



# Lecture 2: Global Change

## Episode 1: A Time of Accelerating Change

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# Overview of the Lecture

## **Episode 1: A Time of Accelerating Change**

Episode 2: Planetary Boundaries

Episode 3: Interview



## Learning Outcomes

- Dimension of the human impact on the global environment in an age of accelerating change
- The four spikes of global change



# Structure of Episode 1

1. Sweeping Global Changes
2. The Four Spikes of Change
3. Conclusion



# Sweeping Changes

Human impacts on the natural environment have increased dramatically in the 20<sup>th</sup> Century due to increases in:

- Human population
  - Our growing hunger for resources and exploitive economic systems are damaging the planet ecological infrastructure.
- Scale of human activities (industry, agriculture, extraction of natural resources)
  - Changes in land use (clearing forests for agriculture) can disrupt ecosystems and affect the chemistry of the atmosphere.



## Sweeping Changes

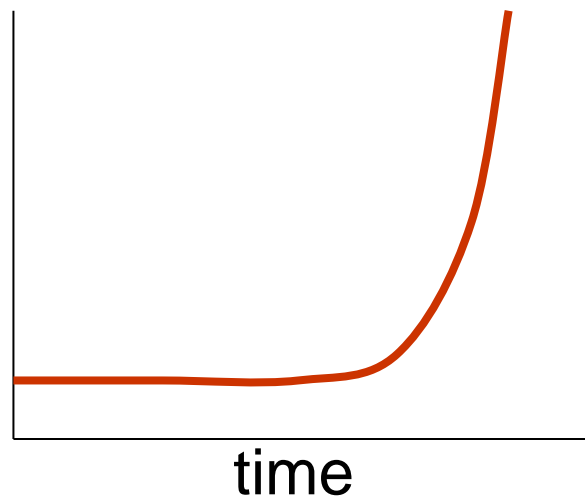
- Climate change is just the tip of the iceberg – many linked environmental, socio-economic and cultural changes are sweeping rapidly across the planet.
- Between one-third and one-half of the land surface has been transformed by human action.
- More atmospheric nitrogen is fixed by humanity than by all natural terrestrial sources combined.
- Carbon dioxide (CO<sub>2</sub>) concentration in the atmosphere has increased by nearly 30% since the beginning of the Industrial Revolution in the 18<sup>th</sup> Century.



# The Four Spikes

## The 20<sup>th</sup> Century – A Time of Accelerating Change The Four “Spikes” of Global Change

- Atmospheric CO<sub>2</sub> spike
- Extinction spike
- Consumption spike
- Population spike



Source: Ed Ayers (2000) God's Last Offer



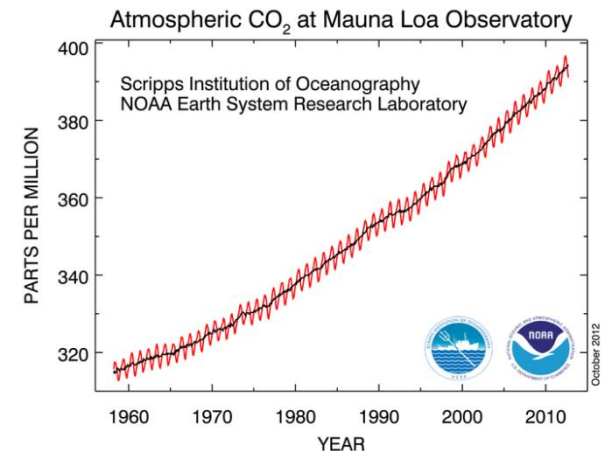
# Atmospheric CO<sub>2</sub> Spike



Source: <http://www.esrl.noaa.gov/>

The NOAA Mauna Loa observatory has recorded CO<sub>2</sub> concentrations in the atmosphere since 1959

- September 2011: 389.00 ppm
- September 2012: 391.05 ppm

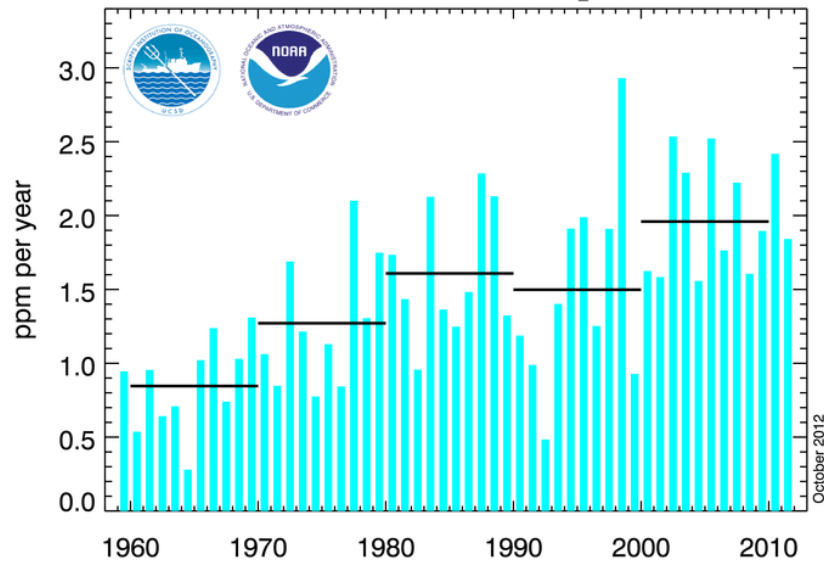




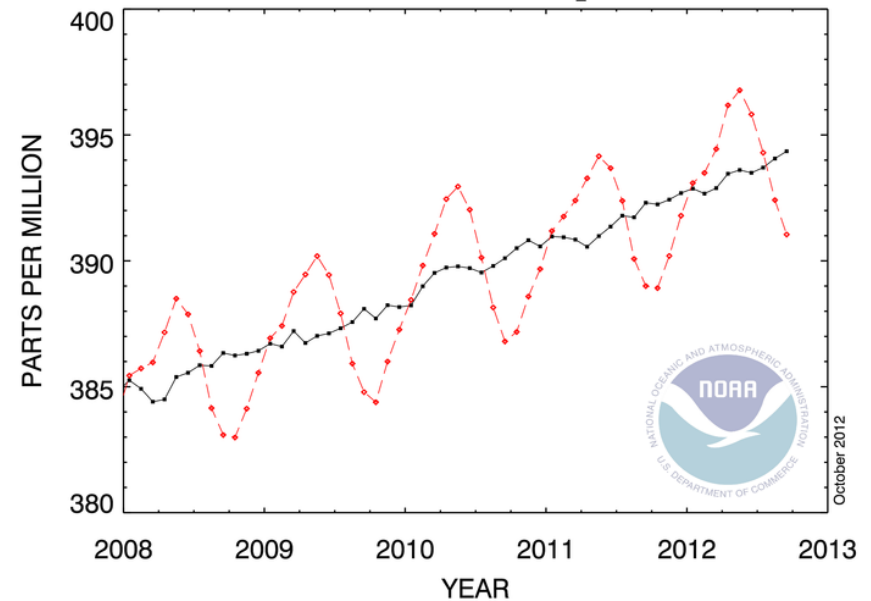


# Atmospheric CO<sub>2</sub> Spike

annual mean growth rate of CO<sub>2</sub> at Mauna Loa



RECENT MONTHLY MEAN CO<sub>2</sub> AT MAUNA LOA

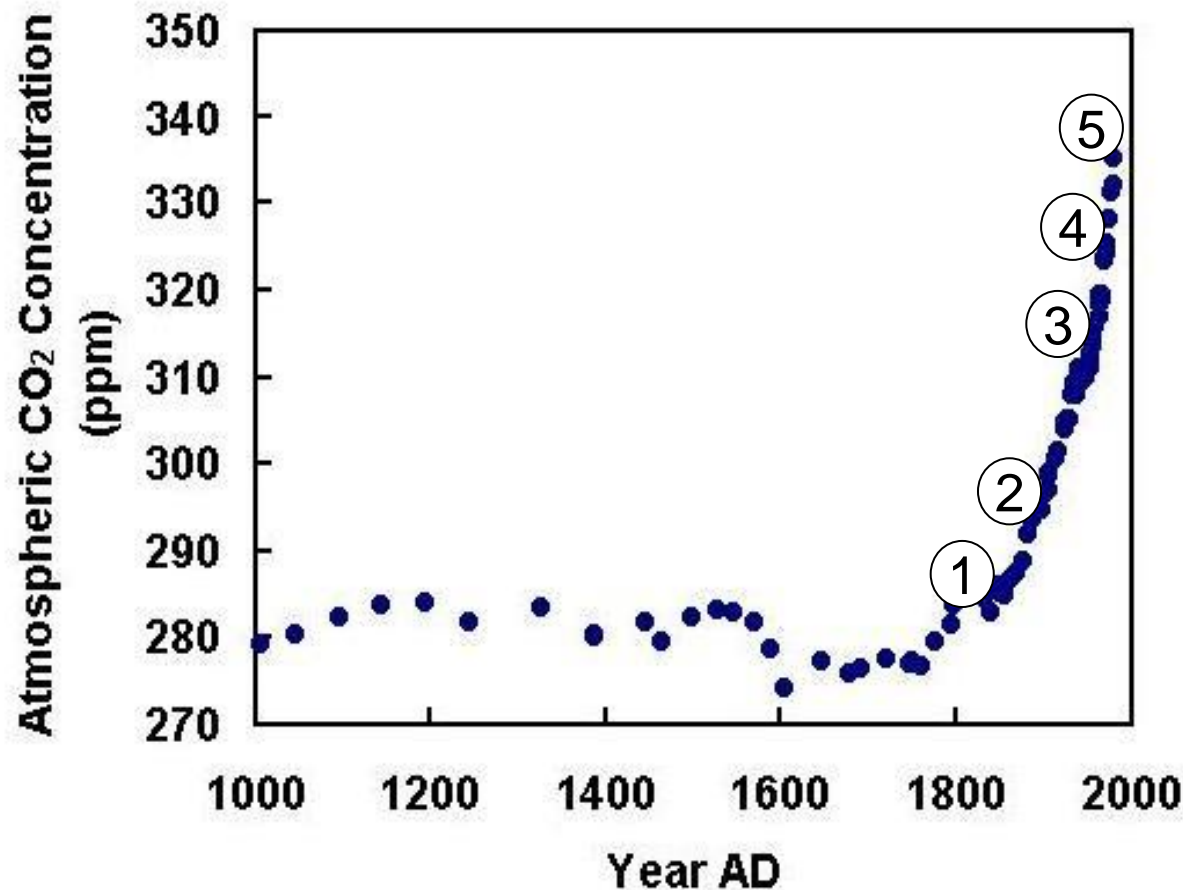


Source: <http://www.esrl.noaa.gov/>



# Atmospheric CO<sub>2</sub> Spike

1. 1850: Shift from wood burning to fossil fuel burning
2. 1900: First cars appear
3. 1980's: scientists suspect link between CO<sub>2</sub> emissions and global warming
4. 1997: Kyoto protocol
5. 2001: Bush withdraws US support of Kyoto agreement

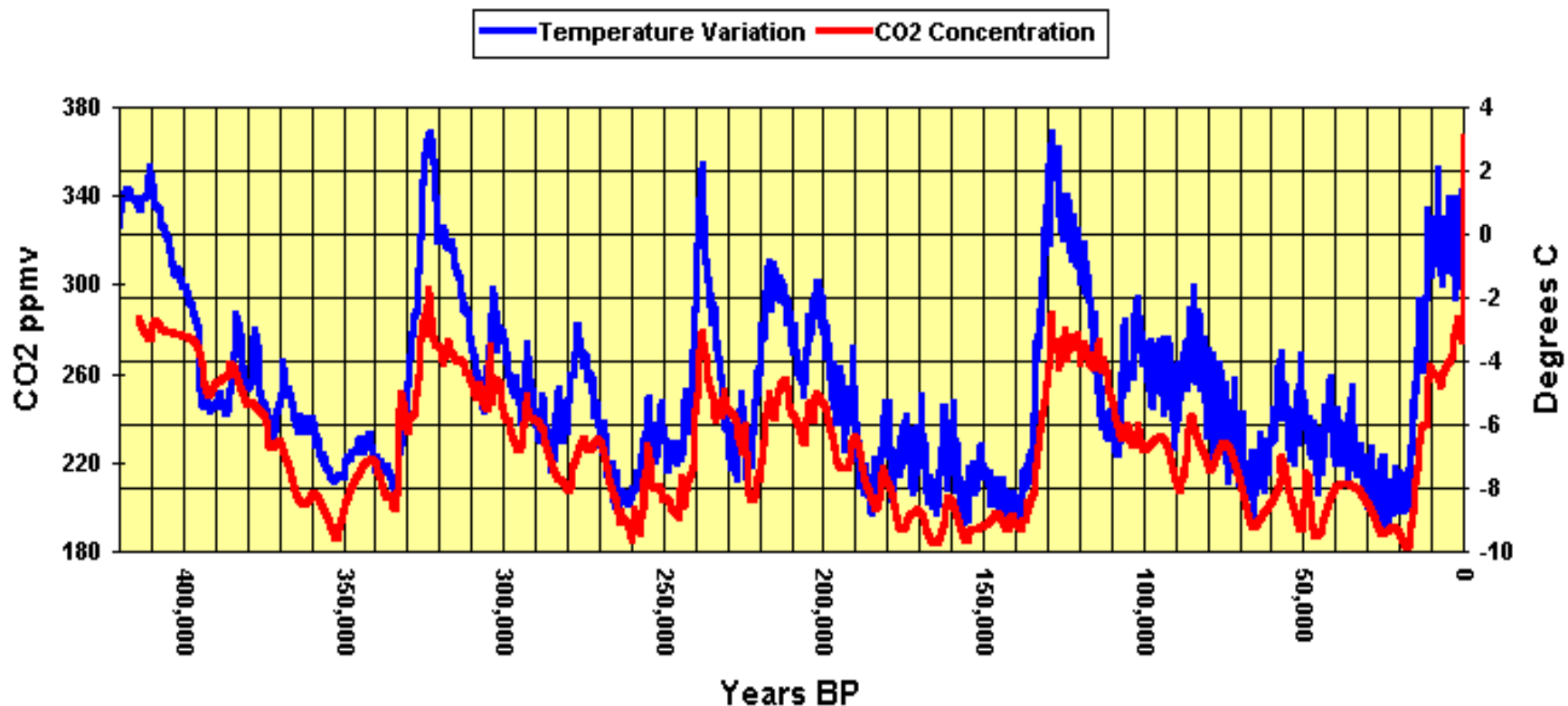


Source: Etheridge et al. (1998)



# Atmospheric CO<sub>2</sub> Spike

## Antarctic Ice Core Data 1

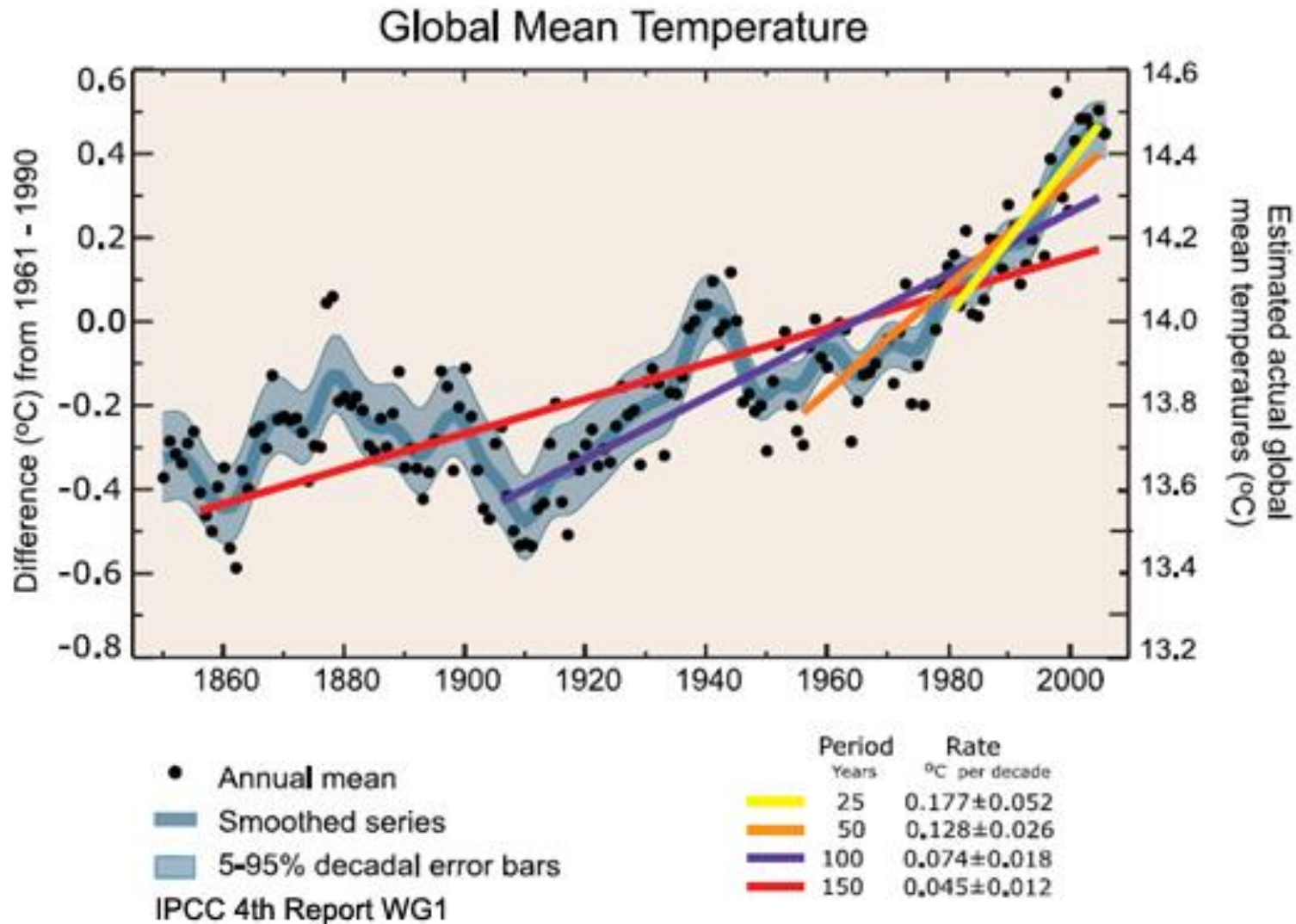


Source:

<http://www.ncdc.noaa.gov/paleo/icecore/antarctica/vostok/vostok.html>



# Atmospheric CO<sub>2</sub> Spike



Source:

<http://www.ncdc.noaa.gov/paleo/icecore/antarctica/vostok/vostok.html>



# Extinction Spike

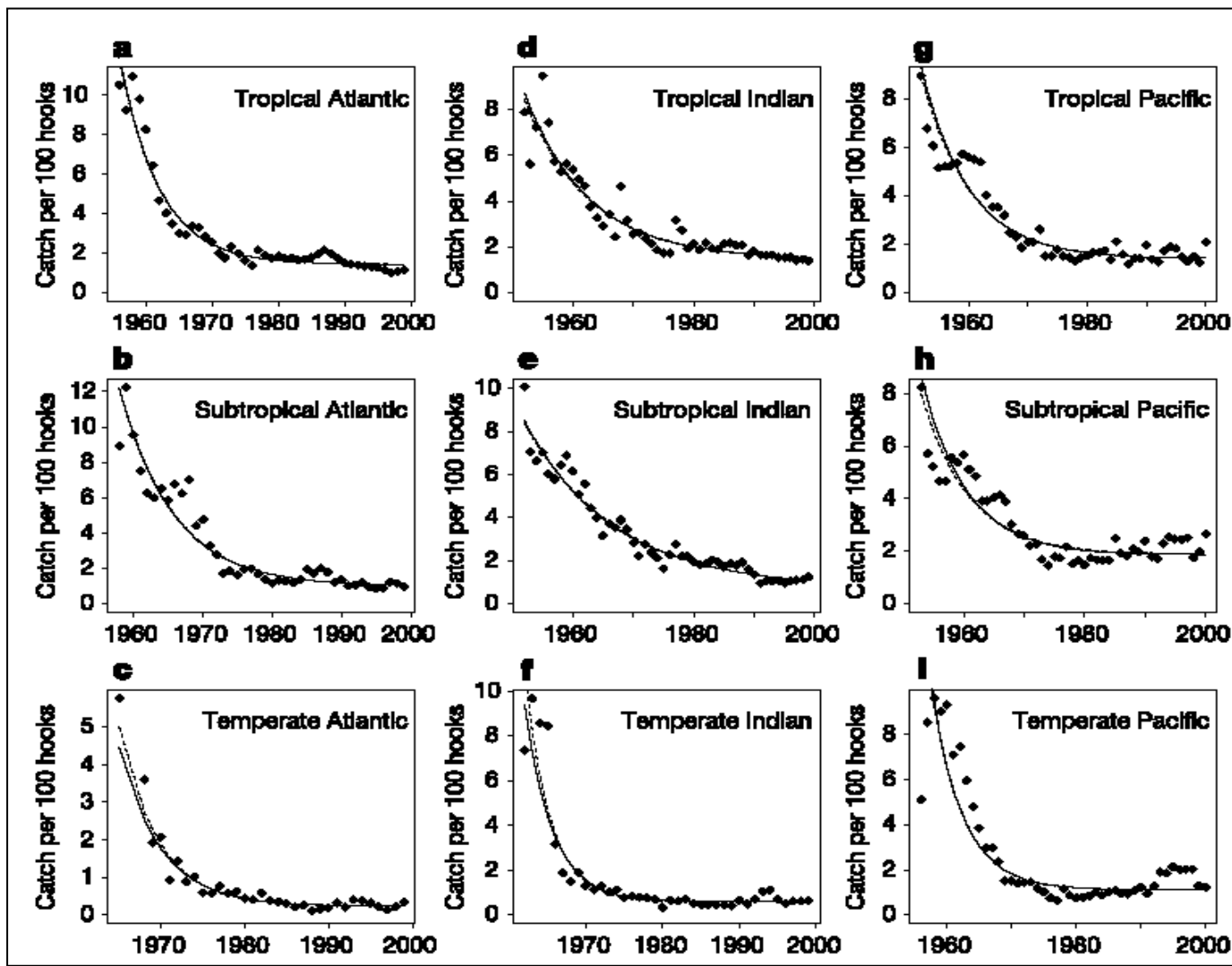
- One Quarter Of All Mammal Species Face Extinction Soon (IUCN-- 2000)
- Monkeys, Apes Are Being Eaten to Extinction (Associated Press)
- Mass Extinction of Freshwater Creatures Forecast (WWF Report)
- 90% OF ALL LARGE FISH GONE FROM WORLD'S OCEANS (Nature-- 2003)
- Amphibians Declining Worldwide (Boston Globe)
- Reptiles Vanishing Faster Than Amphibians (CNN)
- Migratory Birds and Animals Rapidly Dying Out (Environment News Service)
- 1000's Of Medicinal Plants Being Harvested to Extinction (Australian Broadcasting Co.)
- 25% Of World's Conifers Threatened With Extinction (IUCN)
- One in Eight Birds Face Extinction (BirdLife International)
- 90 Percent of Great Ape Habitats Will Be Destroyed by 2030 (United Nations)



Source: [www.cnn.com](http://www.cnn.com)



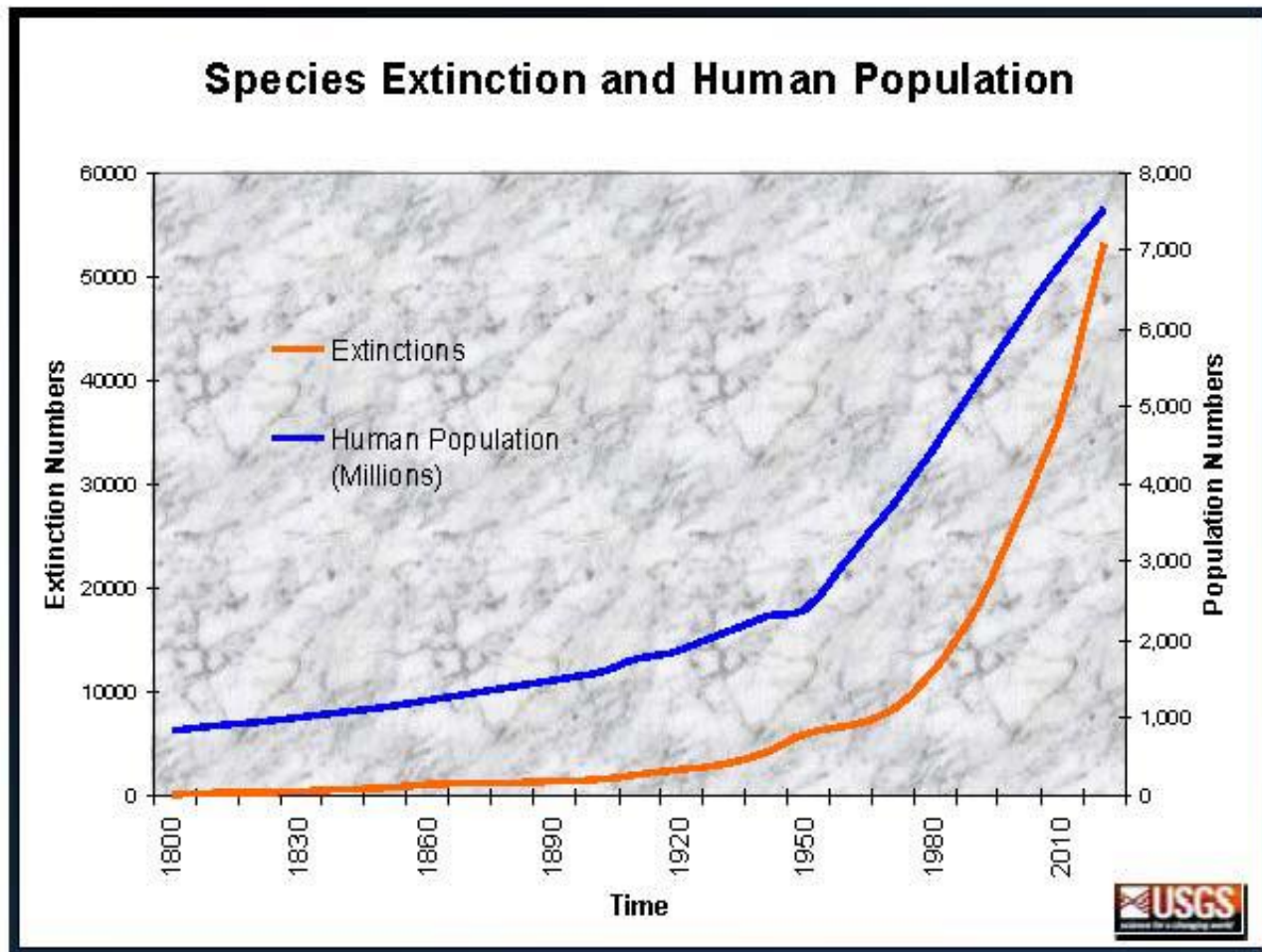
# Extinction Spike



Source: <http://www.usgs.gov/>



# Extinction Spike



Source: <http://www.usgs.gov/>



## Extinction Spike

Selective disappearance of megafauna across America, Europe and Australia:

- 100% of herbivores  $> 1000$  kg
- 75% of herbivores 100-1000 kg
- 41% of herbivores 5-100 kg
- $< 2\%$  of herbivores  $< 5$ kg



Source:  
<http://en.wikipedia.org/wiki/File:Bahariasaurus.jpg>





## Consumption Spike

- In 2000, the number of recently emerged “new consumers” was estimated at 1 billion. They join 850 million long-established consumers.
- New consumers are persons with purchasing power of at least \$2,500 per year.
- Most new consumers come from developing or transition countries (China, India, Indonesia, Brazil, Russia, Mexico, Philippines, Turkey, Thailand....).
- Most significant environmental impact comes from:
  - diet shift towards meat,
  - cars.



## Consumption Spike

- 1.28 billion cattle occupy nearly 24% of Earth's landmass.
- They weight more than the entire human population.
- Meat consumption in 2012: 270 million tons (Discover, Oct2012).
- Meat consumption in 2062: 470 million tons (+73%).
- Meat production consumes vastly more water and produce far more greenhouse gases (70%) than crop foods:
  - 300 m<sup>3</sup> per 1 ton vegetables,
  - 9,000 m<sup>3</sup> per 1 ton nuts,
  - 15,400 m<sup>3</sup> per 1 ton beef.



## Consumption Spike

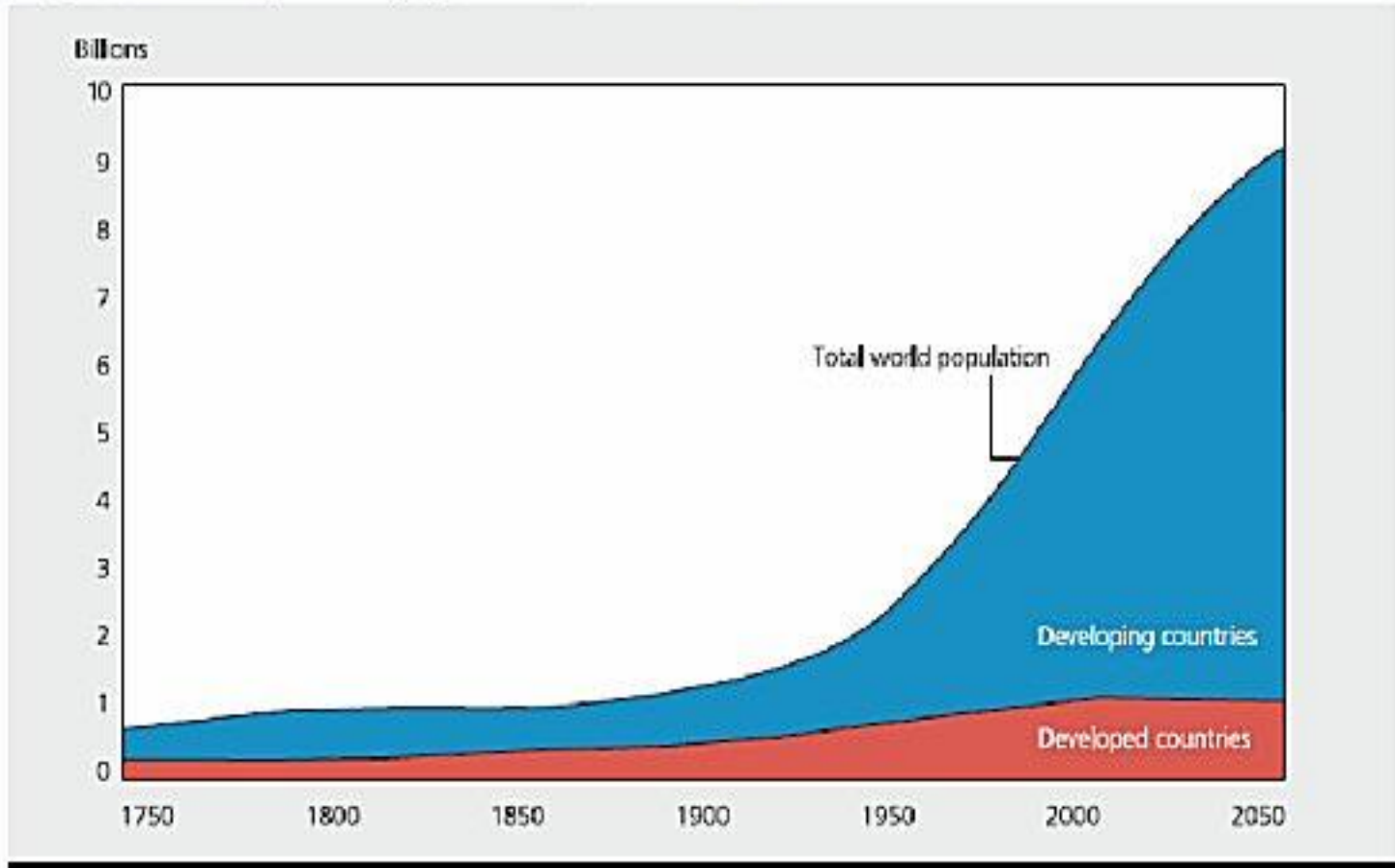
- Forest converted to pasture or production of cattle feed.
- Desertification of marginal rangelands in semi-arid and arid regions.
- Production of greenhouse gases (CO<sub>2</sub>, methane, nitrous oxide).
- Decreased water quality through runoff from fertilized fields and feed lots.
- Introduction of invasive species.



# Human Population Spike

Figure 3.1

World population, 1750–2050



Source: [http://www.wrsc.org/attach\\_image/world-population-1750-2050](http://www.wrsc.org/attach_image/world-population-1750-2050)



# Human Population Spike

- Population spike:
  - ... in 1930: 2 billion
  - ... in 1975: approximately 4 billion
  - ... in 1992: 5.5 billion
  - ... February 2013: 7.07 billion and climbing
- Population has been growing steadily since the end of the Black Death pandemics, around the year 1400.
- Most significant increase in the last 50 years, mainly due to medical advancements and increases in agricultural productivity.



# Human Population Spike

- According to UN's 2010 revision to its population projections, world population will peak at 10.1bn in 2100 compared to 7bn in 2011.  
<http://esa.un.org/wpp/Documentation/publications.htm>
- However, some experts dispute the UN's forecast and have argued that birthrates will fall below replacement rate in the 2020s.
- According to these forecasters, population growth will be only sustained till the 2040s by rising longevity but will peak below 9bn by 2050.  
<http://www.project-syndicate.org/commentary/the-end-of-population-growth>



## Summary

- In the last quarter of the 20<sup>th</sup> century our planet entered a period of crisis – ecological, political, economic – greater than any for the last 300 years.
- In ecological terms probably more catastrophic than any for thousands of years.
- As our technology and productivity continually grows, humans have caused unprecedented alteration in the functioning of ecosystems to meet growing demands for food, fresh water, fiber, and energy.



## Conclusion

Depletion of finite resources and other harmful and permanent effects on the environment:

- Overfished oceans
- Pesticides in ground and water
- Ozone holes
- Rising extinction rates
- Deforestation
- Soil erosion and land degradation
- Pollutants in atmosphere (such as CO<sub>2</sub>)





## Exercises for Self-Study

1. What factors have contributed the most to increased human impacts on the global environment in the 20<sup>th</sup> Century?
2. How does an increasing diet shift towards meat impact the global environment?
3. Explain how the conversion of forests to pastures contribute to climate change.