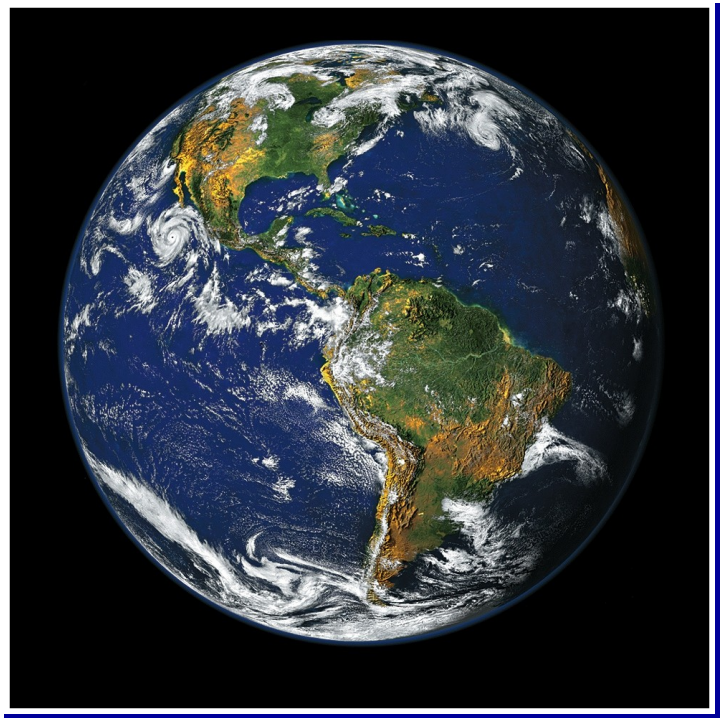


Our Biosphere: Past and Future

Music to gather by

Academy for Lifelong Learning

October 24 - November 14, 2017

Jonathan F. Ormes

JFOrmes@comcast.net

Lecture 4

future

Like the new sign? Comes with a 10 year warranty.

Commons

- Any examples of "commons" you thought of.
  - Any more you think of today, let me know.
- We will make a list of them.

Trash: Where to put it??

Trash gas

- We pay fees to put our waste into sewers.
- We pay fees to have our solid waste disposed of.
- Why should we not pay a fee for dumping waste gases into the atmosphere?
  - Sometimes called "externalities", costs that go unaccounted for.
  - The numbers are large. The lowest estimates start around \$30/ton of CO_2 released.

We are putting our waste into this thin layer that affects everyone.

Tragedy of the Common Atmosphere

- Air moves. My air today will be your air tomorrow. It cannot be owned and isn't regulated.
- Some pollution stays local and leaves the air pretty fast. Other not so fast.
  - State to state arguments on acid rain.
- CO_2 stays in the air for hundreds of years and moves all around.
- There is no international treaty about what you can put into the air.
- What are your ideas about how to deal with this problem?

Citizens Climate Lobby

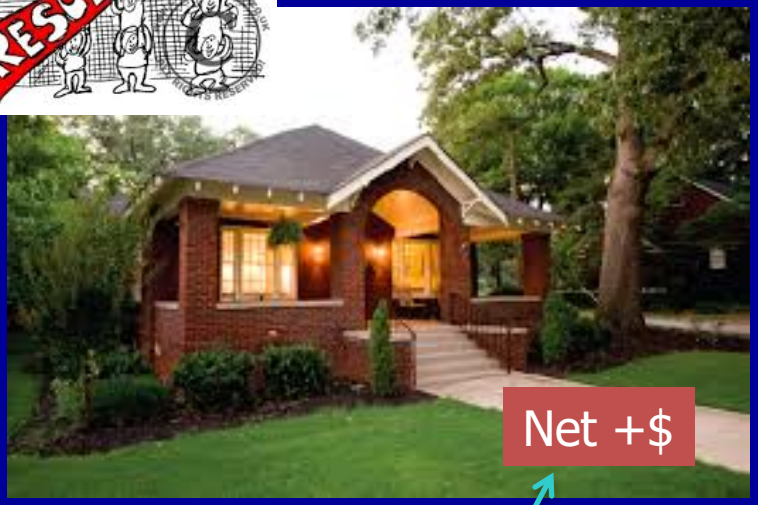
Proposal

Collect fee
$15 per ton of
CO_2 at wellhead
or port of entry
[fee rises $10/yr]

U S Dept. of the Treasury: Trust Fund

All monies returned to households
1 share per adult
0.5 shares per child <18yrs
maximum 3 shares per family

Net -$



Net +$

2 of 3 households have net gain of $.

Net +$

CO_2 emissions are reduced

Renewable energy sources are stimulated. Market will choose the best.

Citizen's Climate Lobby

A major push for a bipartisan solution

carbon fee and dividend

60 Current Climate Solutions Caucus members

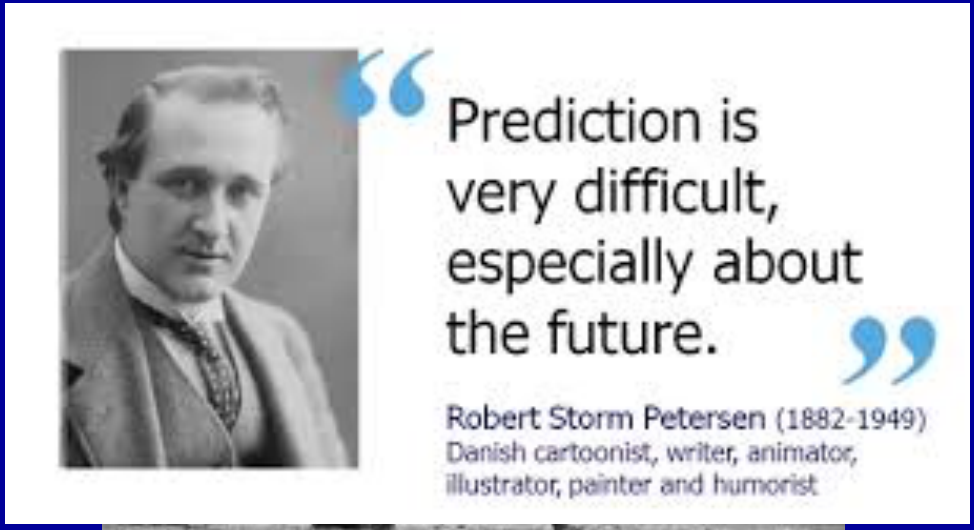
30 democrats, 30 republicans

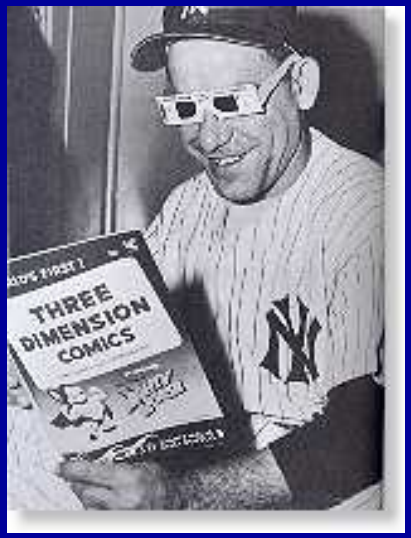
Mike Cofman (R-CO-6)

The future: what can we expect

- “It’s hard to make predictions, especially about the future.”

Lawrence Peter "Yogi" Berra





Climate future

- Why is it hard for people to accept the issues raised by climate change and global warming?
- Is there a distrust of science and scientists?
- Are scientists being alarmist?
- Can people accept "human causation"?
- Can people think about the welfare of their grandchildren?

Climate Modeling

- Predicting the future climate (not weather)
- GCMs: global circulation models
- Improvements needed
  - Clouds and atmospheric chemistry
  - Add convection for lateral air motions
  - Improve spatial resolution (100 km and 40 layers)

Supercomputer:
A big gang of computers

World record 63 petaflops: *Milky Way*, Chinese

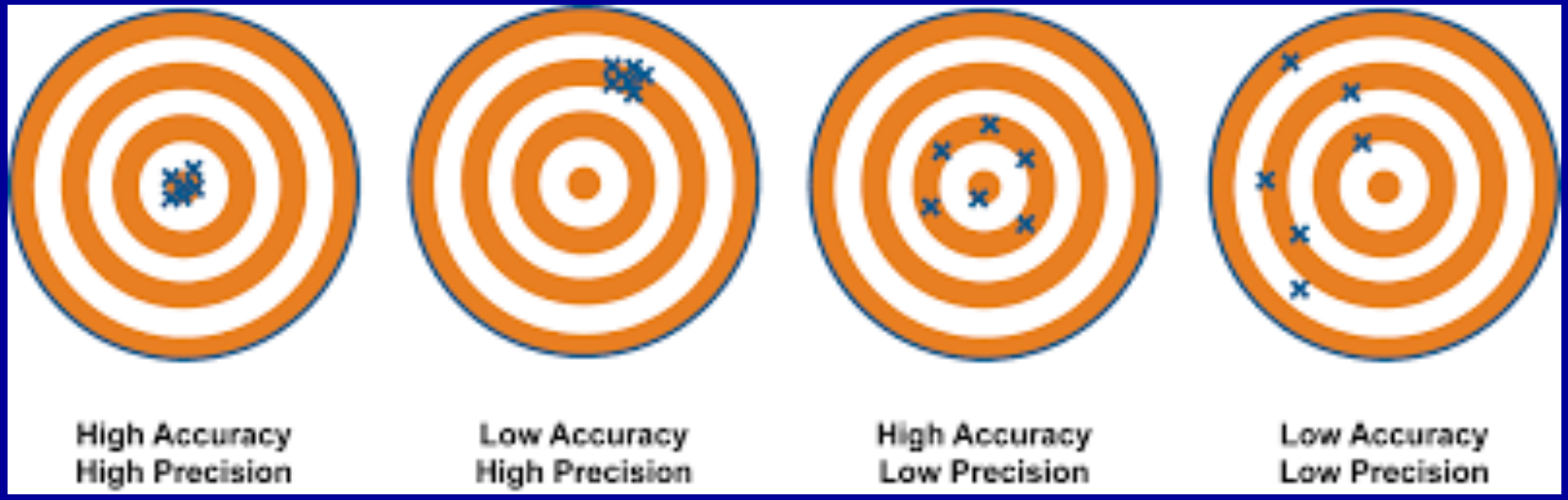
Biggest USA (17.5 petaflops):
Titan at Oak Ridge National Laboratory

Cheyenne, devoted to climate modeling in the USA
NCAR, 2017 (5.34 petaflops)

Accuracy vs. Precision

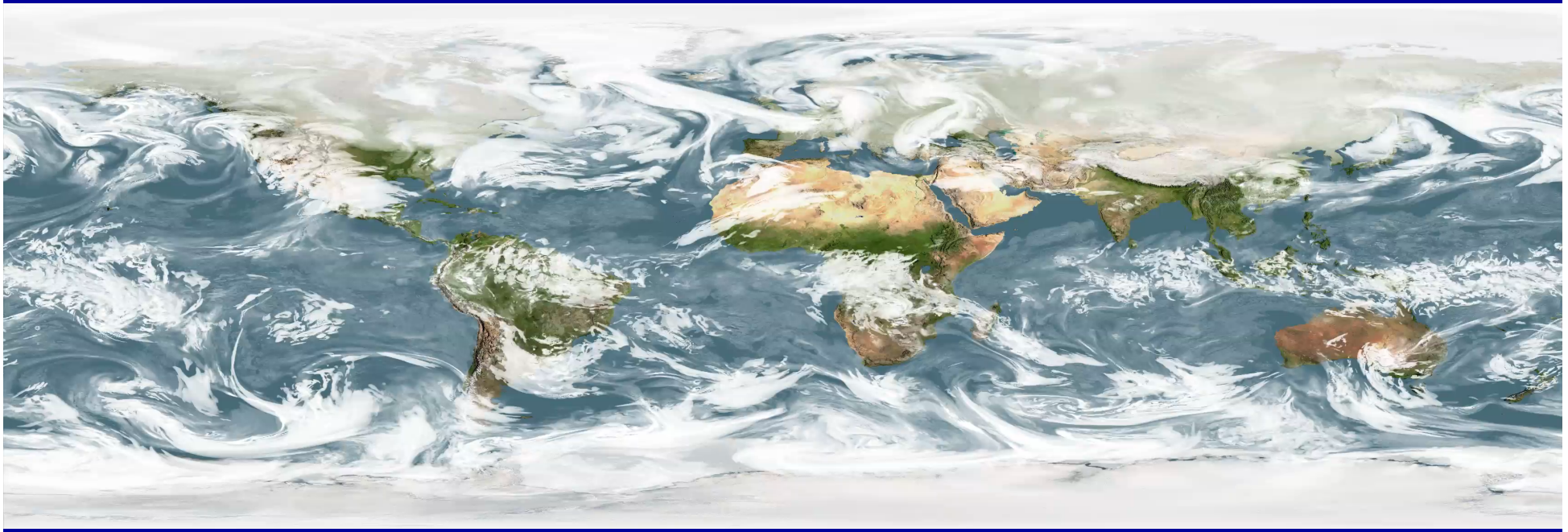
Simulations are evaluated in terms of *accuracy* and *precision*, which are measures of their quality and reliability.

- Accuracy: do the results match the actual 'true' value (realistic).
- Precision: internal consistency (calculations are reproducible).



Models are doing well improving precision, but questions have been raised about whether or not their accuracy has improved. If not it is probably because the science input is not improving too. (E.g. glacier melt, clouds, etc.)

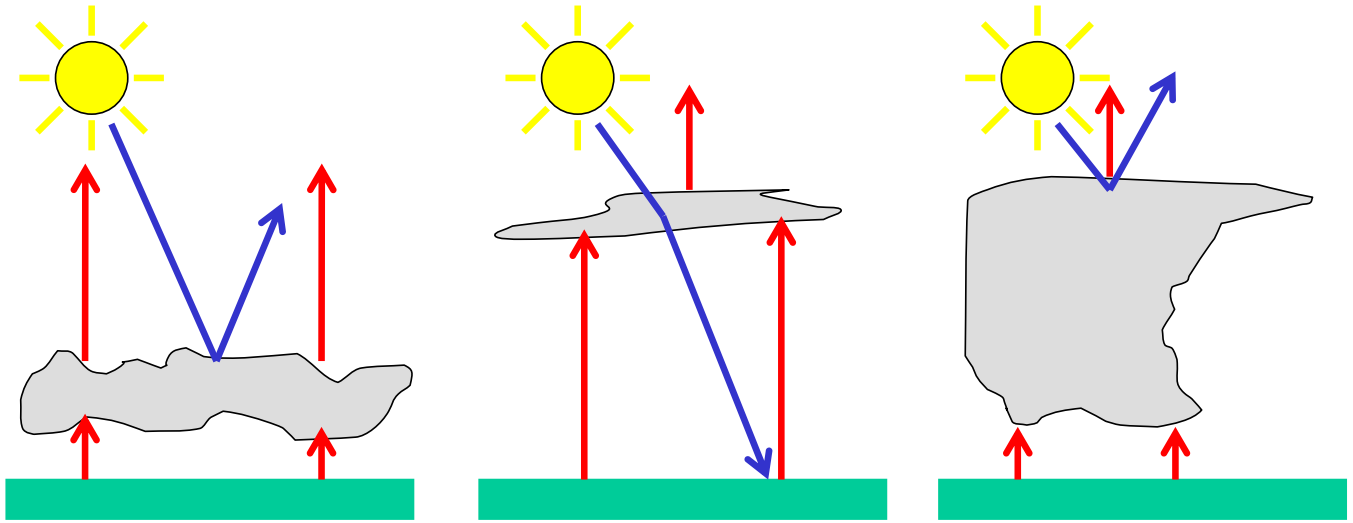
GOES-5 model of the cloud cover at 5 km resolution




stratocumulus
cirrus
Note differences in surface reflectivity
Clouds, too, have different reflective properties.

What about clouds?

Cloud SW and LW Radiative Effects



low-level cloud	high-level cloud	thick cloud
reflection >> 0	reflection ~ 0	reflection >> 0
greenhouse ~ 0	greenhouse << 0	greenhouse << 0
cools the earth	*warms the earth*	(reflection + greenhouse) ~ 0

Slide from Joel Norris, Scripps Institute of Oceanography.

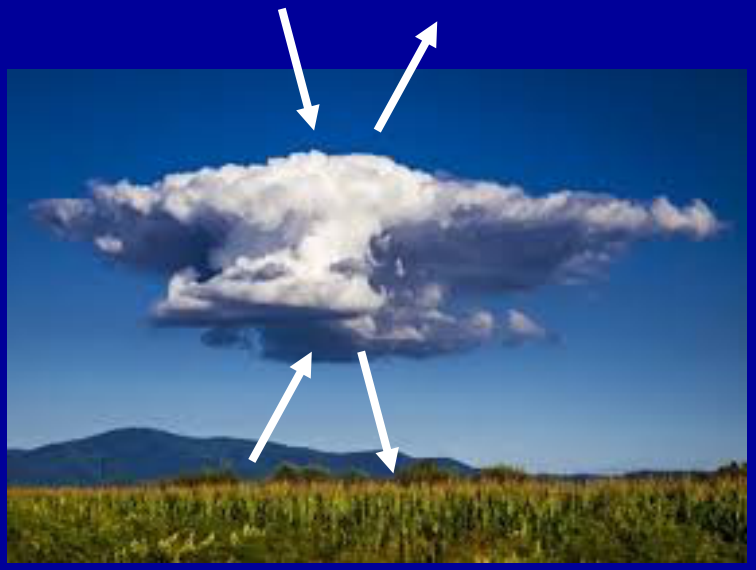
Both Sides Now by Joni Mitchell recorded by Judy Collins, 1967

https://www.youtube.com/watch?v=A7Xm30heHms

Start at 0.35 s

I've looked at clouds from both sides now
From up and down and still somehow
It's cloud's illusions I recall
I really don't know clouds at all

Keeps heat out

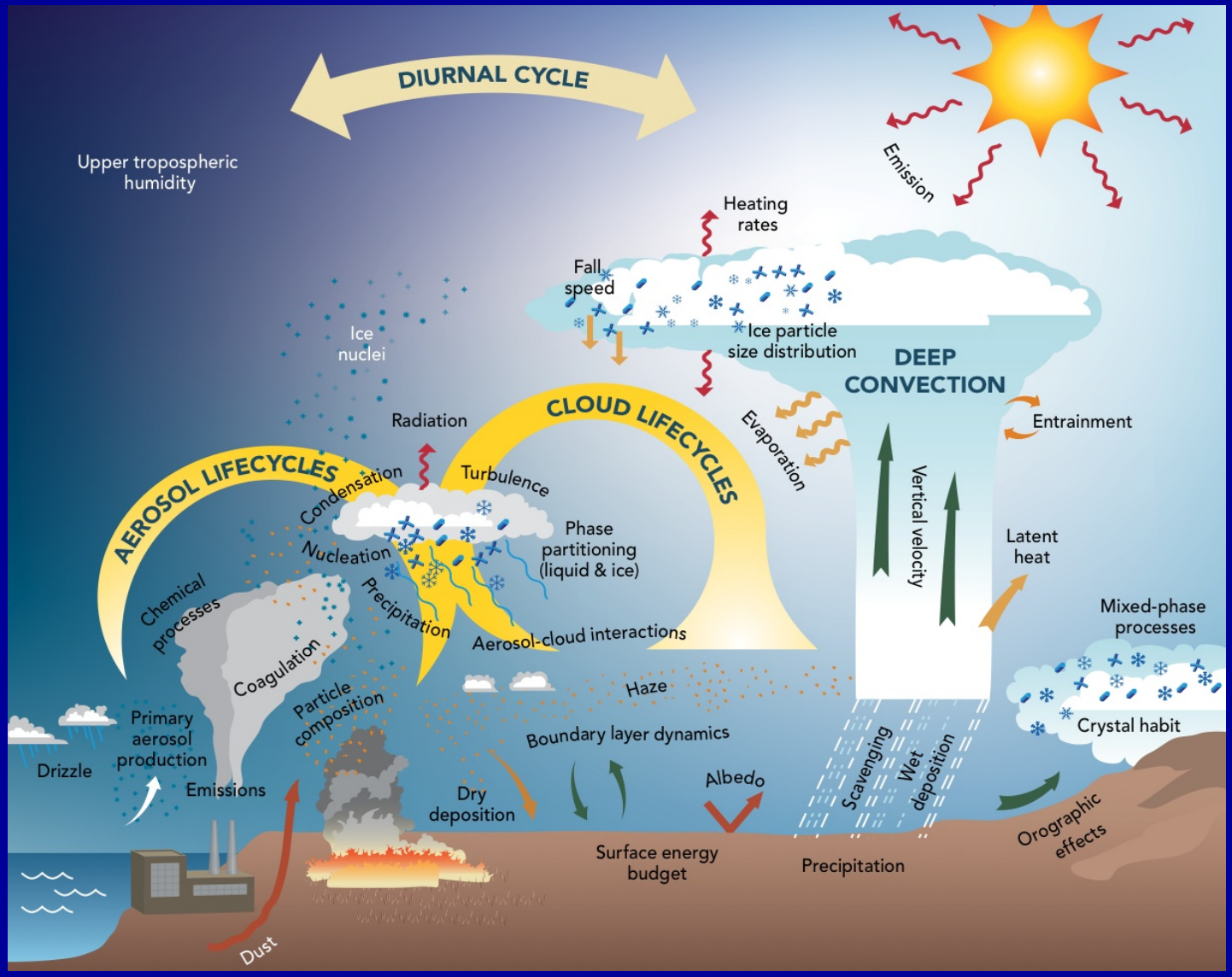


Keeps heat in

Credit: Michelle Stern

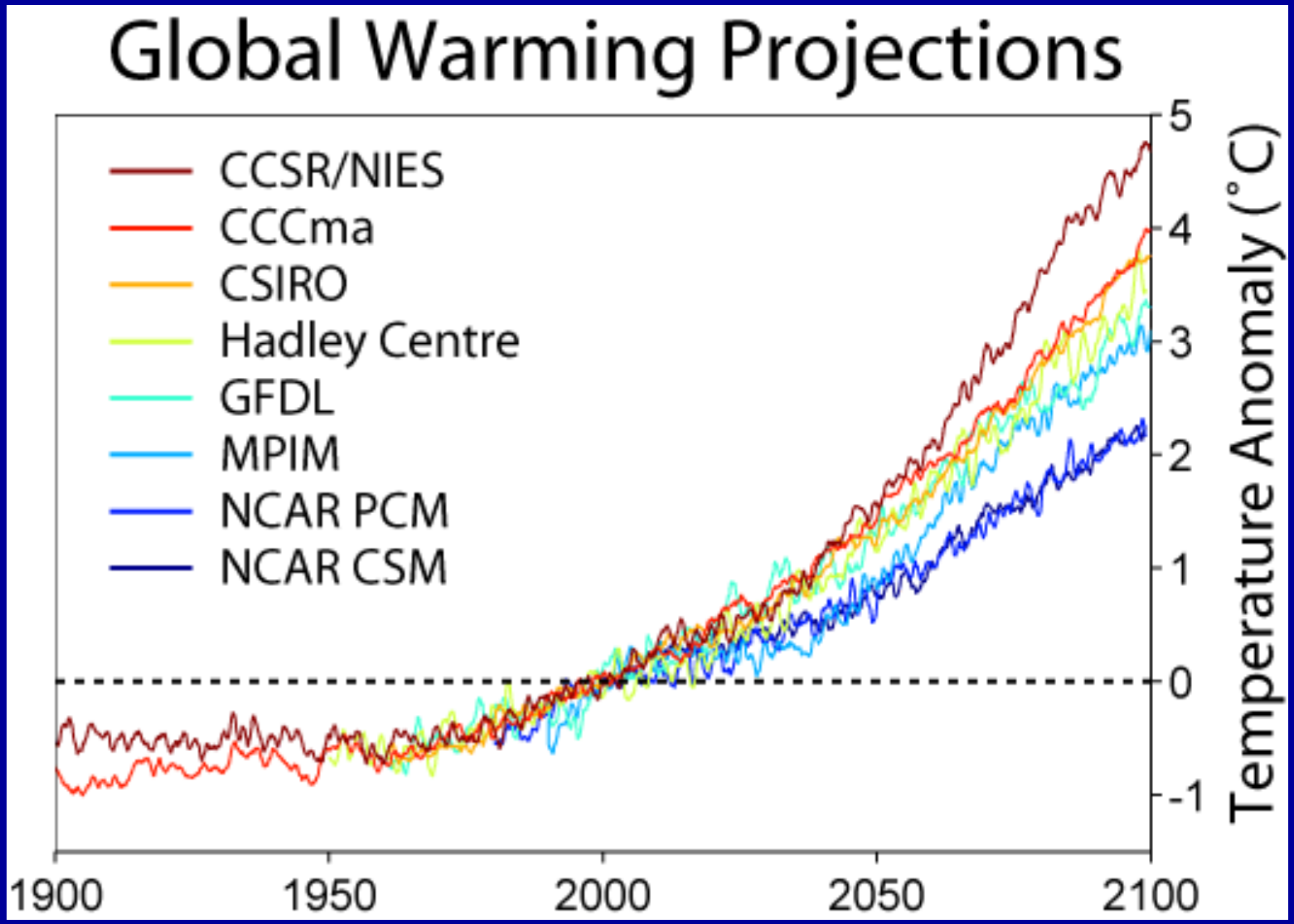
Where have all the bison gone?

Clouds, aerosols, and precipitation are intertwined



Summary on clouds

- Clouds are difficult to model and have complex and uncertain effects on climate.
- Aerosols are important in cloud formation.
- Clouds are important but their net effect on climate is poorly modeled!


Global Warming Projections
CCSR/NIES
CCCma
CSIRO
Hadley Centre
GFDL
MPIM
NCAR PCM
NCAR CSM
5
4
3
2
1
0
-1
Temperature Anomaly (°C)
1900
1950
2000
2050
2100

The human element

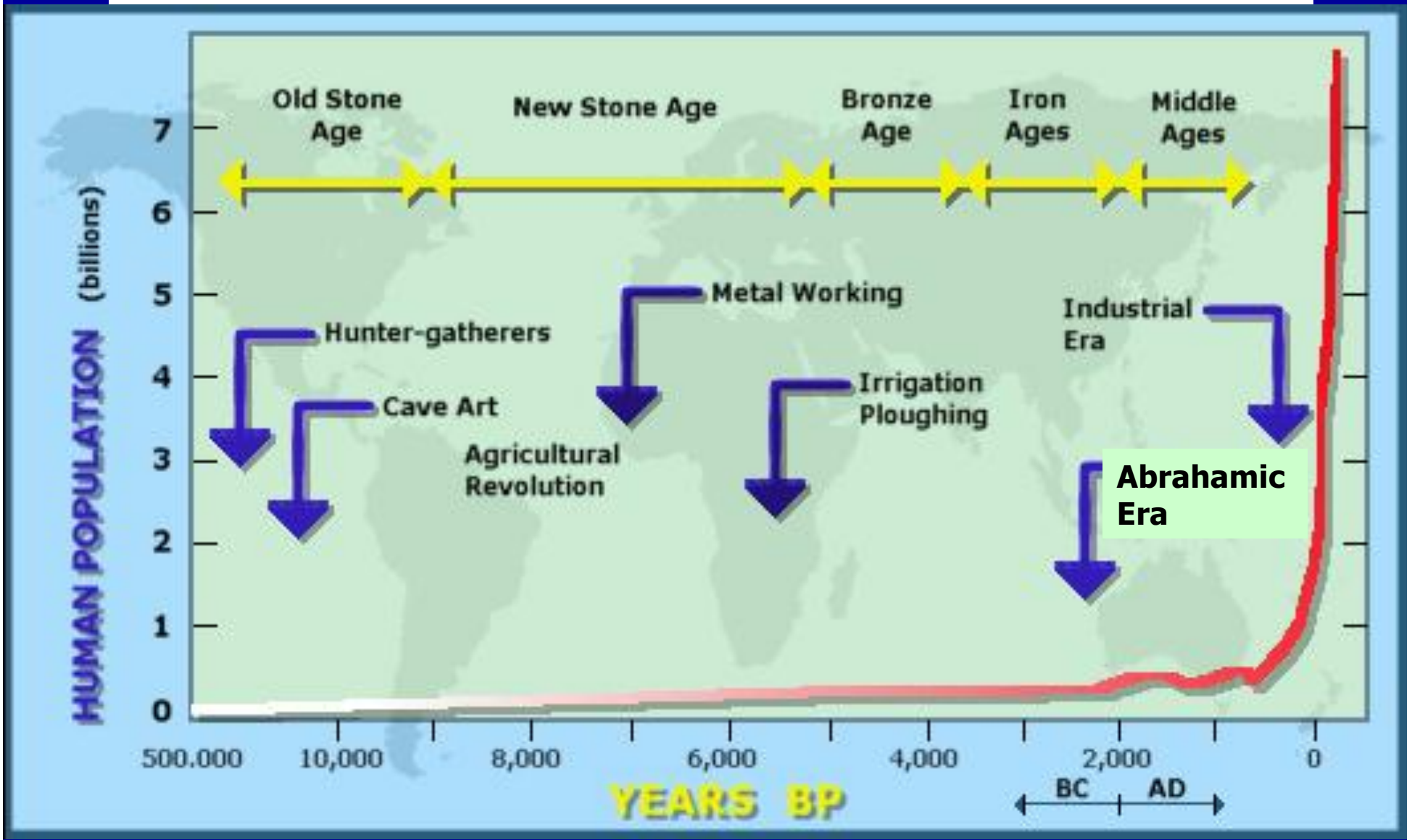
- Population
  - UN projections
- Affluence
  - Economics of growth
  - Closely correlated with energy use

Population

Hominids first appeared in the Neogene Period, about 3.5 M years ago.

Identifiable cultures started about 11,000 years ago.

World Population Growth Through History



20th Century growth rate was “super exponential”
until inflection point circa 1980

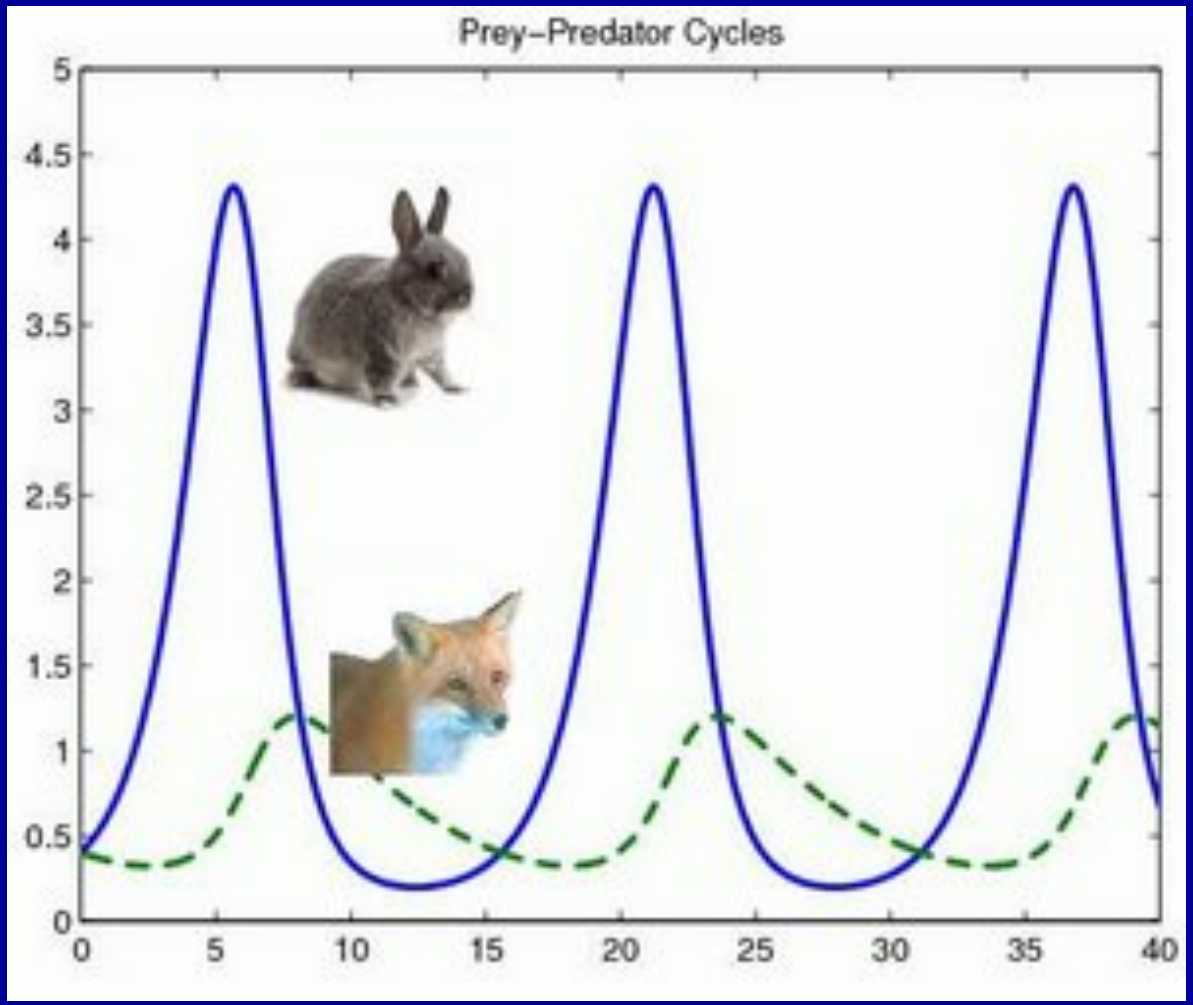
Human species

0.5 billion:	1600	
1 billion:	1802	202 years
2 billion:	1928	126 years
4 billion:	1974	46 years
8 billion:	2030	56 years
9 billion:	2050	20 years

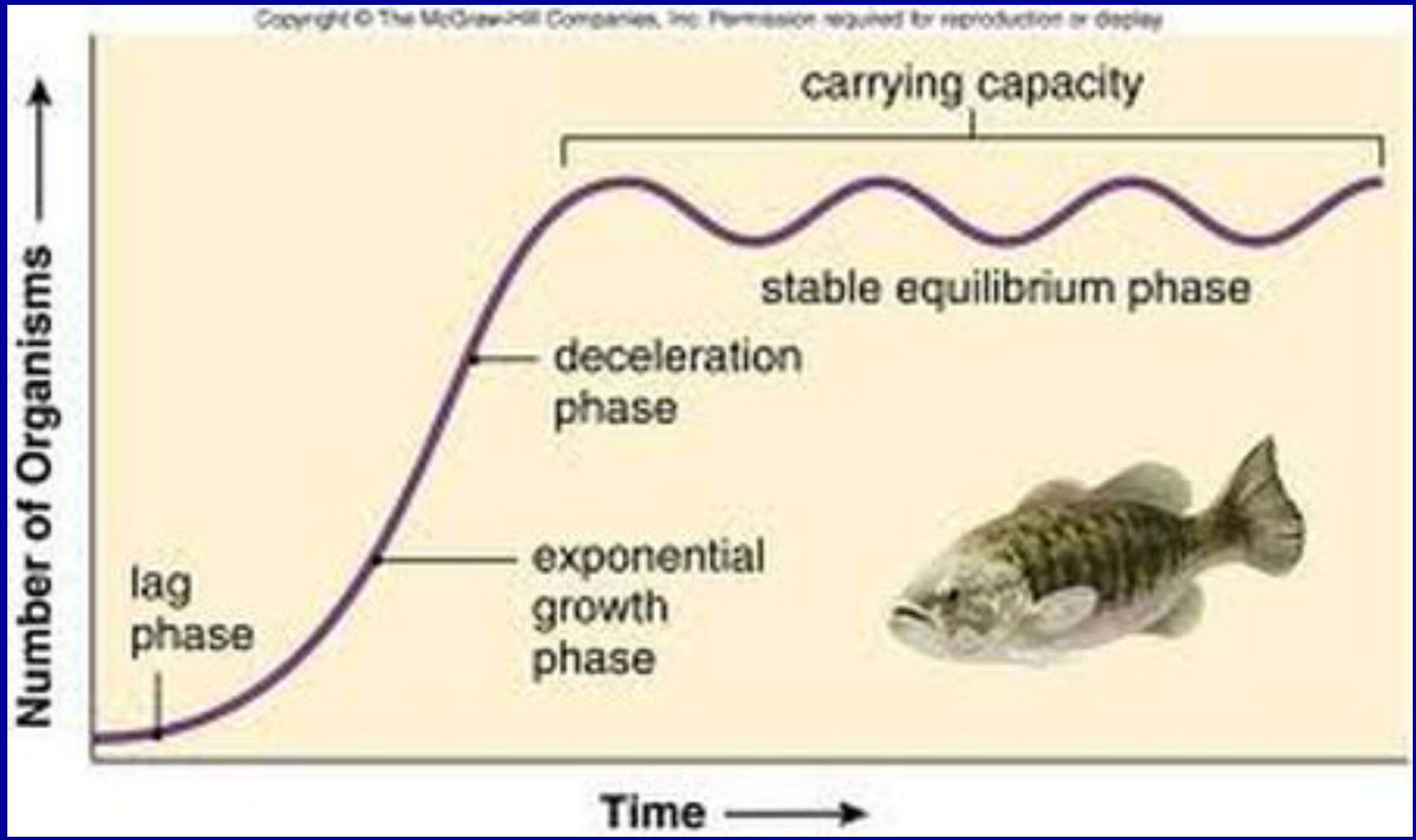
How do we predict the future?

Driven by population and that we can project fairly well.

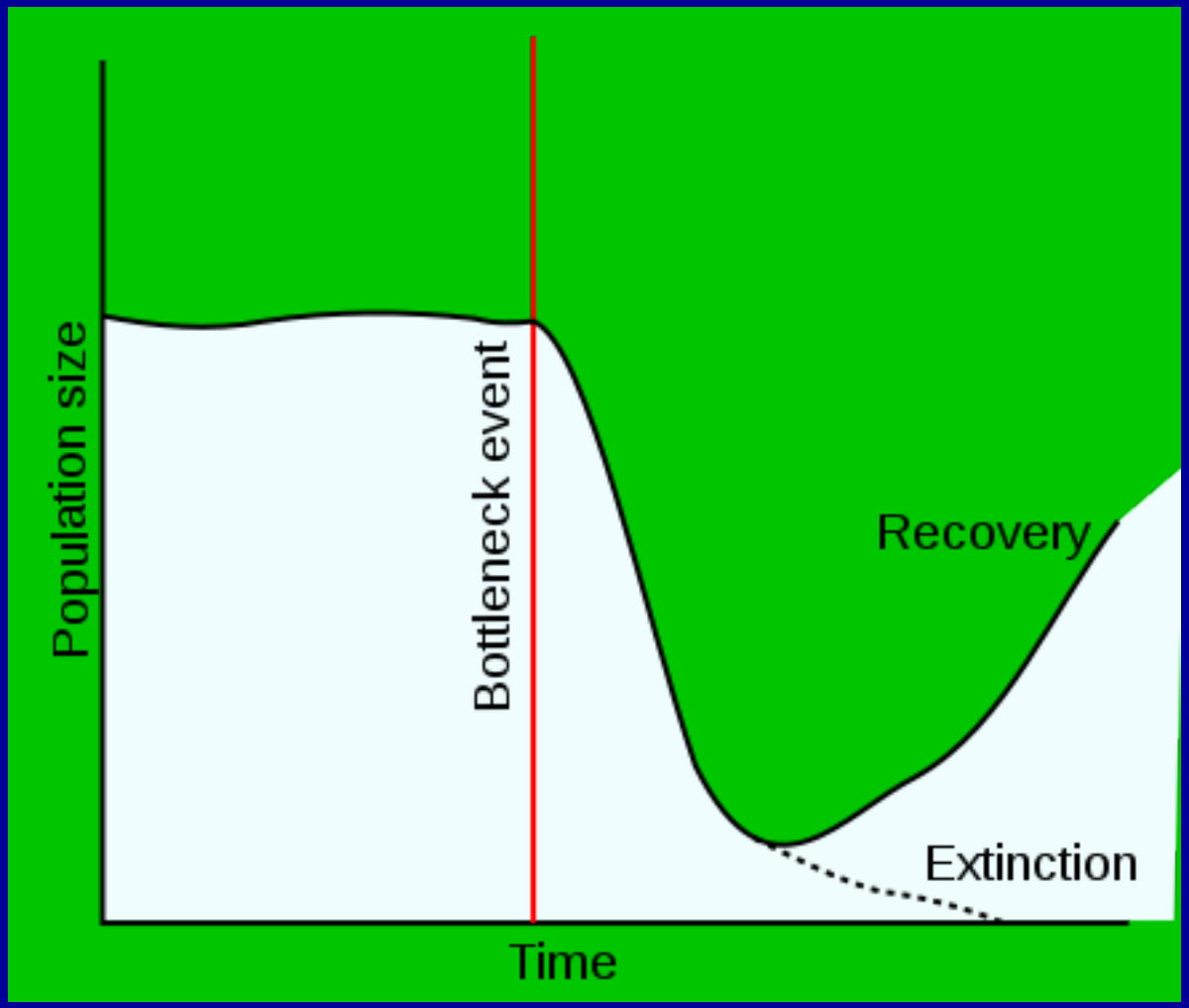
predator prey population cycle



resource limited population model



Population bottleneck

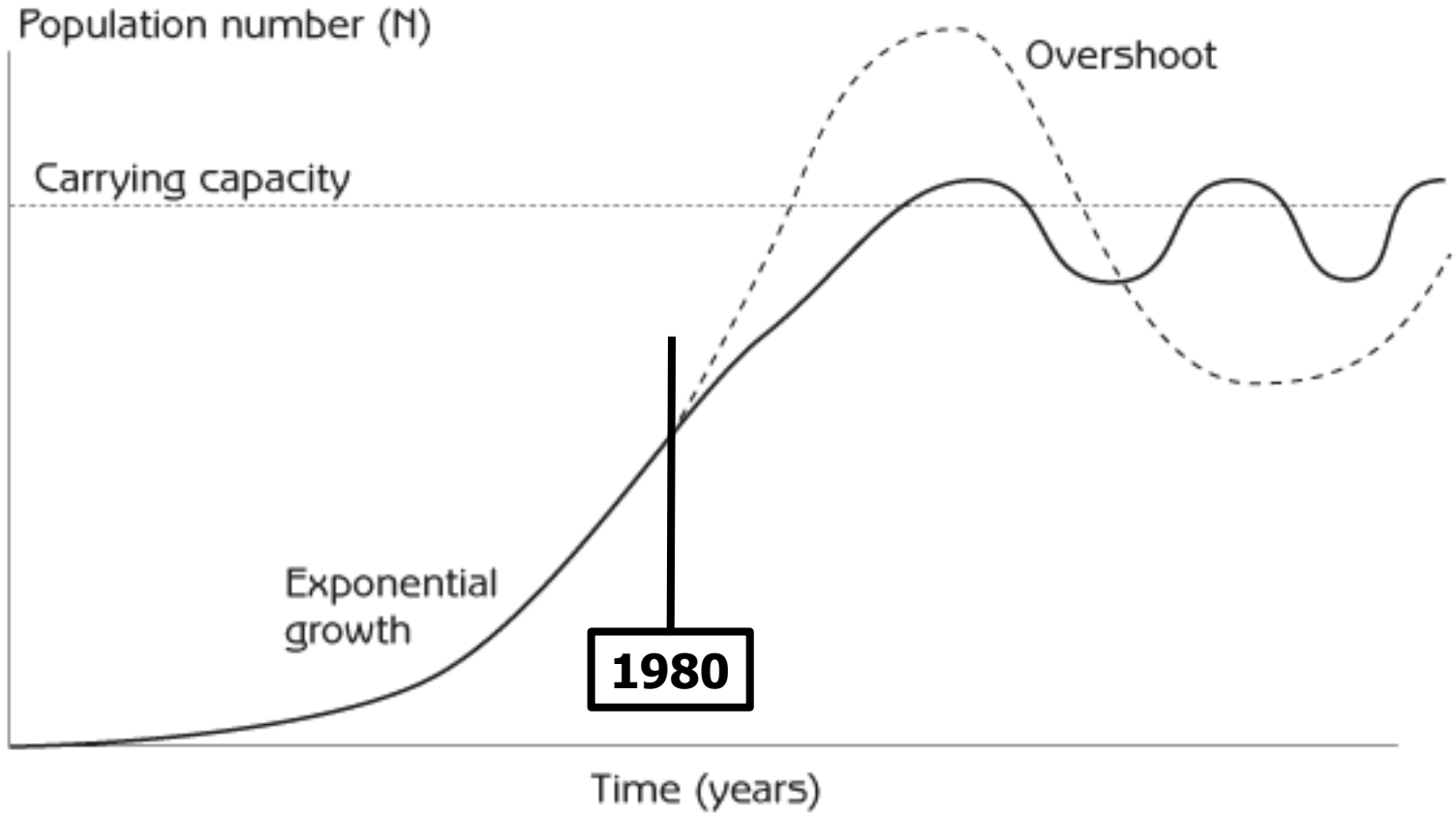


An external event suddenly decreases a population reducing the gene pool.

Human hunting has induced bottlenecks for many species.

- Passenger pigeons
- California condors

Will we overshoot?
Or have we already overshot?

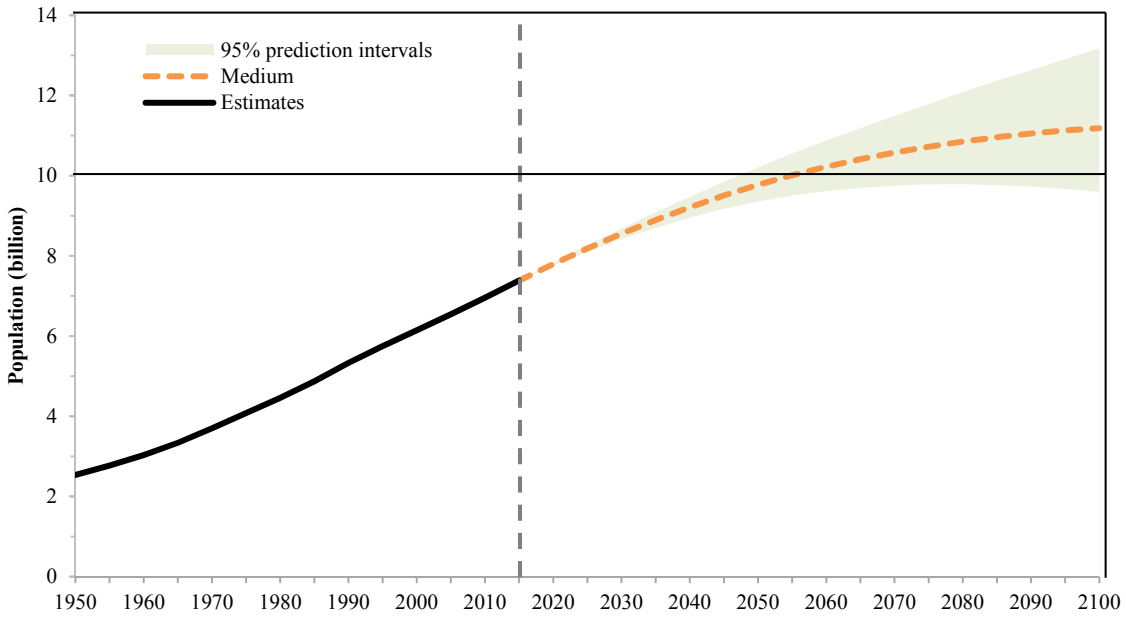


New projection: 2017

World population may go above 11 billion by 2100

"Compared to 2017, the number of persons aged 60 or above is expected to more than double by 2050 and more than triple by 2100, rising from 962 million in 2017 to 2.1 billion in 2050 and 3.1 billion in 2100."

Figure 2. Population of the world: estimates, 1950-2015, and medium-variant projection with 95 per cent prediction intervals, 2015-2100

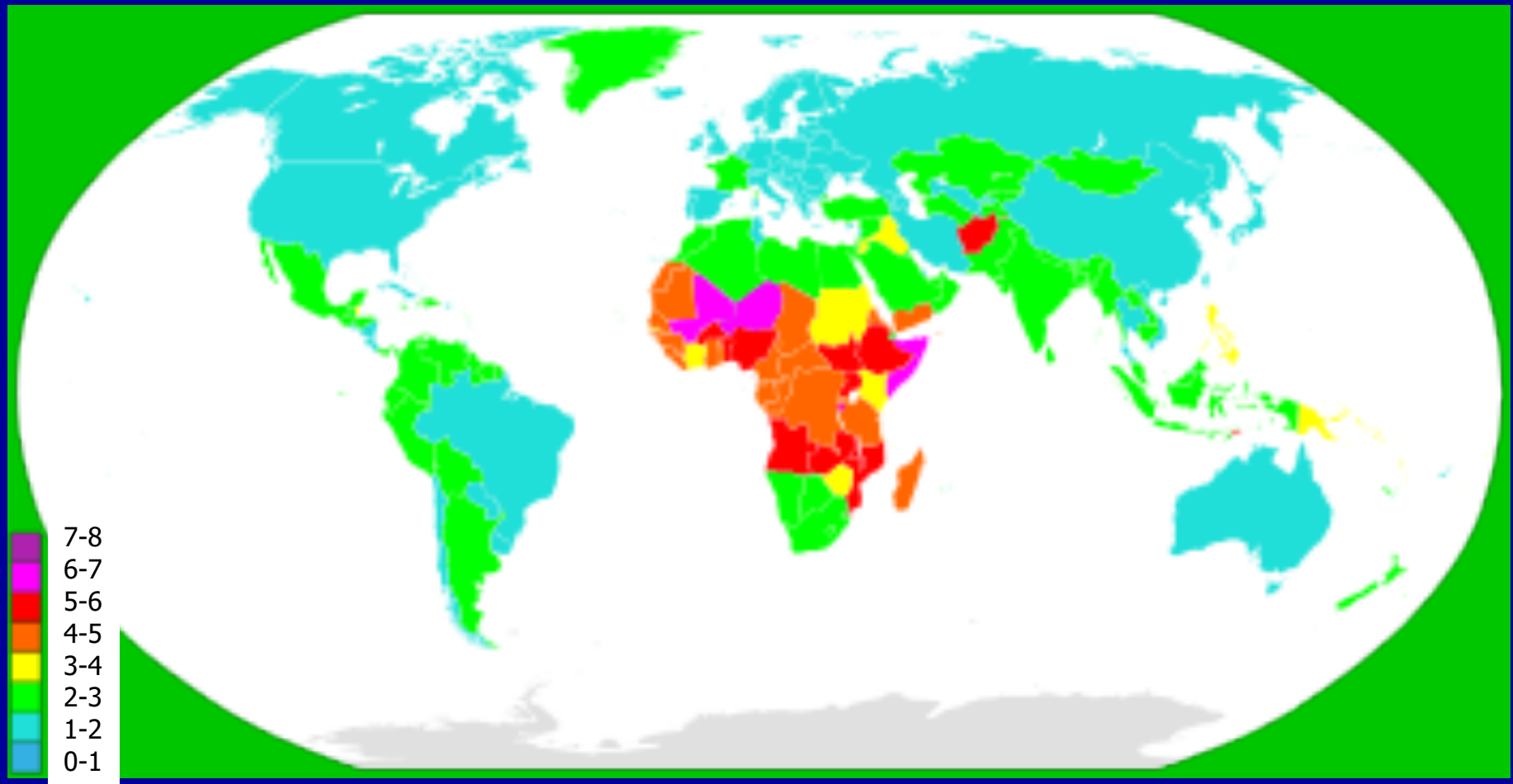


Source: United Nations, Department of Economic and Social Affairs, Population Division (2017). *World Population Prospects: The 2017 Revision*. New York: United Nations.

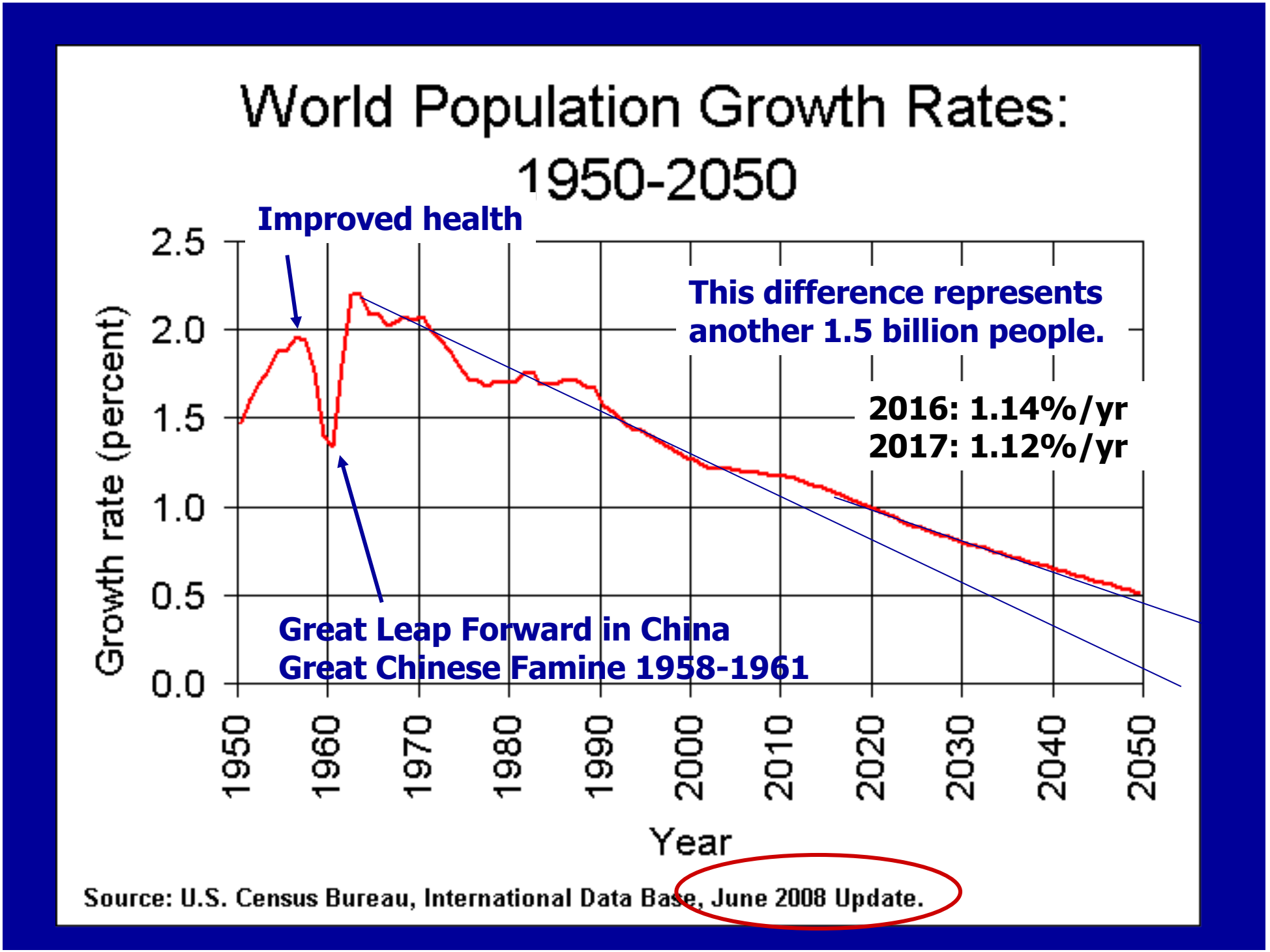
	Population (thousands)				
Region, country or area	*1950*	*2017*	*2030*	*2050*	*2100*
United States of America	158 804	324 459	354 712	389 592	447 483

128,000 voted

Population growth rate



Scale: children per mother


World Population Growth Rates:
1950-2050
Improved health
This difference represents another 1.5 billion people.
2016: 1.14%/yr
2017: 1.12%/yr
Great Leap Forward in China
Great Chinese Famine 1958-1961
Growth rate (percent)
2.5
2.0
1.5
1.0
0.5
0.0
1950
1960
1970
1980
1990
2000
2010
2020
2030
2040
2050
Year
Source: U.S. Census Bureau, International Data Base, June 2008 Update.

Summary

The **high fertility curve** won't happen because the planet cannot support that many people.

Mother Nature will limit population

- How she does it might not be pretty

Babies per woman decrease when

- Children survive
- Children not needed for work
- Empower women
- Family planning is accessible

If you're not pro birth control, you're not pro life!

Credit Hans Rosling, TED talk 2012

Billions and Billions

- There are currently 7.58 billion people;
  1 billion of us use a lot of energy!
- There are billions more people (e.g. China and India) who aspire to an affluent lifestyle.
- Population will probably increase by 30% in the 21st Century.
  - If we do nothing to change lifestyle and assuming everyone has the same lifestyle we have in the USA now, energy use would increase by more than 300%.

For discussion

- How are large-scale demographic changes, such as growing life expectancy and shrinking family sizes, changing the dynamics of our lives, and how should society respond to this?
- How do growing human populations interact with other species and what challenges does this raise for our planet?
- What role does population play in economic and social development, and is there such a thing as an optimum population?

Carrying capacity

We live on a finite planet with an economic system that depends on **growth**.

For ideas about an economy for the future, I recommend the class for next term given by Alec Tsoucatos.

Tuesday 11:30, every week

People require food: requires water and arable land

Growing UN Attention to soil degradation

The UN has declared 2015 as the International Year of Soils to shine the international spotlight on the challenges.

Threats

Nutrient depletion
Salinization
Erosion
Urbanization
Chemical pollution

A terracing project

Intergovernmental Technical Panel on Soils (like IPCC)

24 July, 2014 News release from the UN

http://www.un.org/apps/news/story.asp?NewsID=48342#.U_f0nkur-MA

Land is a fixed resource

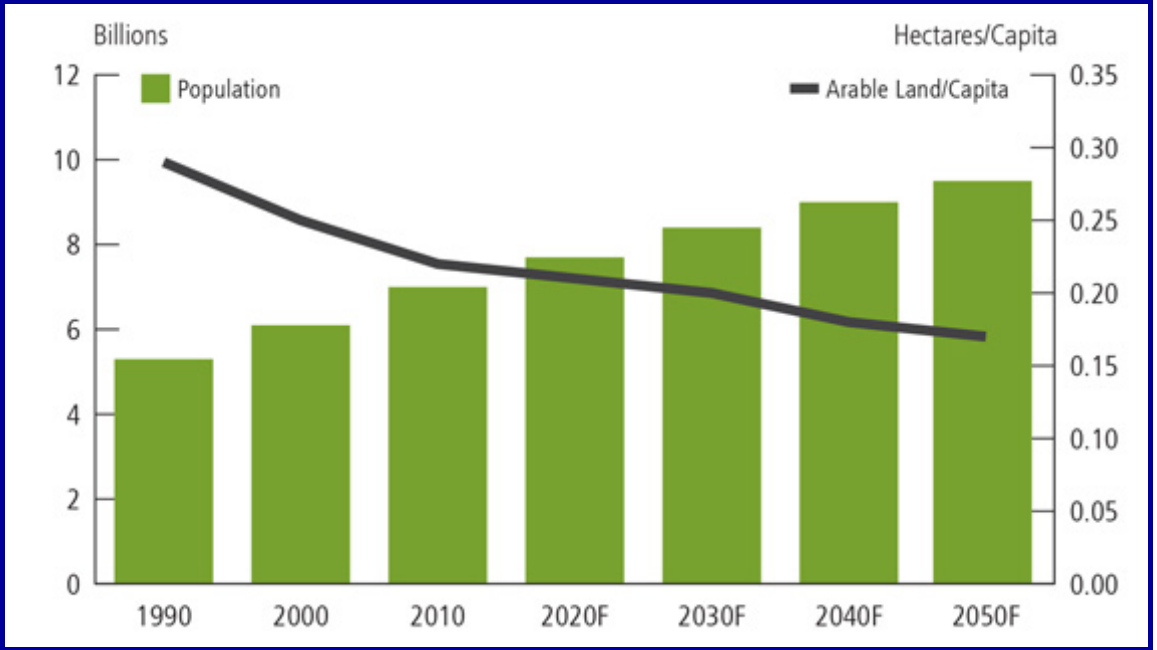
Global scale problem predicted within 70 years

In hectares
1 hectare
= 2.47 acres

UN Intergovernmental Technical Panel on Soils (ITPS like IPCC)

Threats

- Nutrient depletion
- Salinization
- Erosion
- Urbanization
- Chemical pollution



http://www.potashcorp.com/overview/fertilizer-101/global-development-story/global-population-arable-land-per-capita

Source: FAO, United Nations, PotashCorp

Water

Too little and too much
drought and fire

Boulder, Colorado

- September 14, 2013

Fire and ice

The average fire season in the American west is now 105 days longer than in the 1970s.

Source: Climate Central *Western Wildfires—A Fiery Future,* 2016

The precipitation paradox

As global temperatures rise, both drought and heavy rains are increasing.
How can this be?

Over land: warmer air rises, sucking moisture from dry land, intensifying drought

UCAR

Over the oceans: more water evaporates into warmer air, helping increase precipitation intensity worldwide

UCAR

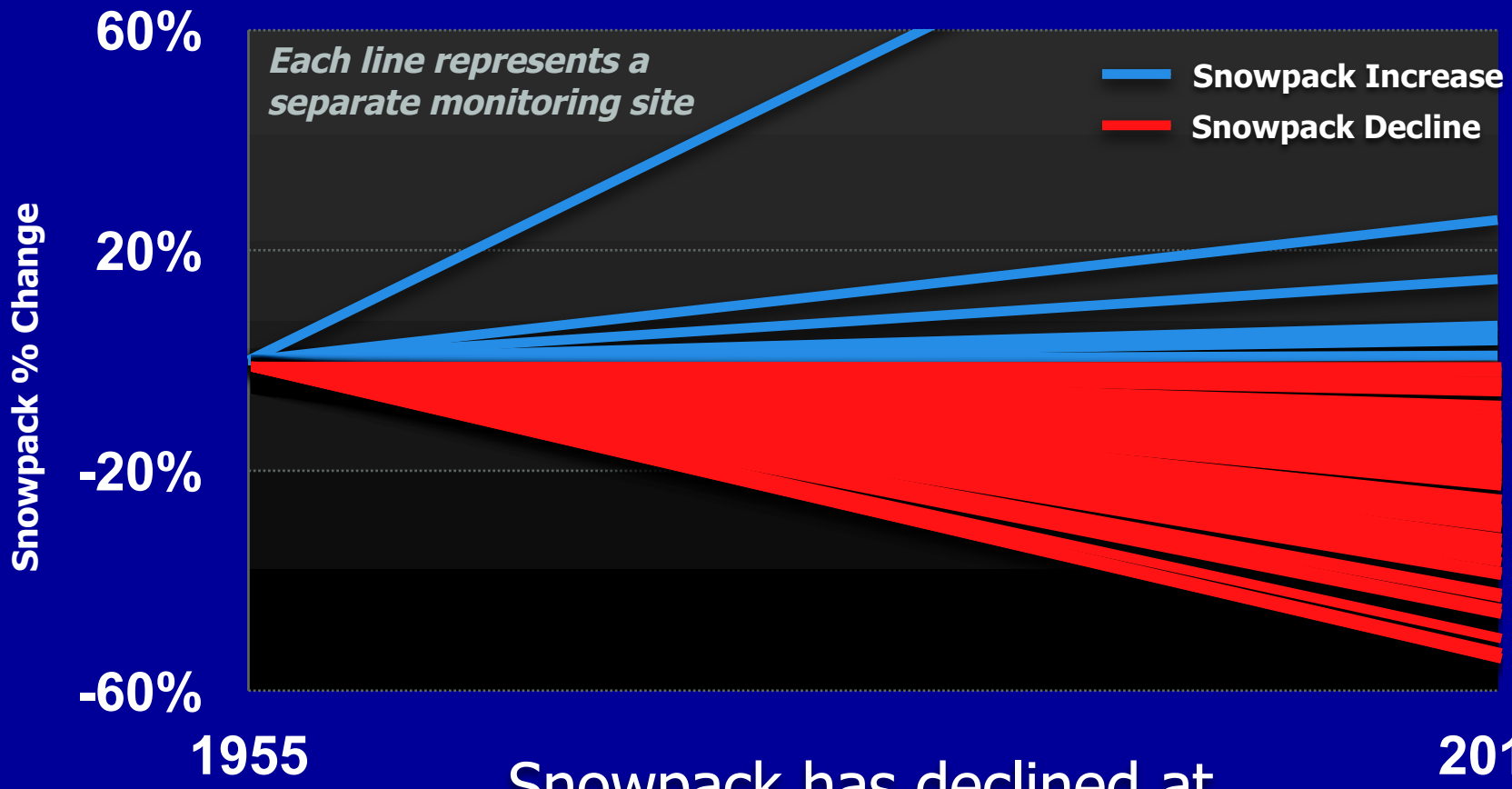
A changing climate is expected to continue the trend toward earlier snowmelt and earlier peak runoff

- *Climate Change in Colorado;*
  A Synthesis to Support Water Resources Management and Adaptation

August 2014

Source: CIRES, University of Colorado Boulder

Trends in Colorado April Snowpack, 1955 – 2016

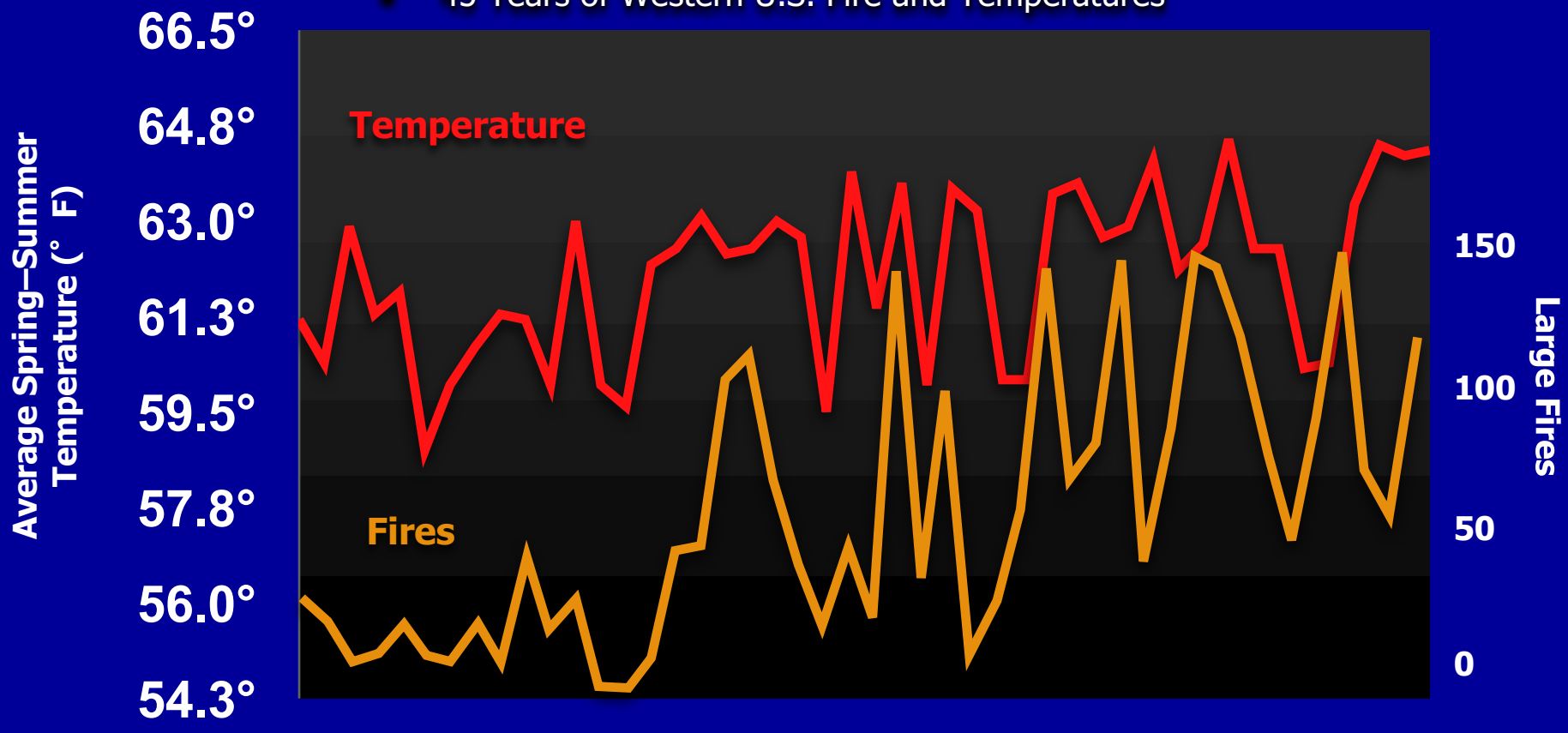


Snowpack has declined at 90% of Colorado's monitoring sites

Data: U.S. Environmental Protection Agency

Hotter Years Typically Have More Fires

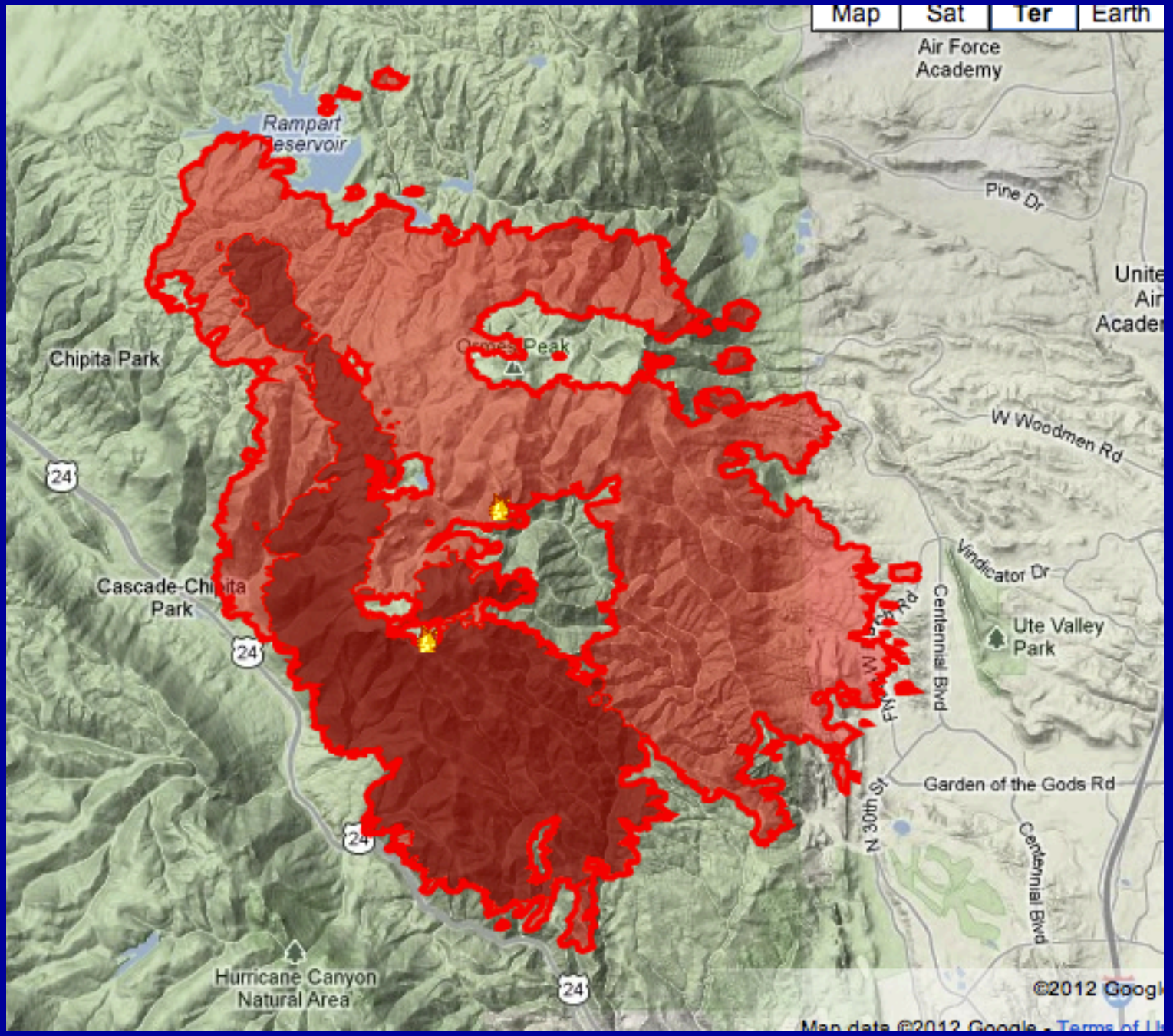
- 45 Years of Western U.S. Fire and Temperatures



Data: Westerling, et al.; Climate Central, "The Age of Western Wildfires," Fig. 9, September, 2012 - Updated 2016

Haswell, Colorado

- June 22, 2016


Map
Sat
Ter
Earth
Air Force Academy
Rampart Reservoir
Pine Dr
Chipita Park
Ormes Peak
W Woodmen Rd
24
Vindicator Dr
Cascade-Chipita Park
Centennial Blvd
Ute Valley Park
Garden of the Gods Rd
N 30th St
Hurricane Canyon Natural Area
©2012 Google
Map data ©2012 Google

Before fire

After fire

Daily per capita consumption of energy (footprint)

	Primitive society	Hunting society	Primitive agriculture	Advanced agriculture	Industrial society	Technological society
Food	2	2	4	6	7	10
Home and commerce		3	4	12	32	66
Agriculture and industry			4	7	24	91
Transportation				1	14	63
Total	**2**	**5**	**12**	**26**	**77**	**230**

Global average = 46,000 kilocalories/capita

units 1000 kilocalories: daily consumption requirement to sustain life 2000 kilocalories
(N.b. *calories* on a food package are actually kilocalories; 1000 *calories* = 1 *kilocalorie*)
2000 kilocalories = 100 watts

Adapted from: E. Cook, "The Flow of Energy in an Industrial Society" Scientific American, 1971 p. 135.

Affluence

- Per capita consumption of goods and services

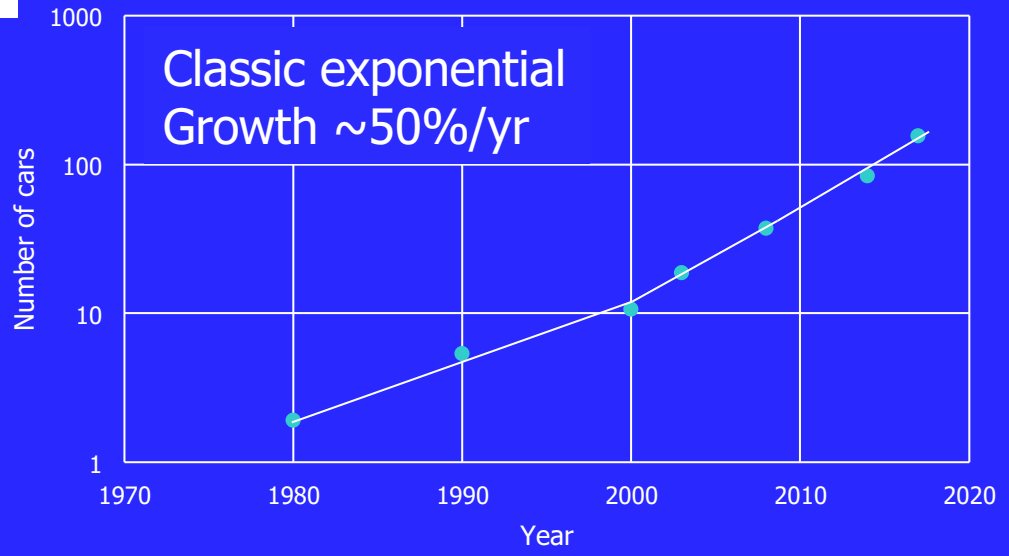
- Represented by GDP per capita
- Equivalently energy consumption per capita

The good life! Cars, travel, restaurant food, fresh fruit from far, far away, ….

Motor Vehicles per Thousand People

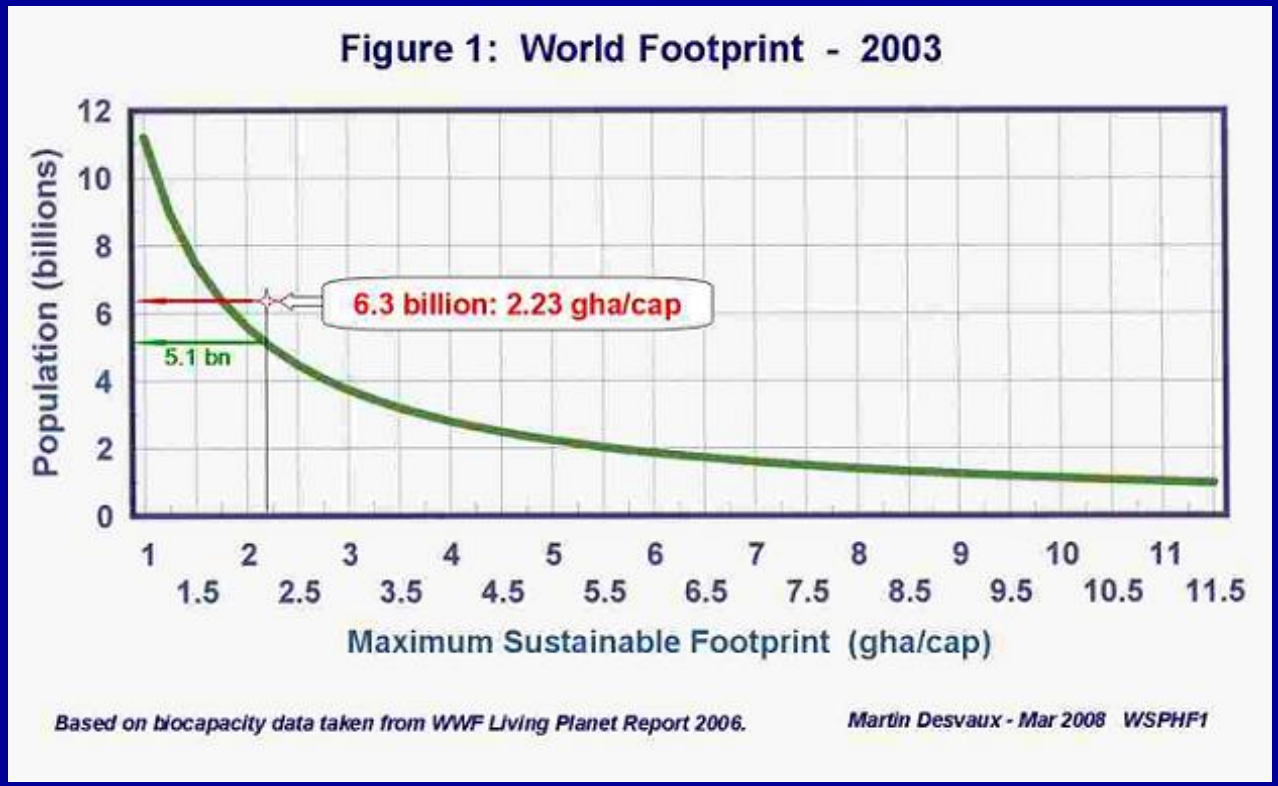
Year	US	China
1950	323.4	
1960	410.3	
1970	528.9	
1980	752.6	1.9
1990	755.2	5.3
2000	761.8	10.6
2003	779.5	18.6
2008		37
2014	797	83
2017	797	154

Number of cars per 1000 persons



Biocapacity of the earth = 11.2 gha

= Maximum per capita footprint ×
size of sustainable population



Available:
1.64 gha/cap

Use
Ave: 2.23 gha/cap
USA: 9.4 gha/cap
EU: 4.8 gha/cap
China: 1.6 gha/cap

gha/cap = global hectares per capita: Global total 11.2 gha

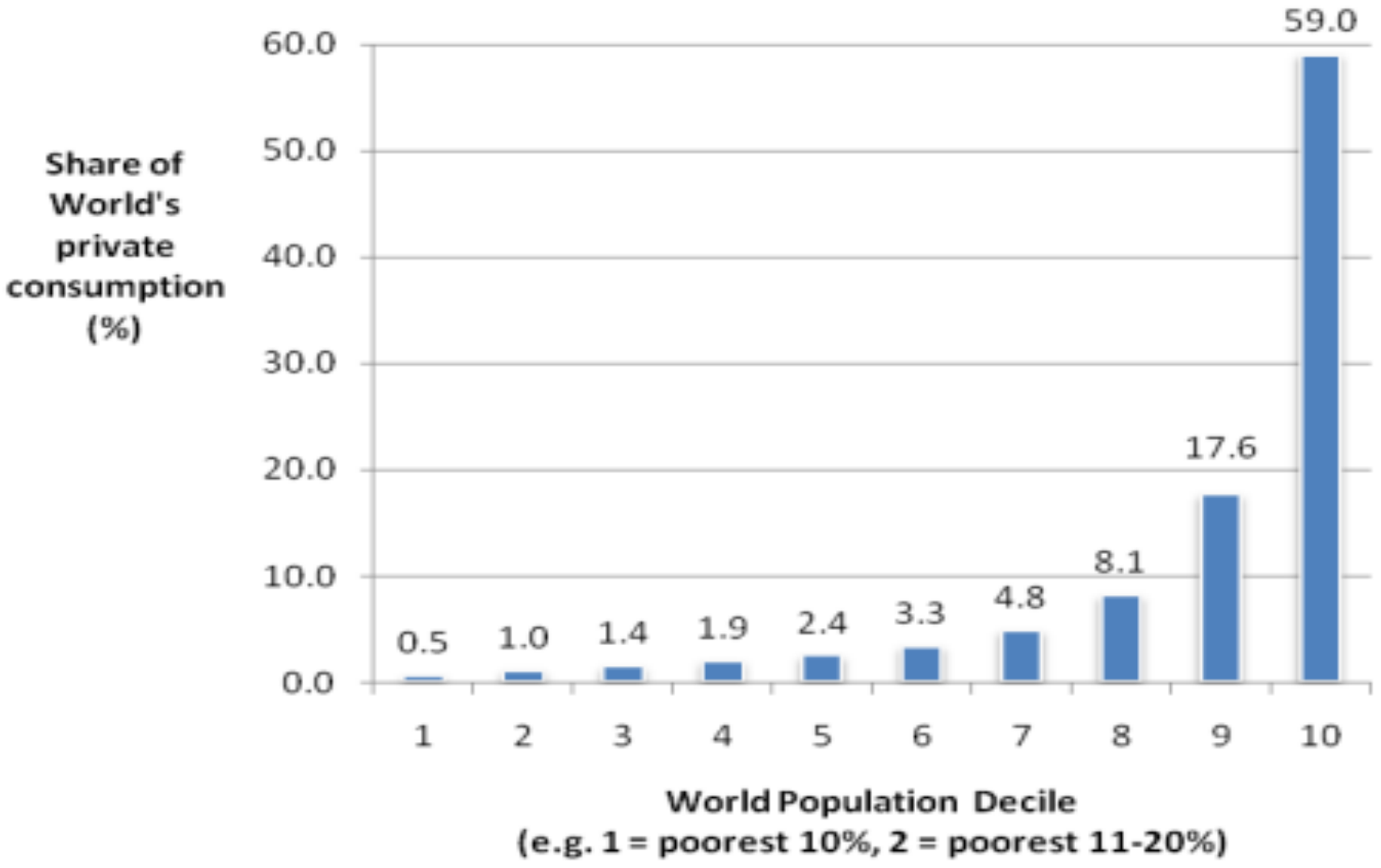
http://www.optimumpopulation.org/opt.optimum.html

(1 hectare = 0.405 acres)

Summary

- Water and land determine the carrying capacity
- We are arguably using more resources than the planet can provide
- Must "borrow" from the Earth to support additional people temporarily (how long??)
  - finite resources provide limit
- More for us, less for other species

Inequality of Consumption, 2005



Source: World Bank Development Indicators 2008

For discussion

- What obligation do we have to other people who aspire to our lifestyle? Do they have the "right" to affluence in spite of the impact on the planet's livability?
- If scarcity comes, what will the impact be on ethics?
- Will it be every person for themselves or will communitarianism survive?