What do we do about climate change?

• Climate change – Fact or Fiction?

• Threats to California?

• Solutions for California?
Climate Change – Fact or fiction?

Extinction Rebellion wants to rally support worldwide around a common sense of urgency to tackle climate breakdown.
For all the demonstrators’ talk of ‘science’ and their insistence on telling ‘the truth’, it could not have been clearer that this global movement is a religious cult.
Toby Young, The spectator, 12 October 2019
Is climate change occurring?
The Greenhouse Effect

Fig. 8.1 Fluxes of radiation in and out of the Earth’s atmosphere which collectively give rise to the greenhouse effect.
History

- **1856 John Tyndall**, Royal Society, demonstrates gases can absorb radiant heat

- **1824 Fourier**, calculated that the planet is our climate is warmer because of gases in the atmosphere – 18 °C on average

- **1897 Arrhenius** calculated that doubling atmospheric CO₂ would lead to a rise 4-6 °C (2-4 °C is current prediction)

- **1950s Charles Keeling** 1950s – measurements of atmospheric carbon dioxide

- **1965 Lyndon B Johnson**, USA President, ‘by the year 2000 the increase in CO₂ will be close to 25% - measureable and marked changes in climate’

- **1979 – NAS** produce stark warning in on impending warming

- **1980s** – apparent that temperature increases were occurring

- **1988, IPCC** (Intergovernmental Panel on Climate Change), formed

- **1992 Earth Summit Rio**, ‘stabilization of GHG emissions to prevent dangerous human-induced climate changes’

Taken from ‘The Scientific Road to Copenhagen’ Stefan Rahmstorf – www.ozean-klima.de
The United Nations Framework Convention (UNFCCC) is the international response to climate change. It is a treaty that establishes the basic obligations of the 196 Parties (States) plus the European Union to combat climate change.

- It was signed at the Earth Summit in 1992 and came into force in 1994.
  - 197 signatories including the USA as of 2015

The objective of the treaty is to "stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.

- The Conference of the Parties (COP) is the supreme decision-making body of the Convention. The Parties meet annually to review progress in the implementation of the Convention where other instruments that support the implementation of the Convention are proposed, evaluated and approved.
Following 1992 Earth Summit- how are we doing? 23 years of progress?

- Little achieved – COP21 (Paris) changed this?
- Carbon dioxide emissions 40% higher in 2008, relative to 1990, from 280 ppm
- Rate of increase three times higher than 1990s – recently hit 400 ppm
- Global temperature already 0.5 C above pre-industrial and 0.3 C since Rio
- Most nations now wish to hold to 2 C rise only
Five important data sets as evidence that the climate is changing and future changes are likely:

1. Vostok ice cores
2. Keeling curve and the rise of carbon dioxide
3. Global temperature changes since 1880 and predicted changes
4. Sea level rise
5. Recent sea ice retreat
1. Vostok ice cores

- Ice drilled in 1970s-80s by French-Russian team,
- Vostok, Antarctica, for past 400,000 years
- CO$_2$ during this time never higher than present
- Likely not for 2 million years

![Graph showing CO$_2$ concentration and temperature over time with data points from 1959 and 2008.](image)
2. The Keeling Curve

Latest CO$_2$ reading
January 27 2015
399.92 ppm

Mauna Loa Observatory
Atmospheric CO$_2$ concentration increase since 1750

- Atmospheric CO$_2$ has increased by 31% since 1750
- Present CO$_2$ level not exceeded in last 420,000 years and likely not in past 20 million years
- Current rate of increase unprecedented in at least 20,000 years
3. Global Temperatures Changes

Combined global land, air, and sea surface temperatures 1860 to August 1998 (relative to 1961–1990 average)

Changes in temperature, sea level and Northern Hemisphere snow cover

(a) Global average surface temperature

(b) Global average sea level

(c) Northern Hemisphere snow cover

IPCC 2007
Temperature change

- Rate and duration of global warming in the 20th Century is greater than any of the previous 9 centuries
- the 1990s were the warmest decade and
- 1998 was the warmest year of the millennium
4. Sea Level Rise

- Since 1880 about a 20 cm sea rise
- Past 15 years accelerated to 3 mm per year
- Since 1993 accurate satellite measurements
- Modern phenomenon
- Logical consequence of warming
- Warm water expands, glaciers and ice sheets melt
5. Sea Ice Cover

[Graph showing the change in Northern Hemisphere summer ice extent from 1950 to 2010. The graph indicates a significant decrease in ice extent over the years, with a prediction for 2008 that includes a lower limit of 7.44 million km².]

Historic data from http://arctic.atmos.uiuc.edu/SEAICE/timeseries.1870-2007

Causes of an increased greenhouse effect

- Fossil fuel burning
- Land-use change (e.g. tropical deforestation)
- These increase the concentration of greenhouse gases in the atmosphere
Greenhouse gases - contribution to global warming

<table>
<thead>
<tr>
<th>Gas</th>
<th>% contribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon dioxide (CO$_2$)</td>
<td>65</td>
</tr>
<tr>
<td>Nitrous oxide (N$_2$O)</td>
<td>5</td>
</tr>
<tr>
<td>Methane (CH$_4$)</td>
<td>20</td>
</tr>
<tr>
<td>Halogenated compounds</td>
<td>10</td>
</tr>
</tbody>
</table>
What will happen over the next 100 years?
RCP – Representative Concentration Pathway

Describe different possible trajectories for CO$_2$ emissions increases
Emissions are on track for 3.2–5.4°C “likely” increase in temperature above pre-industrial levels. Large and sustained mitigation is required to keep below 2°C.

Data: CDIAC/GCP/IPCC/Fuss et al 2014

Over 1000 scenarios from the IPCC Fifth Assessment Report are shown.

Source: Fuss et al 2014; CDIAC; Global Carbon Budget 2014
What about California?

https://fitzlab.shinyapps.io/cityapp/

Sacramento is predicted to have the climate of Bakersfield by 2080
### Top-5 Agricultural States in Crop Cash Receipts, 2016

<table>
<thead>
<tr>
<th>State</th>
<th>Crop Cash Receipts, $1,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. California</td>
<td>$46,041,467</td>
</tr>
<tr>
<td>2. Iowa</td>
<td>$26,840,363</td>
</tr>
<tr>
<td>3. Nebraska</td>
<td>$21,558,070</td>
</tr>
<tr>
<td>4. Texas</td>
<td>$20,878,502</td>
</tr>
<tr>
<td>5. Minnesota</td>
<td>$17,054,672</td>
</tr>
</tbody>
</table>

U.S. total crop cash receipts $357,252,284

> 1/3 of U.S. vegetables grown in California
> 2/3 of U.S. fruits and nuts grown in California
Agriculture in California is very diverse

### Top-20 California Commodities, 2016

<table>
<thead>
<tr>
<th>Rank</th>
<th>Commodity</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Dairy products, Milk</td>
<td>$6.07 billion</td>
</tr>
<tr>
<td>2.</td>
<td>Grapes</td>
<td>$5.58 billion</td>
</tr>
<tr>
<td>3.</td>
<td>Almonds</td>
<td>$5.16 billion</td>
</tr>
<tr>
<td>4.</td>
<td>Cattle and Calves</td>
<td>$2.53 billion</td>
</tr>
<tr>
<td>5.</td>
<td>Lettuce</td>
<td>$1.96 billion</td>
</tr>
<tr>
<td>6.</td>
<td>Berries, all Strawberries</td>
<td>$1.83 billion</td>
</tr>
<tr>
<td>7.</td>
<td>Pistachios</td>
<td>$1.51 billion</td>
</tr>
<tr>
<td>8.</td>
<td>Tomatoes</td>
<td>$1.33 billion</td>
</tr>
<tr>
<td>9.</td>
<td>Walnuts</td>
<td>$1.24 billion</td>
</tr>
<tr>
<td>10.</td>
<td>Oranges, all</td>
<td>$826 million</td>
</tr>
<tr>
<td>11.</td>
<td>Broilers (chickens)</td>
<td>$801 million</td>
</tr>
<tr>
<td>12.</td>
<td>Broccoli</td>
<td>$779 million</td>
</tr>
<tr>
<td>13.</td>
<td>Hay, all</td>
<td>$774 million</td>
</tr>
<tr>
<td>14.</td>
<td>Carrots, all</td>
<td>$735 million</td>
</tr>
<tr>
<td>15.</td>
<td>Rice</td>
<td>$704 million</td>
</tr>
<tr>
<td>16.</td>
<td>Lemons</td>
<td>$594 million</td>
</tr>
<tr>
<td>17.</td>
<td>Peppers, all</td>
<td>$497 million</td>
</tr>
<tr>
<td>18.</td>
<td>Tangerines</td>
<td>$457 million</td>
</tr>
<tr>
<td>19.</td>
<td>Raspberries</td>
<td>$380 million</td>
</tr>
<tr>
<td>20.</td>
<td>Cotton, all</td>
<td>$358 million</td>
</tr>
</tbody>
</table>

**CA produces:**

- 30% of US vegetables
- 60% of US fruits and nuts
- Grows over 400 commodities
- Over 50% of almonds, pistachios, walnuts, grapes, citrus, apricots, dates, figs, kiwis, nectarines, prunes, olives
1. California is getting warmer, particularly for summer temperatures

Figure 1. (a) Global temperature anomalies from 1880–2016, electronically available from National Aeronautics and Space Administration, Goddard Institute for Space Studies (NASA/GISS, on 29 June 2017) [7]; (b) California statewide mean temperature departure, October through September as reported by California Department of Water Resources in 2015 [8]. The black line denotes the 11-year running mean.

https://doi.org/10.3390/agronomy8030025
https://cal-adapt.org/tools/annual-averages/#climatevar=tasmax&scenario=rcp45&lat=38.59375&lng=121.46875&bo-undary=locagrid&units=fahrenheit
2. Californian Climate Future – the climate is changing

<table>
<thead>
<tr>
<th>CLIMATE IMPACT</th>
<th>DIRECTION</th>
<th>SCIENTIFIC CONFIDENCE FOR FUTURE CHANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEMPERATURE</td>
<td>WARMING</td>
<td>Very High</td>
</tr>
<tr>
<td>SEA LEVELS</td>
<td>RISING</td>
<td>Very High</td>
</tr>
<tr>
<td>SNOWPACK</td>
<td>DECLINING</td>
<td>Very High</td>
</tr>
<tr>
<td>HEAVY PRECIPITATION EVENTS</td>
<td>INCREASING</td>
<td>Medium-High</td>
</tr>
<tr>
<td>DROUGHT</td>
<td>INCREASING</td>
<td>Medium-High</td>
</tr>
<tr>
<td>AREA BURNED BY WILDFIRE</td>
<td>INCREASING</td>
<td>Medium High</td>
</tr>
</tbody>
</table>
3. Crop yields are mostly predicted to decline
4. Critical chilling hours required for tree crops are declining
4. Critical chilling hours required for tree crops are declining.

apricot, kiwifruit, peach, nectarine, plum, and walnut are vulnerable.

Walnuts require the highest number of chill hours, implying a future decline in walnut acreage within the valley – many areas will no longer be suitable.
Walnuts from California

- Global production worth $6 billion USD/yr
- U.S. production worth $2 billion, all from California
- Global exports dominated by UC Davis scion releases (mostly ‘Chandler’)
- Clonal walnut rootstocks first developed here over last 20 years and now adopted worldwide (‘RX1’ USPP #20649; ‘VX211’ USPP #21179)
- Rich in polyunsaturated fatty acids
- Walnut tannins implicated in obesity reduction
- Global production projected to reach $8 billion USD by 2025; new planted acreage worldwide dominated by UC Davis releases
6. Overall, Californian agriculture is entering a period of increased vulnerability.
If Californian agriculture suffers, then food supply across the US is impacted.

https://theconversation.com/we-mapped-how-food-gets-from-farms-to-your-home-125475
How can we find solutions to climate change for Californian agriculture?

http://www.climateassessment.ca.gov/
## Findings and solutions

<table>
<thead>
<tr>
<th>Threat</th>
<th>Solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Increased wild fires</strong> – large wildfires 50% more likely by 2100</td>
<td>Prescribed fire burning, better managed forest thinning</td>
</tr>
<tr>
<td><strong>Groundwater and water infrastructure impacted</strong> – flooding and increased drought predicted</td>
<td>Better forecasting. Increased water storage and re-charge of aquifers</td>
</tr>
<tr>
<td><strong>Forests cover 30% of the state. Provide wildlife, recreation. Sixty species of tree</strong></td>
<td>Prescribed fire burning at 35,000 acres per year. Intensive thinning.</td>
</tr>
<tr>
<td><strong>Rangelands</strong> – many non-native grasses and oak scrub. Susceptible to increased drought</td>
<td>Increase sol organic matter through compost application to retain soil moisture – use waste from food, cattle manure</td>
</tr>
<tr>
<td><strong>Biodiversity hotspots</strong> are threatened by climate change</td>
<td>Manage landscape to provide wildlife corridors</td>
</tr>
</tbody>
</table>
| **Agriculture** – over extraction of water, increasing temperature, mean 16% loss of yield | Flood irrigation in wet years, increased soil organic matter }
Paris COP21

ROAD TO COP21
THE 2015 UN CLIMATE AGENDA TOWARDS A NEW GLOBAL AGREEMENT

8-13 February
ADP SESSION (Geneva, Switzerland)

13 February
1st DRAFT OF NEW NEGOTIATING TEXT TO BE RELEASED

31 March
DEADLINE: INDCs SUBMISSIONS (for Parties able to do so)

30 April
DEADLINE: NEW NEGOTIATING TEXT TO BE AVAILABLE

1 November
SYNTESES REPORT ON INDCs AGGREGATE EFFECT TO BE RELEASED BY UNFCCC SECRETARIAT

October
ADP SESSION (to be defined)

1 October
DEADLINE: INDCs SUBMISSIONS

August-September
ADP SESSION (to be defined)

3-14 June
ADP, SBI & SBSTA SESSION (Bonn, Germany)

30 November - 11 December
COP21 (Paris, France)
COP21 KEY OUTCOMES

On December 12th 2015, representatives from 195 countries and the EU gathered in Paris for the 21st United Nations Climate Change Conference, known simply as COP21, reached a universal agreement on global climate action.

A new Ecometrica paper about the outcomes of COP21 goes into more detail on the full results of the conference - however, the five key elements of the agreement can be found below:

1.5°
Mitigation: Ambitious 1.5 degree temperature rise limit.

$100bn
Financing: Unlocking a minimum of 100 billion dollars per year from 2020 onward.

Adaptation: Response to already existing impacts of climate change.

Capacity Building: Global cooperation-knowledge and technologies transfer.

Transparency: On both the measurement and reporting of greenhouse gas emissions.

A full version of the paper is available online at: www.ecometrica.com/blog
June 1 2017, US President Trump states Intention for US to leave the COP21 Paris agreement
Syria and Nicaragua only other states not to sign

Nov 4th 2020, day of withdrawal – day after presidential election
California leading the world in climate change policy

- Executive order for carbon neutrality by 2045 (*UK net zero by 2050*), signed 2018
- Follows AB 32 in 2006
- All electricity from zero carbon sources by 2045
- Provides rest of the world a blueprint for success

https://ww2.arb.ca.gov/our-work/programs/ghg-inventory-program
Conclusions

• Global Climate change is here and California will be subjected to a changing climate in the coming decades

• Agriculture, as one of the most important economic activities of the state, will be critically impacted – largely in a negative way

• California is world-leading in terms of policy development and instruments to mitigate the impacts of and adaption to climate change – first Cap and Trade nation, committed to Net Zero

• Significant issues remain for agriculture – perennial crops, long response time and total dependence on irrigation agriculture – 80% of CA water?

• We need new germplasm – genetic material – suited to hotter, drier environments and where chill requirements are removed