

What is IPAT and how does it help frame environmental issues?

What are current projections for human population growth, economic growth, and technology?

Why should you be “technological realists” about climate change?

IPAT

Impact on the environment =

Population x

Activity per person (or Affluence) x

Technology (impact per activity).

$$I = P \times A \times T$$

- How many of us are there? How much stuff are we doing? How environmentally damaging is the stuff we're doing?

Units analysis (example)

- 30 miles per gallon x 1 gallon per \$4.50
- = 30 miles per \$4.50 = 6.6 miles per dollar.
- Similarly, IPAT: Impact = Population x Activity per person x Impact per activity

IPAT and climate change

Impact (CO₂ and other GHG emissions) =

Population x

Affluence (GDP* per person) x

Technology (Emissions per unit of GDP).

$$I = P \times A \times T \text{ (now you do the units analysis)}$$

* Gross Domestic Product measures a country's economic output (and income).

IPAT and climate change

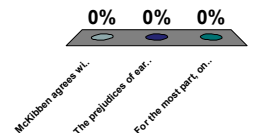
Emissions = Population x GDP per person
x emissions per unit GDP

- What's happening with population?
- What's happening with the economy (GDP per person)?
- What's happening with technology (emissions per unit GDP)?

Which statement is *false* according to the McKibben reading?



1. McKibben agrees with Hardin that we need coercive population control.
2. The prejudices of early social scientists showed up in their work.
3. For the most part, only children are just like other children.



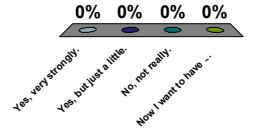


What is McKibben's solution to the population Tragedy of the Commons?

- 0% 1. "Invisible hand"
- 0% 2. "Education"
- 0% 3. "Appeals to conscience"
- 0% 4. "Vigilante action"
- 0% 5. "Mutual coercion"

"The McKibben reading will influence my decisions about family size."

1. Yes, very strongly.
2. Yes, but just a little.
3. No, not really.
4. Now I want to have twelve kids.



IPAT and climate change

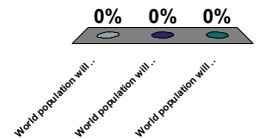
$$\text{Emissions} = \text{Population} \times \text{GDP per person} \times \text{emissions per unit GDP}$$

- What's happening with population?



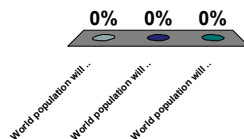
The Lutz et al. reading says that there's an 85% chance that in 2100

1. World population will be <6 billion.
2. World population will be <10 billion.
3. World population will be declining.



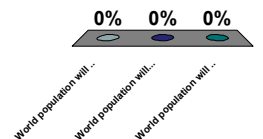
The Lutz et al. reading says that there's a 60% chance that in 2100

1. World population will be <6 billion.
2. World population will be <10 billion.
3. World population will be declining.



The Lutz et al. reading says that there's a 15% chance that in 2100

1. World population will be < 6 billion.
2. World population will be < 10 billion.
3. World population will be declining.



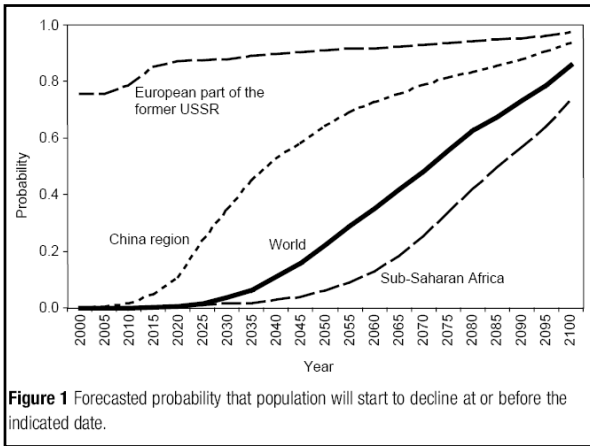
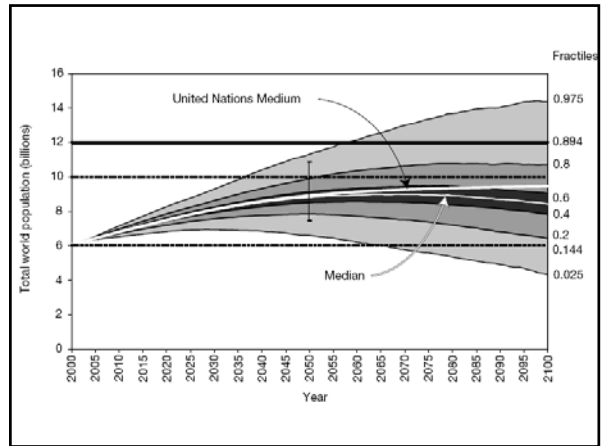
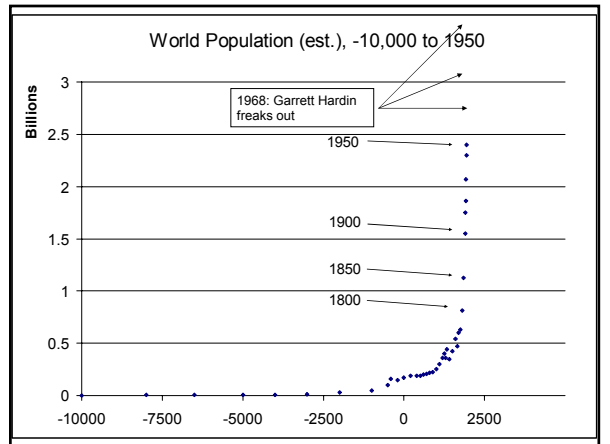
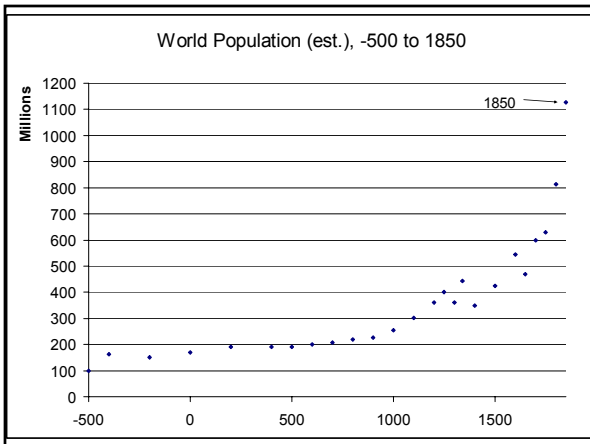
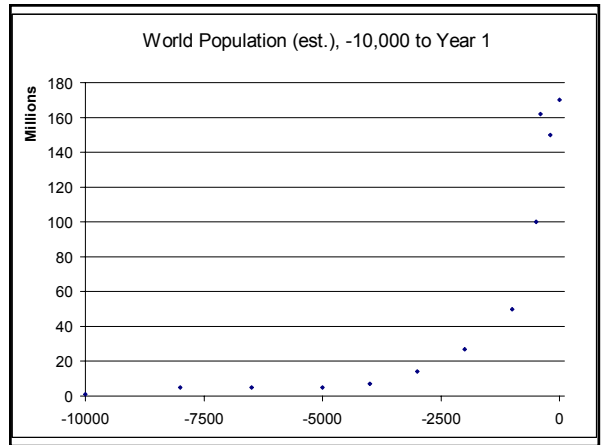


Figure 1 Forecasted probability that population will start to decline at or before the indicated date.



World population estimates

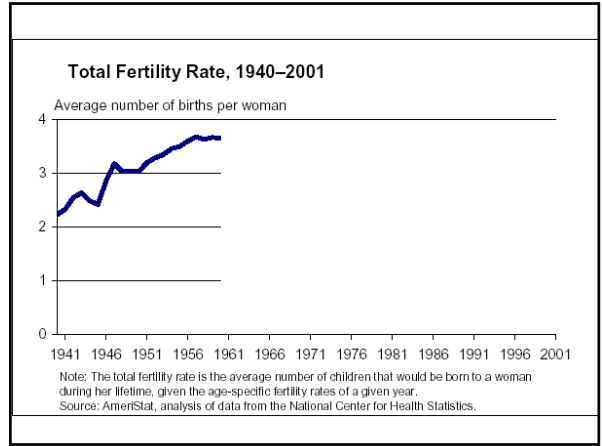
- Population for ≤ 1950 : lower bound estimates from U.S. Census Bureau, [Historical Estimates of World Population](#).
- Population for ≥ 1975 : UN Population Division, [World Population to 2300](#) (2004), Table 1.



Billboard 1968
TOP ROCK'N'ROLL HITS

1 TIGHTEN UP	6 GREEN TAMBOURINE
2 JUDY IN DISGUISE (WITH GLASSES)	7 CRY LIKE A BABY
3 SITTING ON THE ROCK OF THE BAY	8 MONY MONY
4 PEOPLE GOT TO BE FREE	9 YUMMY YUMMY YUMMY
5 CHAIN OF FOOLS	10 THE HORSE

A black and white portrait of a young boy with short hair and glasses, wearing a suit and tie.



How many children did your grandparents have (on average)?

- One
- Two
- Three
- Four
- Five
- Six or more

One	Two	Three	Four	Five	Six or more
0%	0%	0%	0%	0%	0%

How many children did your parents have?

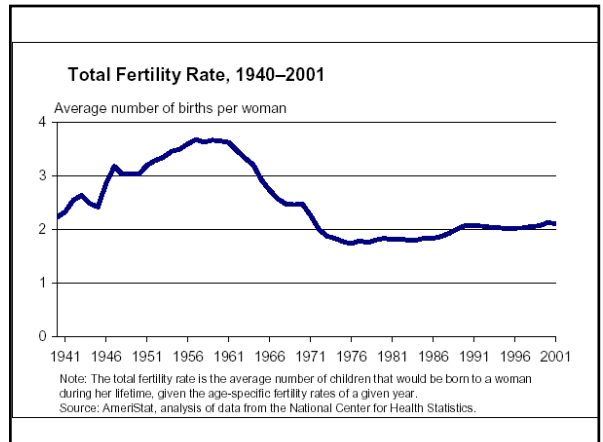
- One
- Two
- Three
- Four
- Five
- Six or more

One	Two	Three	Four	Five	Six or more
0%	0%	0%	0%	0%	0%

How many children do you want?

- One
- Two
- Three or more
- Unsure
- Zero (no kids)
- Zero (adoption)

One	Two	Three or more	Unsure	Zero (no kids)	Zero (adoption)
9%	35%	22%	13%	4%	17%



Demographic transition

- World population is still increasing, but it appears to be heading for a peak of around 9 billion. Why???
- Coercion? Environmental awareness? The invisible hand?
- Mostly just blind luck!
- Is 9 billion a lot or a little?
- The UN's range for 2300 is 2 to 36 billion!

TABLE 26. TEN COUNTRIES OR AREAS WITH HIGHEST AND LOWEST FERTILITY, 1995-2000

Country or area*	Average number of children per woman	
<i>A. Highest fertility</i>		
1. Yemen	7.60	
2. Gaza Strip	7.30	
3. Somalia	7.25	
4. Uganda	7.10	
5. Afghanistan	6.90	
6. Niger	6.84	
7. Angola	6.80	
8. Malawi	6.75	
9. Mali	6.60	
10. Burkina Faso	6.57	
<i>B. Lowest fertility</i>		
1. Spain	1.15	
2. Romania	1.17	
3. Czech Republic	1.19	
4. Italy	1.20	
5. Bulgaria	1.23	
6. Latvia	1.25	
7. Slovenia	1.26	
8. Greece	1.28	
9. Estonia	1.29	
10. Germany	1.30	
WORLD	2.71	

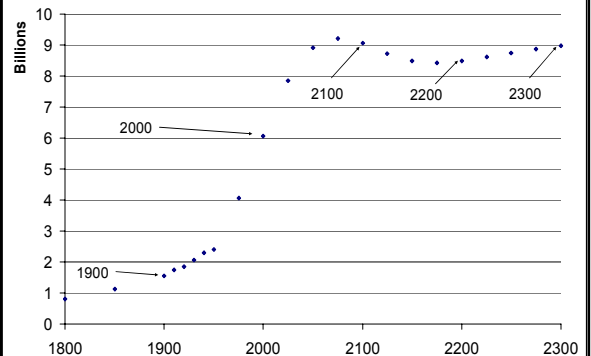
Source: United Nations Population Division.

*Countries or areas with 150,000 persons or more in 1995

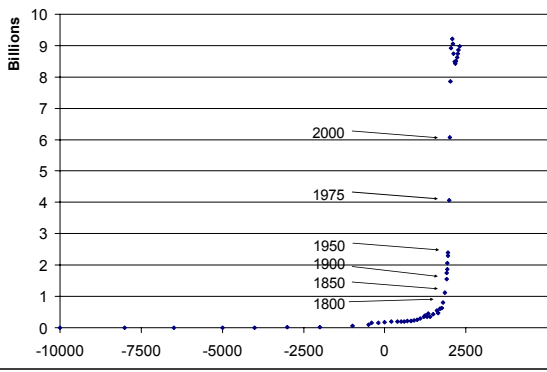
From UN, [The World at Six Billion](#)

- Of the 78 million people currently added to the world each year, 95 percent live in the less developed regions.
- Countries with population over 100 million
 - In 1950: China, India, U.S., Russian federation
 - In 2000, add Indonesia, Brazil, Pakistan, Bangladesh, Japan, Nigeria
 - In 2050, add Ethiopia, Congo, Mexico, Philippines, Vietnam, Iran, Egypt, Turkey.
- World population density will increase from 44 people/sq km in 1999 to 66 in 2050.

World Population (est.), 1800 to 2300



World Population (est.), -10,000 to 2300



IPAT and climate change

$$\text{Emissions} = \text{Population} \times \text{GDP per person} \times \text{emissions per unit GDP}$$

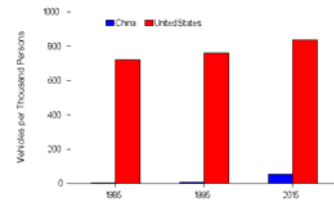
- What's happening with population?
- What's happening with GDP per person?

Per capita GDP

- Gross Domestic Product is a measure of the size of economic activity in a country.
- U.S., 2005: \$42,000 GDP per capita
- China, 2005: \$6,800
- India, 2005: \$3,300
- In 2005, world GDP rose by $\approx 4\text{-}5\%$, so per capita GDP growth was $\approx 3\text{-}4\%$.

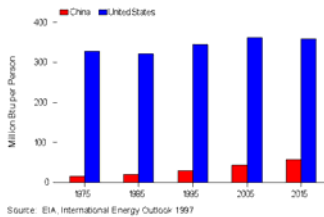
[CIA World Factbook](#)

Vehicles per 1000 People for US and China



Source: J. Dargatzis and D. Gately, Income's Effect on Car and Vehicle Ownership, Worldwide.

Energy Consumption per Capita:
US and China



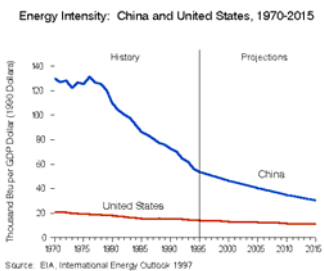
Source: EIA, International Energy Outlook 1997

IPAT and climate change

$$\text{Emissions} = \text{Population} \times \text{GDP per person} \times \text{emissions per unit GDP}$$

- What's happening with population?
- What's happening with GDP per person?
- By 2100, population may be 50% higher, and GDP/person may be 50-500% higher.
- Conclusion: If we're going to reduce GHG emissions, it's gotta be technology.

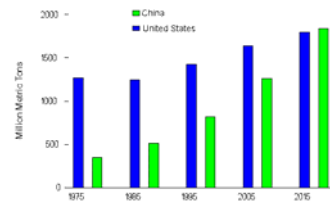
Good news: Energy use per unit of GDP is falling! (Our economies are becoming less energy- and carbon-intensive.)



Source: EIA, International Energy Outlook 1997

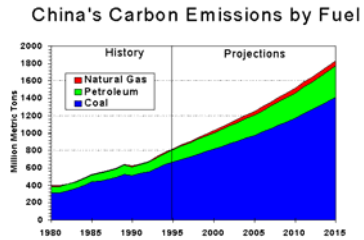
Bad news: The drop in T (technology) has not been keeping pace with increases in P (population) and A (affluence).

US and China Carbon Emissions



Source: EIA, International Energy Outlook 1997

Technological realism: If China and the U.S. keep building coal plants like crazy, IPAT suggests that carbon emissions will not fall.



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