FLORIDA SOLAR ENERGY CENTER

A Research Institute of the University of Central Florida

Into the Storm:
The Twin Challenges of Peak Oil & Global Warming

Keynote Address

2006 RESNET Building Performance Conference

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Philip Fairey

Into the Storm

Any Questions?

- Who is captain of the ship?
- If it were you, what would you want to know?
  - How bad is the storm?
  - How fast are we closing on the storm?
  - How strong is the ship?
  - How large is the ship and . . .
  - How quickly can she be turned?
  - What is Plan B?

What is "Peak Oil"?

The point at which we reach maximum global oil production

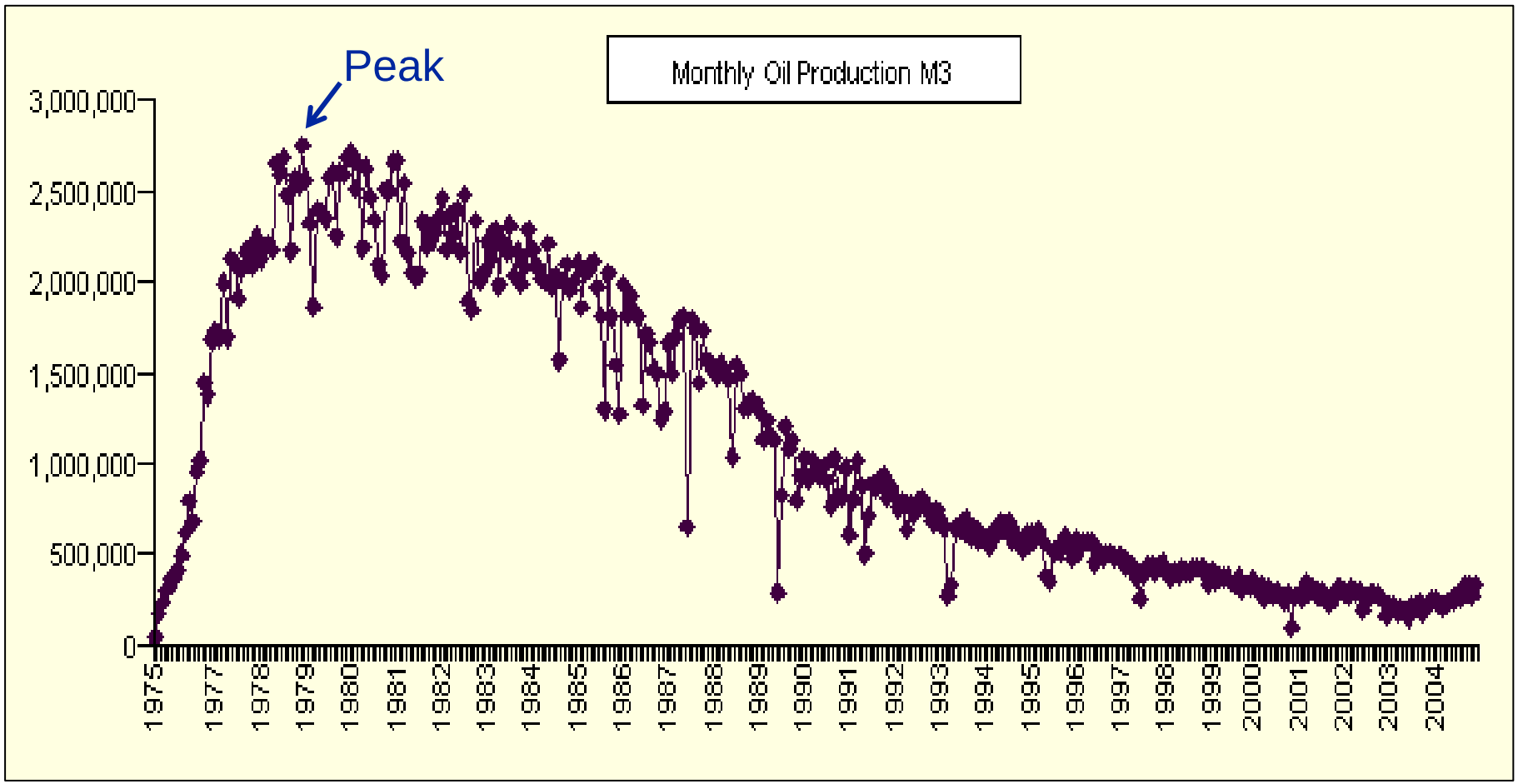
- **Peak Oil <u>IS NOT</u>:**
  - The end of oil
  - An energy crisis
- **Peak Oil <u>IS</u>:**
  - A liquid fuel crisis
  - A potential economic, political and social crisis

Peak Oil Facts

- All oil fields peak
- All oil regions peak
- World oil production will peak (or already has and we just haven't been told)
- The really big fields get discovered early in the game – remember "low hanging fruit" Depletion is a fact of life in the oil business
- We cannot **make** more oil!

North Sea "Forties"

A "Giant" Oil Field (>10 billion bbl)



The Experts on When?

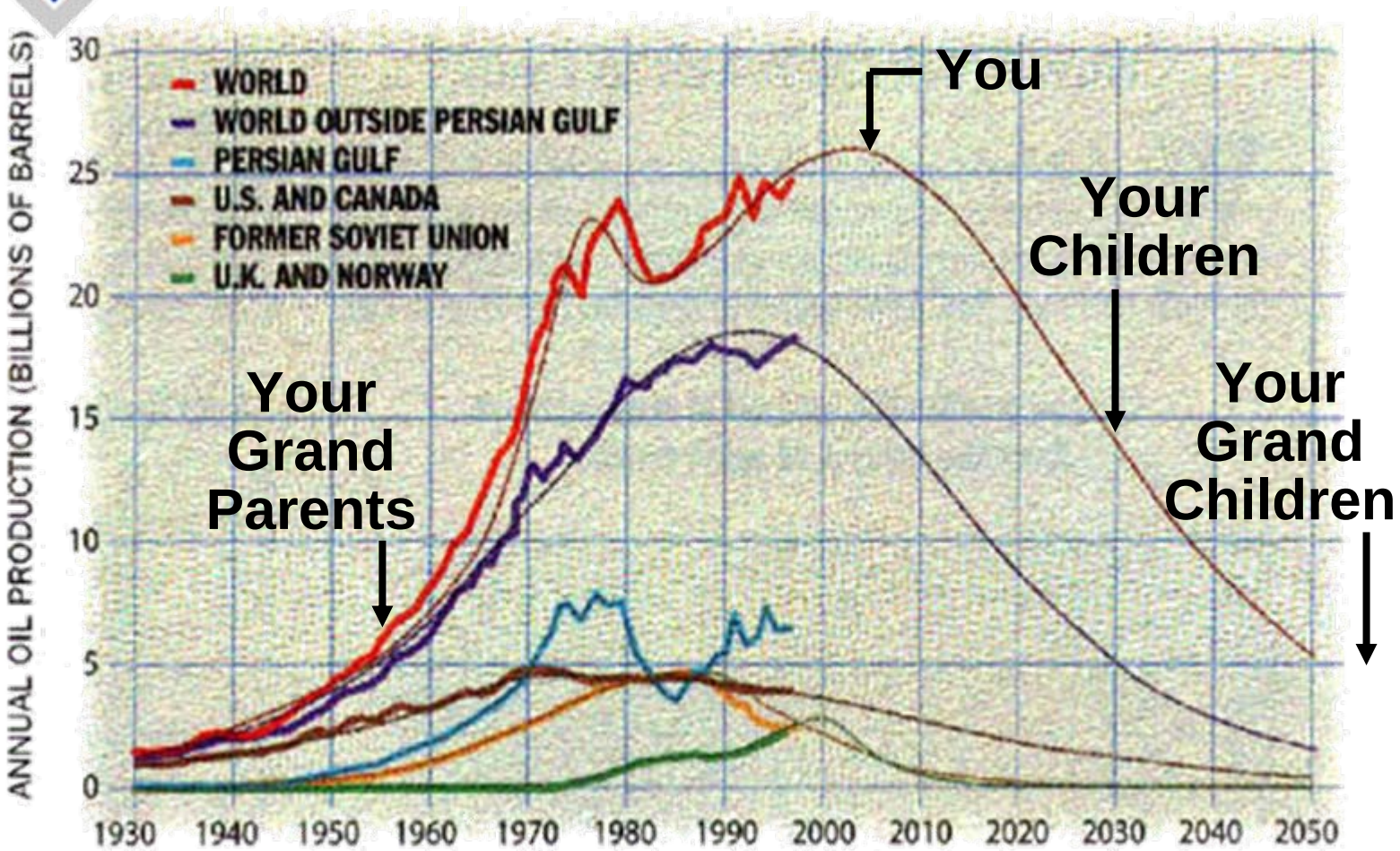
Forecast	Source
2006-2007	Bakhtiari (Iran)
2007-2009	Simmons (U.S.)
After 2007	Skrebowski (U.K.)
2008	Campbell (Ireland)
Before 2009	Deffeyes (U.S.)
Before 2010	Goodstein (U.S.)
After 2010	World Energy Council
2012	Weng (China)
2016	Doug-Westwood (U.K.)
After 2020	CERA (U.S.)
2031 or later	EIA (U.S.)

5 years

5-10 years

> 15 years

World Oil – In Perspective



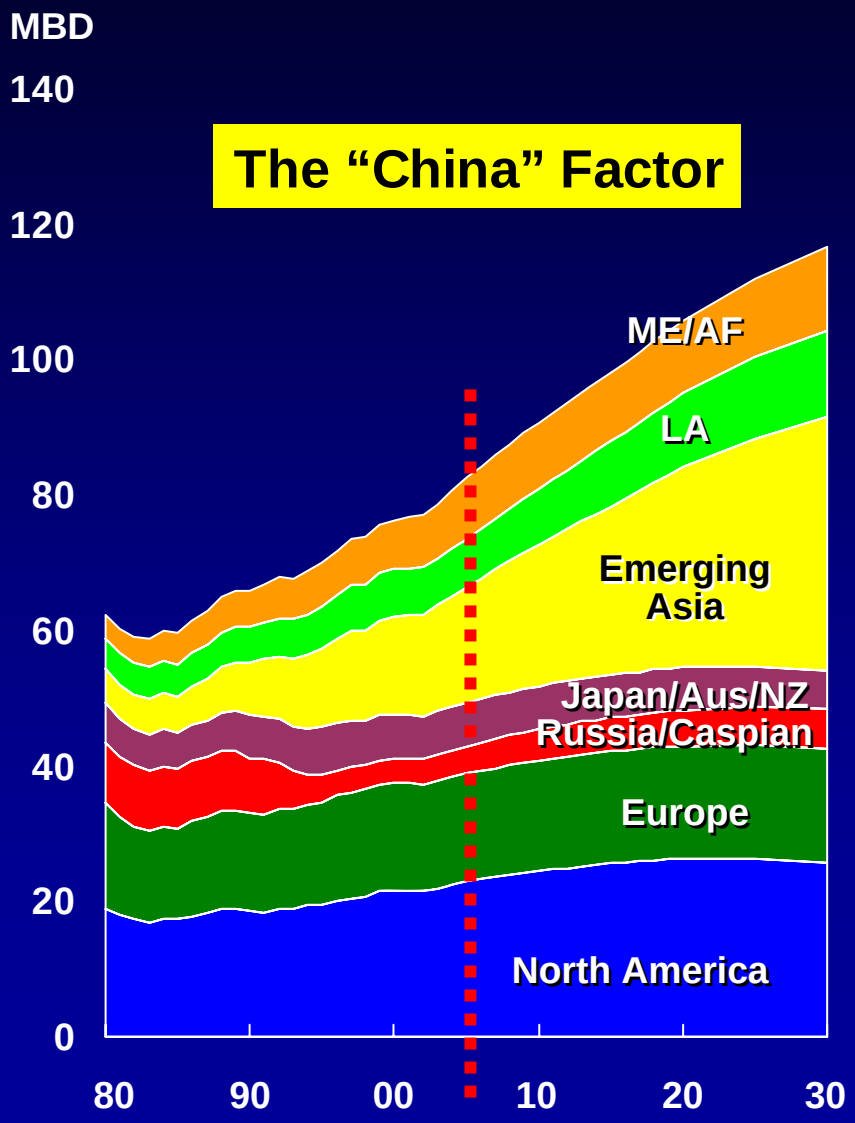
Source: Campbell, Colin J. and Jean H. Laherrere, "The End of Cheap Oil." *Scientific American*, March 1998.

The Underlying Facts

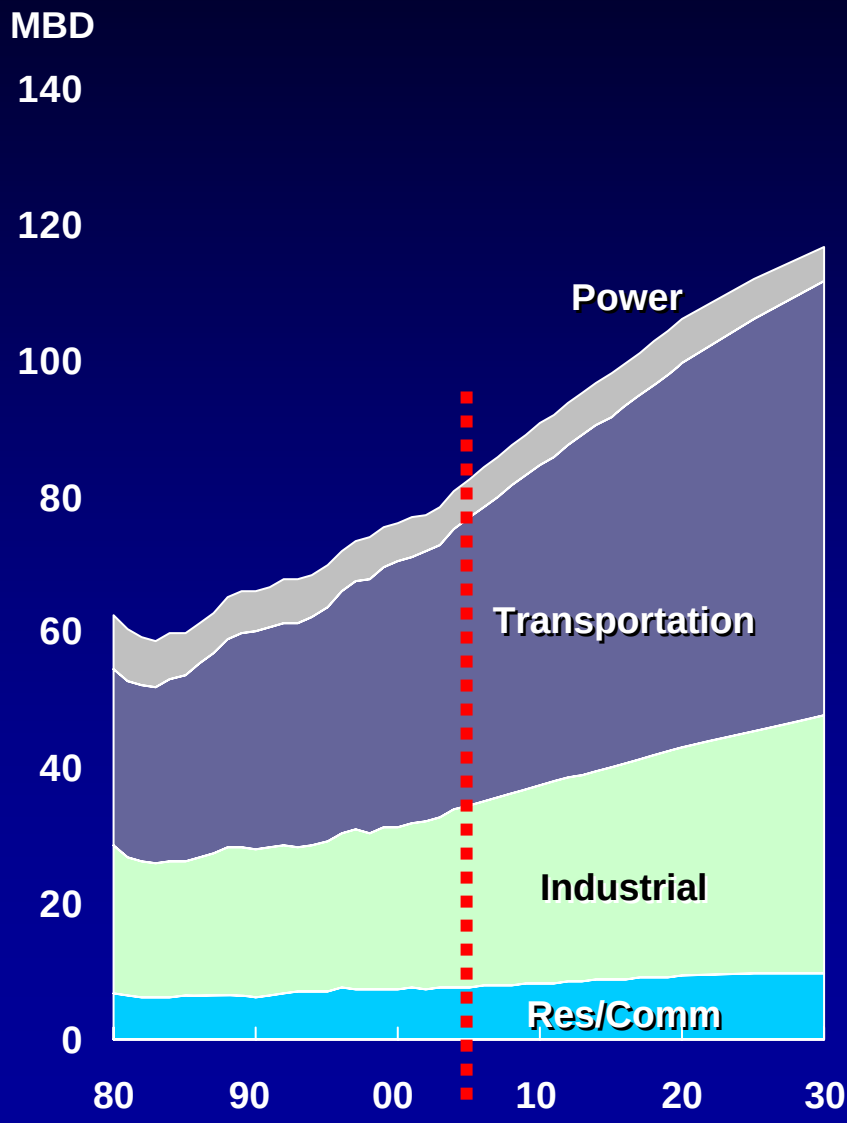
- We are consuming 3-4 barrels of oil for each barrel that is being discovered
- World oil discovery peaked in 1964
- World oil production is declining while world oil demand is rising
- China and India (over half the world's population) are very rapidly expanding their economies and their transportation fuel use (~8% growth per year)!

World Oil Demand

By Region



By Sector



ExxonMobil

Why it Matters

- Oil and gas now dominate our lives
- 40% of all traded energy is oil
- More than 90% of all transportation fuel is oil
  - Trade depends on transport
  - Fuels much electricity generation
- Critical for agriculture
  - Fuels the tractor, transports the produce
  - Basis for synthetic fertilizer and pesticides

Oil Production and Use

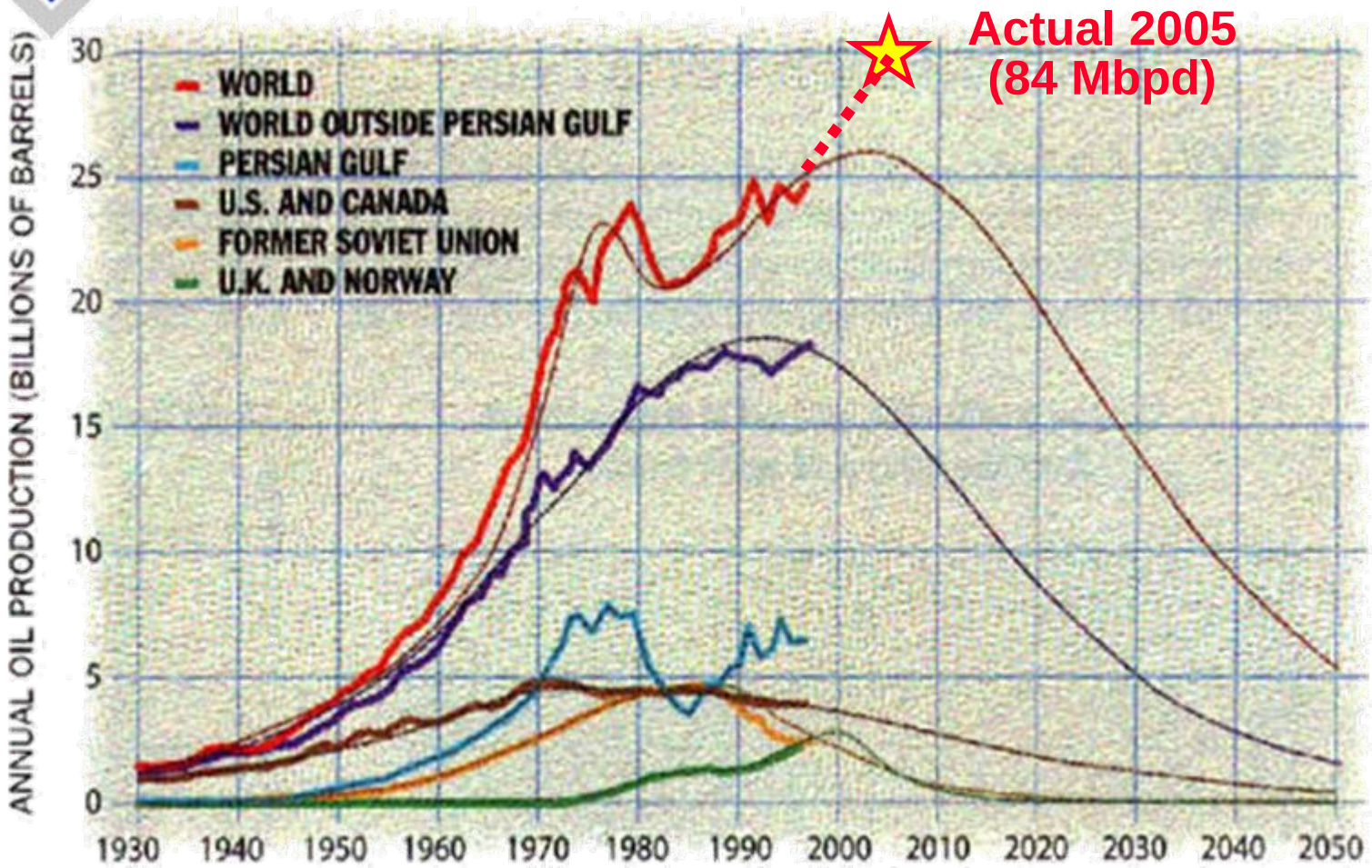
- 2005 world oil use = 84 million barrels per day (Mbpd)
- Over 75% of world's production comes from fields that are 25 years old and in decline
- Experts believe world production will decline between 2% and 8% over the next 5 years
- World demand is predicted to increase by 2% per year over the same period, and . . .
- World oil production may have already peaked!

What Every beer drinker knows: The faster you drink it . . .!

The "Super Straw" Effect

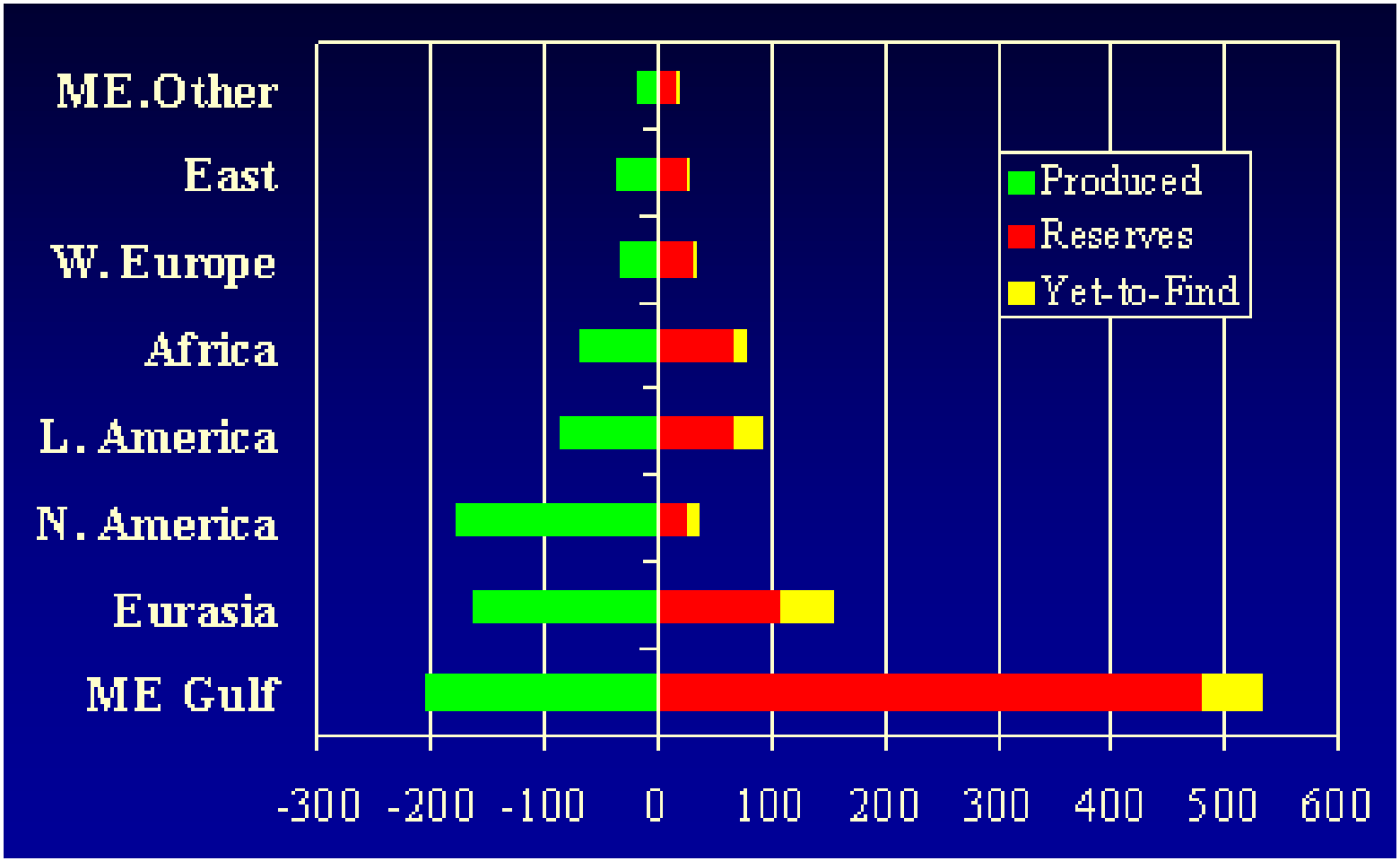
- We are getting much better at extracting oil
  - Better geology – we know where it is
  - Better production technology – we know how to get it out quicker
- The problem – the speed of production does not improve our ability to ultimately produce more oil and may, in fact, reduce total oil recoverability!
- According to recent publications, this may have happened in Saudi Arabian fields.

Scary Fact of the Day

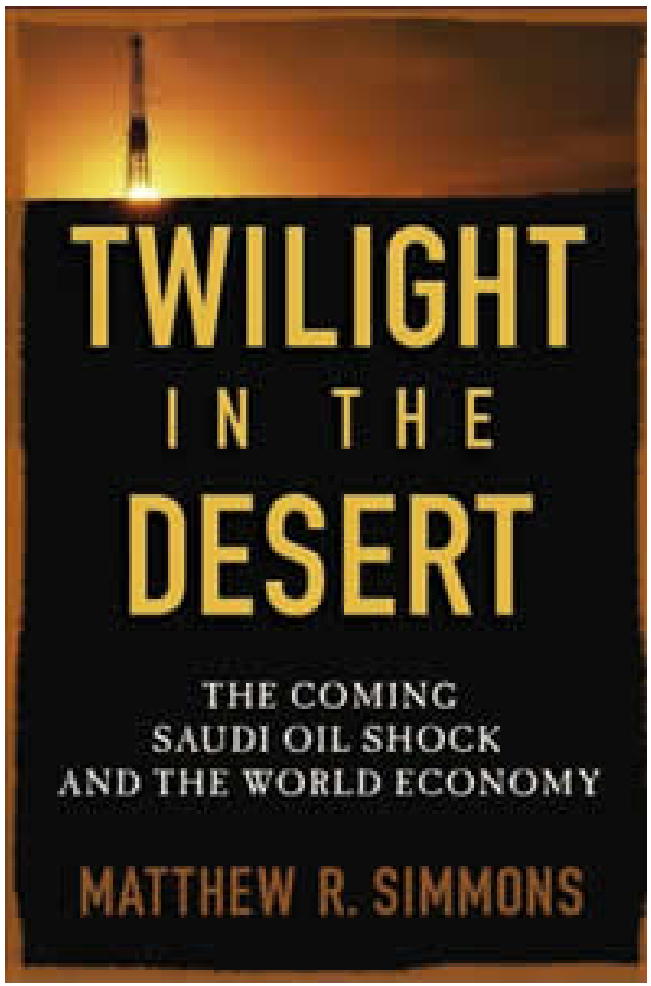


Source: Campbell, Colin J. and Jean H. Laherrere, "The End of Cheap Oil." *Scientific American*, March 1998.

Where The Oil Is



Saudi Oil?



- One "super giant" field (Ghawar) contains 50% of all Saudi oil
- 4 other super giant oilfields make up an additional 40%
- And 3 others are another 8%
- All fields are between 40 and 60 years old
- All are reaching point of decline
- Half of "proven reserves" are questionable
- Remaining oil is increasingly difficult to produce.

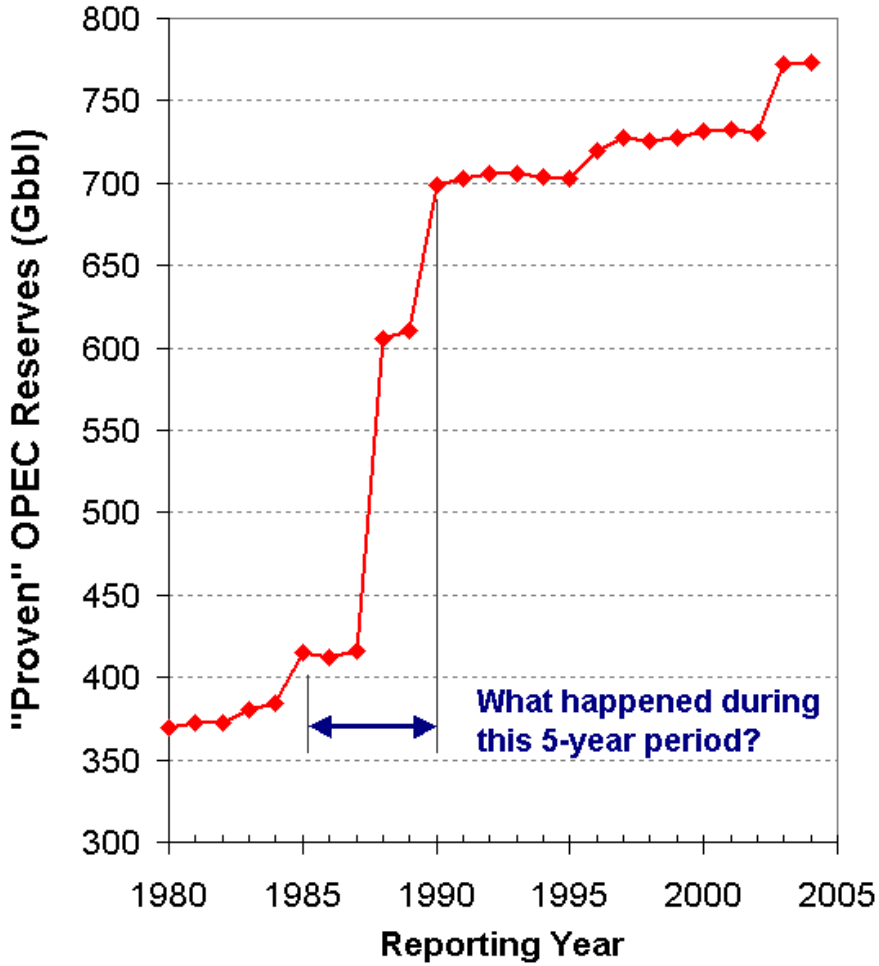
Saudi Importance

- Can produce about 10-12 Mbpd or about 12% of current world oil demand
- Has more than 25% of reported proven reserves worldwide
- Will become the sole arbiter of price when remainder of world oil peaks – this is coming soon, if not herealready
- Using advanced water injection and horizontal "fishbone" drilling technology to the hilt – no secondary recovery likely
- Stopped reporting field-by-field production data in 1982!!

Questions for the Saudis

- Why did the Saudi Arabian government stop reporting field-by-field production in 1982?
- Are there sufficient reasons to believe that the Saudis really have 260 billion barrels of proven reserves as they claim?
- What discoveries followed Aramco's take over by the Saudi government that allowed proven reserves to be revised up from 170 billion barrels in 1989 to 260 billion barrels in 1990?
- Why no independent verification?
- **Why are the detailed data a State secret!**

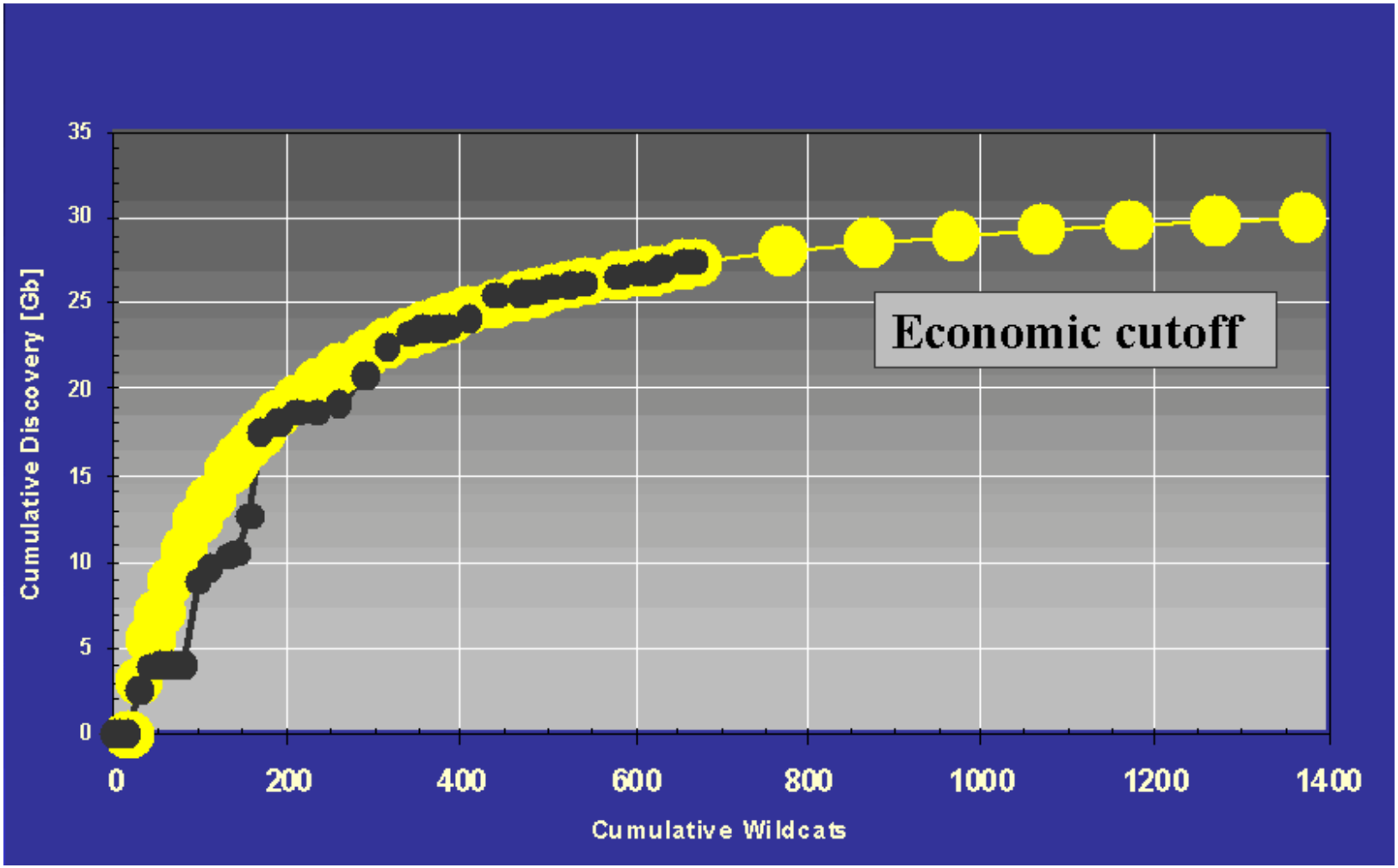
OPEC Reserve Reporting



- Reported 1990 oil reserves are 178% of 1985 reserves!
- Based on what? OPEC oil discovery peaked in 1970's
- Are they competing for OPEC Quota?
- How can we accept these "proven" reserve reports as reliable?

The "Creaming Curve"

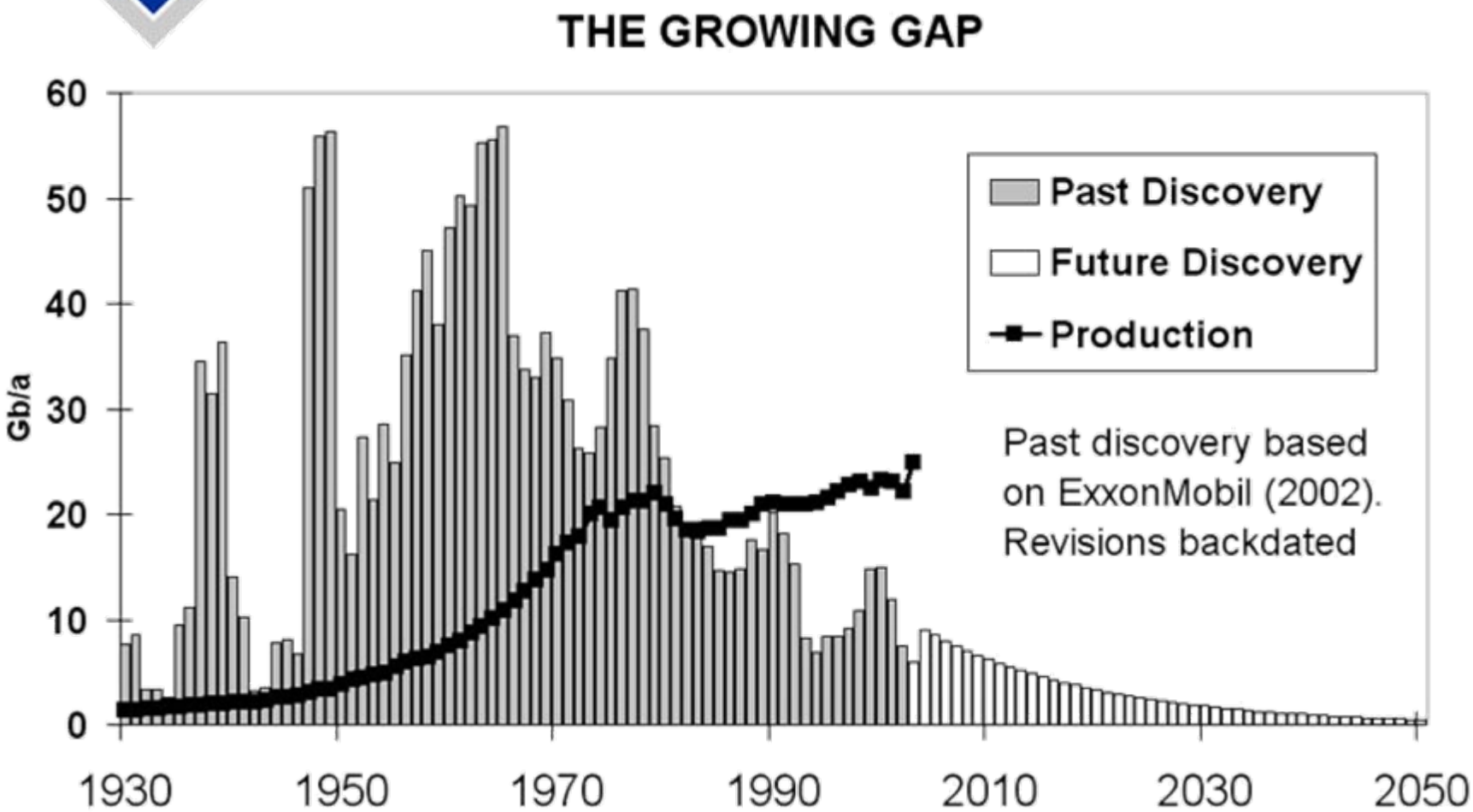
Getting the low hanging fruit first



What Happened?

- Oil companies reported reserves to meet strict Stock Exchange rules
  - Designed to prevent fraudulent exaggeration
  - Smiled on conservative reporting
- Discovery under-reported, revised upwards later
  - Comforting but misleading – false image of steady growth in discovery
  - No conspiracy - just simple commercial prudence
- OPEC over-reported reserves
  - To reassure U.S. and world consumers?
  - To achieve OPEC quota advantages?

New Oil . . . ?

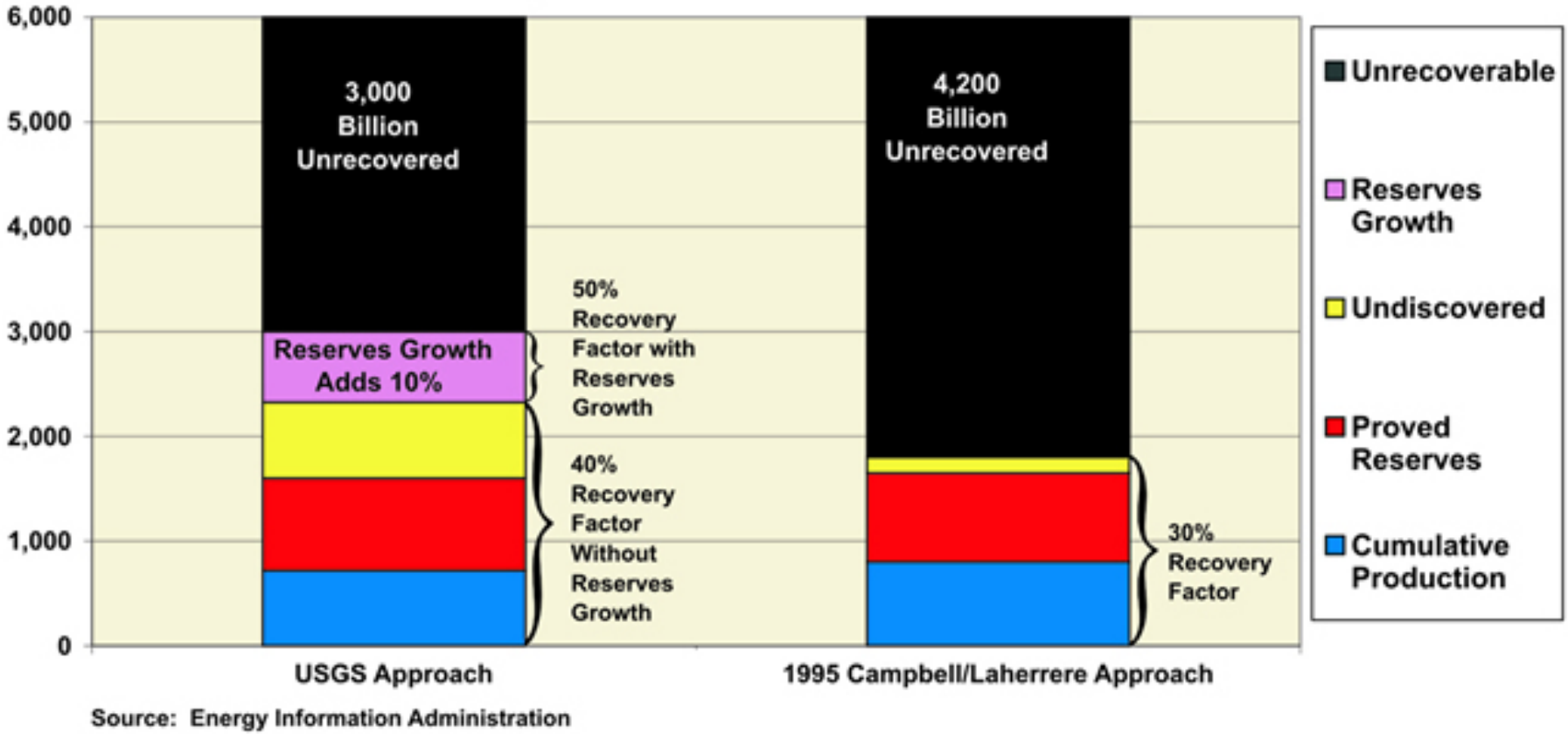


Source: Campbell, C.J. “Oil Depletion – The Heart of the Matter.” Association for the Study of Peak Oil and Gas, October 2003. (http://www.hubbertpeak.com/campbell/TheHeartOfTheMatter.pdf)

Original Oil in Place (OOIP)

50% recovery or 30% recovery?

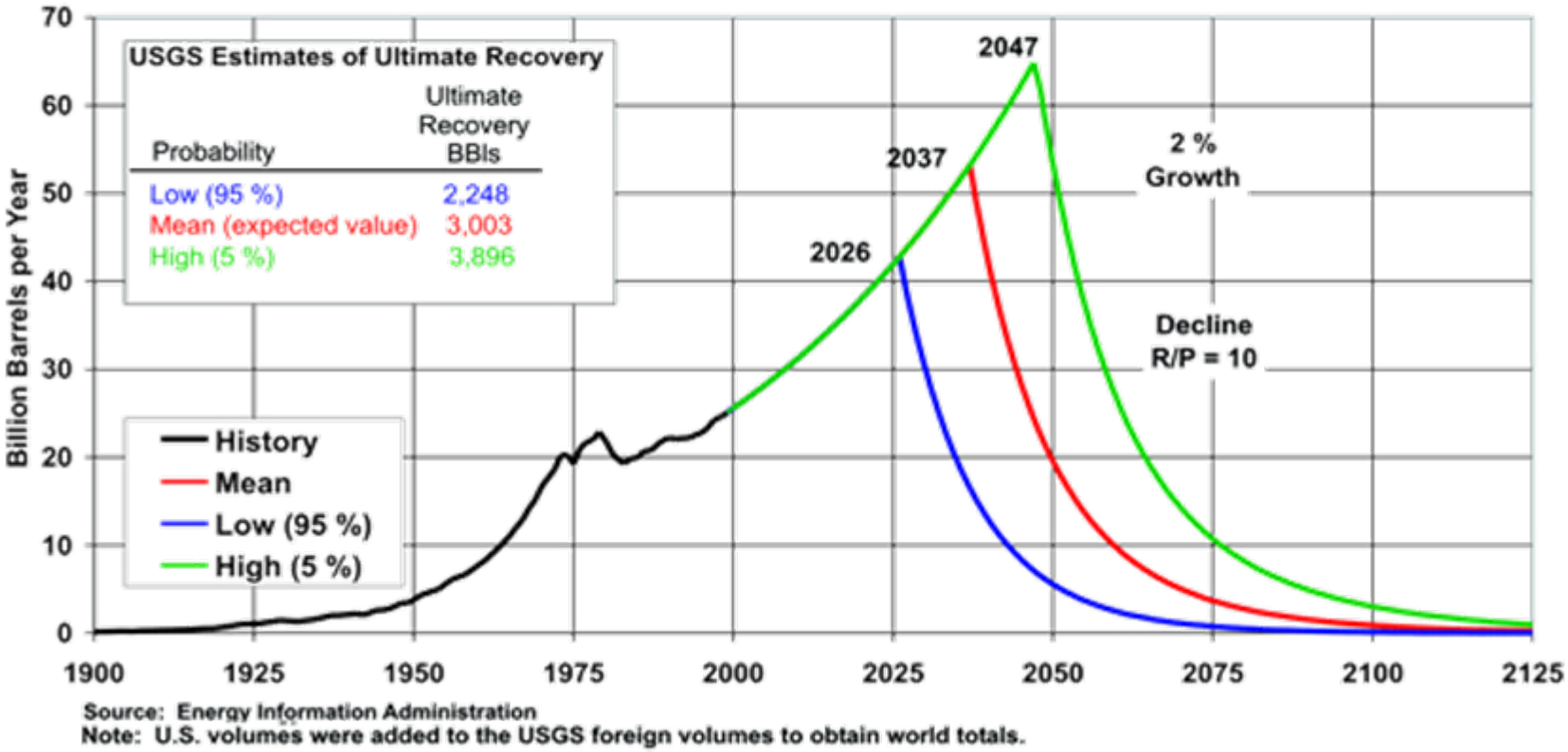
Figure 1. Different Interpretations of a Hypothetical 6,000 Billion Barrel World Original Oil-in-Place Resource Base



Source: Energy Information Administration

EIA Summary Chart

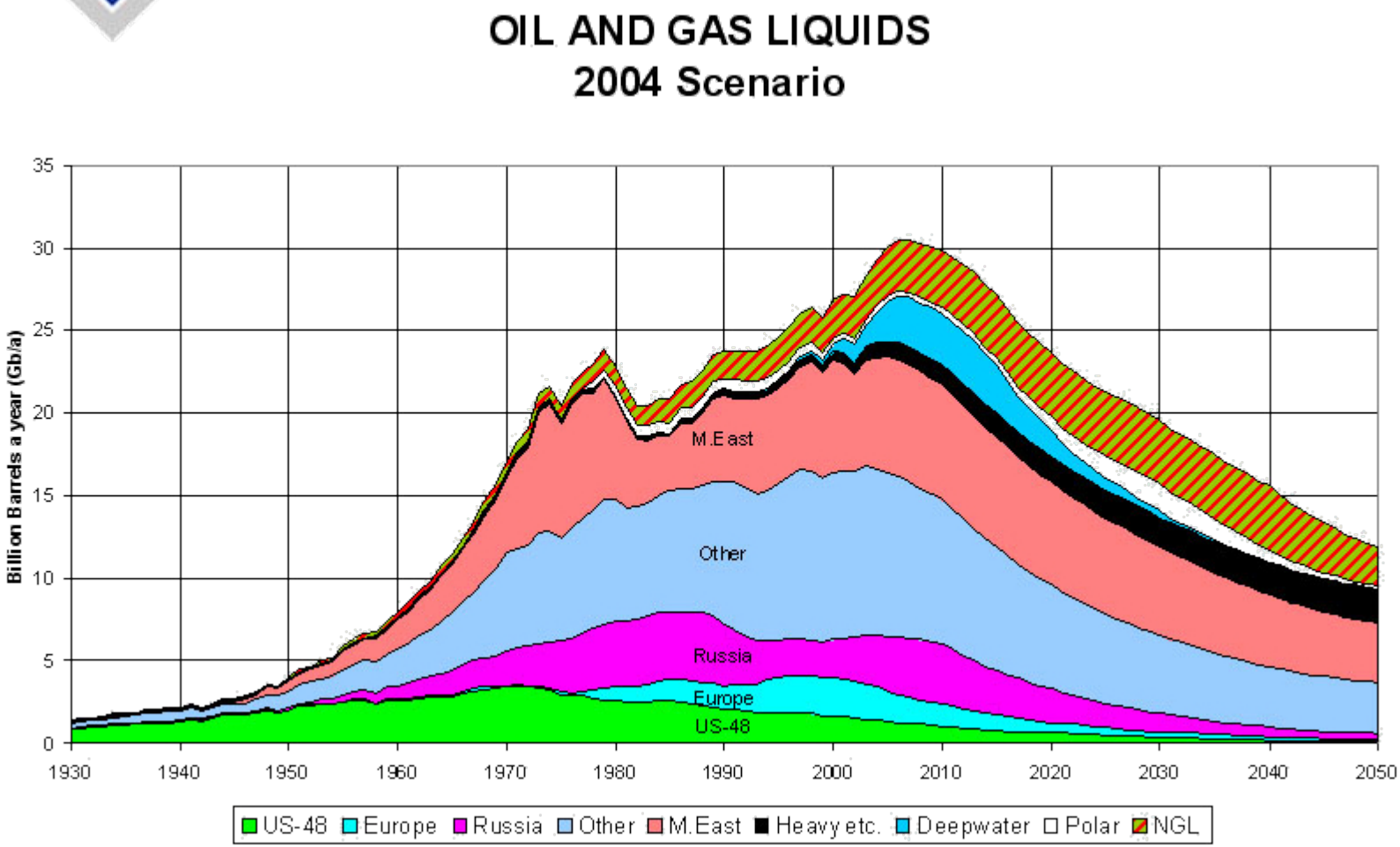
Figure 2. Annual Production Scenarios with 2 Percent Growth Rates and Different Resource Levels (Decline R/P=10)



Source: Energy Information Administration
Note: U.S. volumes were added to the USGS foreign volumes to obtain world totals.

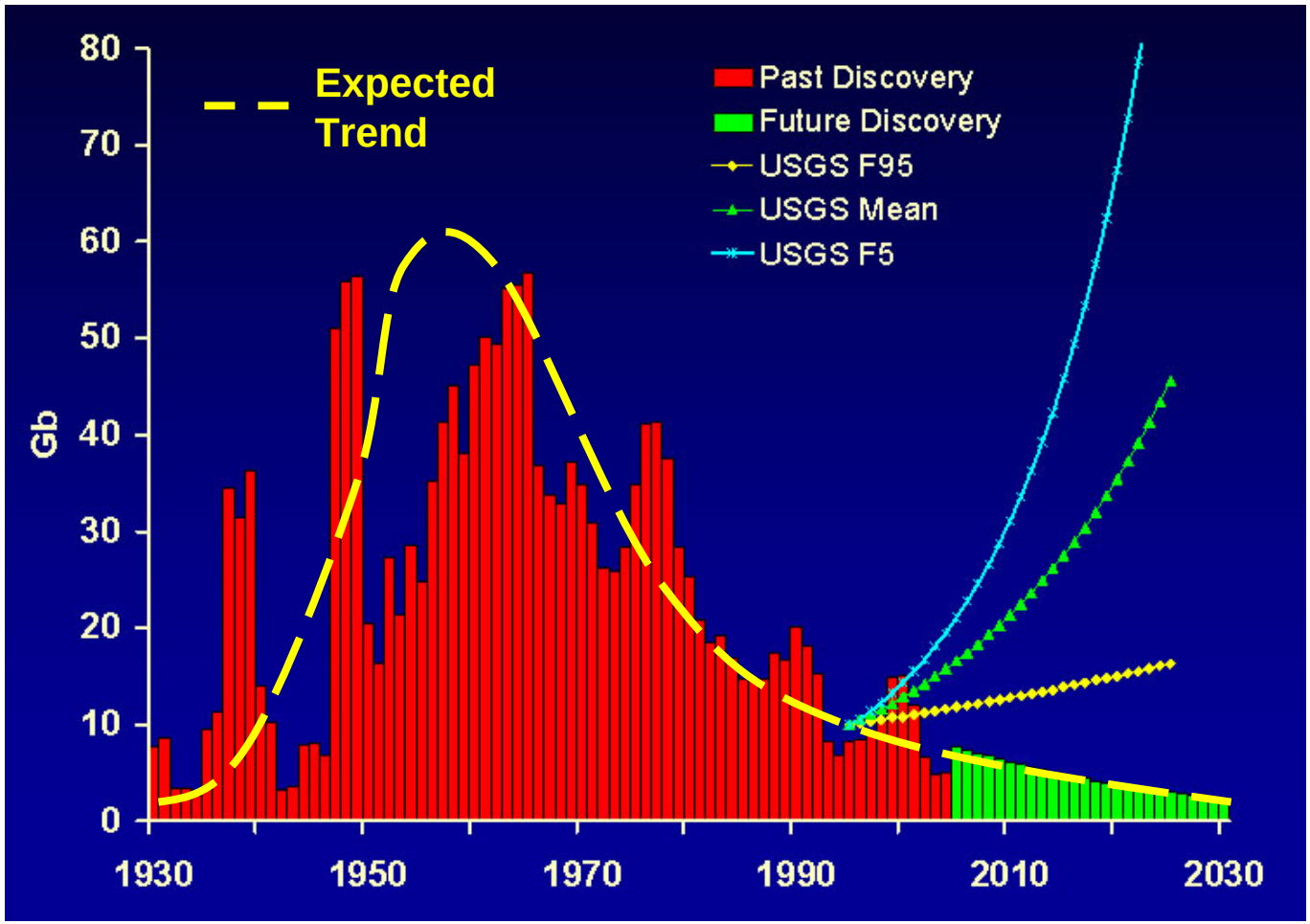
Source: Wood, J.H., et.al. "Long Term World oil Supplies." U.S. DOE Energy Information Administration, July 18, 2004.

Campbell Update



Source: Campbell, C. J. http://www.hubbertpeak.com/campbell/

Who to Believe?



Source: Campbell, C.J. and J. Gilbert, "What We Know and What We Think We Know." Presentation, ASPO Conference, Denver, CO, November, 2005

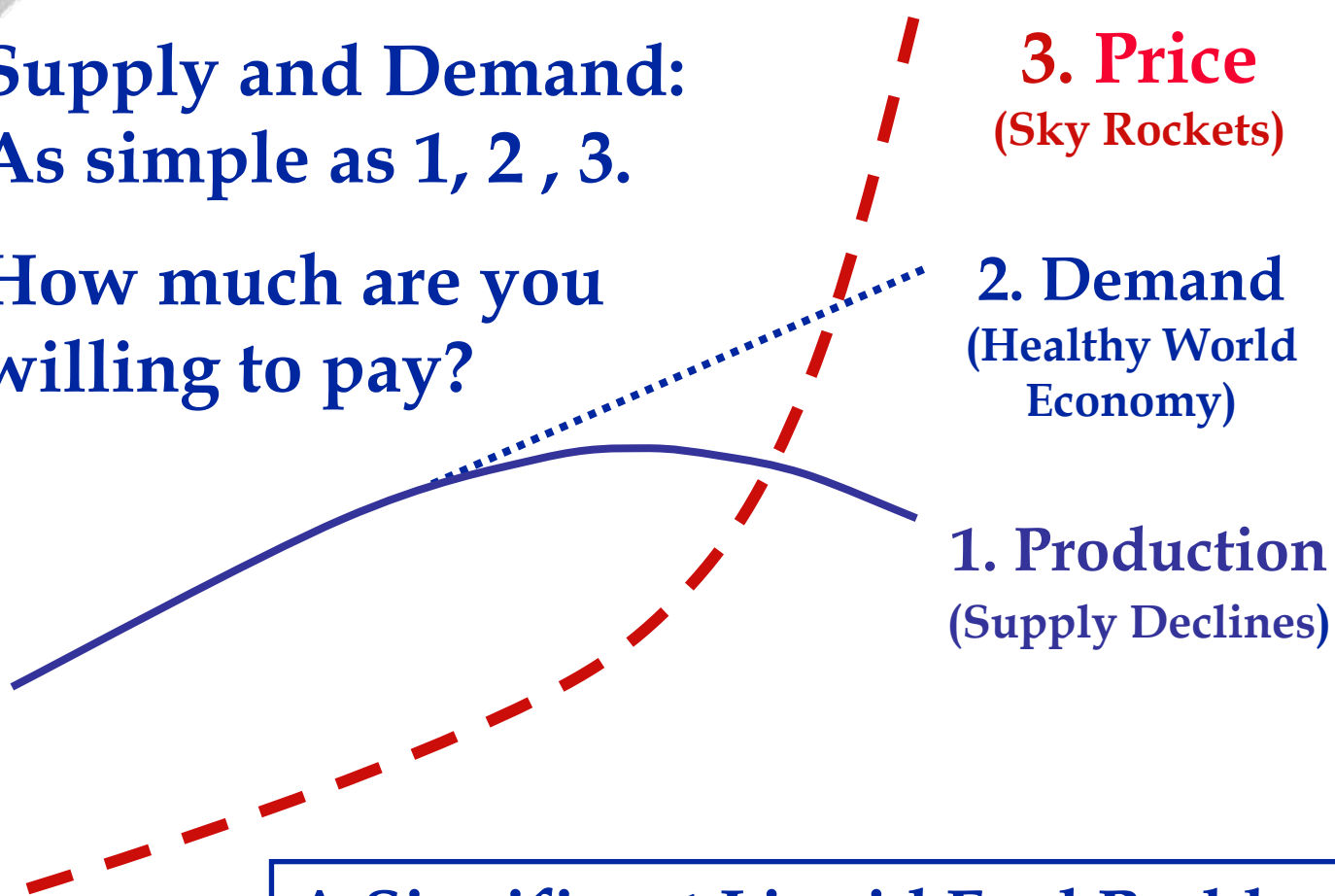
Macro Economics

- Demand is generally inelastic – small changes in supply yield large changes in price
- **Immediate alternatives** don't exist
- **Make it personal** – what would would you be willing to pay:
  - If your spouse or child was deathly ill and you needed to get them to a hospital?
  - To maintain employment and provide for your family?
- "Demand destruction" (outlandish prices, rationing, etc) could become the catch phrase

The Bottom Line

Supply and Demand:
As simple as 1, 2 , 3.

How much are you willing to pay?

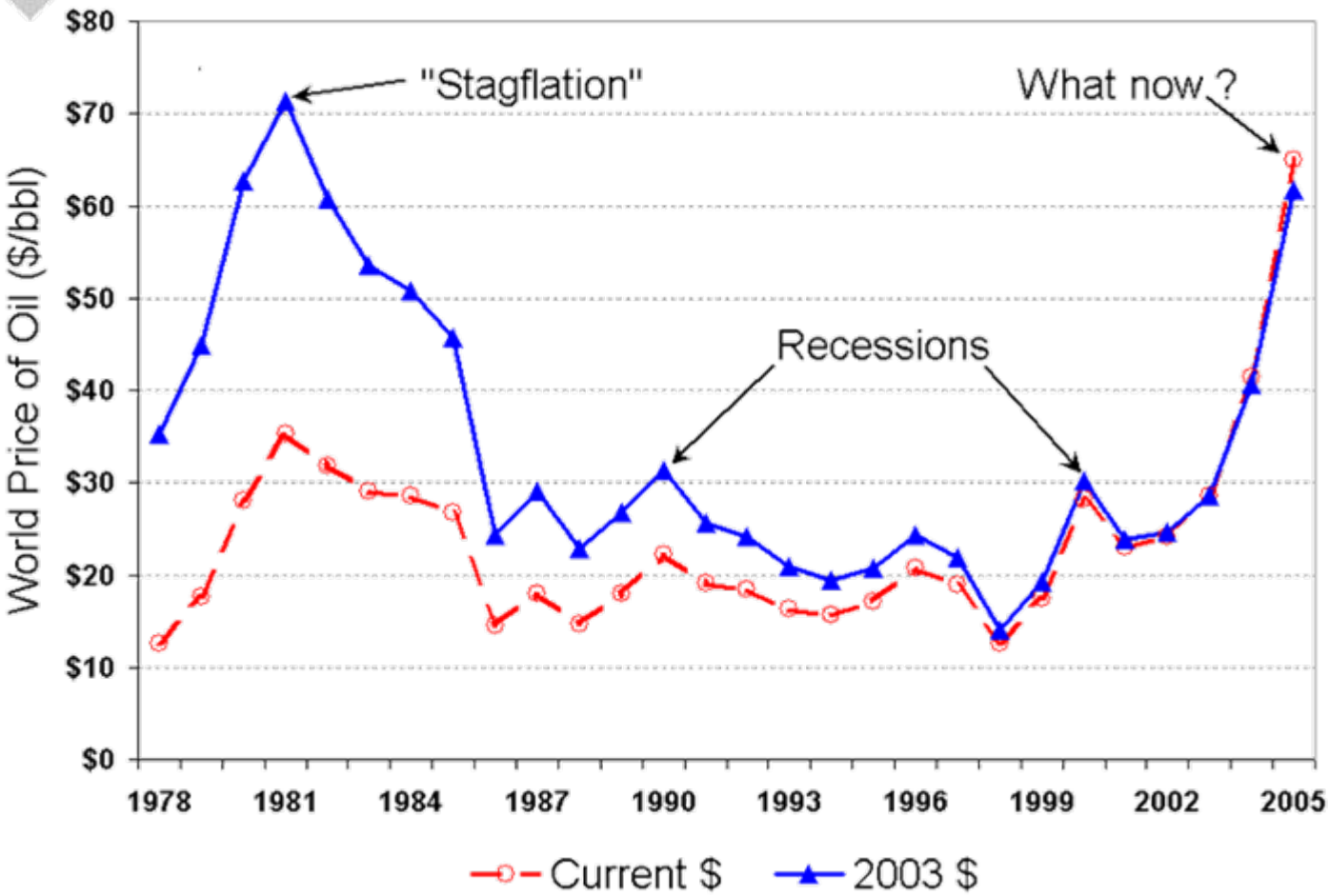


A Significant Liquid Fuel Problem

"Flat Earth" Economics

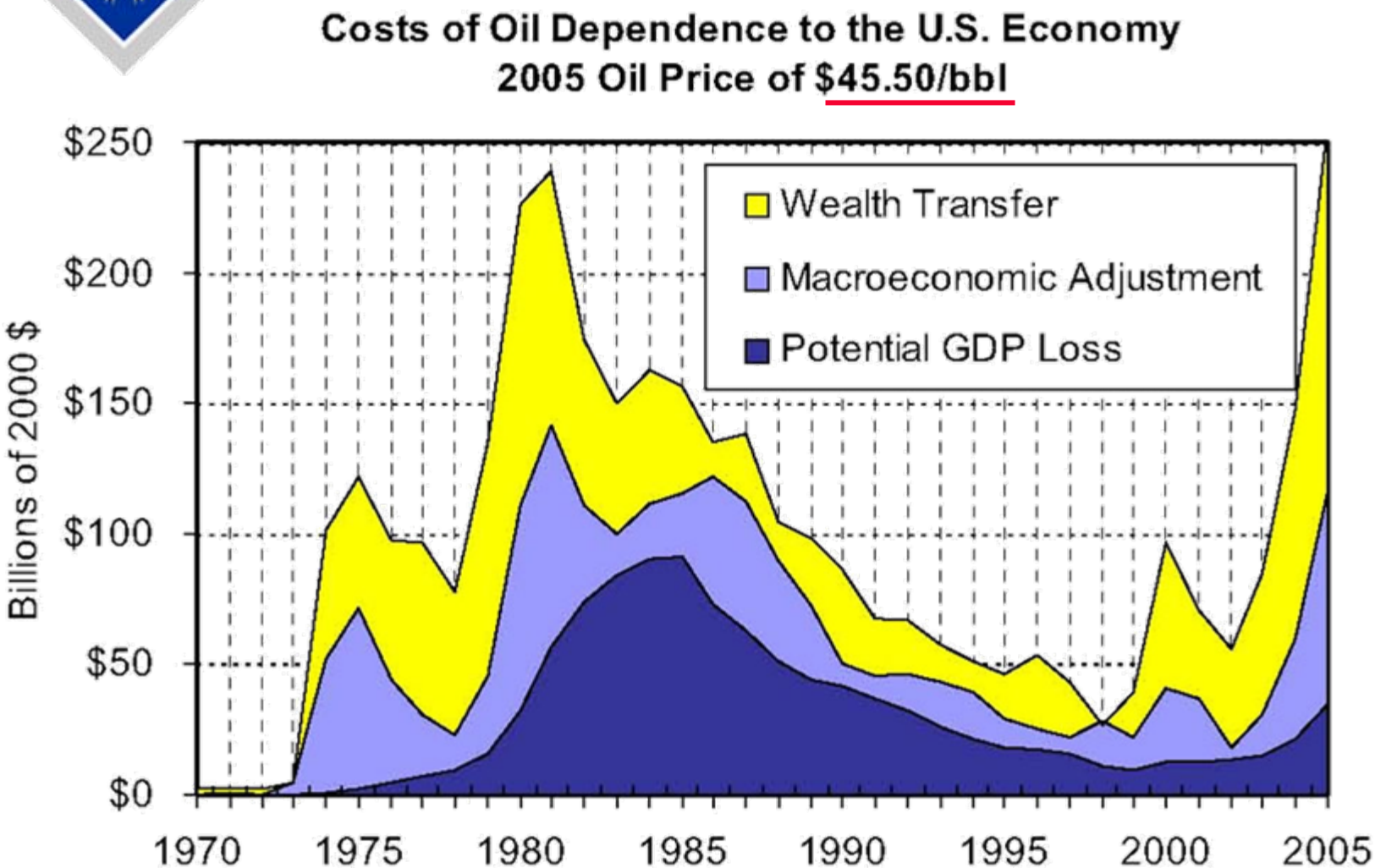
- The "invisible hand" of the free marketplace will always meet demand
- **But . . .**
  - At what price and who will be able to pay?
  - The marketplace **cannot make more oil**?
  - The "sunk" capitol costs (stranded assets) are huge, the lead time for mitigation is extensive, and there is no "Plan B" on the table!
  - What happens if Adam Smith is wrong?

Economics of Dependence



Source: Davis, S. and S. Diegel, "Transportation Energy Data Book: Edition 24." Oak Ridge National Laboratory, Publication No. ORNL-6973, December 2004. (http://cta.ornl.gov/data/index.shtml)

Cost of Dependence



Source: Green, D. and S. Ahmed, "Cost of U.S. Oil Dependence: 2005 Update." Oak Ridge National Laboratory, Publication No. ORNL/TM-05/45, January 2005

Infrastructure Problem

U.S. Fleet Characteristics

Fleet	Size	Median Life (years)	Cost to replace half the fleet (2003 $)
Automobiles	130 million	17	$1.3 trillion
Light trucks, SUVs, etc.	80 million	16	$1 trillion
Heavy trucks, buses	7 million	28	$1.5 trillion
Aircraft	8,500	22	$0.25 trillion

Source: Bezdek, Roger H., "Peaking of World Oil Production: Impacts and the Scope of the Mitigation Problem." ASPO-USA World Oil Conference, Denver, CO, November 2005.

Mitigation Scenarios

- **Scenario I – No action until peaking occurs**
- **Scenario II – Mitigation started 10 years before peaking**
- **Scenario III – Mitigation started 20 years before peaking**

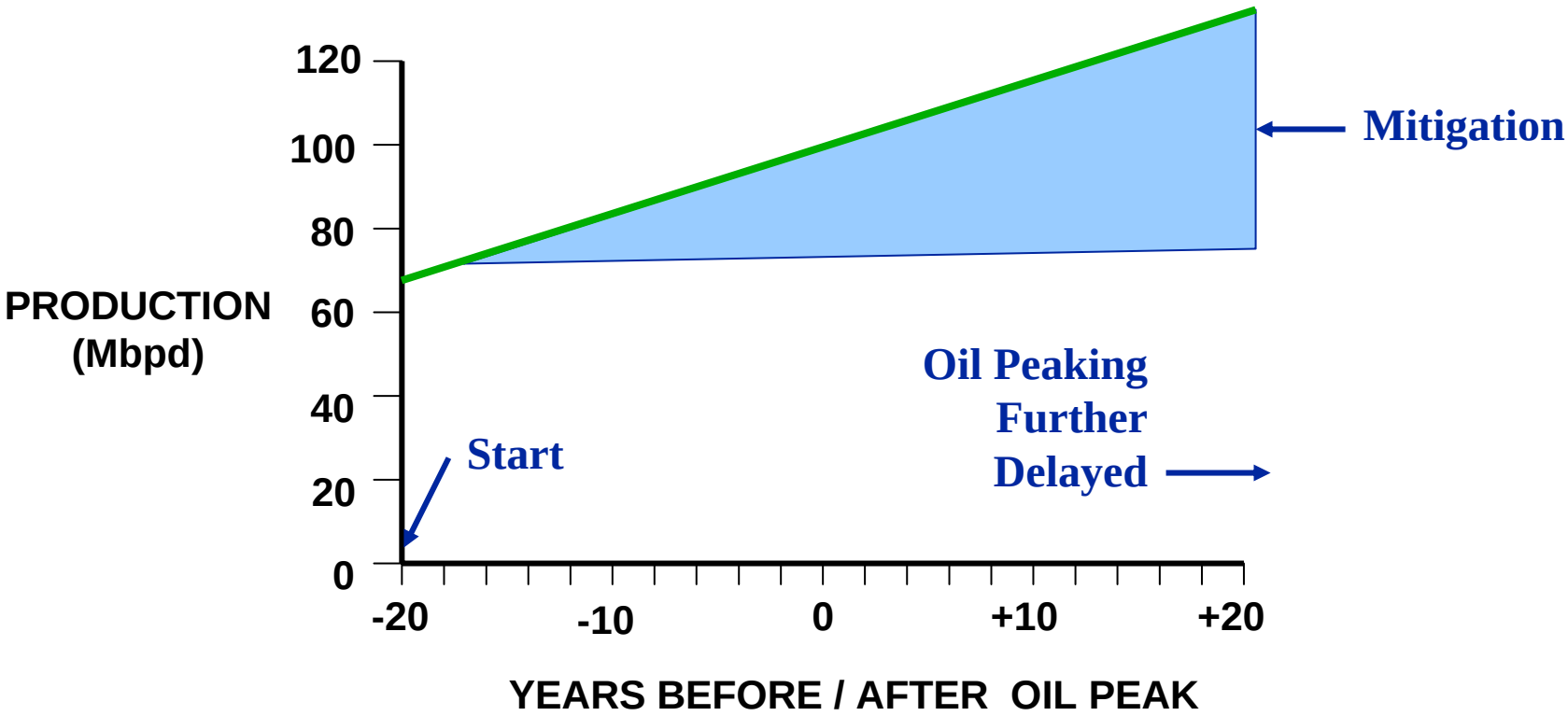
Optimistic limiting case

All mitigation initiated immediately

Crash program implementation

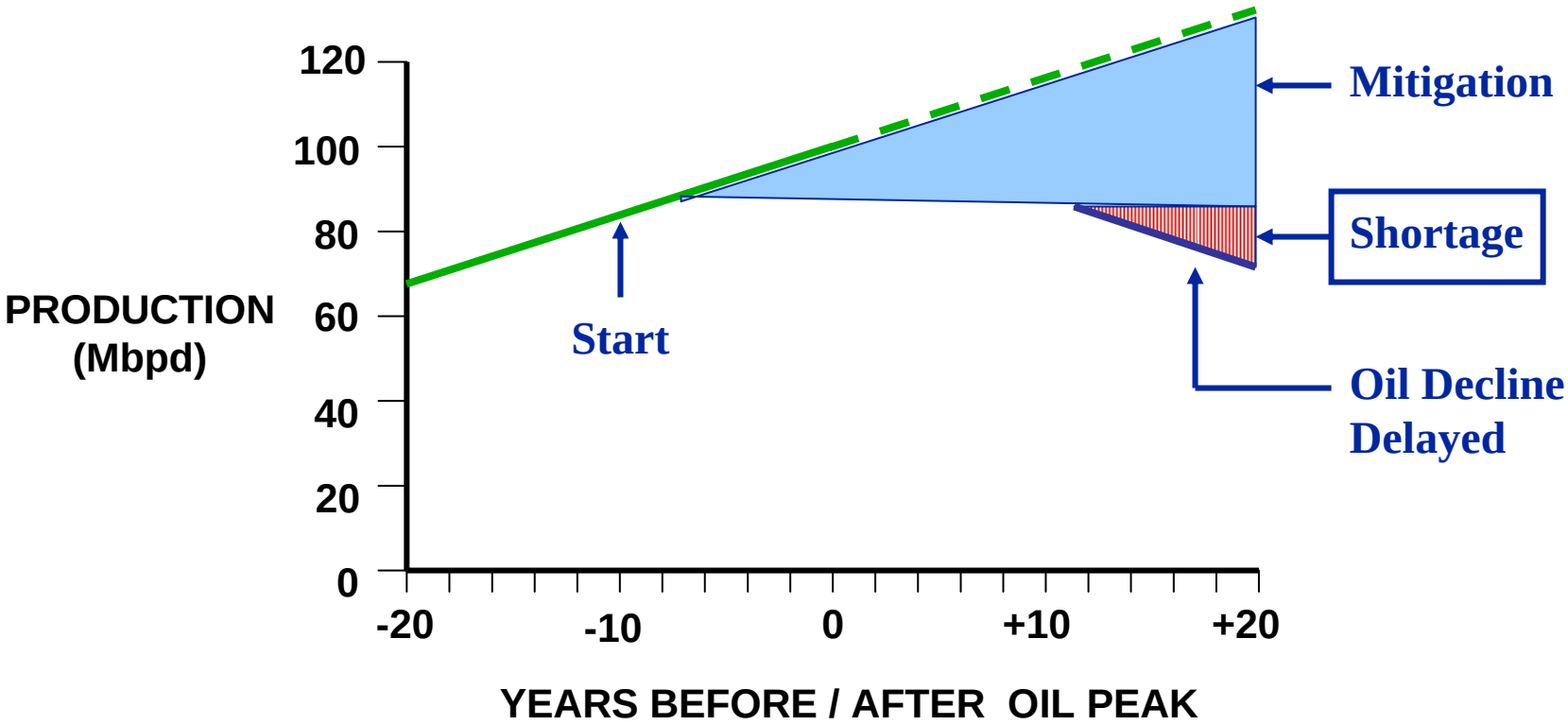
Source: Bezdek, Roger H., "Peaking of World Oil Production: Impacts and the Scope of the Mitigation Problem." ASPO-USA World Oil Conference, Denver, CO, November 2005.

Mitigate 20 Years Prior



Source: Bezdek, Roger H., "Peaking of World Oil Production: Impacts and the Scope of the Mitigation Problem." ASPO-USA World Oil Conference, Denver, CO, November 2005.

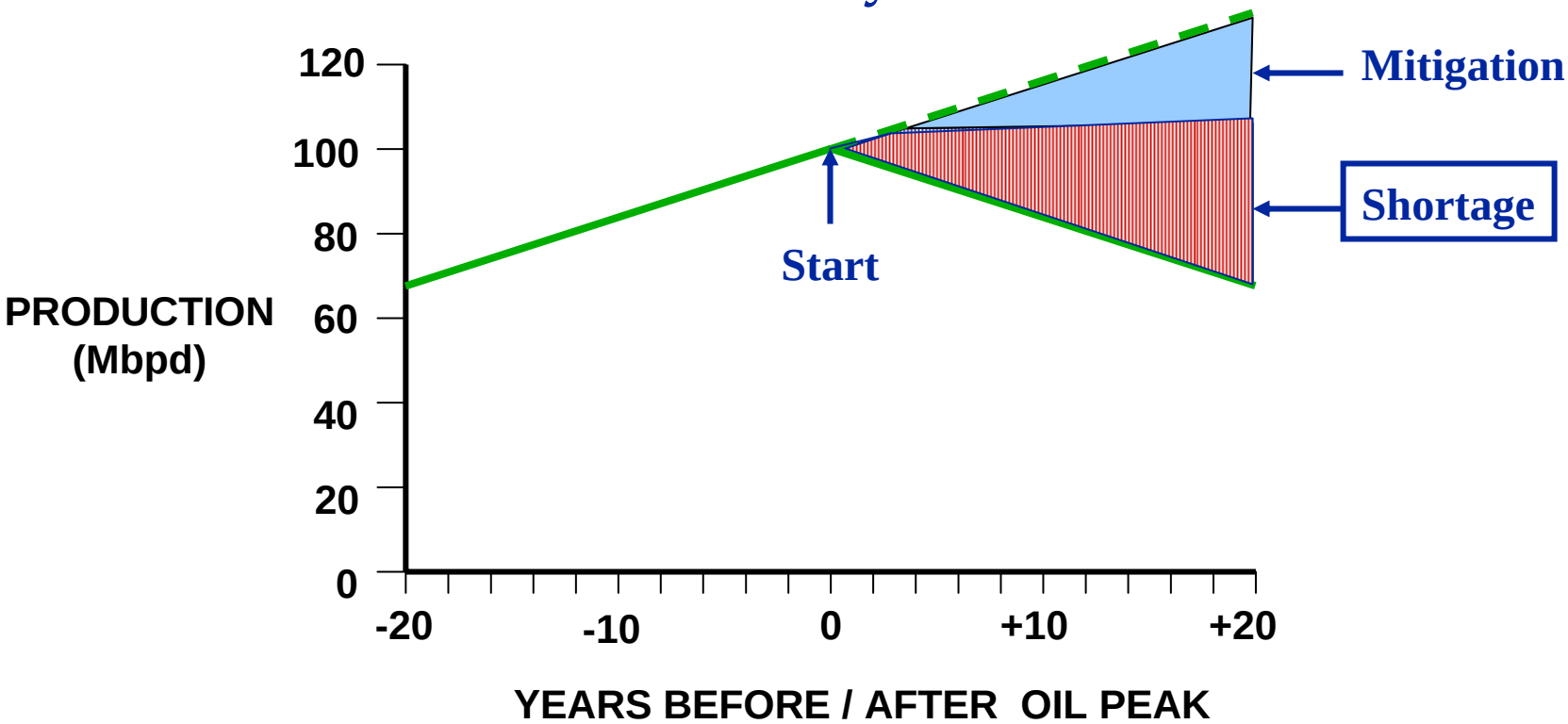
Mitigate 10 Years Prior



Source: Bezdek, Roger H., "Peaking of World Oil Production: Impacts and the Scope of the Mitigation Problem." ASPO-USA World Oil Conference, Denver, CO, November 2005.

Mitigate At Peak

Given human nature, this may be the most likely scenario!



Source: Bezdek, Roger H., "Peaking of World Oil Production: Impacts and the Scope of the Mitigation Problem." ASPO-USA World Oil Conference, Denver, CO, November 2005.

Conclusions

Scenario	Result
Wait for peaking	Oil shortage largest and longest lasting
Start 10 years early	Delays peaking, still shortages
Start 20 years early	Avoids problem, smooth transition

No Quick Fixes – Start Now

Source: Bezdek, Roger H., "Peaking of World Oil Production: Impacts and the Scope of the Mitigation Problem." ASPO-USA World Oil Conference, Denver, CO, November 2005.

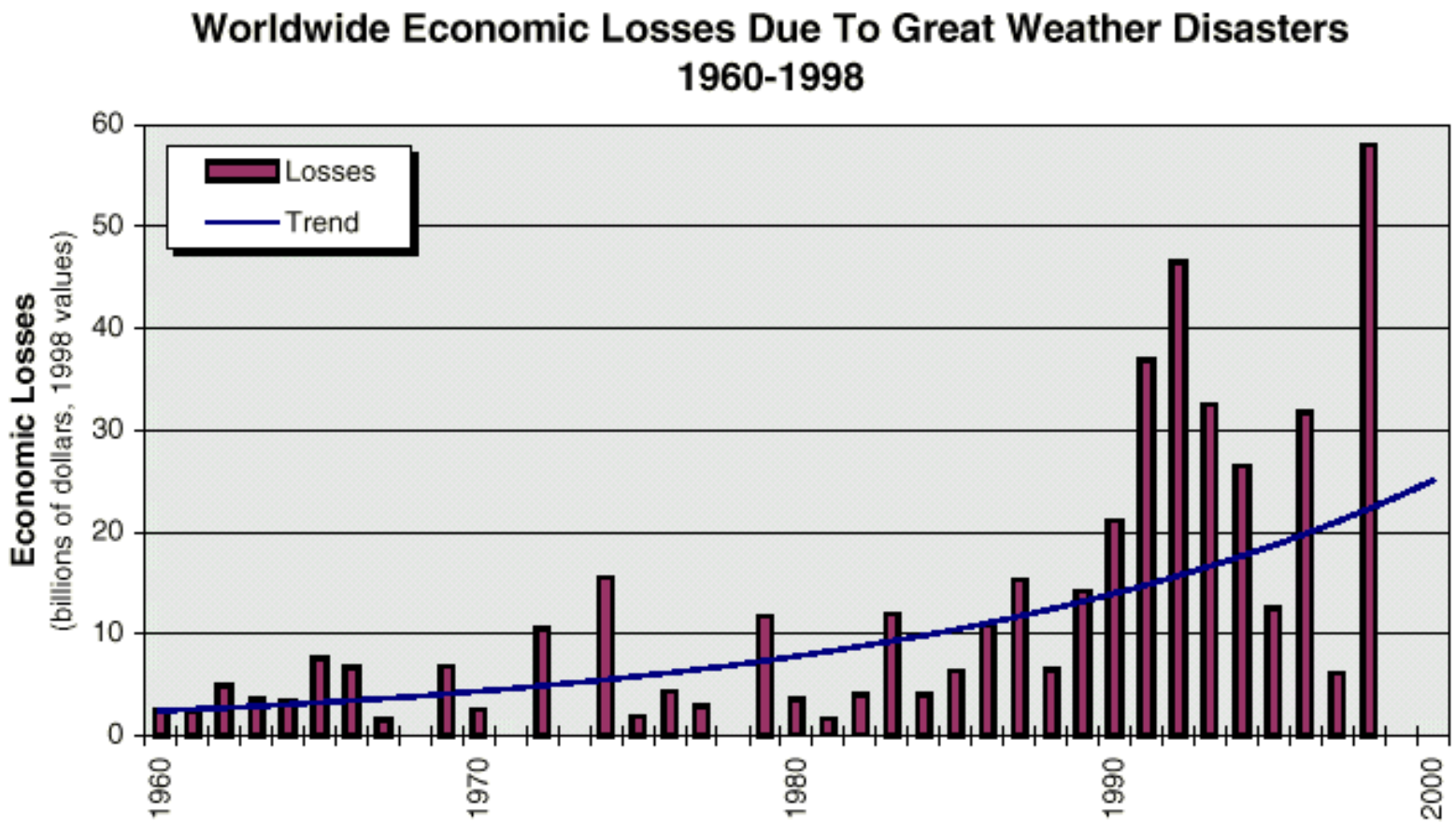
But Not To Worry . . .

- **The world is blessed by much coal**
- At the current U.S. demand for energy, we have 250 years worth left in coal – just dig!
  - Do as the Germans had to in WWII – make transportation fuels from coal
  - Convert electric generation plants from oil and natural gas to coal and nuclear *(but where is the electric transportation infrastructure?)*
- **And this brings us to . . .**

The First Grand Challenge

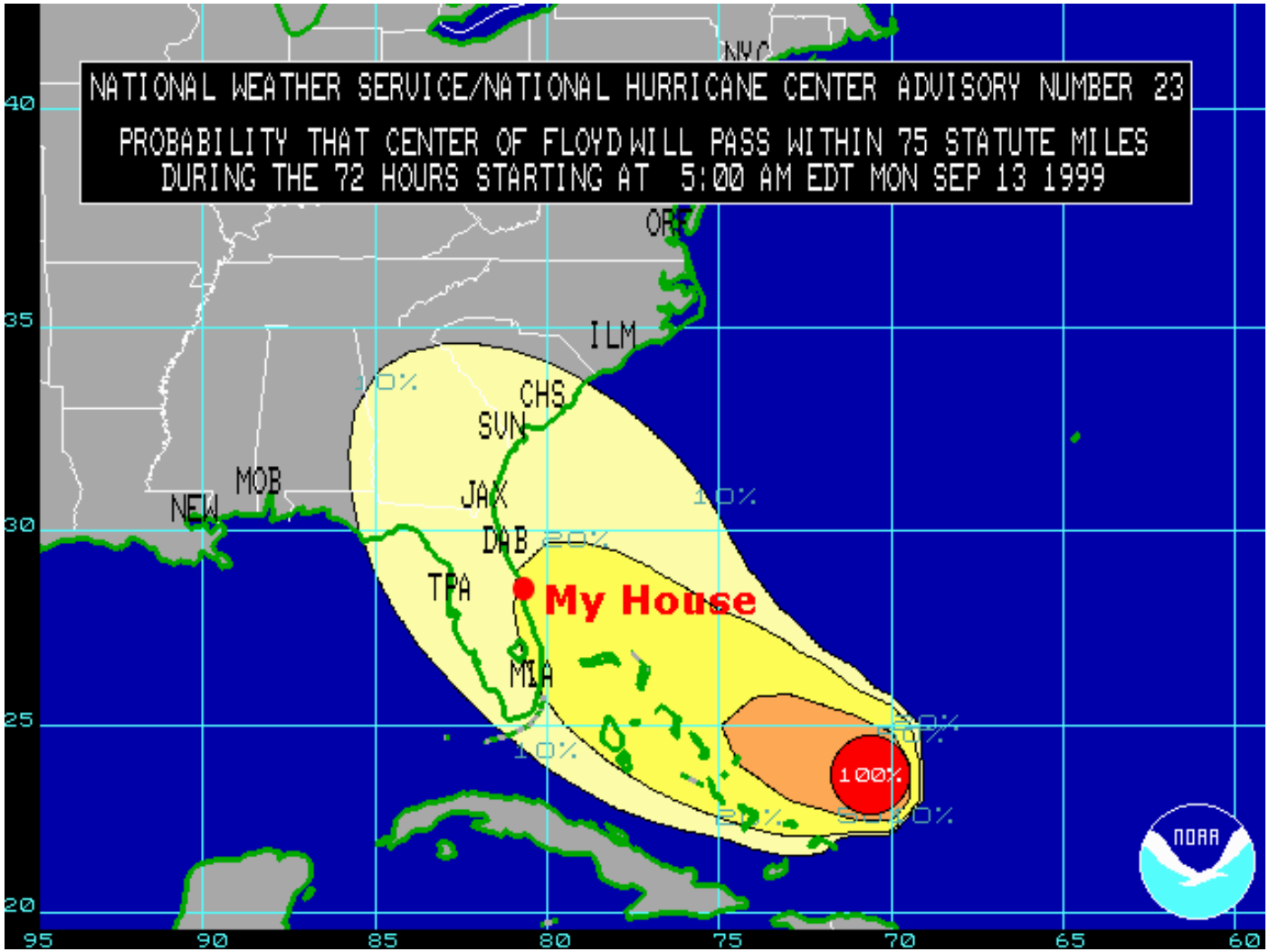
- Global warming is scientifically accepted fact
- **Per unit energy, coal produces 50% more atmospheric CO_2 than oil and 110% more than natural gas**
- Global warming is deadly
  - In France alone, more than 14,000 excess deaths resulted from the 2003 European heat wave
  - 80% of global population lives in close proximity to the sea – major populations are threatened
- Major climatic catastrophe could take down the global insurance industry at $2 trillion per year

Watching Their Losses



It's Personal!

Hurricane Floyd; 09/13/99 – Category 5!



"New Science?"

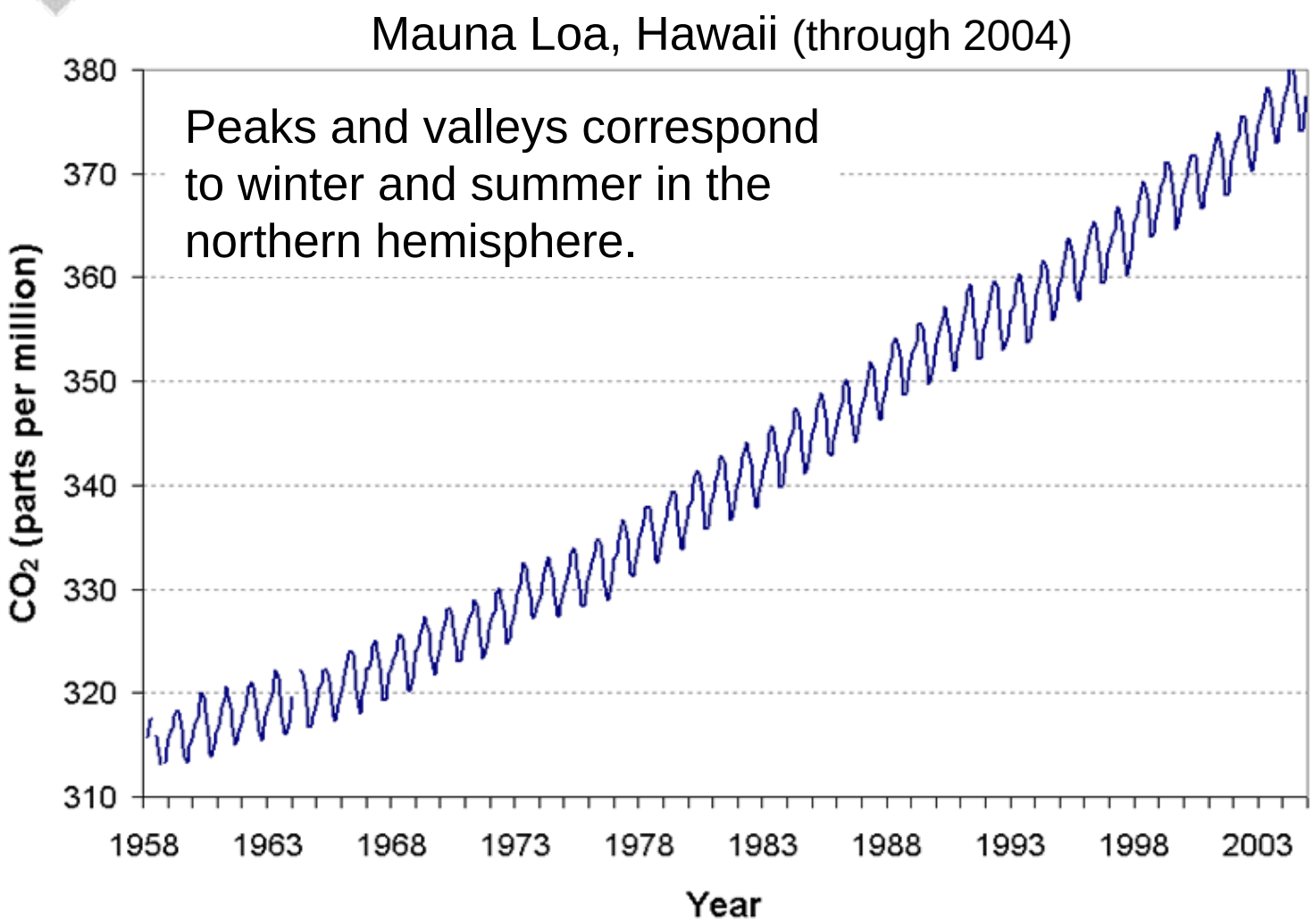
- **1827:** Fourier, a French mathematician, coined the term "greenhouse effect" as causation for the differences in day and night temperatures
- **1860:** Tyndall, a British scientist, first measured absorption of light spectra by CO_2 and water vapor and attributed ice ages to changes in atmospheric gas concentration
- *1896:* Arrhenius, a Swedish chemist, made first quantitative attempt to estimate the effect of atmospheric CO_2 on global temperatures
- **1938:** Callendar, a British meteorologist, was first to claim evidence of "global warming."

New? Well, Not Exactly

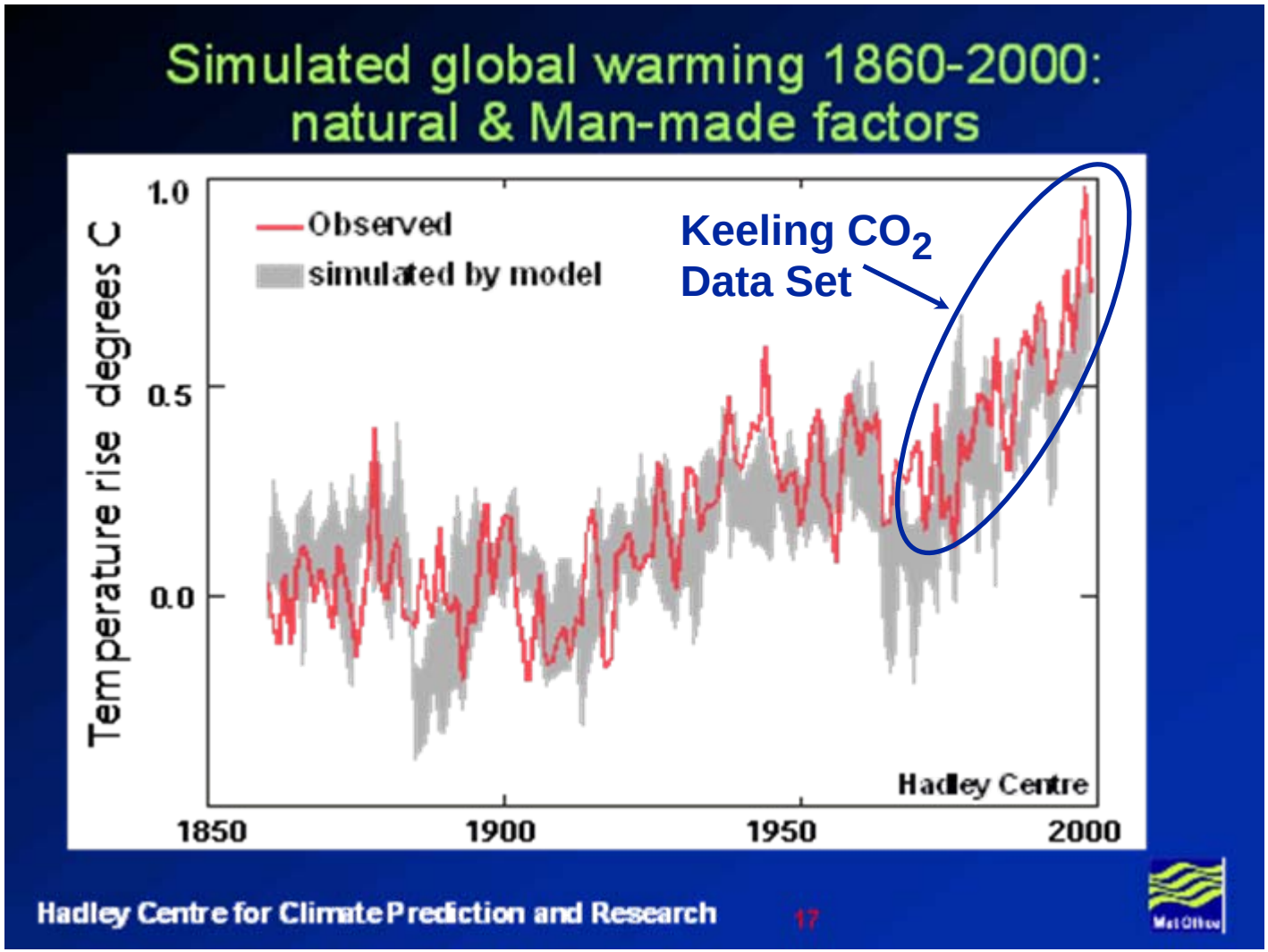
- **1958:** Charles Keeling, an American scientist, began keeping CO_2 records on the peak of Mauna Loa in Hawaii (more on this later)
- **1988:** James Hansen, a leading NASA Scientist, told U.S. Senate committee he was "99% certain" that global warming was occurring and that is was linked to fossil fuel burning
- **1990:** First IPCC report concludes there is a causal relationship between human activities global warming.

Source: King, Sir David (Chief Scientific Advisor to UK Government), "The Science of Climate Change: Adapt, Mitigate or Ignore?" The Ninth Zuckerman Lecture, October 31, 2002.

The "Keeling Curve"



Model vs. Observation



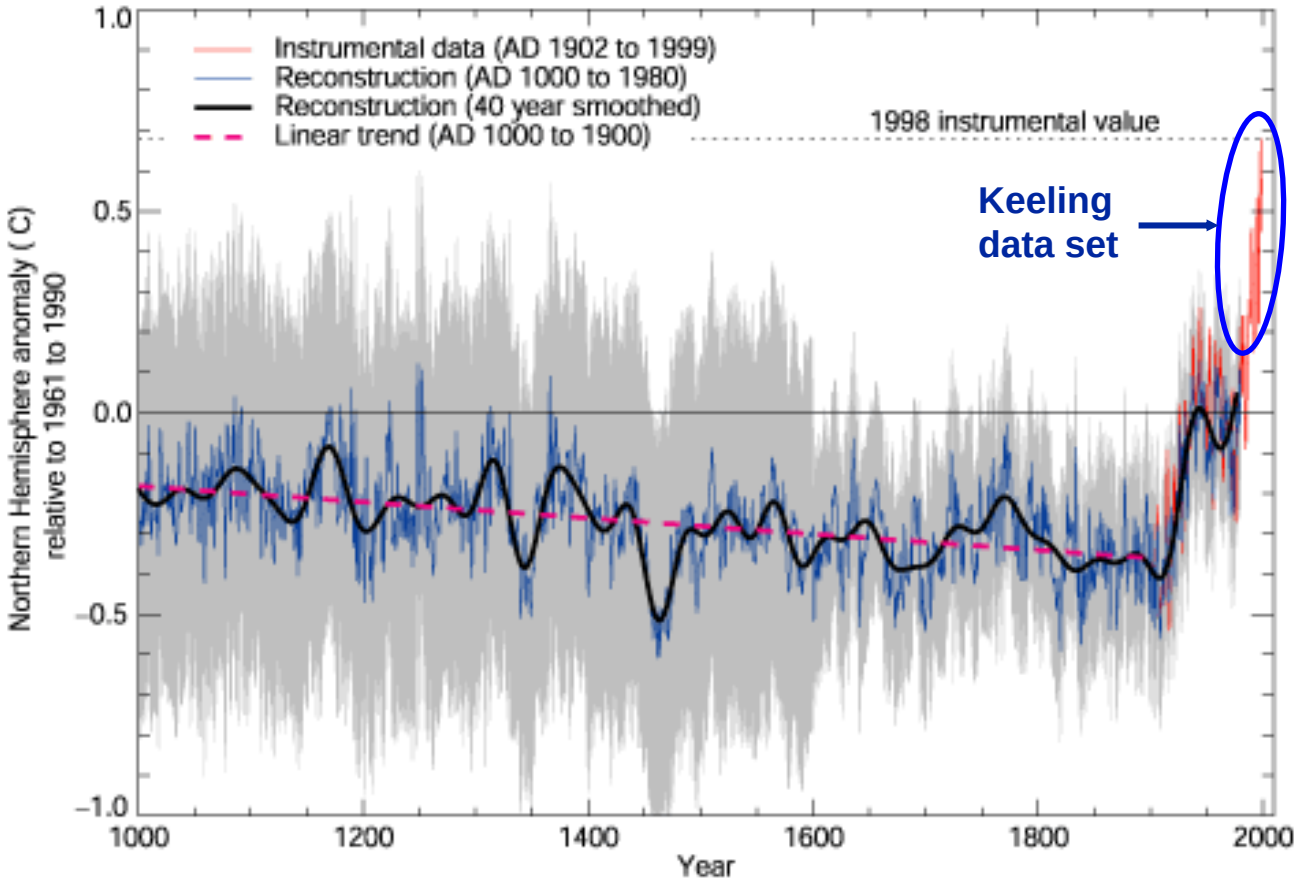
What IPCC Scientists Say

- The average surface temperature will rise between 1.4 C (2.5 F) and **5.8 C (10 F)** by 2100.
- "We must move ahead boldly with clean energy technologies and we should start preparing ourselves for the rising sea levels, changing rain patterns and other impacts of global warming."

Source: *Reuters News Service, January 22, 2001, on IPCC 2000 Draft Summary for Policy Makers and quoting Klaus Toepfer, Head of the United Nations Environment Program.*

The Past 1000 Years!

Data from 2000 IPCC



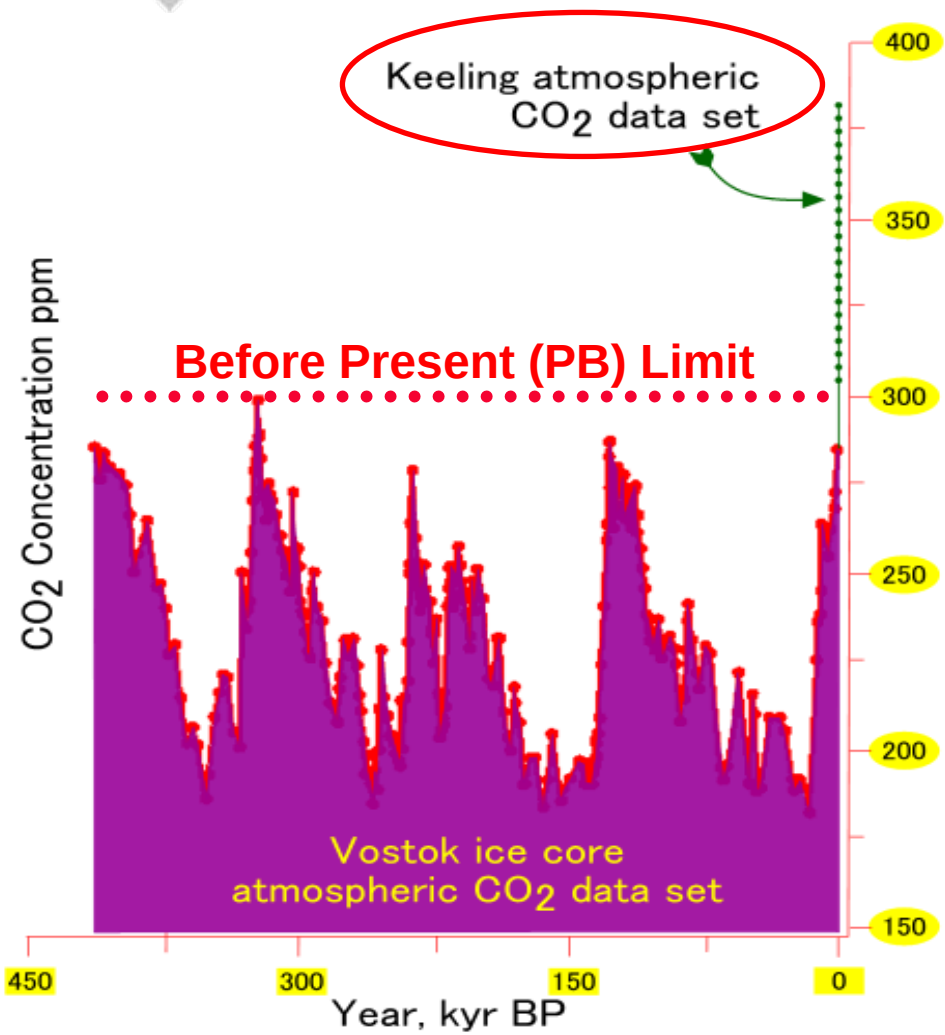
Millenial Northern Hemisphere temperature reconstruction (blue) and instrumental data (red) from AD 1000 to 1999, adapted from Mann et al. (1999). Smoother version of Northern Hemisphere series (black), linear trend from AD 1000 to 1850 (purple dashed) and two standard error limits (grey shaded) are shown.

What's a Degree or So?

"The typical temperature difference for the whole world between an ice age and an interglacial interval is only 3° to 6° C. This should set the alarm bells ringing: A temperature change of only a few degrees can be serious business."

Carl Sagan,
Billions & Billions, *1997.*

400,000+ Years of Data!



- **Eons of data** – well correlated to global temperature change
- What will it take to tip the balance?
- **550 ppm** – very scary
- **+2 ºC** – equally scary
- **Amplification** is entirely possible
- What happens when the "ocean conveyor" stops working?

"Big Bang" Theory

It is at least possible, because the earth has moved into greenhouse gas and temperature regimes never before experienced, that we may exceed some stable state threshold and "jump" to a completely new and very different stable state. This would only make matters worse, probably much worse.

<u>One thing we know for certain – we have entered new and uncharted waters!</u>

Quiz Answers:

Q. Who is Captain of this ship?

A. There is no captain – and worse yet, the crew is misinformed about the dangers of the storm.

Q. How bad is the storm?

A. Highly uncertain – much of the Peak Oil data are highly questionable.

Q. How fast are we closing on the storm?

A. Closing speed is contentious – often argued using sophisticated disinformation campaigns.

Quiz Answers:

Q. How strong is the ship?

A. She may not be strong enough – economic and political systems may not be up to the task.

Q. How large is the ship and how quickly can she be turned?

A. She is extremely large and it will literally take decades to bring her about.

Q. What is Plan B?

A. There is no Plan B!

Grand Challenges

- Where great challenges are well understood, humanity has proven very adaptable and innovative but . . .
- **Great Need** for better and more reliable data
- **Urgent Need** for frank and factual public discourse
- **But . . . It's Political Suicide –**
  - Who will step up to the plate?
  - Probably no one until very late in the game!
- **You are the critical component of Plan B!**