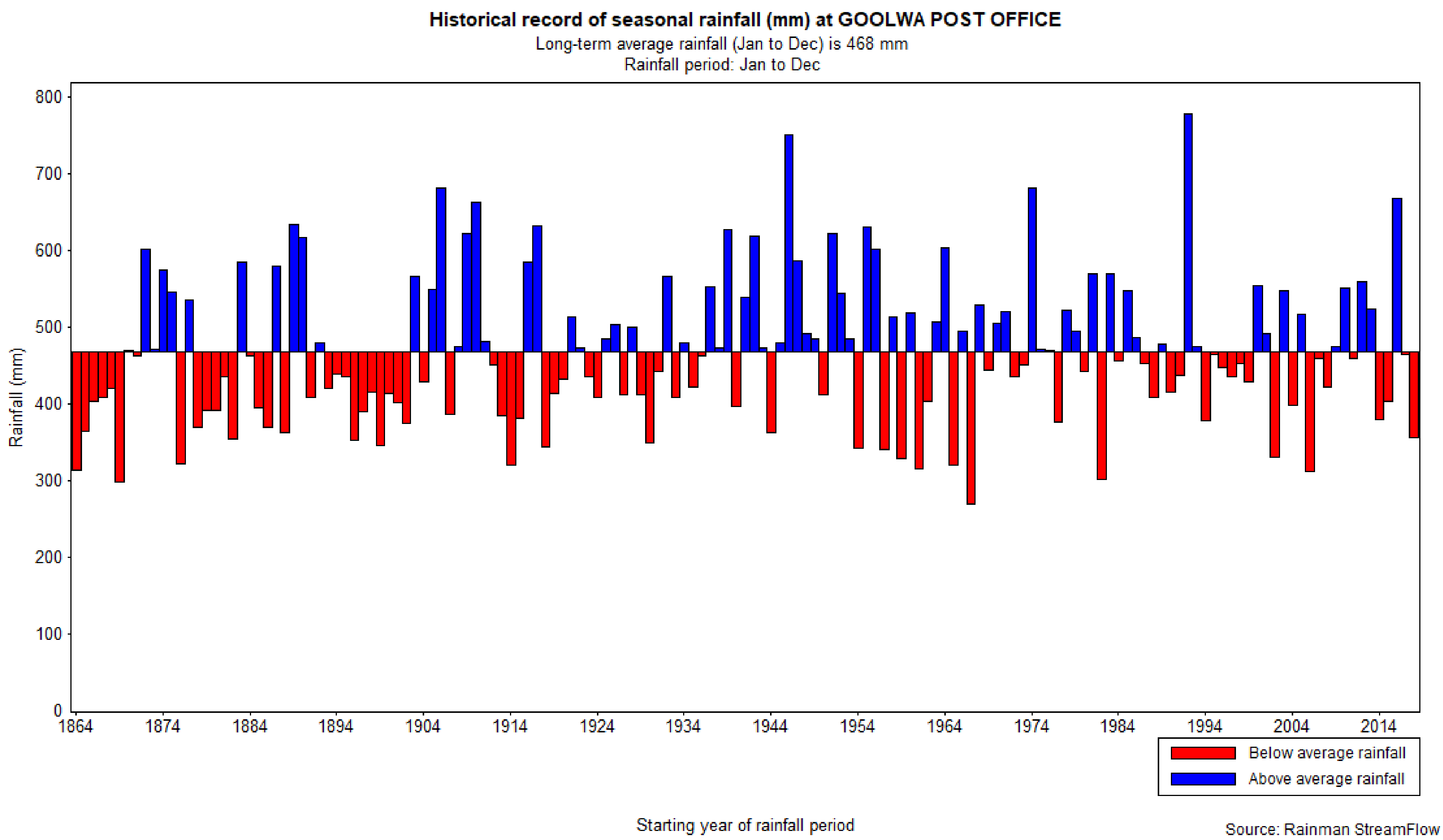
Monthly rainfall (mm) recorded at GOOLWA POST OFFICE

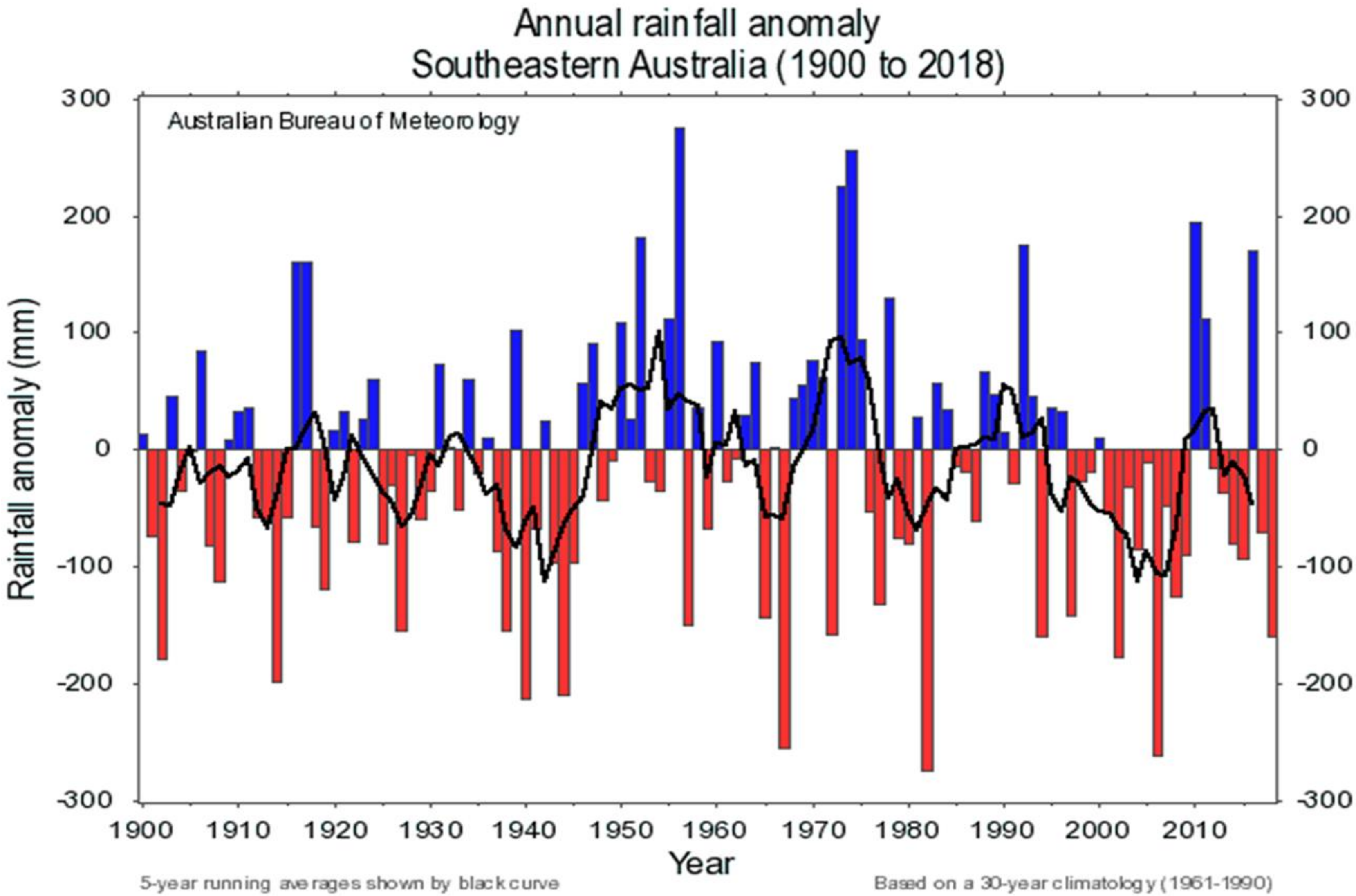
Statistical summary

treamFlow

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Mean	20	20	22	37	53	61	62	56	49	39	28	23	468
Median	12	12	16	33	48	54	58	54	42	34	21	17	460
Standard deviation	22	24	20	26	29	30	27	23	24	22	22	20	96
Highest on record	153	143	116	140	175	175	153	117	175	102	109	160	778
Lowest on record	0	0	0	0	7	12	15	9	10	1	1	0	271
Mean raindays	5	4	6	10	13	15	16	16	13	11	7	6	122
No. of years	156	156	156	155	155	155	155	155	155	155	155	155	155

Historical Annual Rainfall

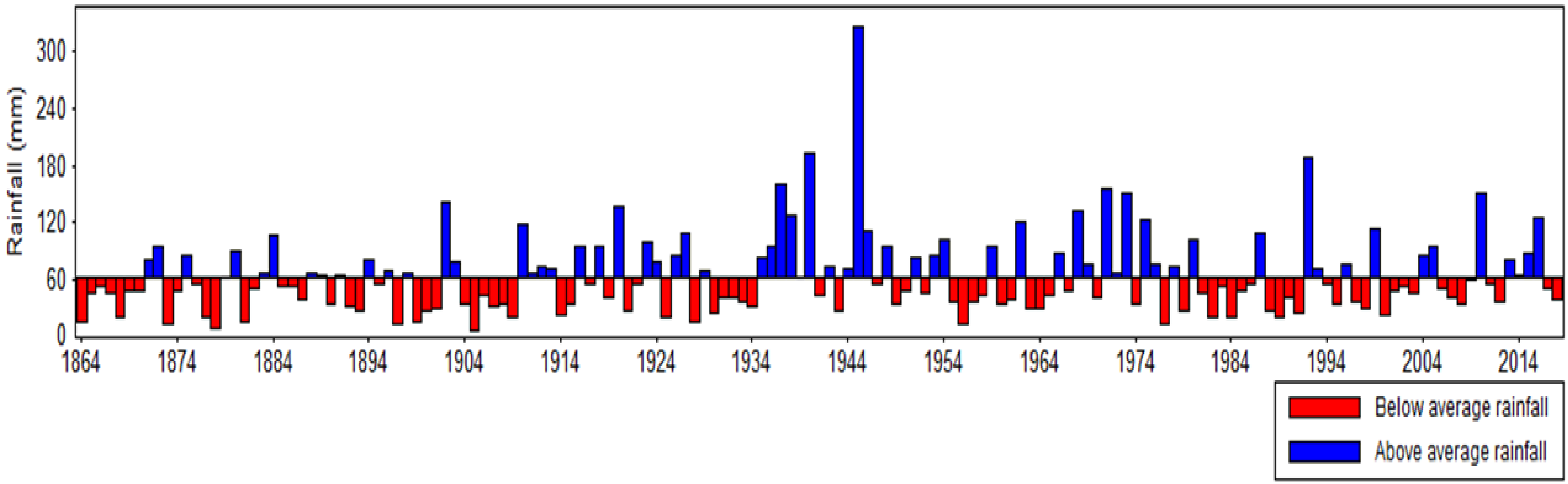



Annual rainfall anomaly
Southeastern Australia (1900 to 2018)
Australian Bureau of Meteorology
Rainfall anomaly (mm)
300
200
100
0
-100
-200
-300
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
Year
5-year running averages shown by black curve
Based on a 30-year climatology (1961-1990)

Historical record of seasonal rainfall (mm) at GOOLWA POST OFFICE

Long-term average rainfall (Dec to Feb) is 63 mm

Rainfall period: Dec to Feb

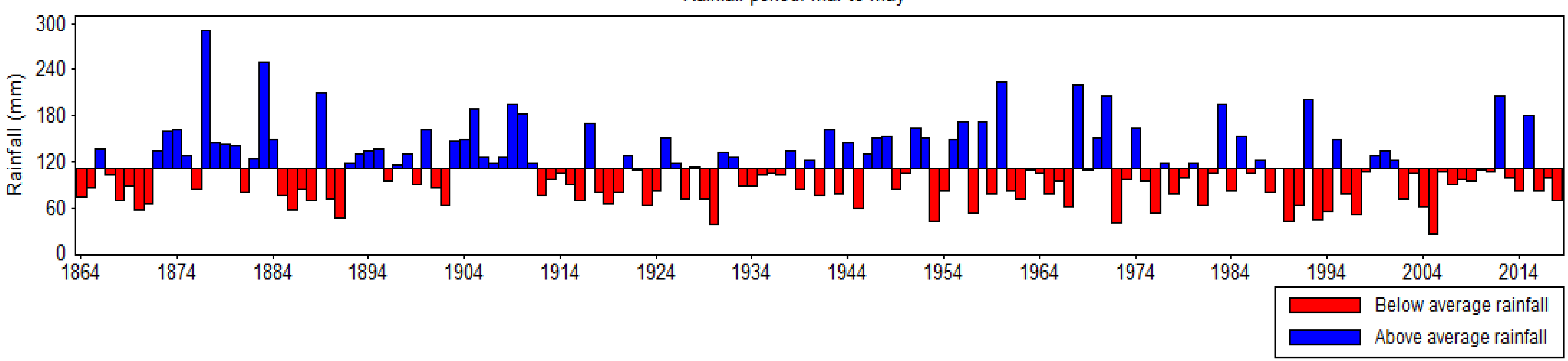


Historical record of seasonal rainfall (mm) at GOOLWA POST OFFICE

Flow

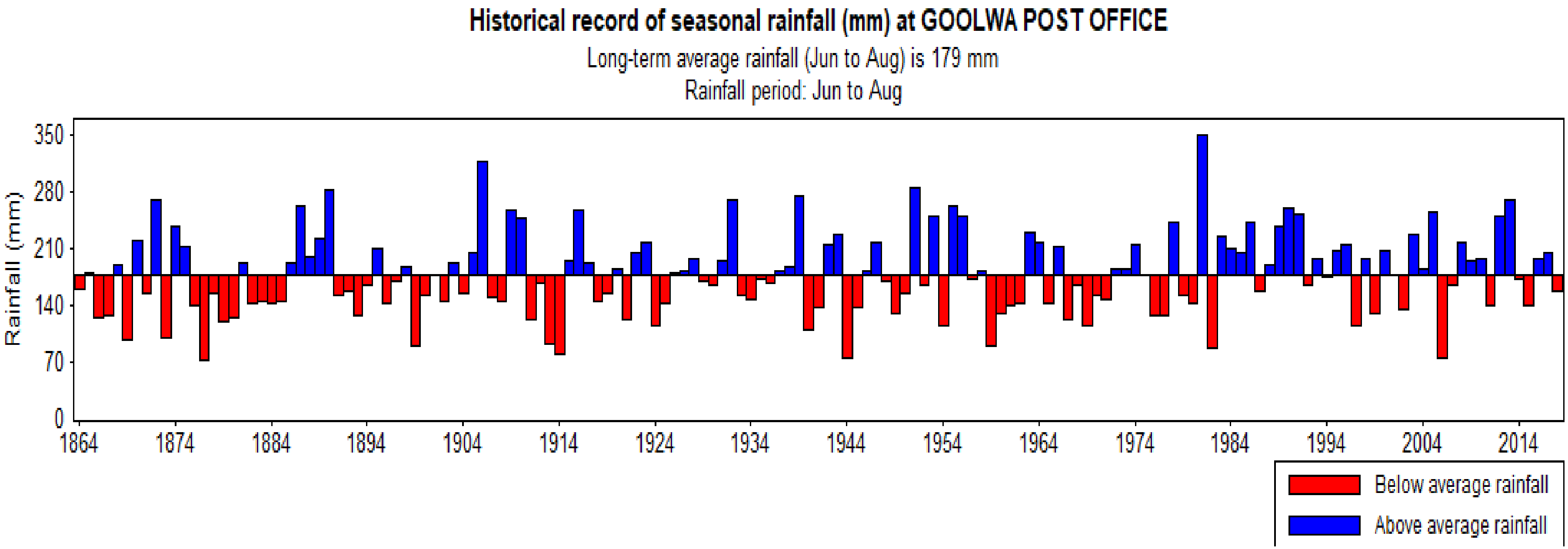
Long-term average rainfall (Mar to May) is 111 mm

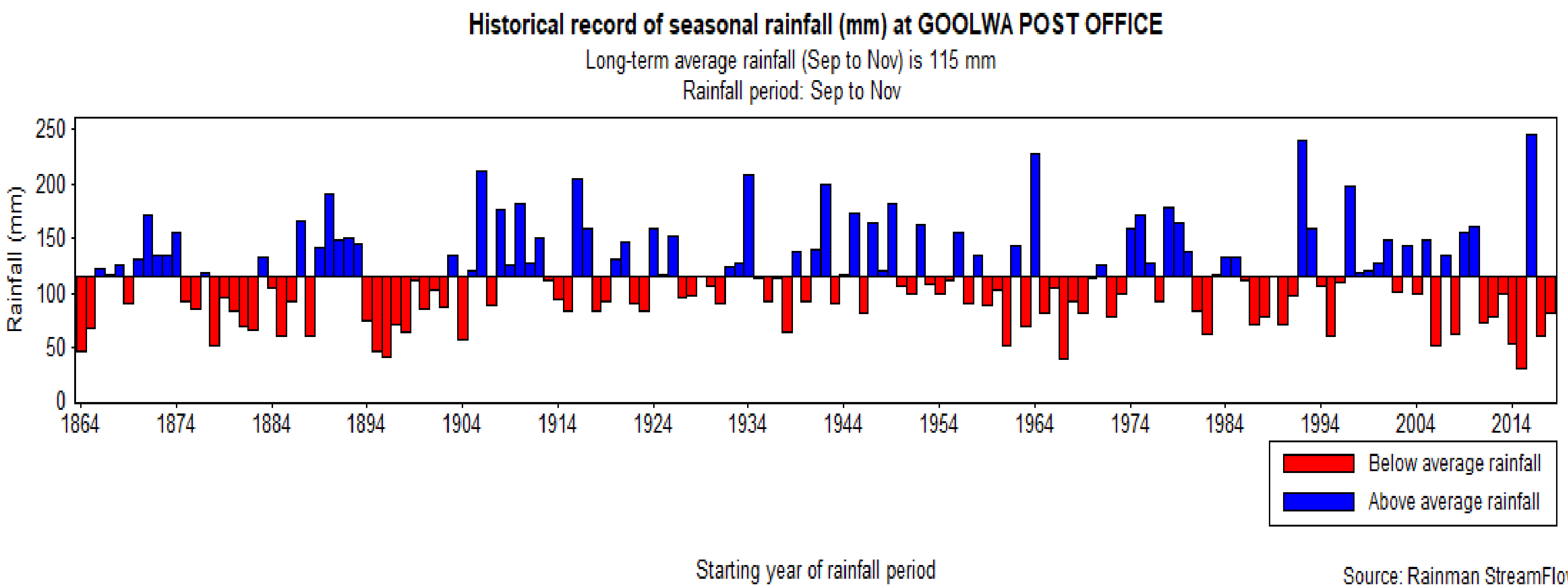
Rainfall period: Mar to May



Starting year of rainfall period

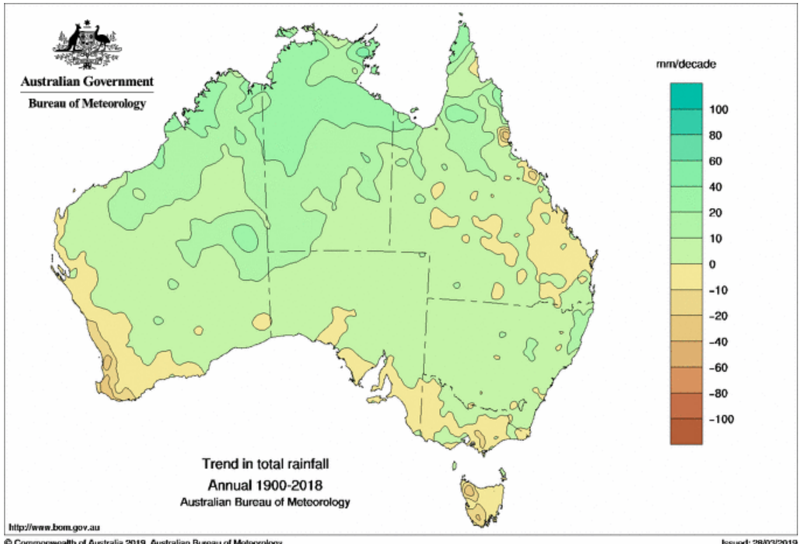
Source: Rainman StreamFlow


Historical record of seasonal rainfall (mm) at GOOLWA POST OFFICE
Long-term average rainfall (Jun to Aug) is 179 mm
Rainfall period: Jun to Aug
Rainfall (mm)
350
280
210
140
70
0
1864
1874
1884
1894
1904
1914
1924
1934
1944
1954
1964
1974
1984
1994
2004
2014
Below average rainfall
Above average rainfall

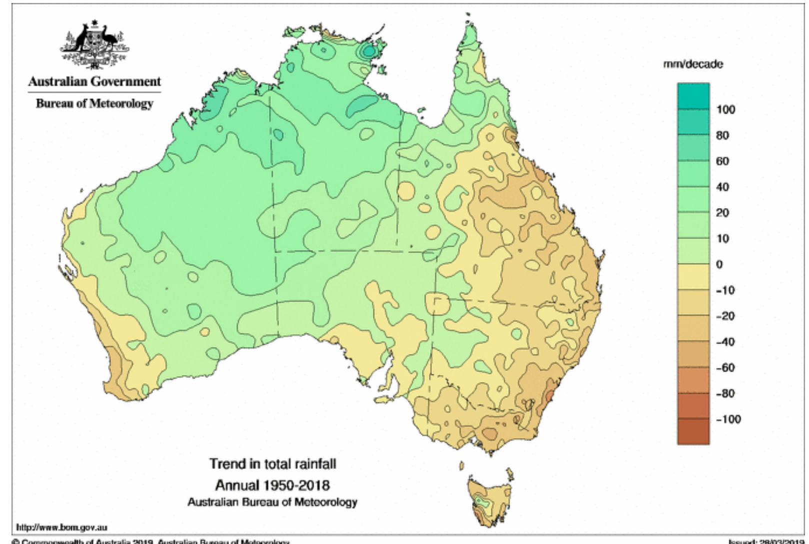

Historical record of seasonal rainfall (mm) at GOOLWA POST OFFICE
Long-term average rainfall (Sep to Nov) is 115 mm
Rainfall period: Sep to Nov
Rainfall (mm)
250
200
150
100
50
0
1864
1874
1884
1894
1904
1914
1924
1934
1944
1954
1964
1974
1984
1994
2004
2014
Below average rainfall
Above average rainfall
Starting year of rainfall period
Source: Rainman StreamFlow

Rainfall trends

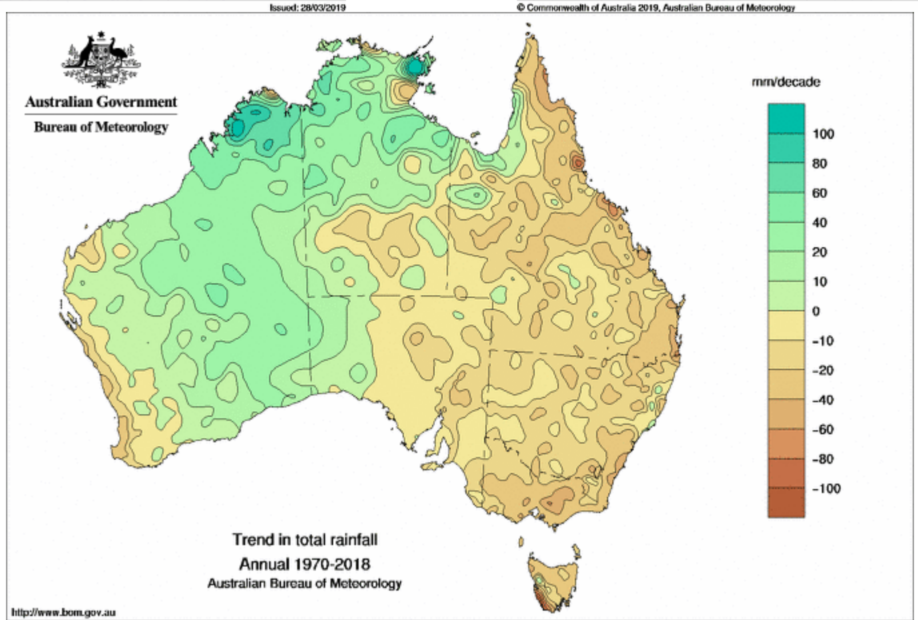
1900-Present



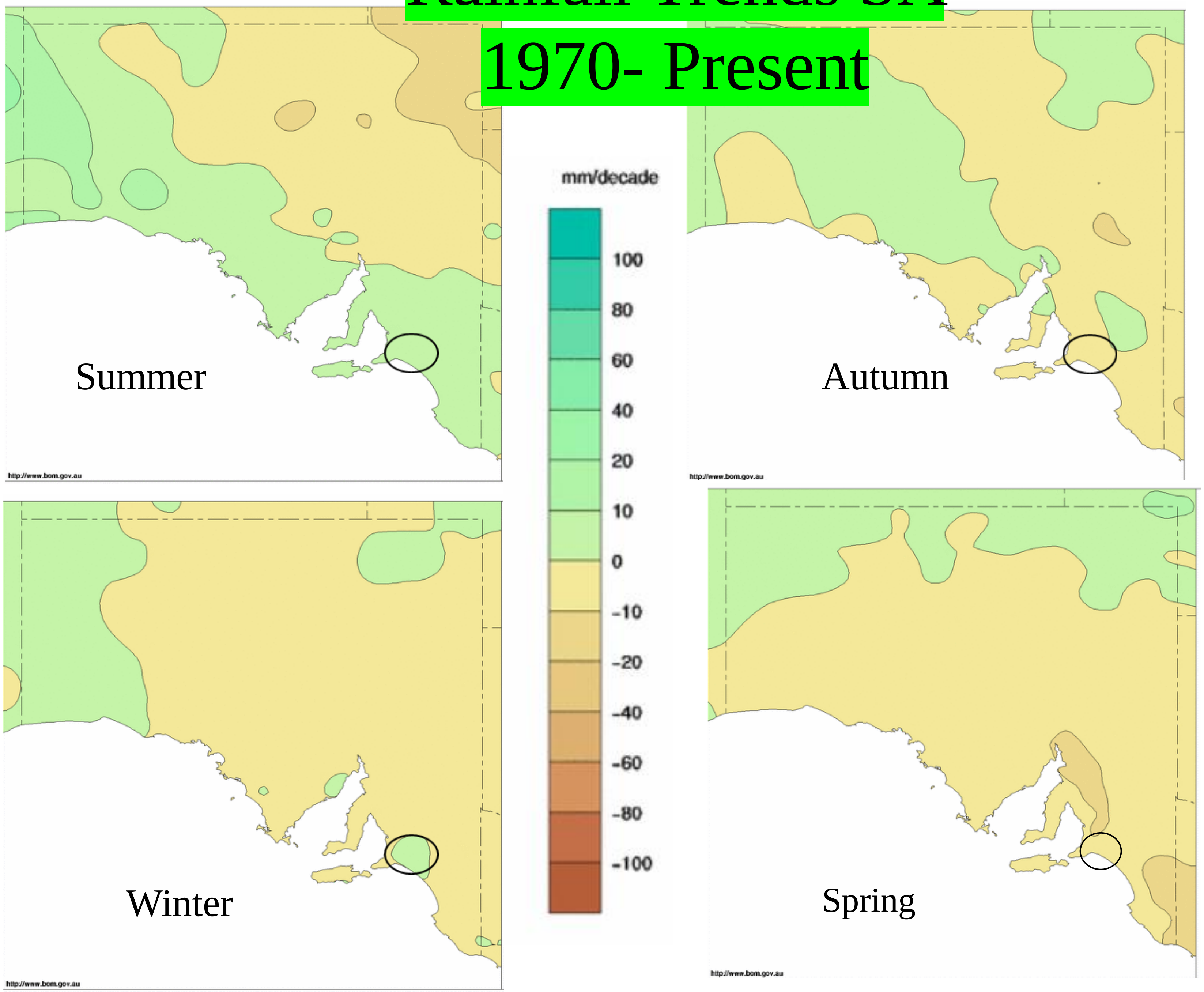
1950-Present



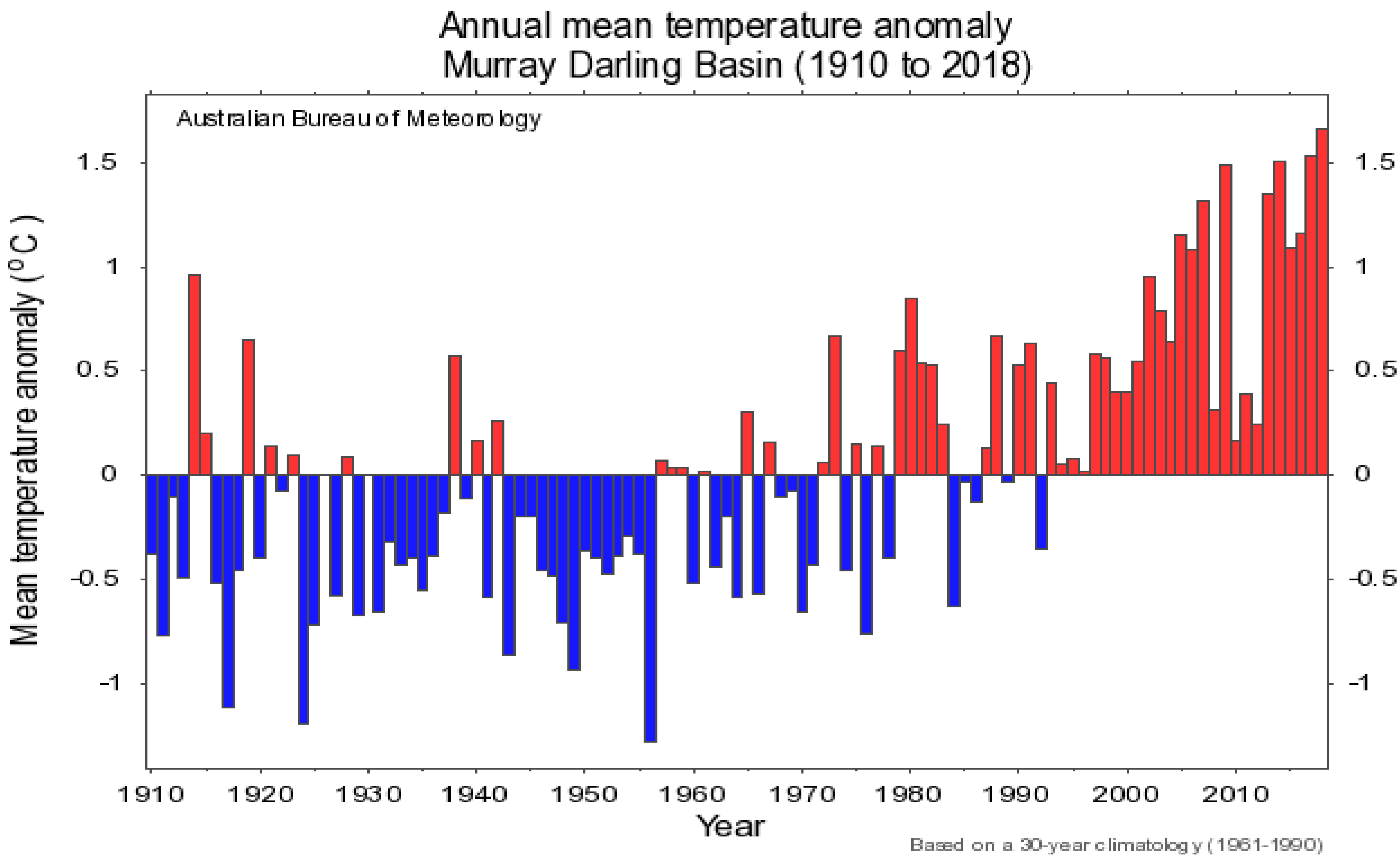
1970-Present



Rainfall Trends SA
1970- Present

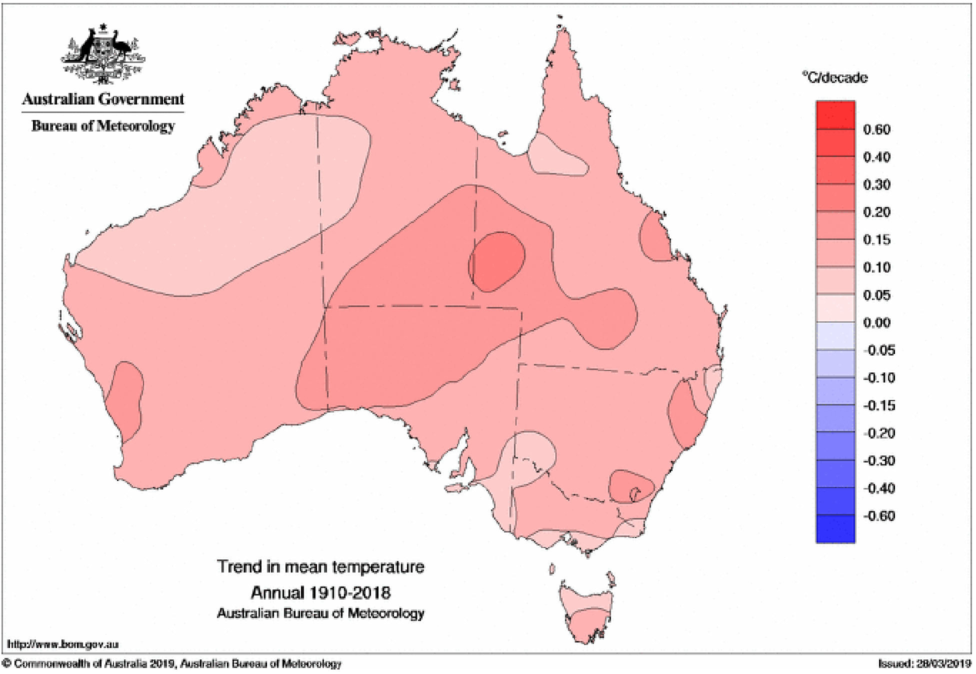


Temperature Trends

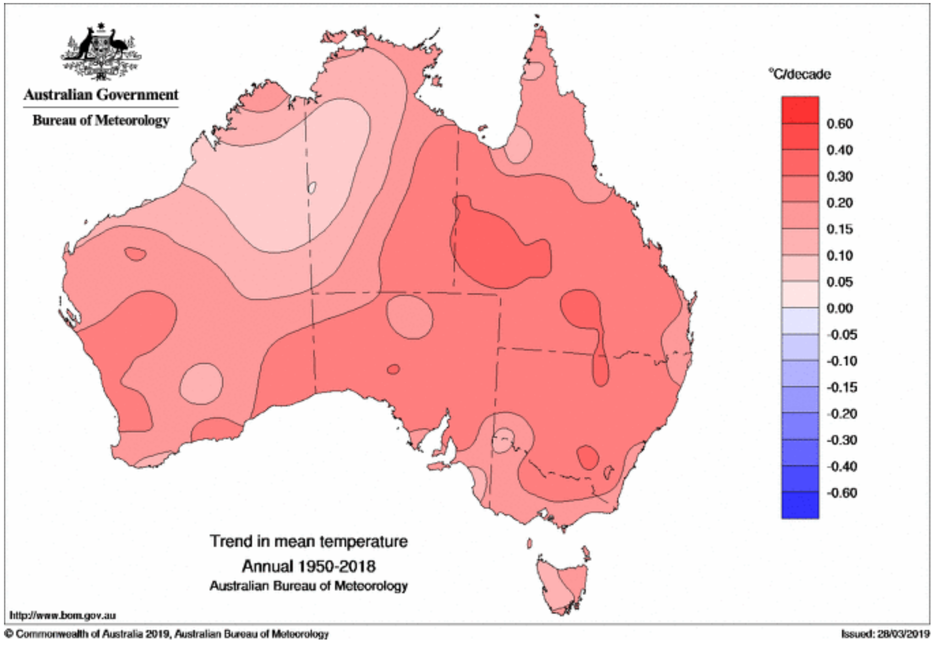


Annual Temperature trends

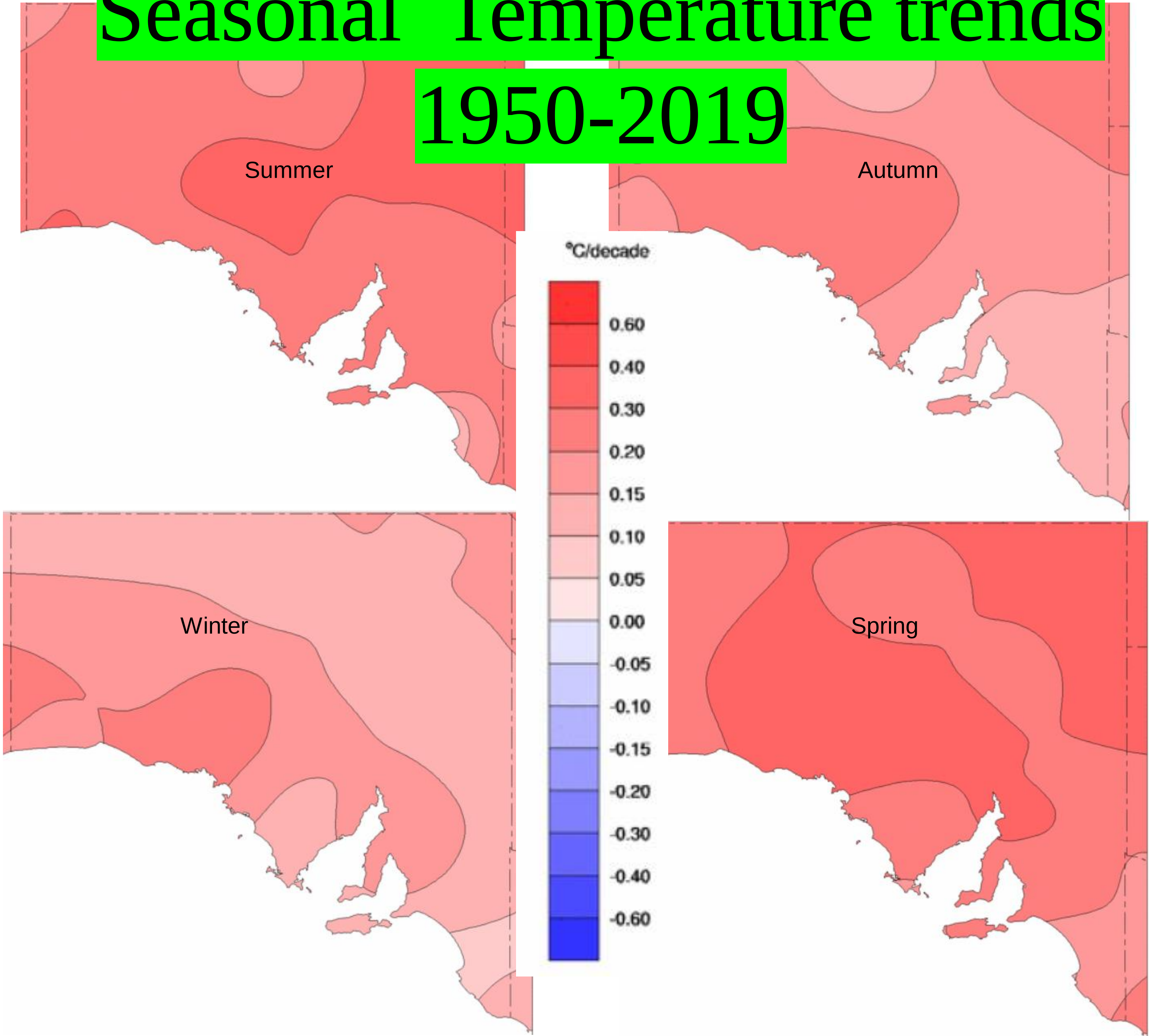
1910-2019



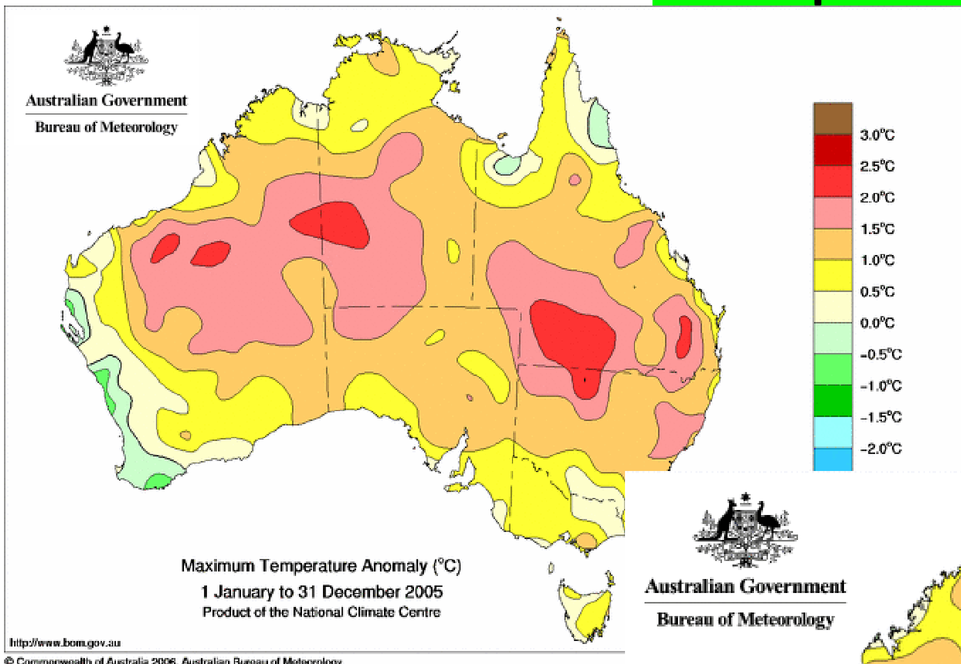
1950-2019

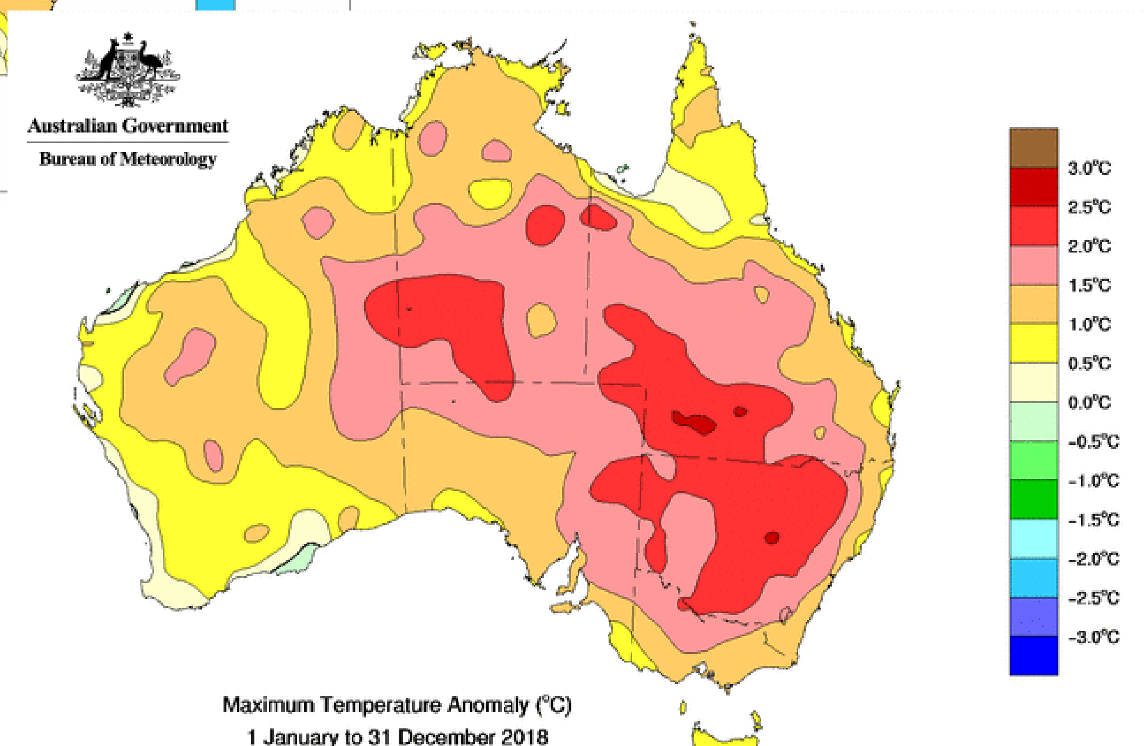


Seasonal Temperature trends 1950-2019



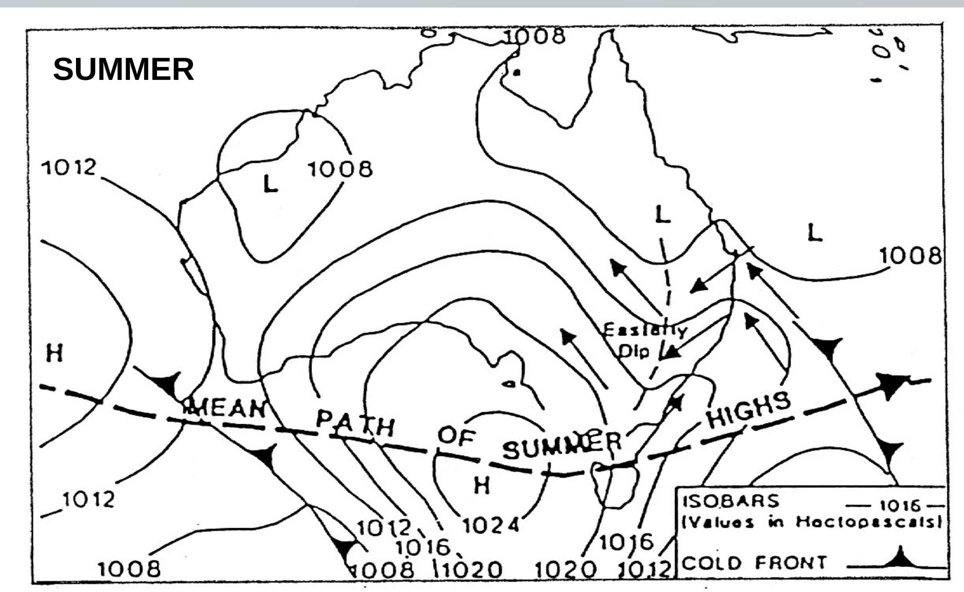
Exceptional years are getting more exceptional

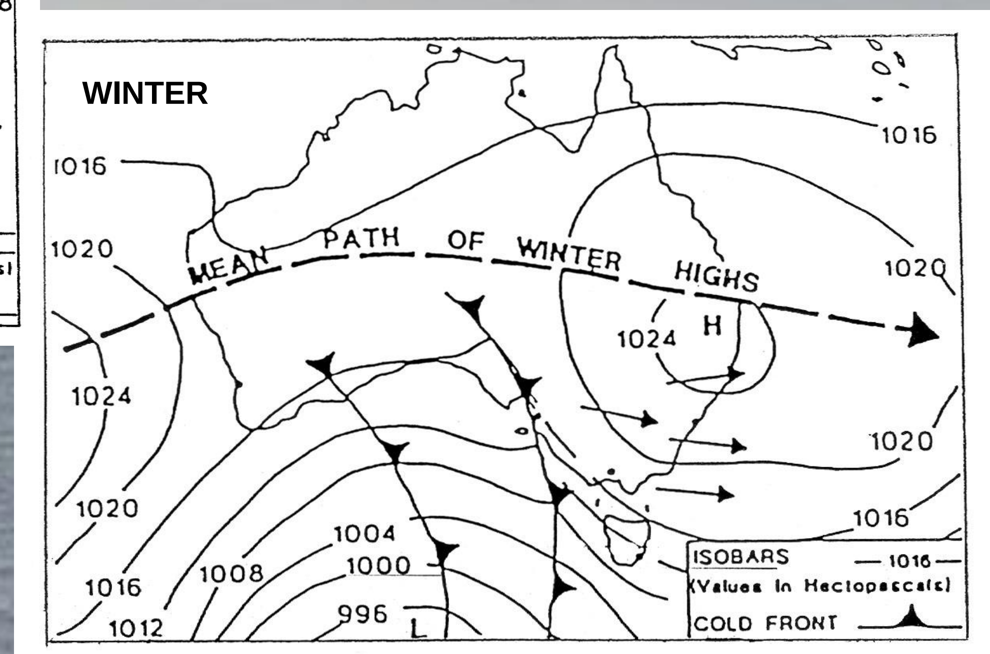


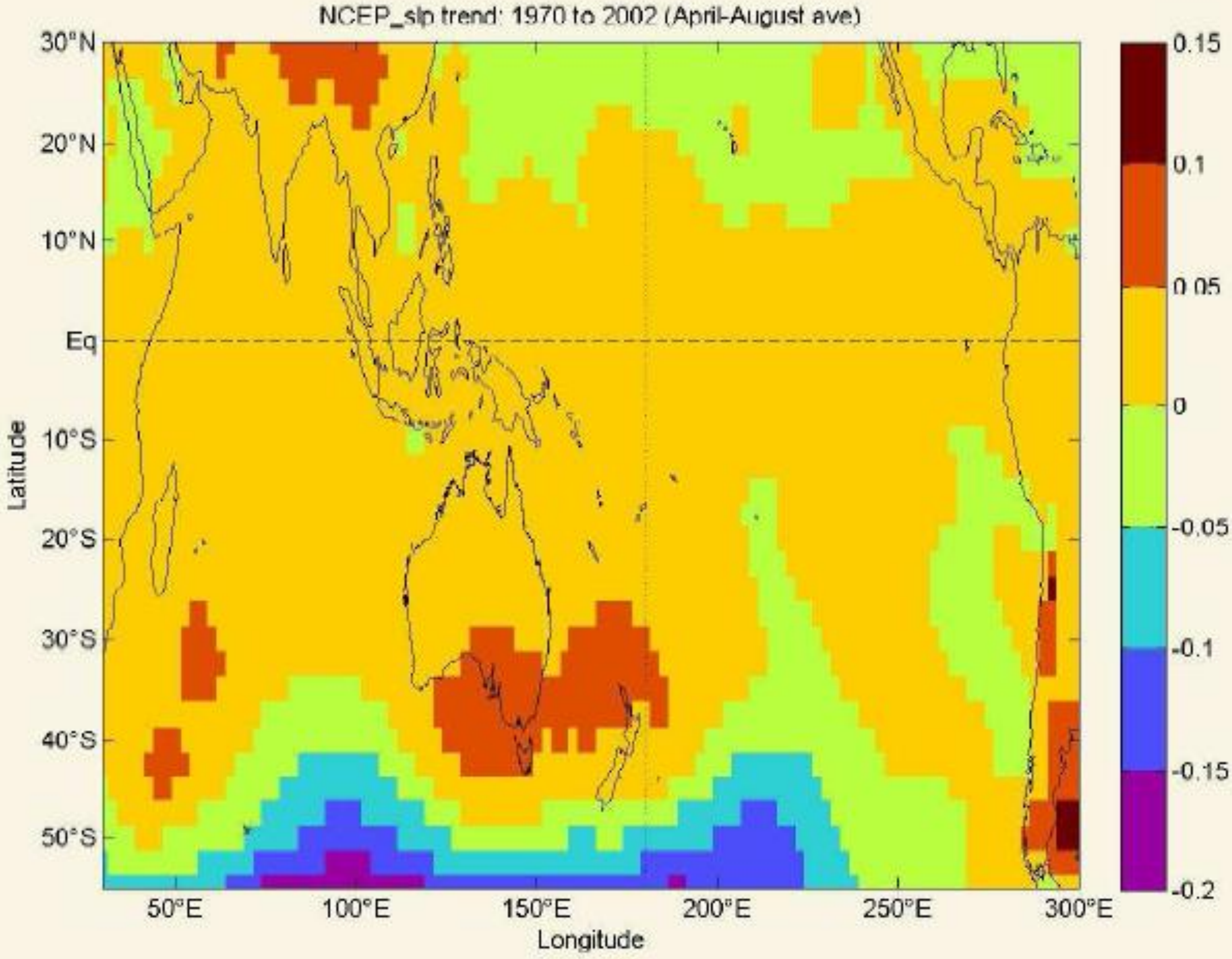


Why the Change?

- Size of Highs and Intensity of Lows have changed






NCEP_slp trend: 1970 to 2002 (April-August ave)
30°N
20°N
10°N
Eq
10°S
20°S
30°S
40°S
50°S
Latitude
50°E
100°E
150°E
200°E
250°E
300°E
Longitude
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2

Summary Trends

- Our local climate has warmed just over 1 °C since 1910 leading to an increase in the frequency of extreme heat events
- Oceans around Australia have warmed by around 1 °C since 1910, contributing to longer and more frequent marine heatwaves.
- Sea levels are rising around Australia, increasing the risk of inundation (and in particular will impact our coasts and river and barrage infrastructures)
- The oceans around Australia are acidifying (the pH is decreasing).
- There has been a decline of around 11 per cent in April–October rainfall in the southeast of Australia since the late 1990s
- Streamflow has decreased across southern Australia.
- There has been a long-term increase in extreme fire weather, and in the length of the fire season, across large parts of Australia

Climate Trends – Alexandrina

Greenhouse emissions

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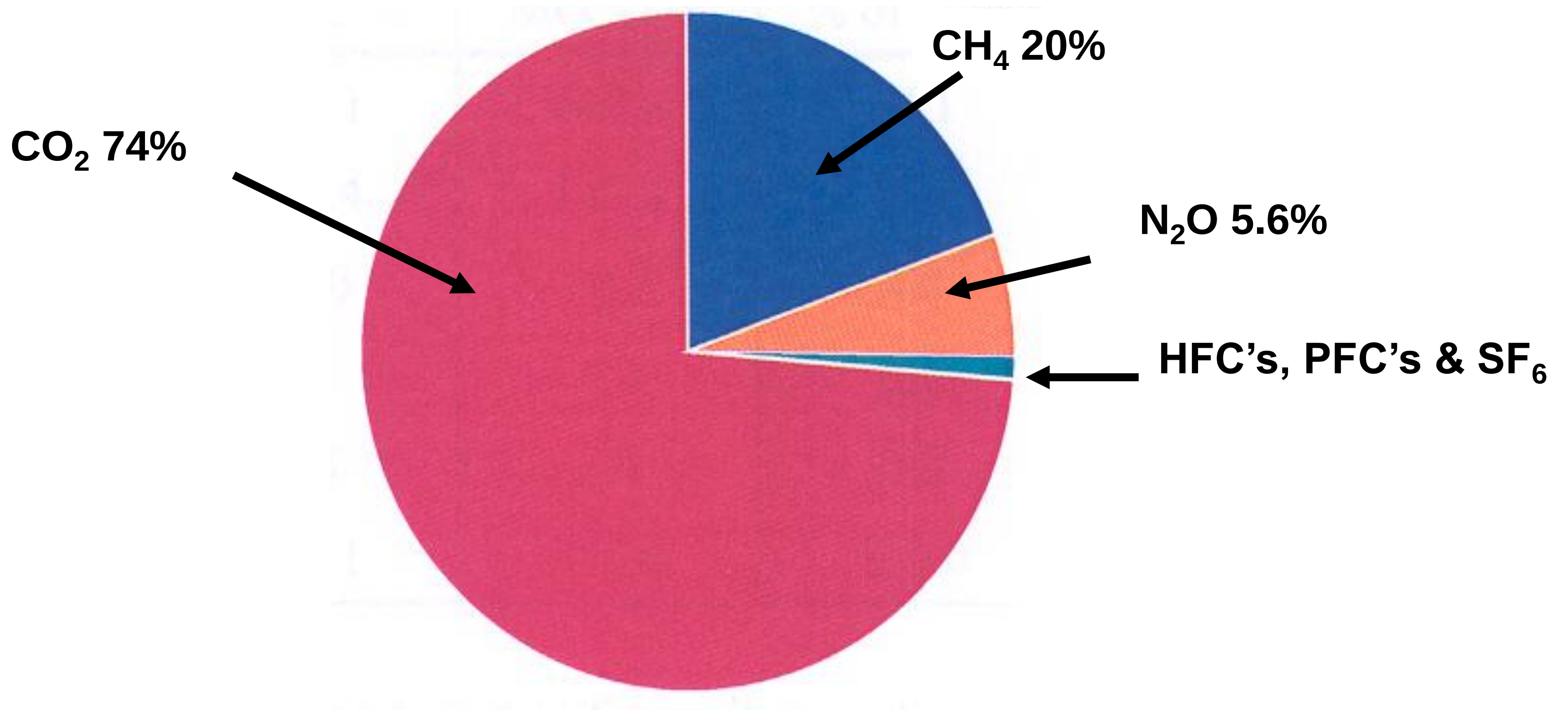
What can Cittaslow do?

Greenhouse Emissions

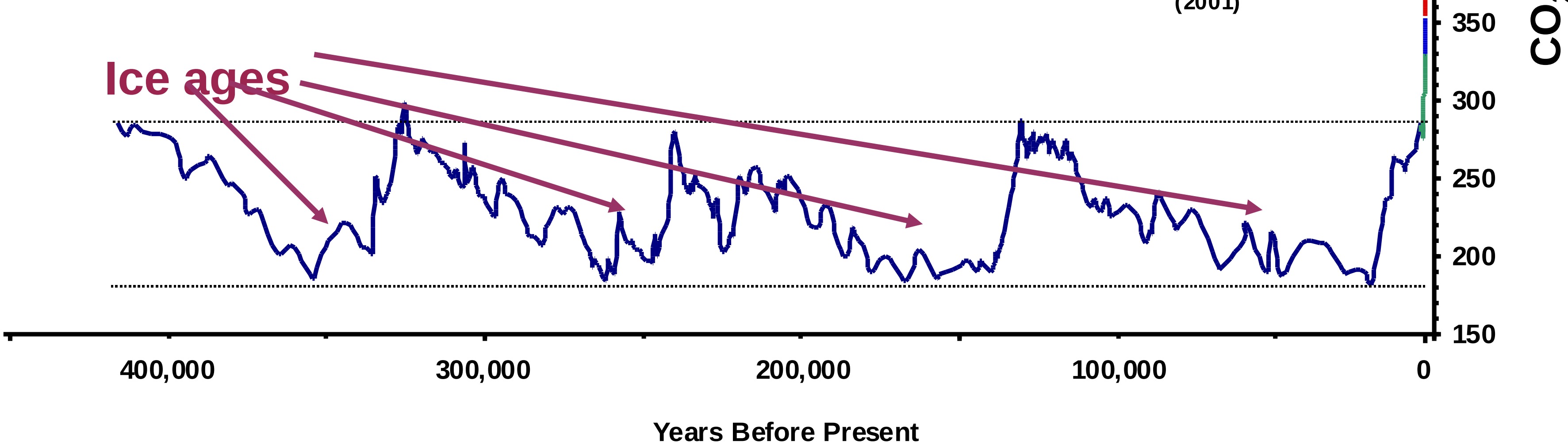
Greenhouse Gases

- **Carbon dioxide (CO_2) ~ GWP = 1**
- **Methane (CH_4) ~ GWP = 21**
- **Nitrous oxide - (N_2O) ~ GWP = 310**

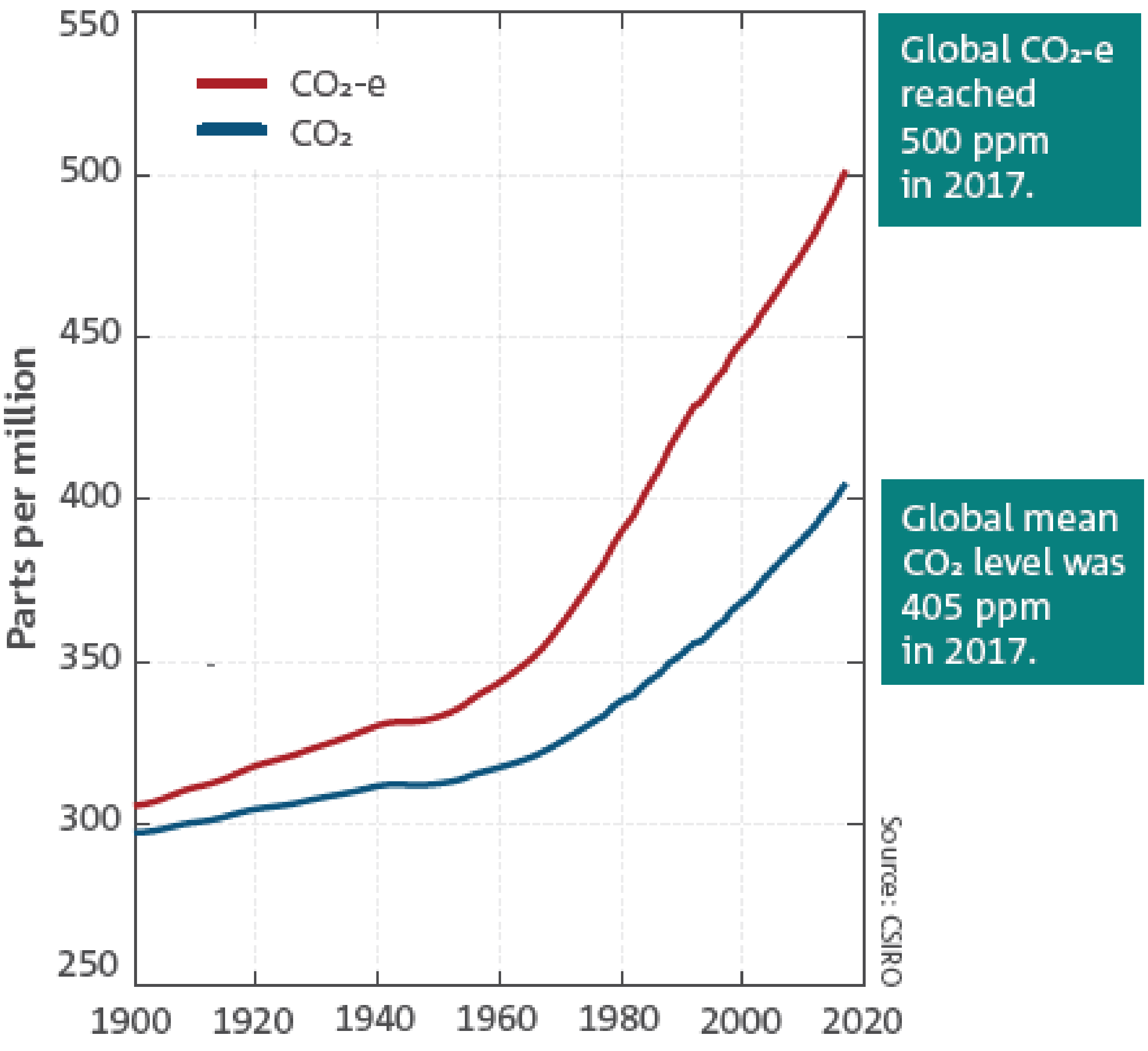
Measurement unit - CO_2e



Trend of CO_2 concentrations



Trend of CO_2 concentrations



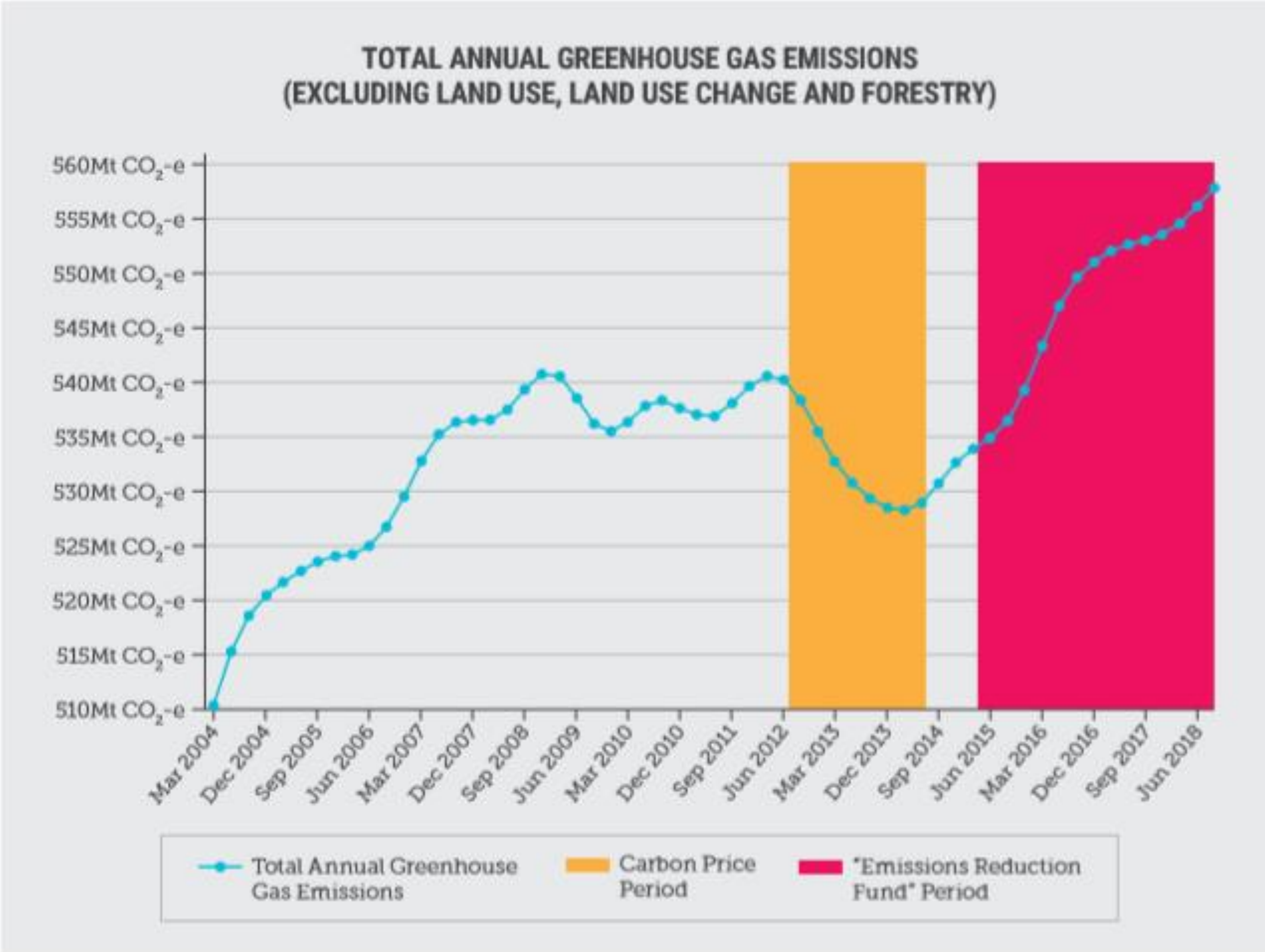
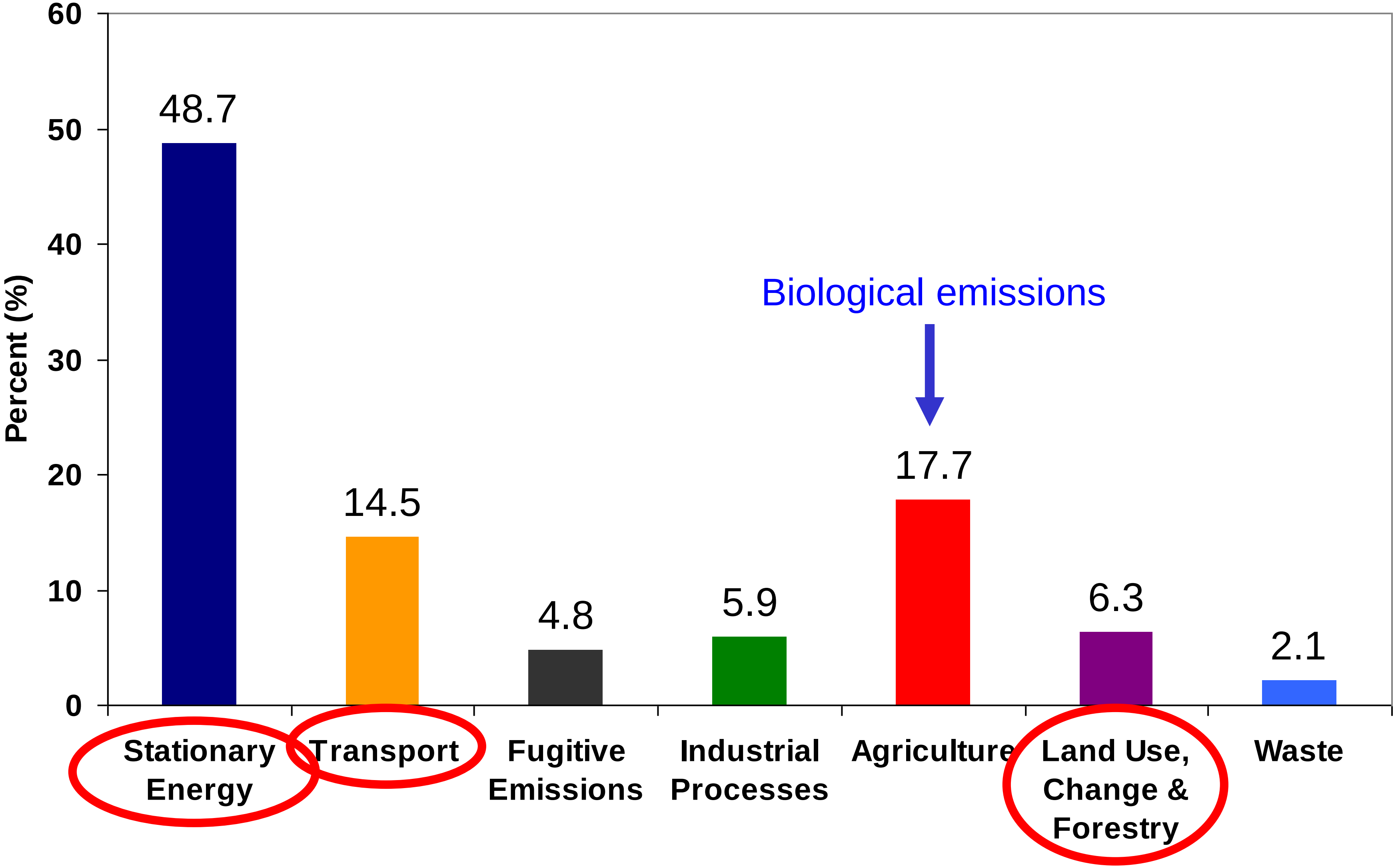


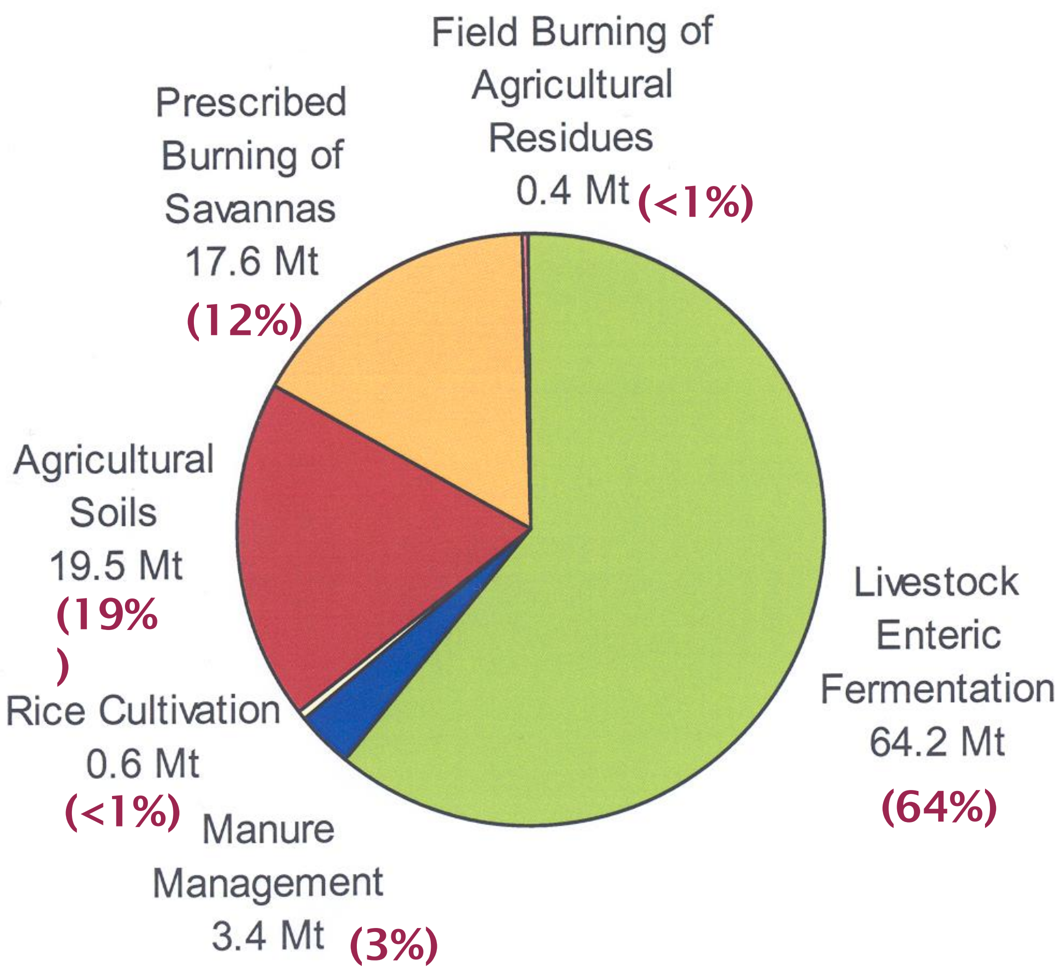
Figure 8: Total annual greenhouse gas emissions (excluding Land Use, Land Use Change and Forestry).
Source: Data from Australian Government 2018a.

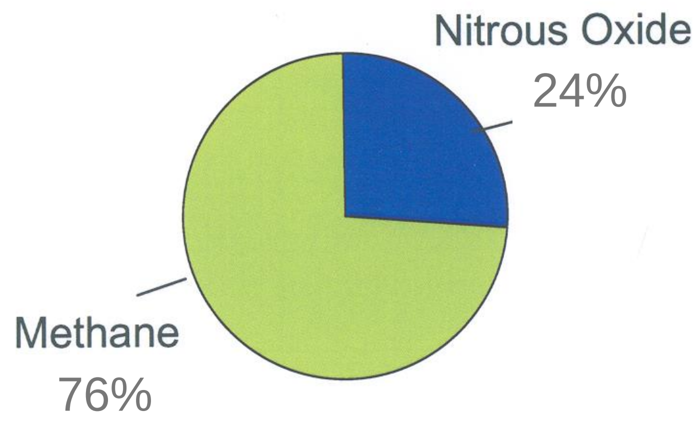
Emissions by sector ~ NGGI 2003



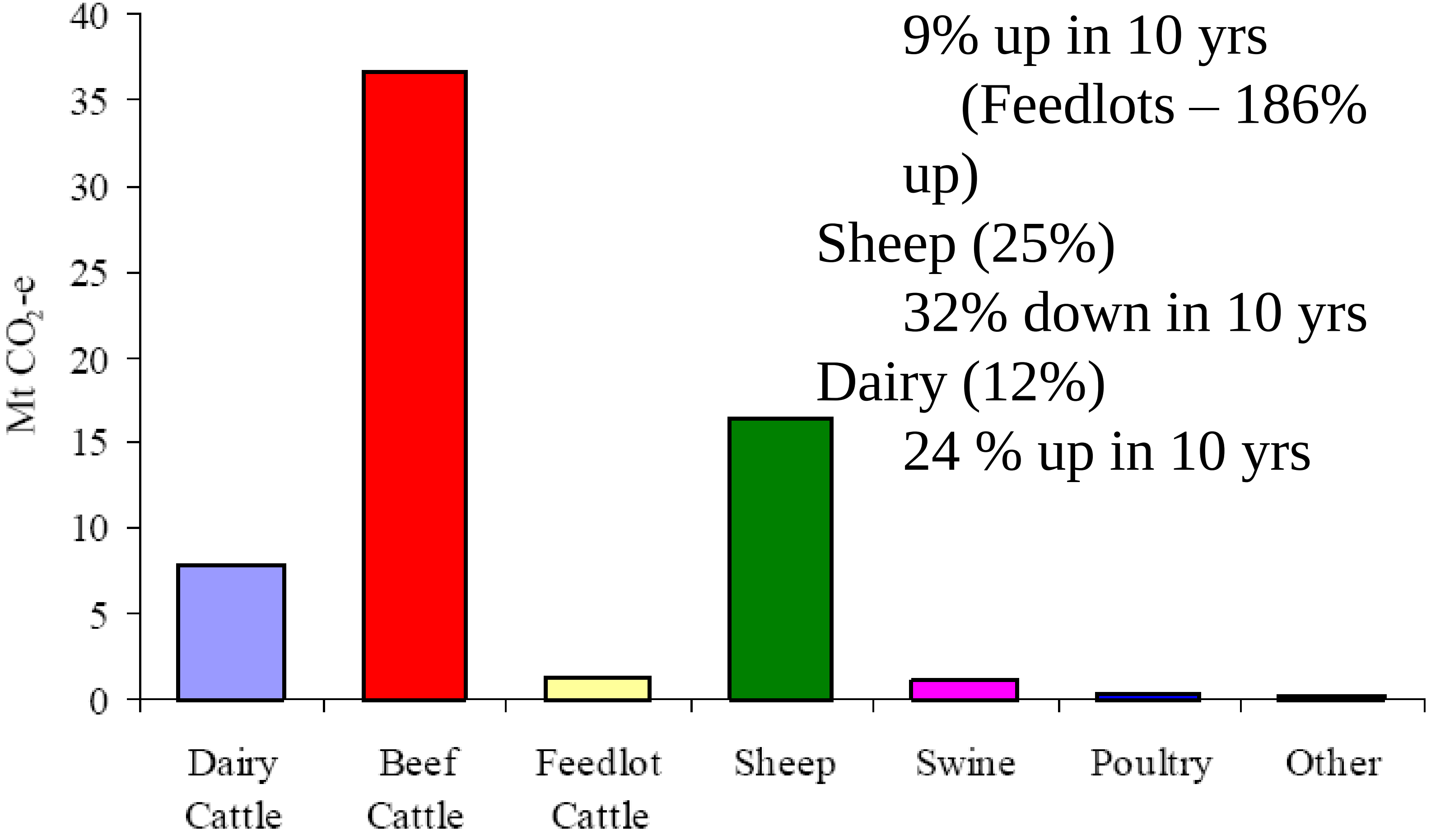
Agriculture emissions 2003

Total emissions = 97.3 Mt CO_2-e





Methane emissions from different livestock classes



Beef (63%)
- 9% up in 10 yrs
  - (Feedlots – 186% up)

Sheep (25%)
- 32% down in 10 yrs

Dairy (12%)
- 24 % up in 10 yrs

AGO 2003

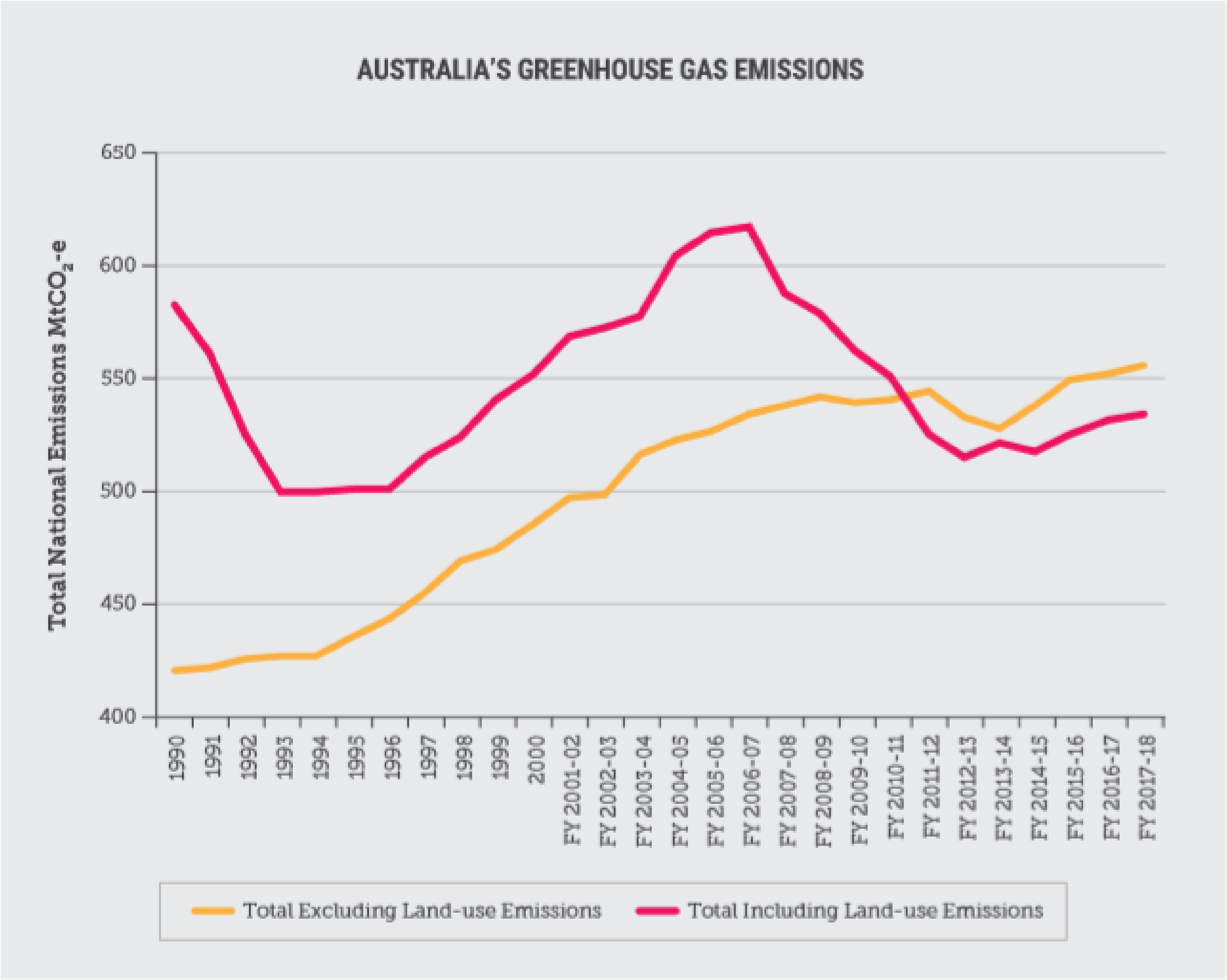
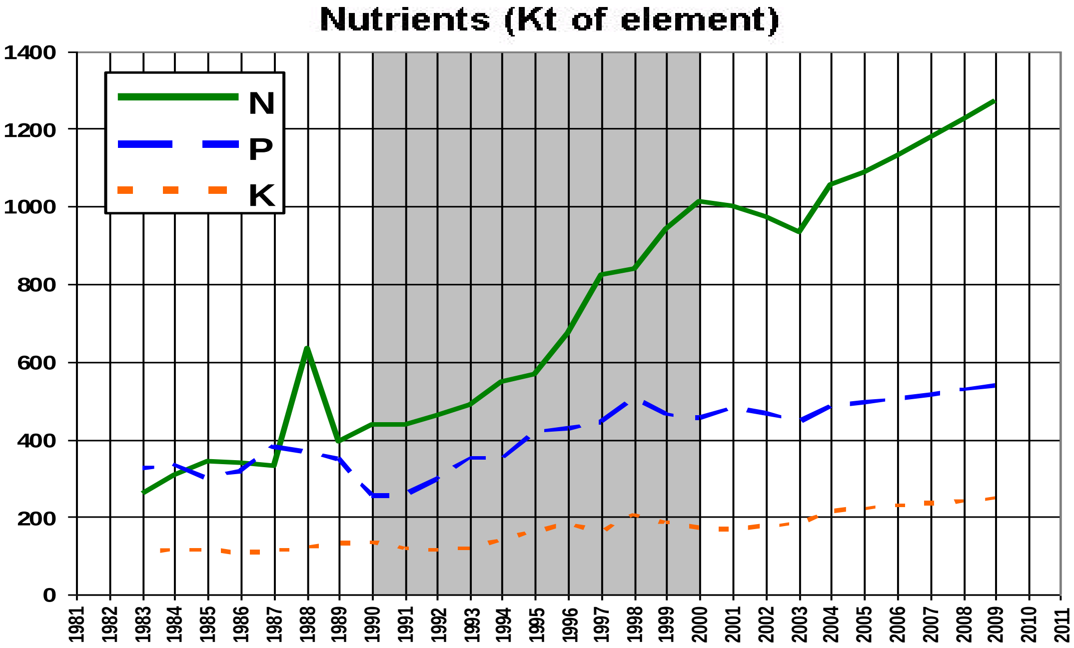


Figure 10: Australia's greenhouse gas emissions (including and excluding land-use emissions). **Source:** Data for 1990 - 2000 from Australian Government 2019b; 2001 - 2018 from Australian Government 2018d.

Nitrogen and Agriculture

- N_2O emissions from agricultural soils by 29% (1990 - 2002)
- 36% in cropping area (1990 - 2000)
- 130% in N fertiliser (1990 - 2000)



FIFA, 2005. Australia - Report for IFA Annual Conference: Agricultural and Fertiliser Demand Situation. AG0 - National Greenhouse Gas Inventory 2000 & 2002.

NASA

Climate Trends – Alexandrina

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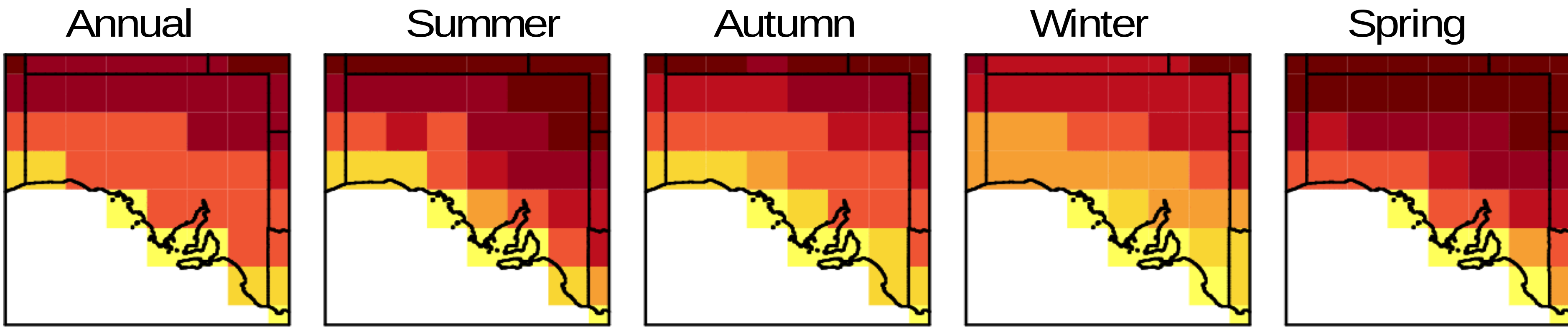
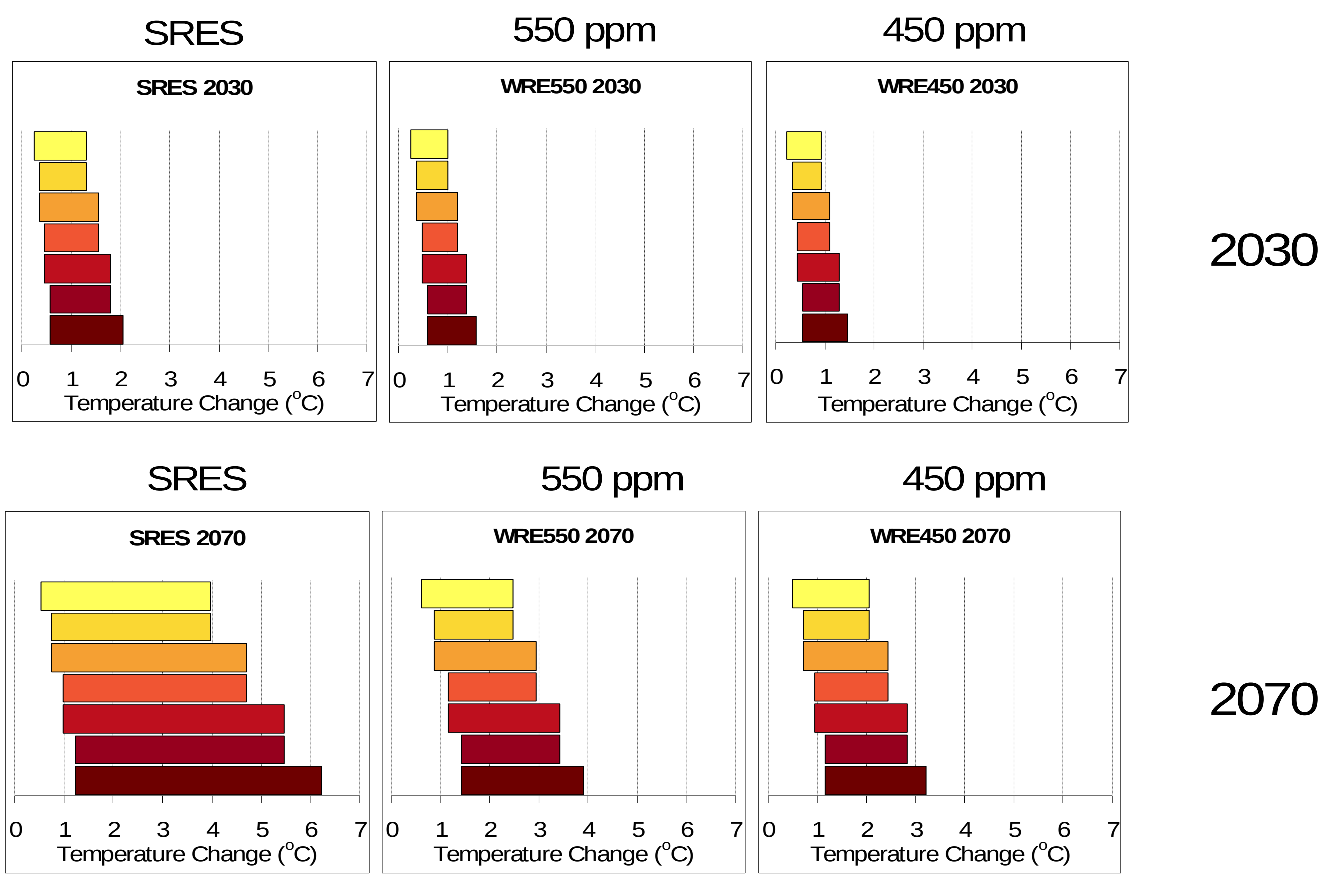
What can Cittaslow do?

Temperature Projections





Rainfall Projections

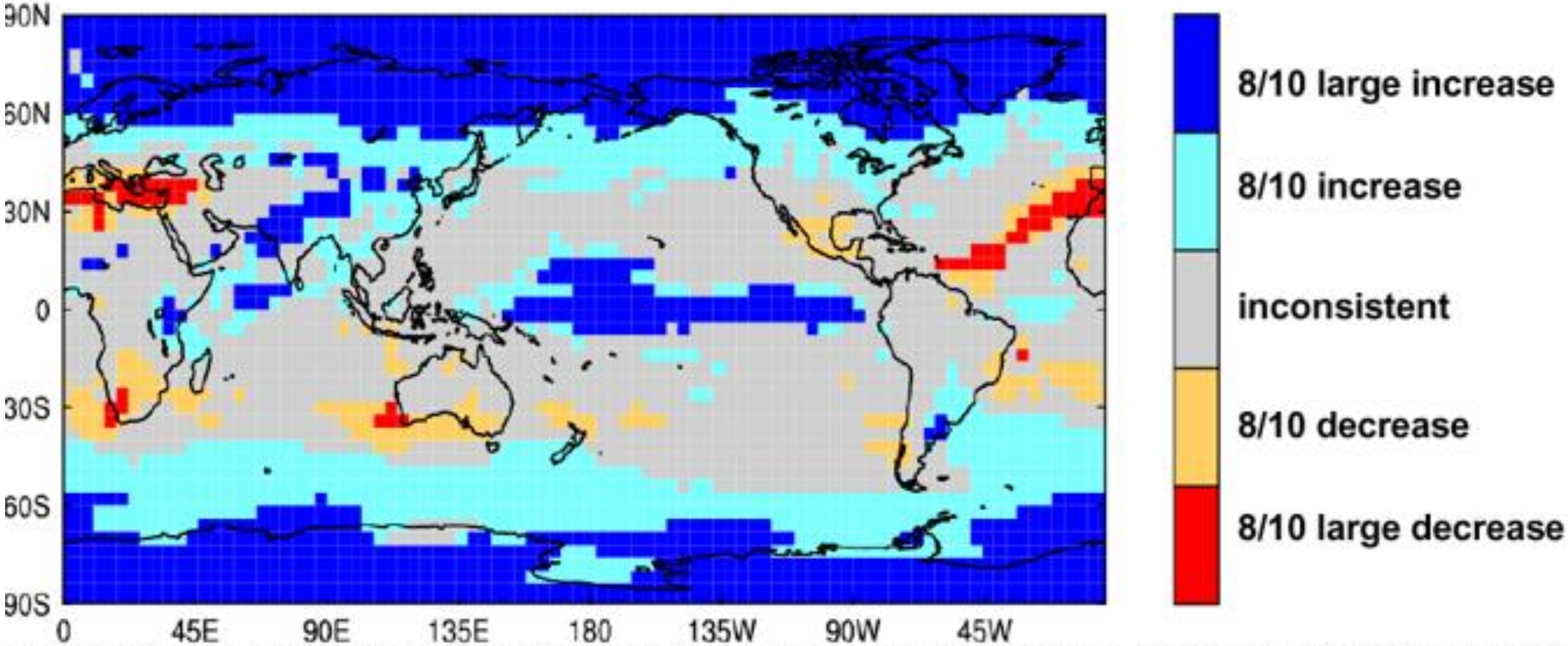
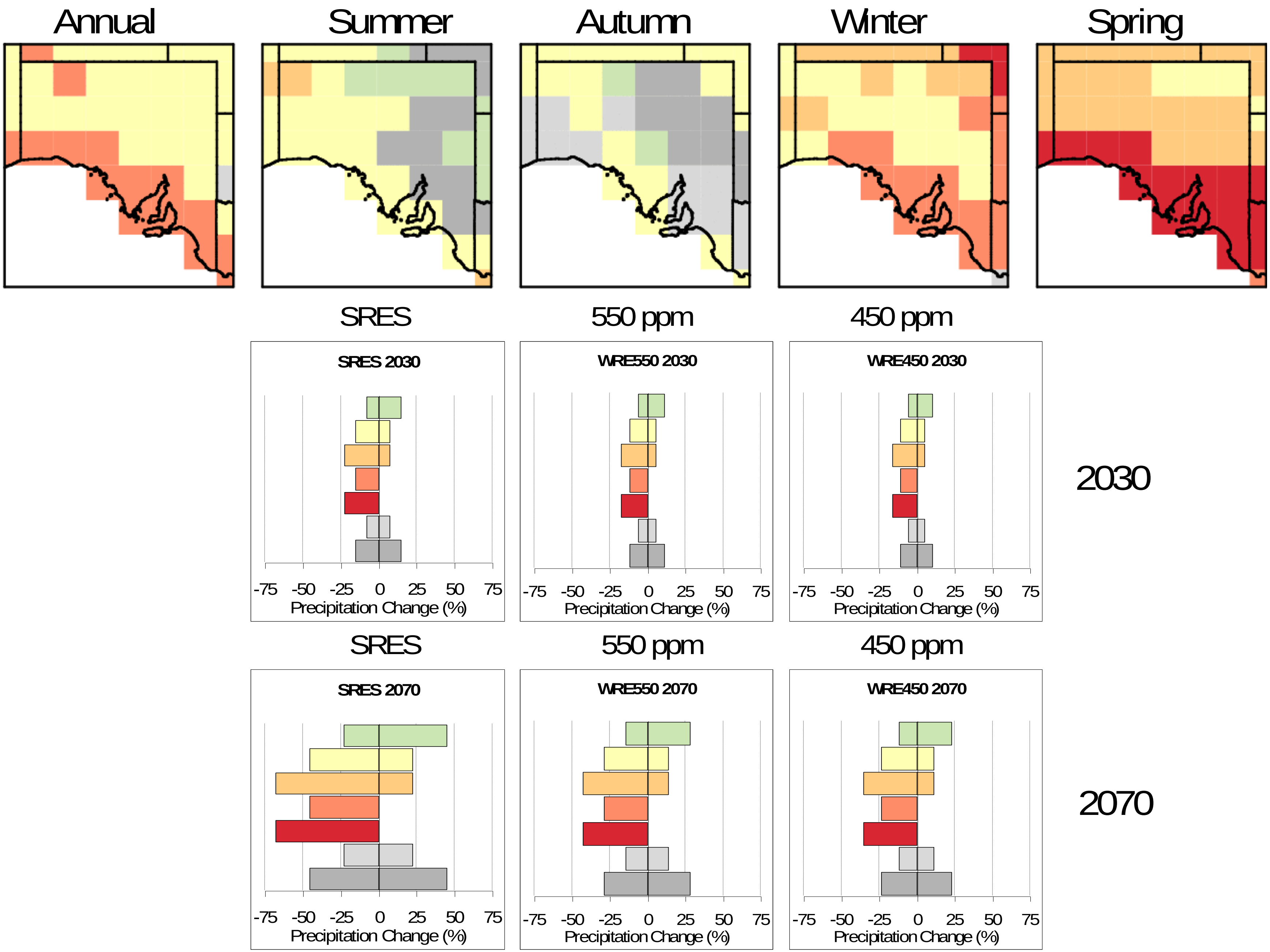


Figure 14: *Inter-model consistency in direction of simulated annual rainfall change in ten GCMs (see Table 1). Large changes are where the average change across the models is greater in magnitude than 5% per °C of global warming.*

Rainfall Projections



Summary Projections

- Australia is experiencing worsening impacts with no reprieve in sight as global greenhouse gas emissions continue to rise.
- By 2040 will be 2 to 5.0ºC warmer than 1990
- We will have even more hot days (over 35º)
- We will have further reduction in rainfall
- Further reduction in streamflow
- Up to 20% more drought months over most of Australia by 2030
- We are and will experience more intense extreme rainfall events
- We have and will see bushfire days never experienced before
- Sea level is continuing to rise and acidity is increasing

Climate Trends – Alexandrina

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Impacts inorganic N

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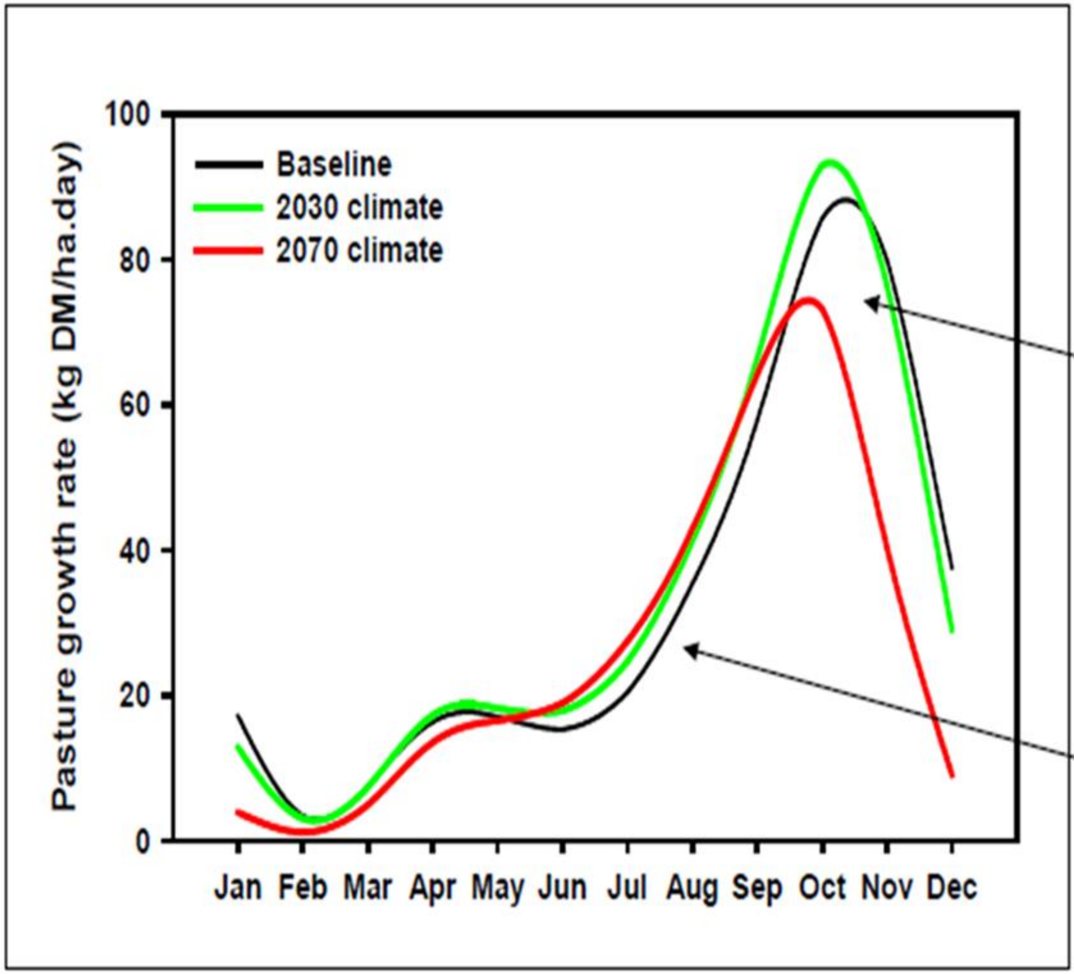
What can Cittaslow do?

Impacts on Agriculture



Will change the seasonal pattern of pasture growth

but a contraction of the spring growing season

With higher pasture growth rates in winter and early spring

Impacts on Agriculture

- Shorter growing season, heat stress and frost stress
- Less water available
- Soil health compromised by inc N and chemical inputs
- Soil microbiome dying – impacts animals, plants and humans
  - Top 10cm of soil sustains most life on earth
- Pest and disease risks increase
- Increased salinity
- Increased acidity
- Less productive land
- More frequent droughts

BUT:

Impacts Agriculture

Agriculture's goal to reach $100 billion in farm gate output by 2030 (up from current $60bn in 2018), was turbo-charged today with the Government giving the green light to a Future Foods Cooperative Research Centre.

https://www.nff.org.au/read/6364/new-future-foods-focus-propels-agricultures.html

- Land given to irrigation along SAMDB has doubled since 2007
- MDB Royal Commission Report shows not enough water in the system
- Environmental watering's constant
- Irrigation allocations only 14% at present
- Future droughts are going to be more common
- N use is likely to increase to increase production

And:

Inorganic N

- Over use of N limits use and update of minerals and liquid carbon pathway
- Doesn’t have to work for it so plants not taking up minerals and trace elements
- Increasing plant susceptibility to pests and diseases
- Requiring the application of expensive insecticides and fungicides
- Reducing farmers profits and adding unnecessary chemicals to the food chain.
- If plants are not taking up then negative effects for animal and human health.
- Vet bills are higher and can be traced back to N fertiliser – dairy

Inorganic N

Carcinogen

Volatile compound – in water, in food and in pastures as N

Globally farmers spend 100 billion on N every year

Many Australian farmers spend 100 – 200k on fertiliser annually

Uptake of N applied to crop or pasture is generally only 10-40% due to substantial losses (totalling 60 to 90%) from

Denitrification

Volatilisation

Leaching

Surface run off

Inorganic N Expense

Australia
73% of the Great Barrier Reef is dead due to fertiliser pollution

CHINA
Severe soil acidification from over-use of N fertilisers

New Zealand
93% of low waters not wadeable due to N fertiliser

Gulf of Mexico
Nitrogen run-off from farmland is the single largest source of nutrient pollution contributing to the massive ‘dead zone’ in the Gulf of Mexico (Ceres 2014).

America
Spends more than $4.8 billion per year to remove nitrate from U.S. drinking water

Excessive use of N and P Worldwide has caused

Soil degradation

Environmental pollution

Reduced soil biodiversity

Reduction in soil microbiome

Increased Soil Acidity

Acid Drinking Water

Trace element deficiencies in plants animals and people

Infertility in 70% of females in Japan and 50% of females in Australia.

Infertility in sheep and cattle

Early onset puberty

Nitrogen Types

Inorganic N

- **Fertiliser Nitrogen** is applied to a crop by growers where the above sources cannot meet the needs of the crop. Fertiliser N can be purchased as ammonium and ammonium nitrate. If not completely used up it can acidify. But also if too much applied it is lost by leaching or denitrification

Organic N

- **Stable Organic Nitrogen** (SON) is released slowly throughout the season, and is by far the largest nitrogen source in the soil.
- **Residue Organic Nitrogen** (RON) is mineralised rapidly into NH_4^+ and NO_3 and is highest following legume. **This is** calculated by subtracting the Ammonium N and Nitrate N from Total N.

How to Loose N

Denitrification

- This is N and $$ loss to the air and can lead to increased acidity over time and occurs when;
  - Soil is anaerobic properties due to past waterlogging or
  - when there is excess N in the system which is not used by plants
  - When N is applied at cold temperatures or low soil moisture
  - Up to 80kgN/ha can be volatilised from bare summer fallows due to denitrification

Leaching

- Once organic-N is converted to nitrate it is prone to leaching
- Occurs on compacted and sandy soils in high rainfall areas
- Subsoil constraints, such as soil acidity, reduce the efficiency of uptake of NO3- by the crop.

Interactions

- Pastures heavily fertilised with nitrogen can become sulphur deficient.
- Avoid liming soils that have recently had nitrogen applied to avoid nitrogen loss to the atmosphere.
- Legumes will fix less nitrogen if they receive inorganic N. They need to be grown in mixtures with non-legumes or they can deplete soil carbon via the same mechanism as inorganic N

N in the soil

Chemical N

100 kg/ha 140kg of single super
50kg/ha Hay Booster

Measurement	Yours	Guide
N Fixation [1] (net) kg/ha/month @ 25°C & 50% FC [3]	0.0	300.0
N Mineralisation [1,2] (net) kg/ha/month @ 25°C & 50% FC [3]	441.8	368.9
Denitrification (net, estimated) kg/ha/month @ 25°C & 50% FC [3]	1491.4	0.0
Ammonium N kg/ha [3]	58.2	24.0
Nitrate N kg/ha [3]	37.3	36.0

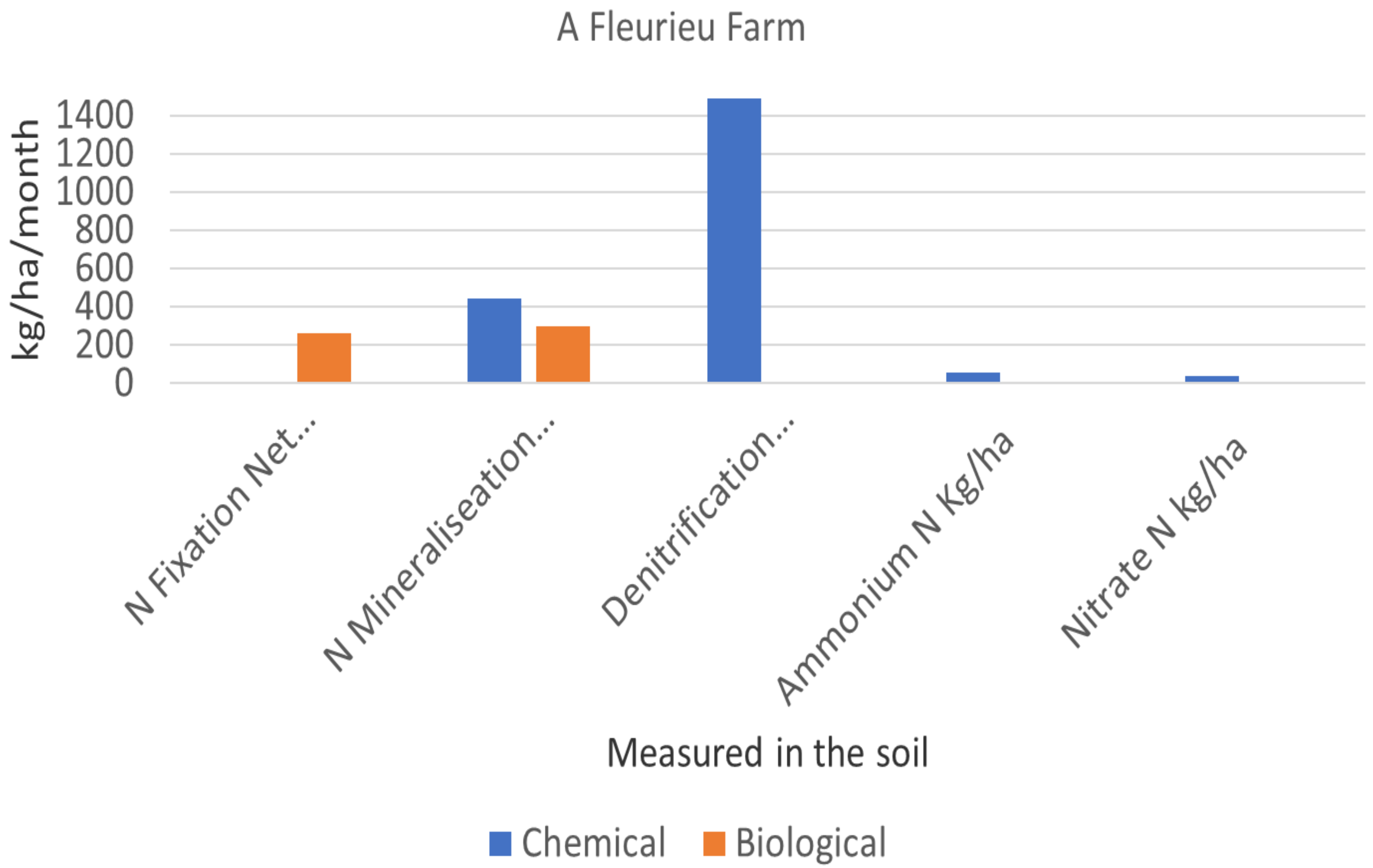
Control

Nothing added

Measurement	Yours	Guide
N Fixation [1] (net) kg/ha/month @ 25°C & 50% FC [3]	360.0	300.0
N Mineralisation [1,2] (net) kg/ha/month @ 25°C & 50% FC [3]	300.2	275.1
Denitrification (net, estimated) kg/ha/month @ 25°C & 50% FC [3]	0.0	0.0
Ammonium N kg/ha [3]	0.2	24.0
Nitrate N kg/ha [3]	4.7	36.0

Test results - Courtesy of Australian Microbiology Laboratories

N Inputs


A Fleurieu Farm
kg/ha/month
1400
1200
1000
800
600
400
200
0
N Fixation Net...
N Mineraliseation...
Denitrification...
Ammonium N Kg/ha
Nitrate N kg/ha
Measured in the soil
Chemical
Biological

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What can Cittaslow do?

Adaptation

Agriculture under less water

- **Use atmosphère to fix organic N**
- **Régénérative farming**
  - Adapts to the situation
  - Mitigates CO_2 production

- **Biochar – Soil Management**
  - reduce soil compaction and water logging
  - reduce the fallow period
  - tillage practices
  - plant breeding
  - incorporating stubble
  - stocking rates and movement
  - Agriculture under less water

Adaptation and Mitigation
Use the atmosphere to fix Organic N

On a global scale, biological nitrogen fixation accounts for around 65% of the nitrogen used by crops and pastures. There is scope for considerable increase. The supply of nitrogen is inexhaustible, as dinitrogen (N2) comprises almost 80% of the earth's atmosphere. The key is to transform inert nitrogen gas to a biologically active form.

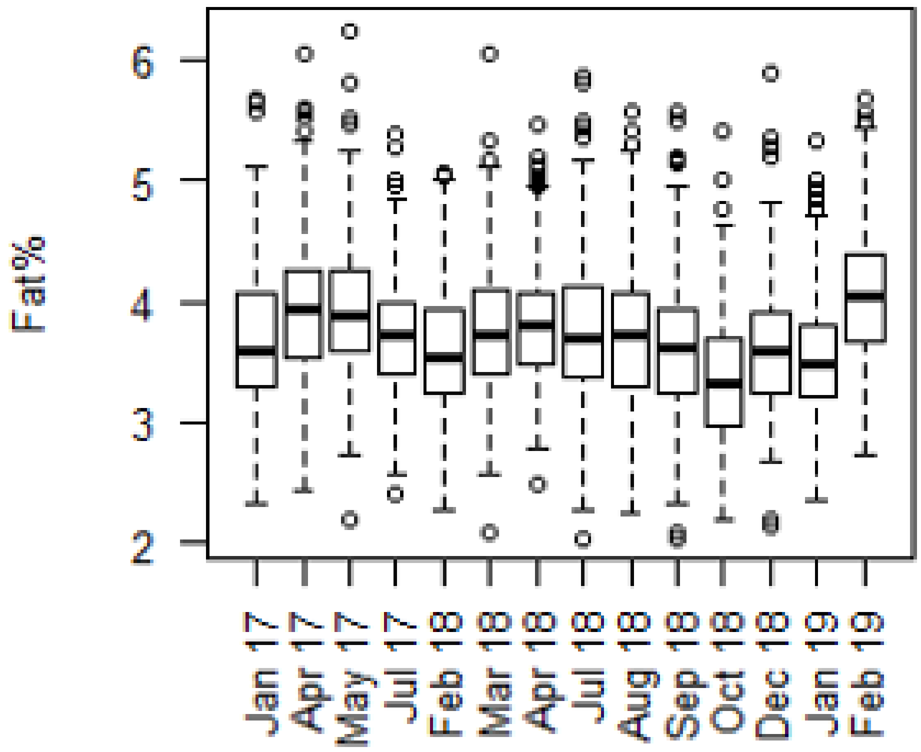
Fortunately, thanks to some 'enzymatic magic', atmospheric nitrogen can be transformed to ammonia by a wide variety of nitrogen-fixing bacteria and archaea — for free.

The storage of nitrogen in the organic form prevents soil acidification

Biochar and Dung Beetles

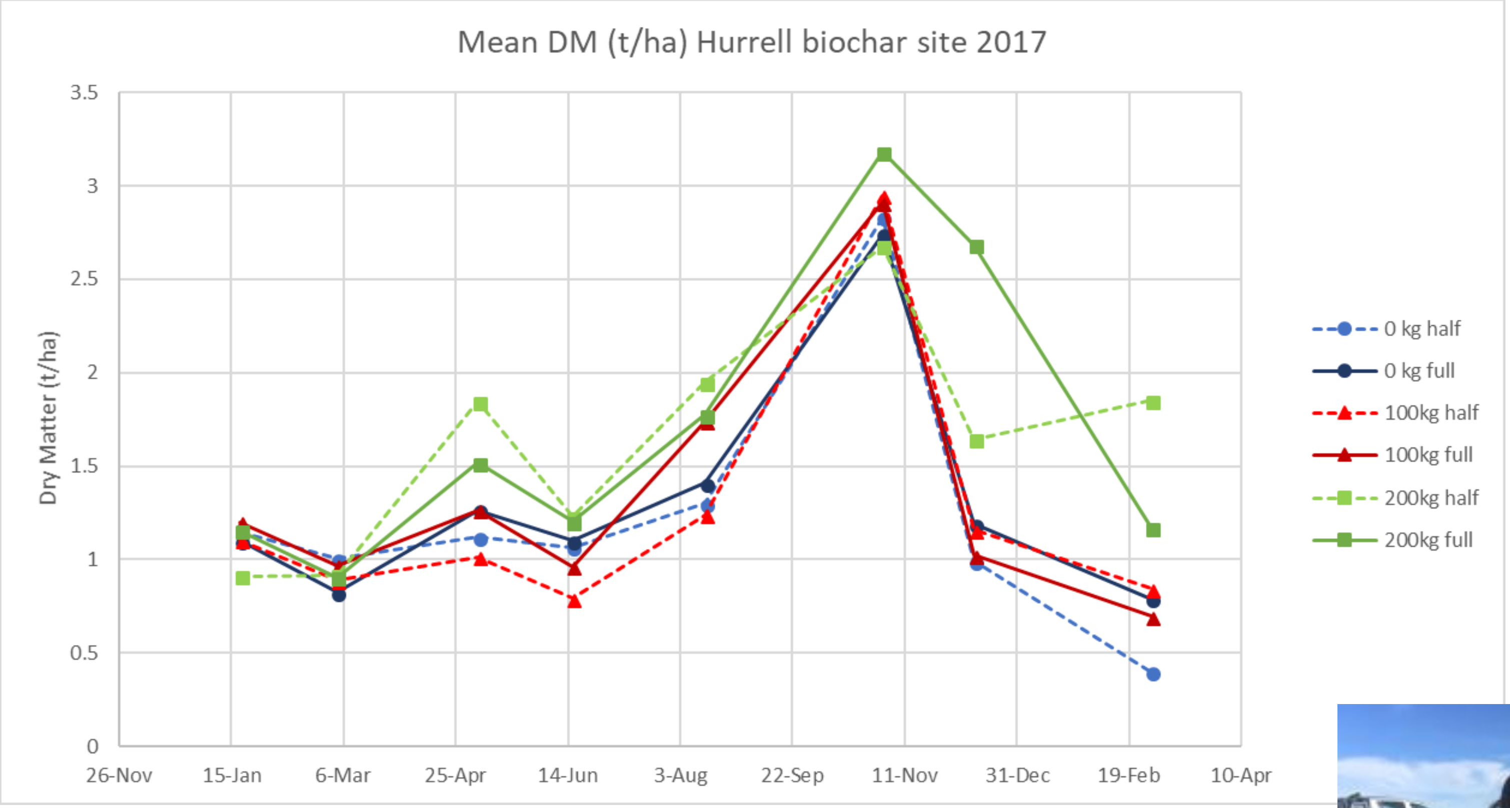
- Biochar dairy feeding trial
- Biochar in the soil to reduce N
- Biochar and organic fertilisers
- Biochar and dung beetle burial

Feeding biochar to dairy cattle Adaptation and mitigation



“Great news on our greenhouse targets. We’ve bred a cow that doesn’t release any methane.”

Biochar under phalaris and Lucerne pasture

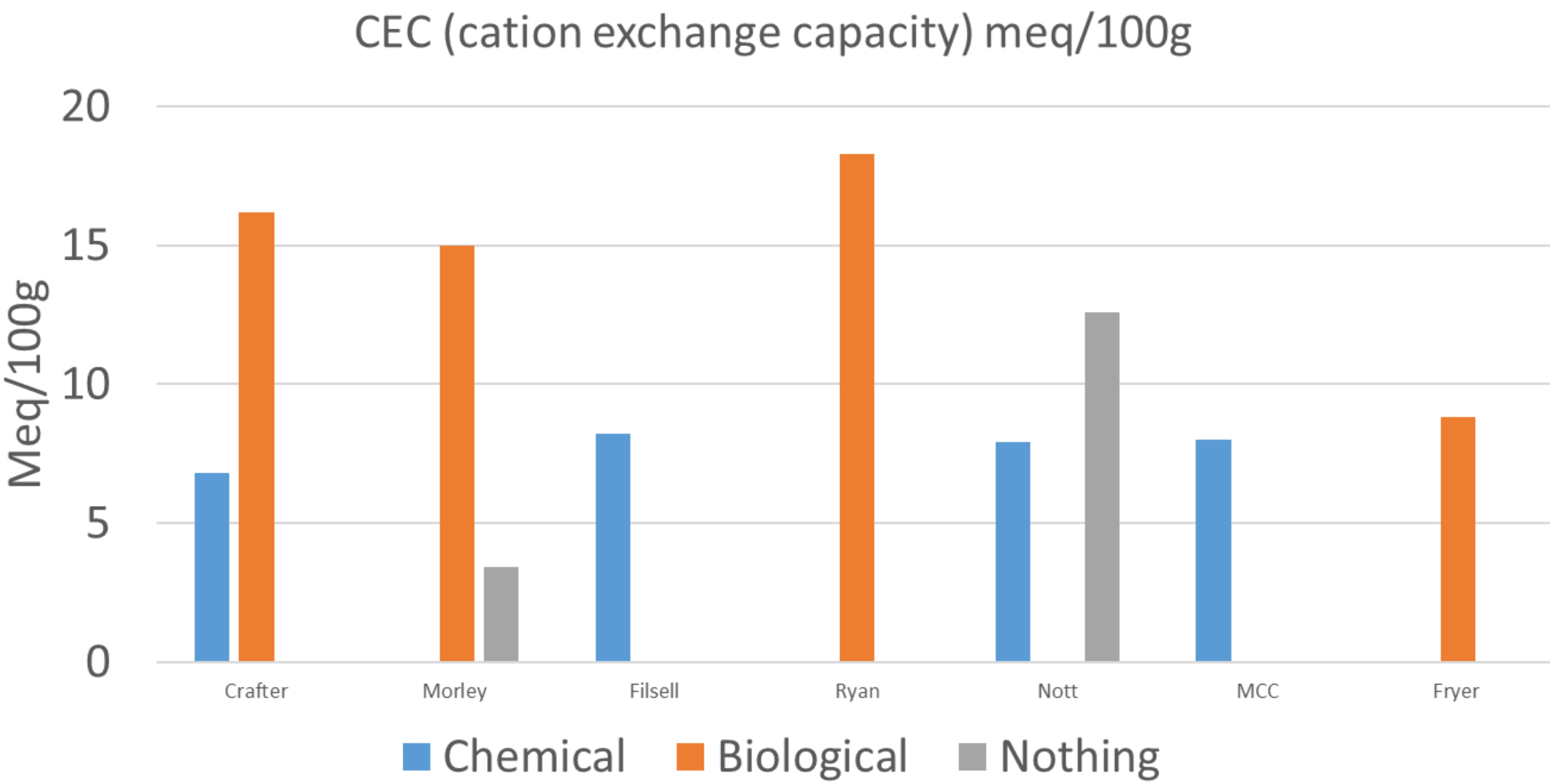


Soil Health and CEC

RATING	CATION EXCHANGE CAPACITY me/100g
low	<3
medium	3–6
high	>6

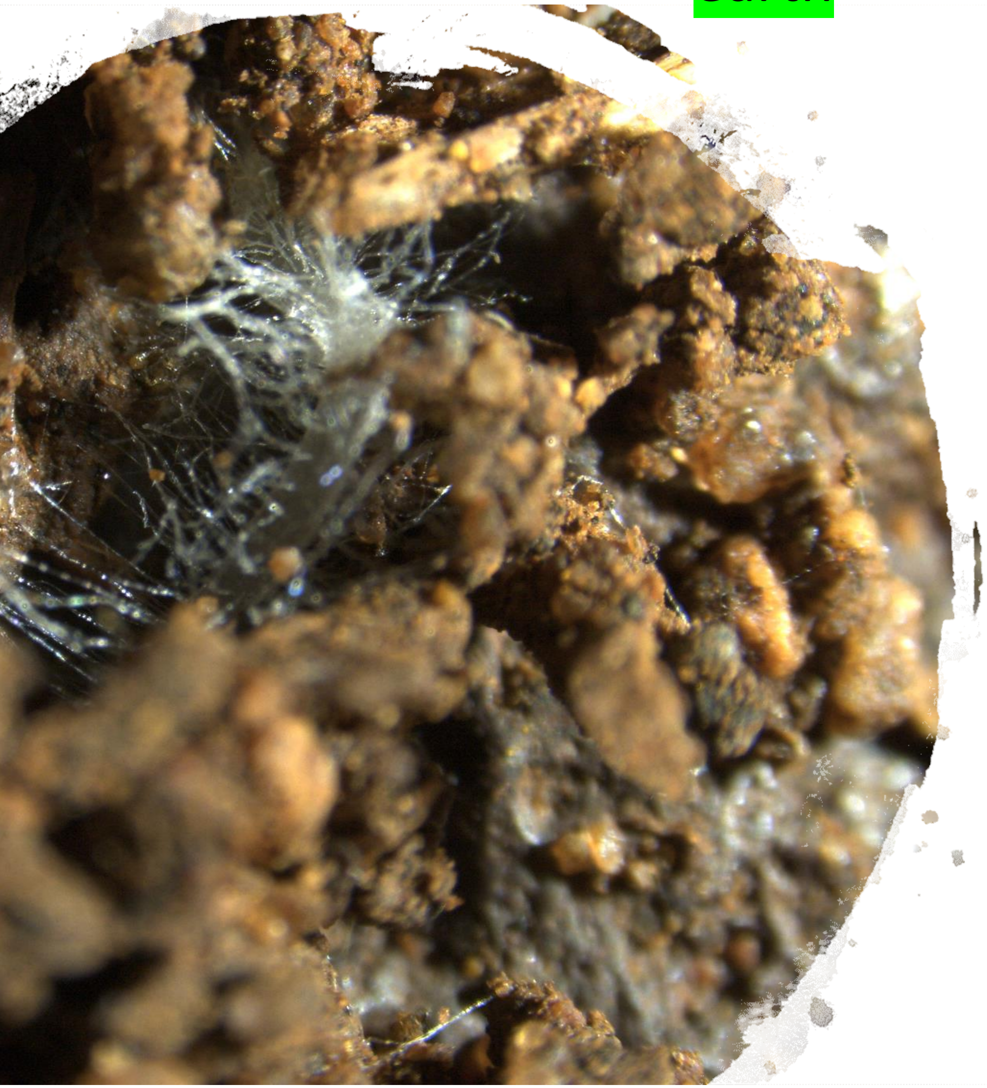
Soils with a low CEC have insufficient nutrients to sustain vigorous plant growth

- The CEC is a major factor affecting soil structure, nutrient availability and soil pH.
- CEC affects the soil's response to fertiliser.
- Many of the nutrients used by plants are in the form of cations
- The five most abundant cations are calcium, magnesium, potassium, sodium and aluminum.
- The total of the concentrations of these five cations approximates the CEC.
- The more clay and organic matter, the higher the CEC.
- Most fertiliser applications will not affect the CEC of a soil.
- A single application of 15 m3/ha of poultry litter can raise the CEC of a sandy soil by 40%
- Biochar raises the CEC of the soil



CEC (cation exchange capacity) meq/100g
Meq/100g
20
15
10
5
0
Crafter
Morley
Filsell
Ryan
Nott
MCC
Fryer
Chemical
Biological
Nothing

Soil Microbiome sustains all life on earth



Pay attention to how you build carbon
Fungi:Bacteria   2:3

- Bacteria and fungi play a role in the mineralisation and immobilisation processes of nutrients in the soil.
- Fungi should be 2 portions and bacteria 3.
- **When out of balance N can not be fixed as easily.**
- More bacteria is needed to break things down not too much fungi in dead matter to sit there.
- Both fungi and bacteria are decomposers in the soil, but they are different in habitats, plant residue degradation nutrient recycling and which organic matter they consume.

Keep the soil microbiome alive

Bacteria

- Have a higher N requirement and take more N from the soil for their own requirements.
- Fertiliser rich in nitrogen therefore favours the bacteria growth but if bacteria too high then N can be immobilised or denitrification occurs.
- Degrade easily and quickly and function as a food source for a wide range of microorganisms.
- Can be increased by adding sugars and starches, proteins (fish and bloodmeal) compost tea and legume residues.
- Like a higher pH

Fungi

- Are generally much more efficient at assimilating and storing nutrients than bacteria.
- Better use of PAW (due to more mycorrhizal fungi but also actively growing plants and grazing management
- To increase add carbon via organic residues, mulch, stubble, don’t graze for a while, cellulose and lignin, increasing the number and species of plants and rotational grazing.
- To reduce use tillage or reduce soil moisture.
- Like a lower pH

Build Soil Carbon – Soil Microbiome

- To fix organic N - Nitrogen-fixing bacteria and archaea, mycorrhizal fungi are needed
- Increase the FLNFB (Free Living Nitrogen Fixing Bacteria) by supplying organic matter as food.
- Support mycorrhizal fungi development.
  - The acquisition and transfer of organic nitrogen by mycorrhizal fungi is highly energy efficient.
  - MF reduce nitrification, denitrification, volatilisation and leaching.
- Encourage grass plants and diversity as the abundance of nitrogen fixing microbes are much greater where there is living groundcover (particularly plants in the grass family)
  - It is now recognised that plant root exudates make a greater contribution to stable forms of soil carbon
- Inoculate with good quality inoculants

Jones 2008 , Leake et al. 2004, Whiteside et al. 2009

Remember

- Biological nitrogen fixation is the key driver of the nitrogen and carbon cycles in all natural ecosystems, both on land and in water. When managed appropriately, biological nitrogen fixation can also be the major determinant of the productivity of agricultural land.
- Many farmers around the world are discovering first-hand how the change from bare fallows to biodiverse year-long green, coupled with appropriate livestock management and reduced applications of inorganic nitrogen, can restore natural topsoil fertility.
- Improving soil function delivers benefits both on-farm and to the wider environment.
- Measuring soil N could save you $
- Too much N at the wrong time can increase denitrification
- N at the right time can support your soil
- If you build soil N and soil health so that more N can be fixed and mineralised
- Consider alternative fertilisers to support soil moisture storage, carbon storage, CEC and hence N fixation and mineralisation
- Improved soil health ensures better uptake of minerals in plant and reduced acidity

Regenerative Agriculture

1) Maintain year-round living cover, via perennial pastures on grazed land and/or multi-species cover crops on farmed land. Almost every living thing in and on the soil depends on green plants (or what was once a green plant) for its existence. The more green plants, the more life.

> It's well accepted that groundcover buffers soil temperatures and reduces erosion, but it is perhaps less recognised that actively growing green groundcover also fuels the liquid carbon pathway which in turn supports, among other things, mycorrhizal fungi, associative N-fixing bacteria and phosphorus solubilising bacteria — all of which are essential to both crop nutrition and the formation of stable humified carbon.

2) Provide support for the microbial bridge, to enhance the flow of carbon from plants to soil. This requires reducing inputs of high analysis N & P fertilisers that inhibit the complex biochemical signalling between plant roots and microbes.

3) Promote plant and microbial diversity. The greater the diversity of plants the more checks and balances for pests and diseases and the broader the range of microhabitats for the soil organisms involved in nutrient acquisition, nutrient cycling and soil building.

4) Biodiverse animal grazing and high grazing pressure. As well as the benefits arising from the addition of manure and urine to soils, high-intensity short-duration grazing increases root exudation and stimulates the number and activity of associative N-fixing bacteria in the rhizosphere, which fire up in response to defoliation and provide the extra N required by the plant for the production of new growth.

How to wean of N Fertiliser

- The activities of both symbiotic and associative N-fixing bacteria are inhibited by high levels of inorganic N. In other words, the more nitrogen fertiliser we apply, the less N is fixed by natural processes.
- Hence it is important to wean your soils off inorganic N — but please do it *slowly*. Microbial communities take time to adjust. Soil function cannot return overnight. The transition generally requires around three years.
- Nitrogen inputs can be reduced 20% in the first year, another 30% in the second year and a further 30% in the third year. In fourth and subsequent years, the application of a very small amount of inorganic N (up to 5kgN/ha) will help to prime natural nitrogen-fixing processes.
- While weaning off high rates of inorganic N you should also aim to maintain as much diverse year-round living groundcover in crops and pastures as possible.

Climate Trends – Alexandrina

Greenhouse emissions

Climate projections

Impacts

Impacts inorganic N

Adaptation and mitigation for agriculture

Policy for agriculture

What can Cittaslow do?

Policy Needed

New Zealand
Permit to Farm as of 1st July 2018)
Will make wadable by 2040

- Australia is now more than halfway between the baseline year 2005 and the target year (2030) for our national emissions reduction target. Yet Australia's greenhouse gas emissions are rising.
- Without action Australia will not even achieve its inadequate 2030 target
- Immediate steps need to be taken by the Federal Government to tackle Australia's rising emissions and get Australia's climate policy back on track to join the global effort to meet the Paris targets
- Federal government are misleading with their claims on accounting of greenhouse gas emissions over the past 5 years.

Source https://www.climatecouncil.org.au/wp-content/uploads/2019/04/Climate-Cuts-Cover-Ups-and-Censorship.pdf

CHINA
Government policy to reduce N use by 50% by 2020

Summary

Ag production needs to increase for economic viability

Less water, more drought , less streamflow

N fertiliser increase can impact soil health and microbiome, plant and human health

Regenerative agriculture can help adapt and mitigate climate change build soil microbiome sequester carbon

Policy for agriculture needed

Climate Trends – Alexandrina

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What can Cittaslow do?

Thank you and Discussion

Climate & Agricultural Support PTY LTD

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