

## Global changes that impact sustainability

Plant Ecology in a Changing World

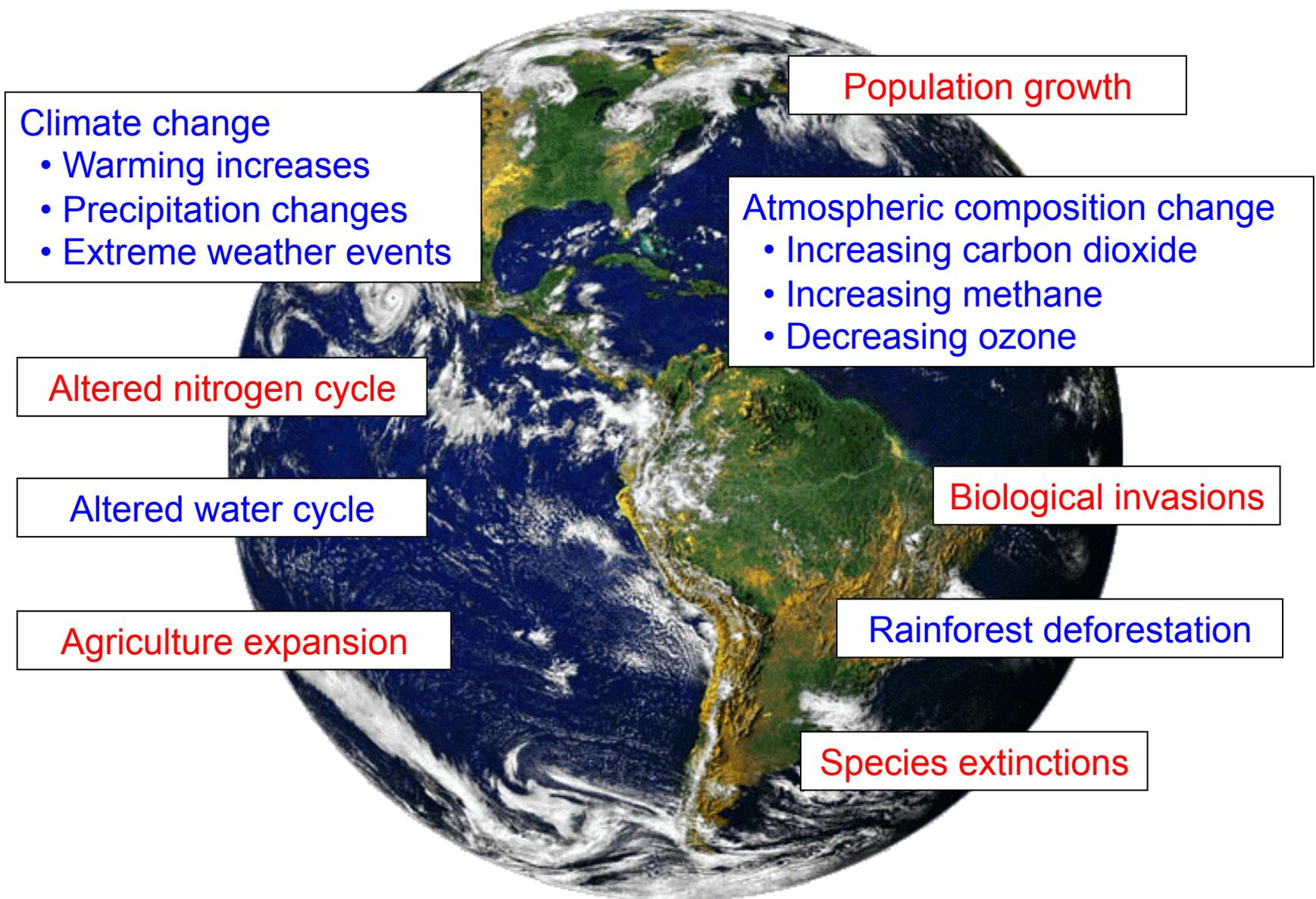
Jim Ehleringer, University of Utah  
<http://plantecology.net>



Global change . . . the times they are a changin’



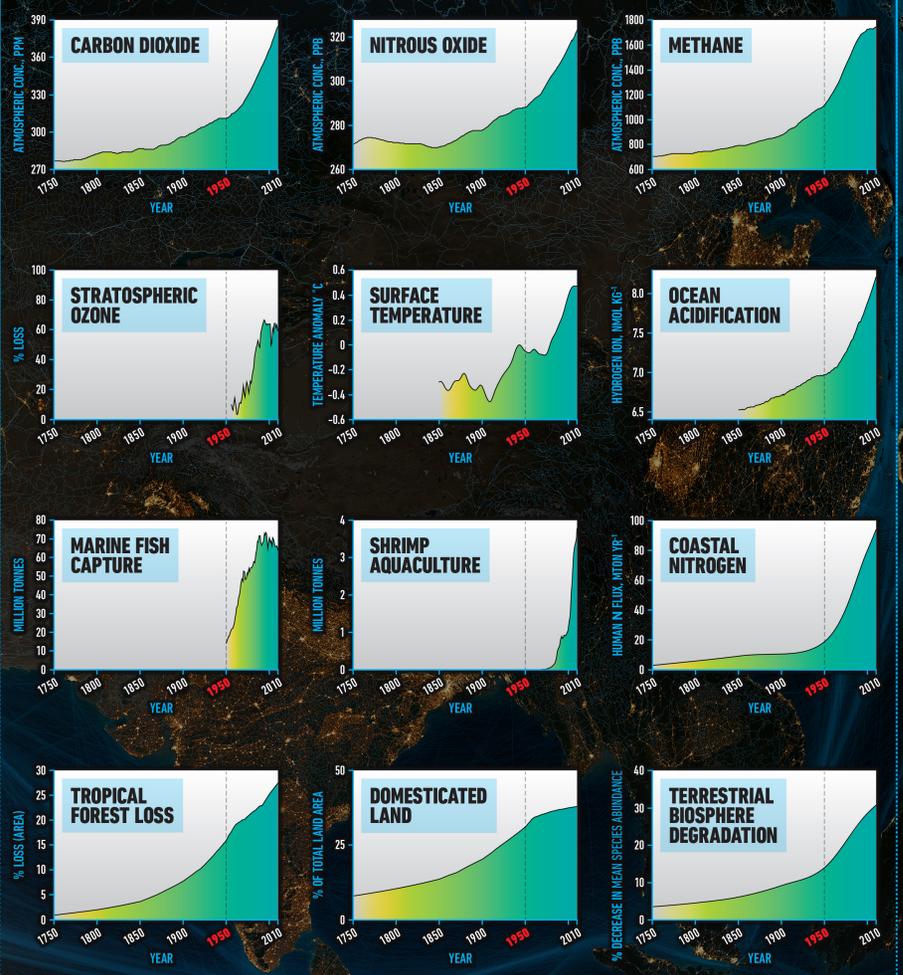
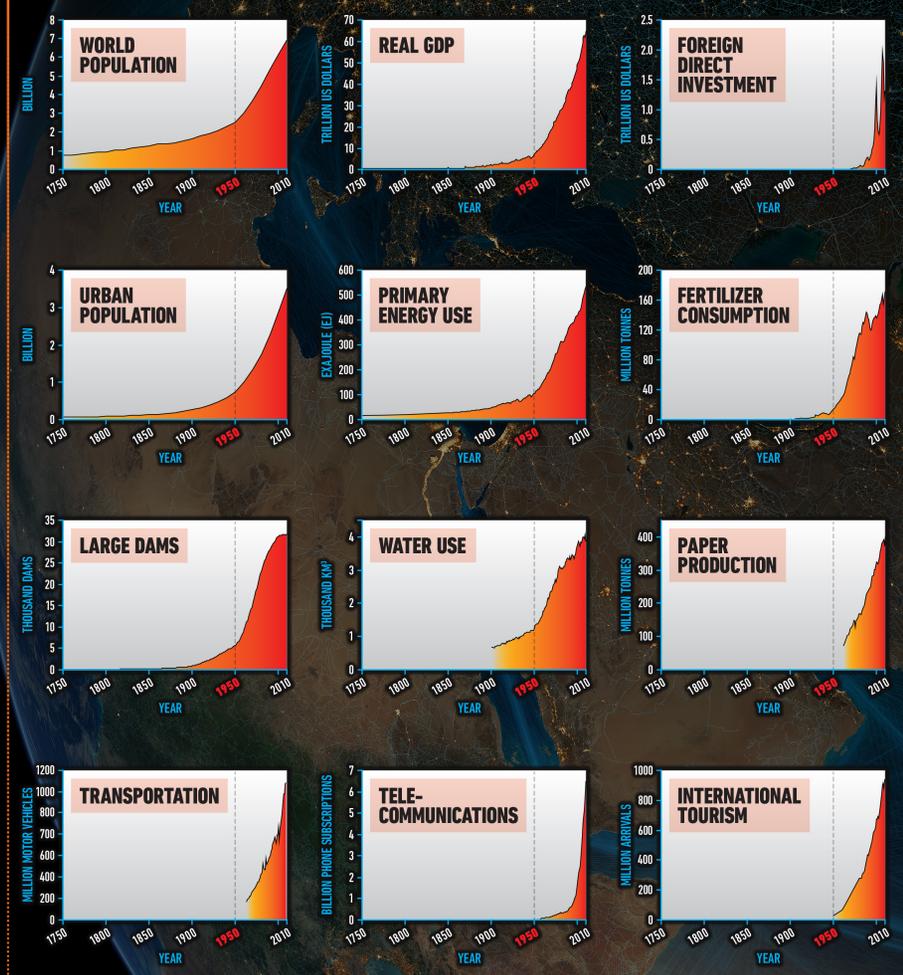
What kinds of global changes are we seeing today?  
Many drivers and responses – one planet, each is connected



# THE GREAT ACCELERATION

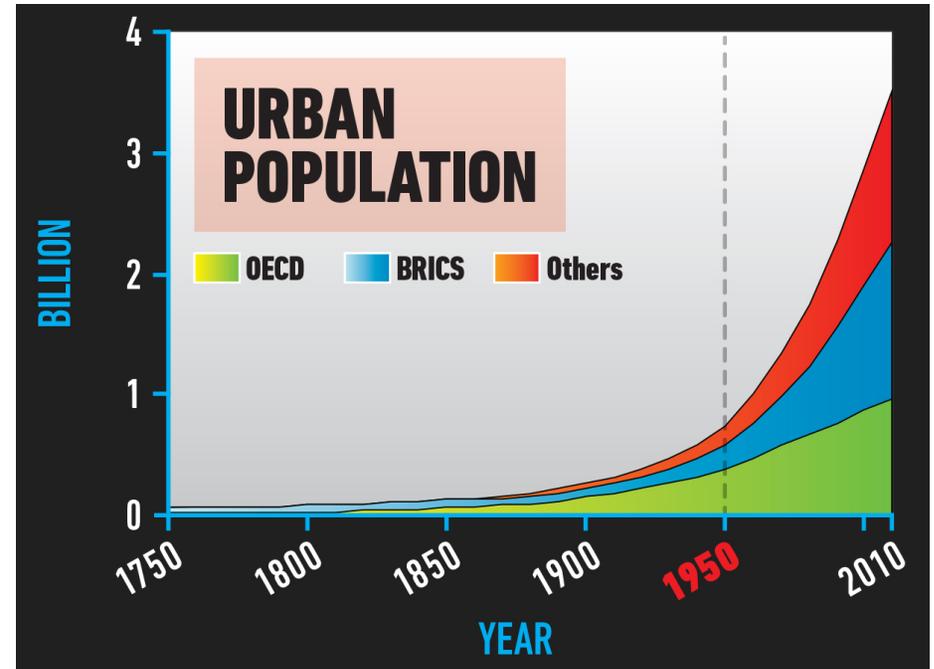
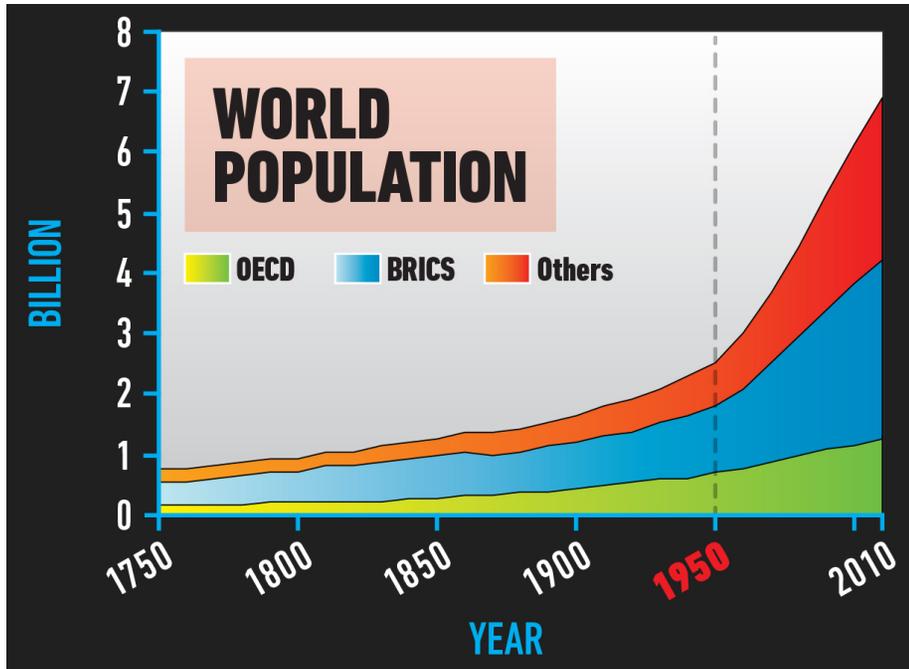
## SOCIO-ECONOMIC TRENDS

## EARTH SYSTEM TRENDS



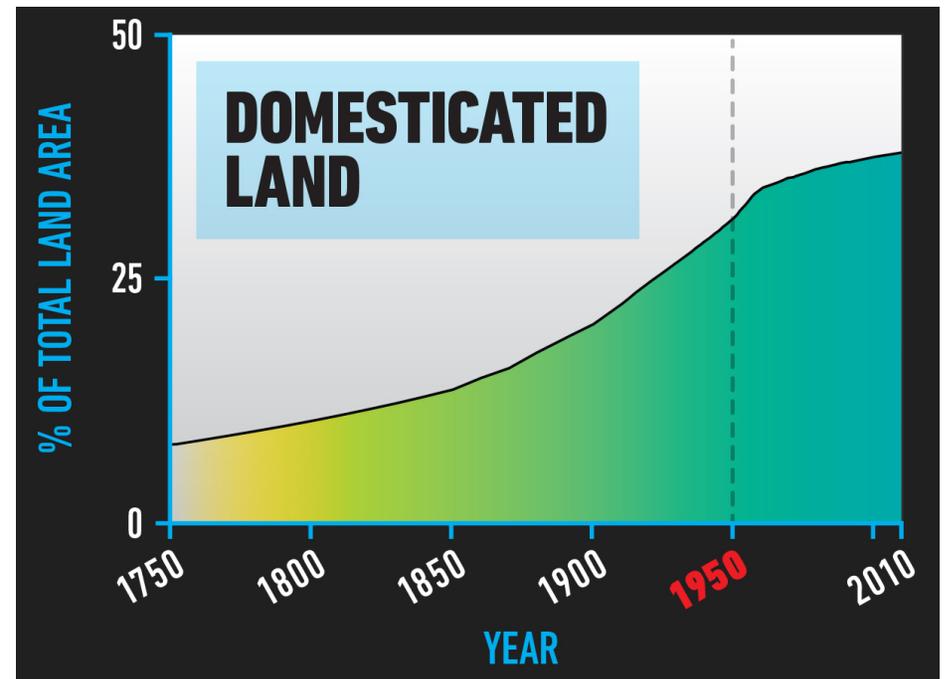
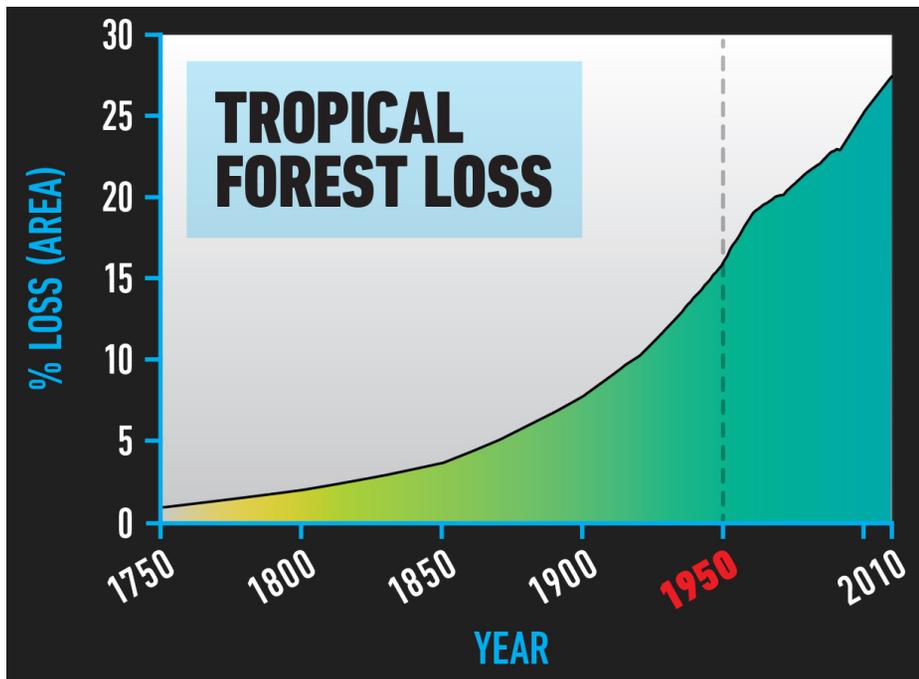
REFERENCE: Steffen, W., W. Broadgate, L. Deutsch, O. Gaffney and C. Ludwig, The Trajectory of the Anthropocene: the Great Acceleration, *The Anthropocene Review*, 16 January 2015.  
 MAP & DESIGN: Félix Pharand-Deschênes / Globaia

Carbon dioxide emissions will clearly be influenced by the energy requirements to satisfy a growing global population.



As the world's population increases, almost all of this growth will be in urban locations.

# Biome-scale changes are underway to accommodate population growth

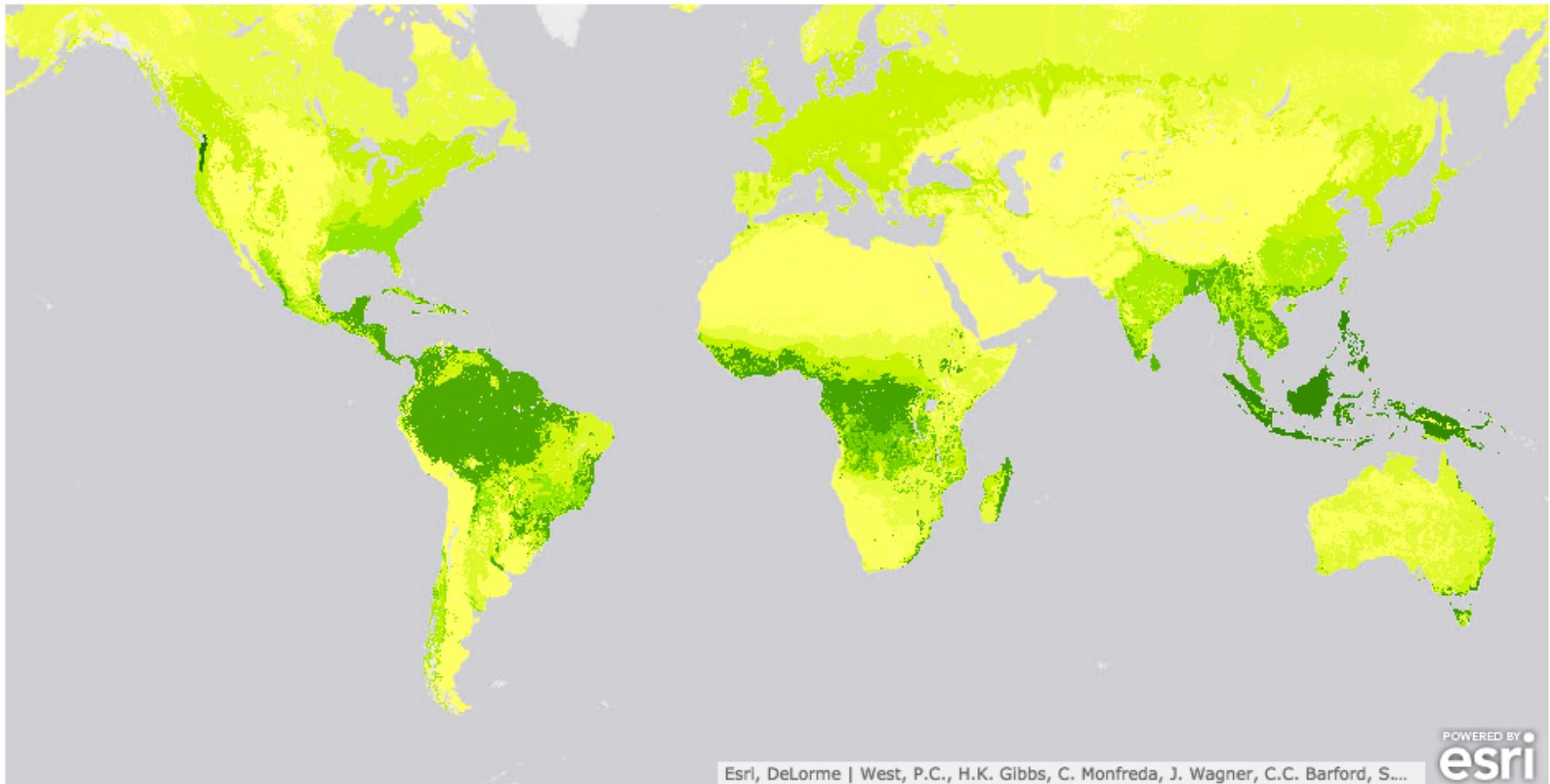
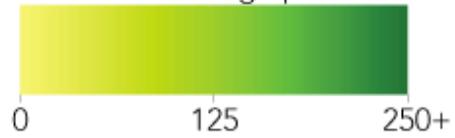


The trajectory of the Anthropocene: The Great Acceleration  
Will Steffen, Wendy Broadgate, Lisa Deutsch, Owen Gaffney and Cornelia Ludwig  
2015 *Anthropocene Review*, Based on Steffen *et al.* (2004) *Global Change and the Earth System*

## Carbon Storage in Potential Vegetation



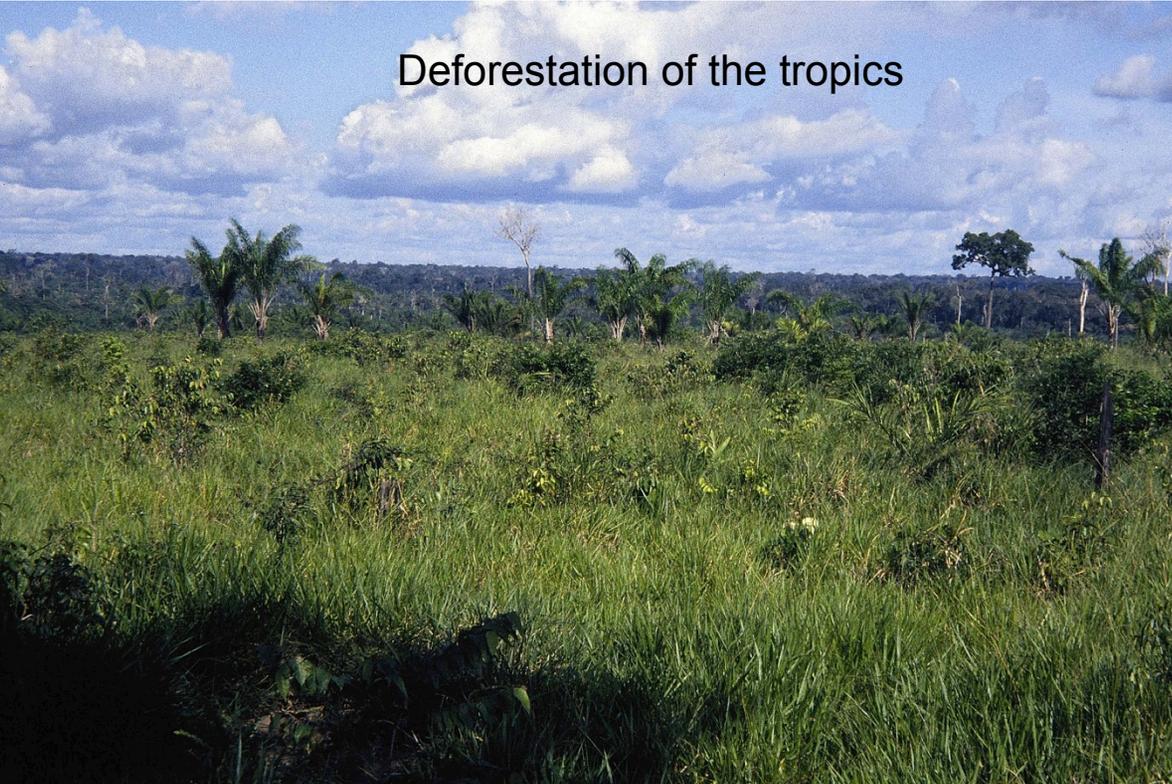
Tons Carbon Storage per Hectare



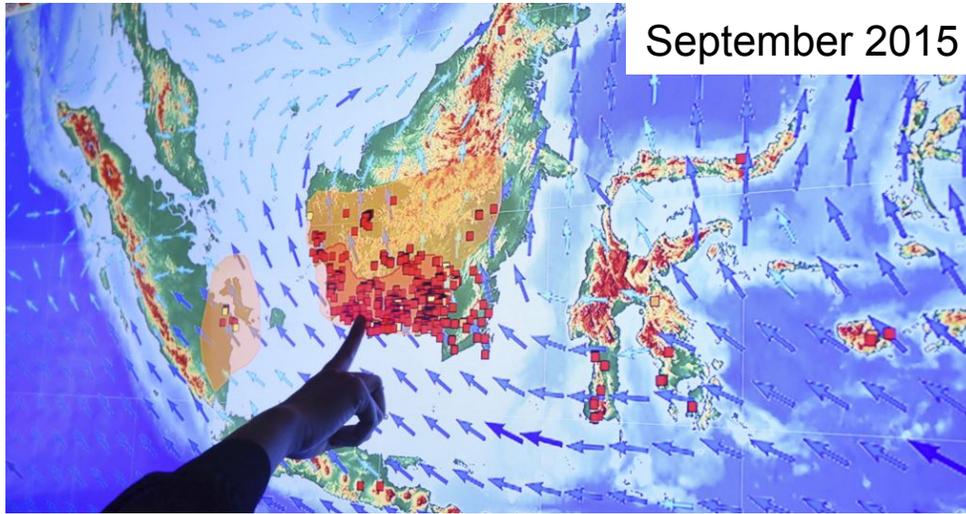
Esri, DeLorme | West, P.C., H.K. Gibbs, C. Monfreda, J. Wagner, C.C. Barford, S...



Deforestation of the tropics



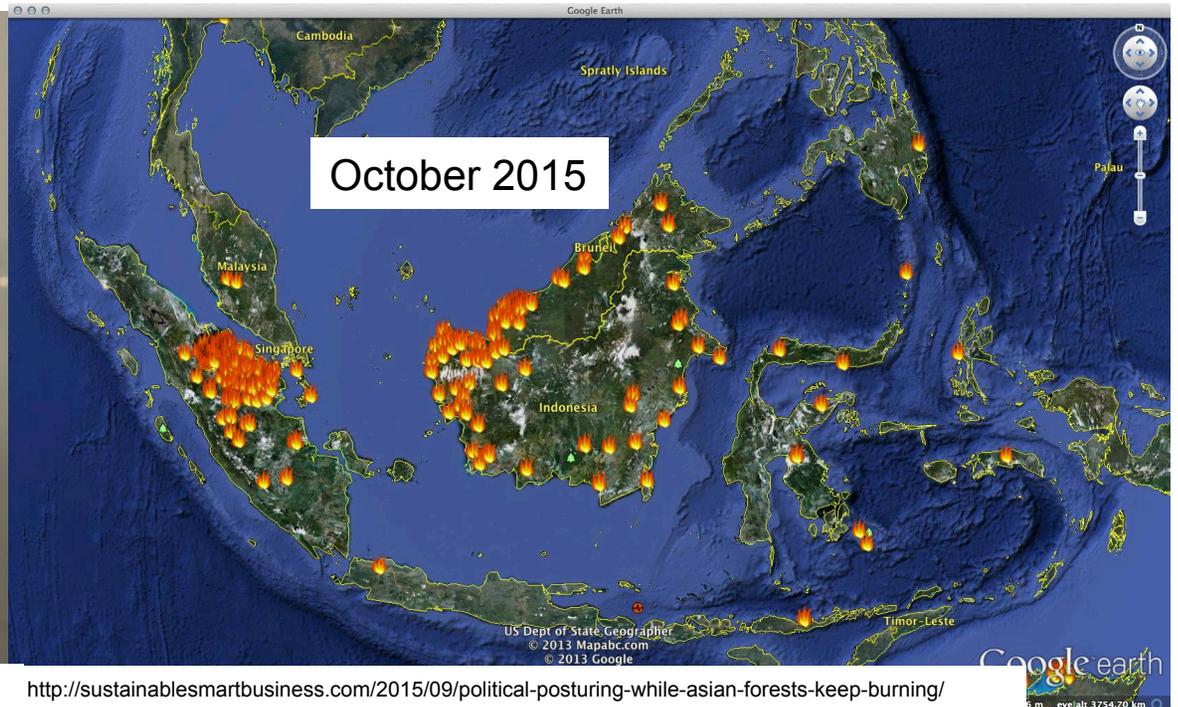
# El Niño events accelerate the conversion of rainforest to agricultural lands



<http://www.voanews.com/content/reu-indonesia-starts-legal-action-against-companies-linked-to-se-asia-haze/2973583.html>



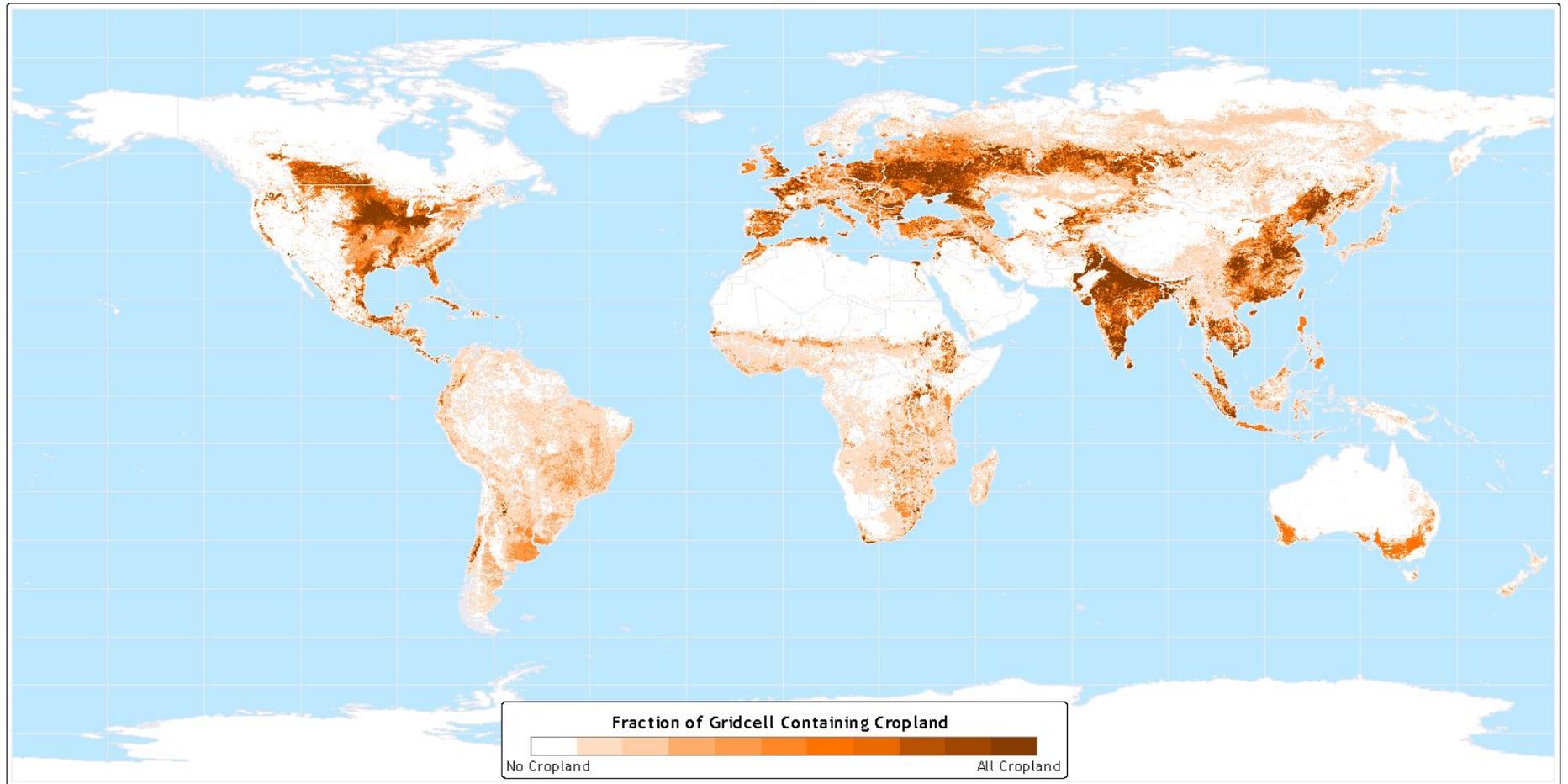
[http://www.todayonline.com/sites/default/files/styles/photo\\_gallery\\_image\\_lightbox/public/2015-10-05T101253Z\\_1\\_LYNXPB940F5\\_RTROPTP\\_3\\_INDONESIA-HAZE.JPG?itok=FuAFoGFT](http://www.todayonline.com/sites/default/files/styles/photo_gallery_image_lightbox/public/2015-10-05T101253Z_1_LYNXPB940F5_RTROPTP_3_INDONESIA-HAZE.JPG?itok=FuAFoGFT)



<http://sustainablesmartbusiness.com/2015/09/political-posturing-while-asian-forests-keep-burning/>

# Cropland Intensity

1992



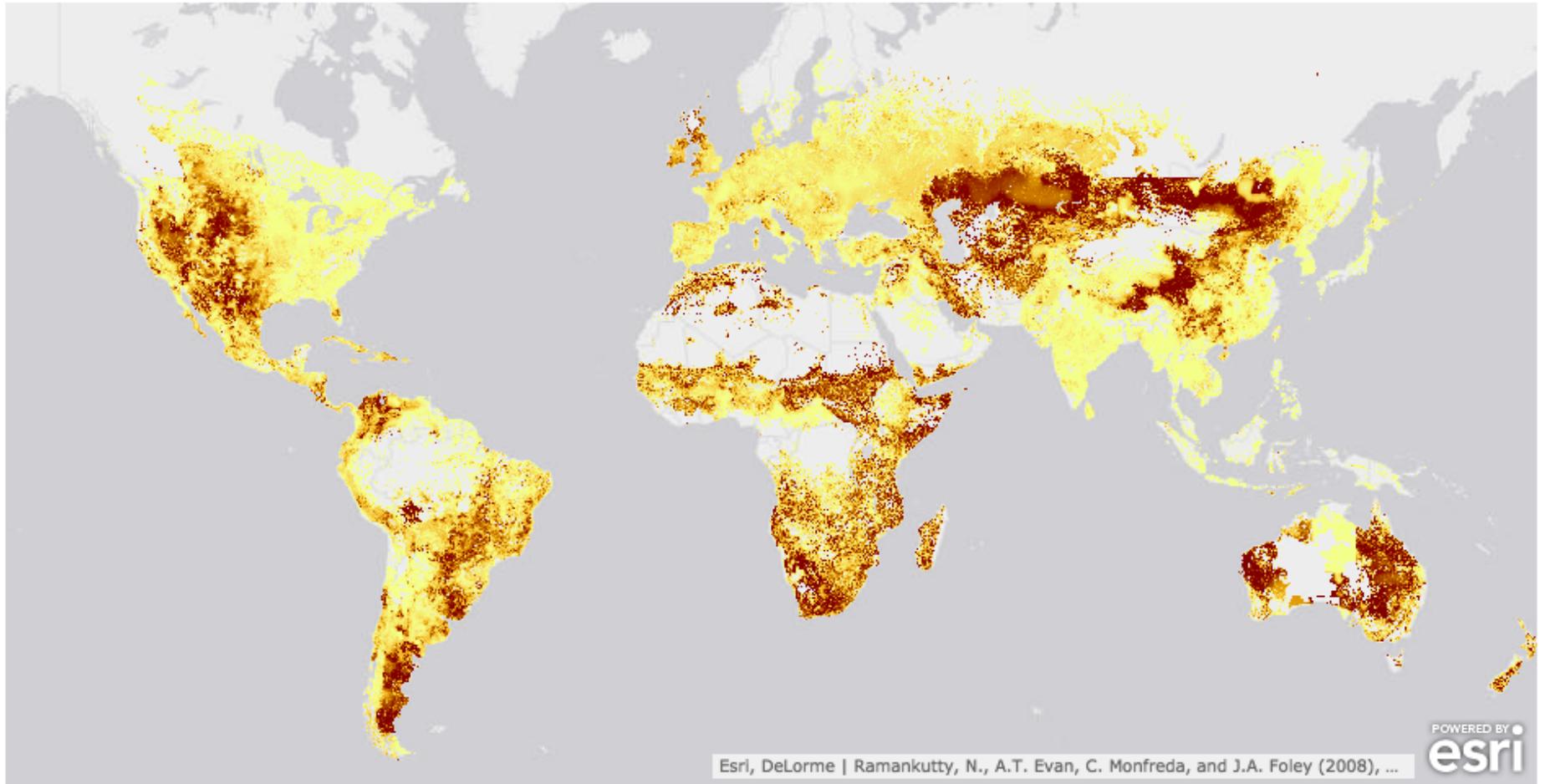
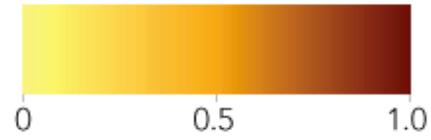
Data taken from: Ramankutty and Foley 1999

**Atlas of the Biosphere**  
Center for Sustainability and the Global Environment  
University of Wisconsin - Madison

# Cropland area in the year 2000

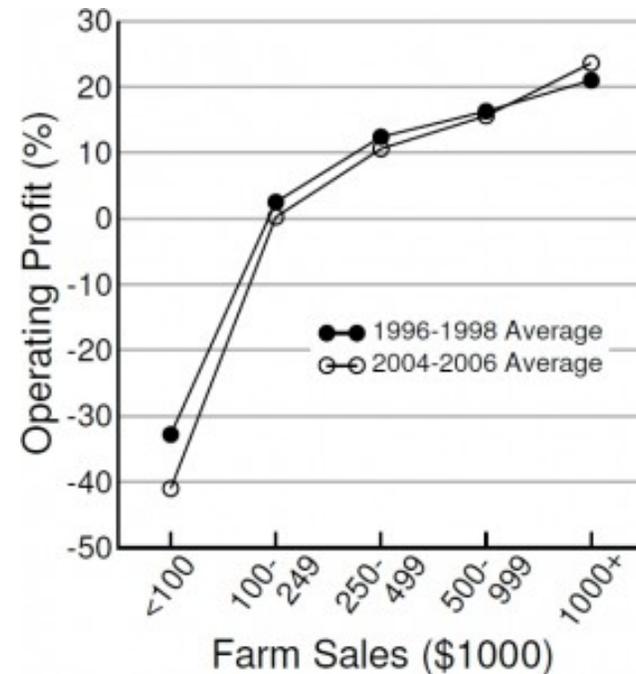
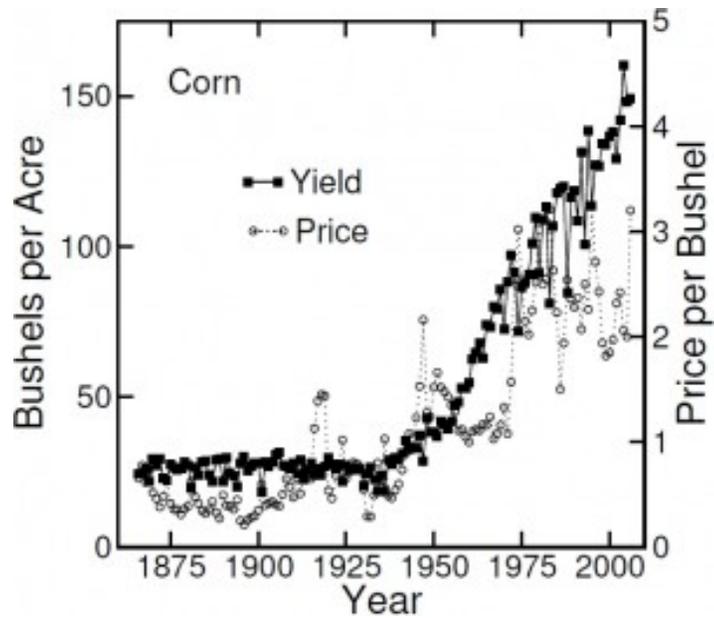
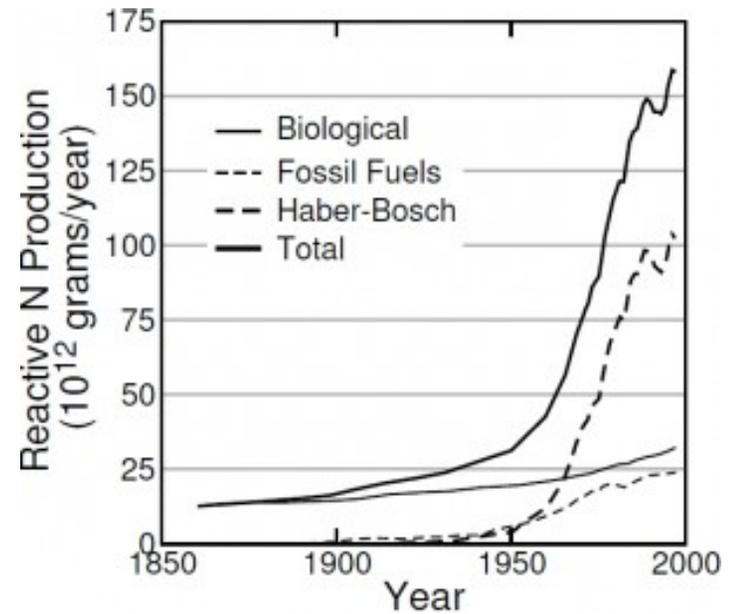


Pasture Area Fraction



Anthropogenic nitrogen fixation greatly exceeds biological processes

Excess use of N is driven by marginal increases in both yield and profit



# Invasive species are in the news each day

cheatgrass



Russian olive



tamarisk



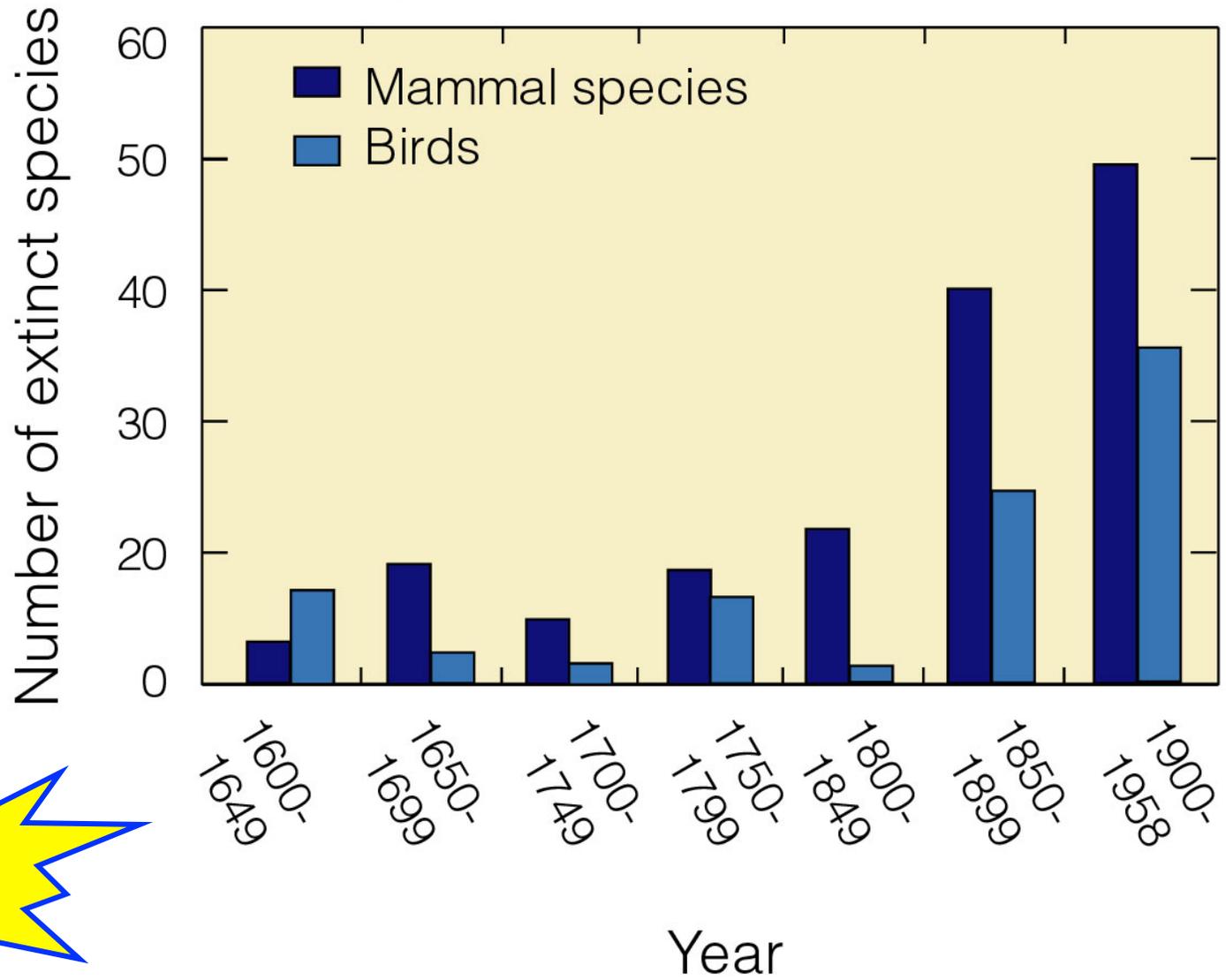
foxtail



myrtle spurge

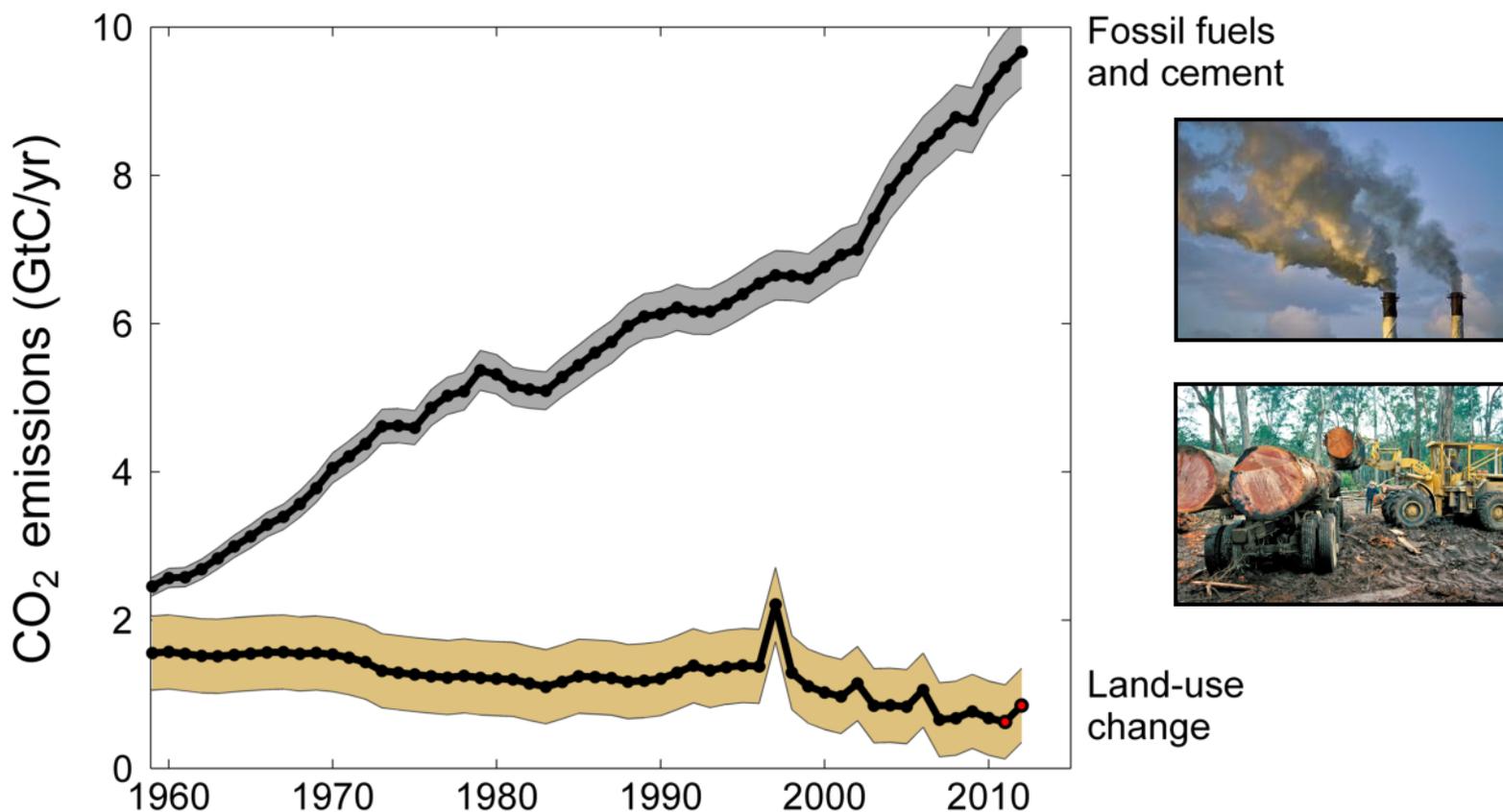


## Species extinctions



# Total Global Emissions

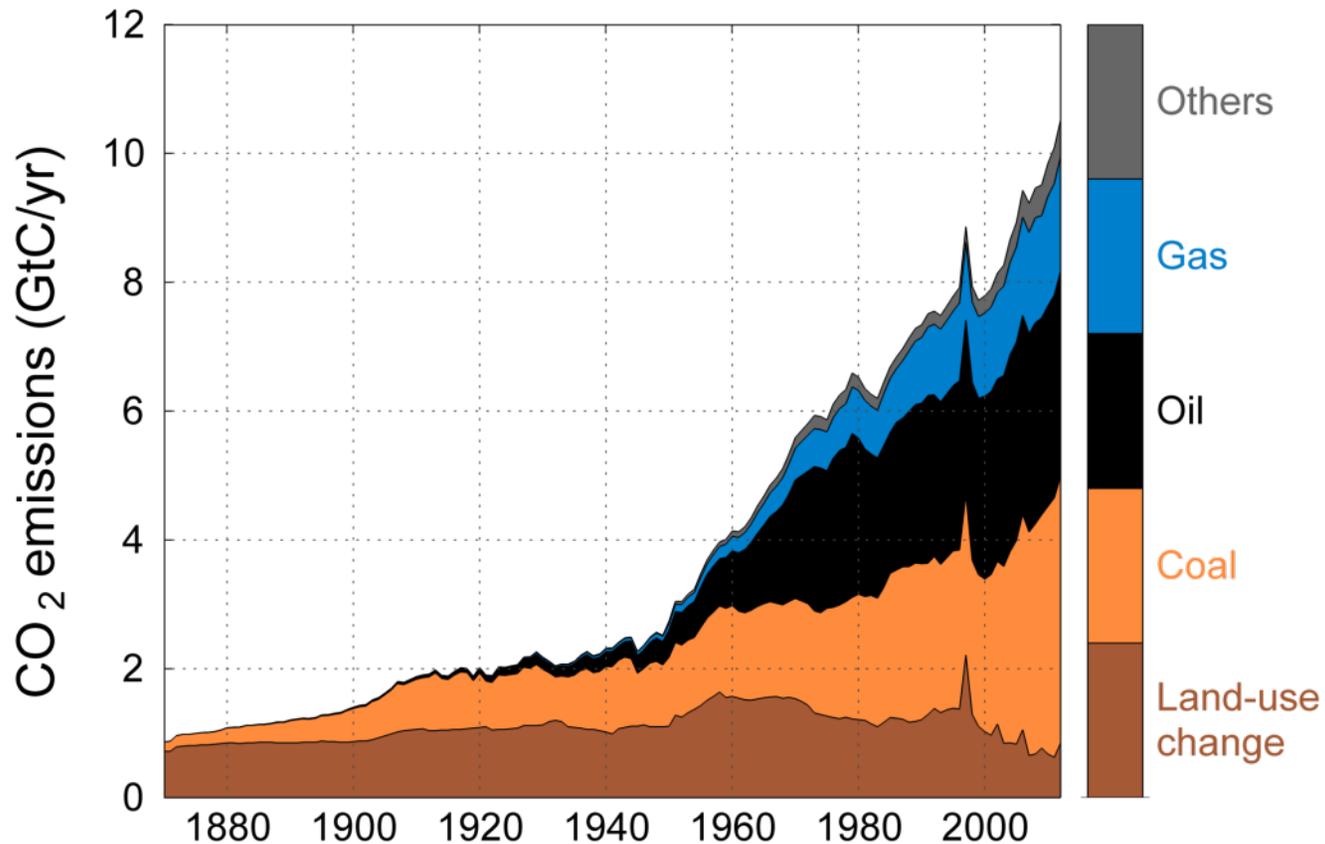
Total global emissions:  $10.5 \pm 0.7$  GtC in 2012, 43% over 1990  
 Percentage land-use change: 38% in 1960, 17% in 1990, 8% in 2012



Land use emissions in 2011 and 2012 are extrapolated estimates

Source: [Le Quéré et al 2013](#); [CDIAC Data](#); Houghton & Hackler (in review); [Global Carbon Project 2013](#)

Land-use change was the dominant source of annual emissions until around 1950. Coal consumption continues to grow strongly.



Others: Emissions from cement production and gas flaring.

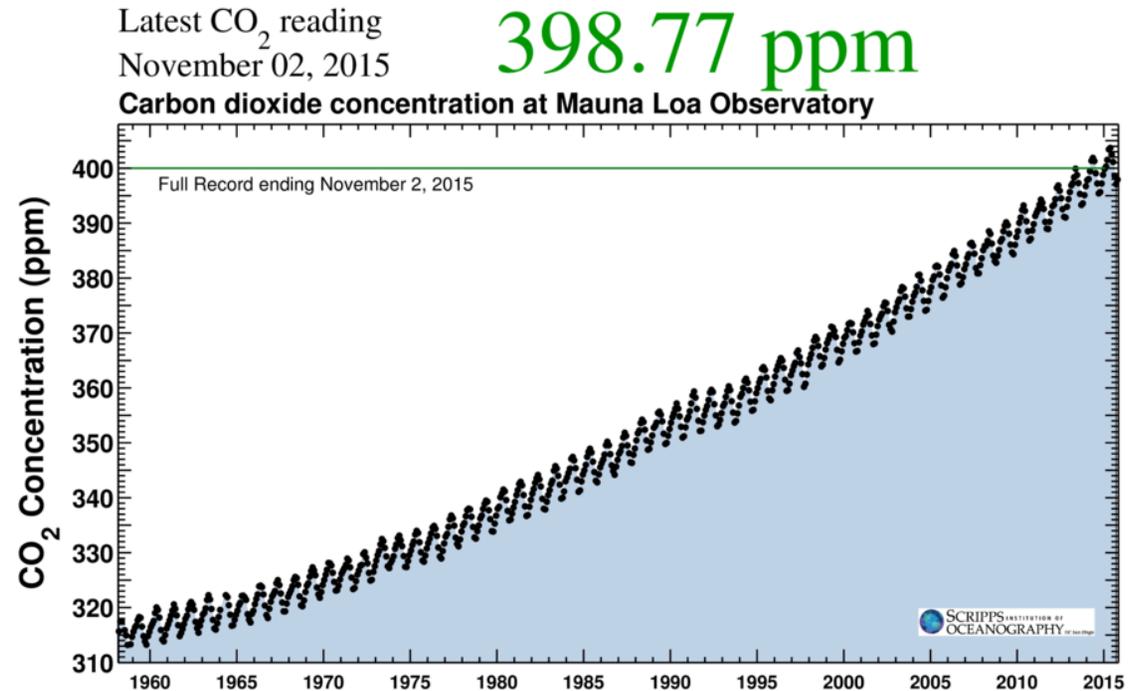
Source: [CDIAC Data](#); Houghton & Hackler (in review); [Global Carbon Project 2013](#)

A set of observations made on a Hawaiian mountain top far from industrial influences

C. David Keeling, 1928-2005

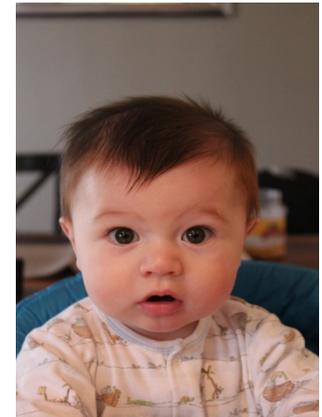


C. David Keeling (SIO, La Jolla) has provided us with the longest continuous record of atmospheric [CO<sub>2</sub>] increase

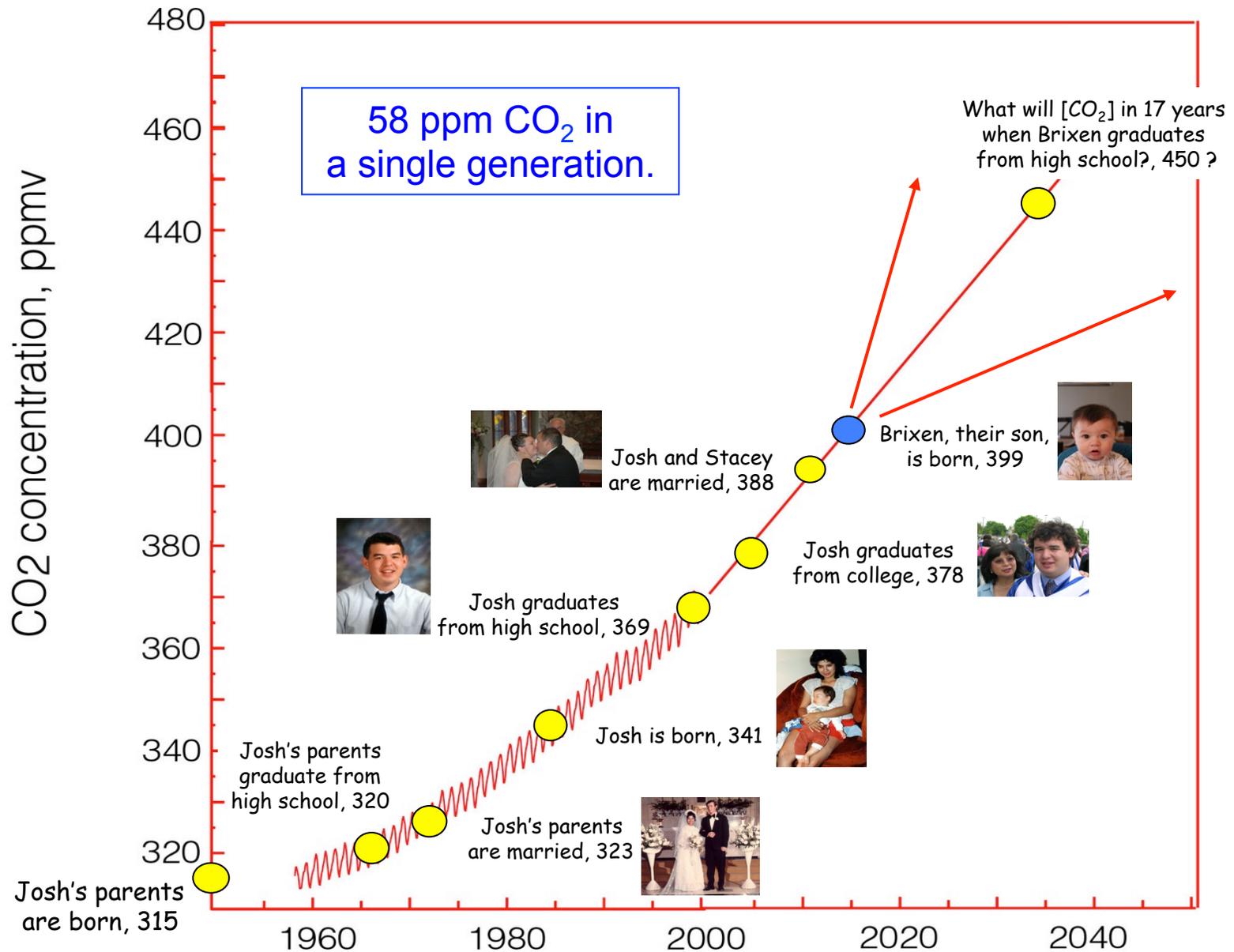


In recognition of this work, Keeling was awarded the Medal of Science, the highest honor this nation awards to a scientist.

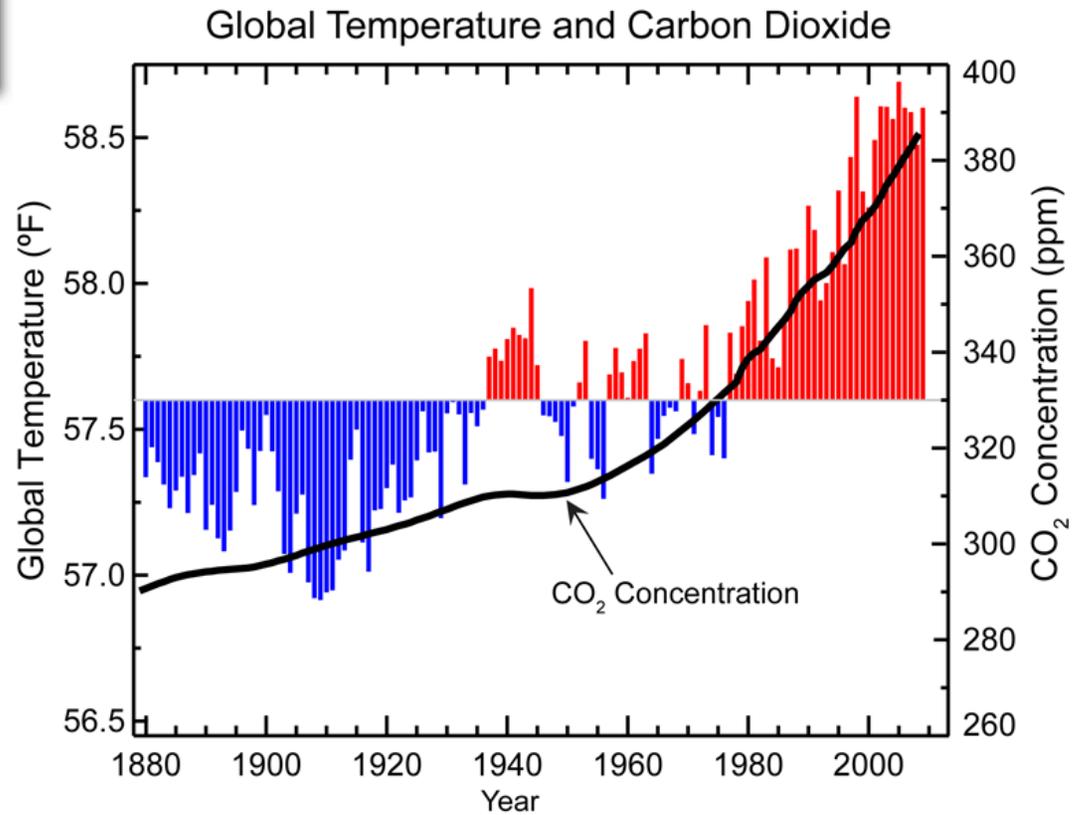
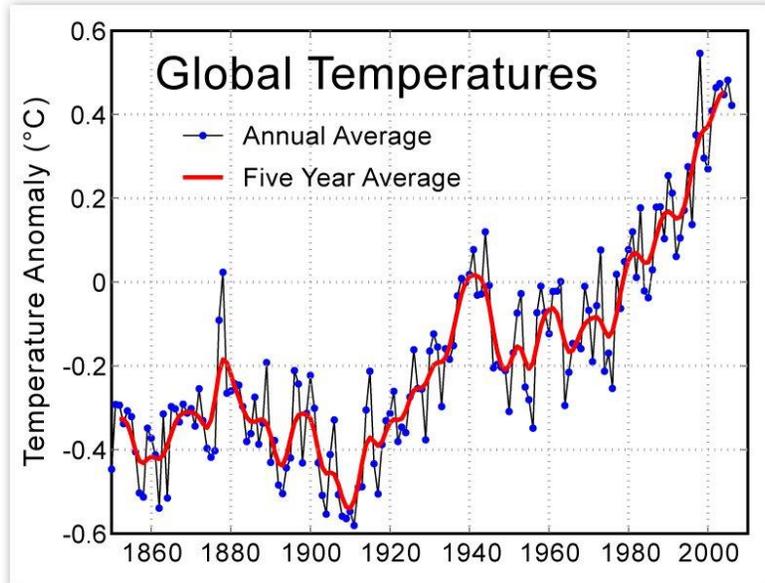
How much can our atmosphere change in just one generation?



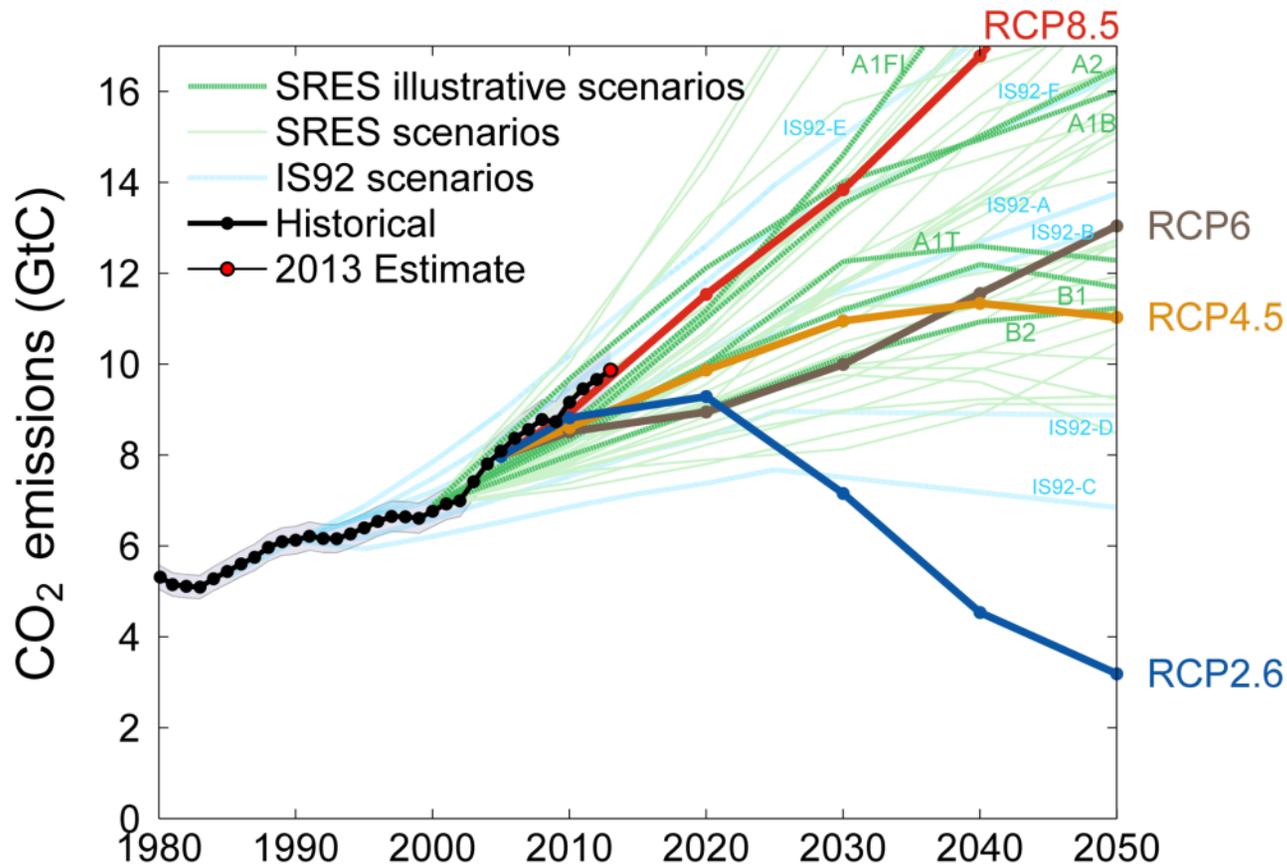
Reducing CO<sub>2</sub> emissions is possible. We can bend the curve.



Our world is changing;  
learn to cope



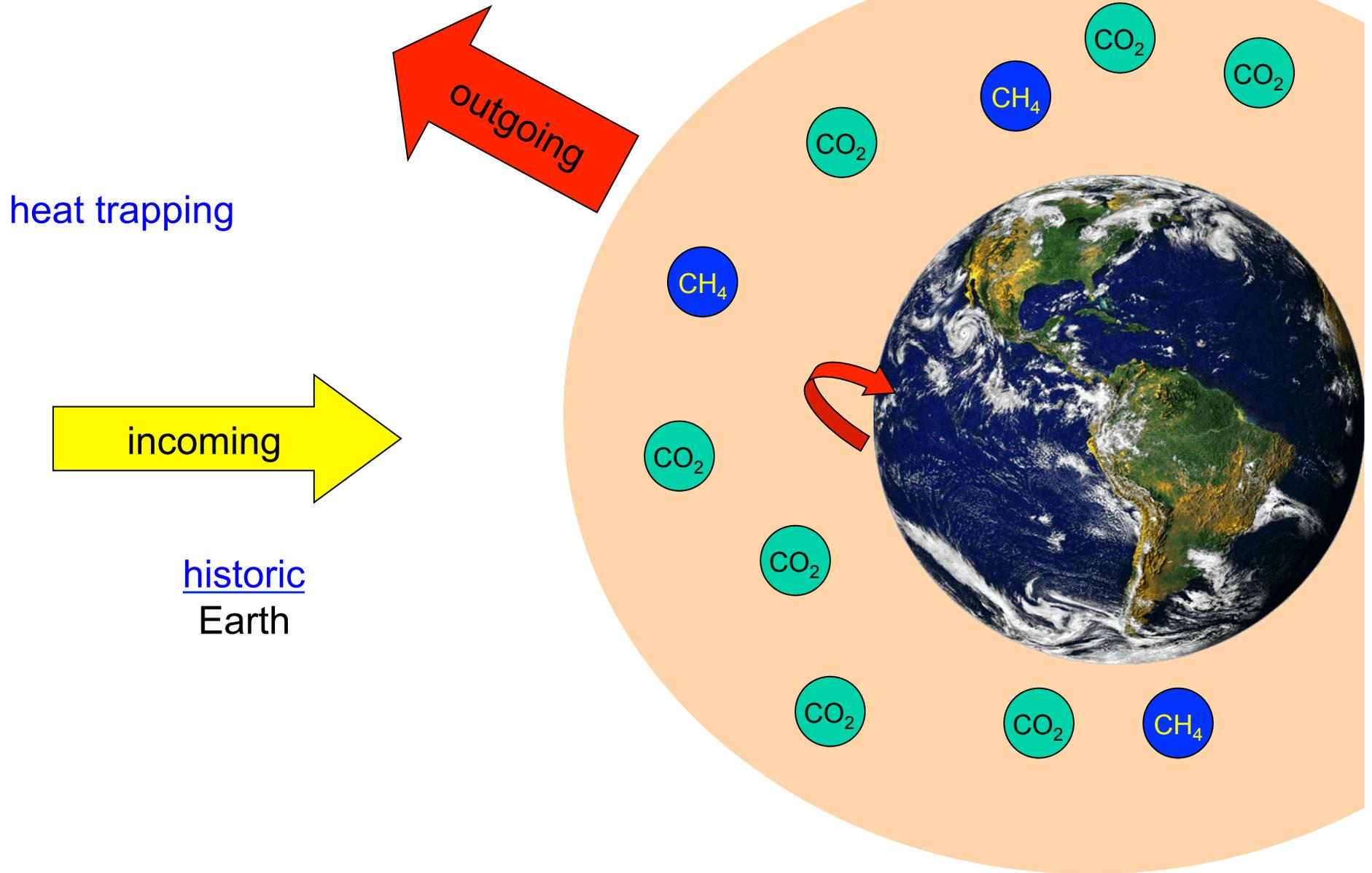
What are the projected changes in the global carbon cycle?  
There is limited certainty in the future emissions trajectories.



Emissions are on track for 3.2–5.4°C “likely” increase in temperature above pre-industrial;  
Large and sustained mitigation is required now to keep below 2°C

Projection

# Greenhouse effect

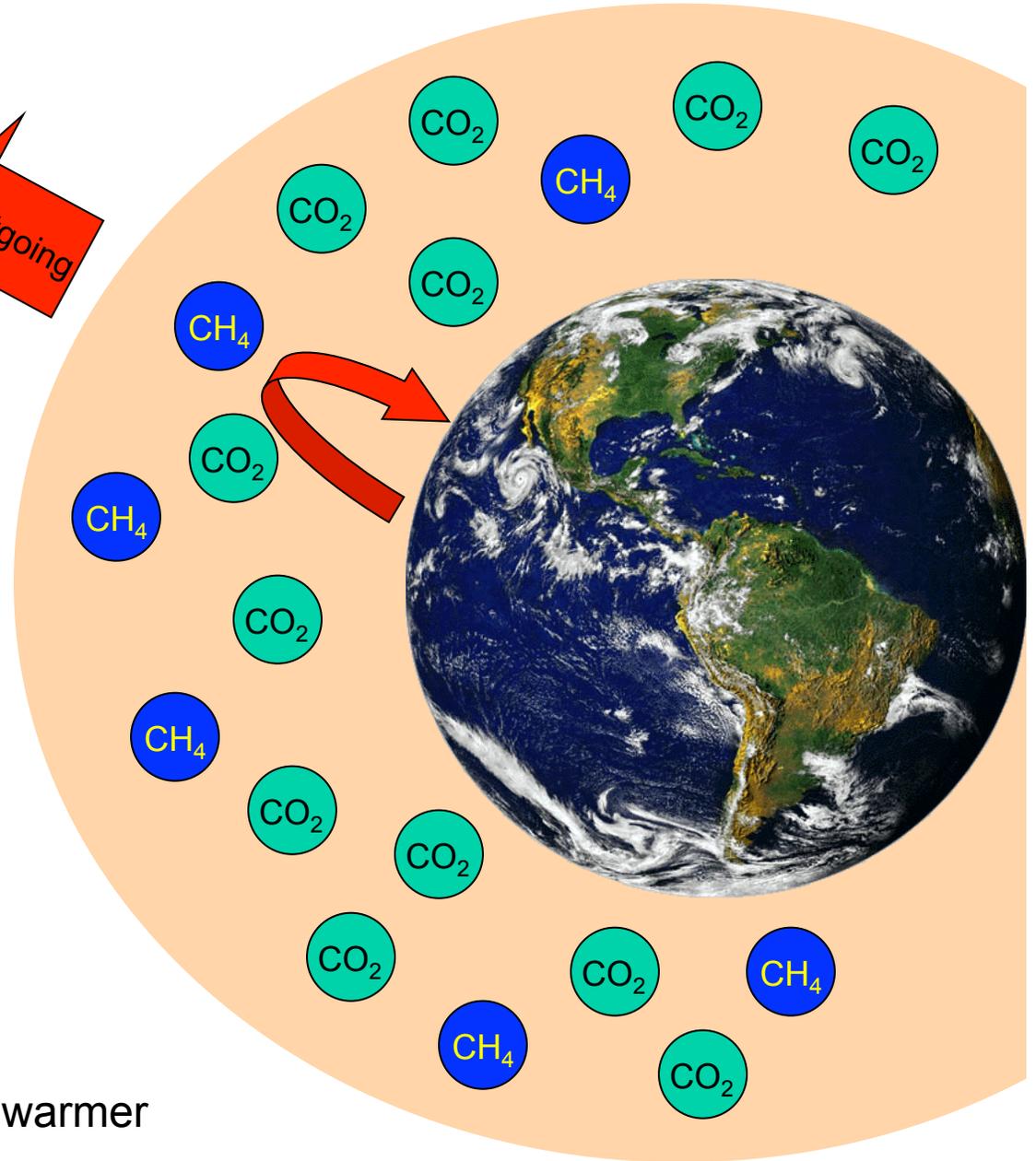


# Greenhouse effect

heat trapping



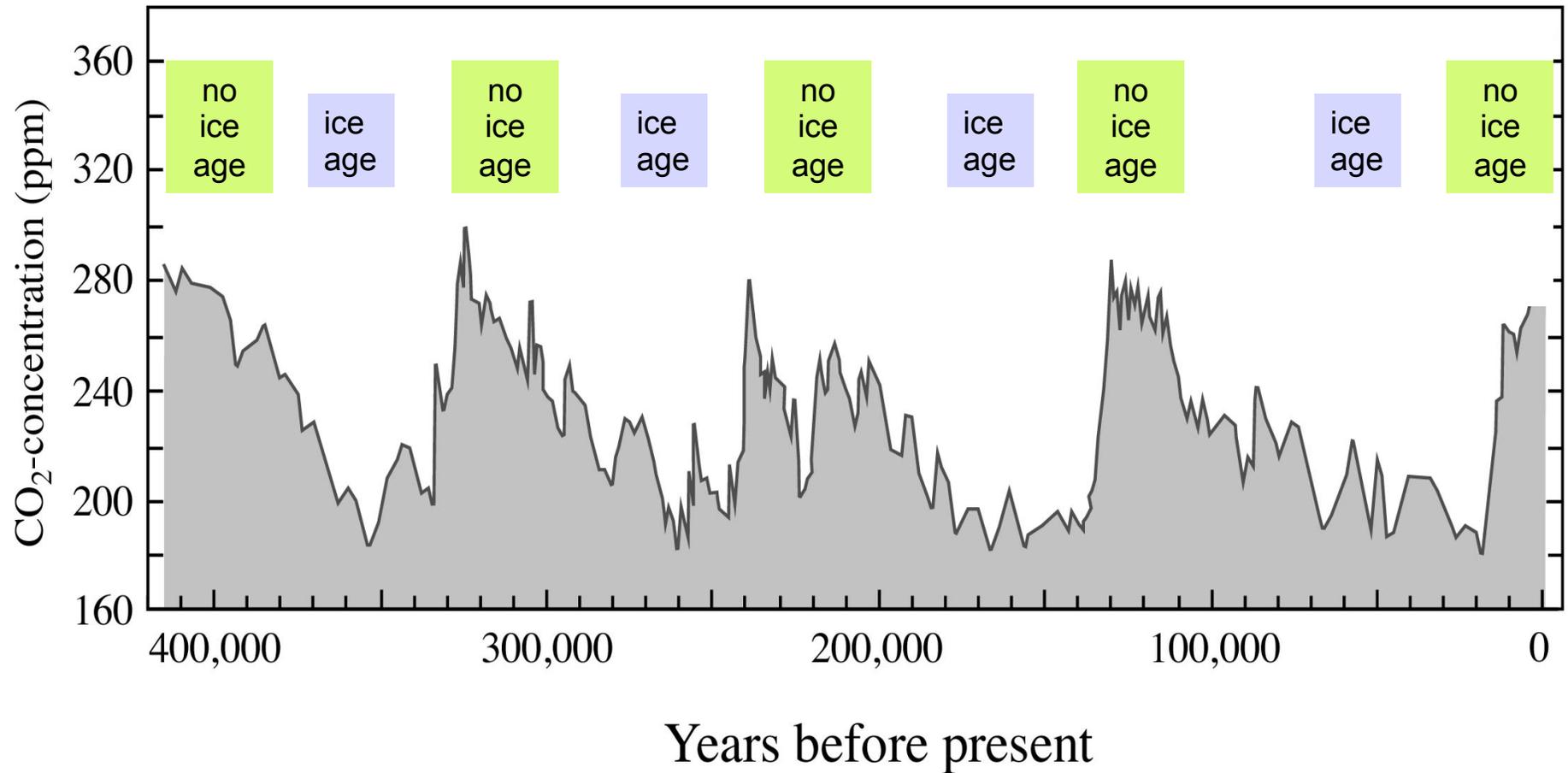
current  
Earth



Nights are getting warmer

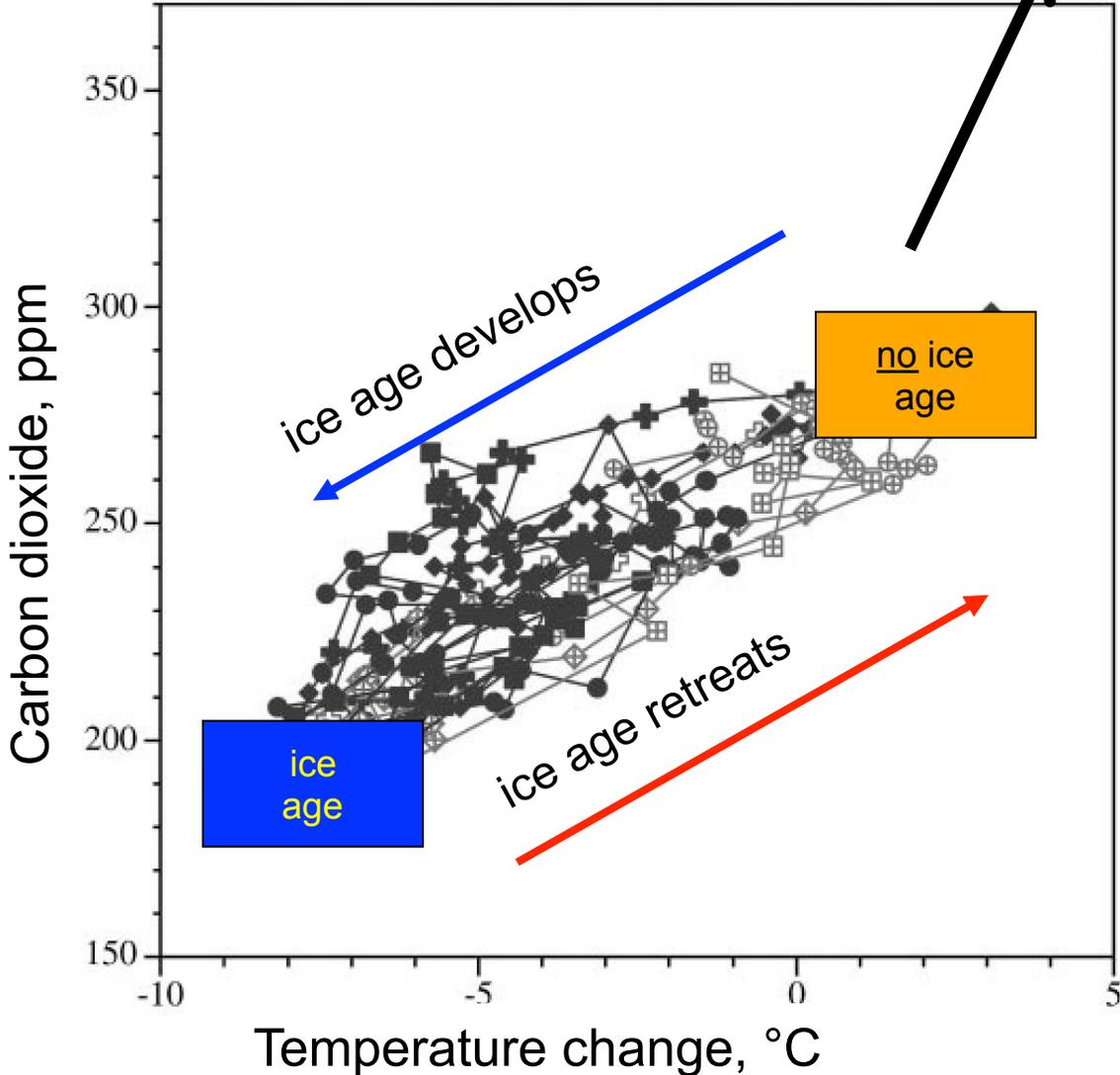
Contained in ice is the record of Earth's recent history

The Vostok ice core record



Reconstruction of changes in the average global temperature using ice core isotopes confirms a link between CO<sub>2</sub> and temperature.

Modern



Source: Falkowski et al. (2000), Science 290:291

Are there biological effects of increasing atmospheric CO<sub>2</sub>?

Yes - direct effects.

positive effects on photosynthesis rates globally

changes in food quality

Yes - indirect effects.

changes in plant distribution affecting animal distributions

changes in insect maturation rates

FACE experiments have been conducted in different ecosystems.



FACE = Free Air CO<sub>2</sub> Enrichment

## FACE Sites- Crops in Arizona



How will the quality of food available to you and to herbivores change with elevated atmospheric CO<sub>2</sub>?

- protein content
- starch content
- fiber content
- secondary compounds



# Assessment of Climate Change in the Southwest United States

A Report Prepared for the  
National Climate Assessment

2015



## Key Message: Increased Wildfire

Increased warming, drought, and insect outbreaks, all caused by or linked to climate change, have increased wildfires and impacts to people and ecosystems in the Southwest. Fire models project more wildfire and increased risks to communities across extensive areas.



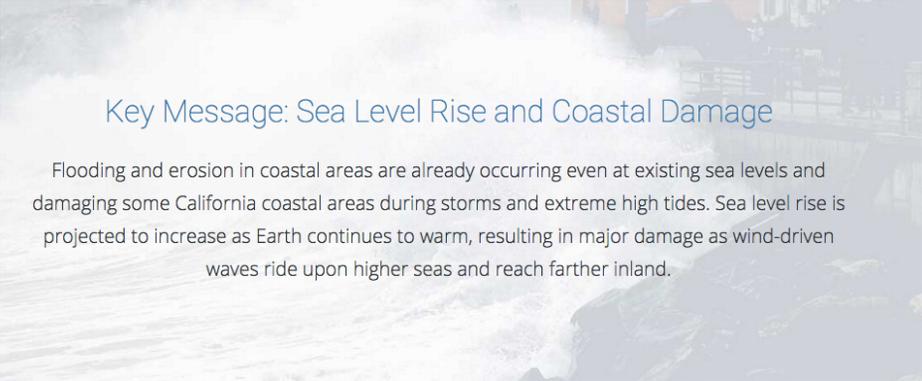
## Key Message: Reduced Snowpack and Streamflows

Snowpack and streamflow amounts are projected to decline in parts of the Southwest, decreasing surface water supply reliability for cities, agriculture, and ecosystems.



## Key Message: Threats to Agriculture

The Southwest produces more than half of the nation's high-value specialty crops, which are irrigation-dependent and particularly vulnerable to extremes of moisture, cold, and heat. Reduced yields from increasing temperatures and increasing competition for scarce water supplies will displace jobs in some rural communities.



## Key Message: Sea Level Rise and Coastal Damage

Flooding and erosion in coastal areas are already occurring even at existing sea levels and damaging some California coastal areas during storms and extreme high tides. Sea level rise is projected to increase as Earth continues to warm, resulting in major damage as wind-driven waves ride upon higher seas and reach farther inland.



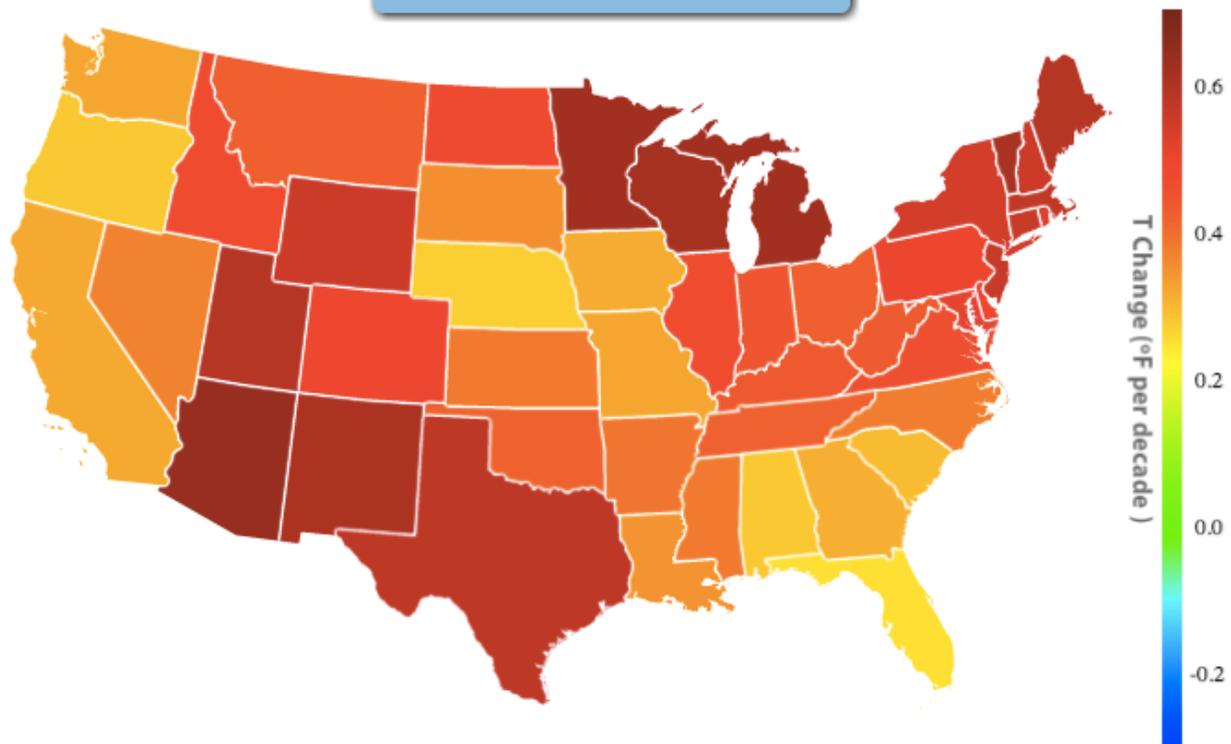
## Key Message: Heat Threats to Health

Projected regional temperature increases, combined with the way cities amplify heat, will pose increased threats and costs to public health in southwestern cities, which are home to more than 90% of the region's population. Disruptions to urban electricity and water supplies will exacerbate these health problems.

# Warming Accelerates after 1970

Trends in Average Temperature Changes, 1970-2011

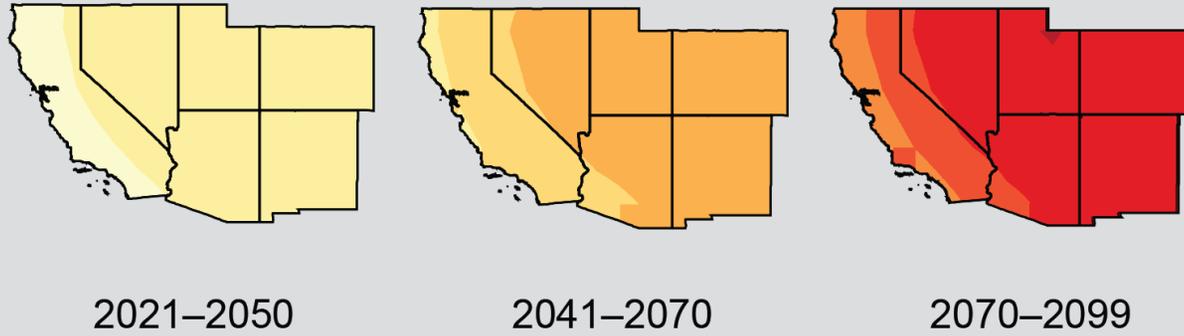
See the 1912-2011 Map »



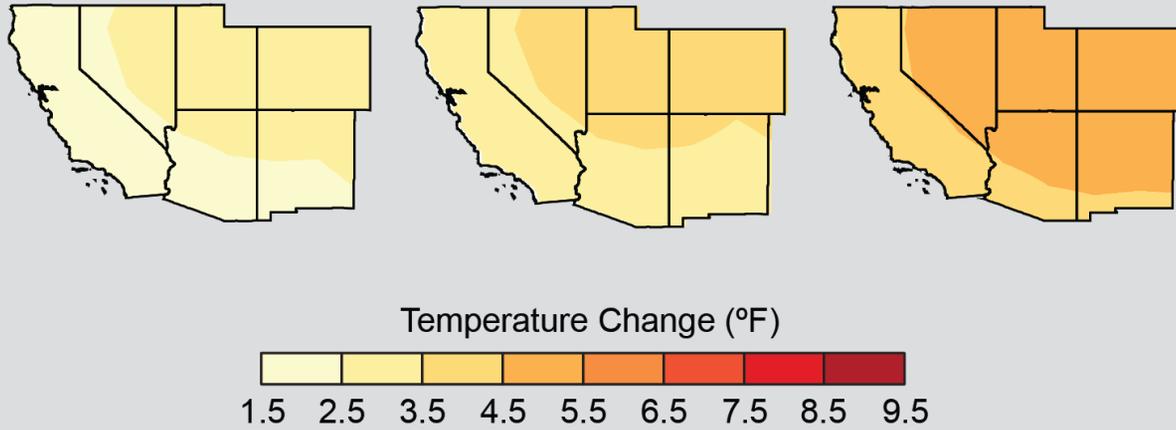
Average annual temperatures have been rising in every state since 1970. This map shows how fast each state has been warming each decade over the past 42 years.

# Projected Temperature Increases

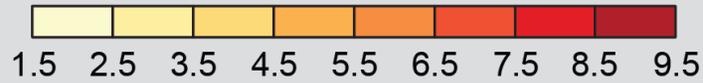
## Higher Emissions (A2)



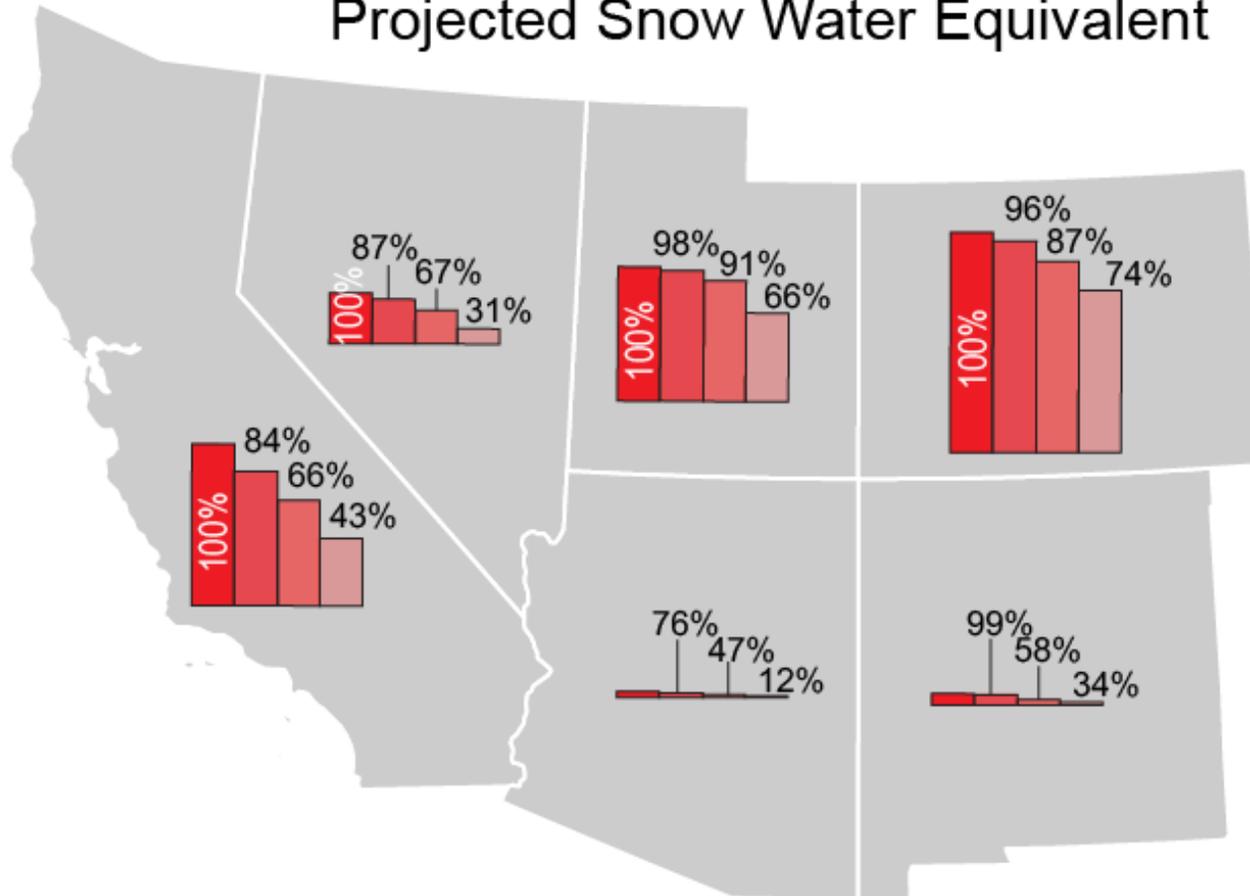
## Lower Emissions (B1)



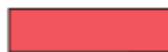
Temperature Change (°F)



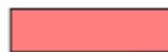
# Projected Snow Water Equivalent



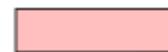
1971-2000



2006-2035



2041-2070



2070-2099