Bringing Climate Change Home

How do we know it is happening & what does it mean for me?

Dr. Heidi Roop

University of Washington Climate Impacts Group

CLIMATE IMPACTS GROUP
UNIVERSITY of WASHINGTON
College of the Environment

@heidiroop| @CIG_UW Image with aerial support from LightHawk

Earth Scientist.

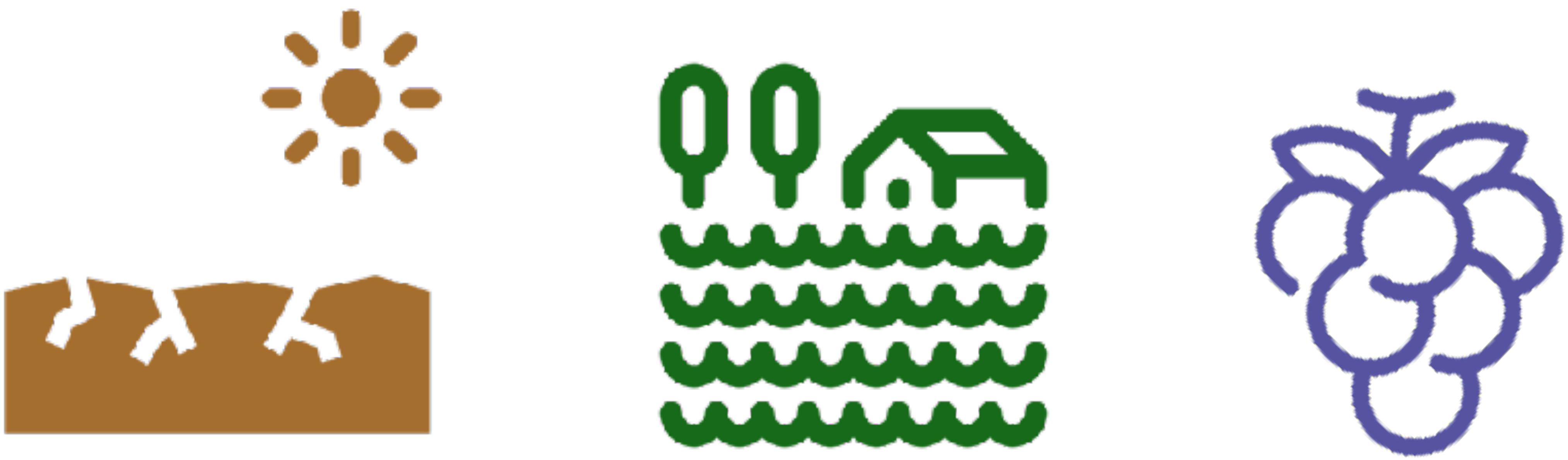
Photos: H. Roop

Established 1995

The **Climate Impacts Group** supports the development of climate resilience by ***advancing understanding*** and ***awareness*** of climate risks. We work closely with public & private entities ***to apply*** this information as they act to shape ***society’s future.***

COLLEGE OF THE ENVIRONMENT
UNIVERSITY *of* WASHINGTON

A FOCUS ON...

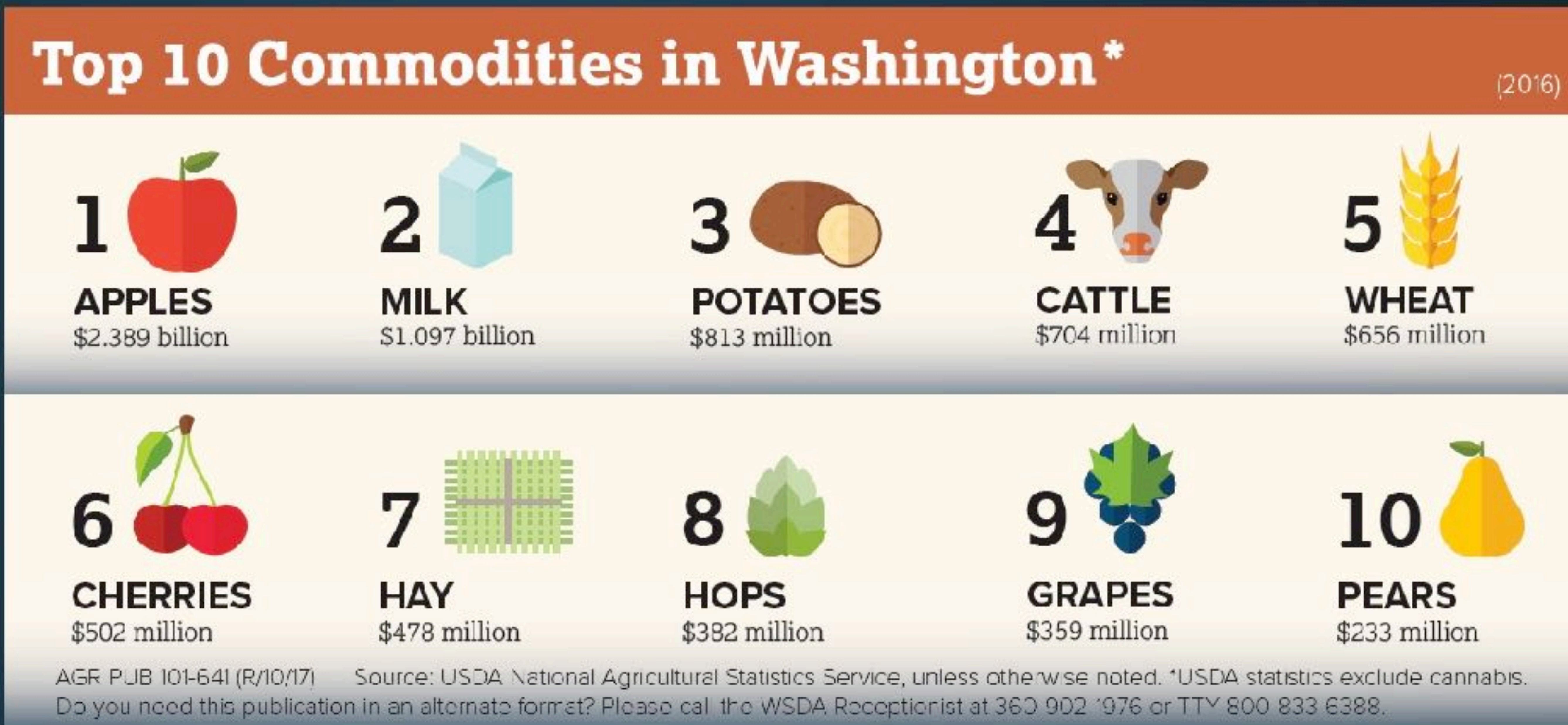


AGRICULTURE.

Washington farmers produce over **300** different commodities

WASHINGTON STATE DEPARTMENT OF AGRICULTURE | 1111 WASHINGTON ST SE, OLYMPIA, WA 98504-2560 | AGR.WA.GOV

WSDA, 2019


Top 10 Commodities in Washington*
(2016)
1 APPLES $2.389 billion
2 MILK $1.097 billion
3 POTATOES $813 million
4 CATTLE $704 million
5 WHEAT $656 million
6 CHERRIES $502 million
7 HAY $478 million
8 HOPS $382 million
9 GRAPES $359 million
10 PEARS $233 million
AGR PUB 101-641 (R/10/17)
Source: USDA National Agricultural Statistics Service, unless otherwise noted. *USDA statistics exclude cannabis.
Do you need this publication in an alternate format? Please call the WSDA Receptionist at 360 902 1976 or TTY 800 833 6388.

WSDA, 2019

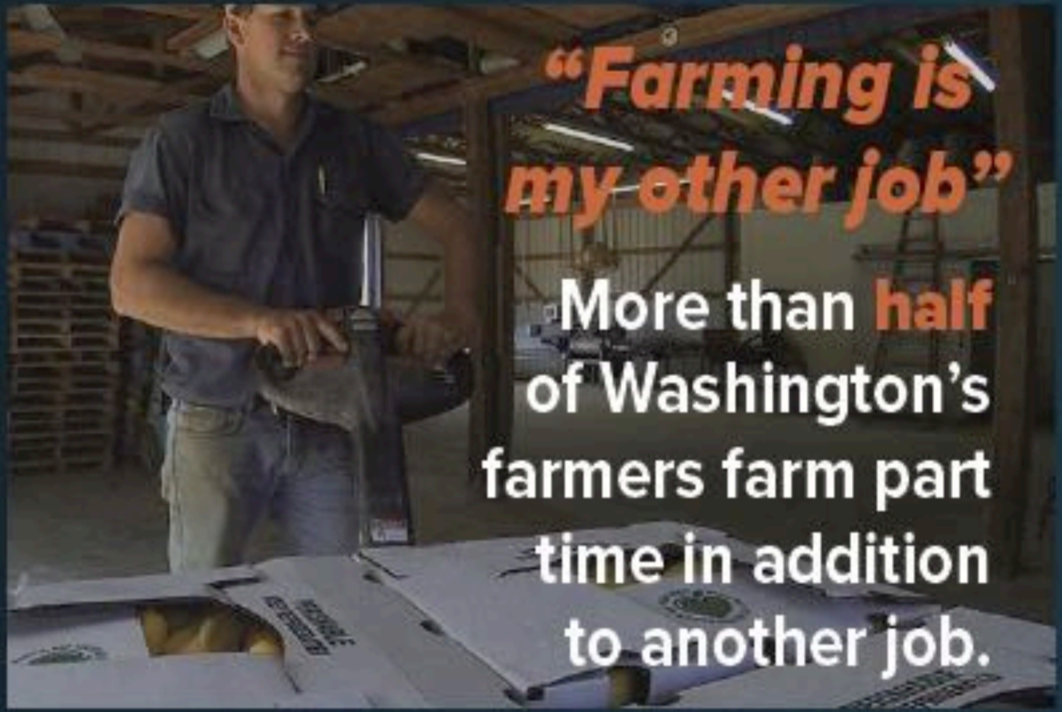
Agriculture and food processing provide over **164,000** jobs in Washington (2013)

35,900+ farms (2016)

800 organic farms (2016)

63% of farms are less than 50 acres

95% of Washington farms are family farms



WSDA, 2019

HOW IS CLIMATE CHANGE CONNECTED TO AGRICULTURE?

H. Roop

Temperature, precipitation

Length of season

Crop suitability &
Productivity

Nutritional quality
of food

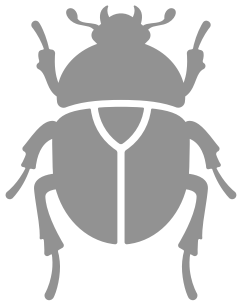
H. Roop

“Climate change has the potential to adversely impact agricultural productivity at local, regional, and continental scales."

NCA, 2018

Crop and livestock production in certain regions will be adversely impacted both by direct and indirect effects of climate change:

‘**DIRECT IMPACTS :** increasing trends in daytime and nighttime temperatures; changes in rainfall patterns; and more frequent climate extremes, flooding, and drought.



‘INDIRECT IMPACTS’: increased weed, pest, and disease pressures; reduced crop and forage production and quality; and damage to infrastructure.

NCA, 2018

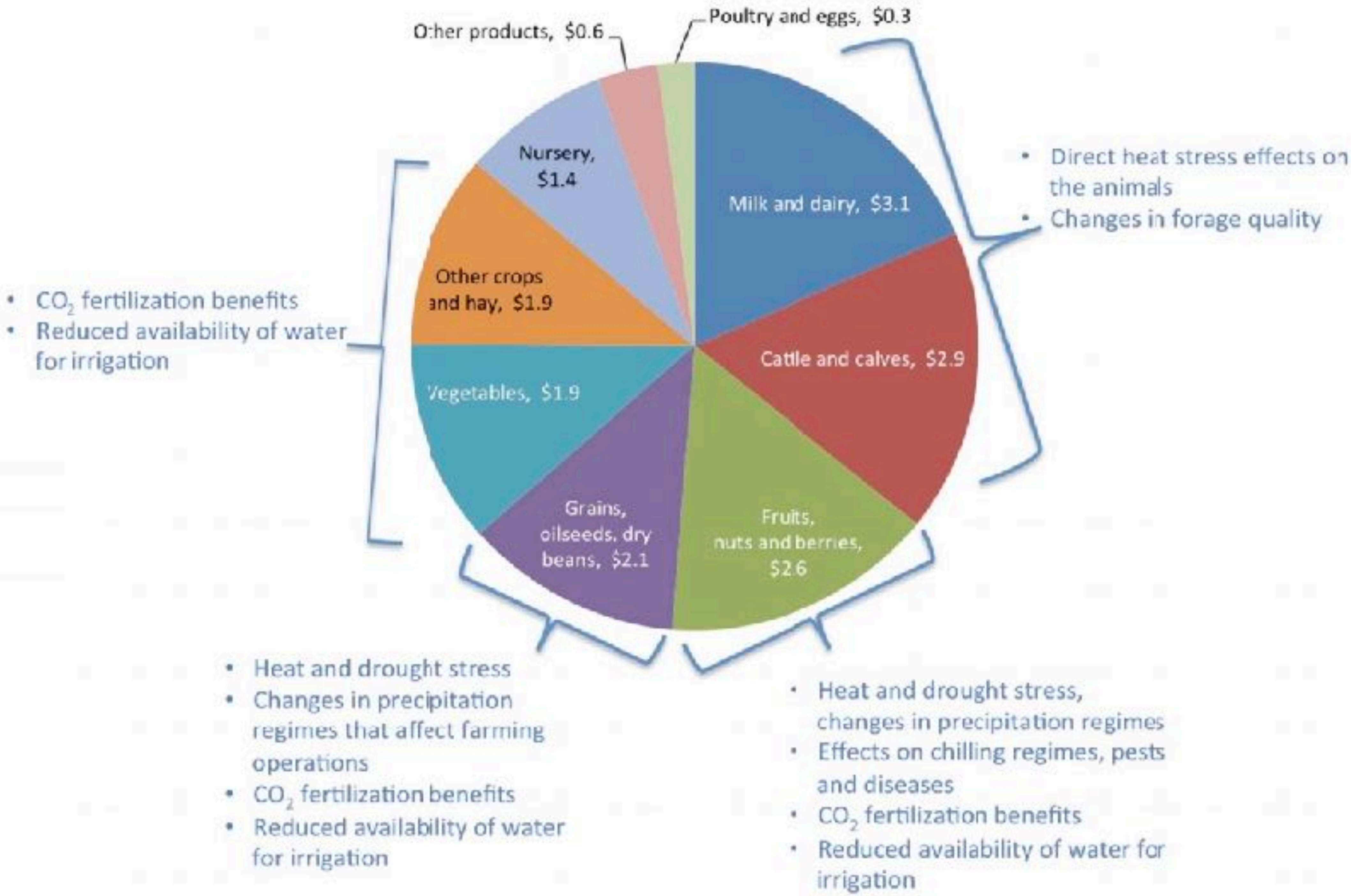
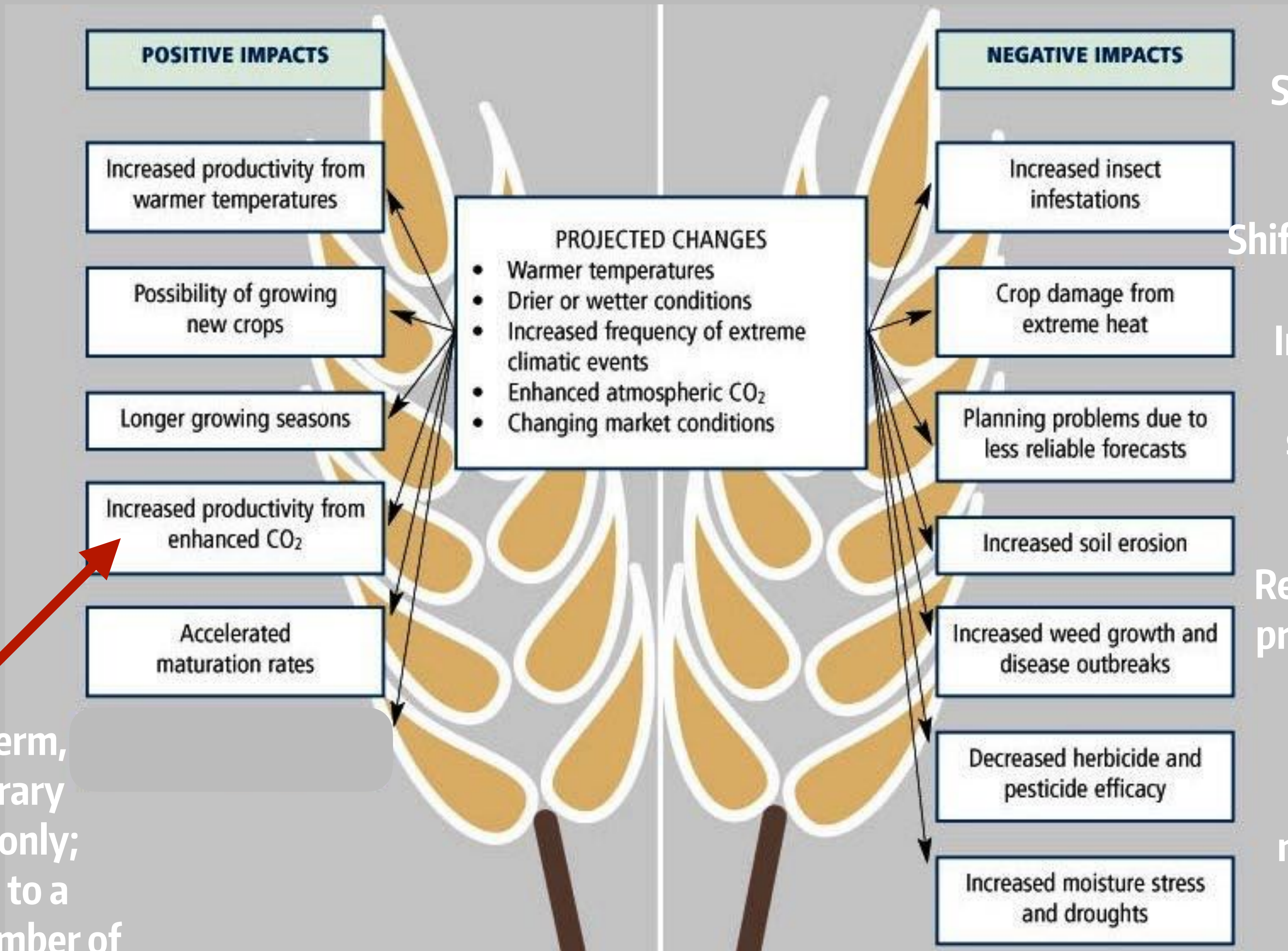


Figure 11-1. Climate change impacts on Pacific Northwest agriculture. Pacific Northwest agricultural commodities, with potential climate change impacts listed for each sector. Market values are shown in $ (billion), with a total value of $16.8 billion. *Figure source: Eigenbrode et al., 2013.*[1]

Snover et al., 2013



Near-term, temporary benefit only; applies to a limited number of crops

Stresses on irrigation

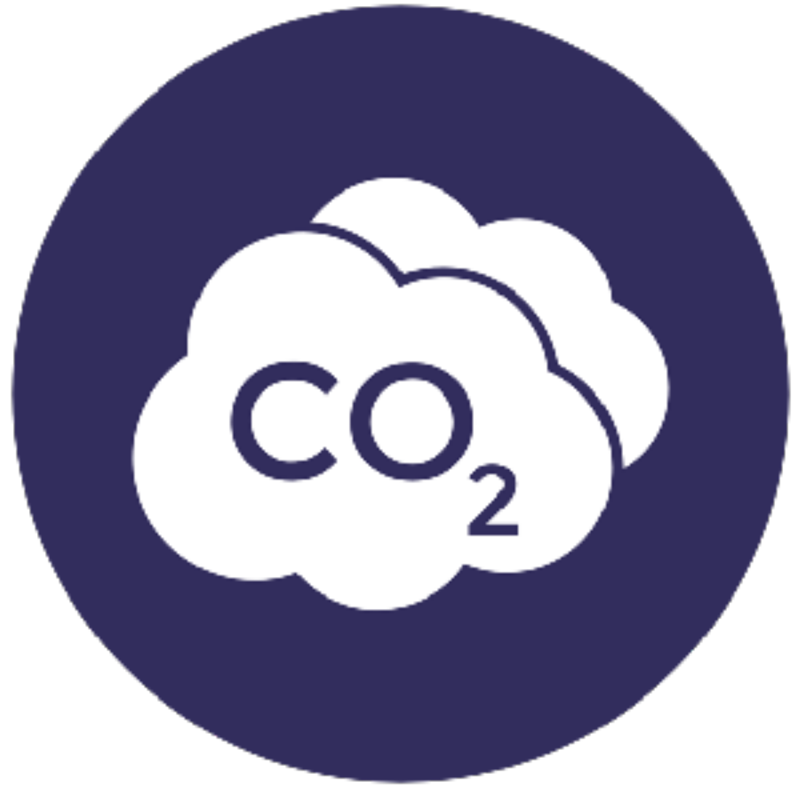
Shift seasonality

Inundation and saltwater intrusion

Reductions in productivity/ yields

Reduced nutritional quality

Modified from Natural Resources Canada

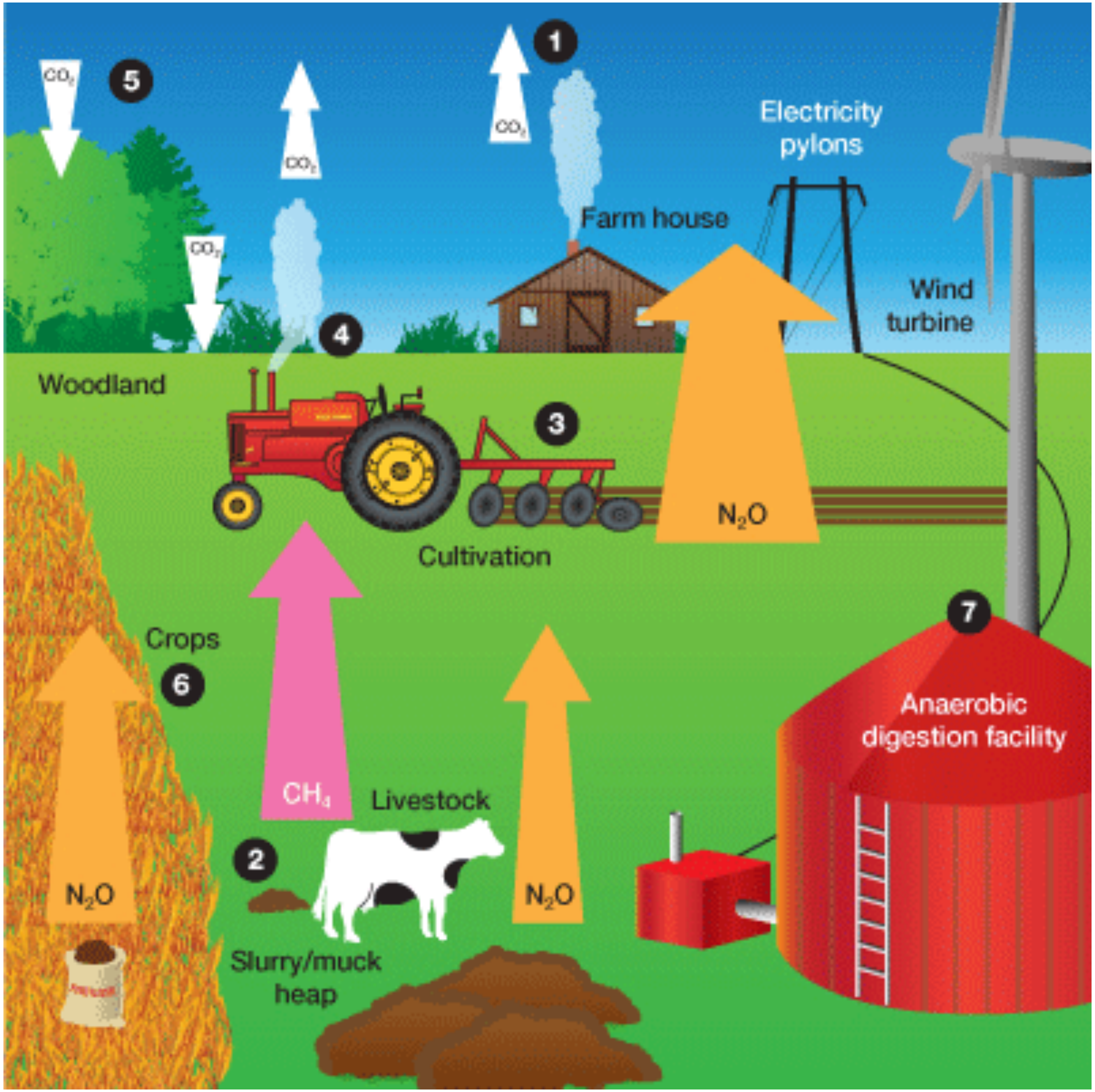


Carbon Dioxide & Greenhouse Gases -

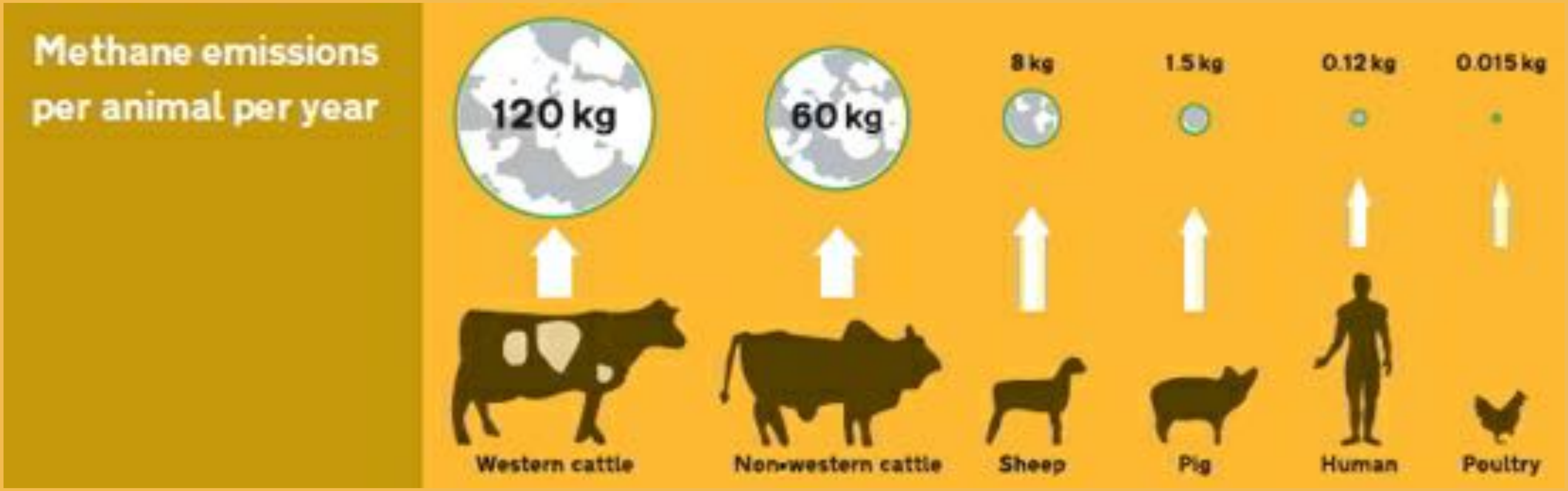
agriculture as source & sink

H. Roop

Greenhouse gas sources & sinks in agriculture



Farming Futures



World Future Council, 2012

Rising carbon dioxide levels **ramp up the process of photosynthesis** – which is what allows plants to transform sunlight into food.

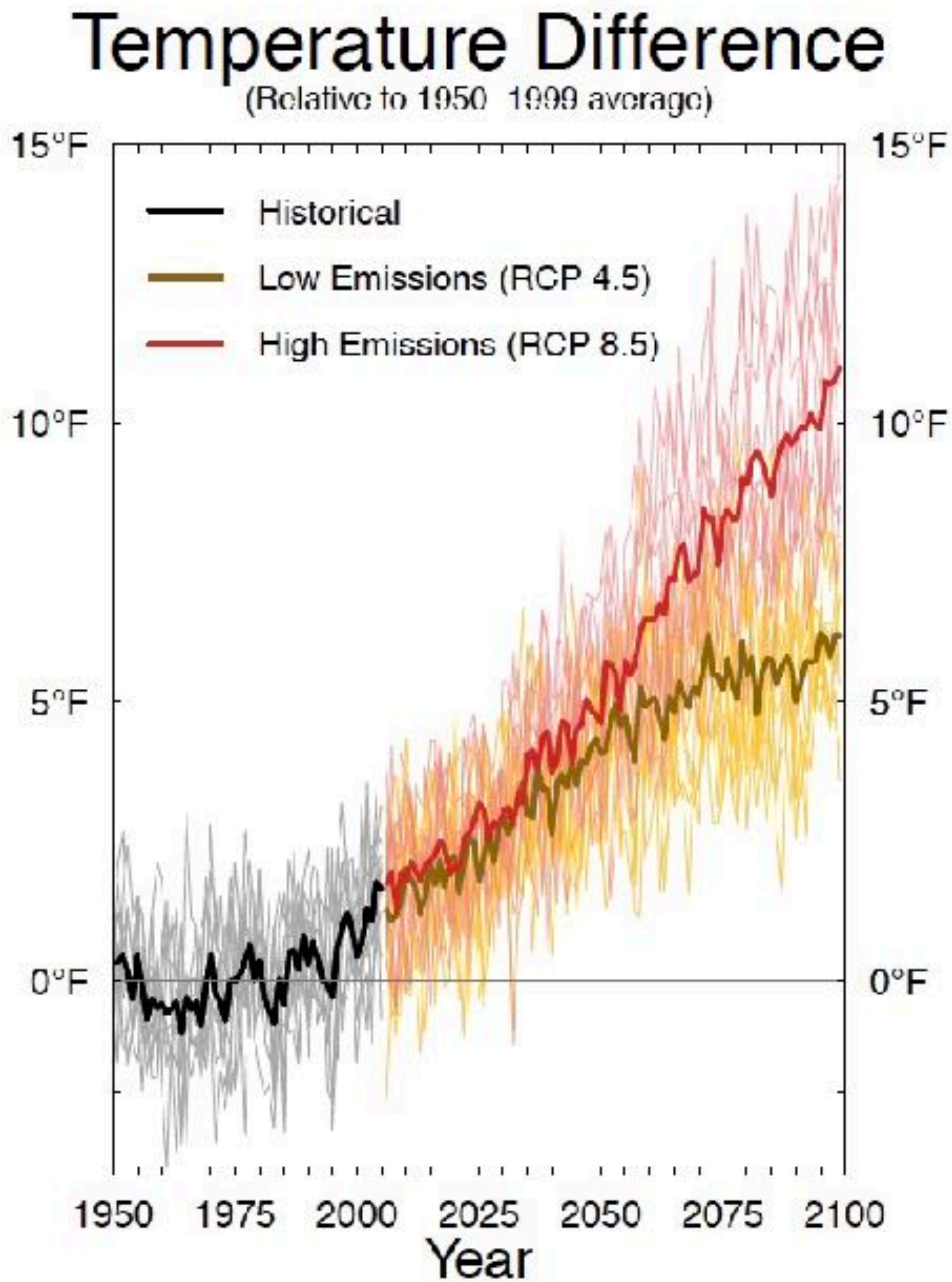
Some crops benefit from the increased CO_2 but the benefit is likely short-term and at the expense of the nutritional density of certain foods (more on that later).

Scheelbeek et al., 2018; PNAS

Increasing Air Temperature

H. Roop

Projected changes in temperature:



for Puget Sound, Climate Impacts Group, 2015

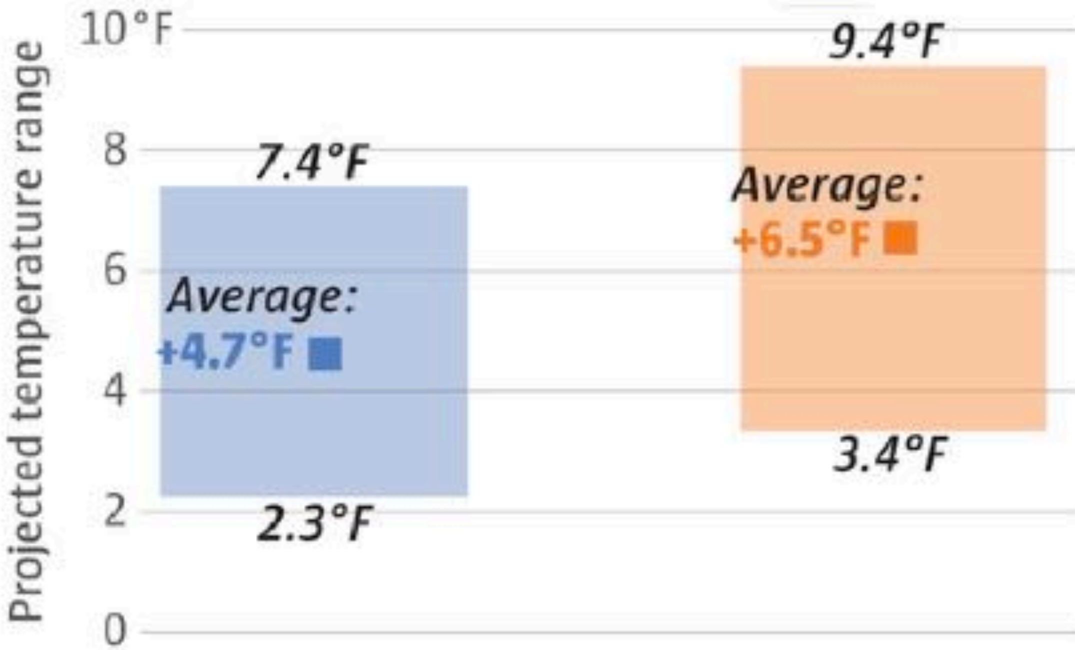
Hotter summers ahead

Climate change is projected to ramp up the heat — and increase the fire risk — of Northwest summers.

INCREASE* OF AVERAGE TEMPERATURE PROJECTIONS FOR 2041-2070

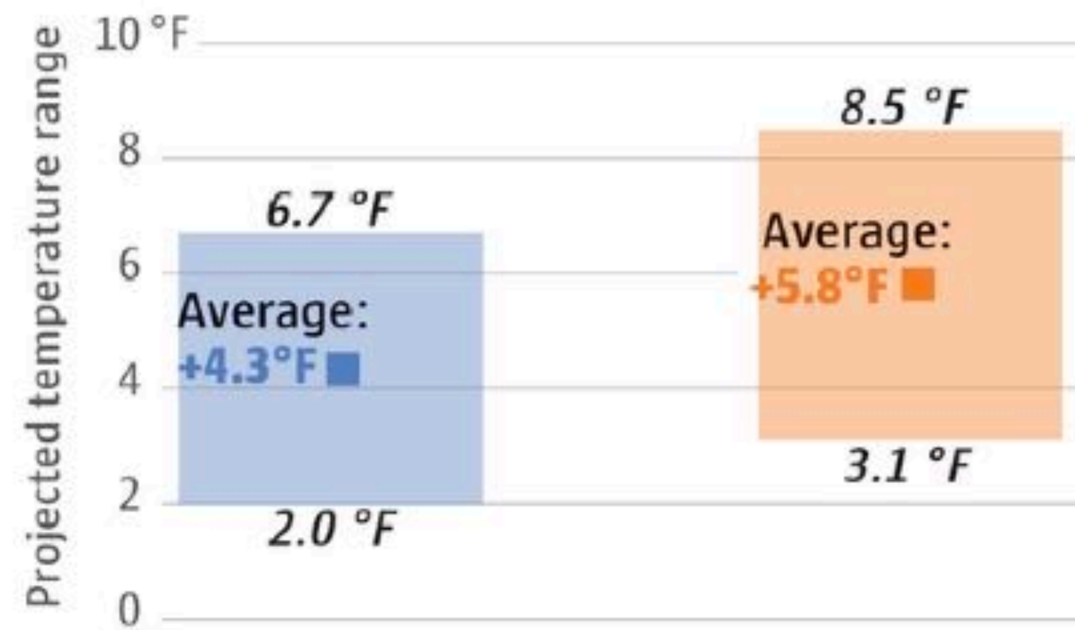
Low greenhouse-gas emissions scenario   High greenhouse-gas emissions scenario

Summer warming in Pacific Northwest



Summer of 2017 saw an increase of 3.6°F above the 1950-1999 average

Annual warming in Pacific Northwest



Climate-change projections:
Low-emissions scenario: 39 models analyzed
High-emissions scenario: 36 models analyzed

***Increase relative to the annual average for 1950-1999**

Sources: UW Cliimate Impacts Group analysis of models, https://CIG.uw.edu. NOAA National Centers for Environmental Information, Climate at a Glance: U.S. Time Series, Maximum Temperature, published September 2017

MARK NOWLIN / THE SEATTLE TIMES

Water -

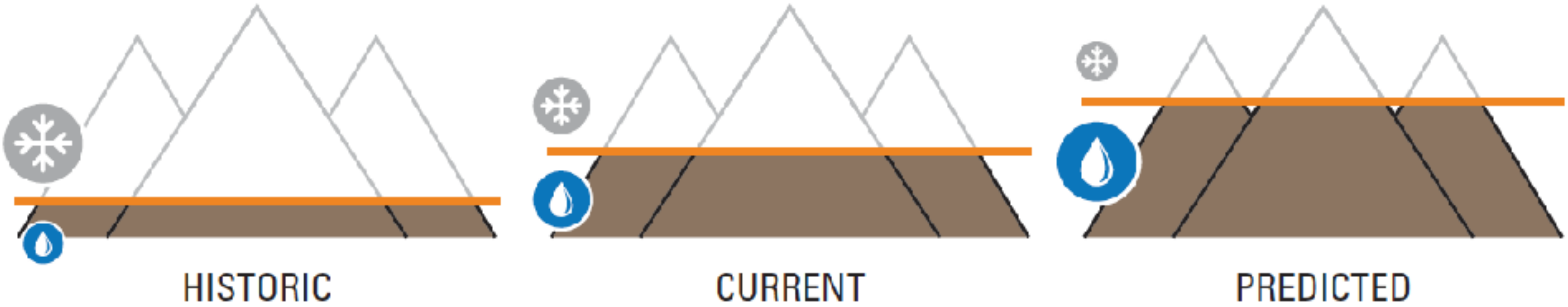
too much, too little

H. Roop


PEAK STREAMFLOW IS OCCURRING
UP TO 20 DAYS EARLIER
Mauger et al., 2015 | Puget Sound | 1948-2002
©CIG; with aerial support from LightHawk


BY THE 2040', SUMMER STREAMFLOW IS PROJECTED TO DECREASE BY 19%.
Puget Sound | April-September | A1B scenario
Mauger et al., 2015

More Precipitation as Rain & Rising Winter Freezing Levels



Modified from Skagit Climate Consortium

Observed Shifts in Streamflow Timing

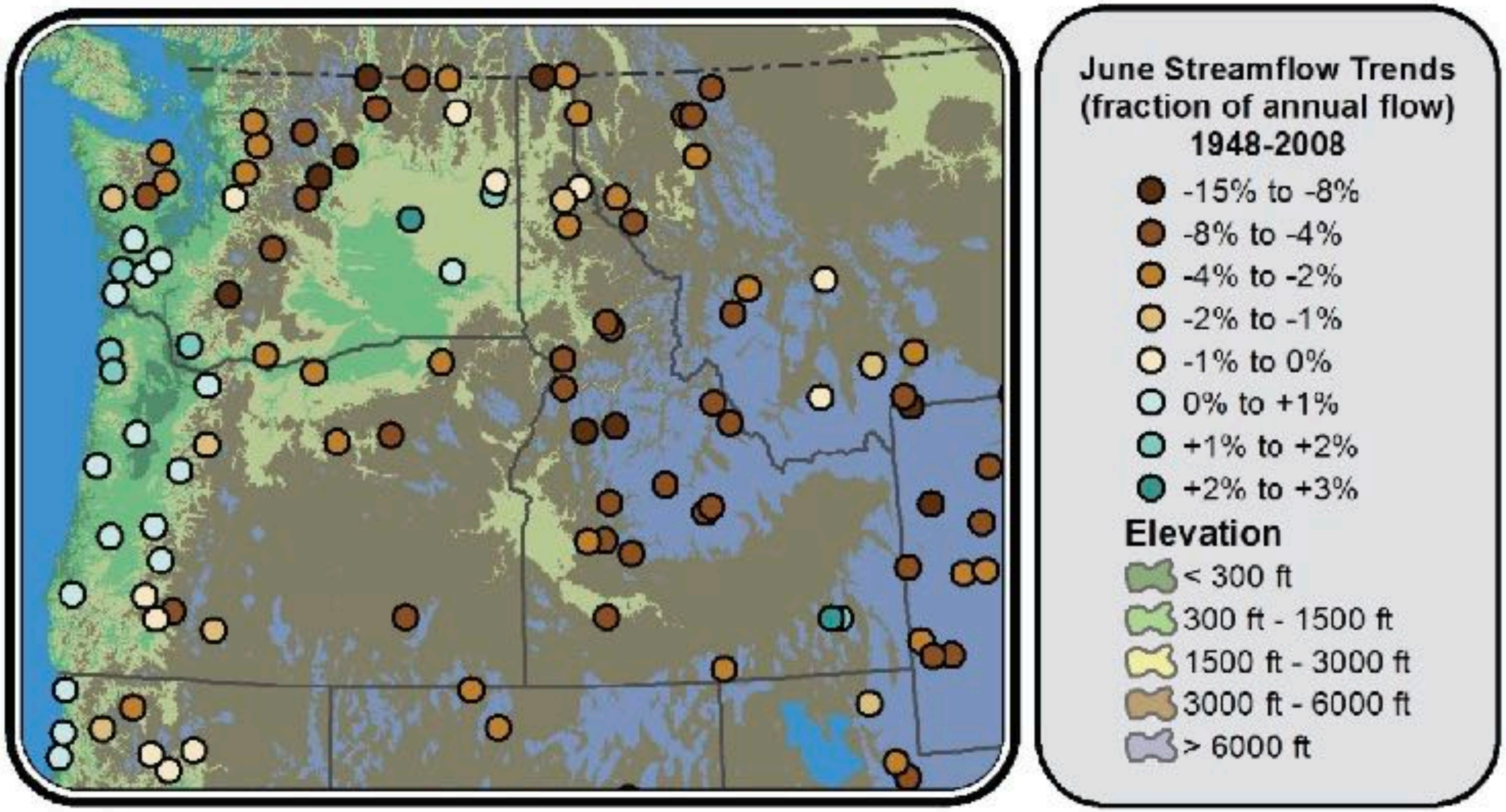
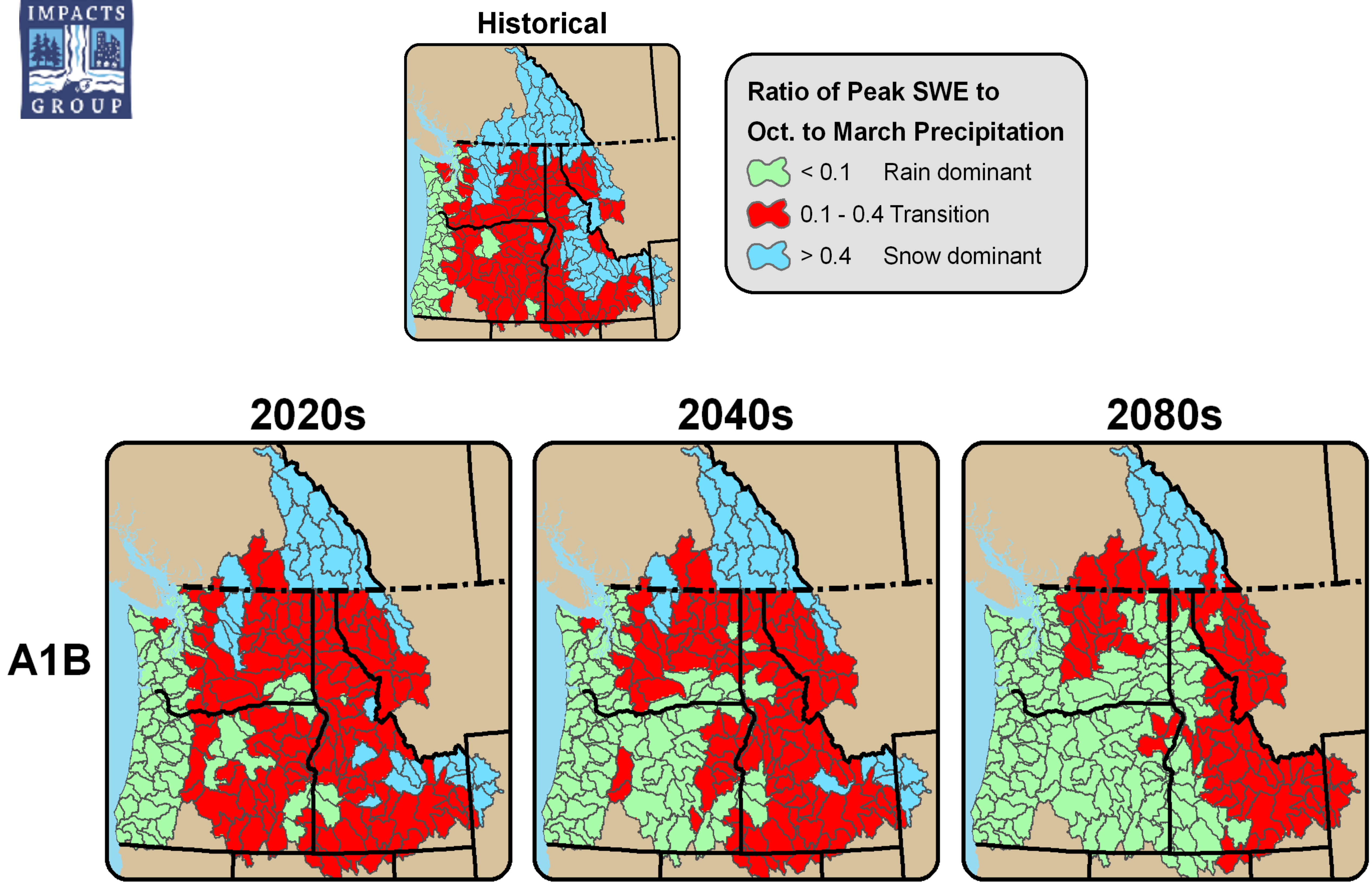


Figure 21.1: Reduced June flows in many Northwest snow-fed rivers is a signature of warming in basins that have a significant snowmelt contribution. The fraction of annual flow occurring in June increased slightly in rain-dominated coastal basins and decreased in mixed rain-snow basins and snowmelt-dominated basins over the period 1948 to 2008. [16] The high flow period is in June for most Northwest river basins; decreases in summer flows can make it more difficult to meet a variety of competing human and natural demands for water. (Figure source: adapted from Fritze et al. 2011 [16]).

NCA, 2014

Basin Transformations: Shifting from snow to rain



A1B: Medium emissions scenario

Mauger et al., 2015

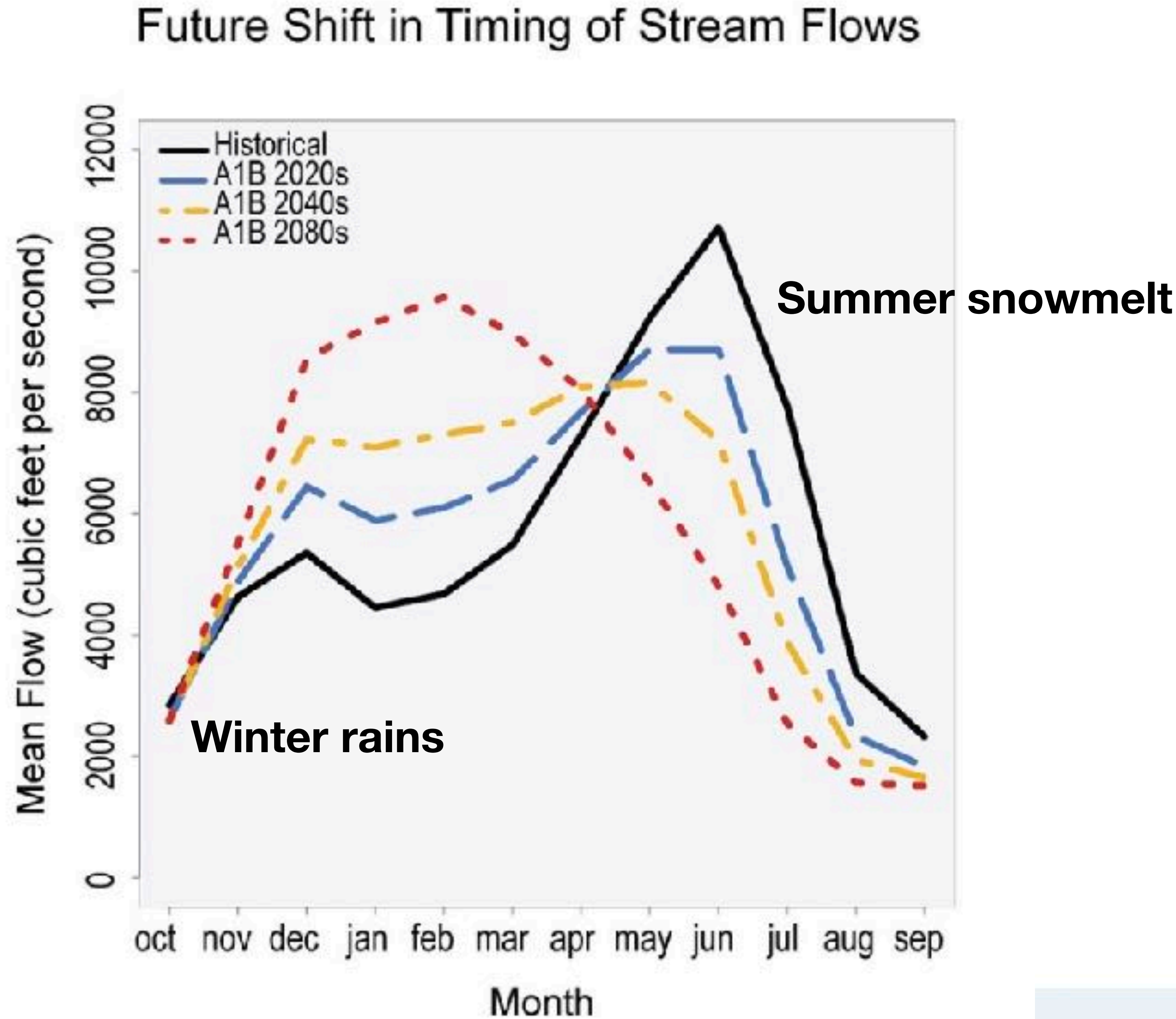
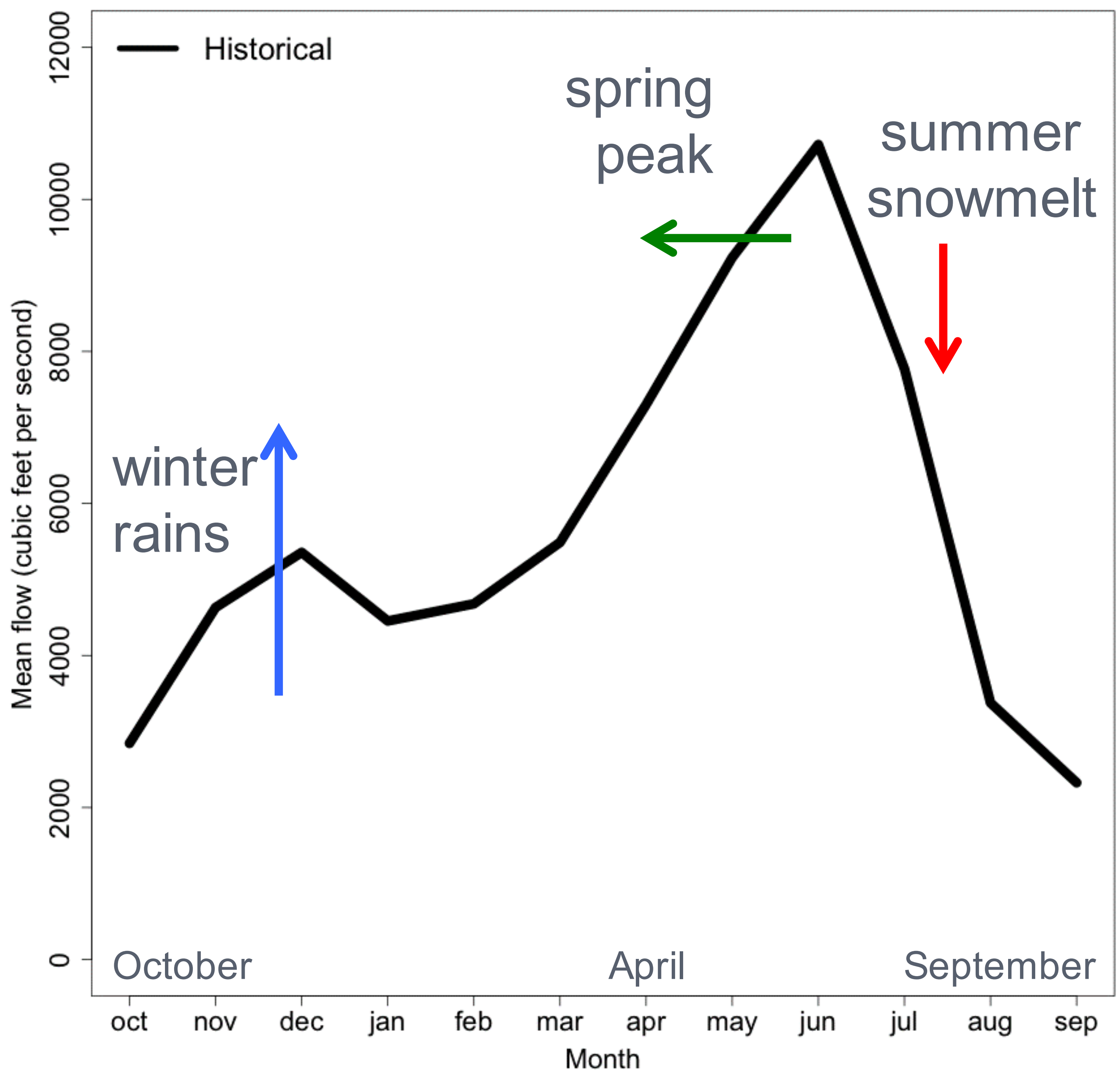


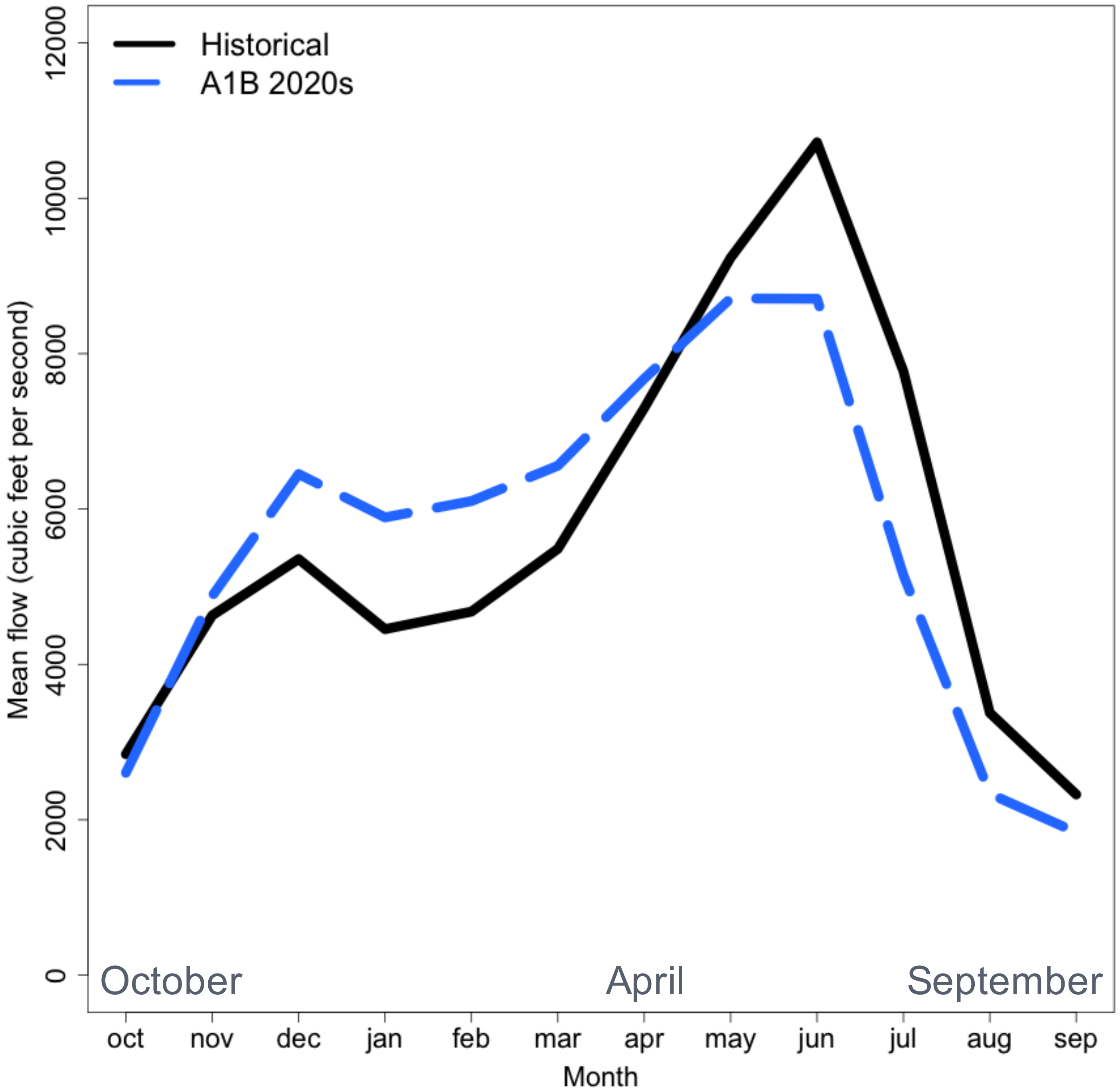
Figure 21.2: (Left) Projected increased winter flows and decreased summer flows in many Northwest rivers will cause widespread impacts. Mixed rain-snow watersheds, such as the Yakima River basin, an important agricultural area in eastern Washington, will see increased winter flows, earlier spring peak flows, and decreased summer flows in a warming climate. Changes in average monthly streamflow by the 2020s, 2040s, and 2080s (as compared to the period 1916 to 2006) indicate that the Yakima River basin could change from a snow-dominant to a rain-dominant basin by the 2080s under the A1B emissions scenario (with eventual reductions from current rising emissions trends). (Figure source: adapted from Elsner et al. 2010).[17]

Shifting Streamflows – Yakima Basin



Elsner et al. 2010

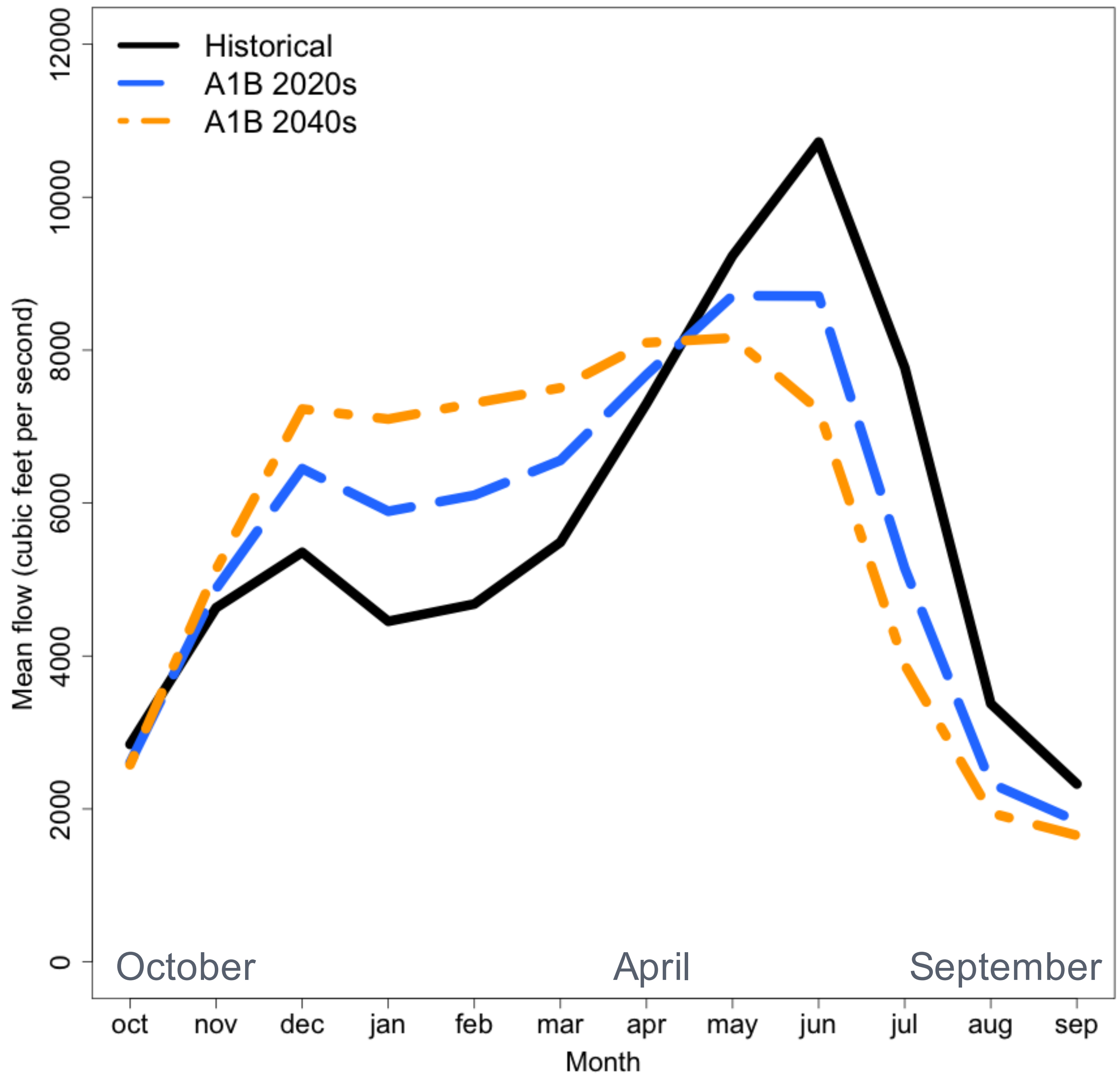
Shifting Streamflows – Yakima Basin



Elsner et al. 2010

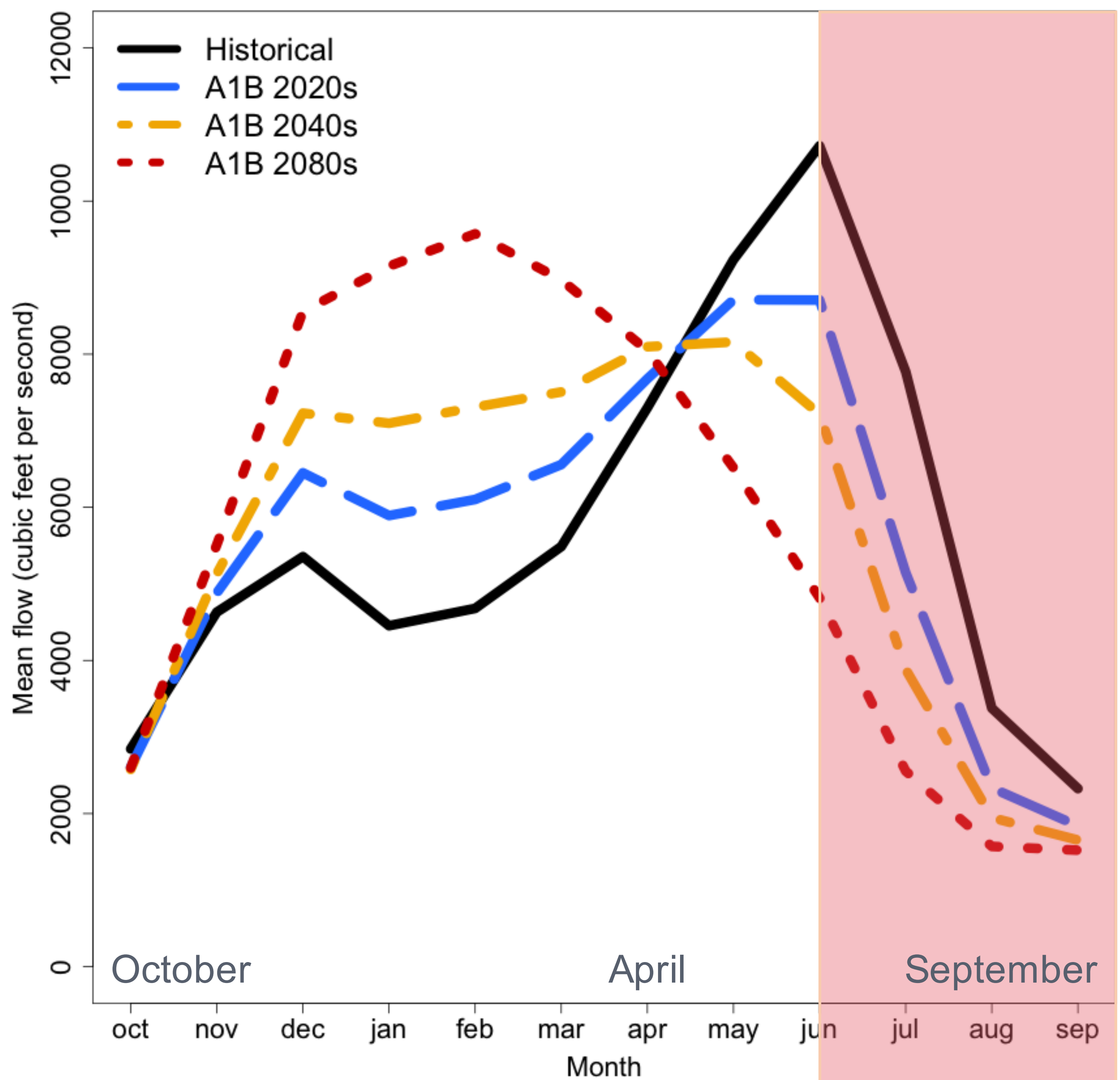
A1B: medium emissions scenario

Shifting Streamflows – Yakima Basin



Elsner et al. 2010

Shifting Streamflows – Yakima Basin



Water needed for:

- irrigation,
- instream flows,
- fall hydro-production

Elsner et al. 2010

In the Yakima basin, water shortage years – years with **curtailed water delivery** to junior water rights holders – are projected to **increase from 14%** of years historically to **36% to 77%** of years by the 2080s.

1979-1999 | for low & medium greenhouse gas scenario

Vano et al., 2010

Models predict 22% less rain during summer months by the 2050's

Puget Sound | Mauger et al., 2015


BY THE 2080's, THE WETTEST DAYS
IN THE PACIFIC NORTHWEST ARE PROJECTED
TO INCREASE BY 22%.
RCP8.5 | relative to 1970-1999
©CIG; with aerial support from LightHawk

Land Area and Extreme Precipitation

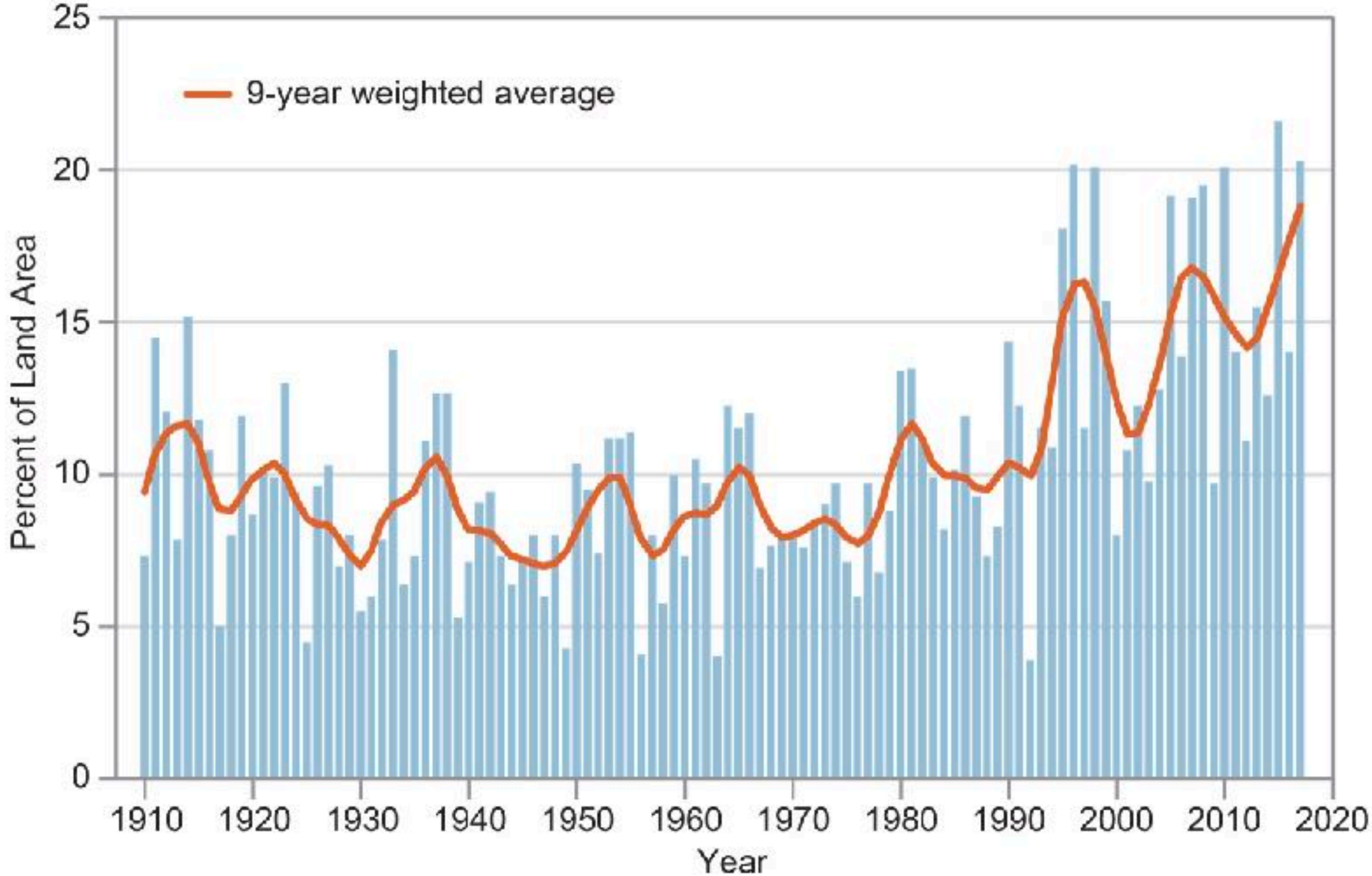
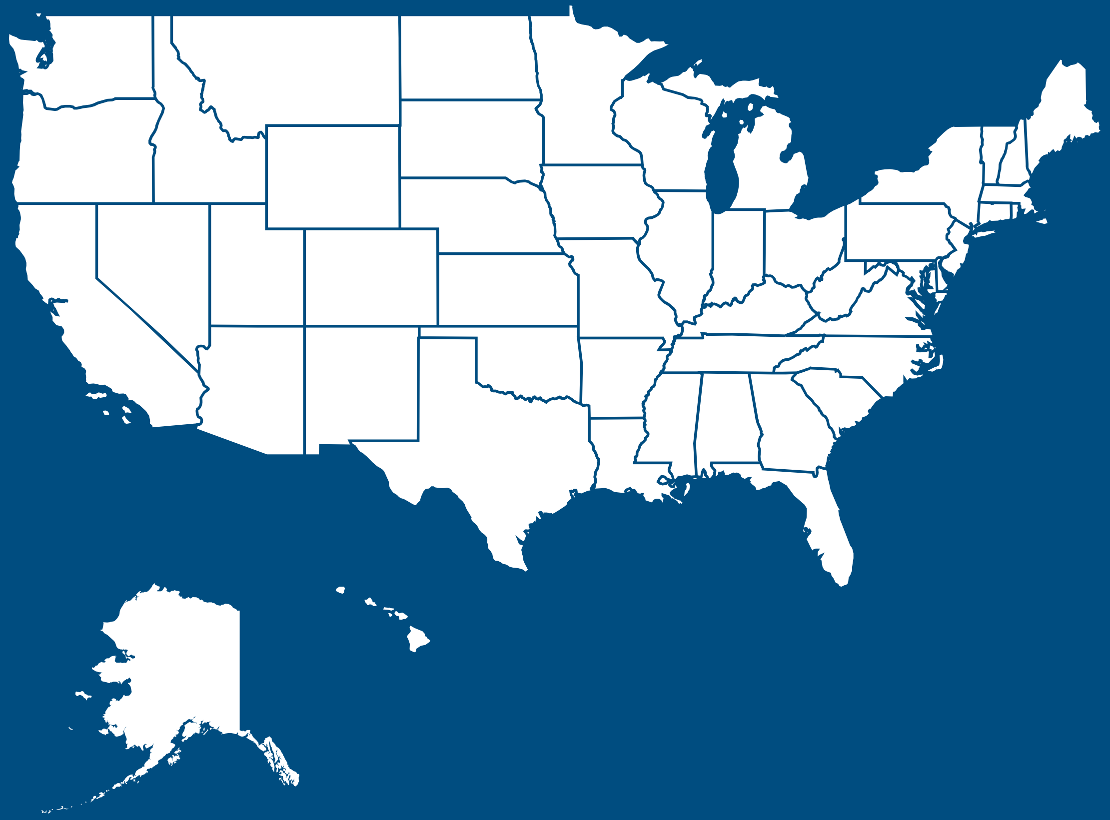


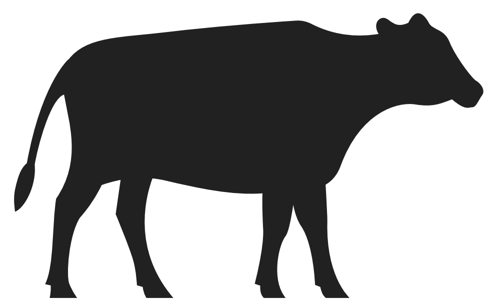
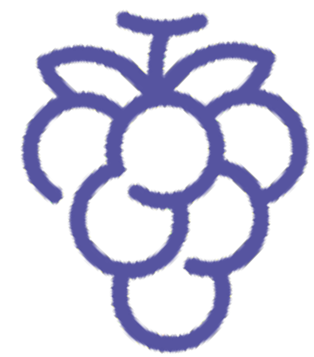
Figure 10.4: The figure shows the percent of land area in the contiguous 48 states experiencing extreme one-day precipitation events between 1910 and 2017. These extreme events pose erosion and water quality risks that have increased in recent decades. The bars represent individual years, and the orange line is a nine-year weighted average. Source: adapted from EPA 2016.[171]

NCA, 2018; from EPA, 2016

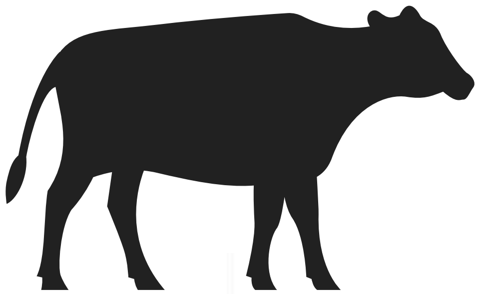


In the United States, property and crop damage from floods averaged nearly $8 billion per year (in 2011 dollars) from 1981 -2011.

Modified from NCA, 2018

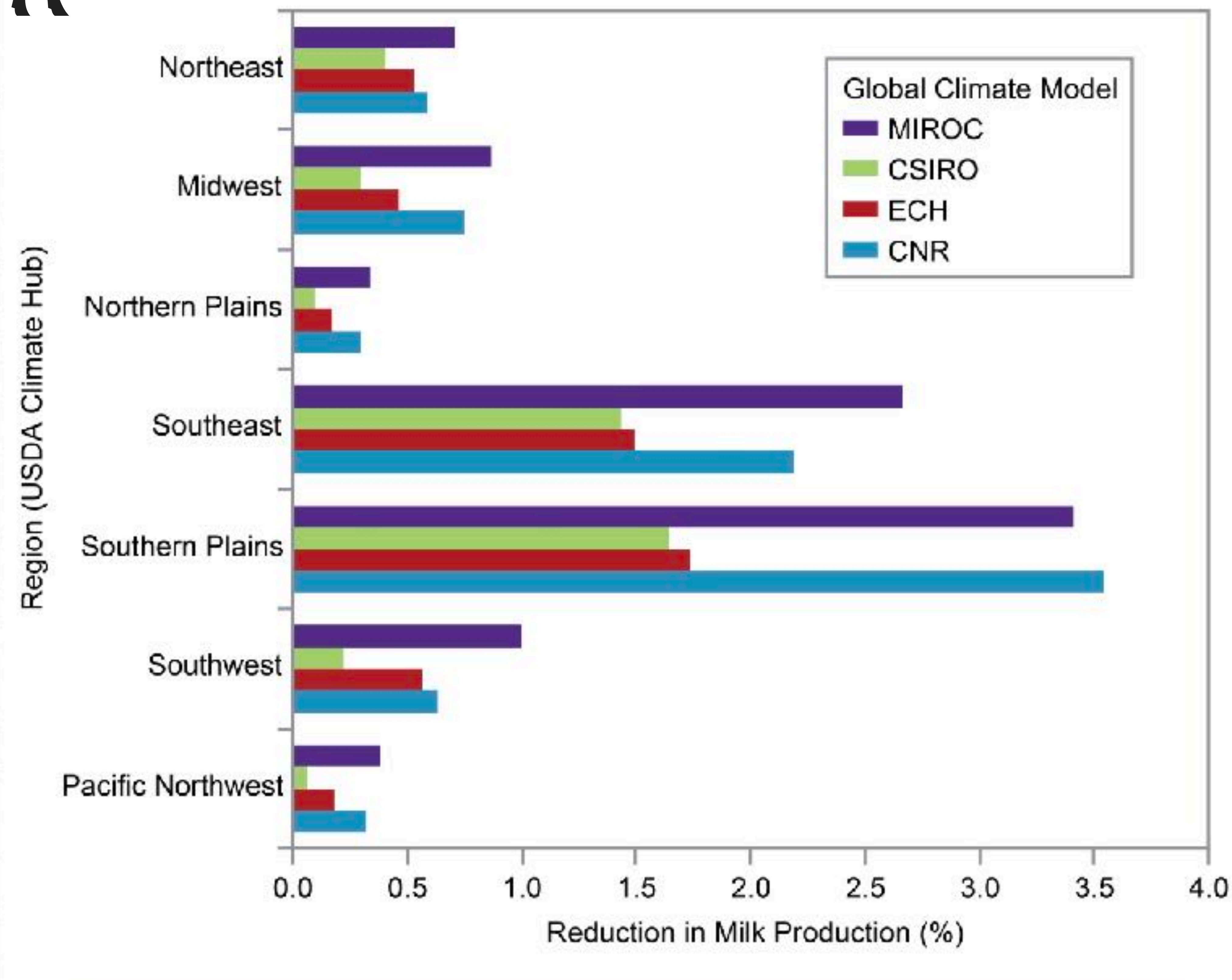
 

Productivity & Suitability



Projected Reduction in Annual Milk Production

(in 2030 compared to 2010)



after Key et al., 2014; from NCA, 2018

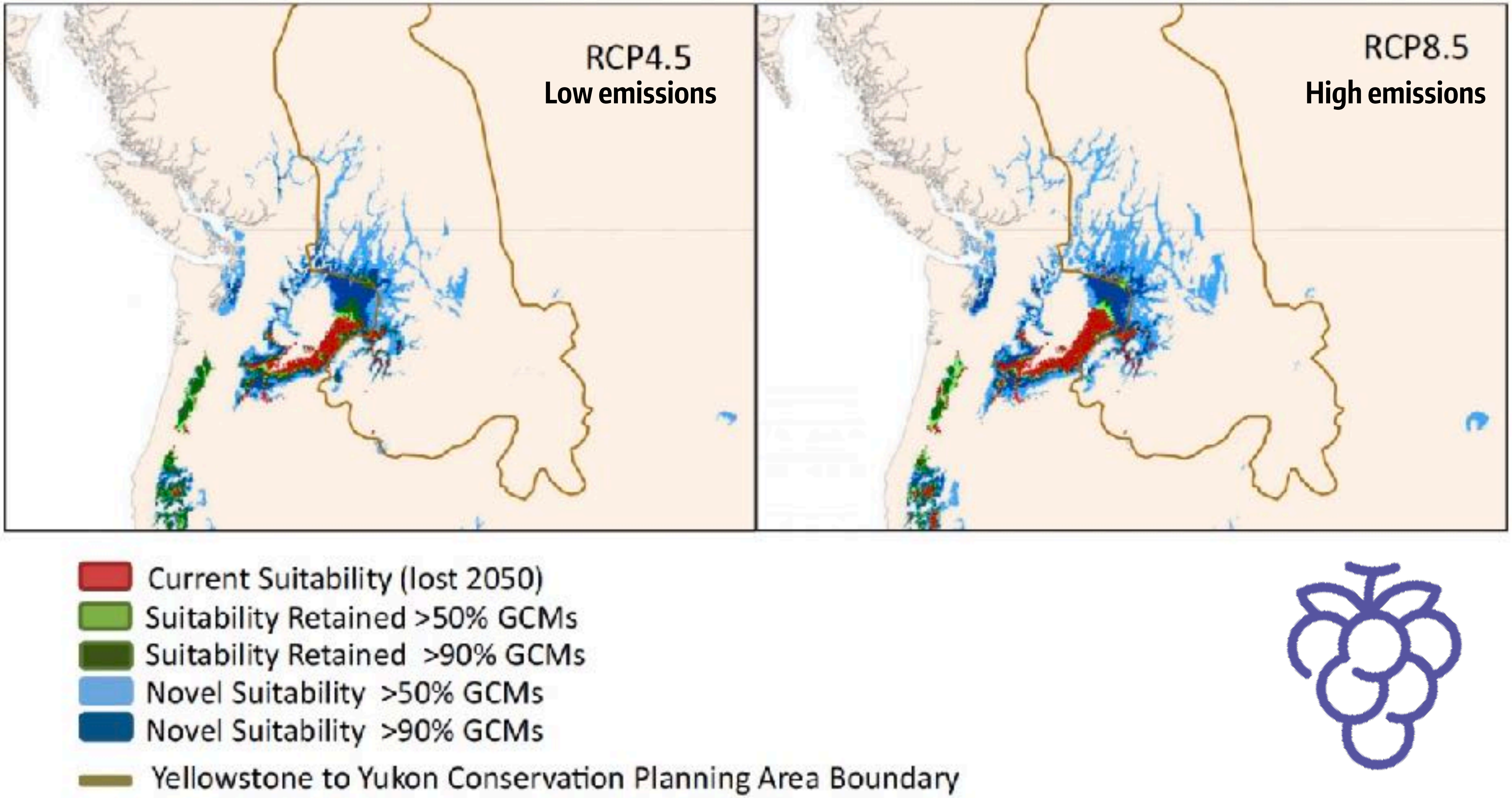


Figure 8-1. New areas becoming suitable for cultivating wine grapes. Projected changes in areas of climatic suitability for grapes for 2050 (2041-2060, relative to 1971-2000), under a low (RCP 4.5, left) and high (RCP 8.5, right) greenhouse gas scenario (see Section 1). Area suitable for viticulture is projected to increase from ~1.7 million acres to >+ 22 million acres under RCP 4.5 and to >+ 29 million acres under RCP 8.5 (increasing by a factor of 13 and 19, respectively). Results for both greenhouse gas scenarios indicate that the lowlands of Puget Sound will become newly suitable for grape production. *Figure source: Hannah et al. 2013* [D,15]

Mauger et al., 2015

Diurnal Temperature Range

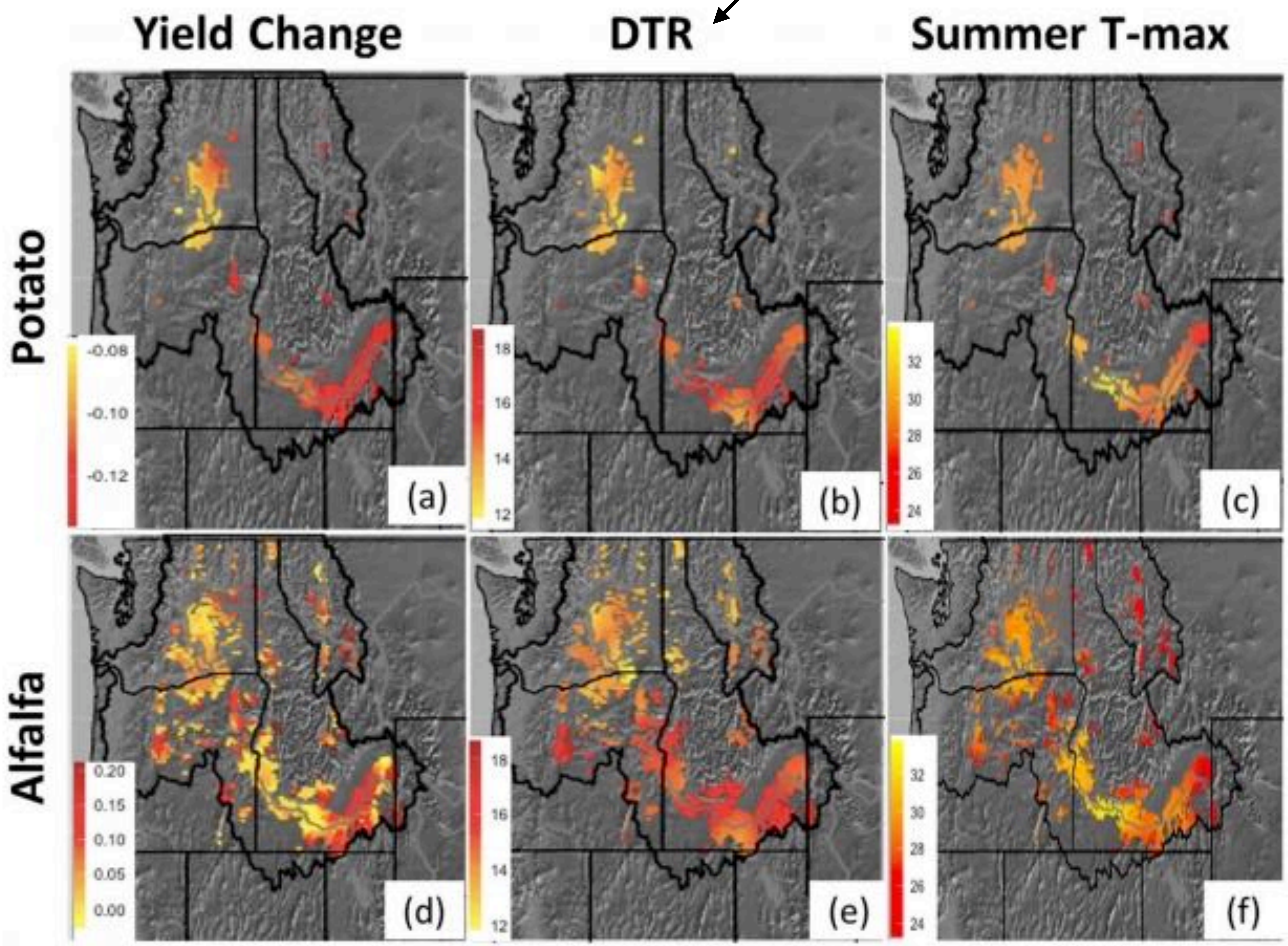


Figure 5. (a, d) Average changes in potato and alfalfa yields between 2030s middle climate scenario and historical condition, expressed as a fraction of historical yields; (b, e) average annual diurnal temperature range (DTR, calculated as Tmax-Tmin) in the 2030s for potato-growing and alfalfa-growing areas; and (c, f) 2030s daily maximum temperature (Tmax) averaged over the summer (June–August) for potato-growing and alfalfa-growing areas.

Rajagopalan et al., 2017

Health, Nutrition & Access

Many countries are already experiencing rapid price increases for basic food commodities, mainly due to production losses associated with more frequent weather extremes and unpredictable weather events.

The United States is a major exporter of agricultural commodities, and a disruption in its agricultural production will affect the agricultural sector on a global scale.

Food security is likely to become an even greater challenge as climate change impacts agriculture.

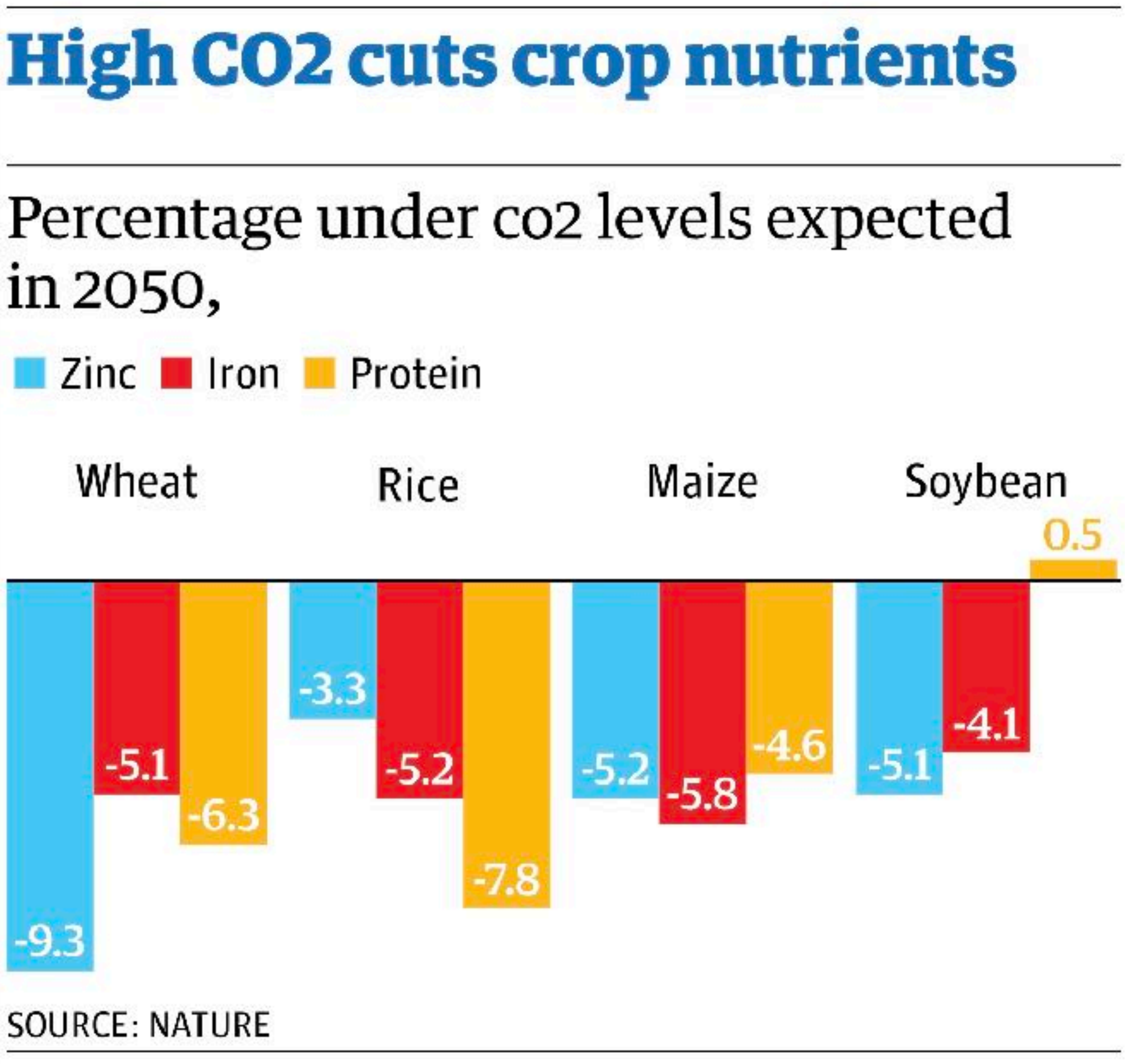
Food security will be further challenged by projected population growth as the world seeks to feed a projected 9.8 billion people by 2050.

NCA, 2018

Rising carbon dioxide levels **ramp up the process of photosynthesis** – which is what allows plants to transform sunlight into food.

While rising CO_2 certainly helps plants grow, it has the side effect of causing them to produce more simple carbohydrates such as glucose. **This can come at the expense of other important nutrients including protein, zinc and iron.**

Scheelbeek et al., 2018; PNAS



Myers et al., 2014 | Nature

Climate change in our backyard:

Change with 1.5°C		Risks
More very hot days (above 90°F)	↑ 67%	Heat-related illness and deaths Warmer streams stressing salmon More frequent harmful algal blooms
Reduced snowpack (April 1st snow water equivalent)	↓ 38%	Reduced water storage Irrigation shortages Winter and summer recreation losses
Higher winter streamflow (October-March)	↑ 16%	River flooding Costly stormwater management and flood protection Negative effects on salmon populations

Change with 1.5°C		Risks
Lower summer streamflow (April-September)	↓ 23%	Reduced summer hydropower Conflicts over water resources Negative effects on salmon populations
Sea level rise (at 2100 due to delayed response)	↑ 1.4 feet	Coastal flooding and inundation Damage to coastal infrastructure and communities Bluff erosion

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2015: A postcard from the future?

2015

Temperature: ~2.7°C (4.8°F) warmer than pre-industrial
Snowpack: ~70% below normal (1970-1999 average)

FISHERIES
Low summer streamflow & warm waters resulted in fishery closures

>250,000 Columbia River sockeye salmon died

RECREATION
Low snowpack led to reductions in winter & summer recreation

42% shorter ski season at Stevens Pass

WILDFIRE
The most severe wildfire season in Washington's recorded history

>1,000,000 acres burned

>$253 million fire supression

AGRICULTURE
Warm temperatures & reduced water availability stressed WA agriculture

17 major crops with reduced yields

$633-733 million economic losses

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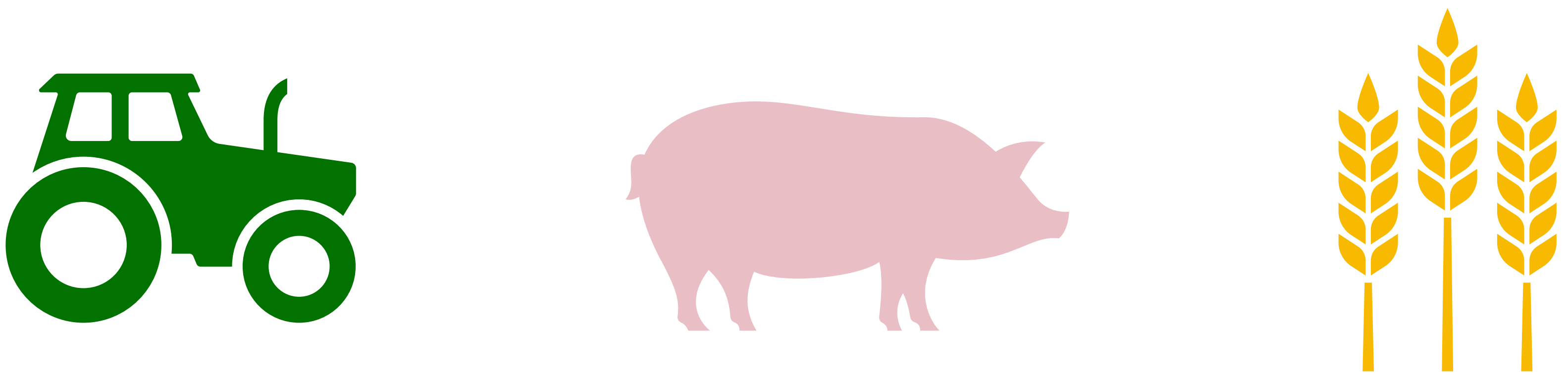
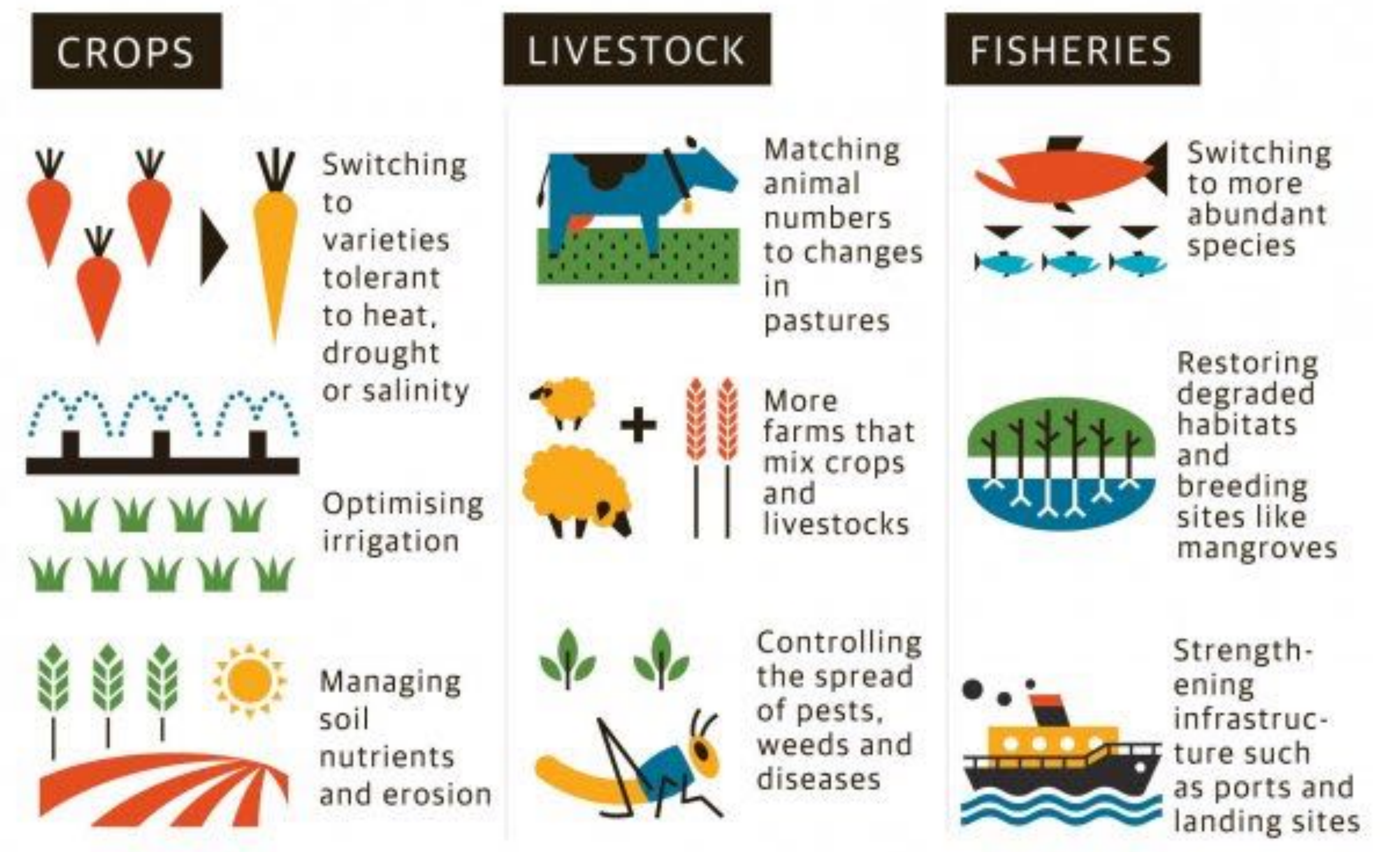
Snover et al., 2018



The ability of producers to adapt to climate change through planting decisions, farming practices, and use of technology can reduce its negative impact on production.

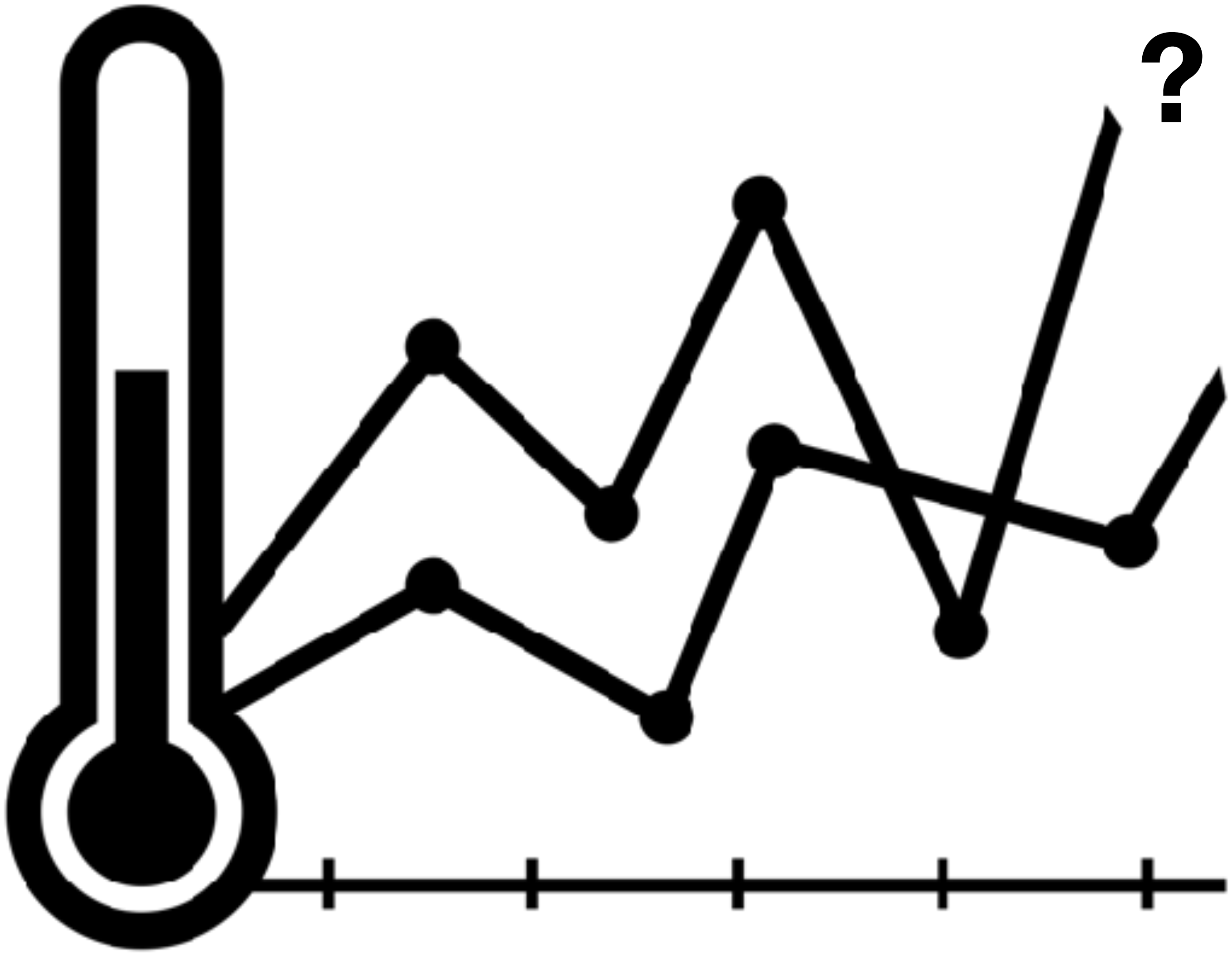
NCA, 2018

Potential Adaptation Actions

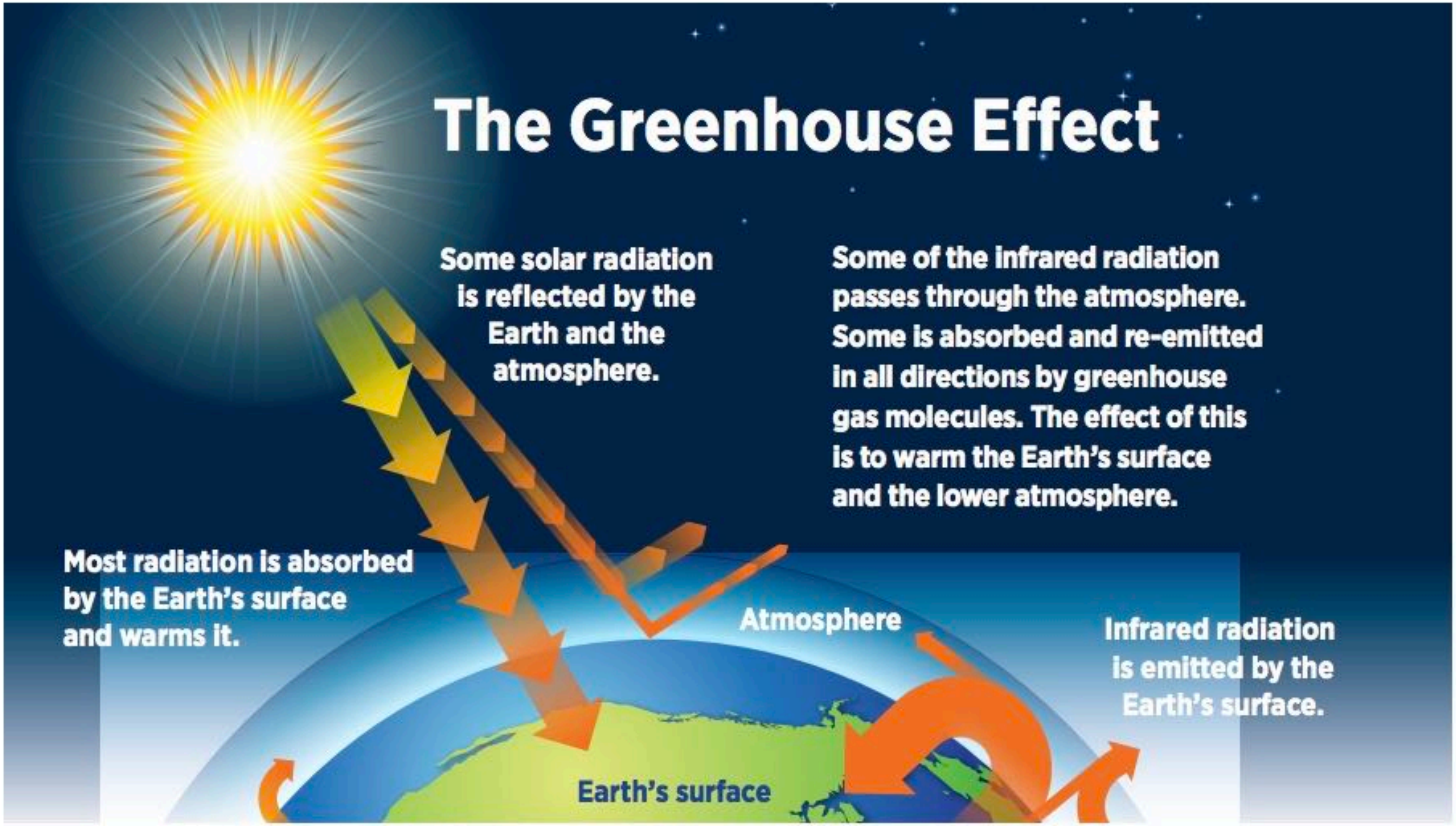


CCAFS, 2019

WHERE DOES THE HEAT COME FROM?



Greenhouse gases create Earth's "duvet".



From: EPA

GHG = Greenhouse Gas

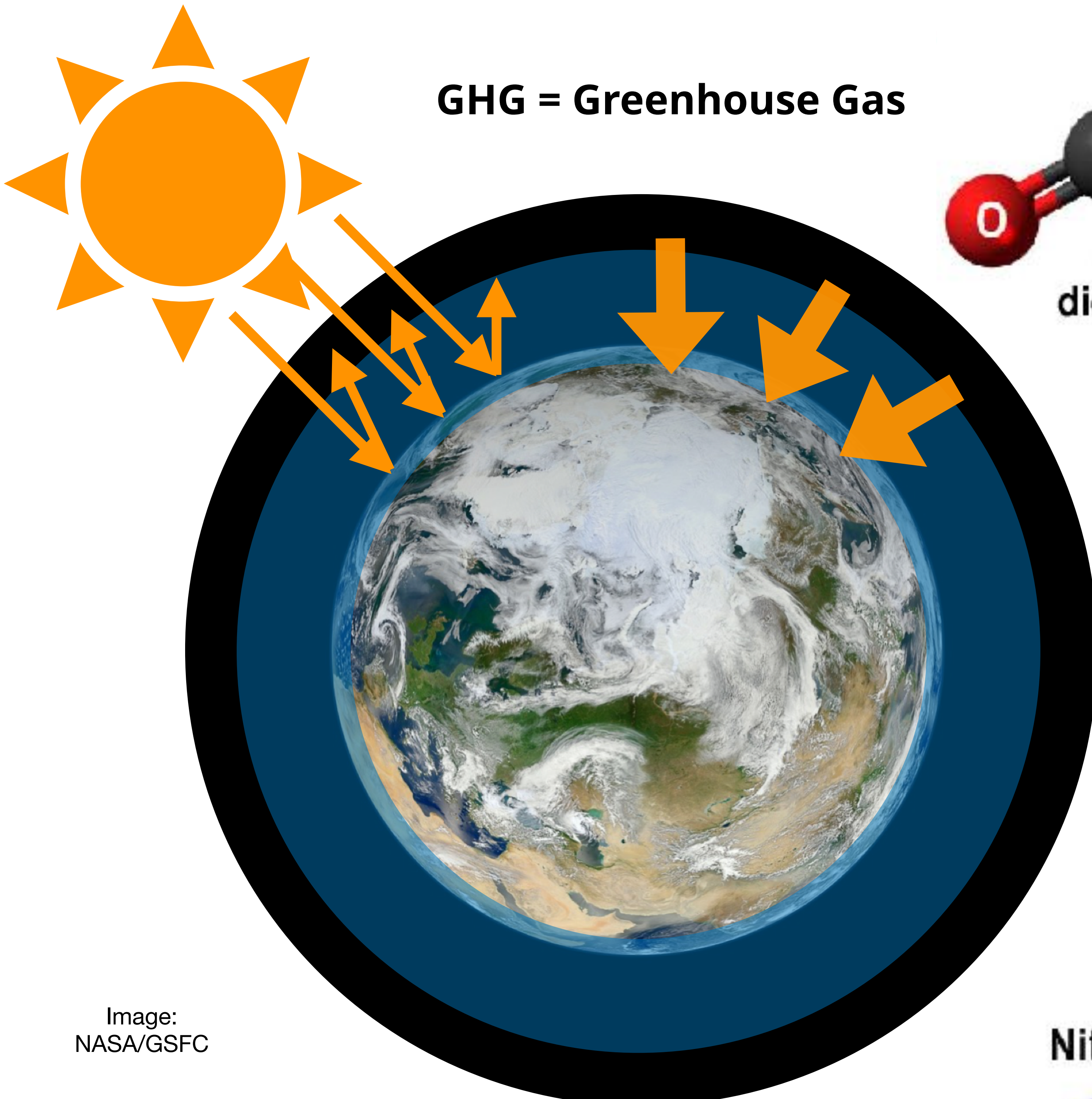
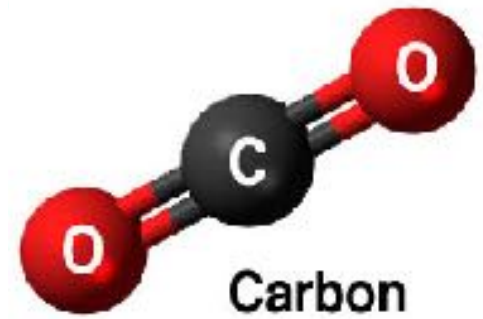
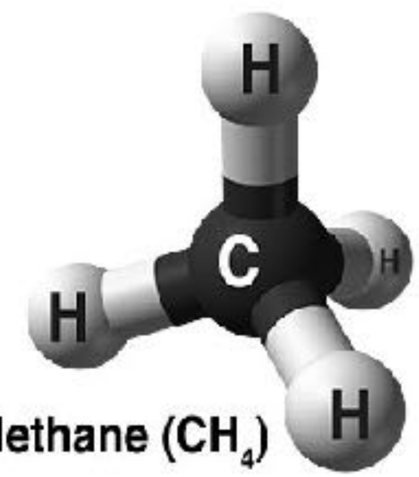


Image: NASA/GSFC



Carbon dioxide (CO_2)

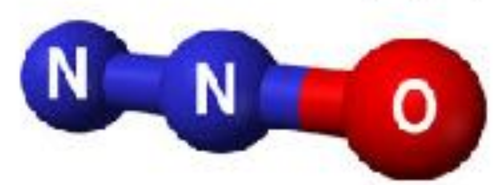
Released through natural (volcanic eruptions) & human activities (deforestation, land use changes & burning fossil fuels).



Methane (CH_4)

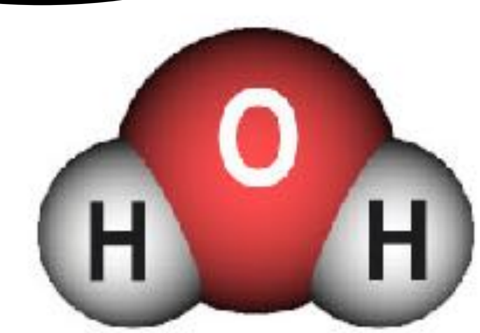
Produced by natural sources & human activities, including the decomposition of waste in landfills, agriculture, rice cultivation, and ruminant digestion.

Nitrous oxide (N_2O)



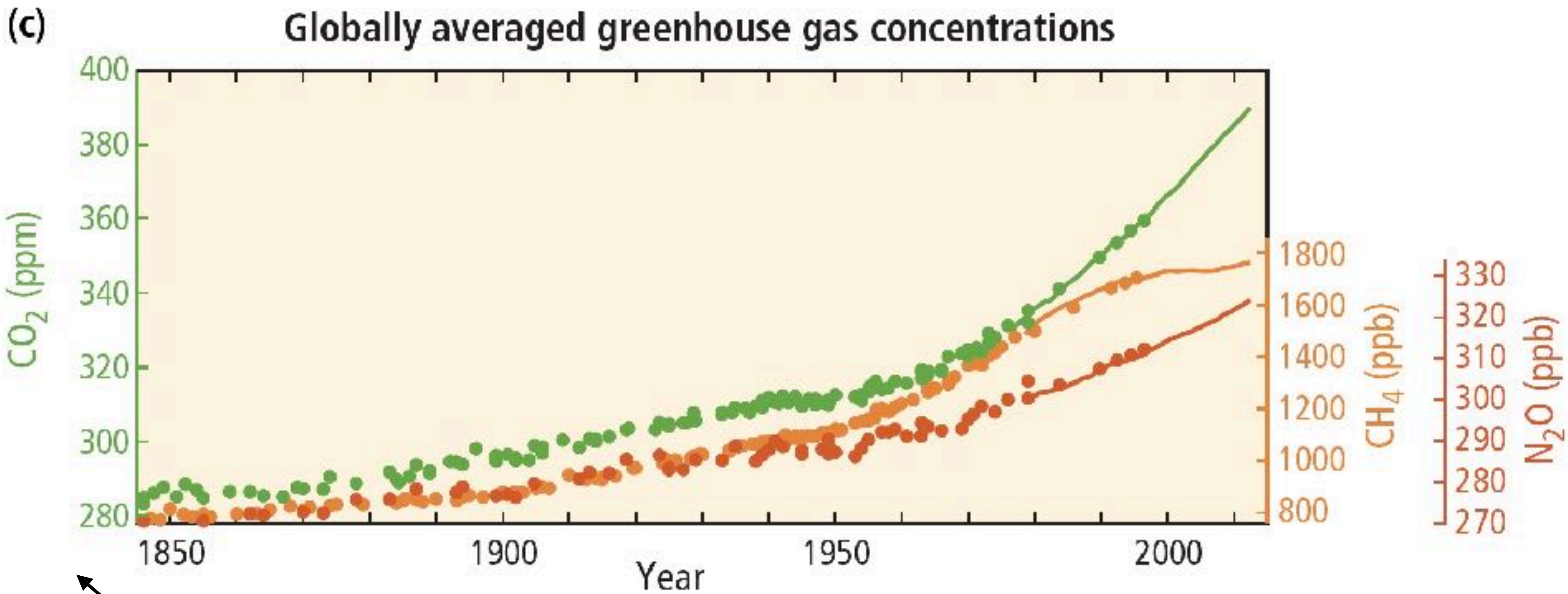
Produced by the use of commercial & organic fertilizers, fossil fuel combustion, nitric acid production & biomass burning.

The most abundant GHG. Water vapor increases as the atmosphere warms.



Water vapor (H_2O)

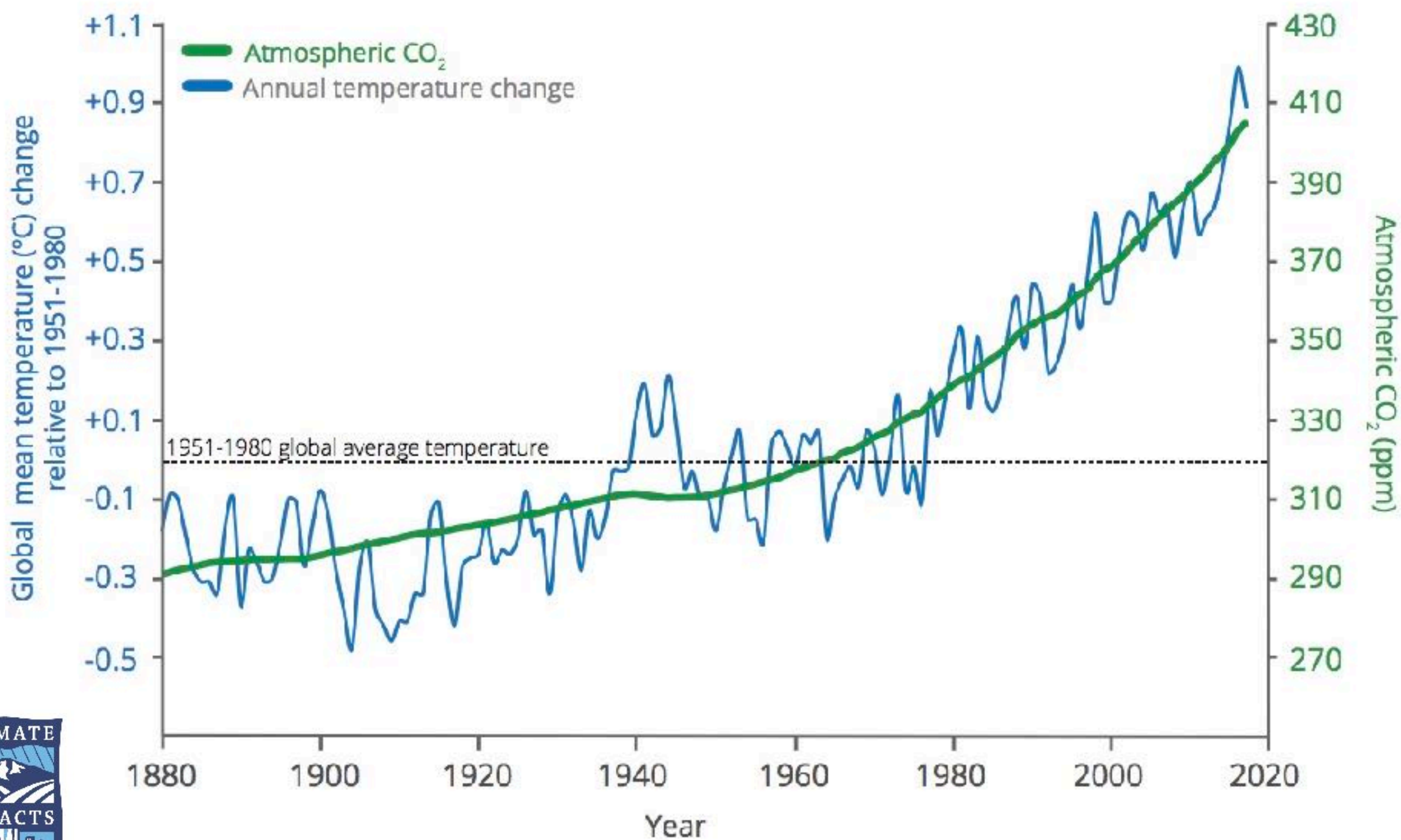
Modified from NASA.gov



We are going to look at the past later…

From: IPCC, 2014

~1.8ºF warming globally since the late 1800's



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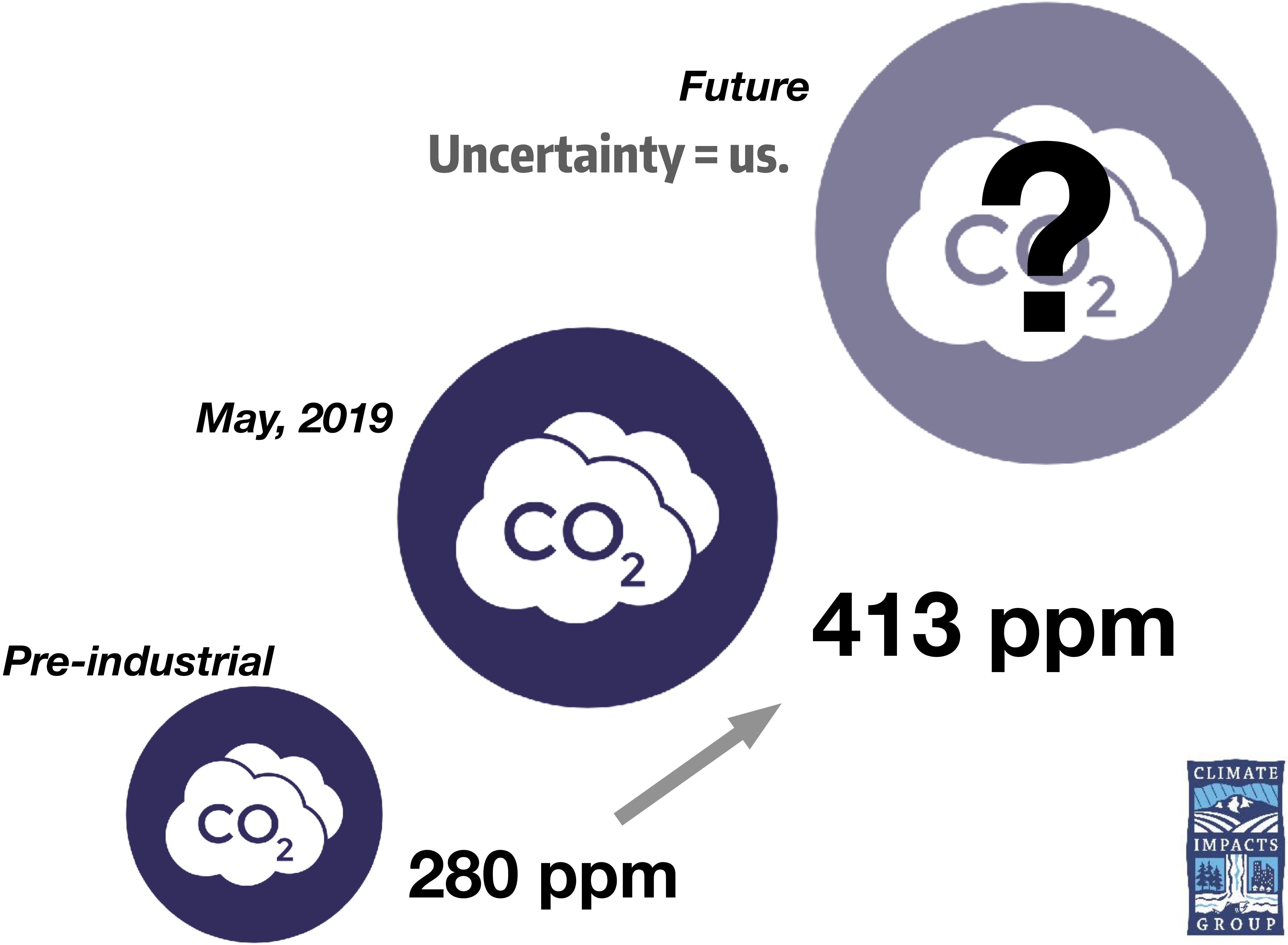
Created by H. Roop from NASA GISS, NOAA ESRL, NOAA NCEI data

There is high confidence (>95%) that human-produced greenhouse gases have caused much of the observed increase in Earth's temperature over the past 50 years.

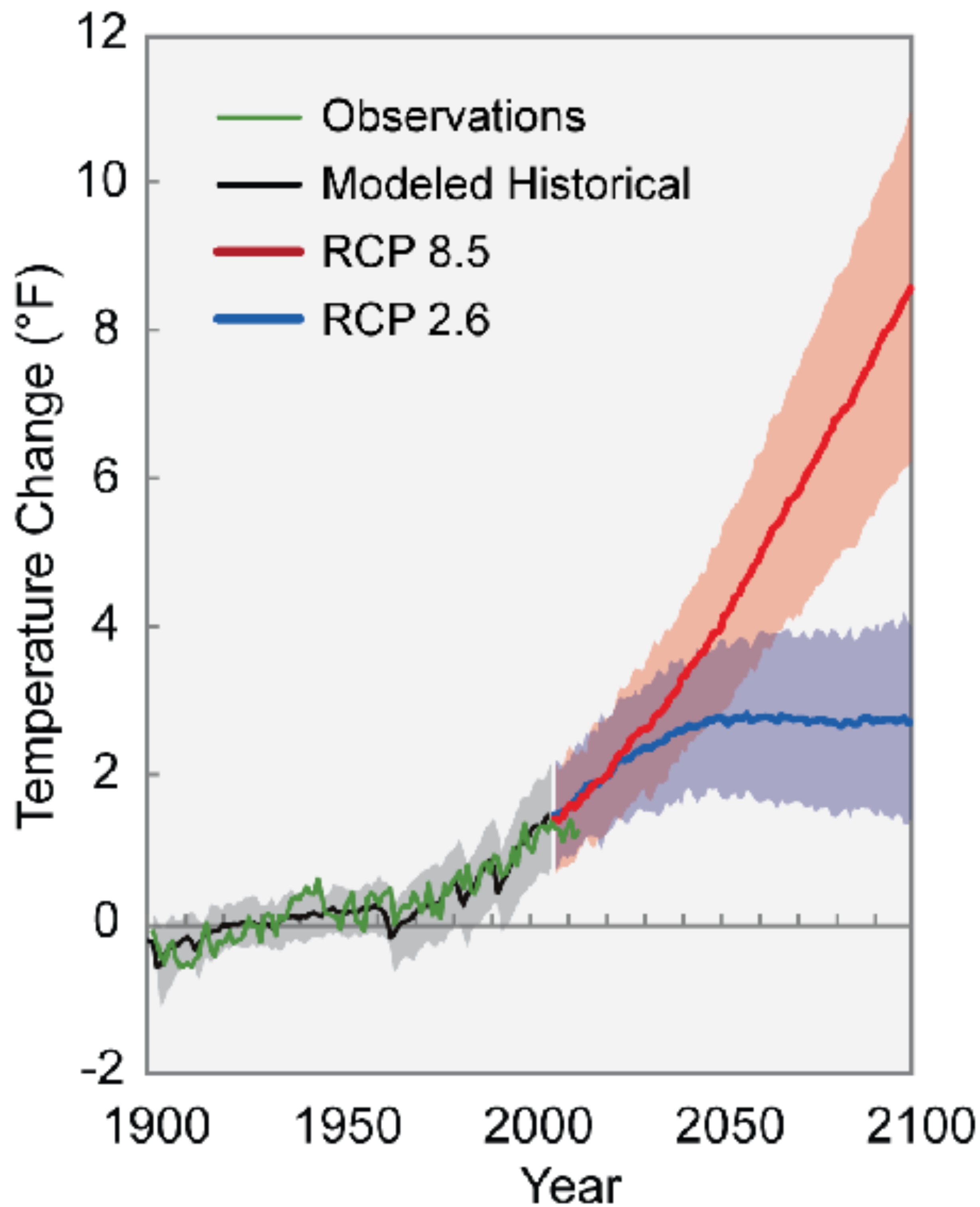
IPCC, 2014; Images: H. Roop



ppm= parts per million

Heidi Roop, UW Climate Impacts Group

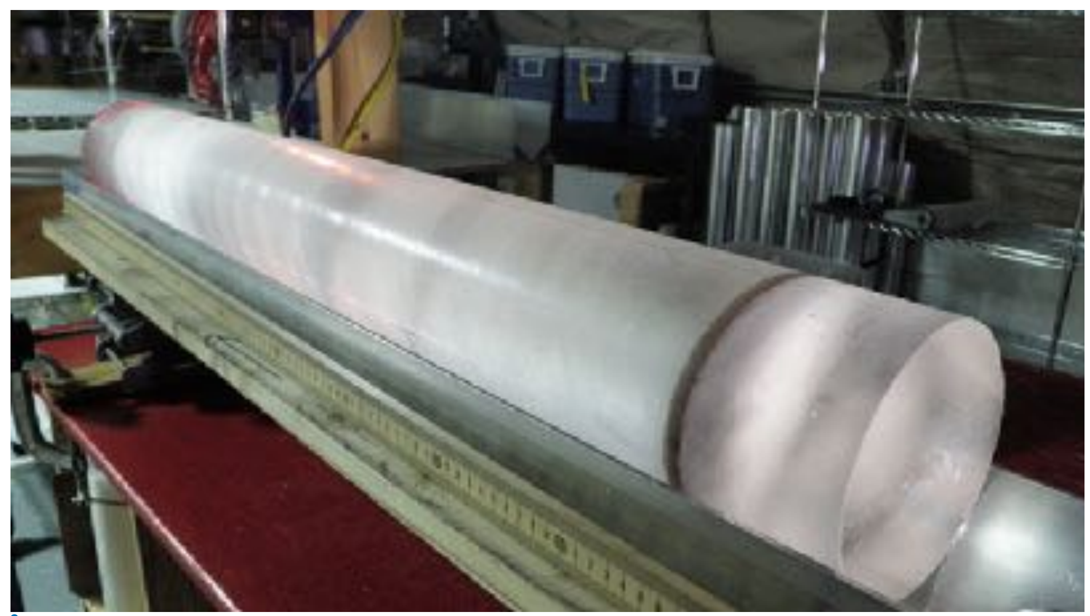
Emissions of Greenhouse Gases Determine Temperature Rises



NCA, 2018

HOW HAS CLIMATE CHANGED?

Lakes & Ice!



Ice!

H. Roop, Climate Impacts Group

FROM ICE CORES WE HAVE DIRECT MEASUREMENTS OF GREENHOUSE GASES BACK 800,000 years!

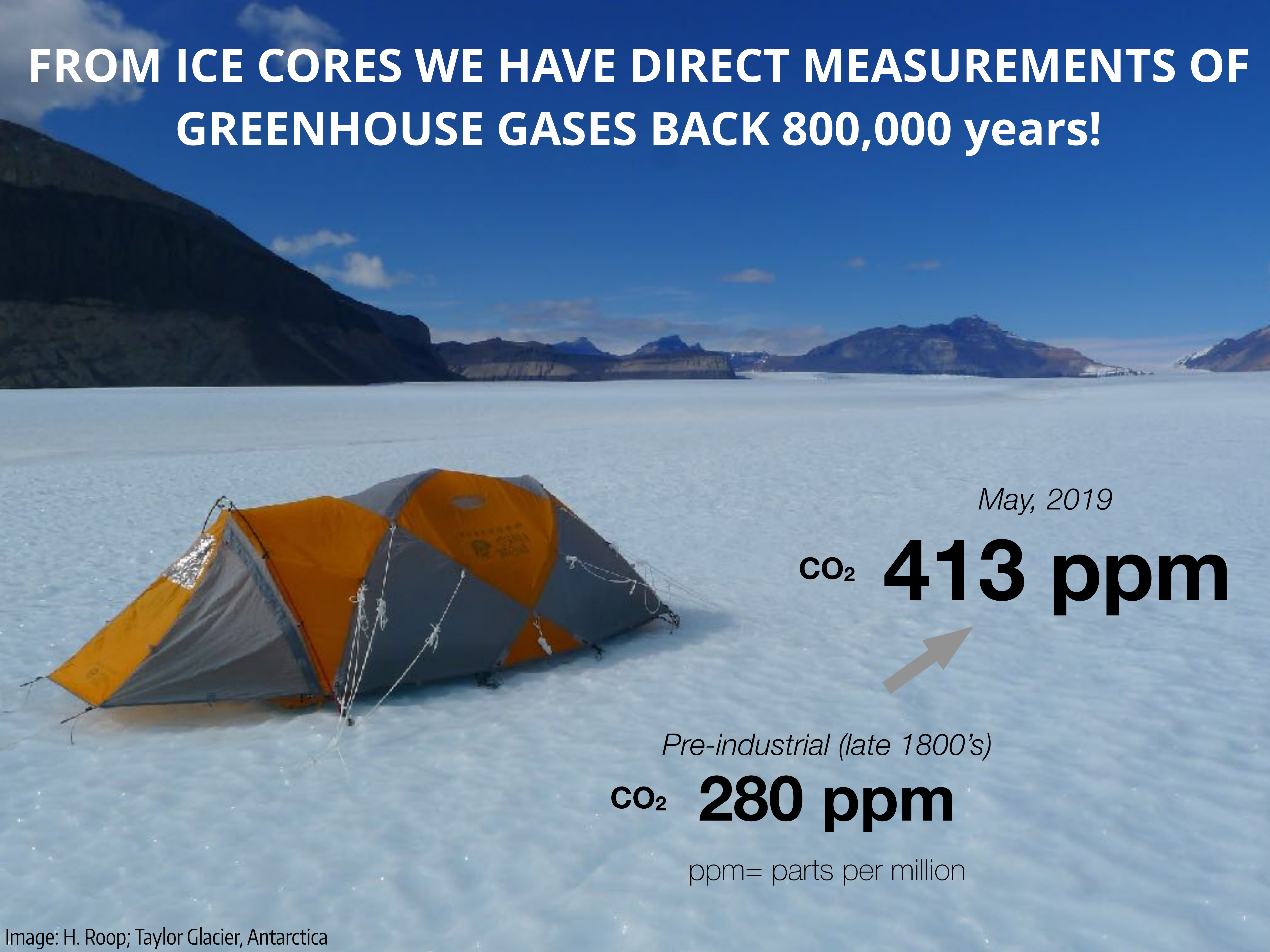
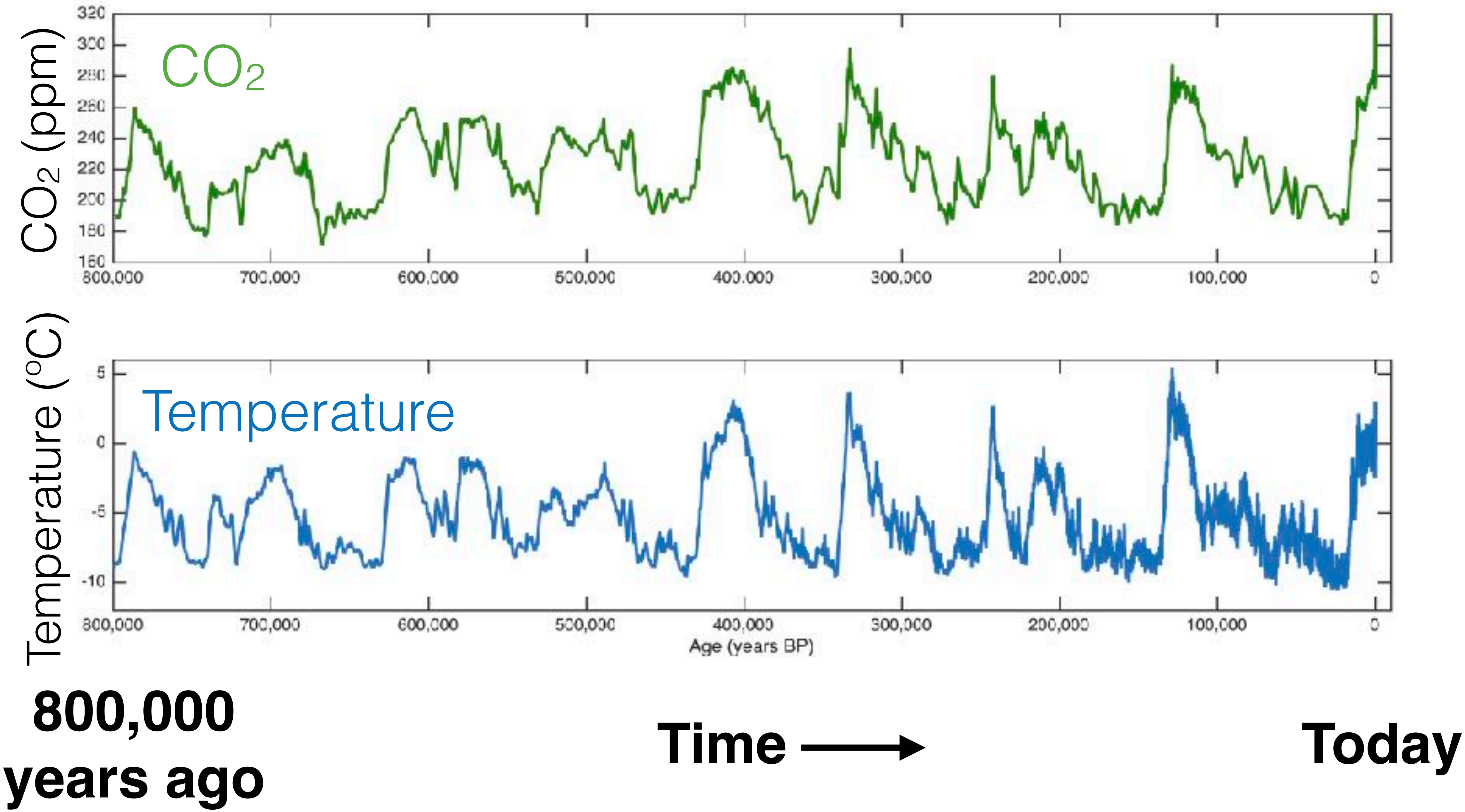


Image: H. Roop; Taylor Glacier, Antarctica

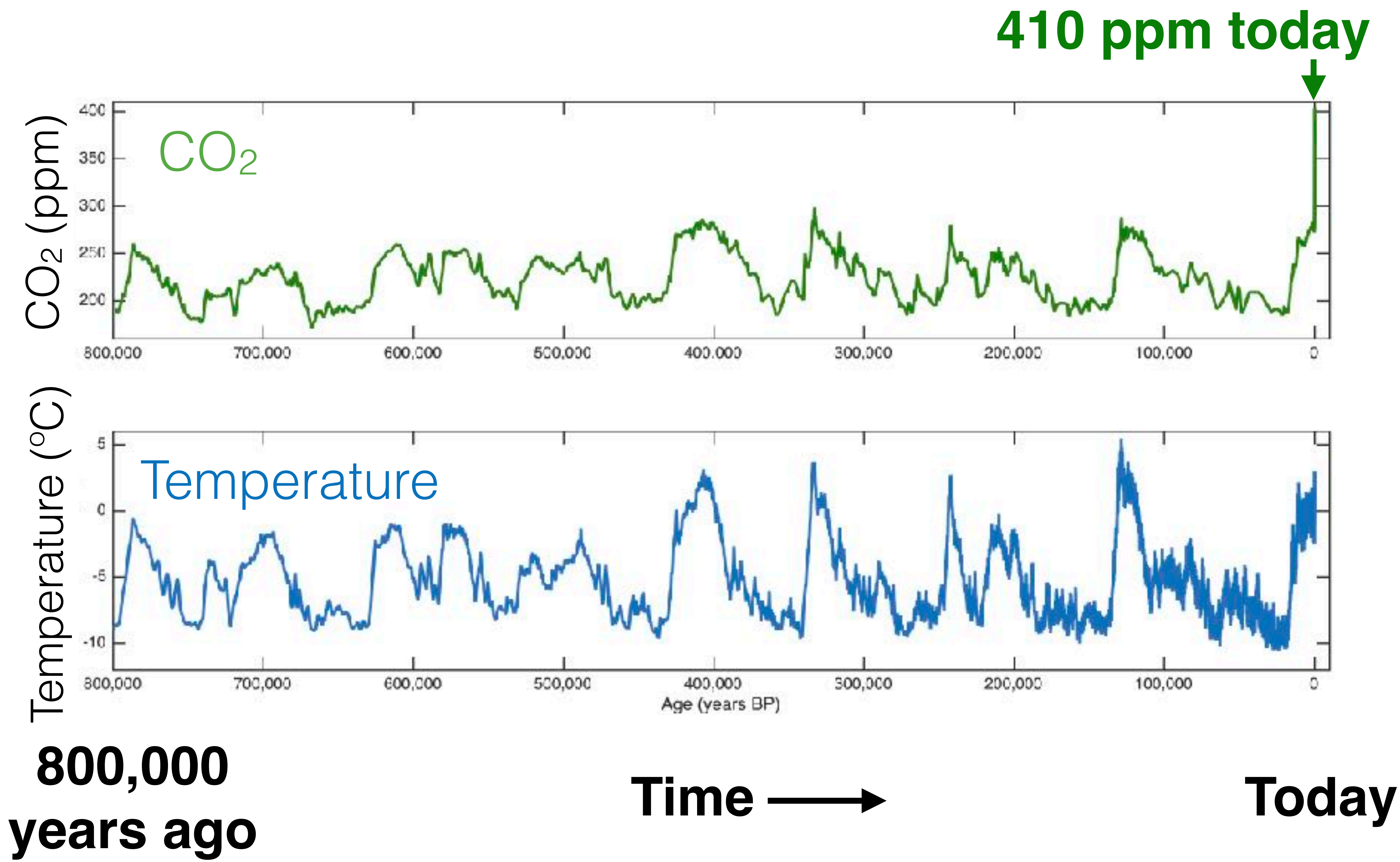

ANCIENT AIR!
Image: P. Neff

800,000 yrs of CO_2 & Temperature

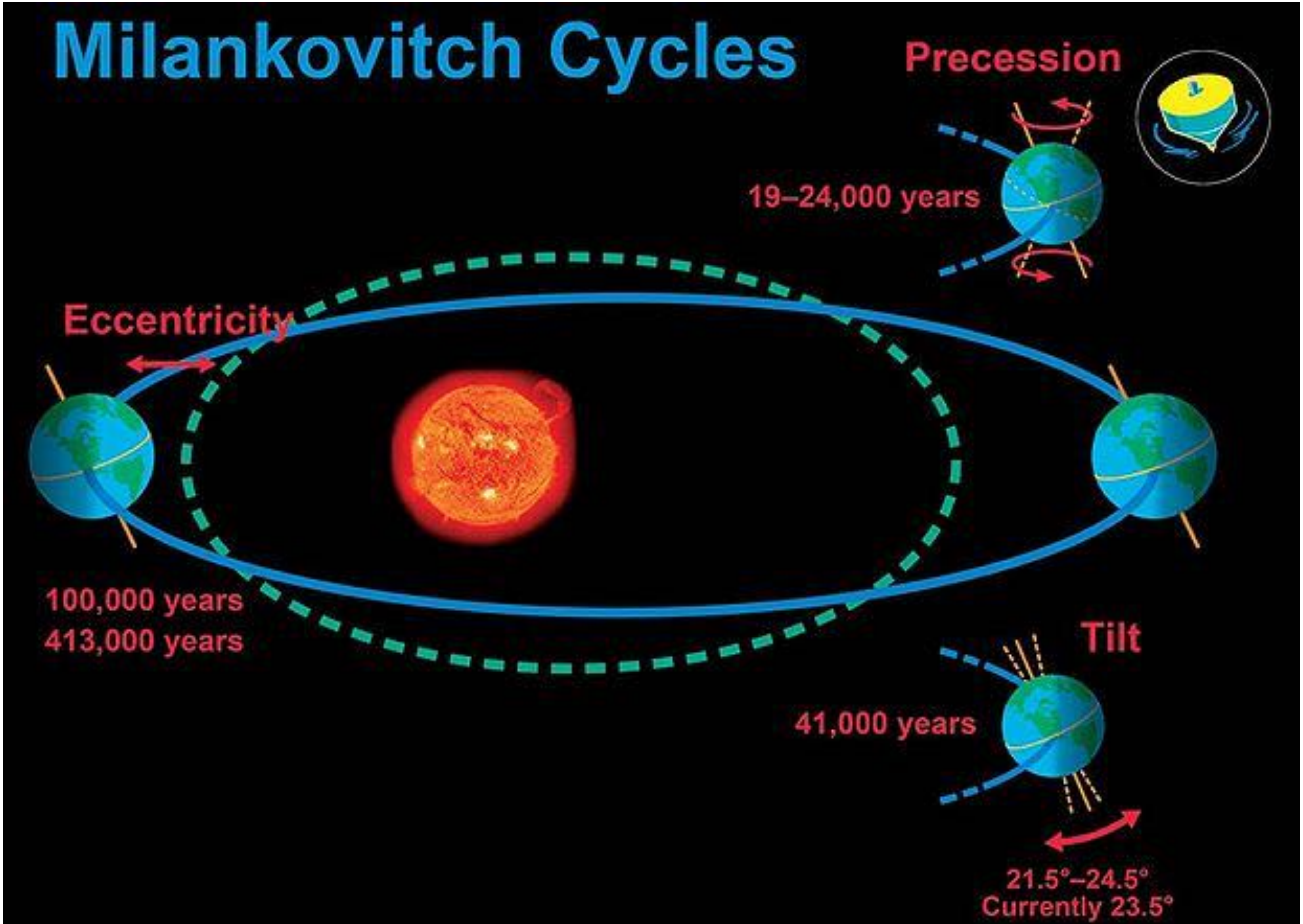


Data: Jouzel et al., 2007; Luthi et al., 2008

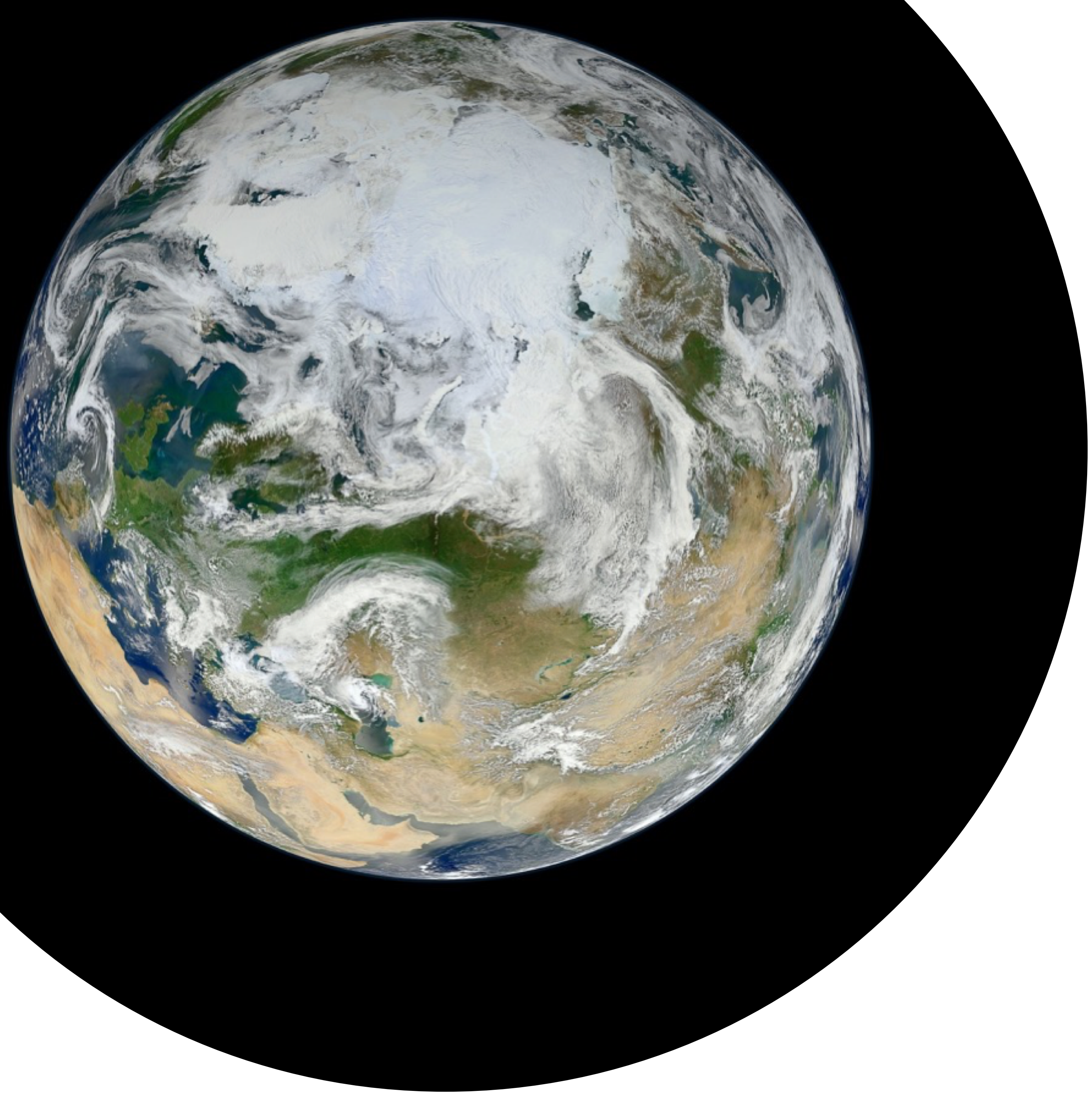
800,000 yrs of CO_2 & Temperature



Data: Jouzel et al., 2007; Luthi et al., 2008



Universe Today

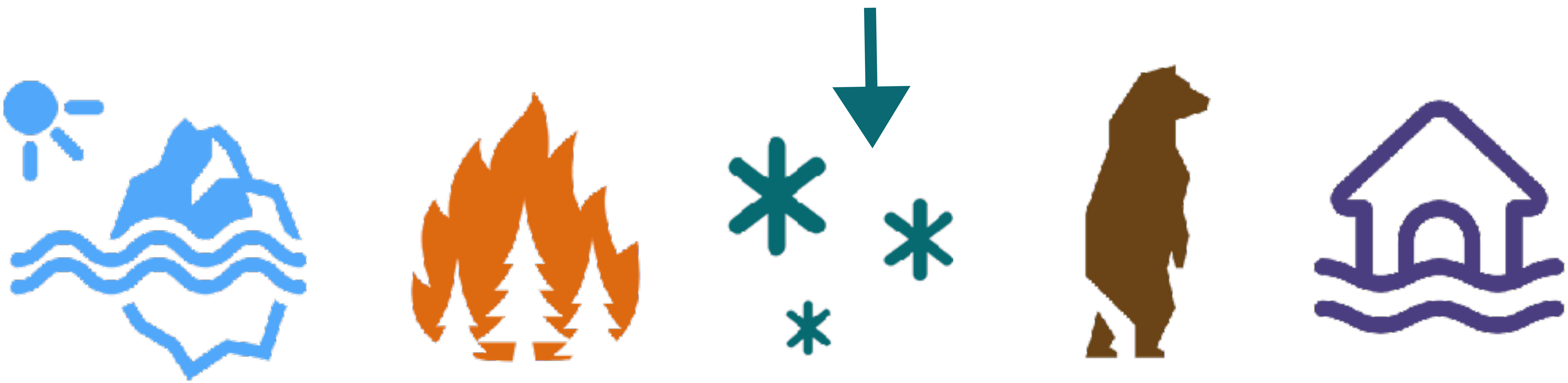


"The global climate continues to change rapidly compared to the pace of the natural variations in climate that have occurred throughout Earth's history."

- 4th National Climate Assessment
November 2017

Image: NASA/GSFC/Suomi NPP

So we have evidence that today is different.



What can we do about it?

H. Roop, Climate Impacts Group

HOW WE 'FEEL' FUTURE CLIMATE CHANGE DEPENDS ON:

Our actions **now** to reduce emissions of greenhouse gases (*mitigation*)

+

How well we **prepare** our communities & the systems we rely on (*adaptation*)

Heidi Roop, UW Climate Impacts Group


"We need to adapt to climate change even as we seek to mitigate it."
- Nives Dolsak & Aseem Prakash, 2018

Photo: H. Roop

CLIMATE IMPACTS GROUP

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