ECOR 1010

Technology, Society & Environment
Lecture 1

Energy & Sustainability

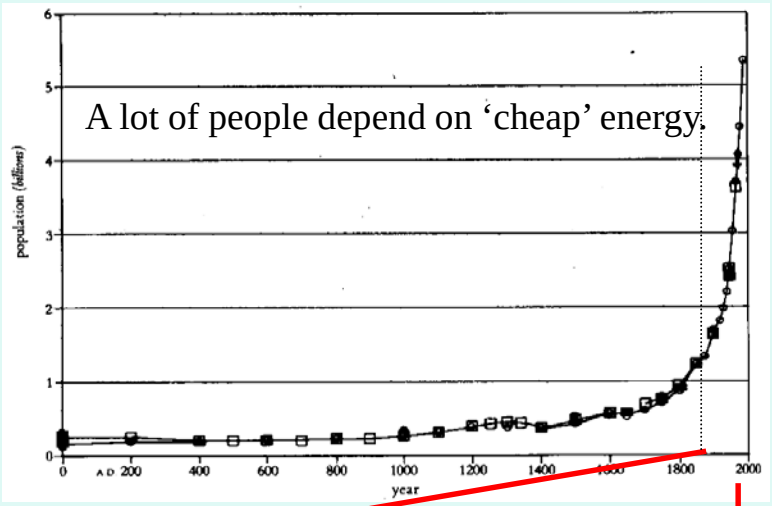
The Unique Role of Exo-Somatic* Energy in Modern Civilization

- Energy is the key to everything else. Without energy, nothing can happen.
- No factor has played a greater role in the recent explosive growth of the human enterprise than abundant cheap energy (fossil fuels).
- In addition, no other resource has changed the structure of economies, the nature of technologies, the balance of geopolitics, and the quality of human life as much as petroleum.

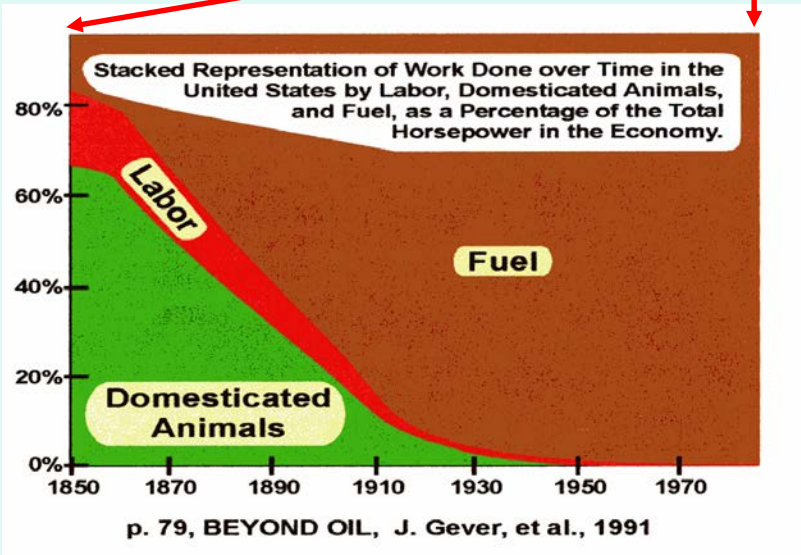
* Outside the body; extragenetic

Technology Rules: Two Great (Energetic) Leaps Forward

- The adoption of agriculture ten millennia ago led to a 13-fold increase in average human population growth compared to the previous 10 millennia.

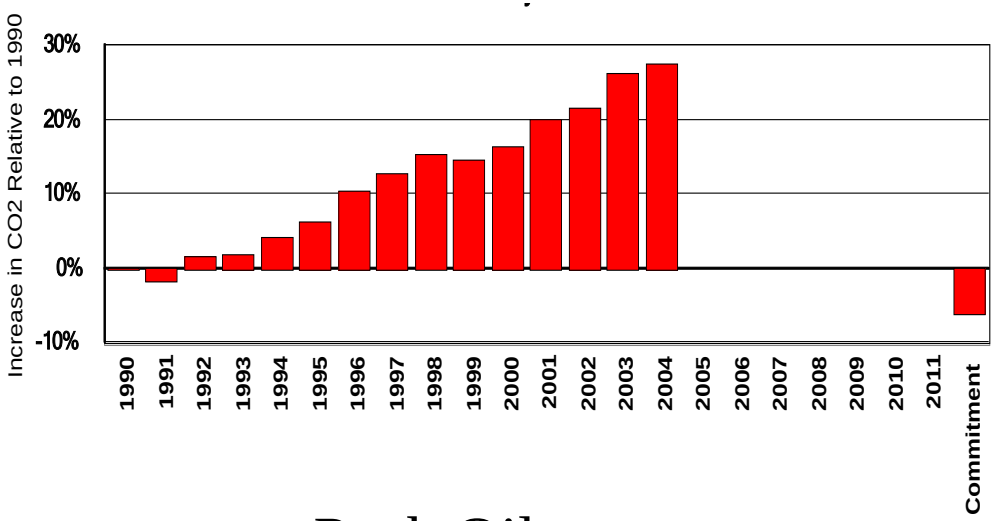


- The discovery and widespread use of fossil fuels, particularly petroleum, is the major physical factor behind the four-fold expansion of the human population (and every other measure of humanity) in just the past 150 years.

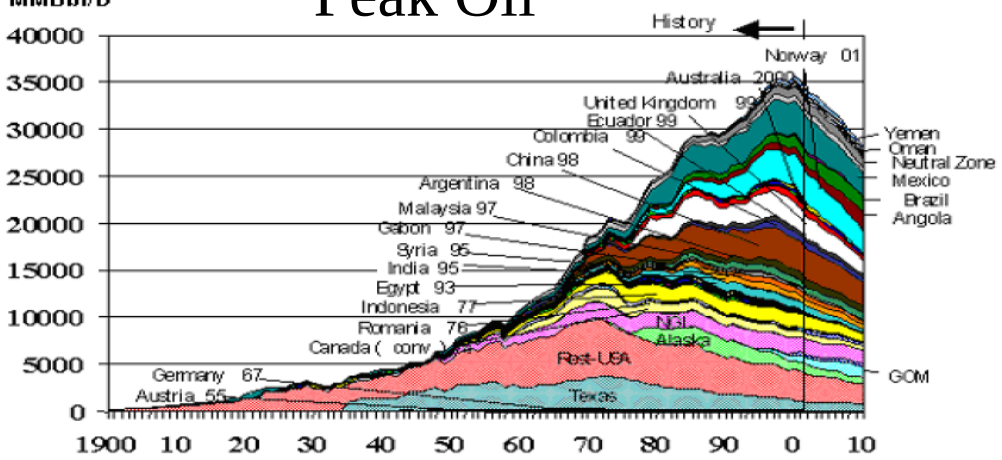


Two Reasons for Moving Beyond Fire and Fossil Fuels:

- Most people know that we may be forced to use less fossil fuel to avoid risk of serious climate change. Indeed, that's what the Kyoto debate is all about. However…
- Fewer people are aware that we may soon have less fossil fuel to burn because the inexpensive, easily accessible stocks are being depleted.



Peak Oil



Sustainable Energy Consumption – Oil ?

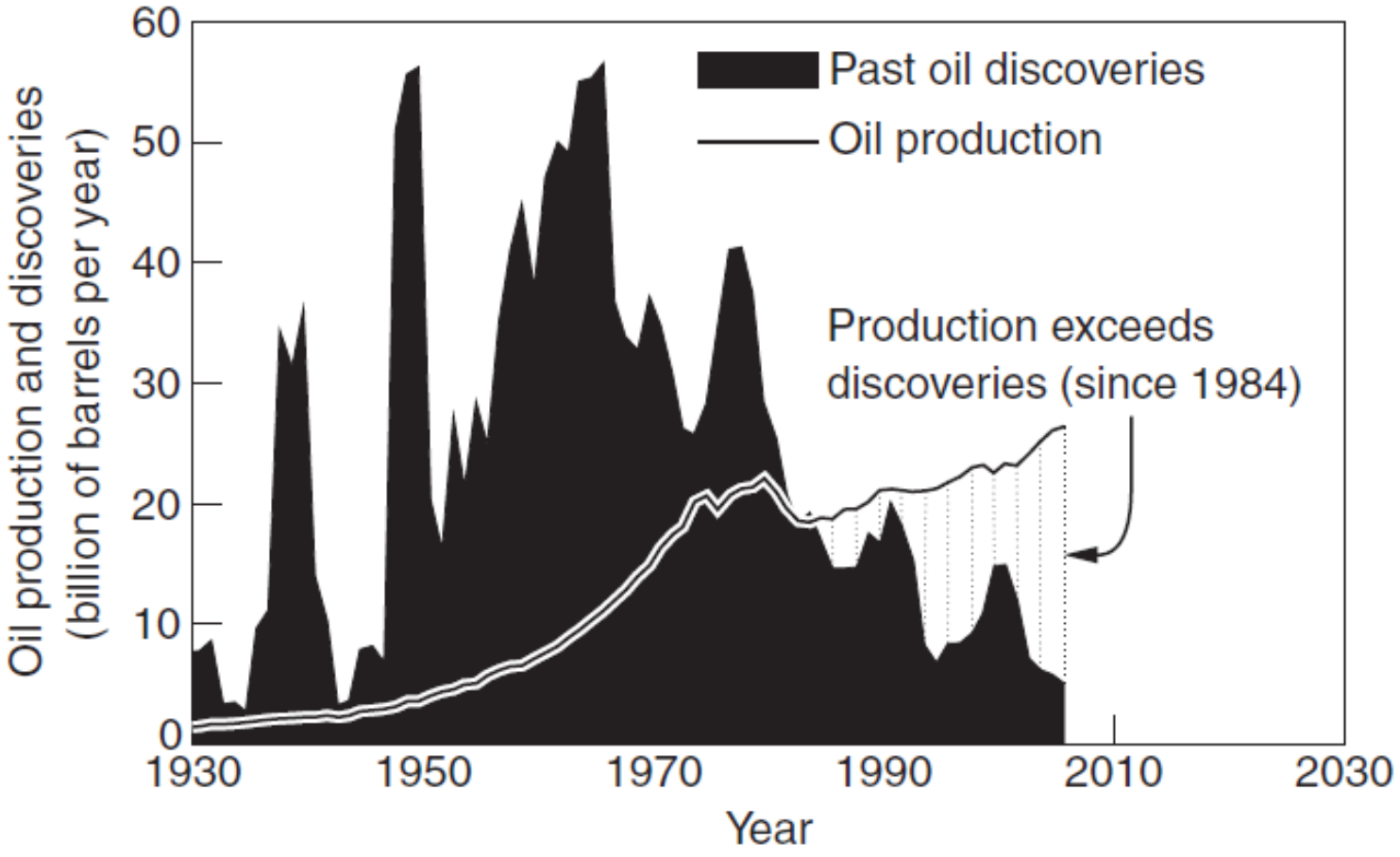


Figure 9.6 The growing gap between world oil production and discoveries [27].

Oil & Gas Consumption Not Sustainable

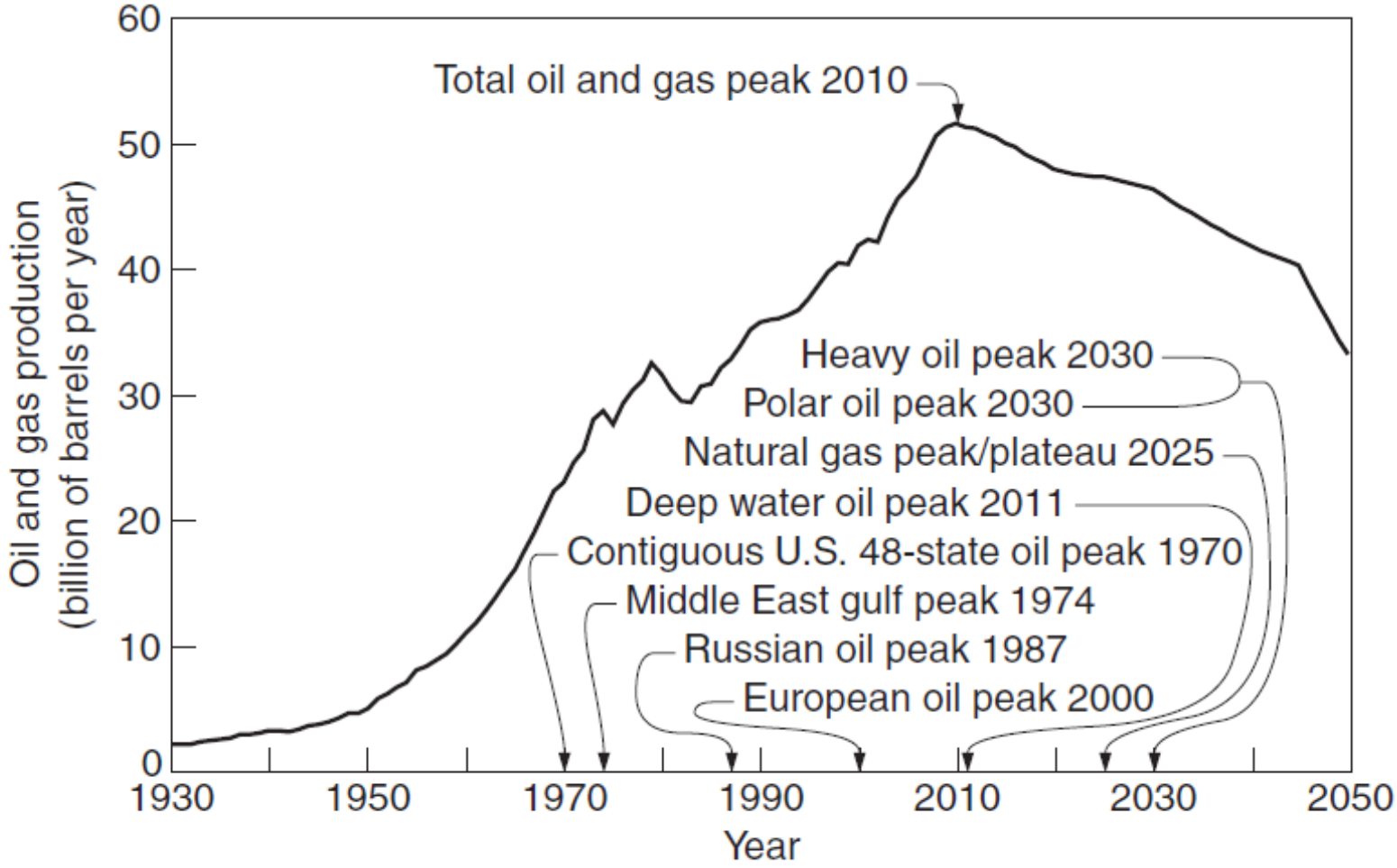


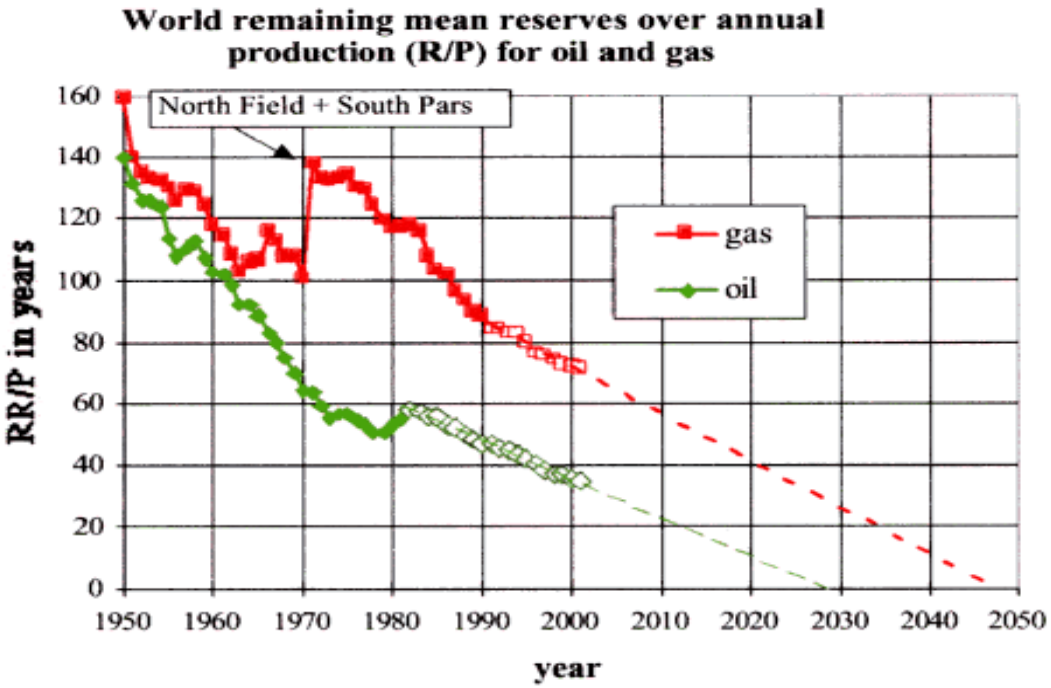
Figure 9.5 Campbell's 2006 total oil and gas production forecast [26, 27].

Is This Good or Bad ?

The Problem with Accessibly:

Coal resources are available in almost every country worldwide. At current production levels, proven coal reserves are estimated to last 164 years (World Coal Institute). In contrast, proven oil and gas reserves will be depleted this century. Over 68% of oil and 67% of gas reserves are concentrated in the Middle East and Russia.

Oil is gone before 2030 and gas is just 20 years behind (Laherrere 2003)



The Next 100 Years ?

Year		**2000**	**2050**	**2100**
Population (POP)	billions	6	9.5	10.5
GDP (in 2000 $)	$US trillion	32	80	230
GDP/POP	$US/capita	5,300	8,400	22,000
Energy (E)	EJ*	429	770	1,390
Coal		100	220	650
Oil		163	160	110
Natural Gas		95	200	160
Nuclear		9	20	90
Hydropower		9	20	30
Trad. Biomass		45	70	90
Modern Biomass		7	50	120
Wind		<<1	20	90
Other Renewables		<<1	10	50
E/GDP	MJ/$US	13.6	9.6	6
E/POP	GJ/capita	71.4	81	132

*1 EJ = 10^{18} Joules

(from: Jaccard, Sustainable Fossil Fuels)

The Next 100 Years ?

Year		2000	2050	2100
Population (POP)	billions	6	9.5	10.5
GDP (in 2000 $)	$US trillion			230
GDP/POP		5,300	8,400	22,000
Energy (E)	EJ*	429	770	1,390
Coal		100		650
Oil		163		110
Natural Gas		95	200	160
Nuclear		9		90
Hydropower		9	20	30
Trad. Biomass		45	70	90
Modern Biomass		7	50	120
Wind		<<1		90
Other Renewables		<<1	10	50
E/GDP	MJ/$US	13.6		6
E/POP	GJ/capita	71.4		132

Population ×1.75
per capita wealth ×4.15

Population ×1.75
Energy Use ×3.24

from <¼ to nearly ½

reduced oil

Increases ×10
≈6% of total

Increases ×100
≈6% of total

More Energy Efficient Wealth Creation

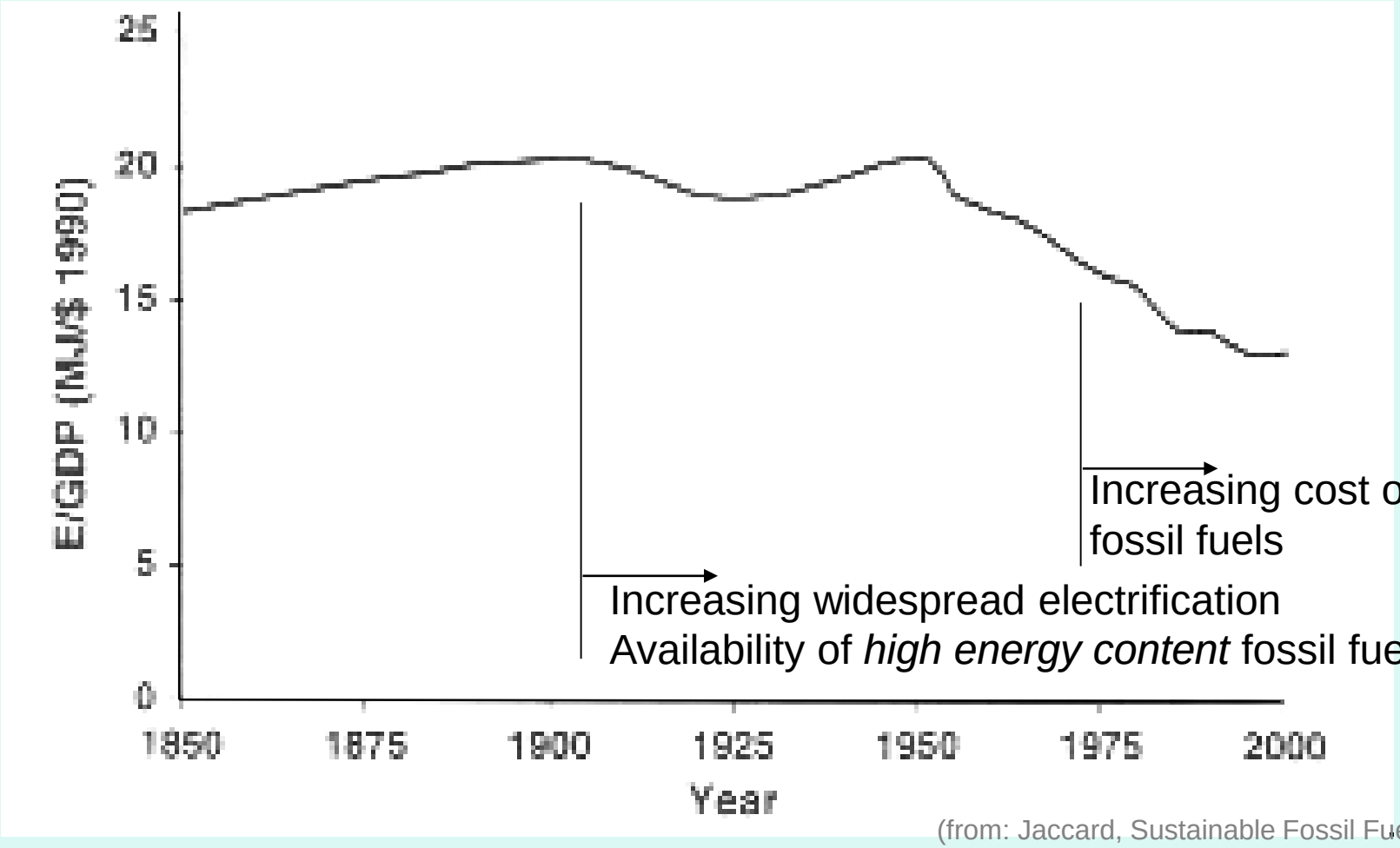
But, more wealthy people

*1 EJ = 10^{18} Joules

(from: Jaccard, Sustainable Fossil Fuels)

What will this mean for the environment?

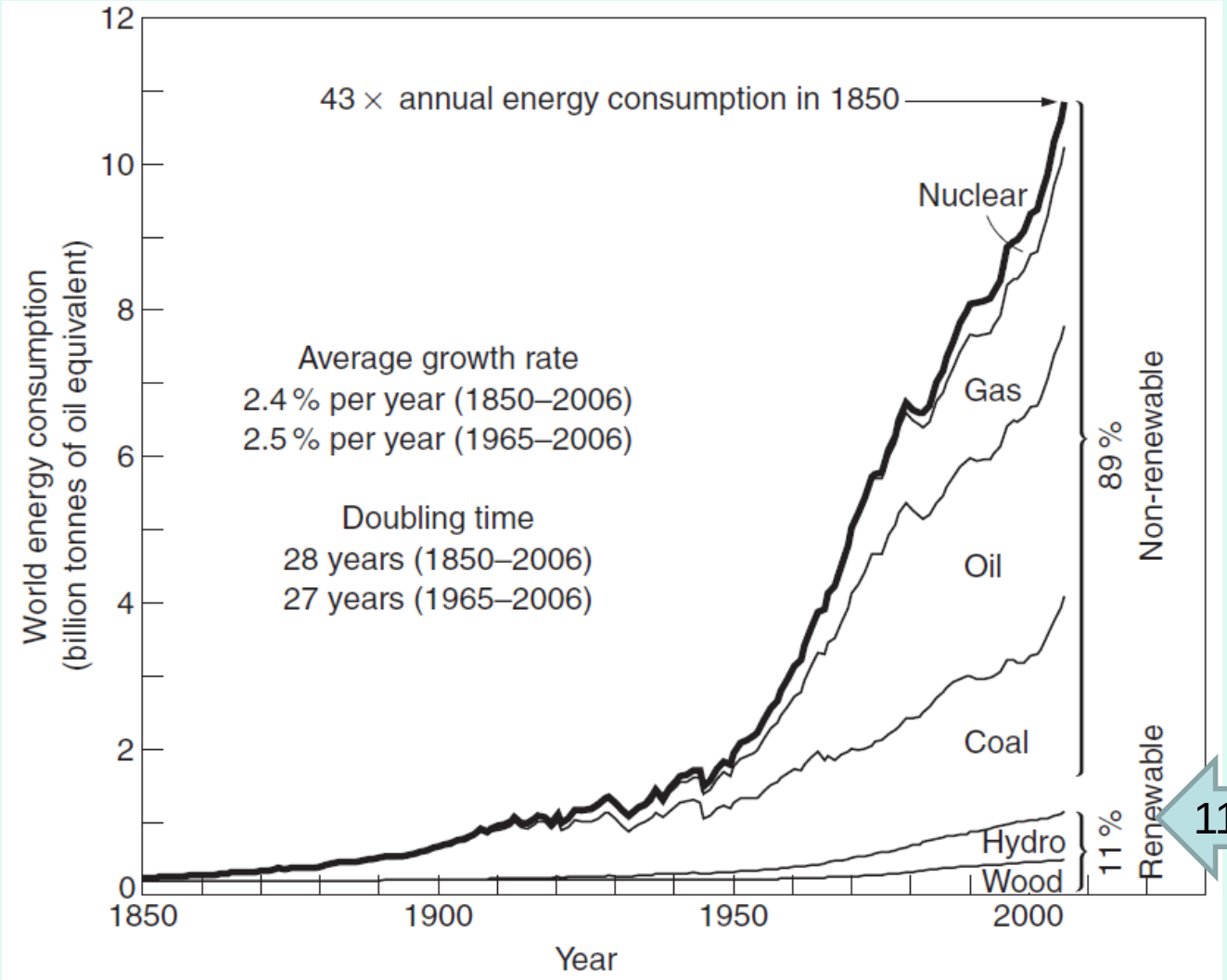
Global History
Energy Consumption / Wealth (GDP)



(from: Jaccard, Sustainable Fossil Fuels)

More Energy Efficient Wealth Creation →

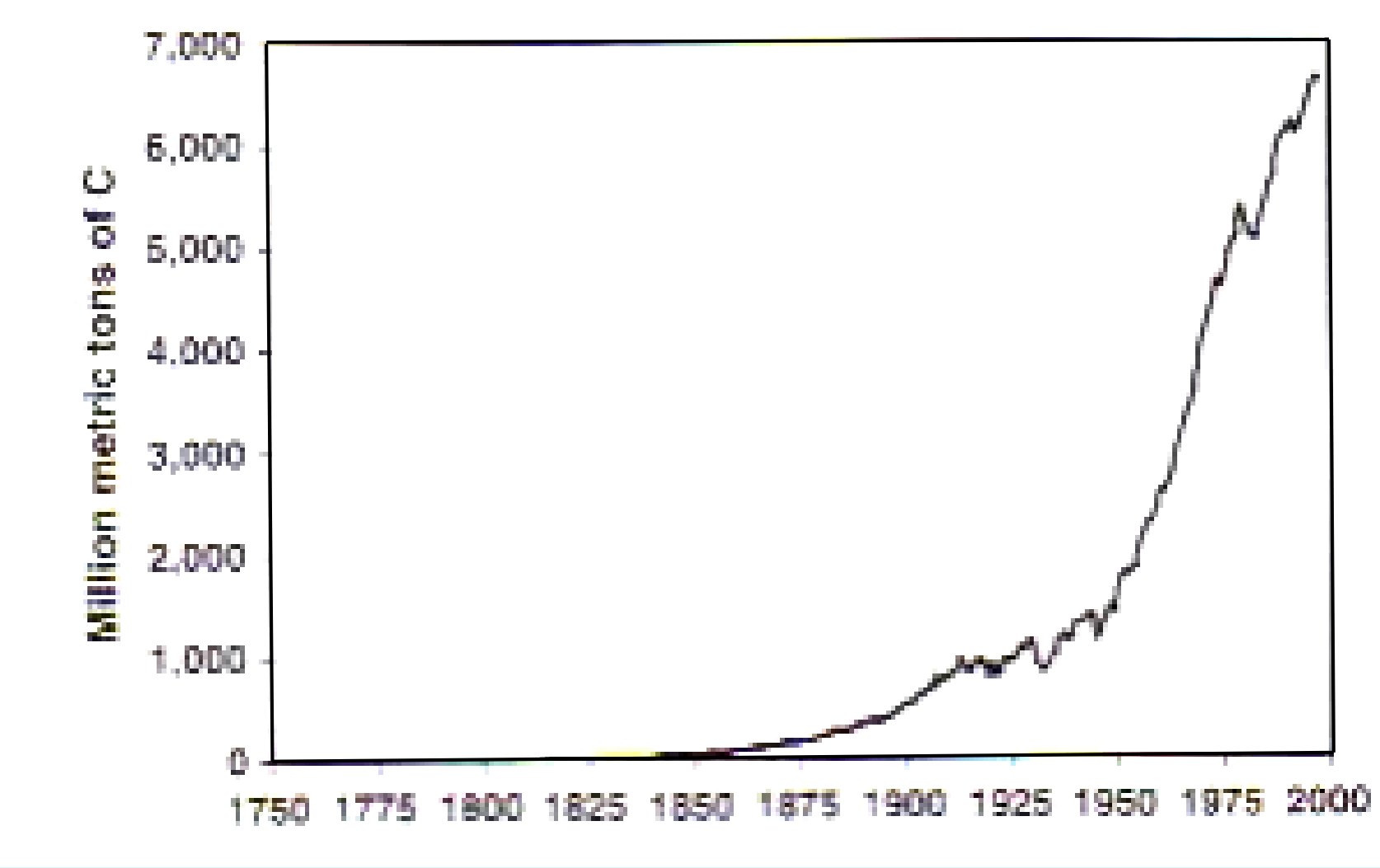
Global Energy Consumption



11% renewables

Figure 9.4 Primary annual world energy consumption 1850 to 2006 [22–24]. A tonne of oil equivalent equals 42 gigajoules (GJ) or 12 megawatt-hours (MWh) of thermal energy.

Global CO_2 Emissions



(from: Jaccard, Sustainable Fossil Fuels)

Canada's GDP, Energy Consumption and CO_2 Emissions

We can cut emissions and still grow the economy!

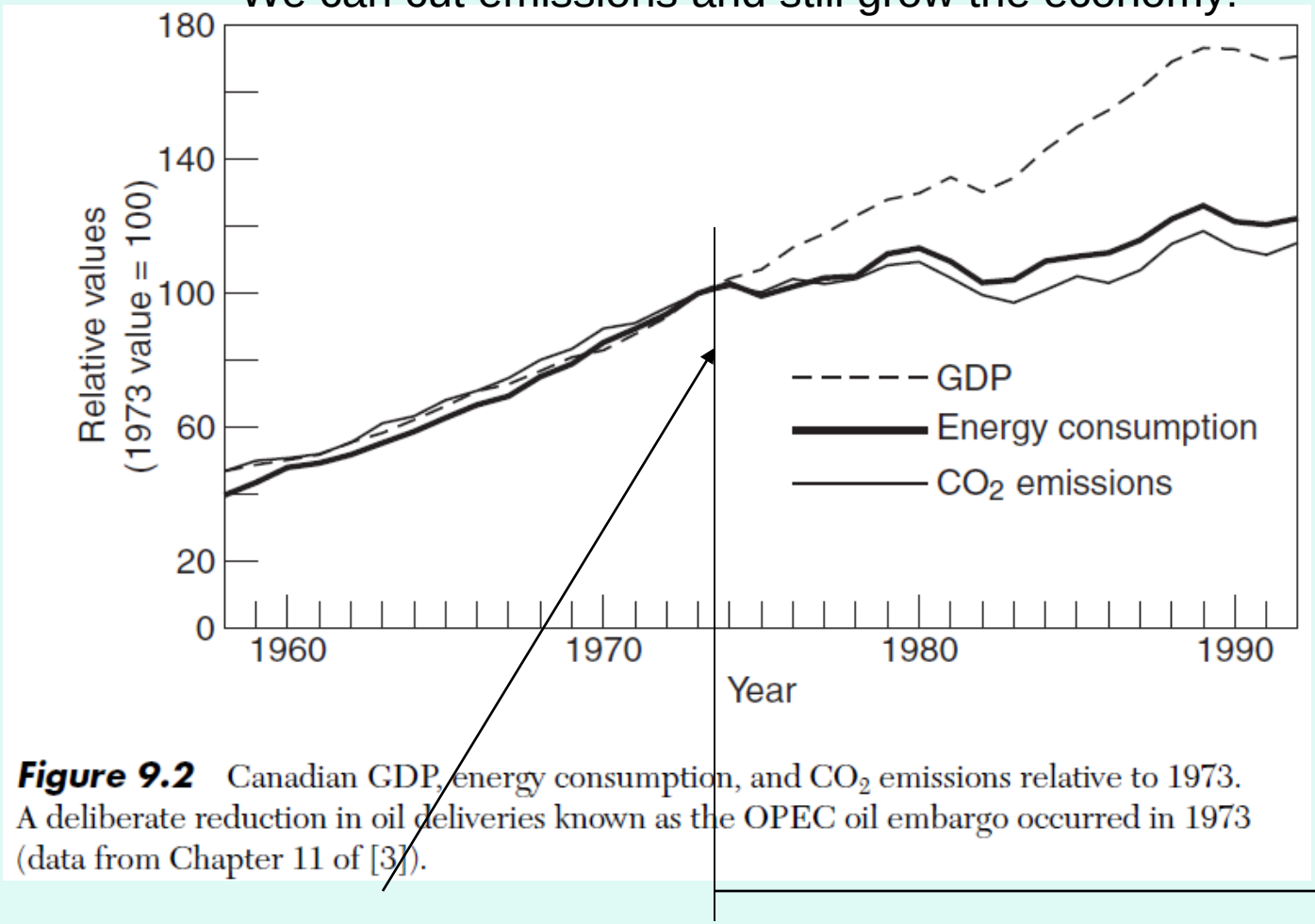


Figure 9.2 Canadian GDP, energy consumption, and CO_2 emissions relative to 1973. A deliberate reduction in oil deliveries known as the OPEC oil embargo occurred in 1973 (data from Chapter 11 of [3]).

OPEC Oil Embargo

More efficient energy use as result of energy crisis.

Process of Global Warming and Climate Change - 1

- Fossil Fuel emissions
  - Combustion of fossil fuels produces waste gas which is released into atmosphere.
    - Mainly carbon dioxide (CO_2).
    - Human activity produces more CO_2 than can be absorbed by plant life.
- Greenhouse effect
  - Sun's radiation passes through atmosphere and warms Earth's surface.
  - Absorbed energy is eventually re-emitted as thermal radiation, which is partially blocked by carbon dioxide (CO_2), methane (CH_4), etc in atmosphere.
  - CO_2 can stay in atmosphere for many decades.

Process of Global Warming and Climate Change - 2

- Global Warming
  - Greenhouse effect is essential since it cushions Earth from stark temperature extremes that exist on planets without an atmosphere.
  - BUT, small deviations in Earth's solar energy balance can produce large effects leading to global warming or cooling.
- Climate Change
  - Severe storms, droughts, floods, increase in sea level caused by small deviations in solar energy balance.

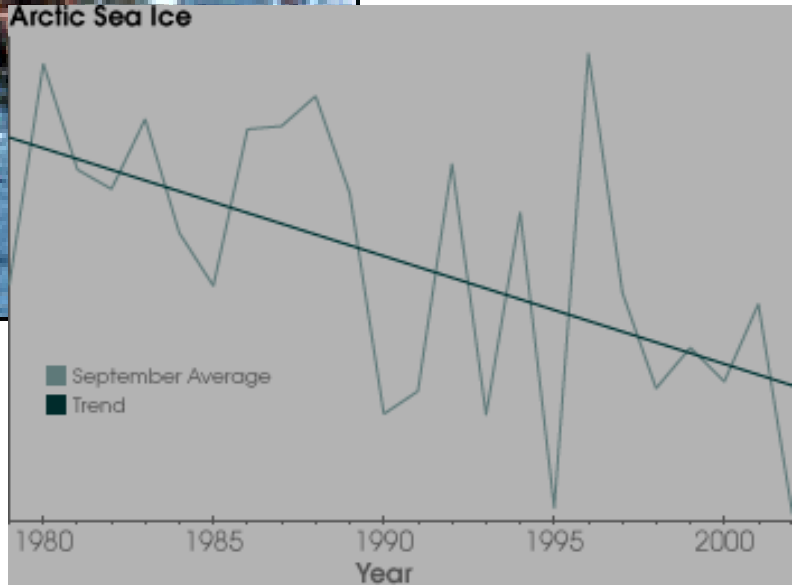
Consequences of Climate Change - 1

- Intergovernmental Panel on Climate Change (IPCC) issued *5th Assessment Report* (AR5) in 2014
  - Shows with great certainty that climate change directly linked to global warming.
    - Caused by GHGs that result mainly from human burning of fossil fuels.
- Human cause
  - Worldwide atmospheric concentrations GHGs at levels which greatly exceed pre-industrial values.

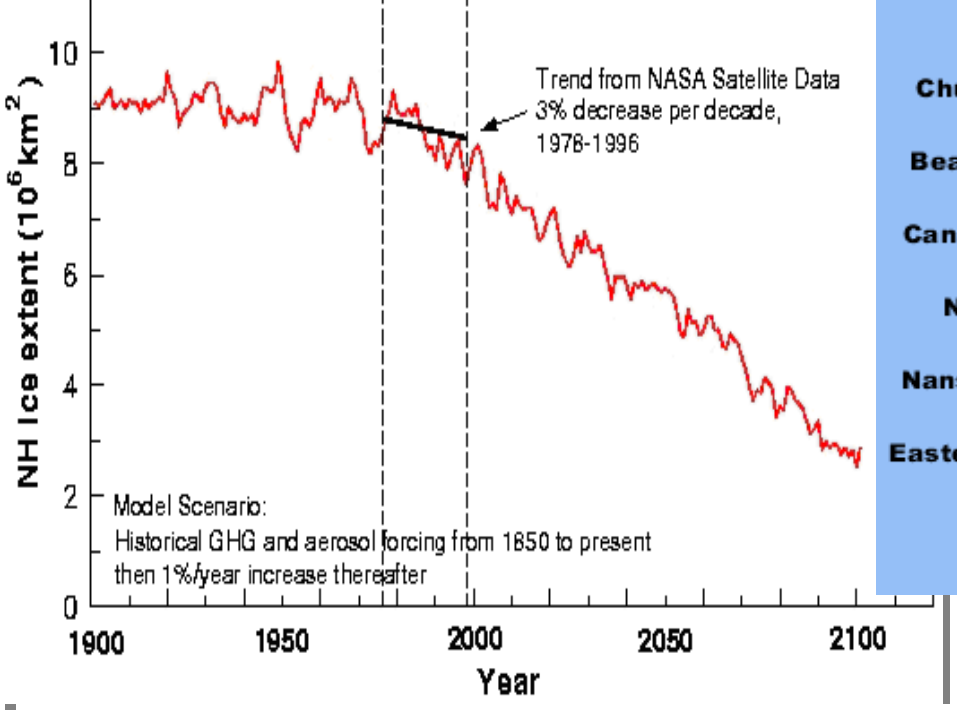
Consequences of Climate Change - 2

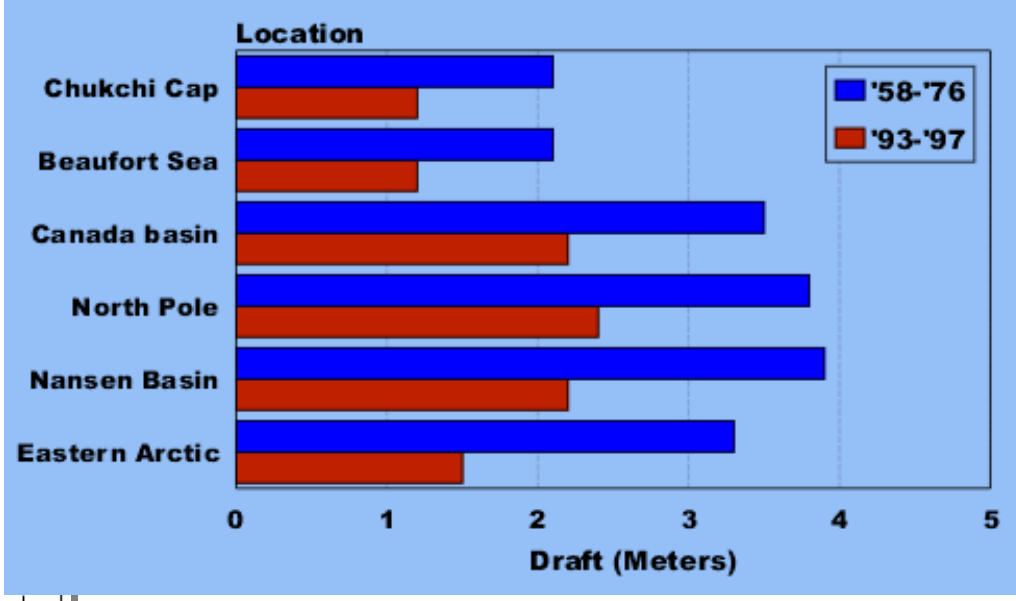
- Temperature rise
  - Will rise 1.8 ^{o}C to 4 ^{o}C over next century.
    - Even if 2000 levels of GHGs maintained, temperature rise of 1 ^{o}C due to GHGs already in atmosphere.
    - Greatest temperature rise will be in Arctic and Antarctic.
- Sea level rise
  - Decline in ice volume may lead to increase in sea level of 18 cm to 59 cm or more.
    - Risk of floods in vulnerable coastal cities.

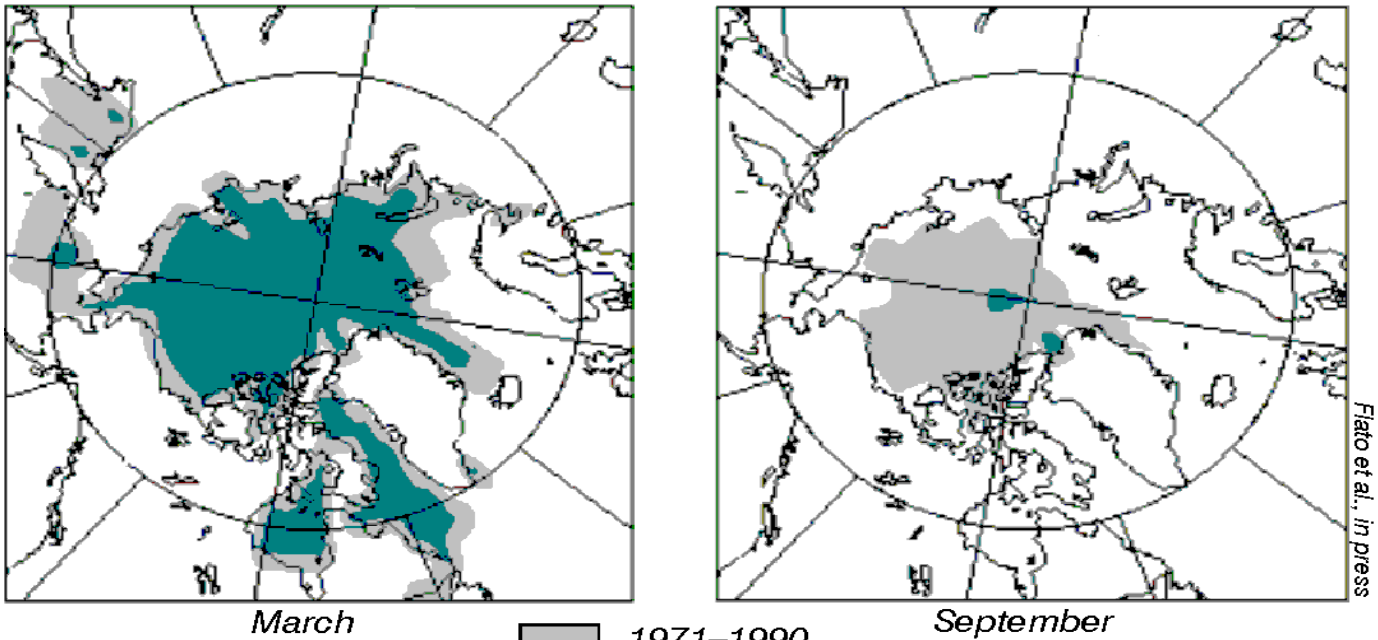
Your view of the effects of climate change may depend on where you live…



Arctic Sea Ice melts as temperature increases



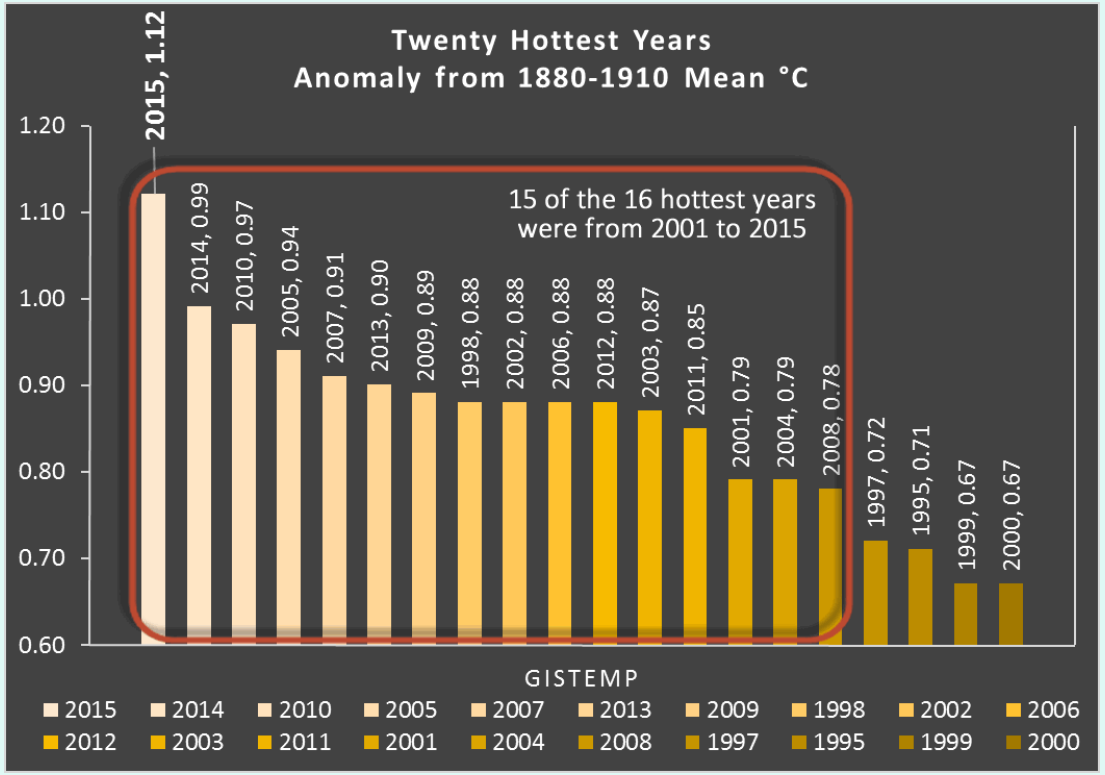




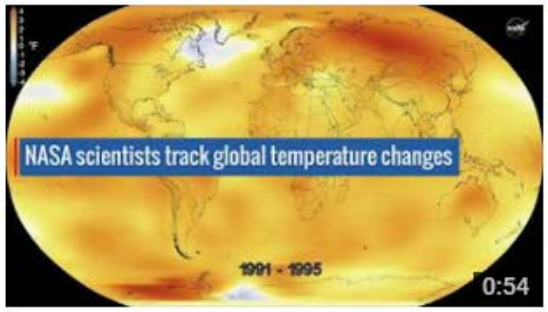
Sea ice is thinning and may Disappear during Summer & Fall

Consequences of Climate Change - 3

- Present observations
  - Changes in arctic temperatures, ocean salinity, wind patterns, extreme weather conditions.
  - 15 of 16 hottest years since 1850 occurred between 2001-2015.

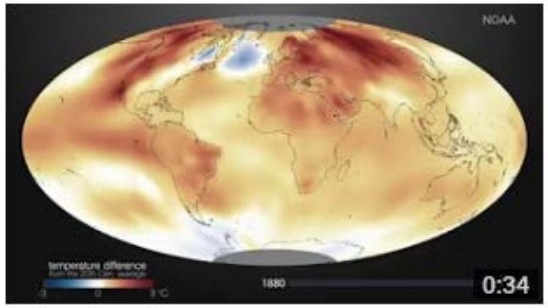


It is getting hotter



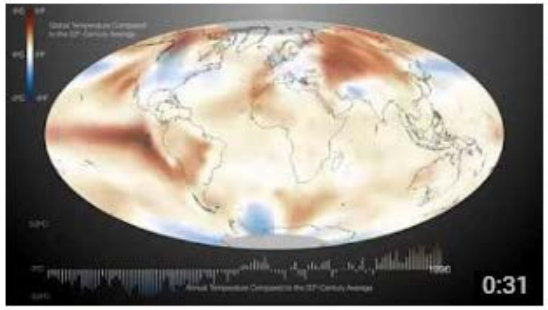
2016 was the hottest year on record

The Oregonian
1 year ago • 245 views
2016 was the **hottest year on record**, according to findings by the National Oceanic and Atmospheric Administration and NASA, ...



2015 Was the Warmest Year on Record

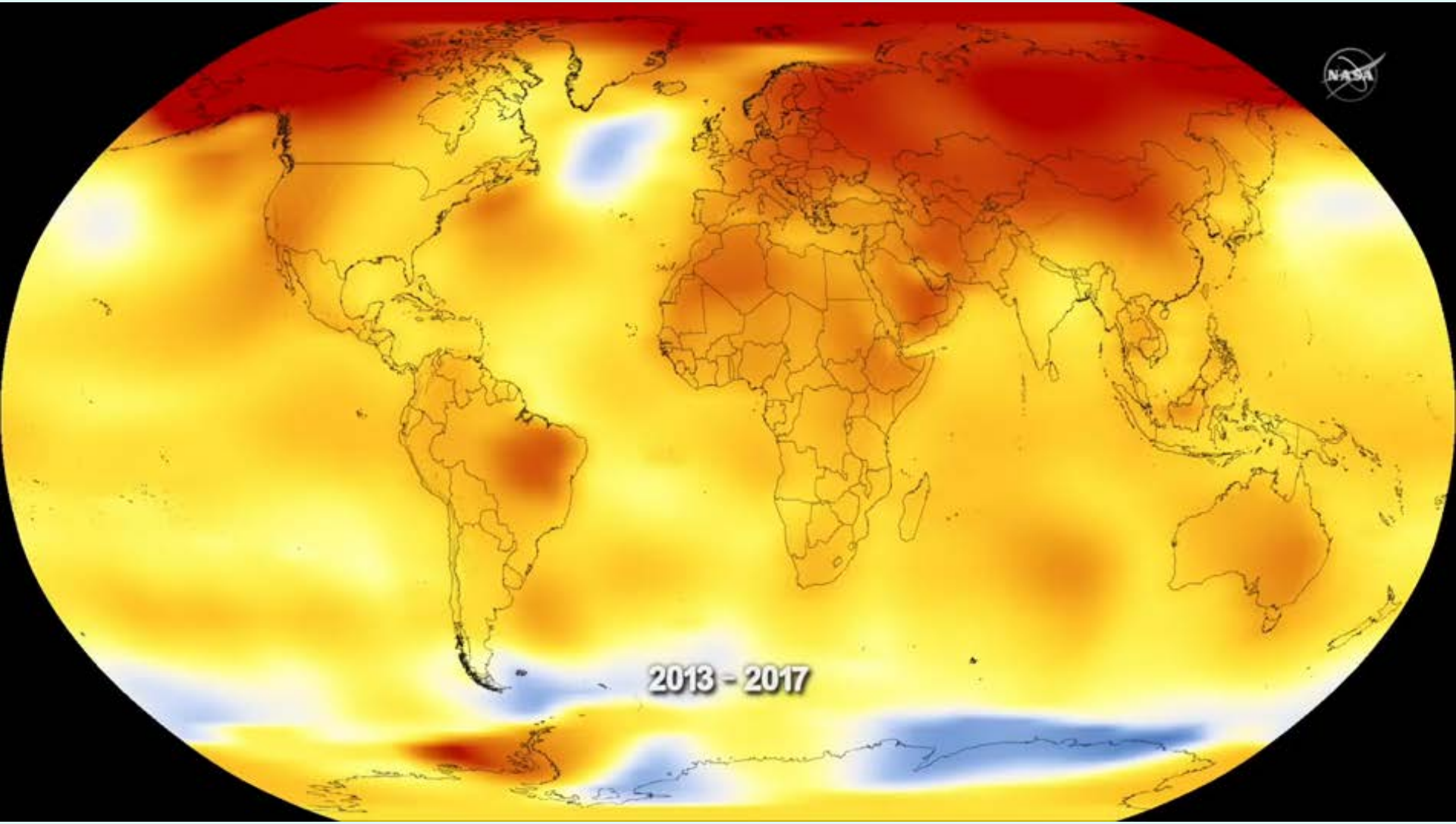
NOAAVisualizations
2 years ago • 31,753 views
According to NOAA, the globally averaged temperature, over land and ocean surfaces for 2015, was the highest since **record** ...



2014 Was the Warmest Year on Record

NOAAVisualizations
3 years ago • 18,287 views
Analysis by NOAA shows that in 2014, the combined land and ocean surface temperature was 1.24°F (0.69°C) above the 20th ...

2017 – the second hottest year



All-time heat records set all over the world

Jason Samenow - The Washington Post -

Video provided by The Weather Network

Washington Post
July 4 2018

From the normally mild summer climes of Ireland, Scotland and Canada to the scorching Middle East, numerous locations in the Northern Hemisphere have witnessed their hottest weather ever recorded over the past week.

Large areas of heat pressure or heat domes scattered around the hemisphere led to the sweltering temperatures.

No single record, in isolation, can be attributed to global warming. But collectively, these heat records are consistent with the kind of extremes we expect to see an increase in a warming world.

Let's take a tour around the world of the recent hot-weather milestones.

A massive and intense heat dome has consumed the eastern two-thirds of the United States and southeast Canada since late last week. It's not only been hot but also exceptionally humid. Here are some of the notable all-time records set:

Denver tiedits all-time high-temperature record of 105 degrees on June 28.

Burlington, Vt., set its all-time warmest low temperature ever recorded of 80 degrees on July 2.

Montreal recorded its highest temperature in recorded history, dating back 147 years, of 97.9 degrees (36.6 Celsius) on July 2. The city also posted its most extreme midnight combination of heat and humidity.

Ottawa posted its most extreme combination of heat and humidity on July 1.

Excessive heat torched the British Isles late last week. The stifling heat caused roads and roofs to buckle, the Weather Channel reported, and resulted in multiple record highs:

All-time heat records set all over the world

Jason Samenow - The Washington Post - July 4, 2018

Video provided by The Weather Network

Washington Post
July 4 2018

As we reported, **Quriyat, Oman**, posted the world's hottest low temperature ever recorded on June 28: 109 degrees (42.6 Celsius).

These various records add to a growing list of heat milestones set over the past 15 months that are part and parcel of a planet that is trending hotter as greenhouse gas concentrations increase because of human activity:

In April, Pakistan posted the hottest temperature ever observed on Earth during the month of 122.4 degrees (50.2 Celsius).

Dallas had never hit 90 degrees in November before, but it did so three times in four days in 2017.

In late October 2017, temperatures soared to 108 degrees in Southern California, the hottest weather on record so late in the season in the entire United States.

On Sept. 1, 2017, San Francisco hit 106 degrees, smashing its all-time hottest temperature.

In late July 2017, Shanghai registered its highest temperature in recorded history, 105.6 degrees (40.9 Celsius).

In mid-July, Spain posted its highest temperature recorded when Cordoba Airport (in the south) hit 116.4 degrees (46.9 Celsius).

In July 2017, Death Valley, Calif., endured the hottest month recorded on Earth.

In late June 2017, Ahvaz, Iran, soared to 128.7 degrees Fahrenheit (53.7 Celsius) — that country's all-time hottest temperature.

In late May 2017, the western town of Turbat in Pakistan hit 128.3 degrees (53.5 Celsius), tying the all-time highest temperature in that country and the world-record temperature for May, according to Masters.

All-time heat records set all over the world

Jason Samenow - The Washington Post - July 4, 2018

Video provided by The Weather Network

Washington Post
July 4 2018

midnight combination of heat and humidity.

Ottawa posted its most extreme combination of heat and humidity on July 1.

Excessive heat torched the British Isles late last week. The stifling heat caused roads and roofs to buckle, the Weather Channel reported, and resulted in multiple record highs:

Scotland provisionally set its hottest temperature on record. The U.K. Met Office reported Motherwell, about 12 miles southeast of Glasgow, hit 91.8 degrees (33.2 Celsius) on June 28, passing the previous record of (32.9 Celsius) set in August 2003 at Greycrook. Additionally, **Glasgow** had its hottest day on record, hitting 89.4 degrees (31.9 Celsius).

In **Ireland**, on June 28:

Belfasthit 85.1 degrees (29.5 Celsius), its record.

Shannonhit 89.6 degrees (32 Celsius), its record.

In **Northern Ireland**, **Castlederghit 86.2 degrees** (30.1 Celsius) on June 29, its record.

A large dome of high pressure, or heat dome, has persistently sat on top of Eurasia over the past week, resulting in some extraordinarily hot weather:

Yerevan, Armenia: On July 2, the capital city soared to 107.6 degrees (42 Celsius), a record high for July and tying its record for any month.

Several locations in southern Russia topped or matched their warmest June temperatures on record on the 28th.

Consequences of Climate Change - 3

- Other consequences
  - Inland flooding, drought, insect plagues, species extinction.
- Irreversibility
  - Vast peat bogs exist under permafrost in subarctic.
    - Increase of 2 ^{o}C may cause these bogs to decay, releasing huge amounts of GHGs.

Defining Sustainability

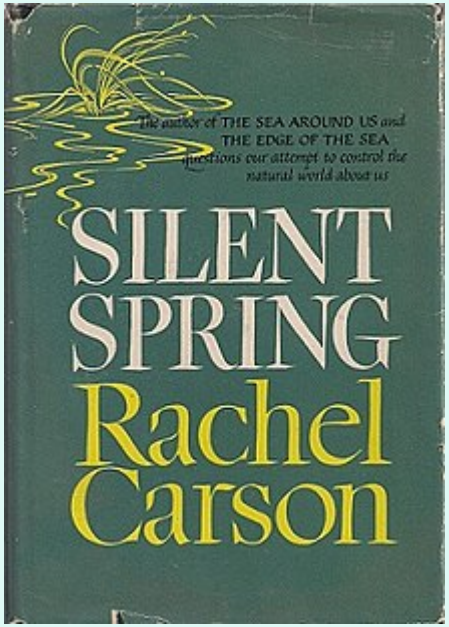
- Brundtland Commission of United Nations:
  - "Sustainable development is development that meets the needs of the present, without compromising the ability of future generations to meet their own needs."
- Paul Hawken, in *The Ecology of Commerce*:
  - "leave the world better than you found it, take no more than you need, try not to harm life or the environment, make amends if you do."

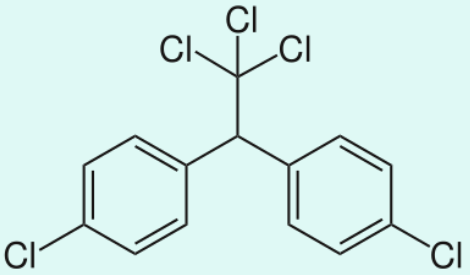
History of Sustainable Development - 1

1962 - Rachel Carson publishes "Silent Spring".

- This book brought together research on toxicology, ecology and epidemology to suggest that agricultural pesticides were building to catastrophic levels.
- This was linked to damage to animal species and to human health.
- It shattered the assumption that the environment had an infinite capacity to absorb pollutants.

- 5th in the Modern Library List of Best 20th-Century Nonfiction
- 78th in the National Review's 100 best non-fiction books of the 20th century.
- In 2006, Silent Spring was named one of the 25 greatest science books of all time by the editors of Discover Magazine.
- In 2012, the American Chemical Society designated the legacy of Silent Spring a National Historic Chemical Landmark at Chatham University in Pittsburgh.





Naturalist Sir David Attenborough said that *Silent Spring* was probably the book that had changed the scientific world the most, after the *Origin of Species* by Charles Darwin.