

Overview of Climate Change: Causes, Consequences, and their Mitigation

David I Gustafson, Ph.D.
Director, CIMSANS
dgustafson@ilsi.org
+1-314-409-7123

International Life Sciences
Institute Research Foundation



cimsans

Center for Integrated Modeling of
Sustainable Agriculture & Nutrition Security



International Conference on
Climate Change and Implications for
Water Resources & Nutrition Security
Bangalore, India
15 November 2013

Climate Change Impacts on Food Security are Becoming Front Page News



Size of the Challenge is Very Real

- In a recent paper, the Ehrlich's paint a very dire future

PROCEEDINGS
— OF —
THE ROYAL
SOCIETY **B**

rspb.royalsocietypublishing.org

Perspective



Cite this article: Ehrlich PR, Ehrlich AH. 2013
Can a collapse of global civilization
be avoided? Proc R Soc B 280: 20122845.
<http://dx.doi.org/10.1098/rspb.2012.2845>

Can a collapse of global civilization be avoided?

Paul R. Ehrlich[†] and Anne H. Ehrlich

Department of Biology, Stanford University, Stanford, CA 94305, USA

Environmental problems have contributed to numerous collapses of civilizations in the past. Now, for the first time, a global collapse appears likely. Overpopulation, overconsumption by the rich and poor choices of technologies are major drivers; dramatic cultural change provides the main hope of averting calamity.

1. Introduction

Virtually every past civilization has eventually undergone collapse, a loss of socio-political-economic complexity usually accompanied by a dramatic decline in population size [1]. Some, such as those of Egypt and China, have recovered from collapses at various stages; others, such as that of Easter Island or the

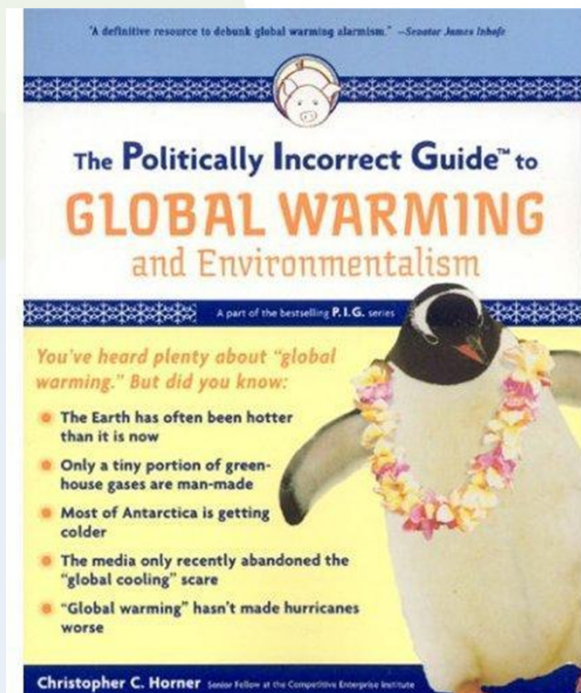
ILSI Research Foundation has launched a new Center to study climate change impacts on agriculture and nutrition security

- **Context of the Issue:** Three major megatrends are converging to threaten global nutrition security
 1. Global population growth and changing diets will increase food demand two-fold by 2050
 2. Current crop productivity gains and food storage losses barely keep pace with demand today
 3. Future climate change will differentially affect specific crops and regions – adaptation strategies are currently inadequate

Overview of Climate Change: a defining issue for our time

- **Primary man-made cause: Greenhouse Gases (GHGs) – CO₂, CH₄, N₂O**
- **Consequences for nutrition security**
- **Mitigation opportunities**
- **Conclusions**

Skepticism about the Theory of Man-Made Global Warming Abounds



- Though some of the skepticism is silly or opportunistic, sincere scientists are raising legitimate questions about the theory

“Like a nature hike through the Book of Revelations [sic]” – Al Gore, *An Inconvenient Truth* (the movie)

CHAPTER 11

18 The nations were angry; and Your wrath has come. The time has come for judging the dead, and for rewarding Your servants the prophets and Your saints and those who reverence Your Name, both small and great – and for destroying those who destroy the earth.

⋮

CHAPTER 16

Then I heard a loud voice from the temple saying to the seven angels, “Go, pour out the seven bowls of God’s wrath on the earth.”

2 The first angel went and poured out his bowl on the land, and ugly and painful sores broke out on the people who had the mark of the beast and worshiped his image.

3 The second angel pouted out his bowl on the sea, and it turned into blood like that of a dead man, and every living thing in the sea died.

4 The third angel poured out his bowl on the rivers and springs of water, and they became blood.

⋮

8 The fourth angel poured out his bowl on the sun, and sun was given power to scorch people with fire.

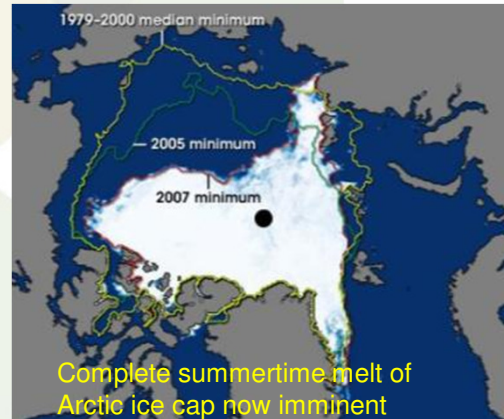
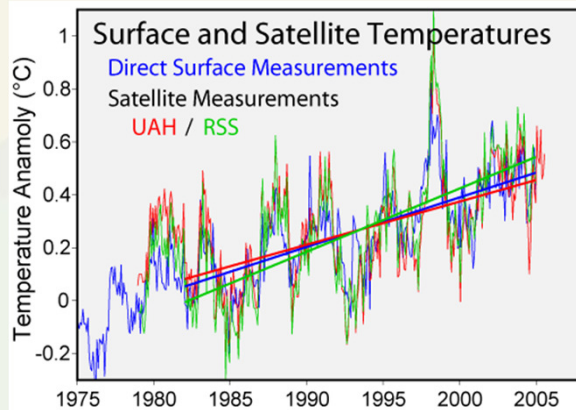
9 They were seared by intense heat and they cursed the name of God, who had control over these plagues, but they refused to repent and glorify him.

The time has come ...
for destroying those who
destroy the earth.

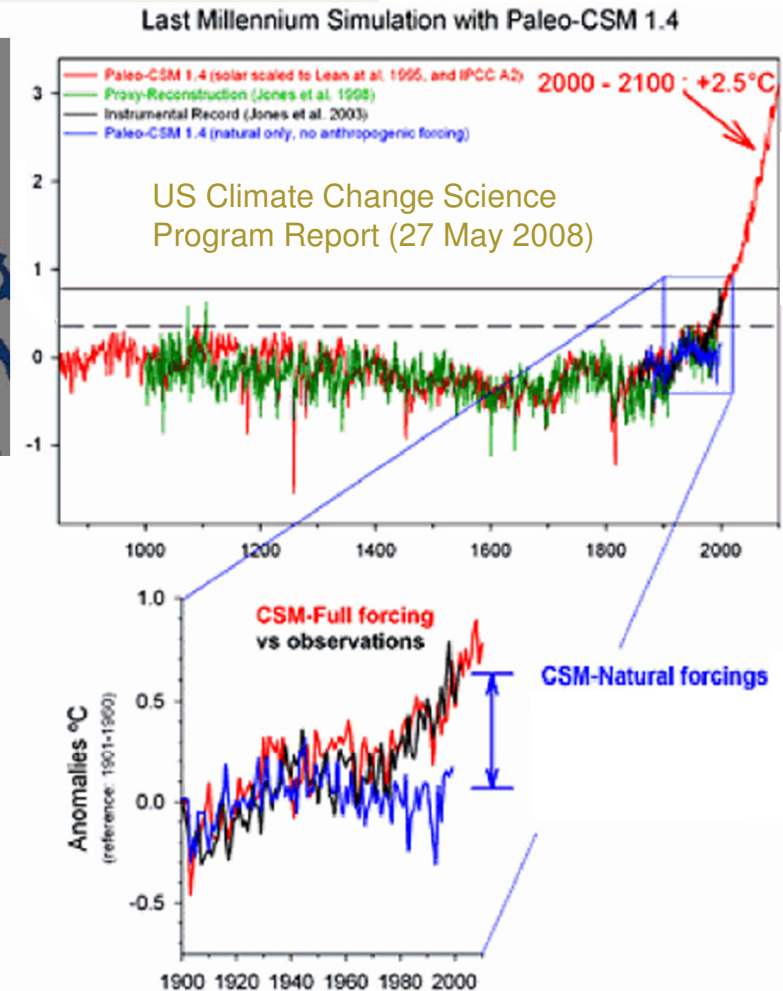
... every living thing in
the sea died.

They were seared by
intense heat ...

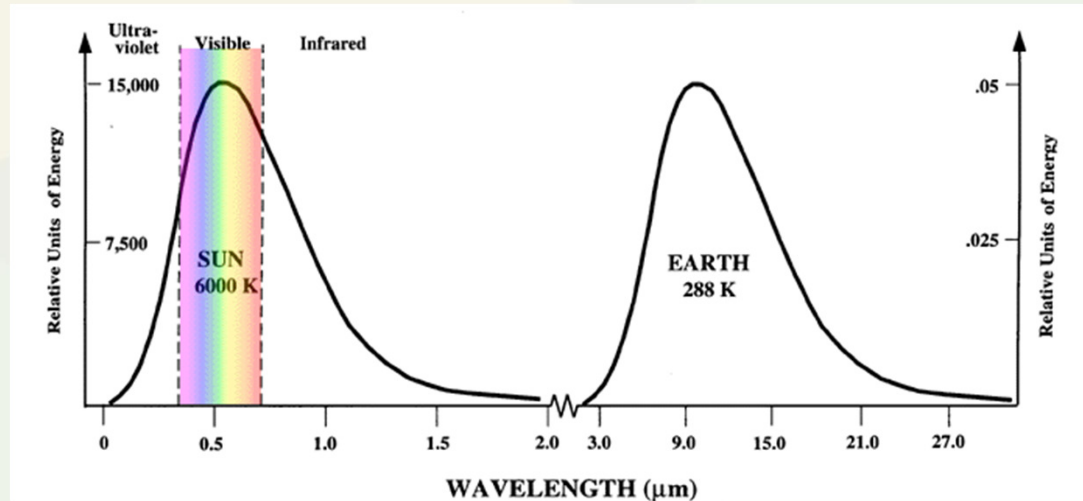
Temperatures are Increasing



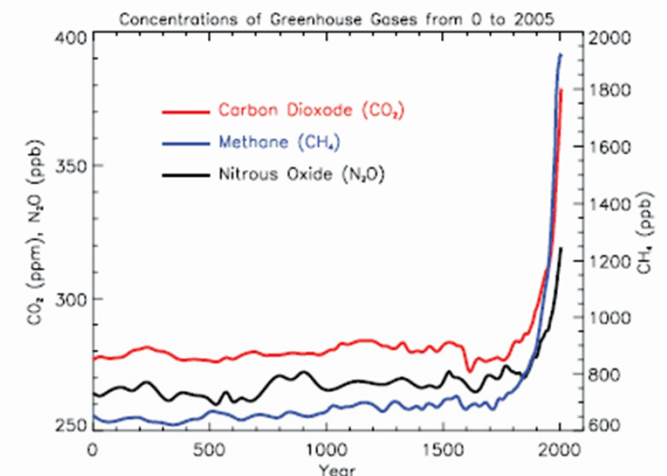
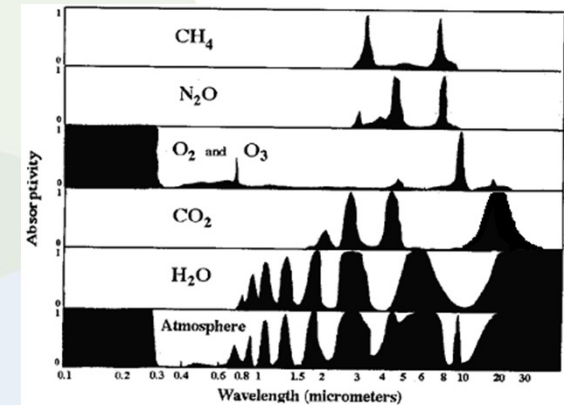
- All temperature measures agree surface warming is underway
- Unanimous corroborative data (glaciers, migration dates, etc.)
- Unprecedented rate of warming began in late 1960's, linked by modeling to man-made causes



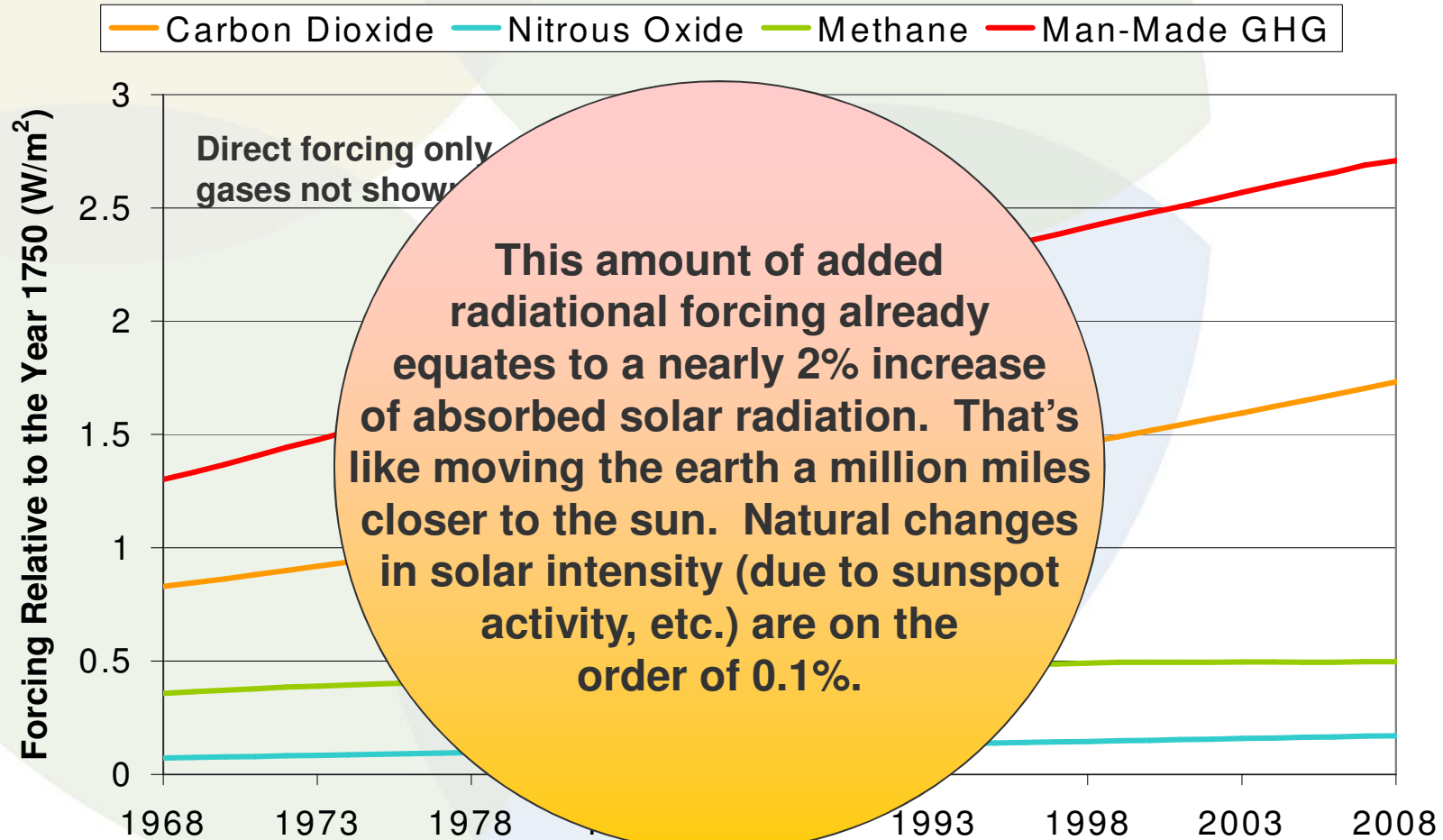
Emission & Absorption Facts



- Water accounts for 90% of greenhouse effect (70% as vapor, 20% as clouds)
- CO₂ comes next (4-8% of total effect)
- Methane and nitrous oxide far less important, but also increasing



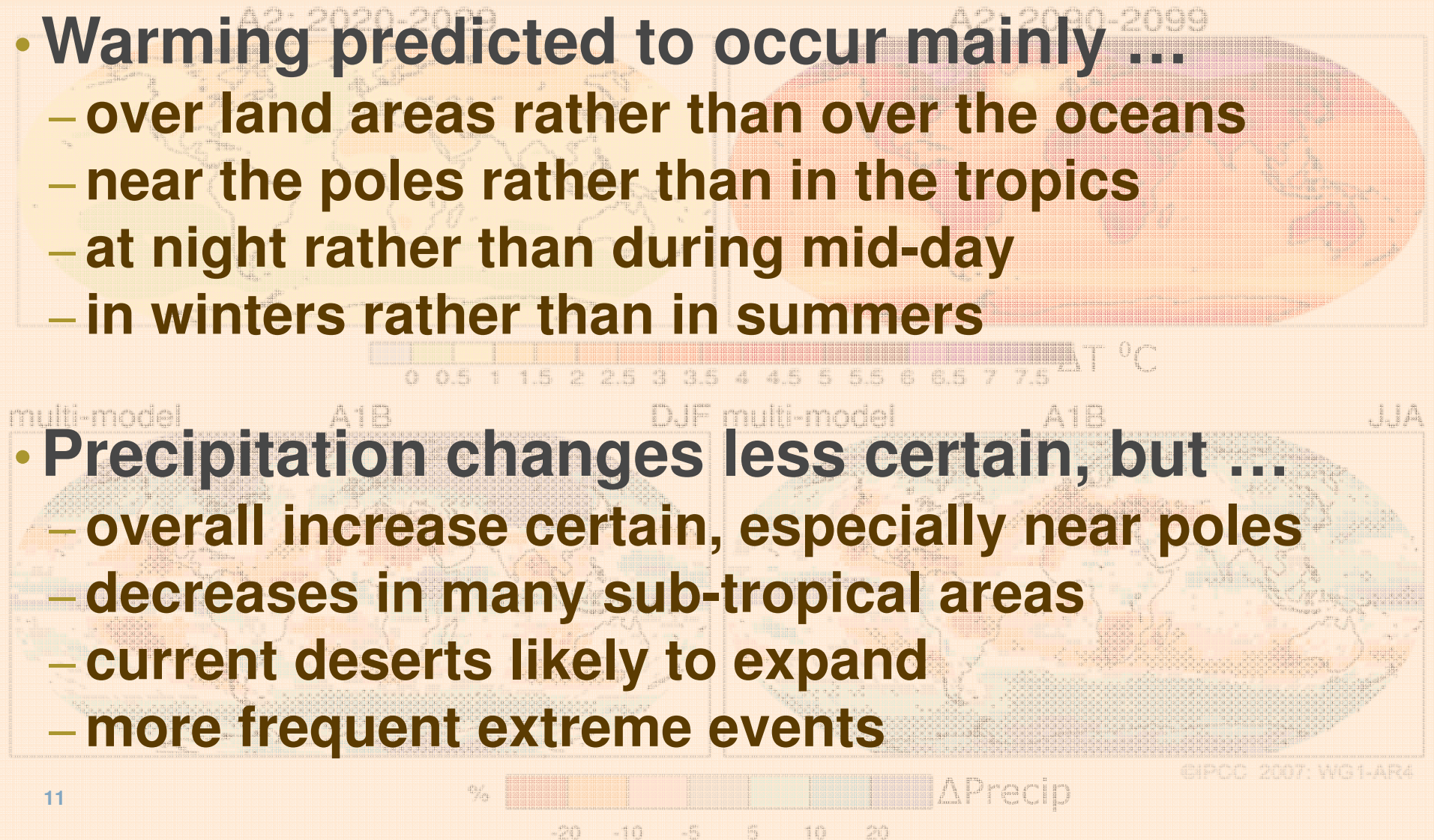
GHG Forcing, Significance



source: NOAA GHG Inventory

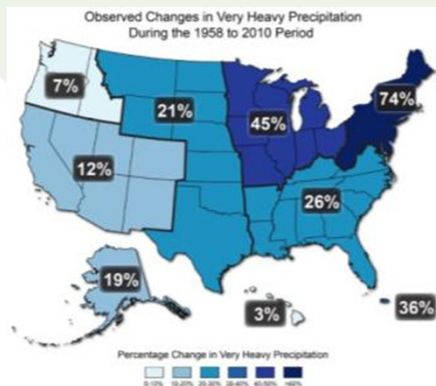
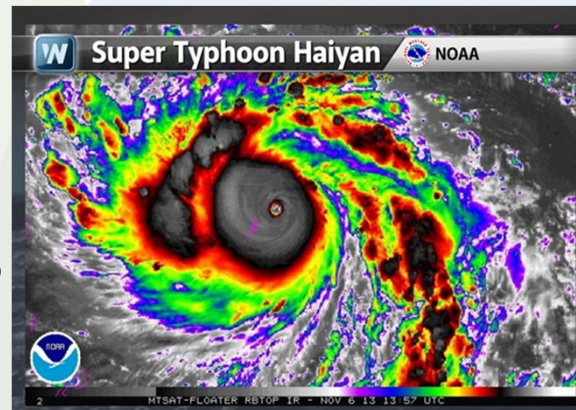
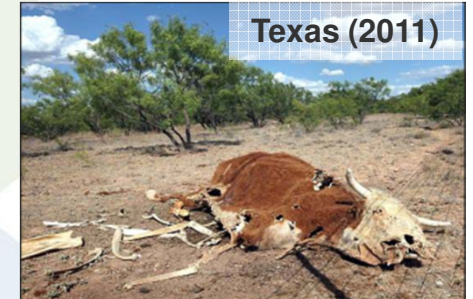
Global Warming Impacts Predicted to be Non-Uniform

- **Warming predicted to occur mainly ...**
 - over land areas rather than over the oceans
 - near the poles rather than in the tropics
 - at night rather than during mid-day
 - in winters rather than in summers
- **Precipitation changes less certain, but ...**
 - overall increase certain, especially near poles
 - decreases in many sub-tropical areas
 - current deserts likely to expand
 - more frequent extreme events

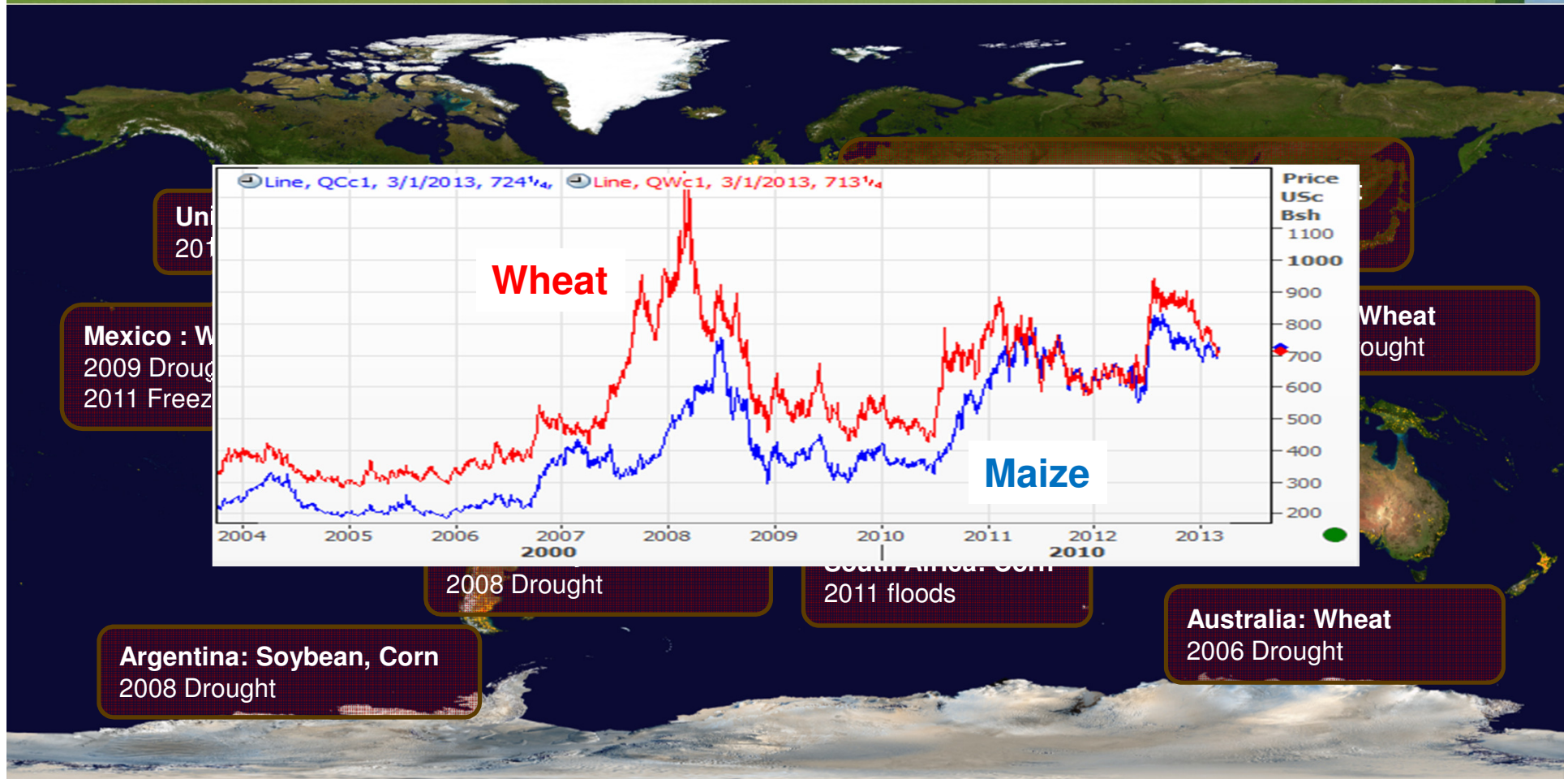


Increases in Frequency and Intensity of Extreme Weather Events

- **Floods**
 - **Drought**
 - **Heat waves**
 - **Wind-storms**
 - **Severe t-storms**
 - **Tropical cyclones**
- 

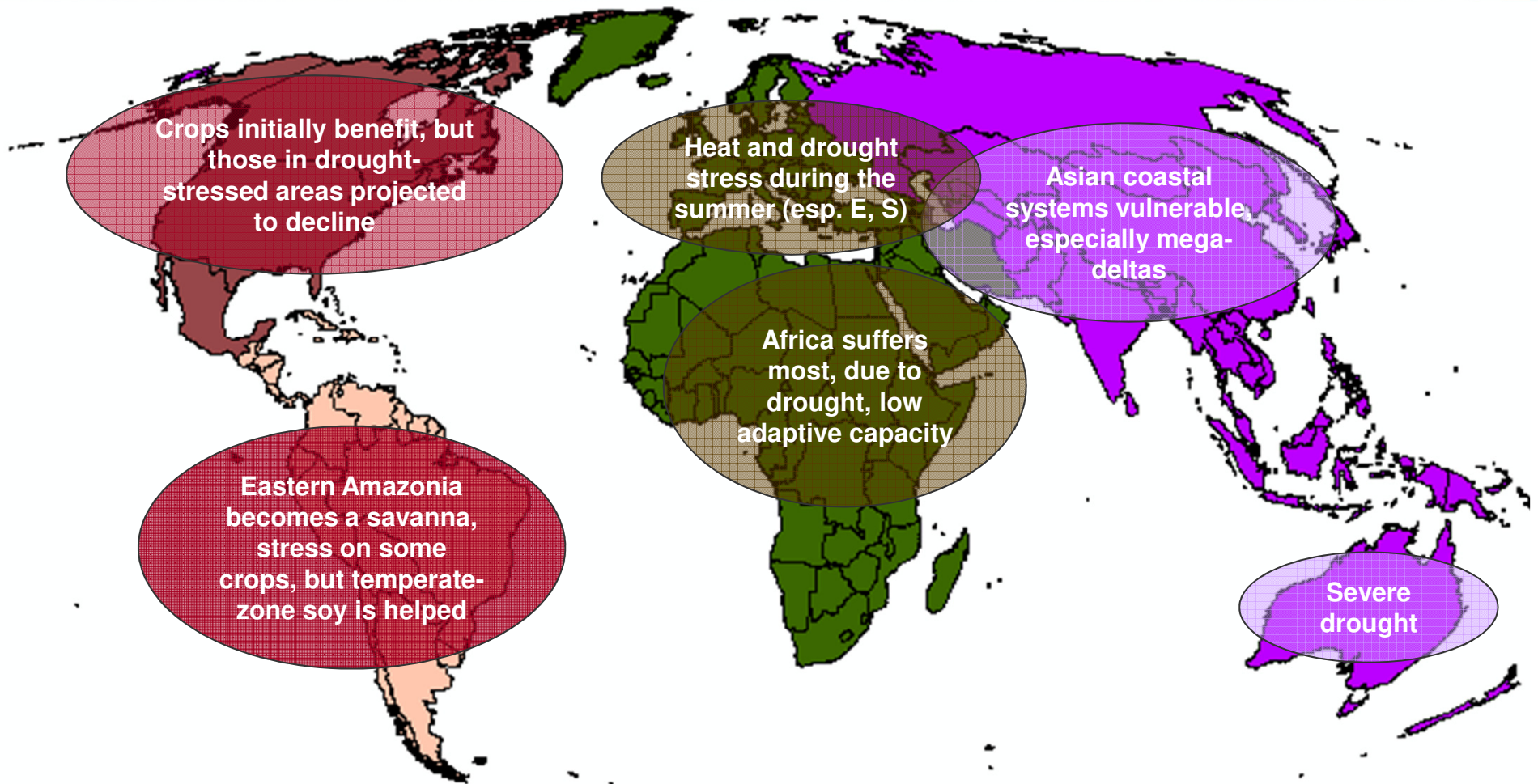


Food Production Impacted by Increased Frequency and Intensity of Extreme Weather



source: World Bank

Agricultural Impacts Globally



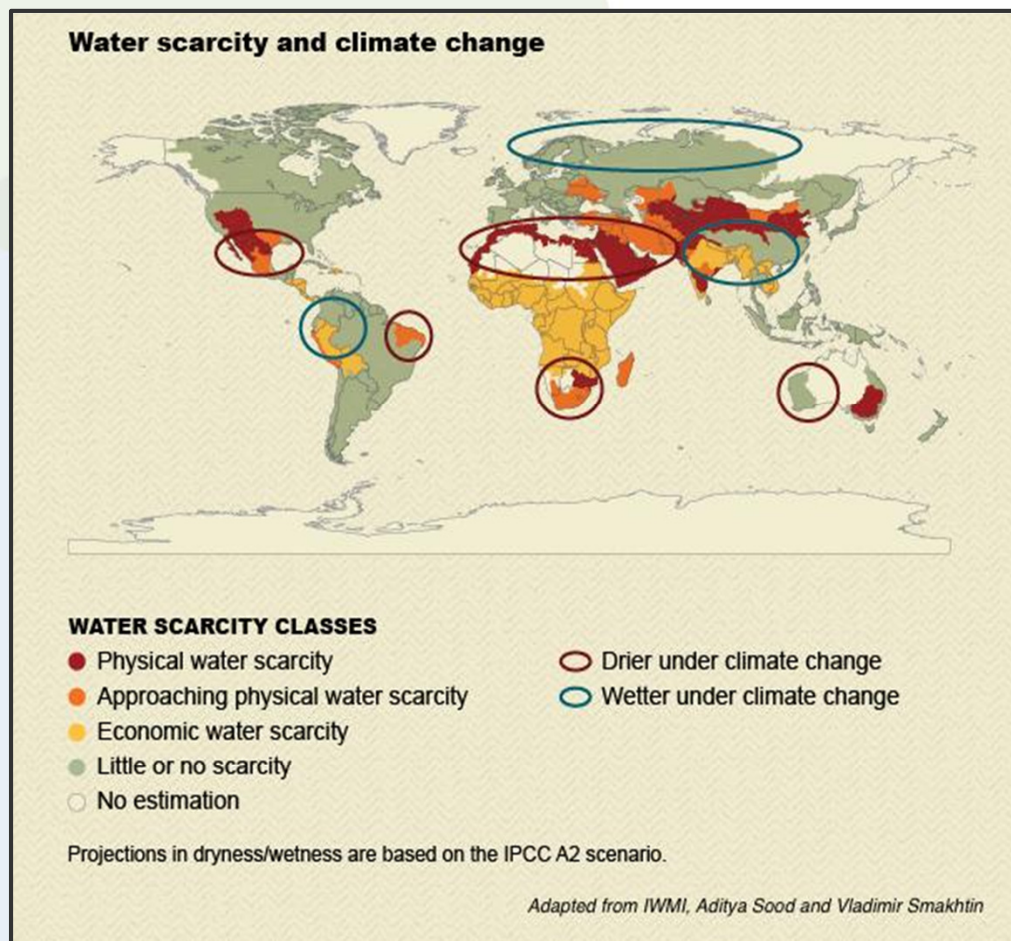
Variations in Water Availability will Impact Regional Crop Yields in Different Ways

Water scarcity will worsen in many agricultural regions.

Some regions will suffer flooding and other effects of excess moisture.

Crop yields will decline as water scarcity and heat stress continue.

Certain staple crops are highly sensitive to heat and drought.



Indirect Impacts on Agriculture



Weeds

Range and reproductivity increase
Pathogen and insect host implications



Insects

Lepidopteran and Coleopteran range expansion
Insect-vectored mycotoxin increase
Potential new pest targets (aphids, spider mites, etc.)



Diseases

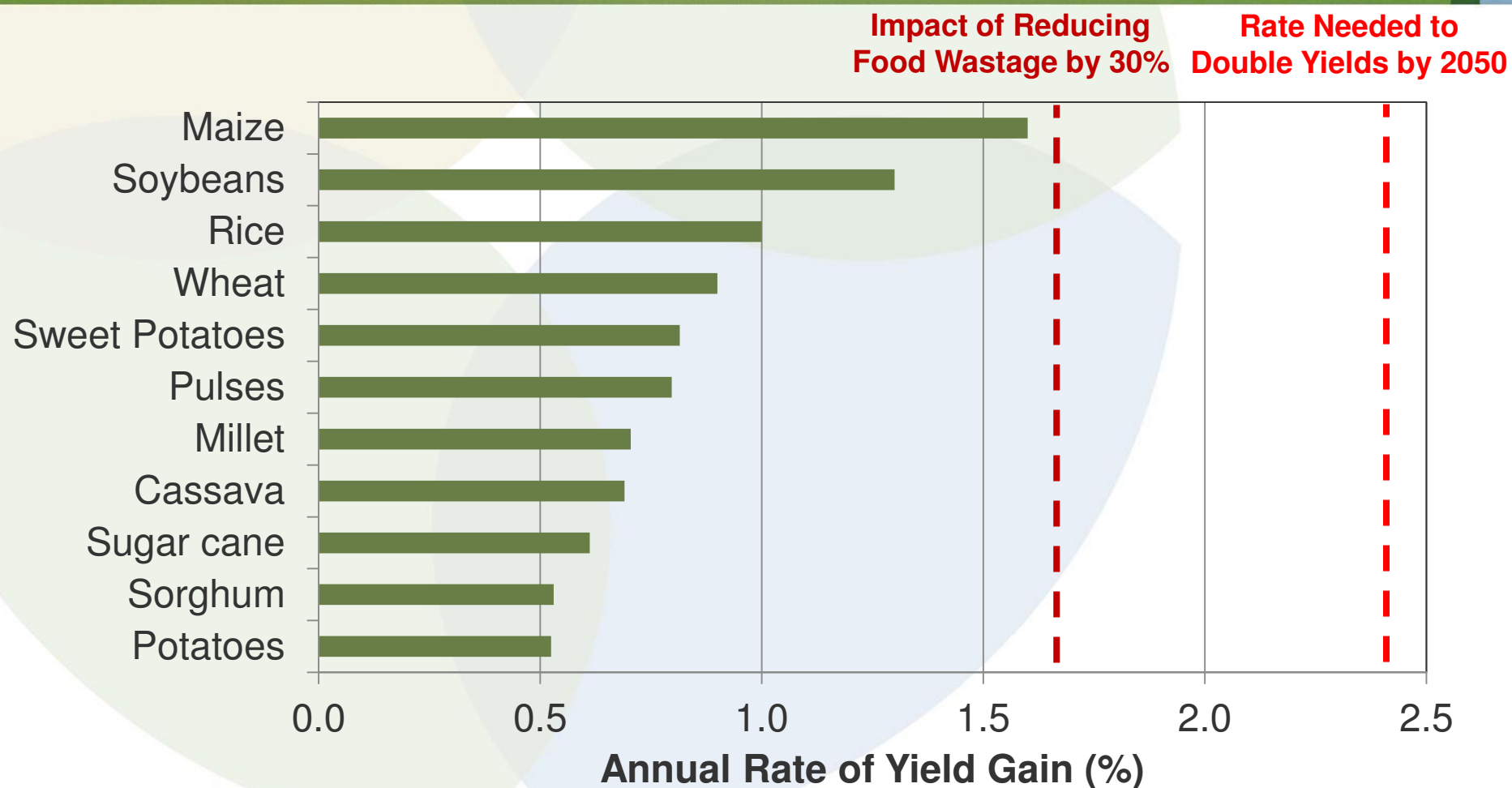
Nematodes under hot dry conditions
Foliar and stalk diseases under hot and wet conditions



Soil Health

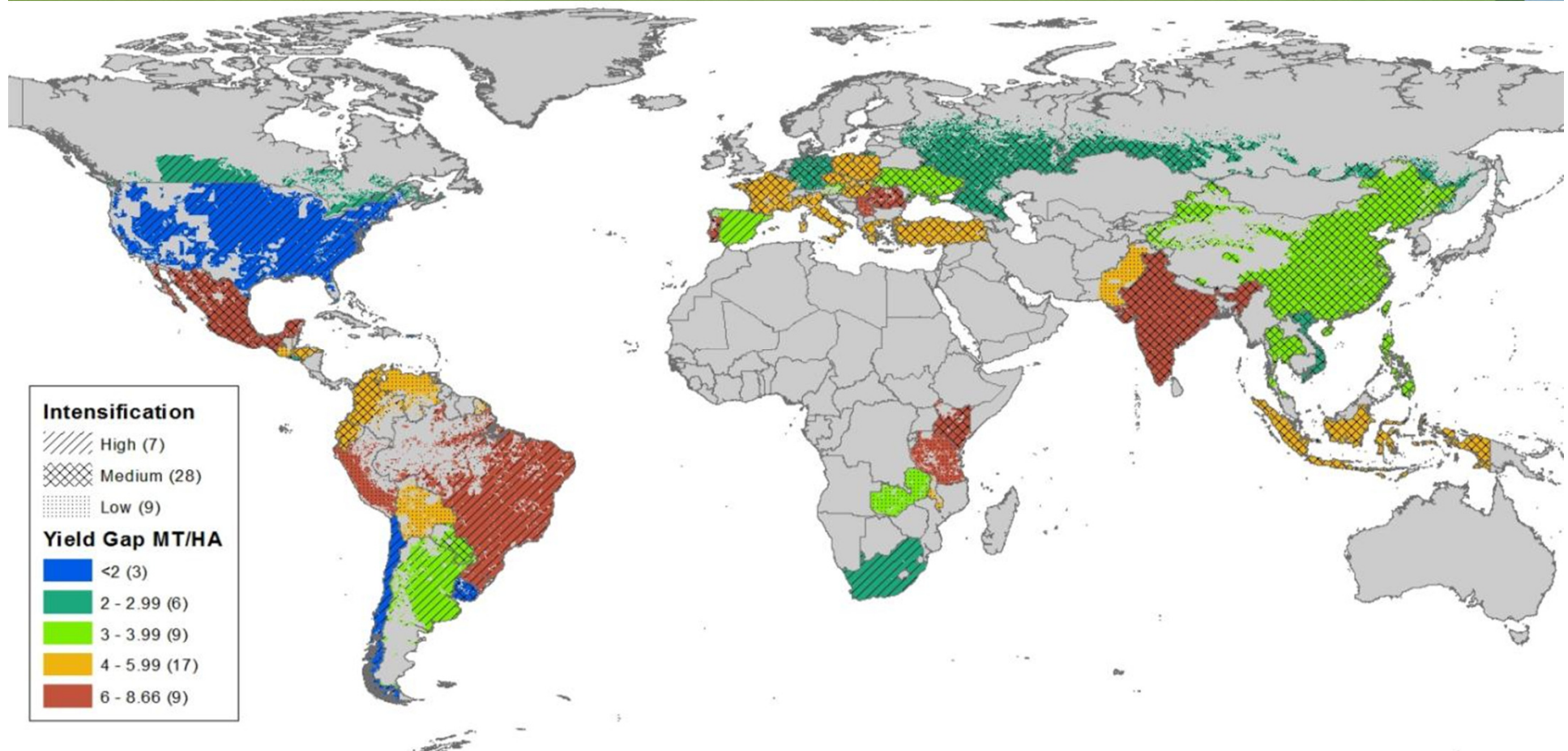
Changes in mineral content due to droughts

Annual Rates of Yield Increases for Staple Crops Vary with Technology Investment



Global rates of yield gain (1961-2011), based on data available from FAOSTAT

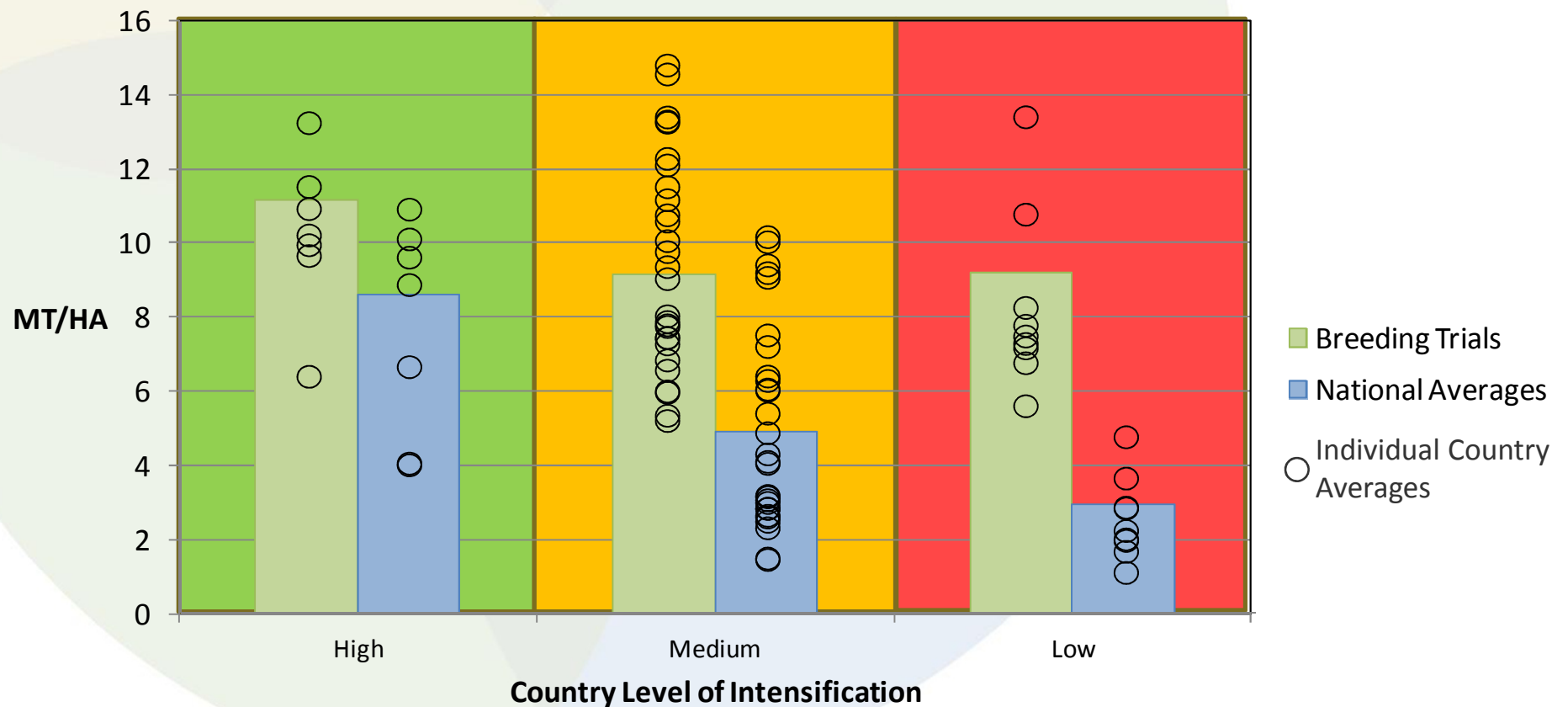
Maize Yield Gaps Vary with Level of Ag Intensification



Data Sources: Country Boundaries: Esri; Maize Growing Areas: LUGE (Land Use and the Global Environment) Lab, McGill University

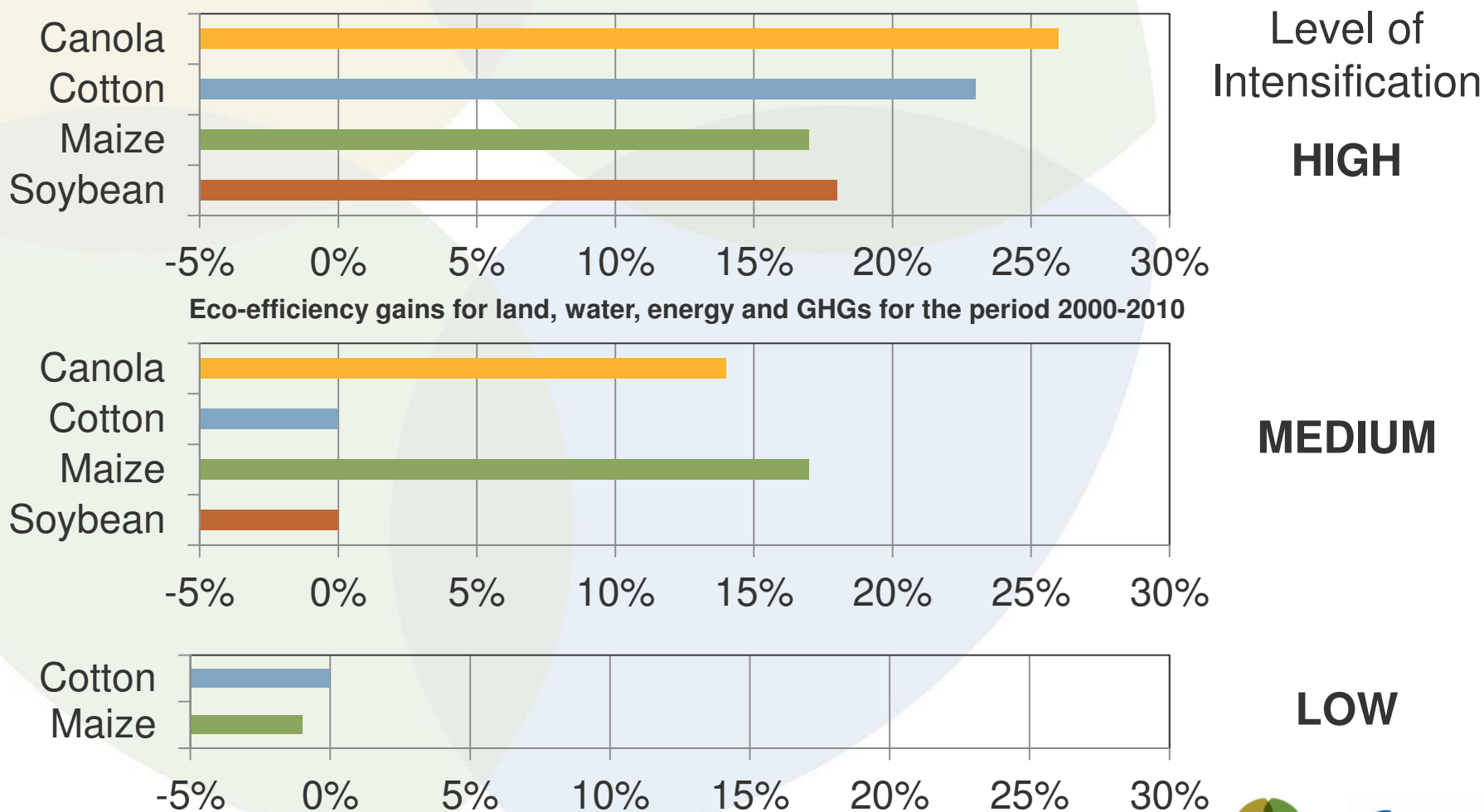
source: Gustafson, et al. *Climate adaptation imperatives* (2013)

Ag Intensification Needed in More Regions to Reduce Maize Yield Gaps



source: Gustafson, et al. *Climate adaptation imperatives* (2013)

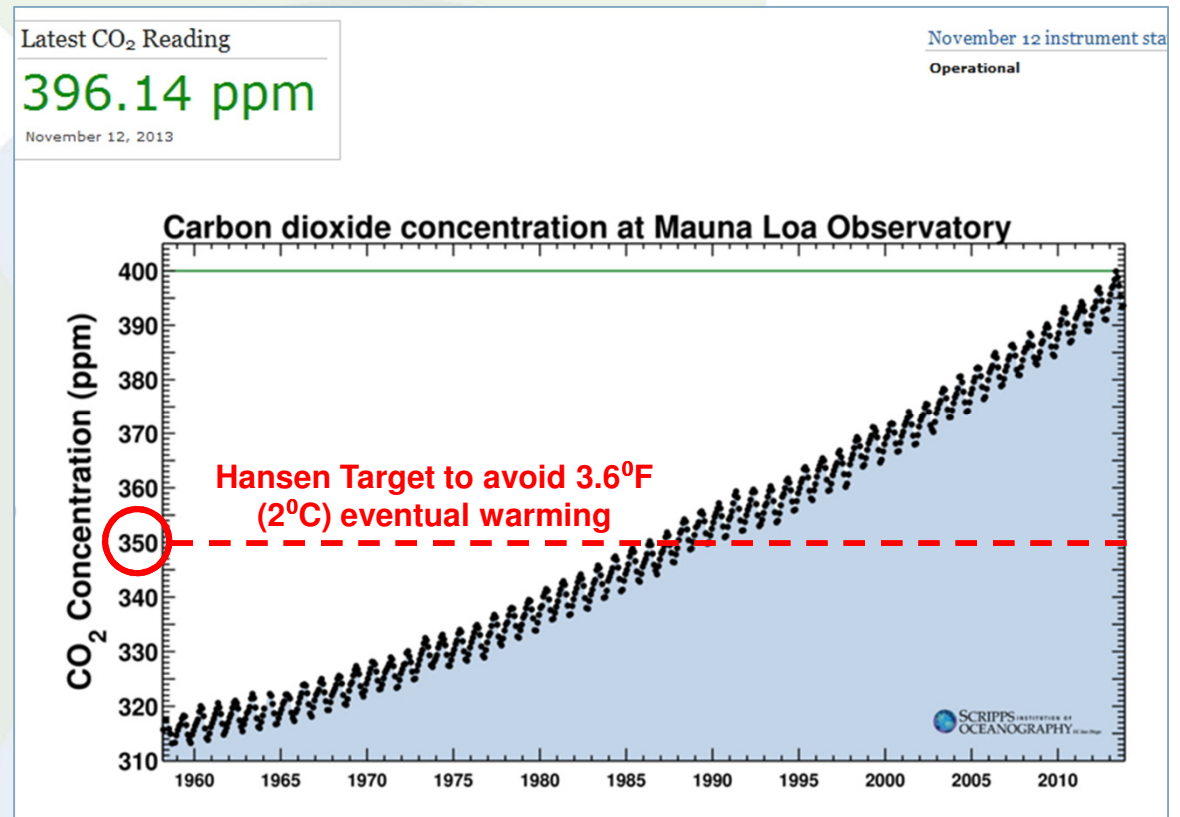
Much Greater Eco-Efficiency Gains for High Intensification Countries (2000-2010)



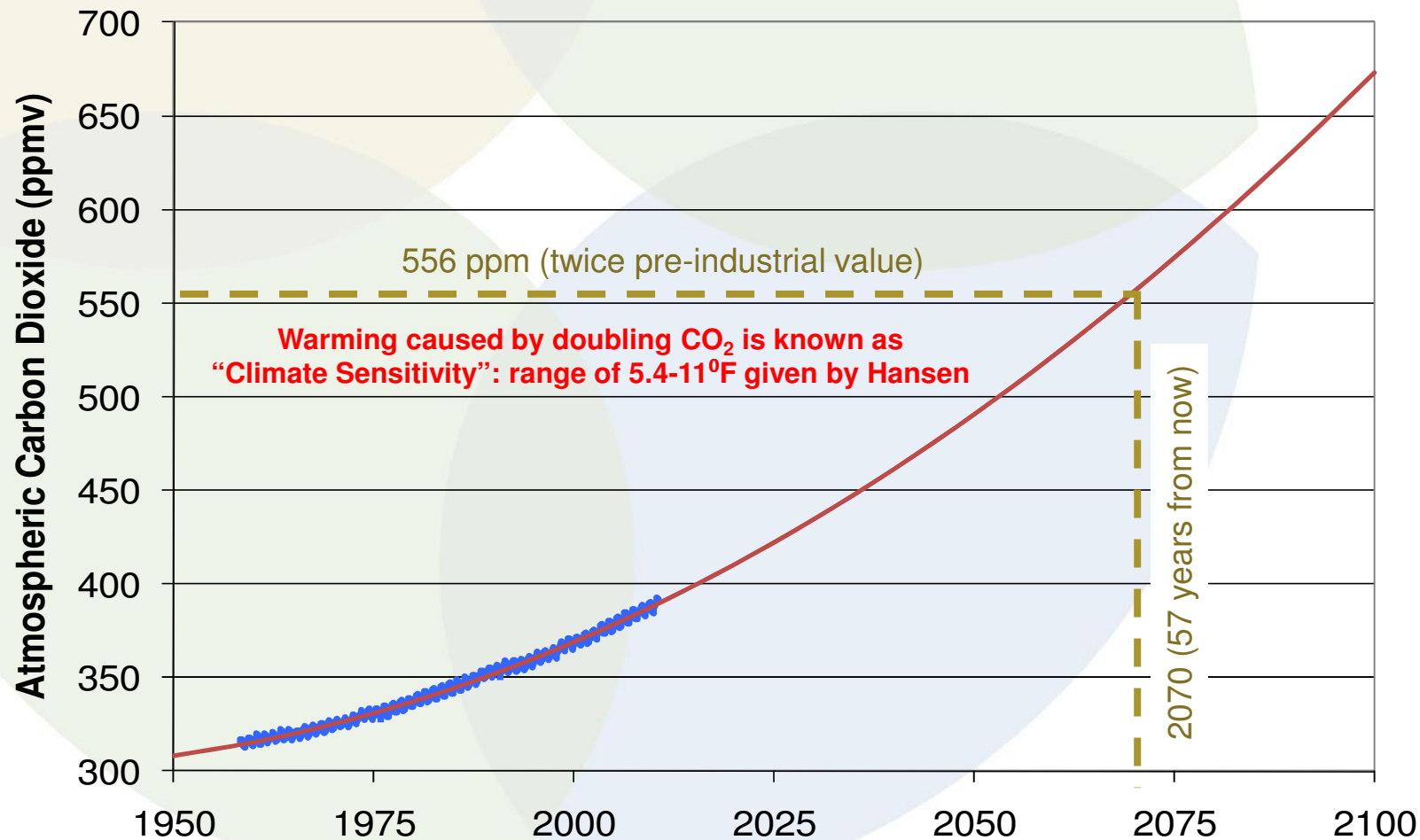
source: Shryock, et al., *Climate adaptation imperatives* (2013)

No Evidence of Mitigation Yet

- Monitoring at Mauna Loa (Scripps Institute, UCSD) shows CO₂ levels continue to climb
- Peaked over 400 ppm for the first time earlier this year
- Already far beyond “safe” level of 350 ppm

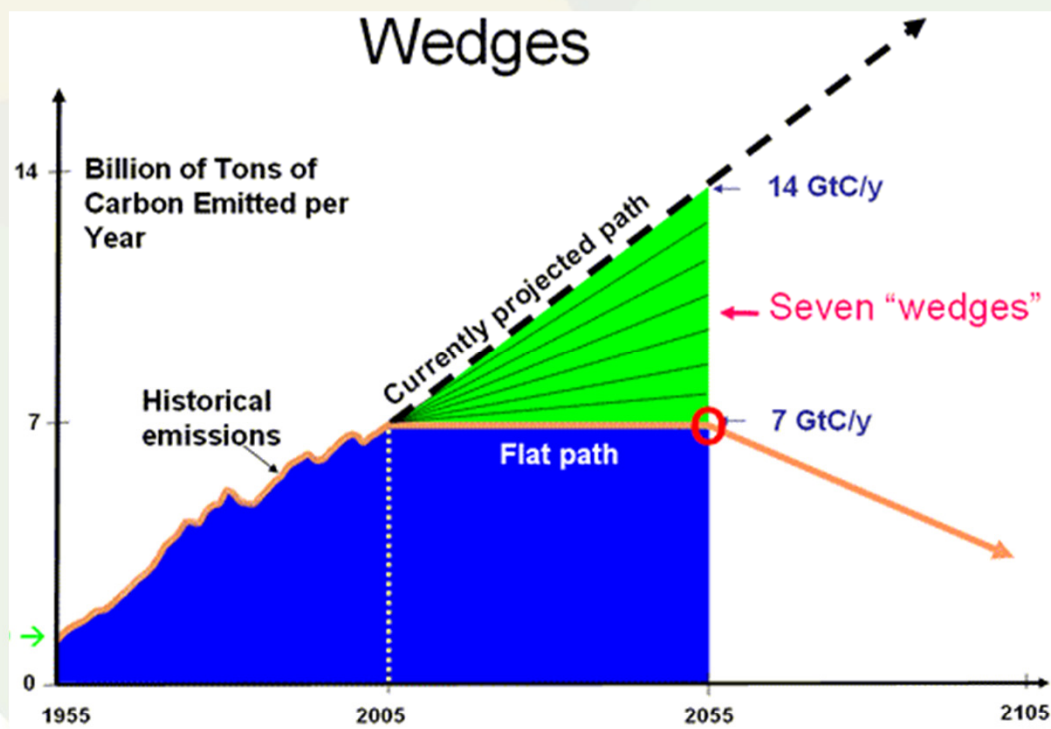


Without Intervention, CO₂ Levels are Poised to Double by 2070



data source: Mauna Loa Observatory

Socolow's "Wedges" – Ag Could Help Mitigate GHG Emissions



Wedge options:

- Increase automobile fuel efficiency
- Reduce car miles traveled
- Cut electricity use
- Raise efficiency at coal fired plants
- Replace coal-fired plants with gas-fired
- Install carbon capture and storage (CCS) at coal-fired plants
- Install CCS at coal plants that produce hydrogen for vehicles
- Install CCS at coal-to-syngas plants
- Nuclear fission
- Increase wind power
- Increase solar power
- Plug-in fuel-cell cars
- **Increase biofuels**
- **Stop deforestation**
- **Expand conservation tillage**

- Each wedge represents 25B tons of carbon that needs to be cut out of predicted future emissions over the next 50 years to avoid doubling atmospheric carbon dioxide over pre-industrial levels.

source: Pacala & Socolow, *Science*, 350:968-972 (2004).

Conclusions

- **Climate change is already underway and will only intensify in the future**
- **Impacts to water resources and nutrition security are serious and increasing**
- **Mitigation efforts to date have not reduced emissions – no serious plans under discussion**
- **Given the above, it is imperative to initiate action now, to prepare for further climate challenges**