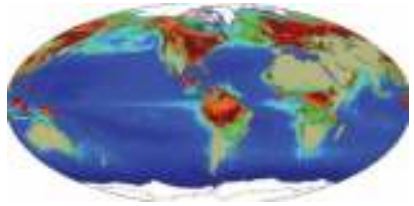
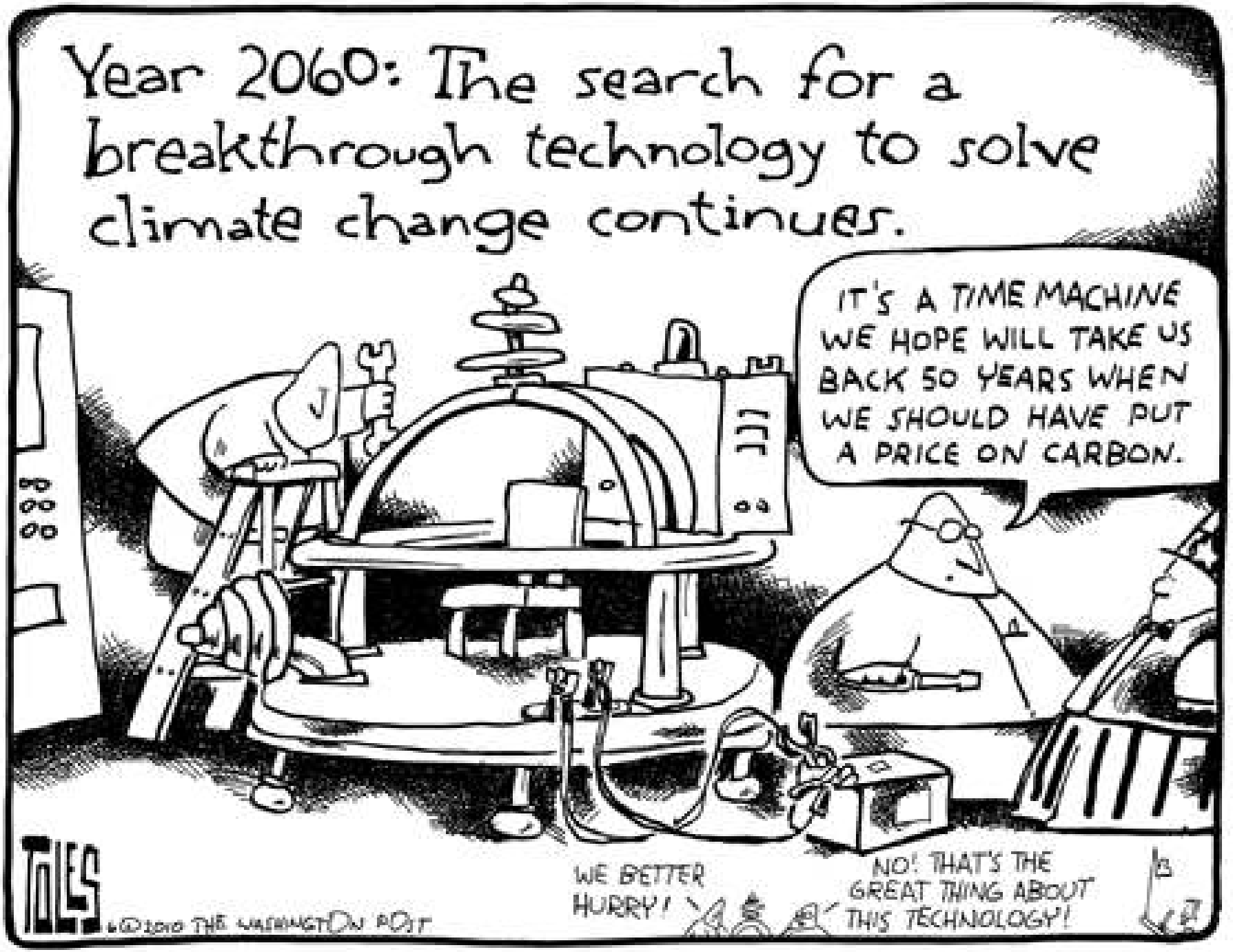
The Velocity of Climate Change: 2010

Chris Field

Carnegie Institution: Department of Global Ecology
www.global-ecology.org

CARNEGIE INSTITUTION FOR SCIENCE | DEPARTMENT OF GLOBAL ECOLOGY




Year 2060: The search for a breakthrough technology to solve climate change continues.
IT'S A TIME MACHINE WE HOPE WILL TAKE US BACK 50 YEARS WHEN WE SHOULD HAVE PUT A PRICE ON CARBON.
WE BETTER HURRY!
NO! THAT'S THE GREAT THING ABOUT THIS TECHNOLOGY!
TOLES
©2010 THE WASHINGTON POST

Article 2 of the UNFCCC

The ultimate objective of this Convention and any related legal instruments that the Conference of the Parties may adopt is to achieve, in accordance with the relevant provisions of the Convention, stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner.

Article 2 of the UNFCCC

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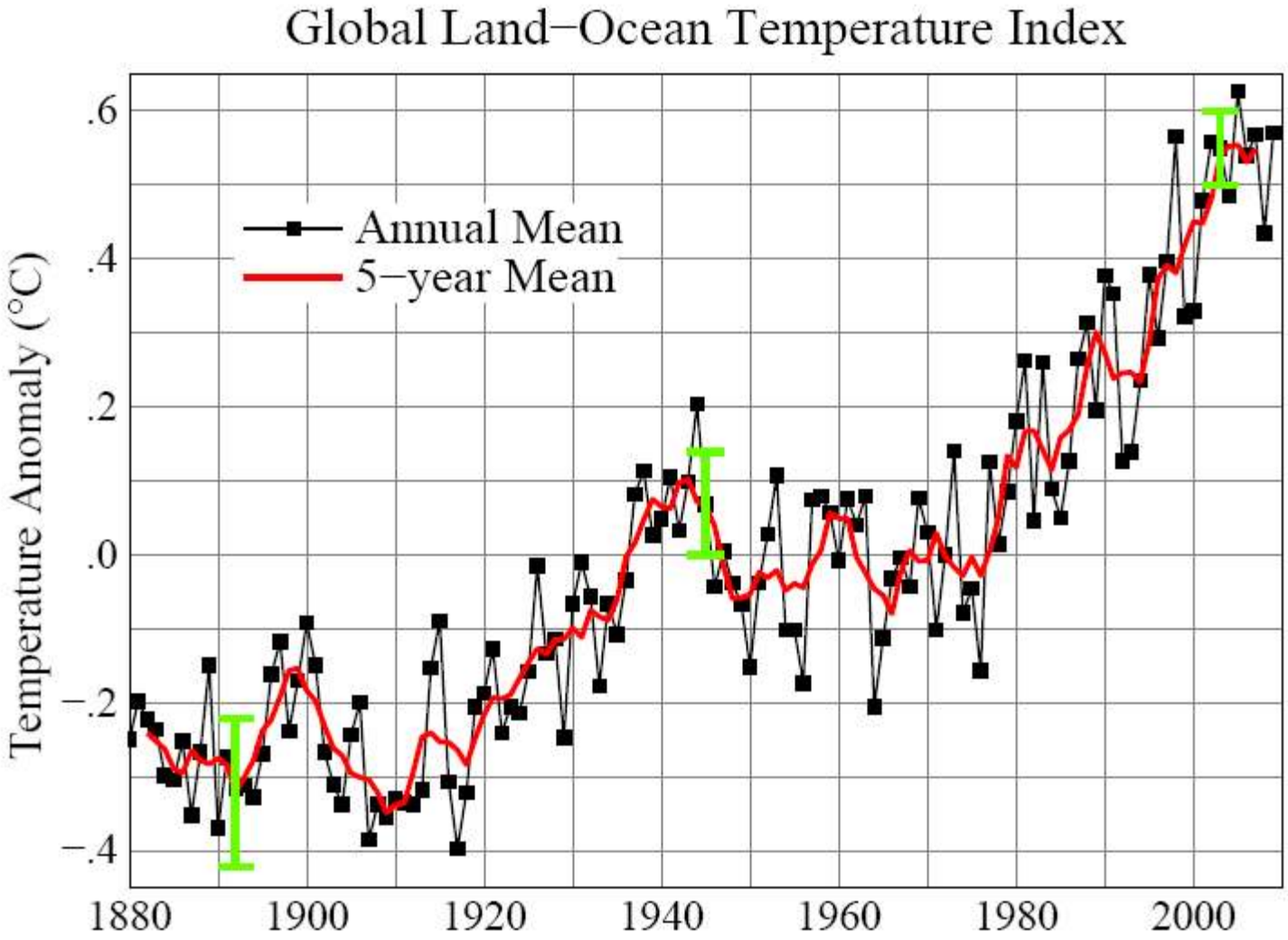
Risk = probability x consequence

- Loaded dice
- Car driving toward a cliff in the fog
- Dumping nails on the road of life

The velocity of climate change

- The rate of the climate changes
- The history of understanding climate change
- The velocity required for ecosystem and societal responses – adaptation
- Commitments to future climate change
  - Inertia
  - Permanence
  - Infrastructure
- The pace of human responses

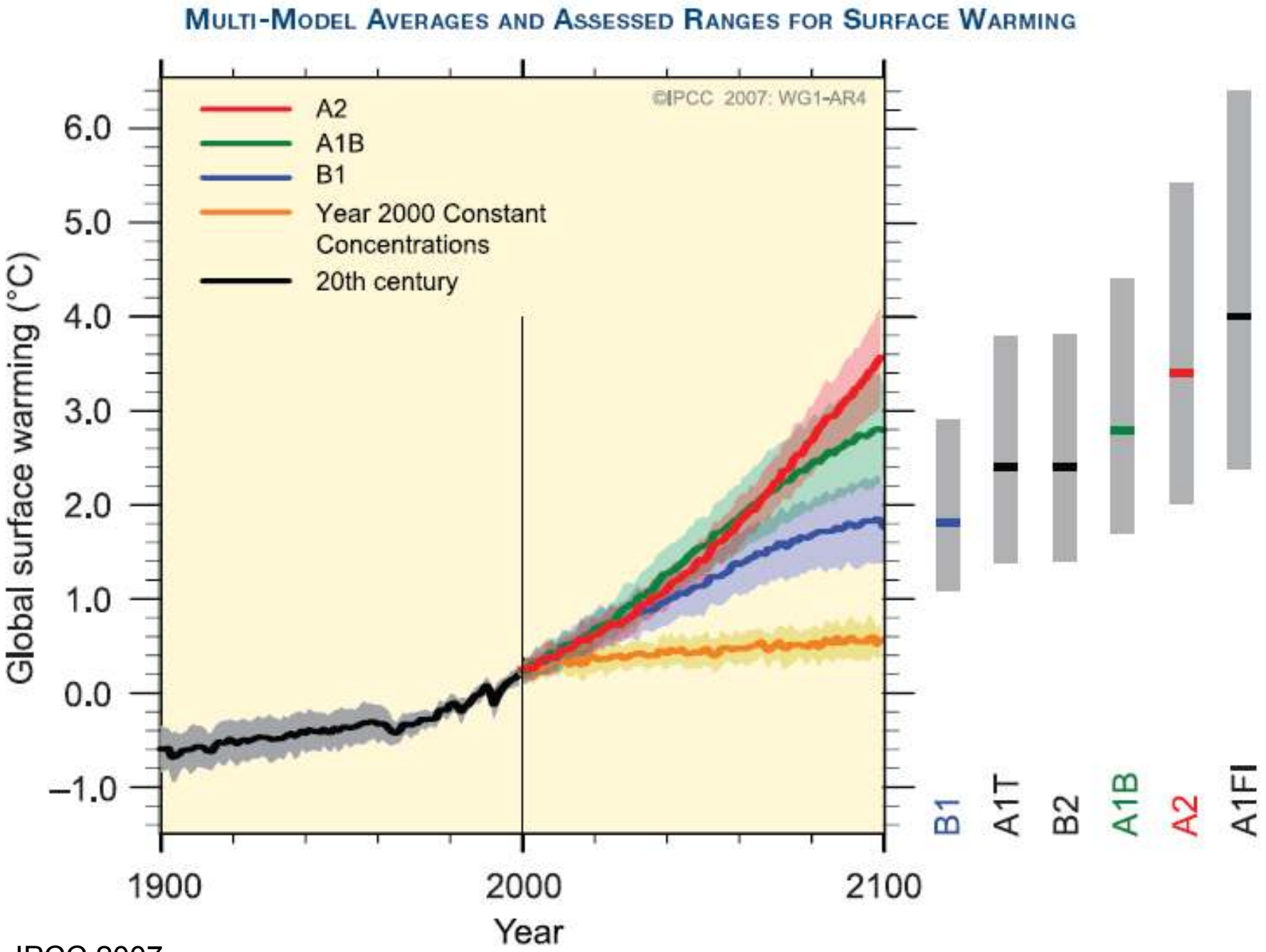
"Warming of the climate system is unequivocal"



Black : annual mean, global met stations

Red: 5-year running mean, global met stations

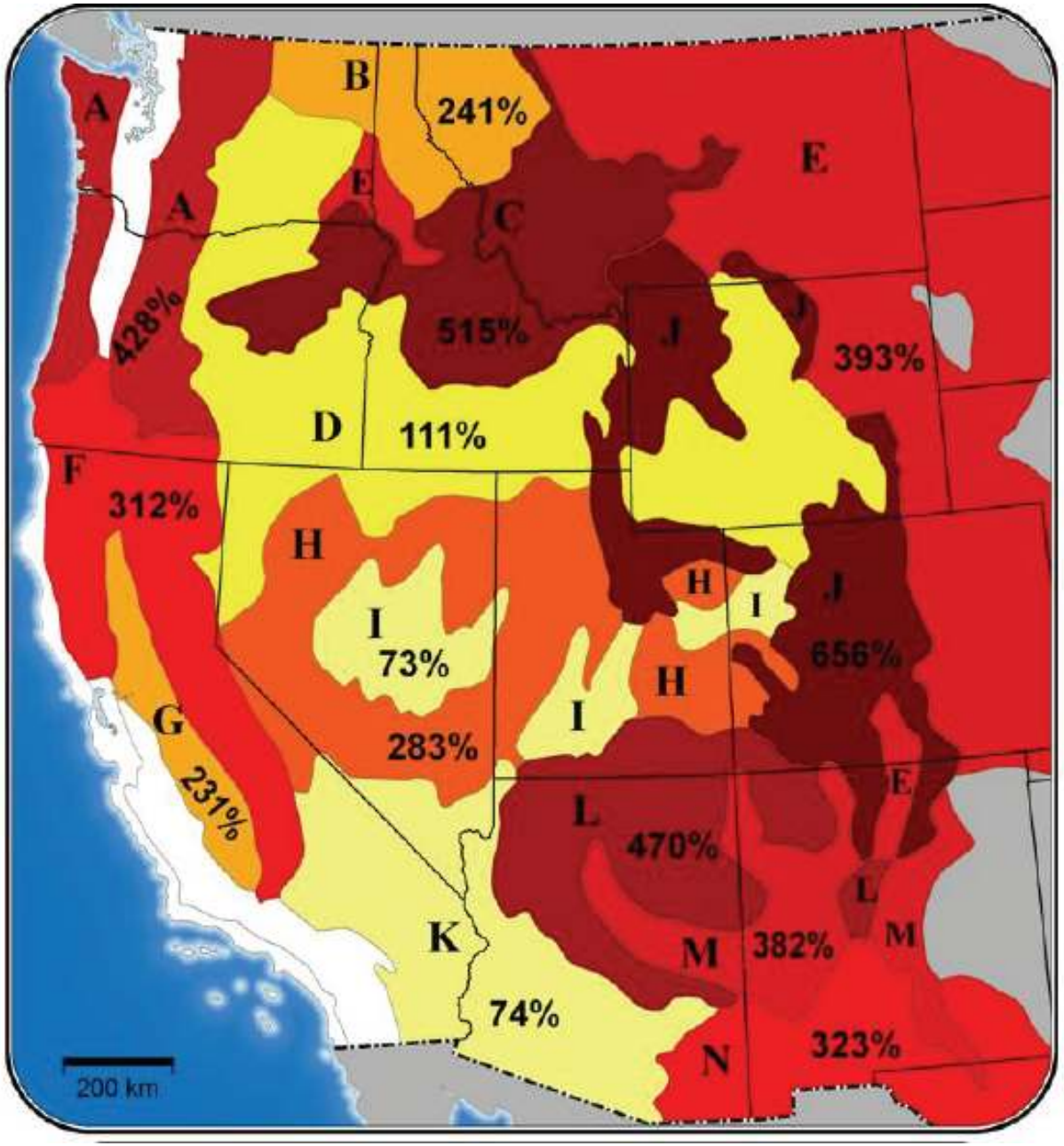
NASA Goddard Institute for Space Studies, updated through 2009


MULTI-MODEL AVERAGES AND ASSESSED RANGES FOR SURFACE WARMING
©IPCC 2007: WG1-AR4
A2
A1B
B1
Year 2000 Constant Concentrations
20th century
Global surface warming (°C)
6.0
5.0
4.0
3.0
2.0
1.0
0.0
–1.0
1900
2000
2100
Year
B1
A1T
B2
A1B
A2
A1FI

IPCC 2007

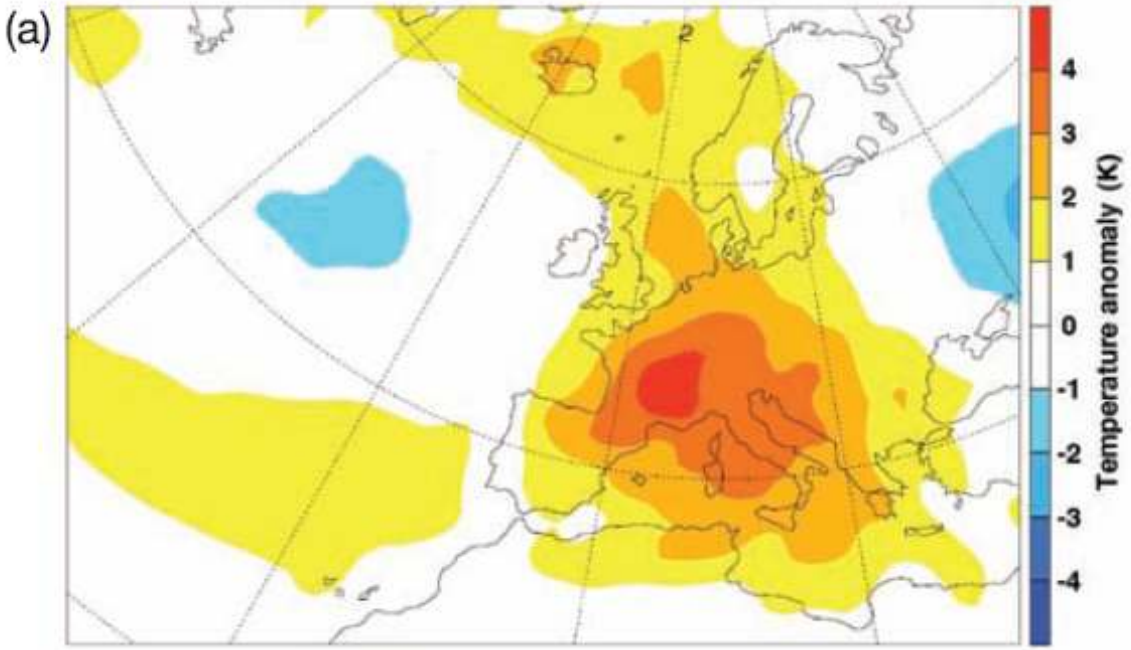
Fire in the west

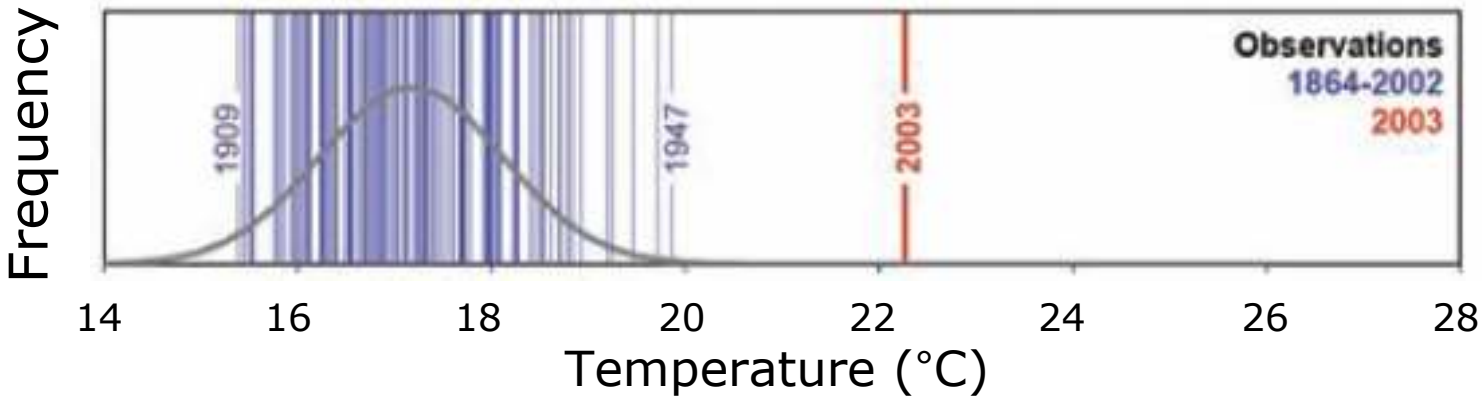
- Increase in area burned annually for each 1°C increase in temperature
- An exceedingly sensitive system



National Research Council, 2010, Climate Stabilization Targets

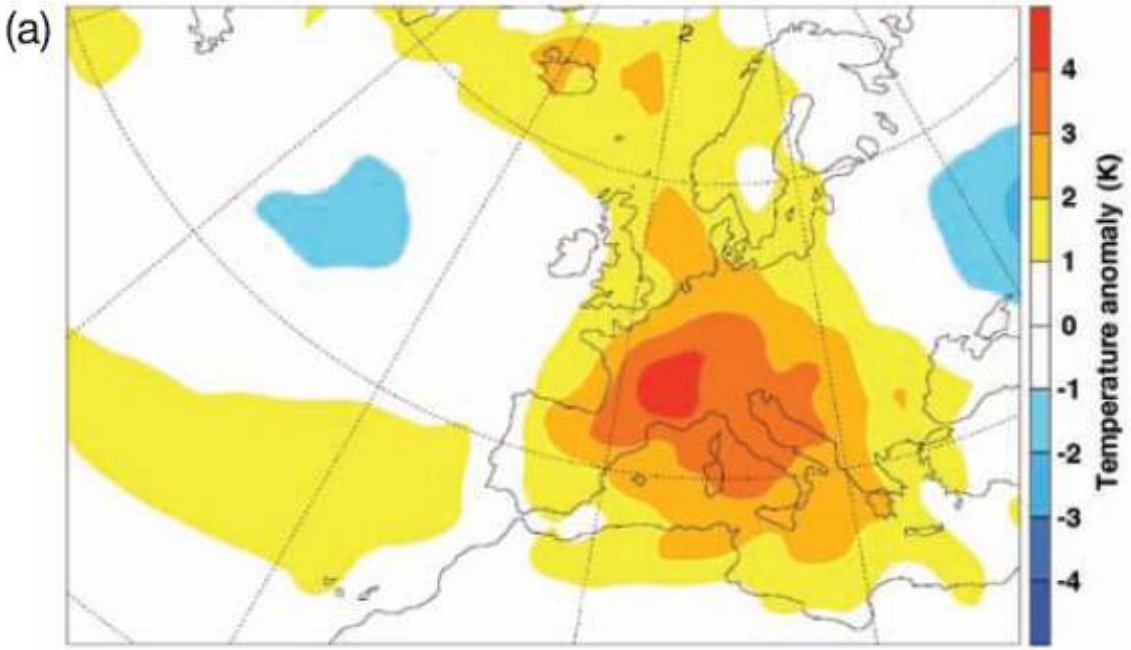
Risk of extreme events

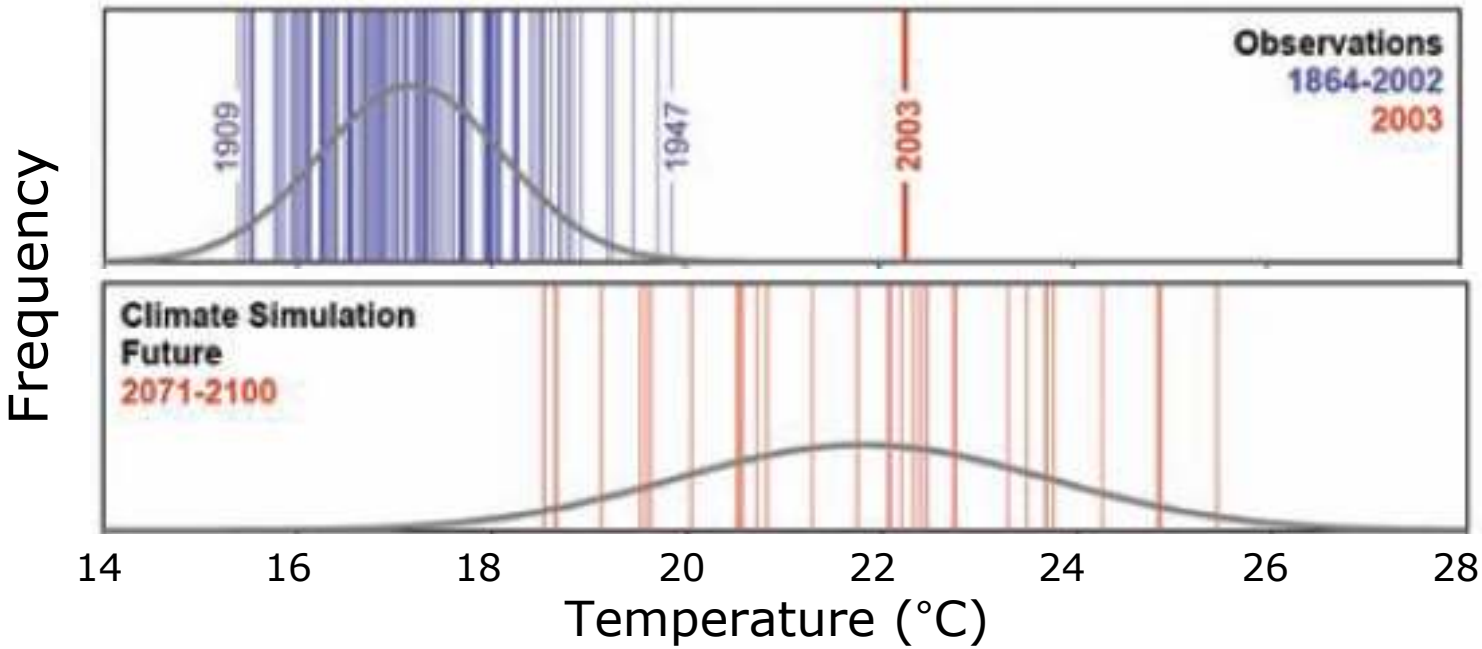




Alcamo et al. 2007 IPCC WGII

Risk of extreme events





Alcamo et al. 2007 IPCC WGII

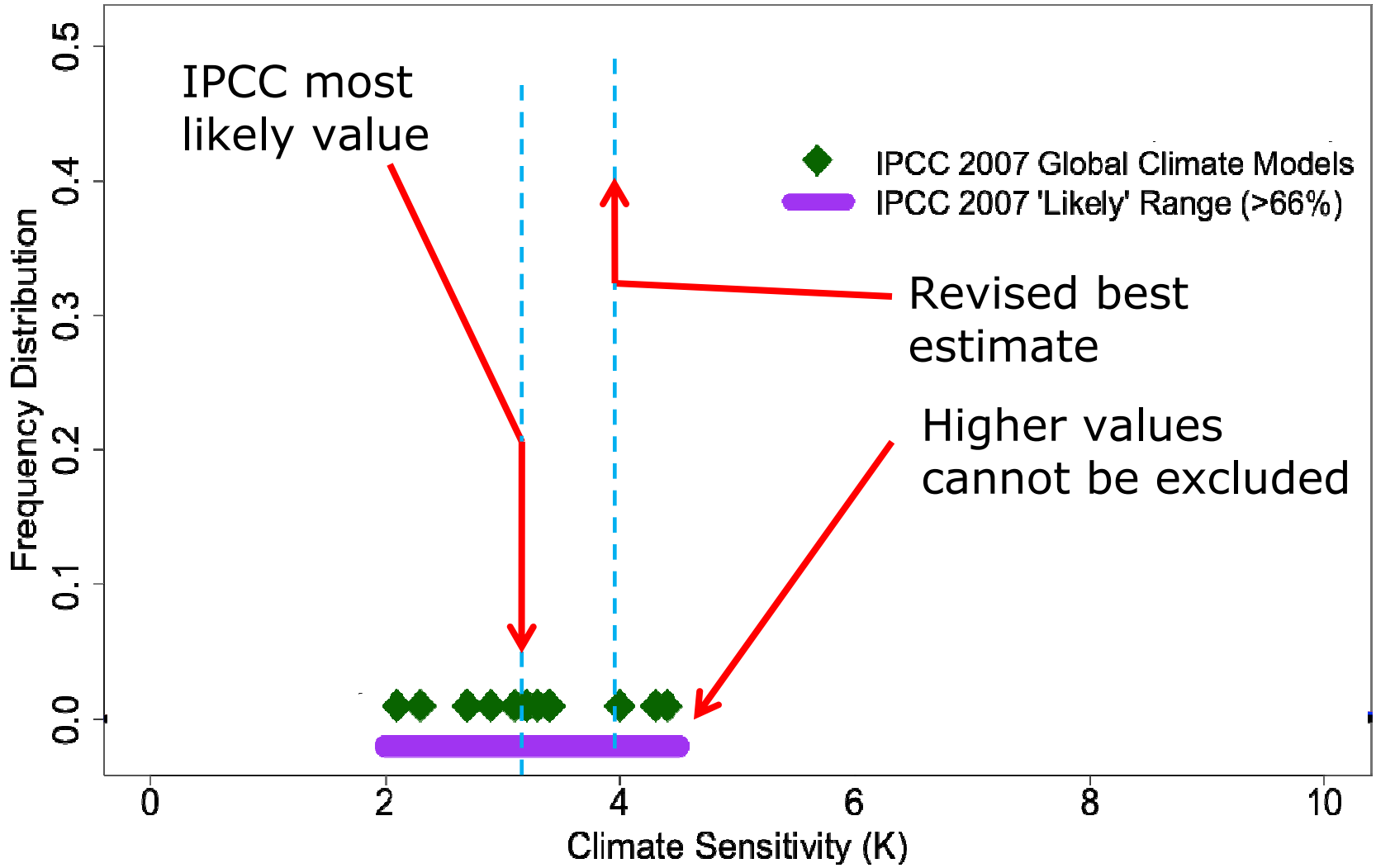
THE
LONDON, EDINBURGH, AND DUBLIN
PHILOSOPHICAL MAGAZINE
AND
JOURNAL OF SCIENCE.

[FIFTH SERIES.]

APRIL 1896.

XXXI. *On the Influence of Carbonic Acid in the Air upon the Temperature of the Ground.* By Prof. SVANTE ARRHENIUS *.

Climate sensitivity: Uncertainty in a key parameter



Carolyn Snyder thesis, Stanford, 2010

Decades of knowing…

We "will modify the heat balance of the atmosphere to such an extent that marked changes in climate . . . could occur“

1965: Environmental Pollution Board of the President's Science Advisory Committee.

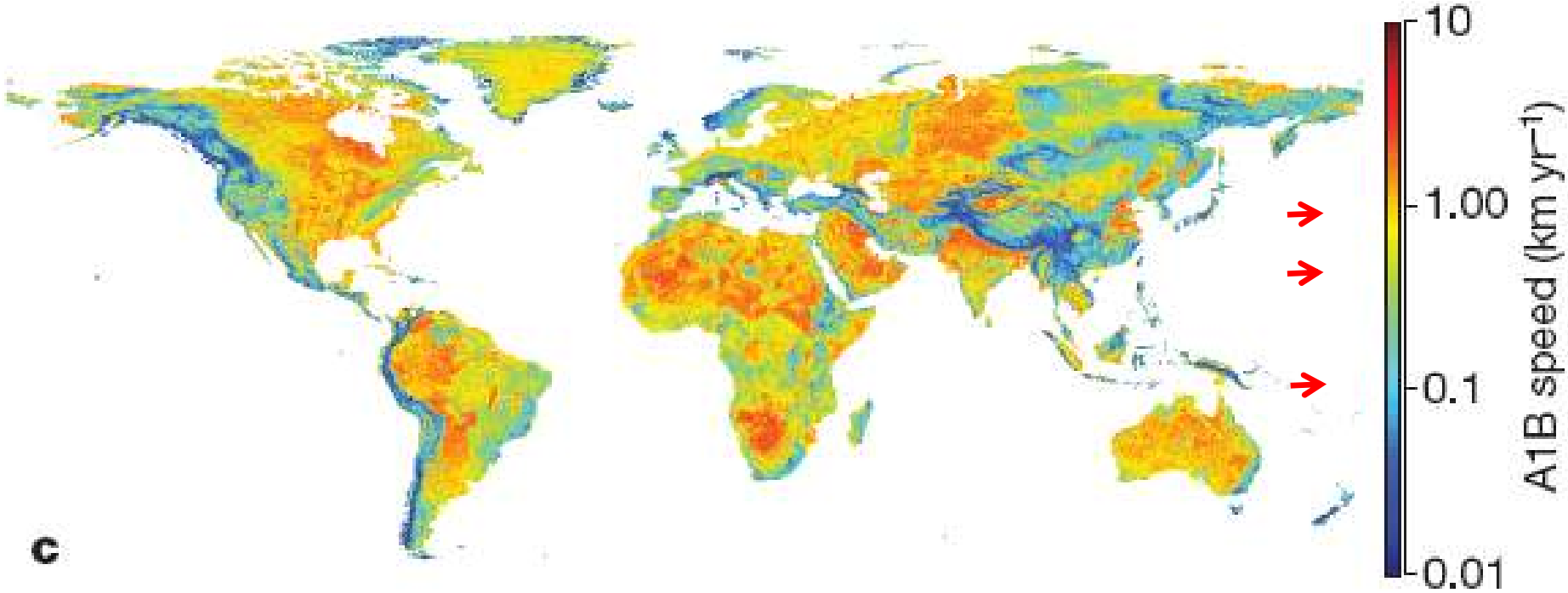
"This generation has altered the composition of the atmosphere on a global scale through . . . a steady increase in carbon dioxide from the burning of fossil fuels.“

February 1965, President Lyndon B. Johnson

"If carbon dioxide continues to increase, [we] find no reason to doubt that climate changes will result, and no reason to believe that these changes will be negligible.“

National Academy of Science (Charney Report), 1979

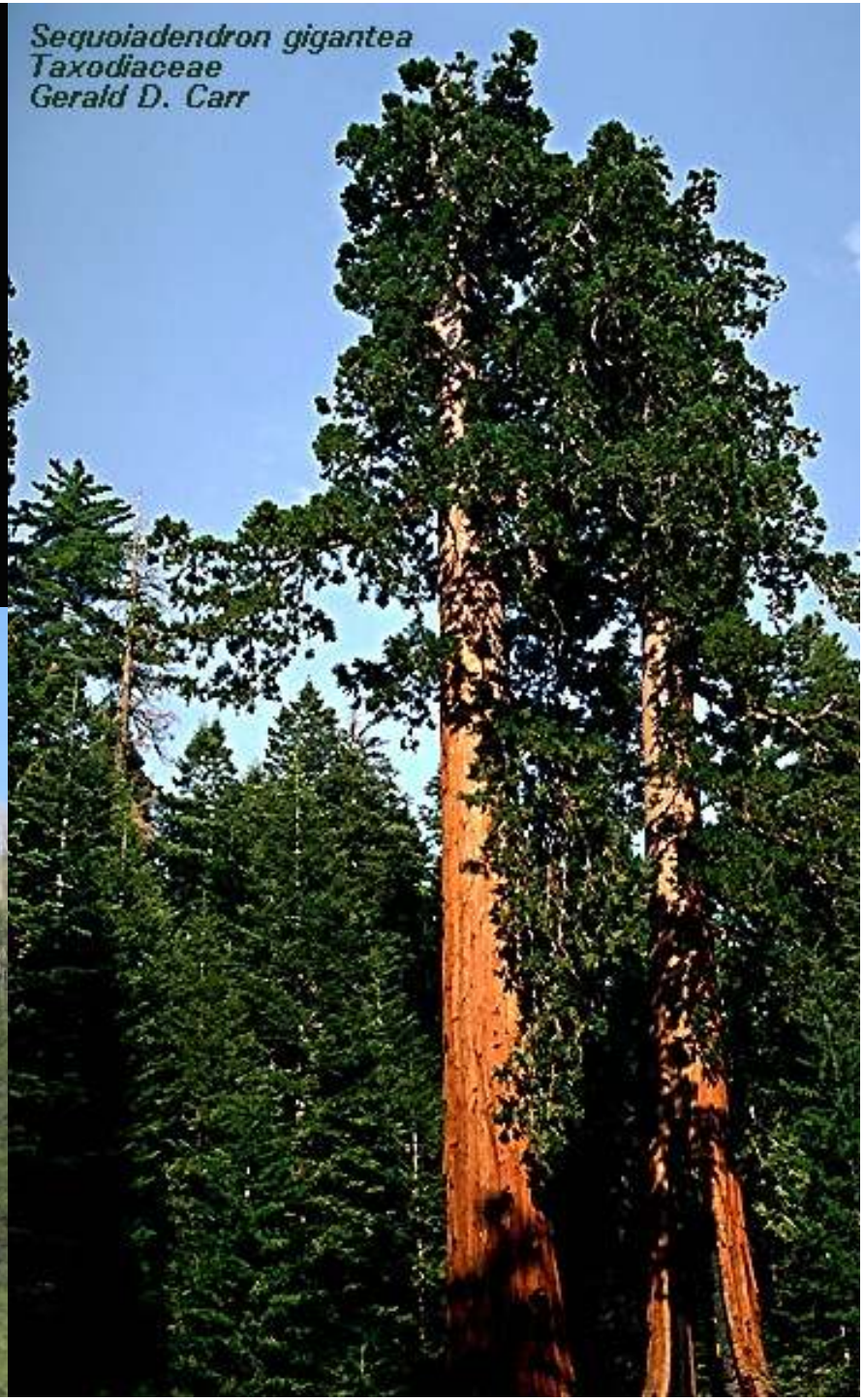
(°/yr)/(°/km) = (km/yr)



Loarie et al. Nature 2009

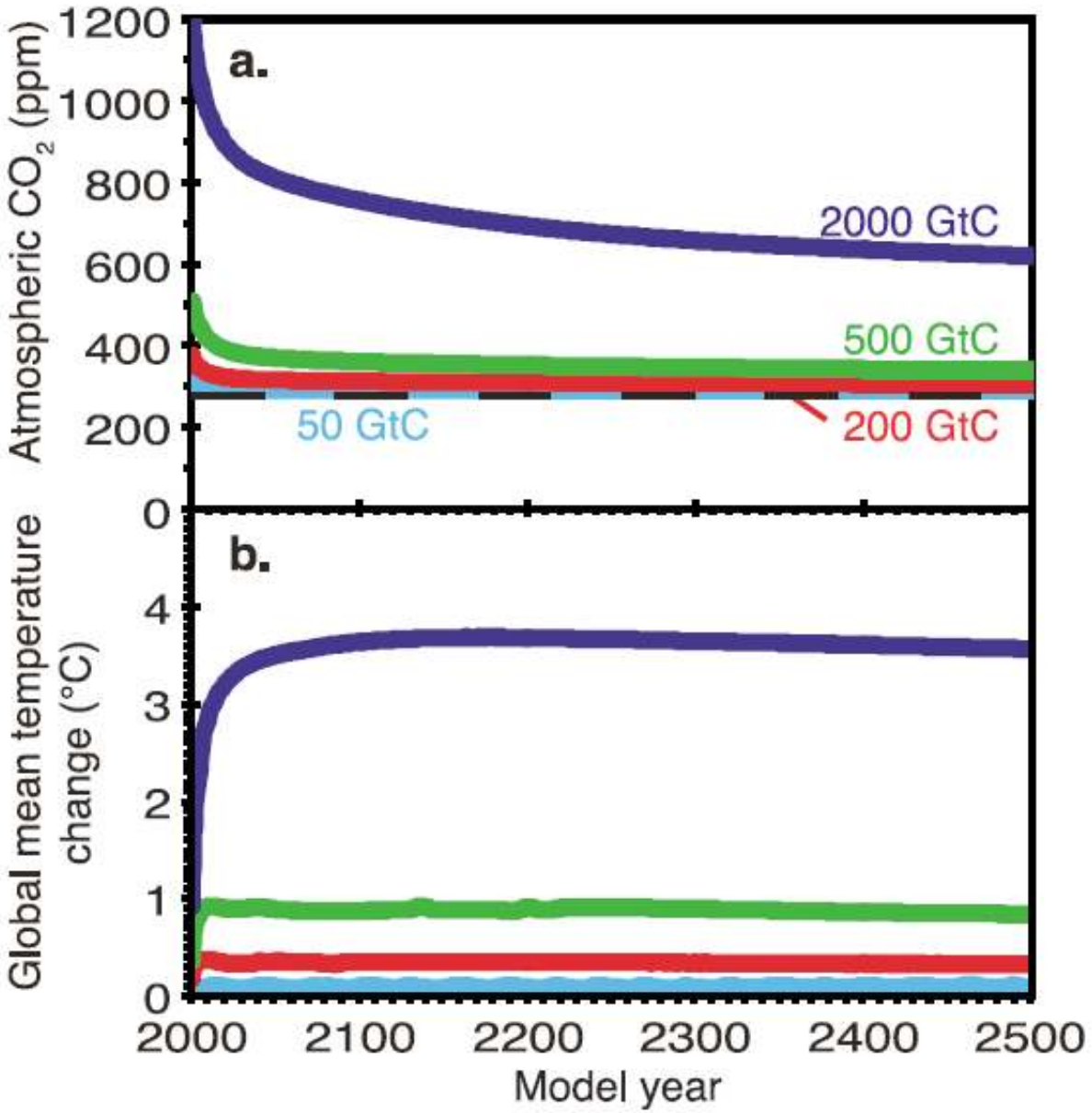
Euphydryas editha bayensis

Centaurea solstitialis



Angel Watkins, US Forest Service, 2007

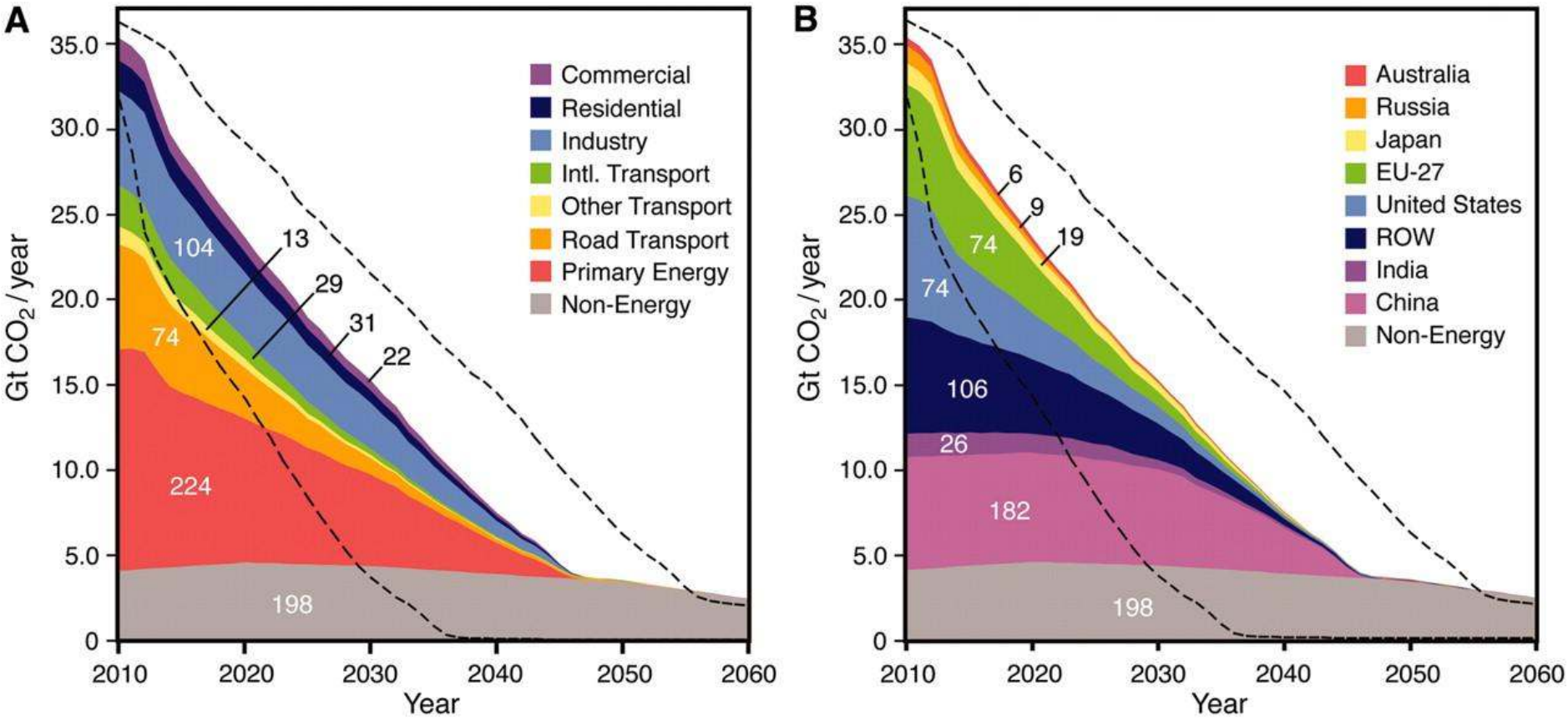
Permanent climate change



Matthews and Caldeira 2007 GRL

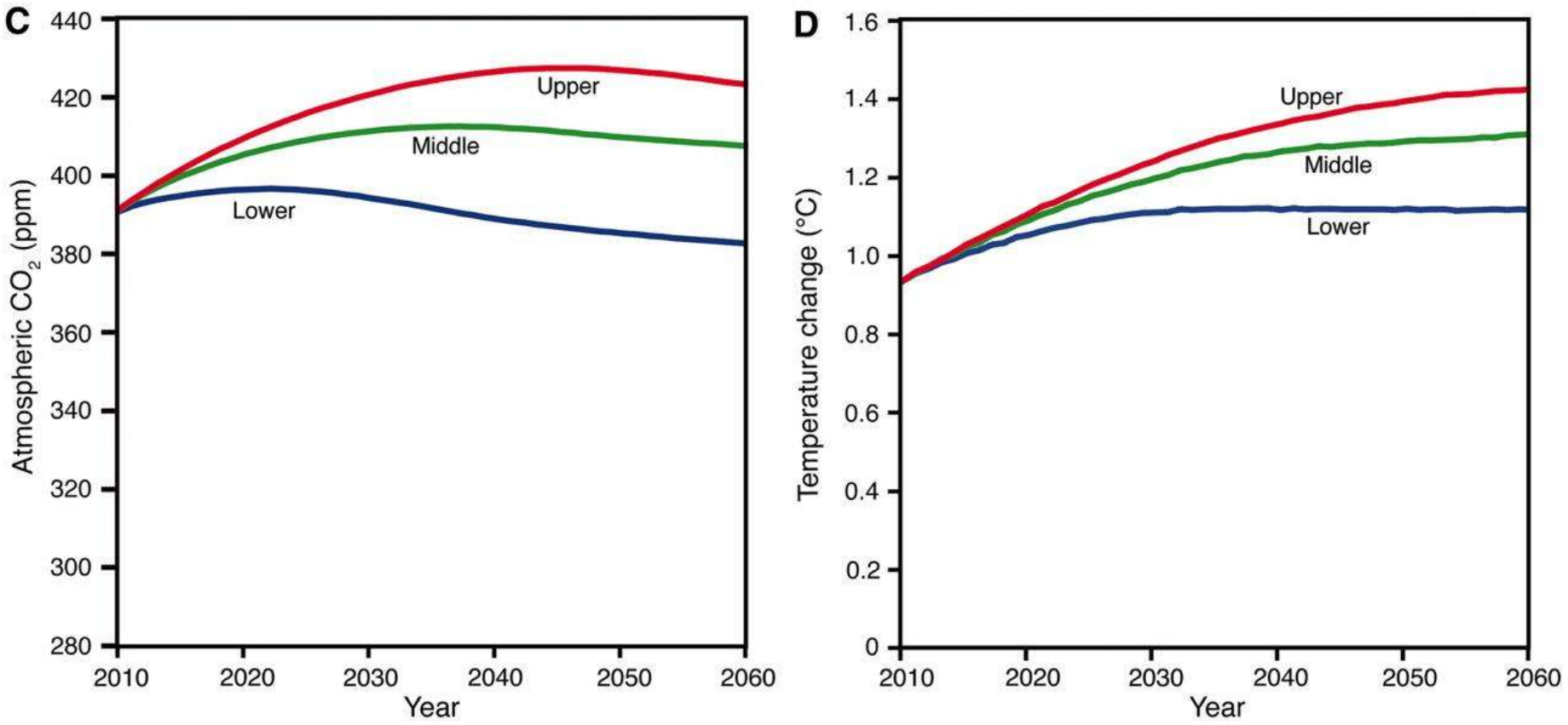
Ansel Adams, 1942

Emissions commitments from existing infrastructure



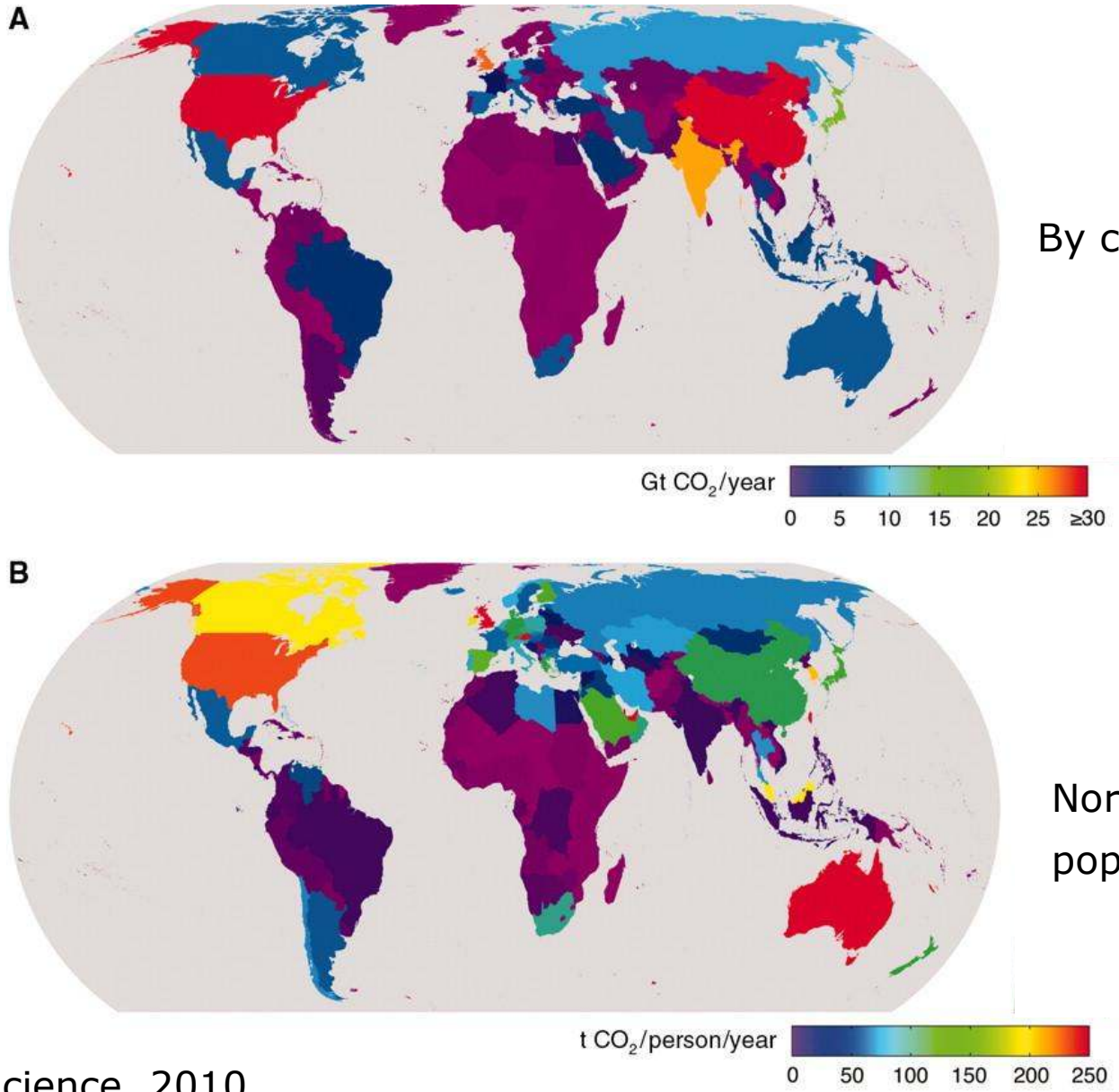
Davis et al. Science, 2010

Emissions commitments from existing infrastructure



Davis et al. Science, 2010

Fig. 2 A Regional emissions commitment from existing energy and transportation infrastructure (A) and normalized by regional population (B).



By country

Normalized for population

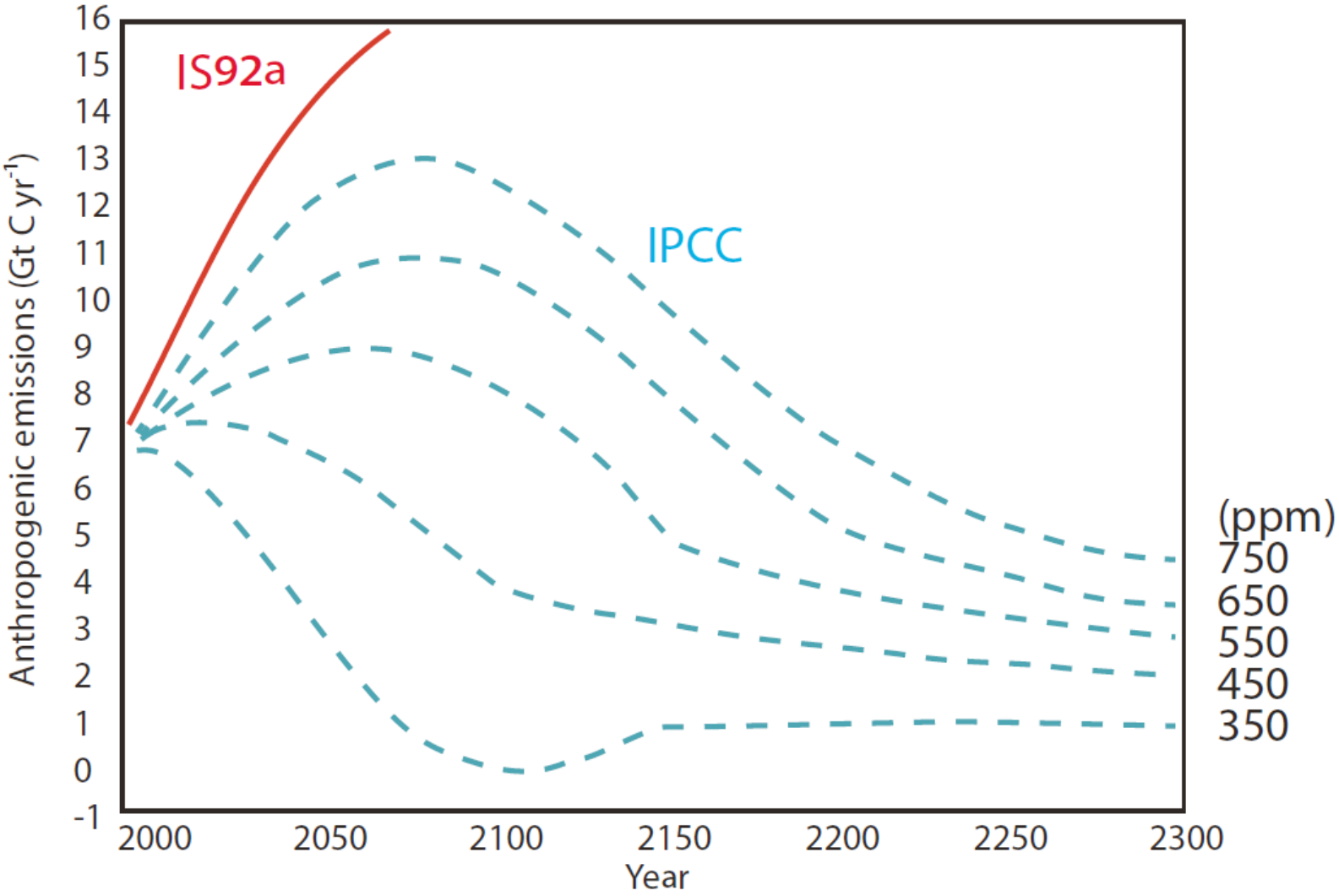
Davis et al. Science, 2010


Photo: Thames River Barrier Navigational Control

Delay?

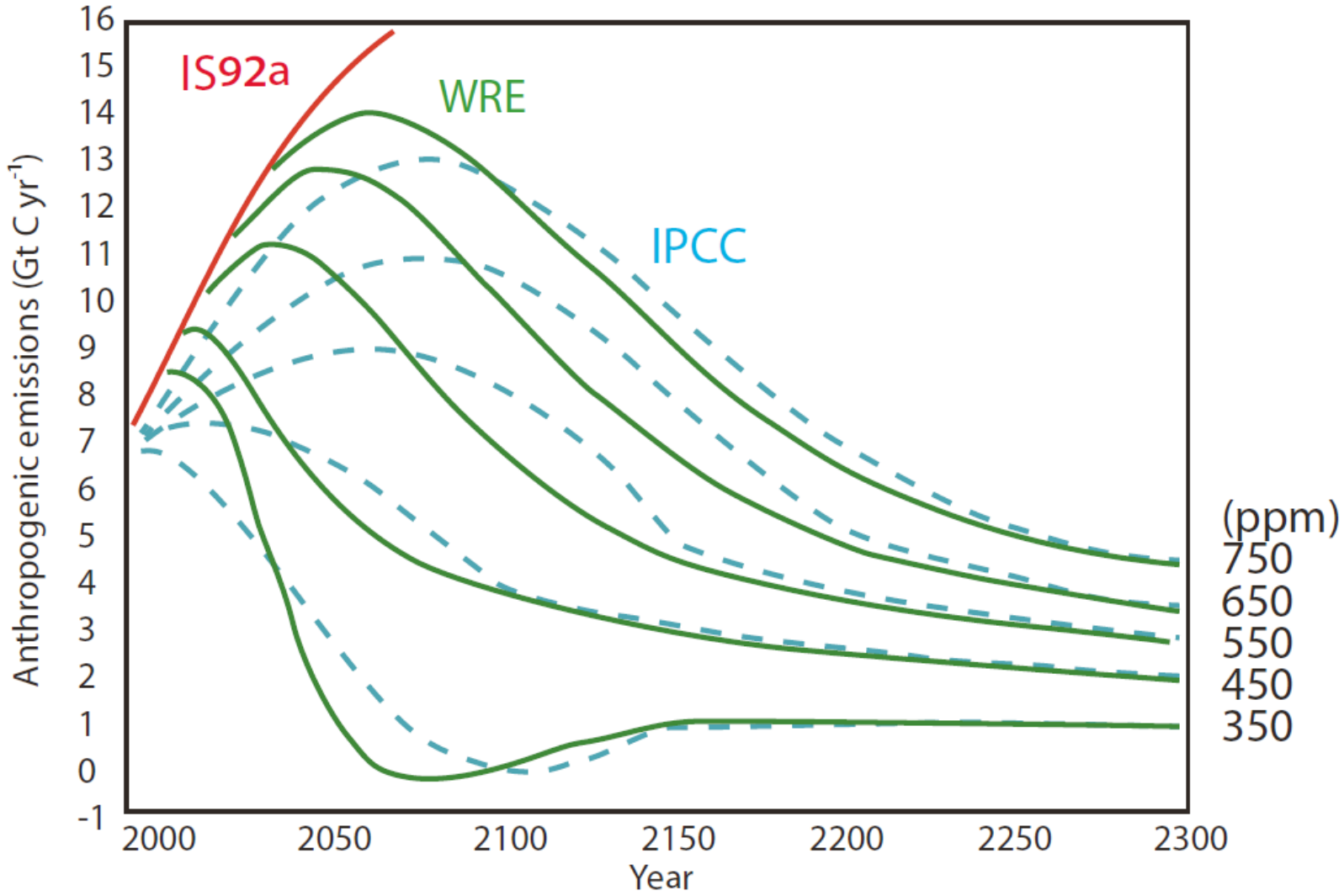
- Avoid unnecessary expenditures
- Allow natural progress with technology development
- Start from a position of greater wealth

Questionable economics of rapid emissions reduction



Wigley et al. Nature 1996

Questionable economics of rapid emissions reduction



Wigley et al. Nature 1996

Delay?

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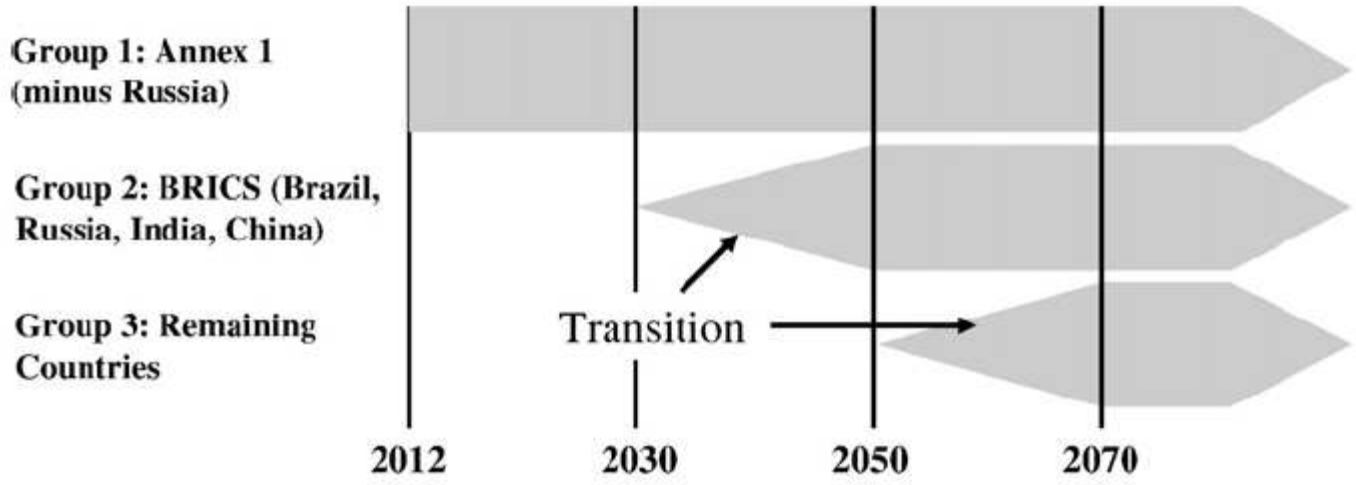


Clarke et al. Energy Economics, 2009

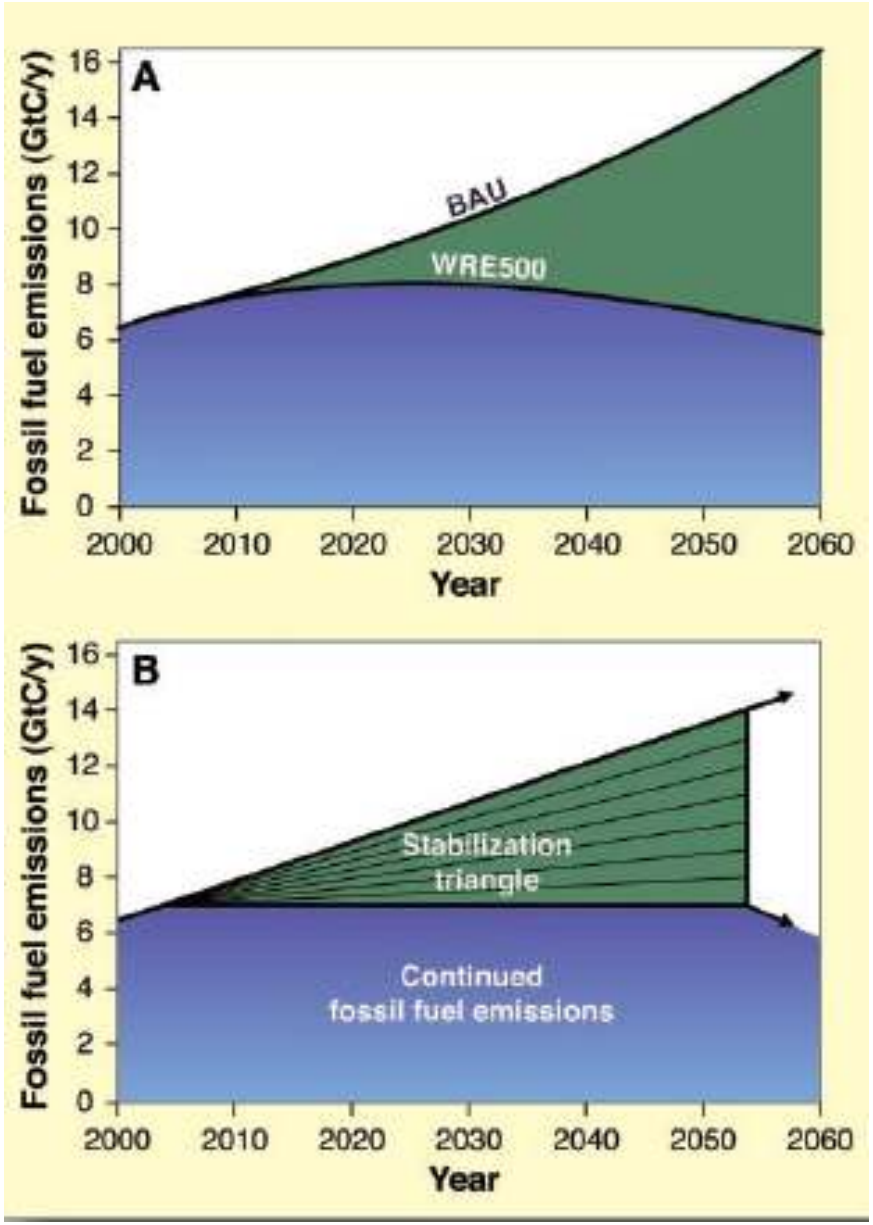
The implications of delaying action

	Model	650 CO2-e		550 CO2-e				450 CO2-e			
		Full	Delay	Full		Delay		Full		Delay	
		Not-to-exceed	Not-to-exceed	Overshoot	Not-to-exceed	Overshoot	Not-to-exceed	Overshoot	Not-to-exceed	Overshoot	Not-to-exceed
1	ETSAP-TIAM	+	+	+	+	+	+	+	+	+	X
2	FUND	+	+	+	+	+	+	+	X	X	X
3	GTEM	+	+	+	+	+	X	+	X	X	X
4	IMAGE	+	+	+	+	+	+	X	X	X	X
	IMAGE-BECS	N/A	N/A	N/A	N/A	N/A	N/A	+	X	X	X
5	MERGE Optimistic	+	+	+	+	X	X	X	X	X	X
	MERGE Pessimistic	+	+	+	+	+	+	X	X	X	X
6	MESSAGE	+	+	+	+	+	X	+	X	X	X
	MESSAGE-NoBECS	+	N/A	+	+	N/A	N/A	+	X	X	X
7	MiniCAM-Base	+	+	+	+	+	X	+	+	+	X
	MiniCAM-LoTech	+	+	+	+	+	X	+	X	X	X
8	POLES	+	+	+	+	+	X	X	X	X	X
9	SGM	+	+	+	+	+	+	X	X	X	X
10	WITCH	+	+	+	+	+	+	X	X	X	X

The "+" means that the team was able to produce the scenario; darkened cells with an "X" mean that the team was not able to produce the scenario. "N/A" means that the scenario was not attempted with the given model or model version.

Clarke et al. Energy Economics, 2009

Is the technology available?



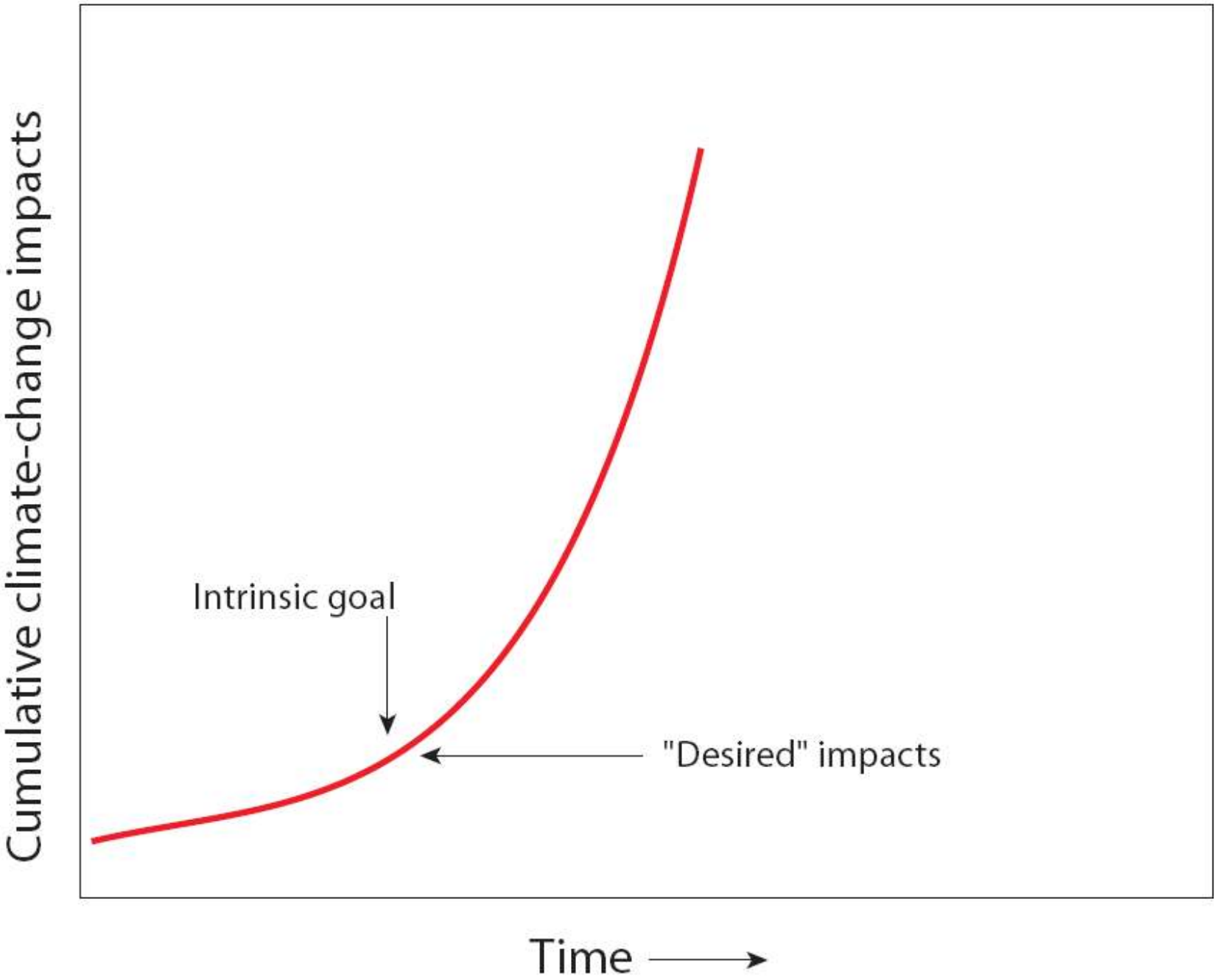
Humanity already possesses the fundamental scientific, technical, and industrial know-how to solve the carbon and climate problem for the next half-century.

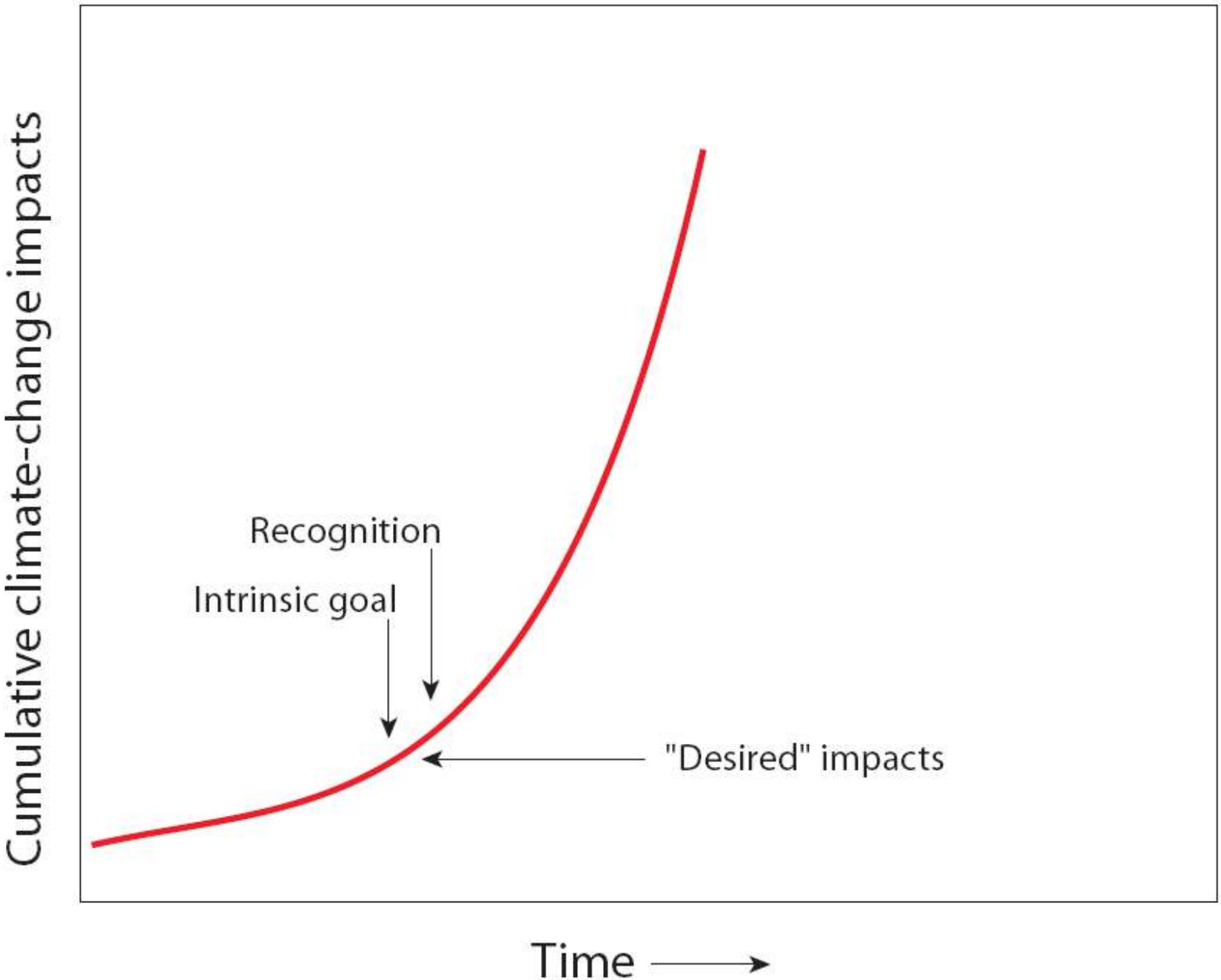
Pacala & Socolow,Science, 2004

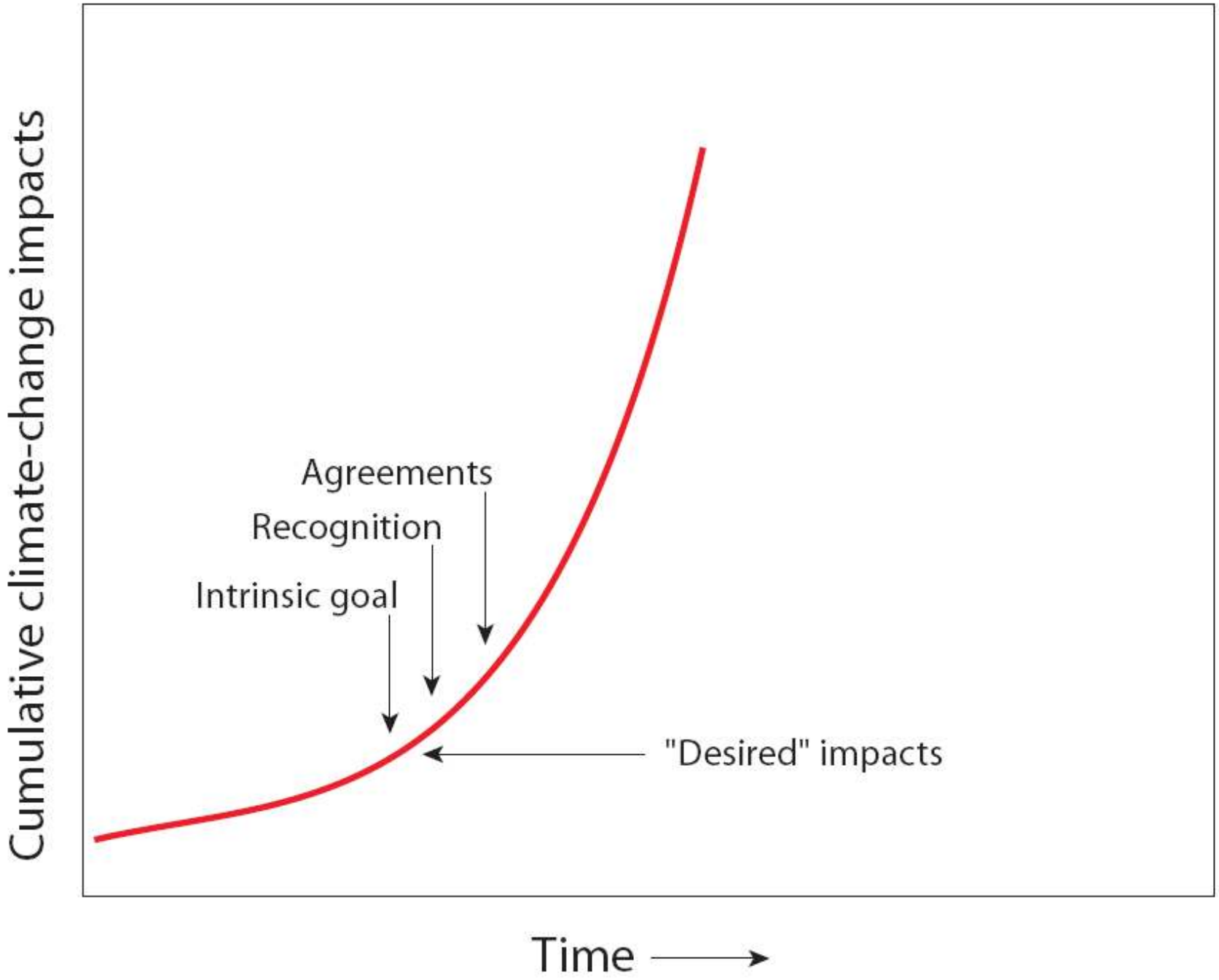
Size of the challenge

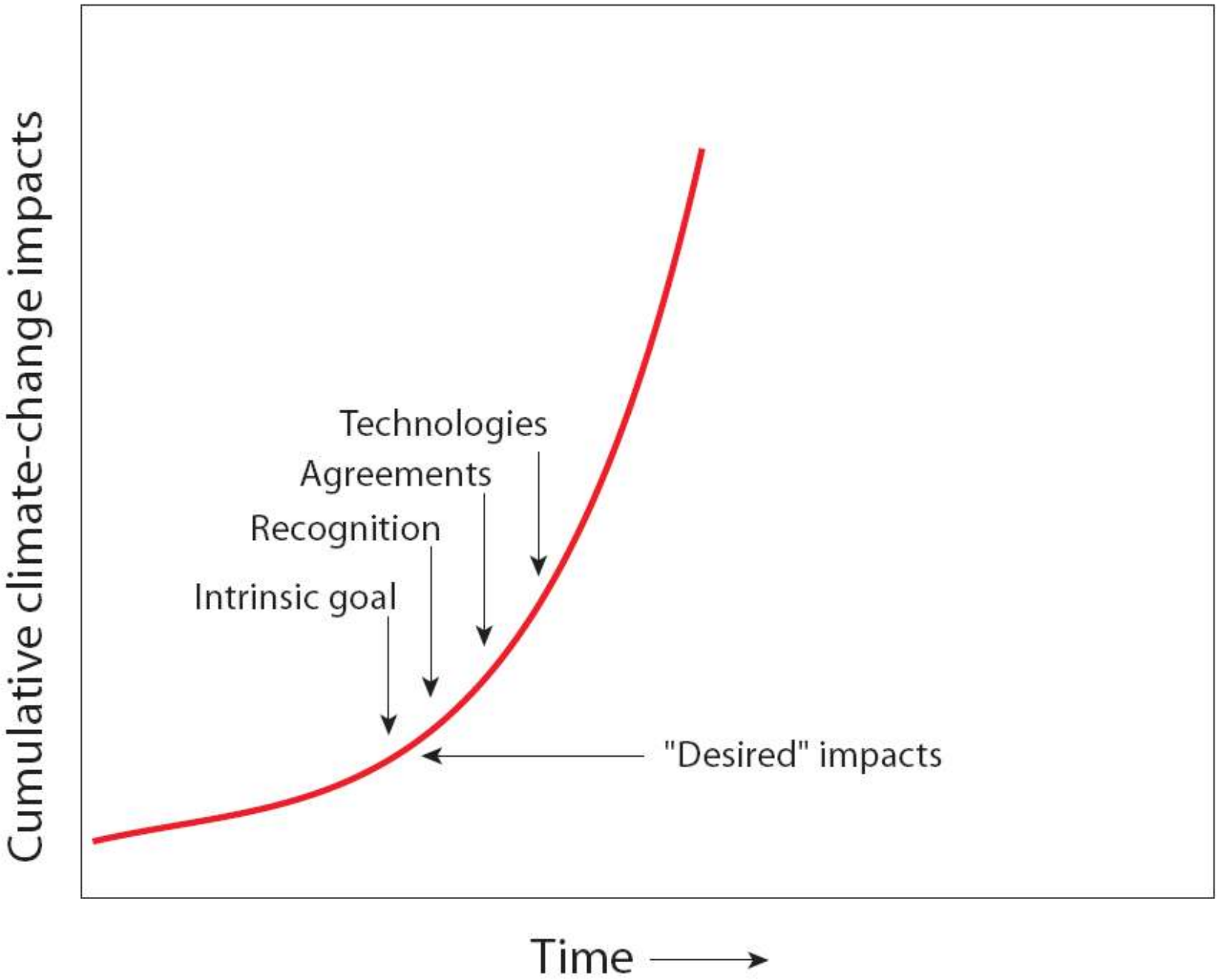
- Global energy use ~ 15 TW (15×10^{12} W)
- Global economic growth ~3% yr^{-1}
- 3% of 15 TW = 450 GW
  - 450 new big powerplants (~ 1/day)

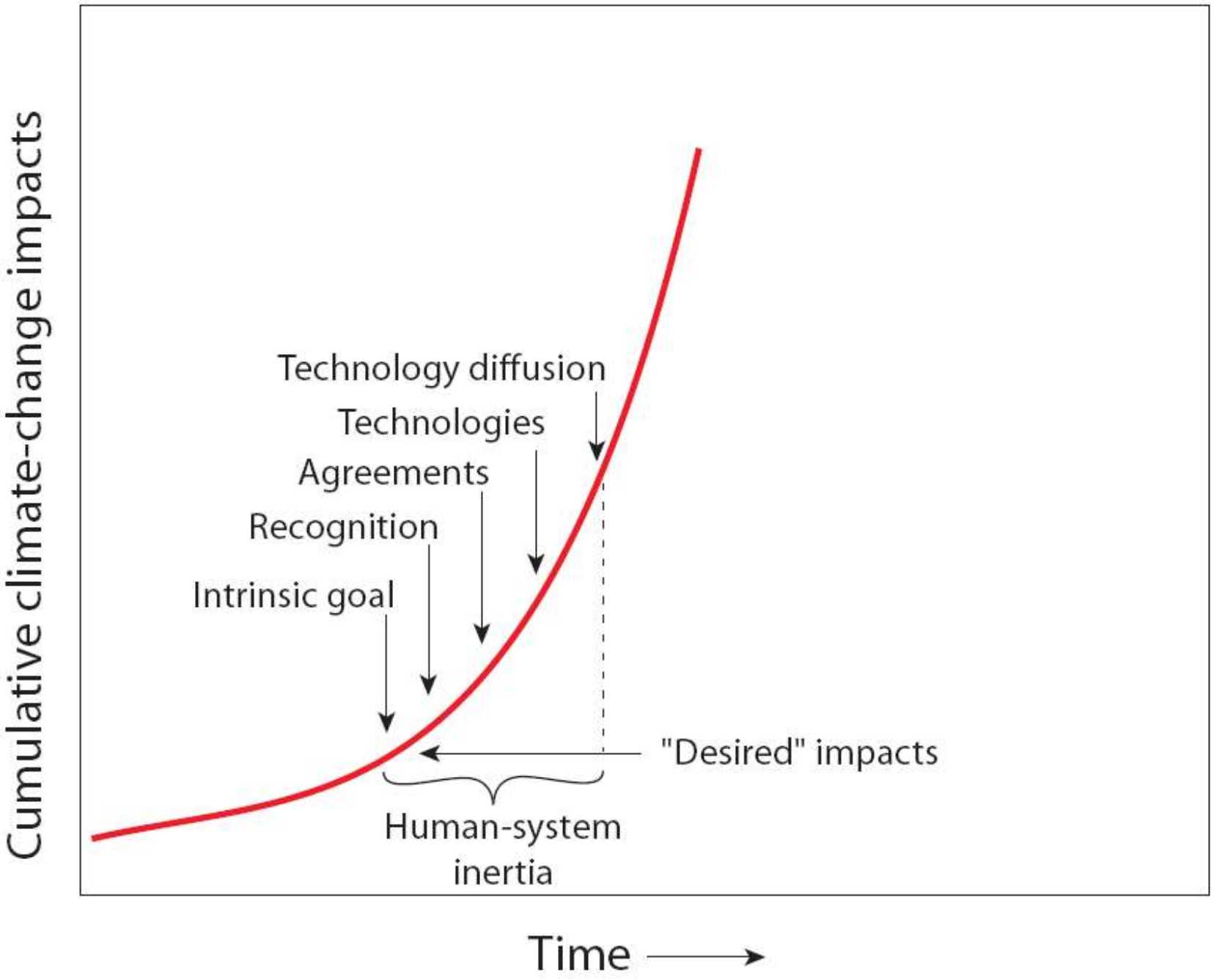
- Past intensity improvements ~1.5% yr^{-1}
  - 225 new big powerplants (~ 0.5/day)

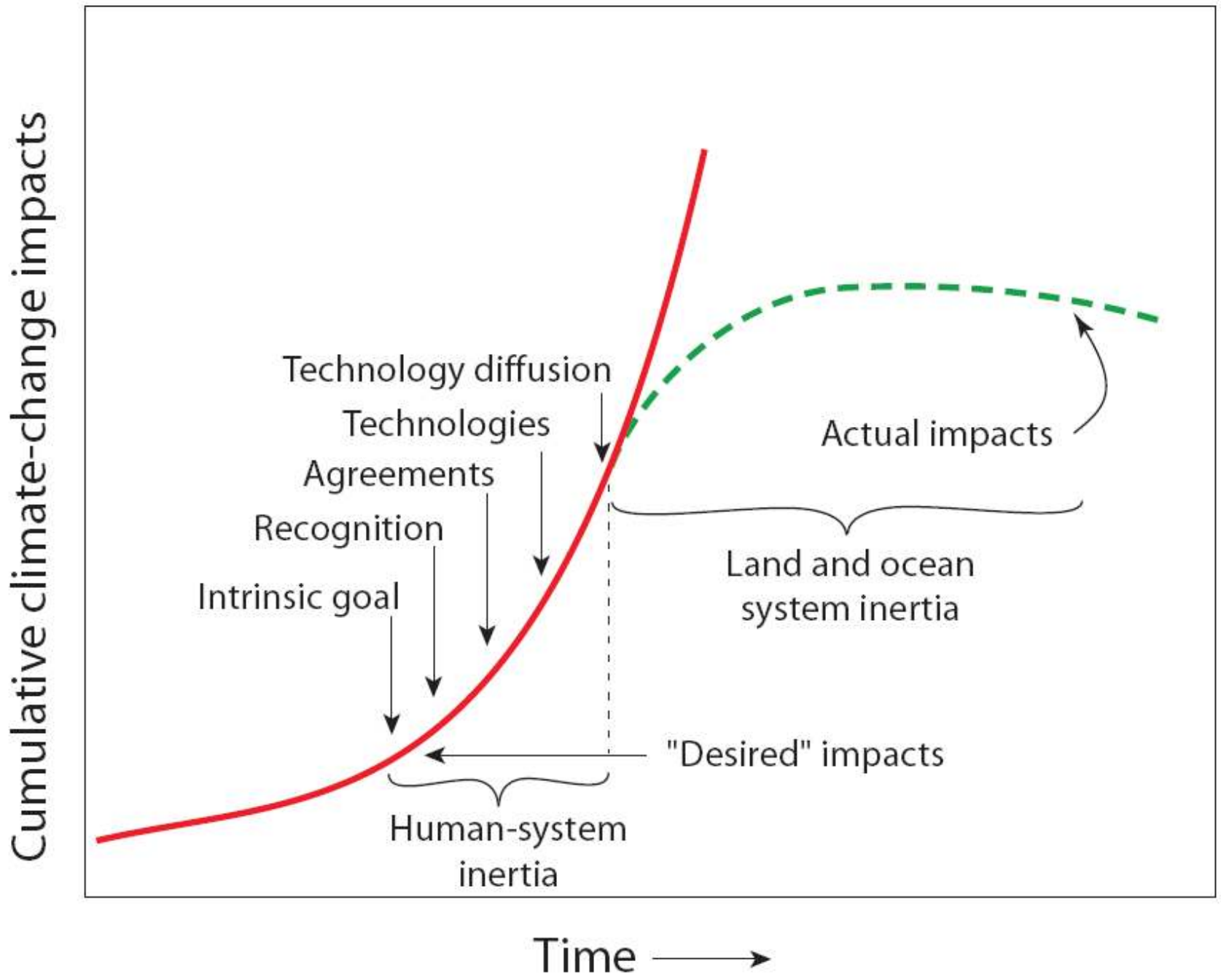

Cumulative climate-change impacts
Intrinsic goal
"Desired" impacts
Time

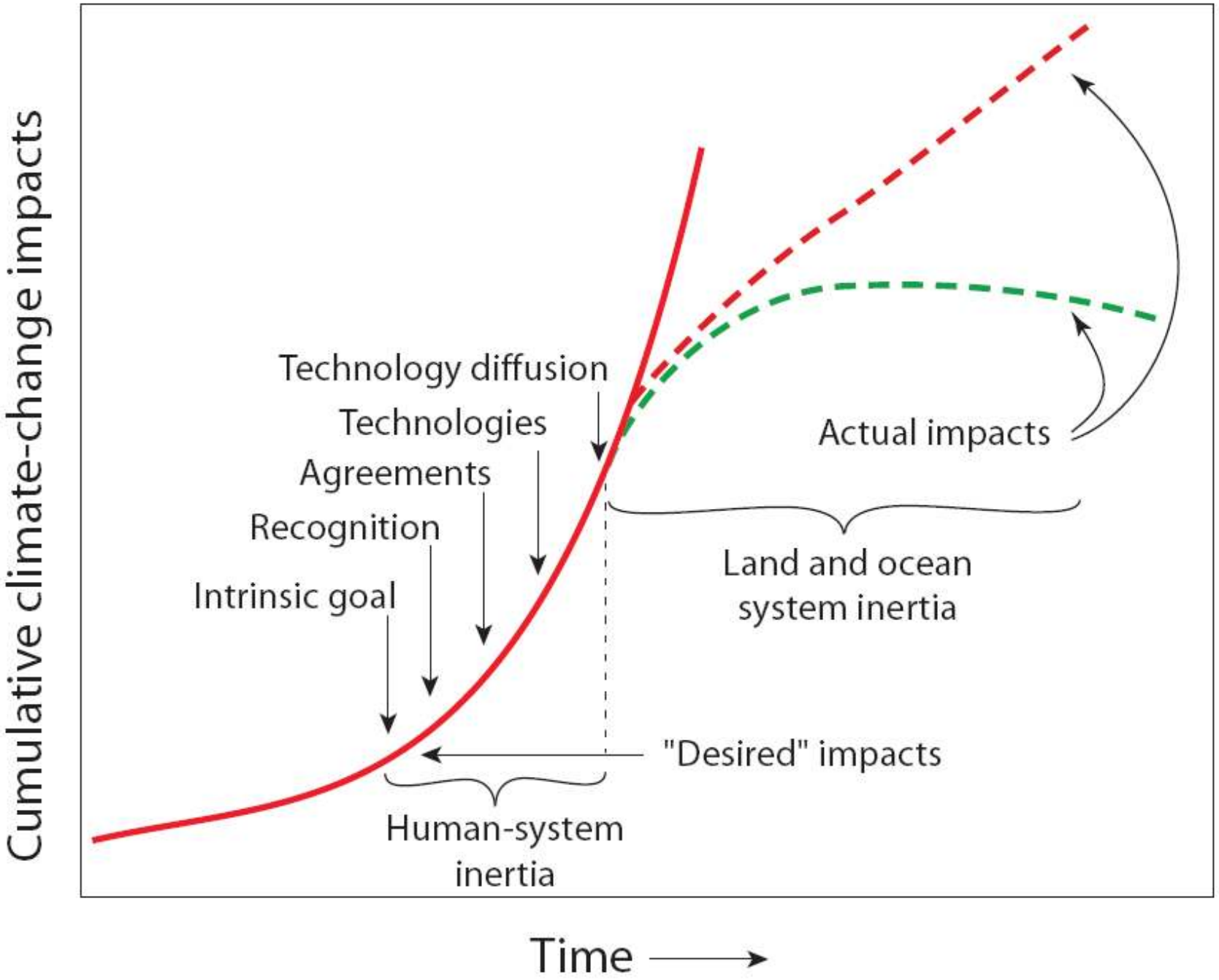

Cumulative climate-change impacts
Recognition
Intrinsic goal
"Desired" impacts
Time


Cumulative climate-change impacts
Agreements
Recognition
Intrinsic goal
"Desired" impacts
Time


Cumulative climate-change impacts
Technologies
Agreements
Recognition
Intrinsic goal
"Desired" impacts
Time


Cumulative climate-change impacts
Technology diffusion
Technologies
Agreements
Recognition
Intrinsic goal
"Desired" impacts
Human-system inertia
Time


Cumulative climate-change impacts
Technology diffusion
Technologies
Agreements
Recognition
Intrinsic goal
Actual impacts
Land and ocean
system inertia
"Desired" impacts
Human-system
inertia
Time


Cumulative climate-change impacts
Technology diffusion
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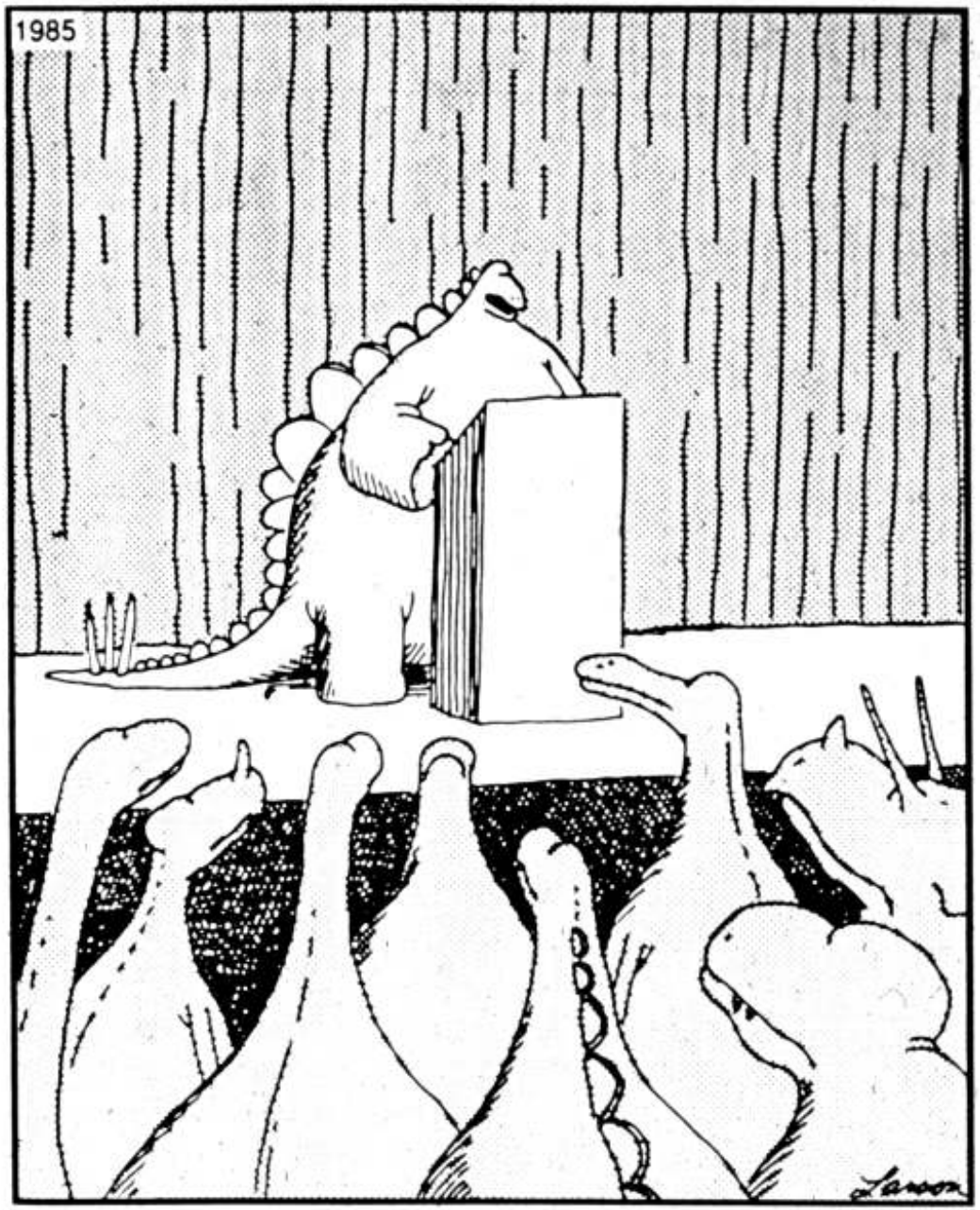
system inertia
"Desired" impacts
Human-system
inertia
Time

The choice is ours -

"The picture's pretty bleak, gentlemen…. The world's climates are changing, the mammals are taking over, and we all have a brain about the size of a walnut."

Gary Larson, 1985

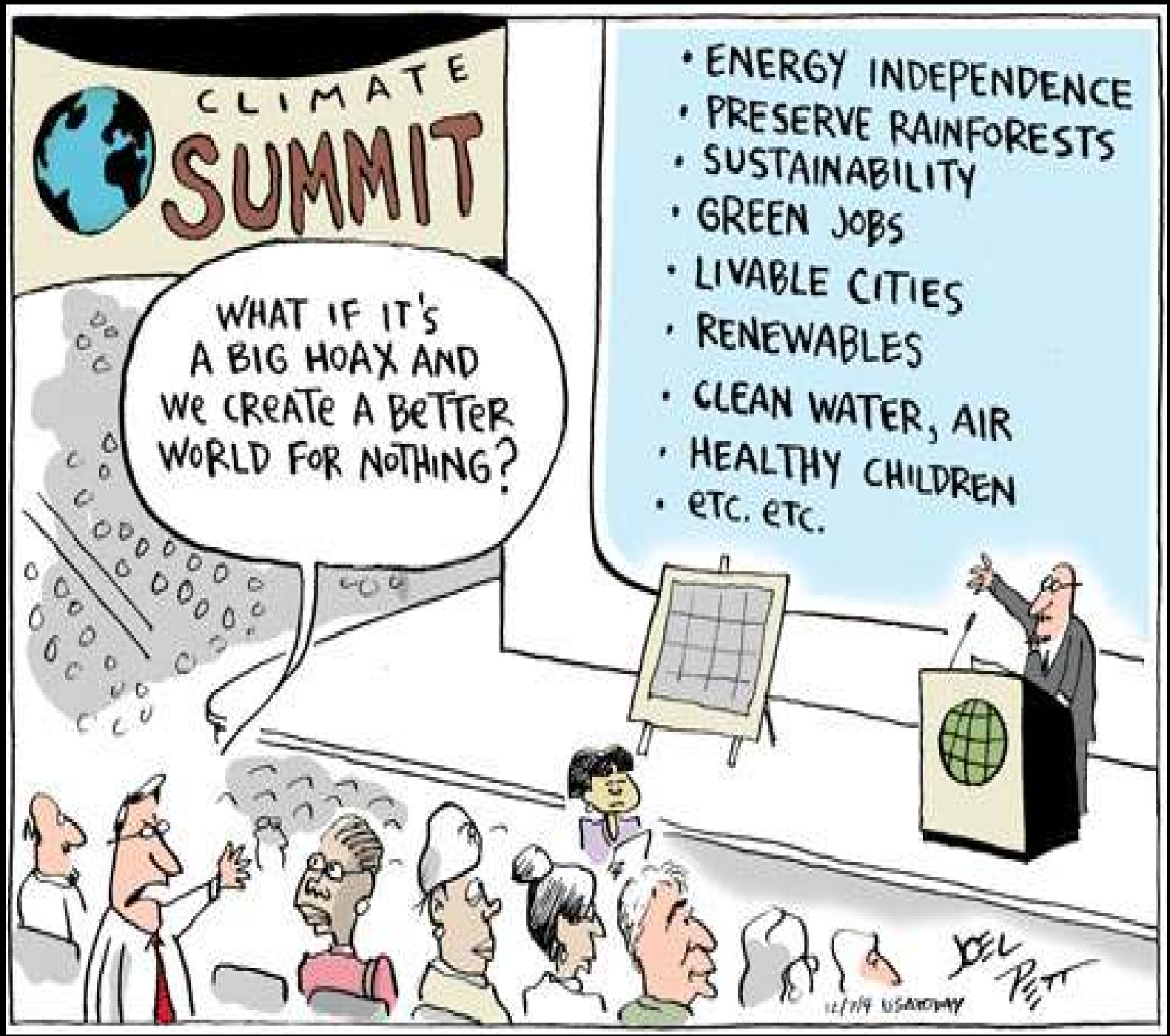


With 25 years of progress…

Patrick Chapatte, 2010

The velocity of climate change

- Climate changes persist many centuries
- Climate changes alter risk profiles
  - 100% certainty is a hopeless target
- Developing solutions takes time
- Artificial controversy
  - Costs time and opportunity
  - Lets risks and damages accumulate
  - Postpones co-benefits
  - Jeopardizes leadership opportunities


CLIMATE
SUMMIT
WHAT IF IT'S A BIG HOAX AND WE CREATE A BETTER WORLD FOR NOTHING?
• ENERGY INDEPENDENCE
• PRESERVE RAINFORESTS
• SUSTAINABILITY
• GREEN JOBS
• LIVABLE CITIES
• RENEWABLES
• CLEAN WATER, AIR
• HEALTHY CHILDREN
• ETC. ETC.
JOEL PETT

Thanks to:

- Carolyn Synder: Climate sensitivity from paleo records
- Bill Anderegg: Sudden Aspen Decline
- Scott Loarie: The velocity of climate change
- Ken Caldeira: Permanence of climate change and Emissions commitments from existing infrastructure

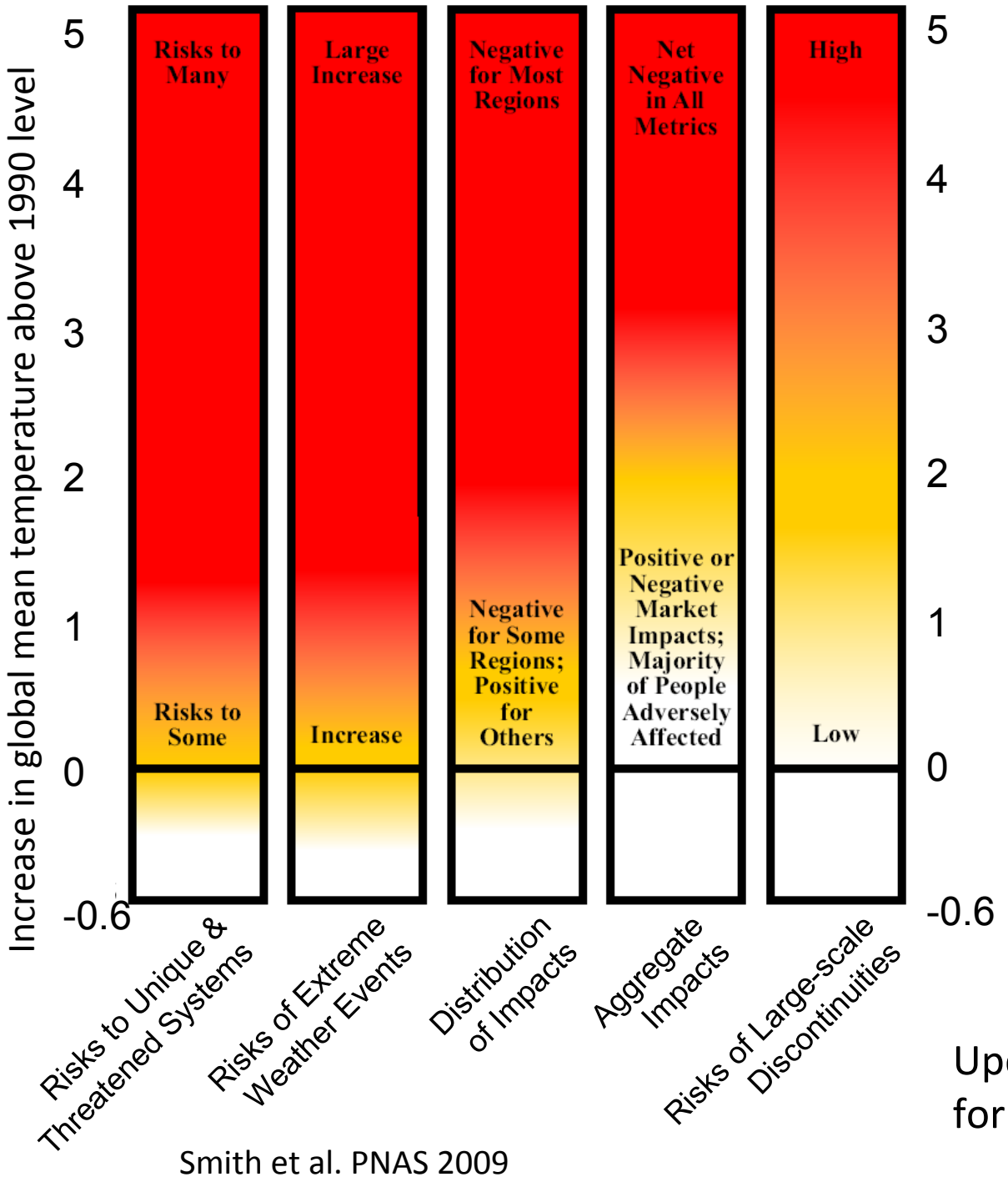
- Steve Schneider (1945-2010)

IPCC procedures

- Hundreds of top scientists
- Comprehensive assessment
- Multi-stage, broad-based, monitored review
- Plenary approval line-by-line, by governments

IPCC reasons for concern

- Schneider et al, Chapter 19, WG2, AR4
  - Risks to unique and threatened systems
  - Risks of extreme weather events
  - Distribution of impacts
  - Aggregate impacts
  - Risks of large-scale discontinuities



Smith et al. PNAS 2009

Updated Reasons for Concern, 2009

Errors in the 2007 IPCC report

- WGII – Himalayan glaciers
- WGII – Netherlands sea level

AR4, WGII, ch 10, p. 493. Glaciers in the Himalaya are receding faster than in any other part of the world (see Table 10.9) and, if the present rate continues, the likelihood of them disappearing by the year 2035 and perhaps sooner is very high if the Earth keeps warming at the current rate.

AR4, WGII, ch 12, p. 547. The Netherlands is an example of a country highly susceptible to both sea-level rise and river flooding because 55% of its territory is below sea level where 60% of its population lives and 65% of its Gross National Product (GNP) is produced.

Climategate

- No problems with any of the science.
- None.

Are the researchers in it for the money?

"Is it any wonder that those who benefit the most from continuing to do nothing emphasize the controversy among scientists and the need for continued research?"

Giere R, Bickle J, Mauldin R. 1991. Understanding Scientific Reasoning. Holt, Rinehart, and Winston.

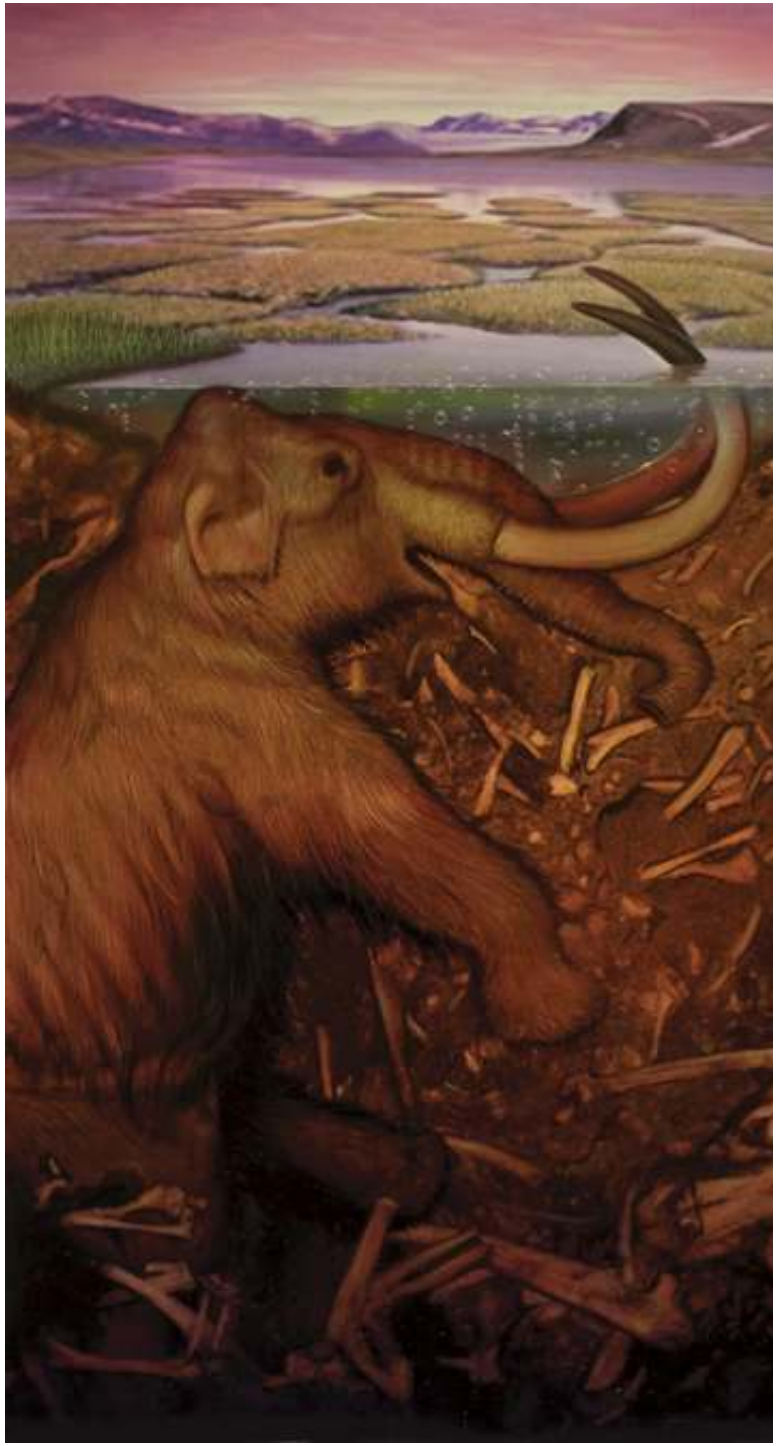
Values

- Present versus future
- Aggregate good versus distributional equity
- Easy versus difficult to monetize
- Human versus non-human stakeholders
- Sensitivity to low-probability, high consequence events (risk aversion)

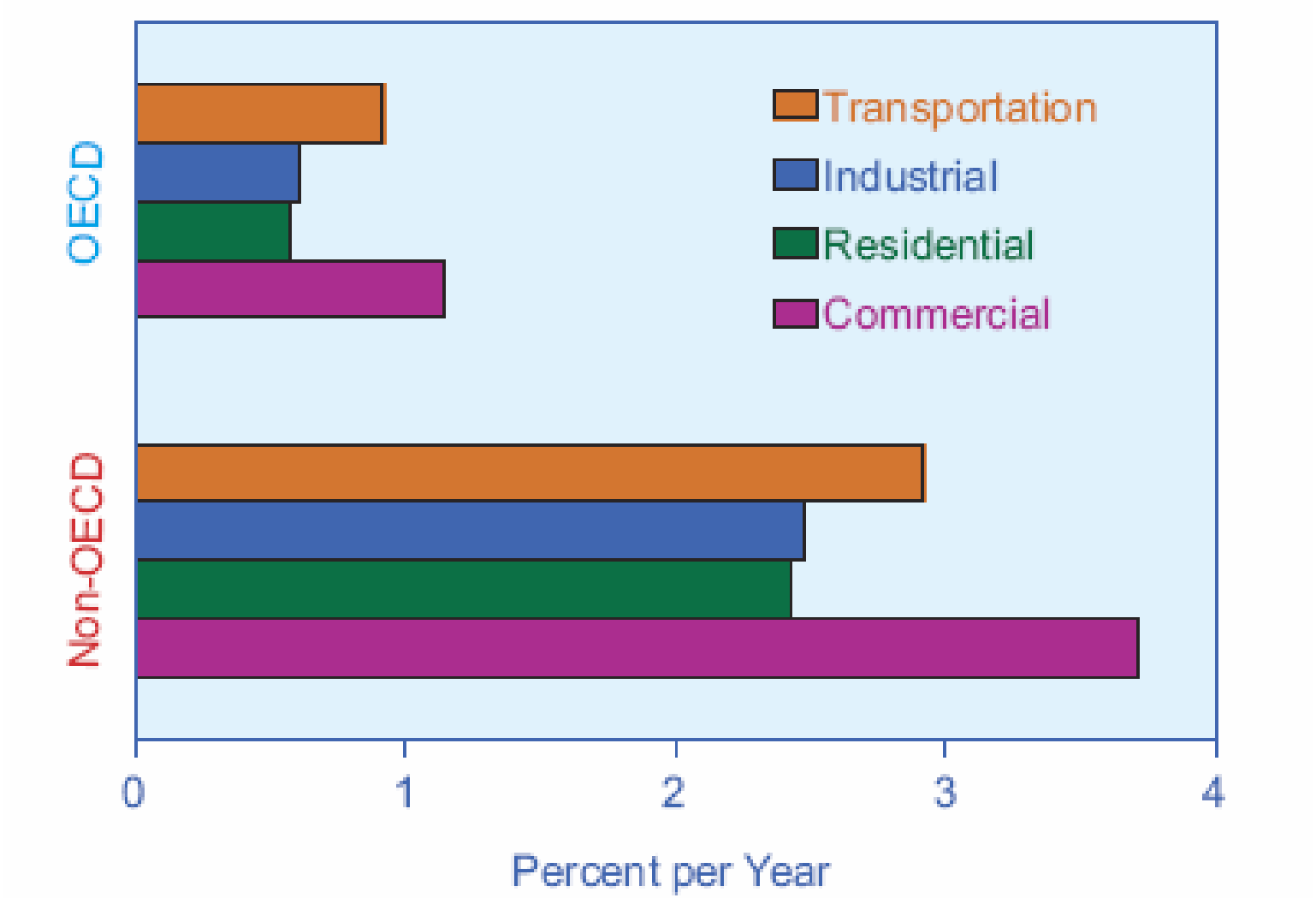
The velocity of climate change

- Solutions take time
  - Science
  - Development
  - Scaling-up / industrialization
  - Scaling up / policy landscape
  - Scaling up / global challenges
  - Avoiding early retirement costs

Energy sources, efficiency, and adaptation change the world incrementally and quantitatively.

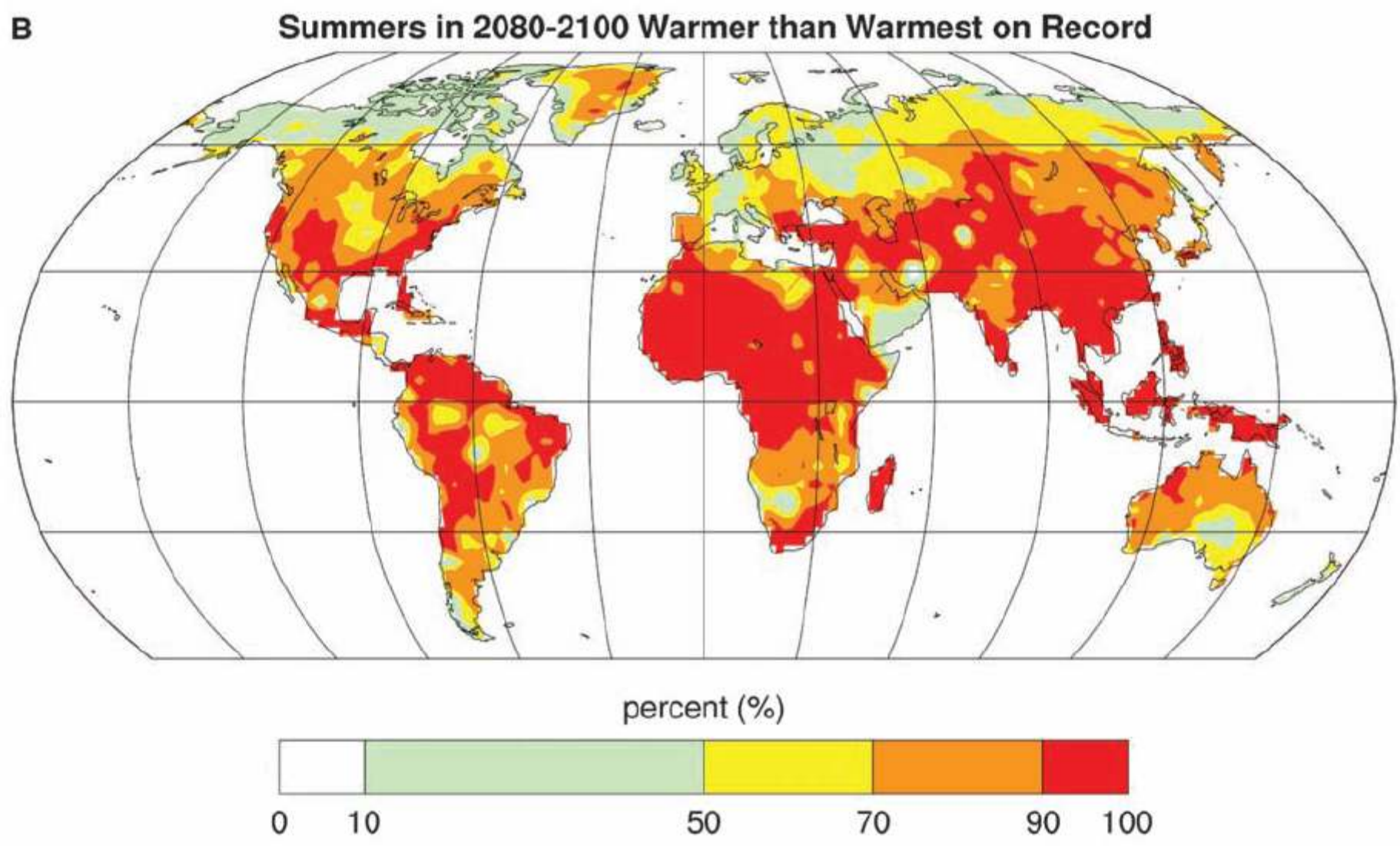


Projected growth in energy demand 2004-2030



EIA 2006

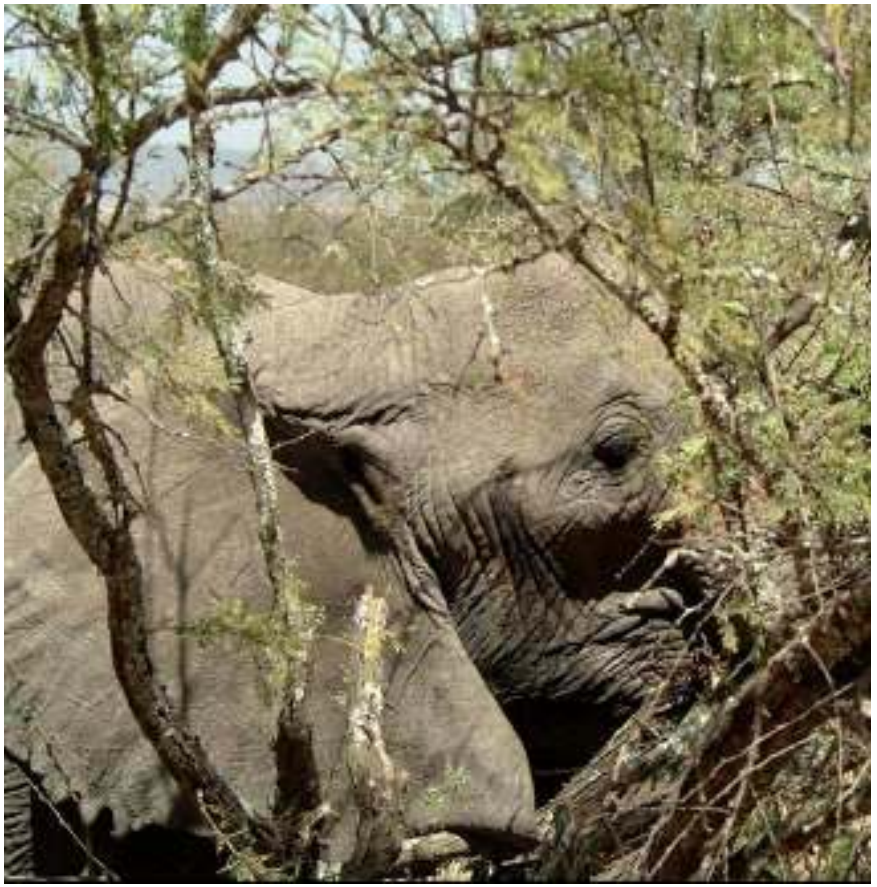
Risk of extreme heat



Battisti and Naylor Science 2009 (A1B scenario, 23 Climate models from IPCC AR4)

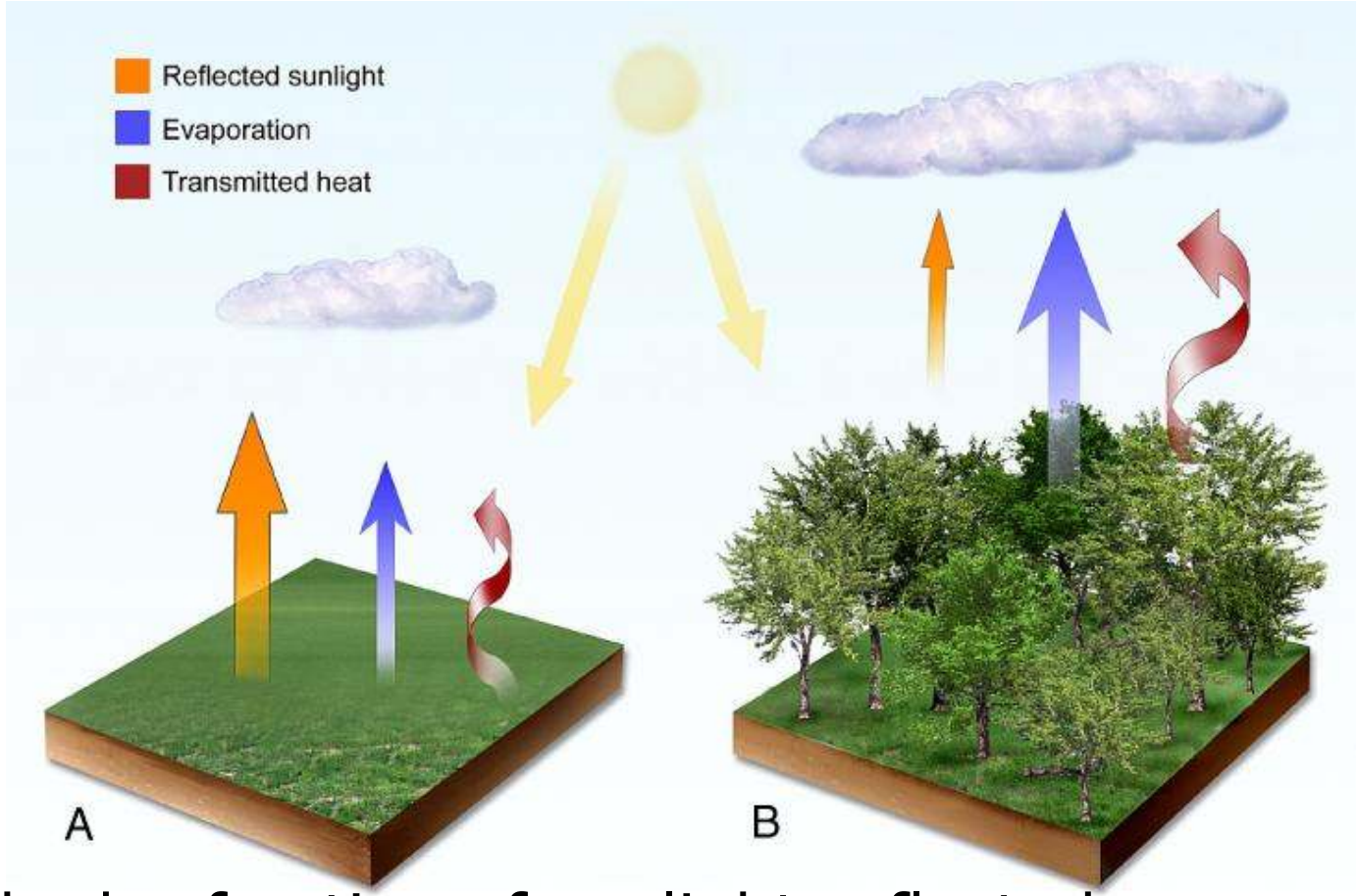
The earliest effects of humans on climate?

Illustration by Tim O'Brien
For article by Adam Wolf
Stanford Magazine, 2008



Dan L Perlman, EcoLibrary.org

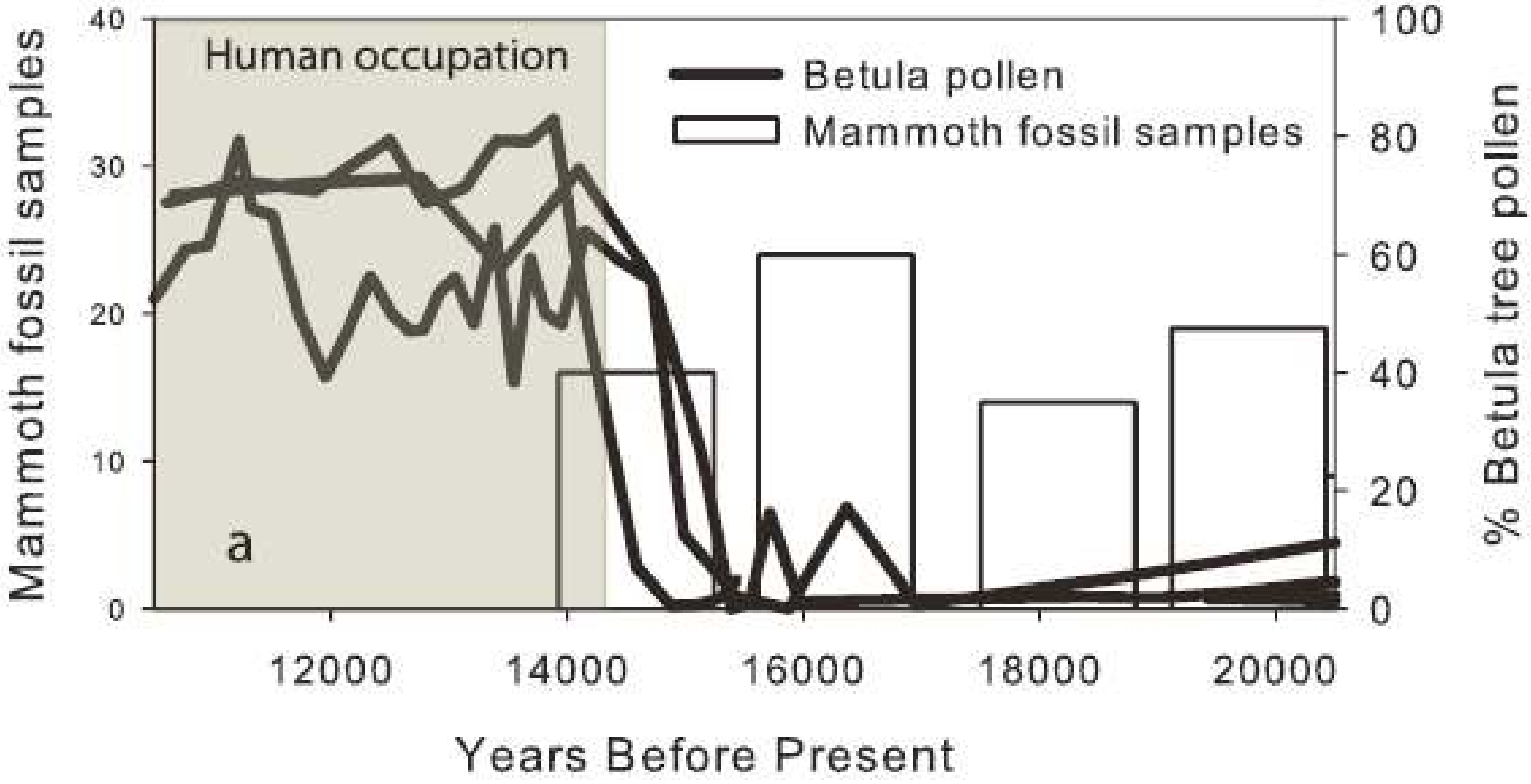
Direct forcing of climate



- Albedo: fraction of sunlight reflected
  - Grassland: ~20%
  - Deciduous forest: ~ 15%
  - Conifer forest: ~ 10%
  - Snow: ~90%

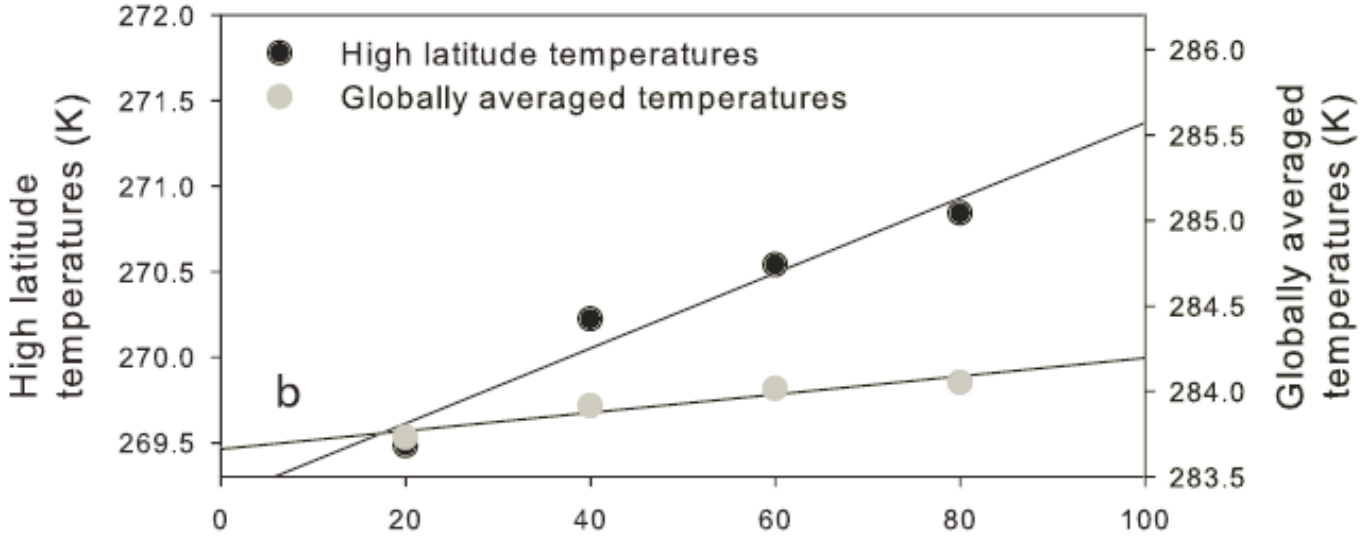
Jackson et al. Env. Res. Let. 2008

Early human climate changes?



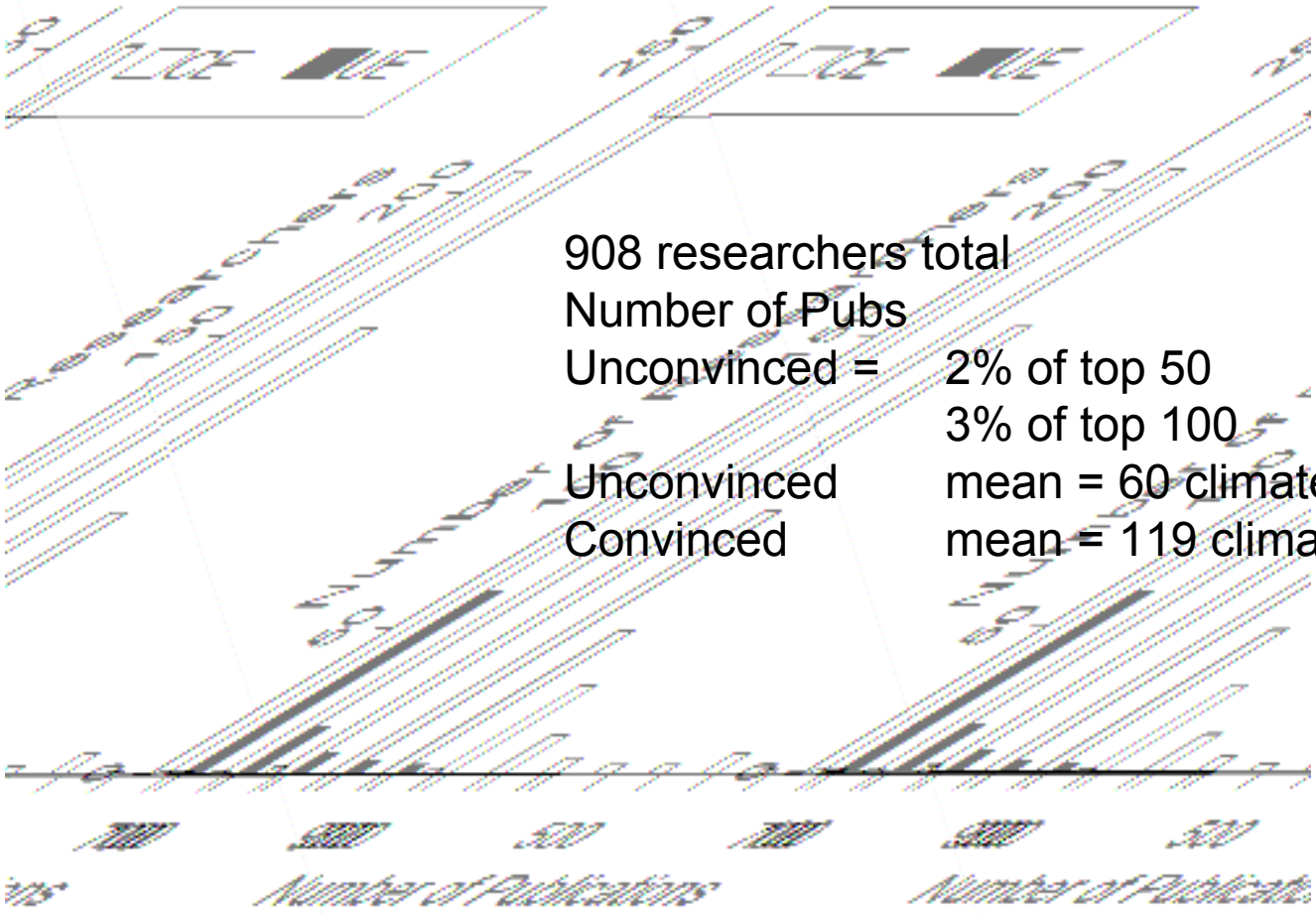
Doughty et al. Geophysical Research Letters, 2010

Climate leverage from early hunting



Doughty et al. Geophysical Research Letters, 2010

Expertise in climate science



Anderegg et al. 2010 PNAS