15.992 S-Lab: Laboratory for Sustainable Business
Spring 2008

Ecological and Economic Sustainability

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S-Lab
7 Feb 2008

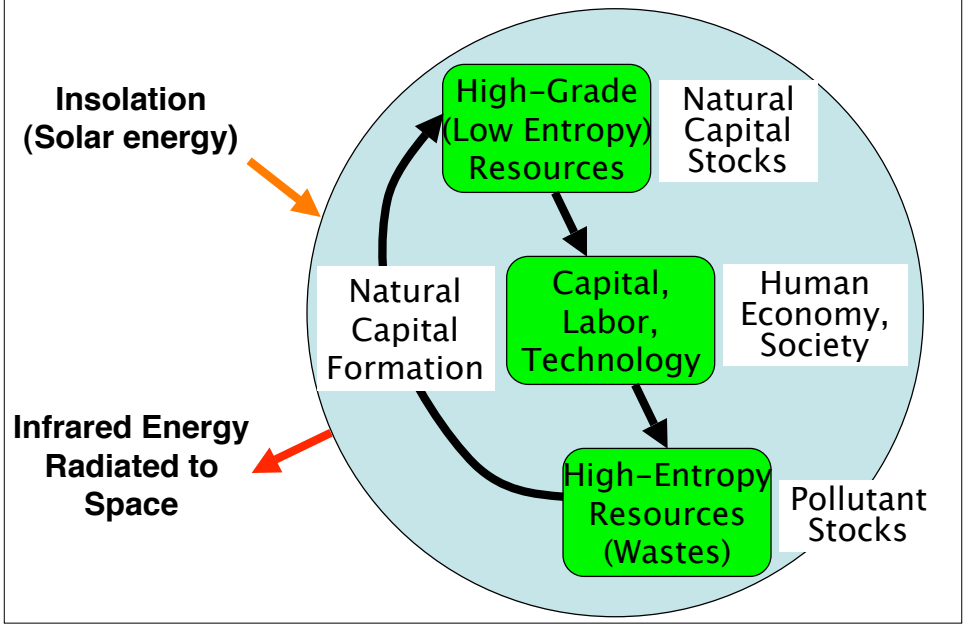
What is sustainability?
What is sustainable development?

Brundtland Commission (1987):

"Sustainable development is development that *meets the needs of the present without compromising the ability of future generations to meet their own needs.*"

http://www.un-documents.net/wced-ocf.htm

A Finite Planet



Necessary Conditions for a Sustainable World

1. **Renewable resources**
   can be used no faster than the rate at which they regenerate.
2. **Pollution and wastes**
   can be emitted no faster than natural systems can absorb them, recycle them, or render them harmless.
3. **Nonrenewable resources**
   can be used no faster than renewable substitutes for them can be introduced.

Source: Herman Daly

1. Renewable resources

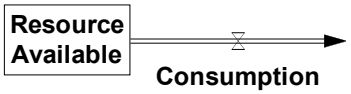
can be used no faster than the rate at which they regenerate.

2. Pollution and wastes

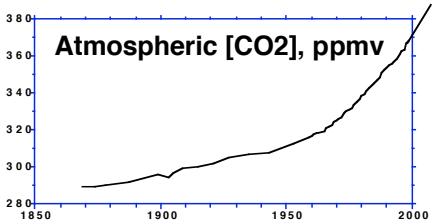
can be emitted no faster than natural systems can absorb them, recycle them, or render them harmless.

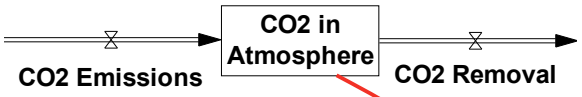
3. Nonrenewable resources

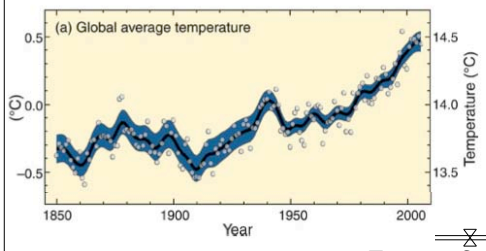
can be used no faster than renewable substitutes can be introduced.



Example: Earth's Energy Balance and Climate Change

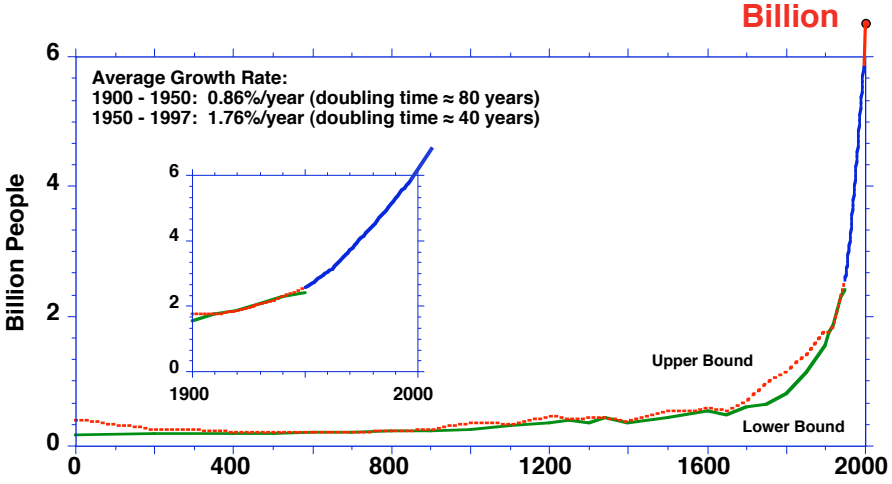






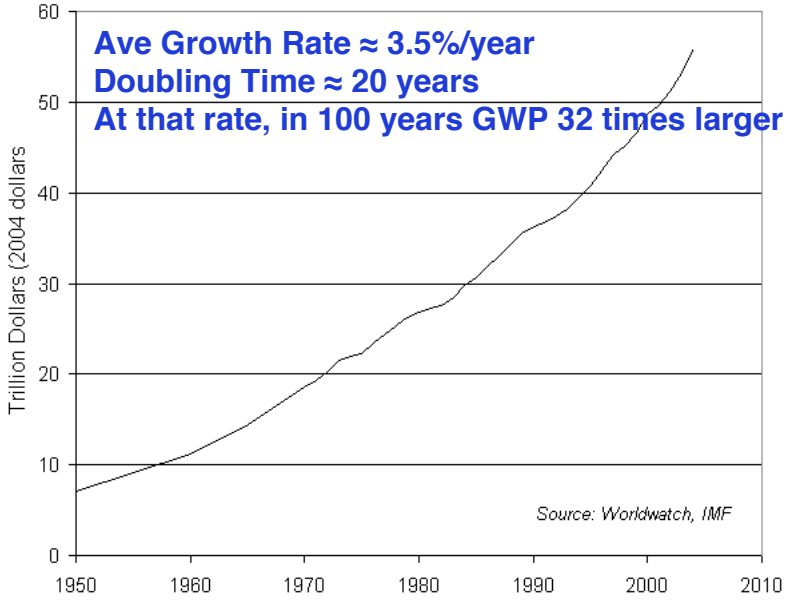
World Population Growth

February 2008:
6.65
Billion

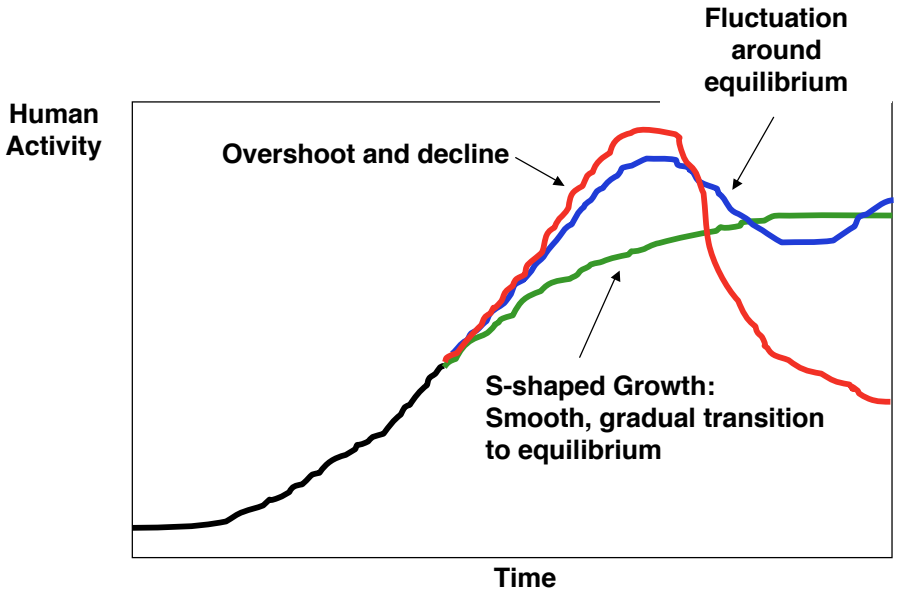


Net Increase today: ≈ 77 million/year

Real Gross World Product, 1950-2004



Possible Futures



How will growth end?

Growth in human activity cannot continue forever on a finite planet.

How will we make the transition?

Voluntarily or involuntarily?

Smoothly & peacefully or catastrophically?

With what population?

What standard of living?

What quality of life?

What degree of equity and social justice?

What role for nature, other species?

IPAT

Impact = Population * Affluence * Technology

Example:

$$\frac{CO_2 \text{ Emissions}}{} = \text{Population} * \frac{\text{Income}}{\text{Capita}} * \frac{\text{Emissions}}{\text{Dollar}}$$

$$\frac{\text{Tons}}{\text{year}} = \text{People} * \frac{\$/\text{Year}}{\text{Person}} * \frac{\text{Tons}}{\$}$$

Impact

=

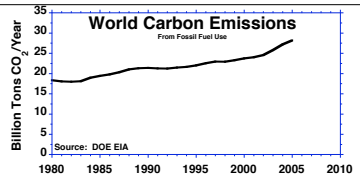
Population

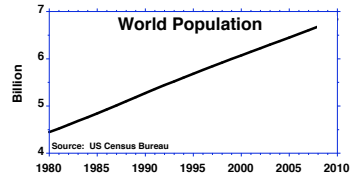
*****

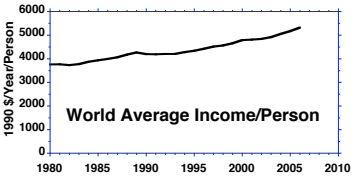
Affluence

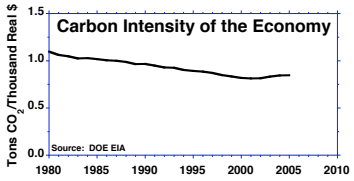
*****

Technology









Impact

=

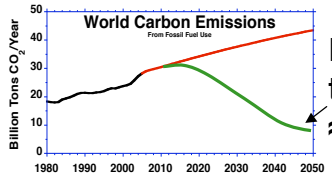
Population

*****

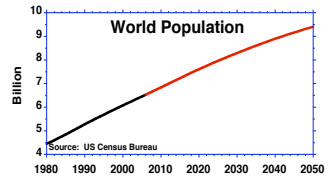
Affluence

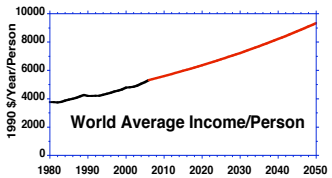
*****

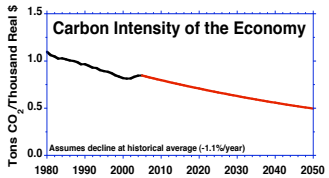
Technology



Emissions required to stabilize [CO2] at ≈ 450-500 ppm





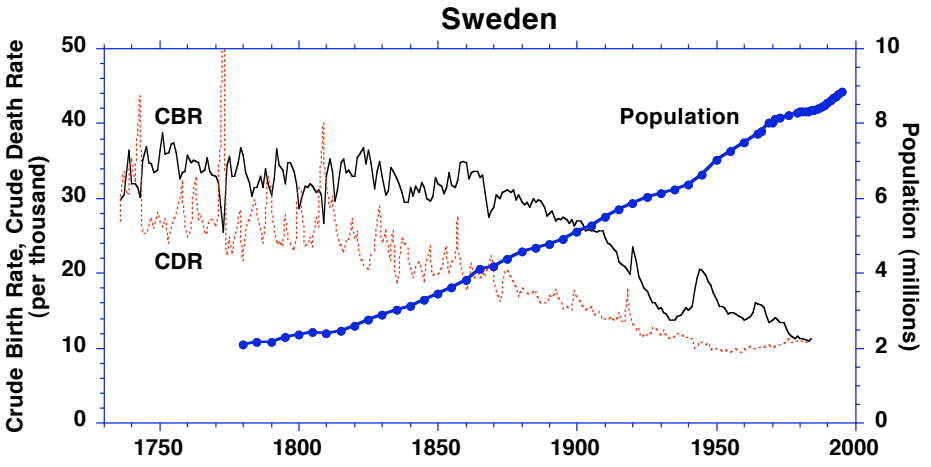


How will we achieve sustainability?

- Better Technology?
- Lower Consumption?
- Lower Population?

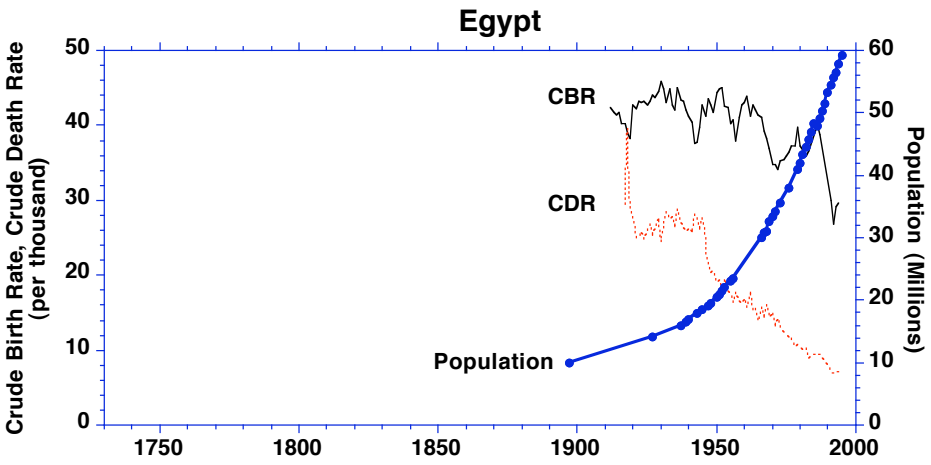
- Huge technical, economic, political, social and ethical issues for each
- All options linked by intricate feedbacks

Demographic Transition: Early Industrializer



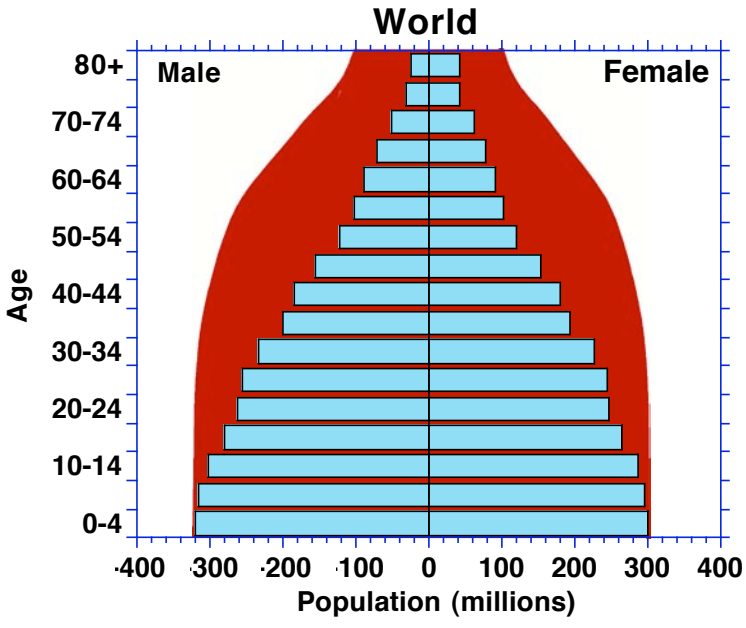
Before industrialization: High Death and Birth Rates -> Slow pop growth
During transition: Death rates fall faster than birth rates -> Rapid growth
After Transition: Low Death and Birth rates -> Slow, no, or even negative growth

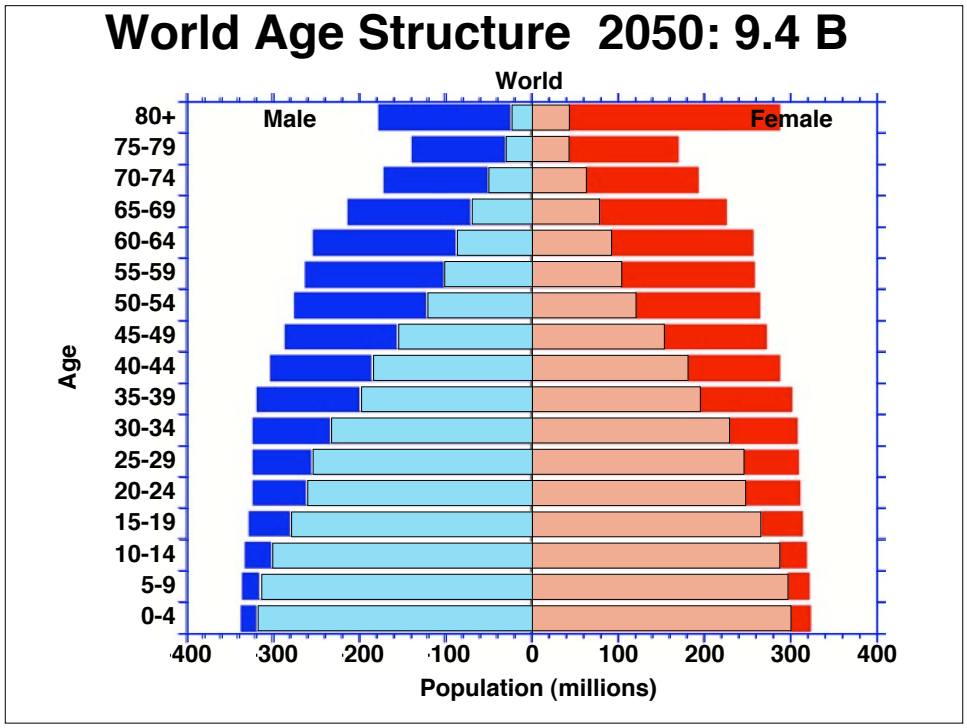
Demographic Transition: Later Industrializer

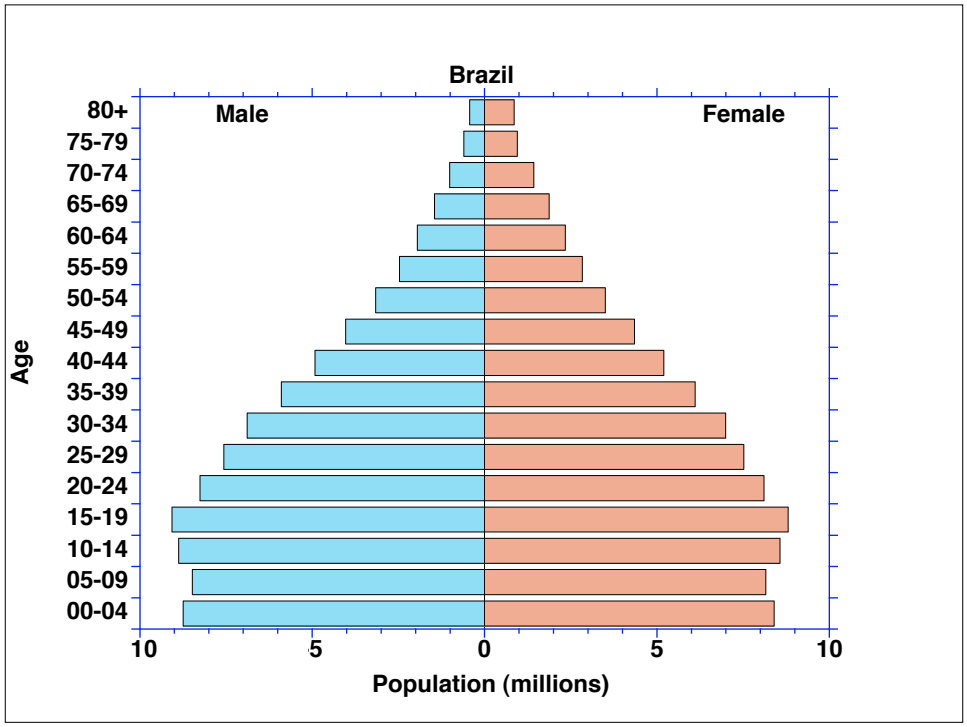


Much faster drop in Death Rate; Same slow decline in Birth Rate.
Result: Faster population growth to higher level before transition complete.

Population Inertia




World Age Structure 2050: 9.4 B
World
Male
Female
80+
75-79
70-74
65-69
60-64
55-59
50-54
45-49
40-44
35-39
30-34
25-29
20-24
15-19
10-14
5-9
0-4
Age
400
300
200
100
0
100
200
300
400
Population (millions)


Brazil
Male
Female
80+
75-79
70-74
65-69
60-64
55-59
50-54
45-49
40-44
35-39
30-34
25-29
20-24
15-19
10-14
05-09
00-04
Age
10
5
0
5
10
Population (millions)

Human Ecological Footprint

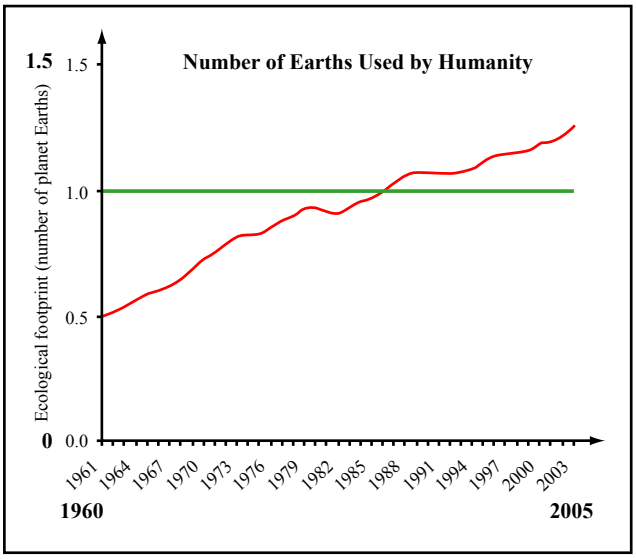


Image by MIT OpenCourseWare. Adapted from Figure 1 in Wackernagel, et al. "Tracking the Ecological Overshoot of the Human Economy." *PNAS* 99, no. 14 (2002): 9266-9271.

Footprint and Biocapacity (Carrying Capacity)

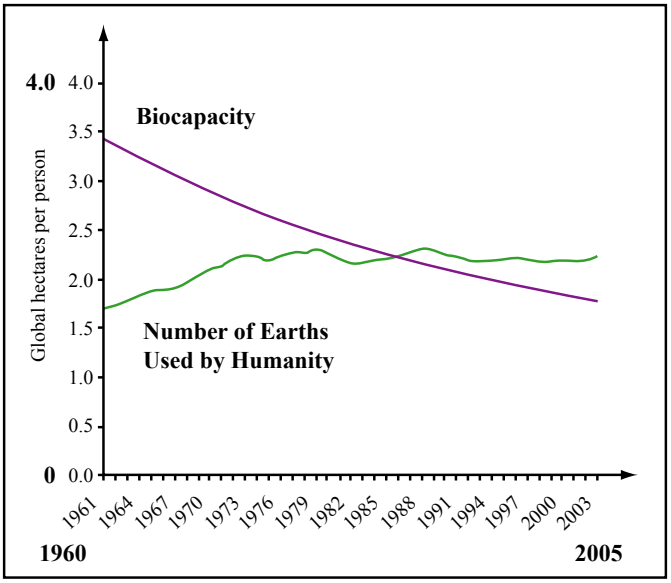
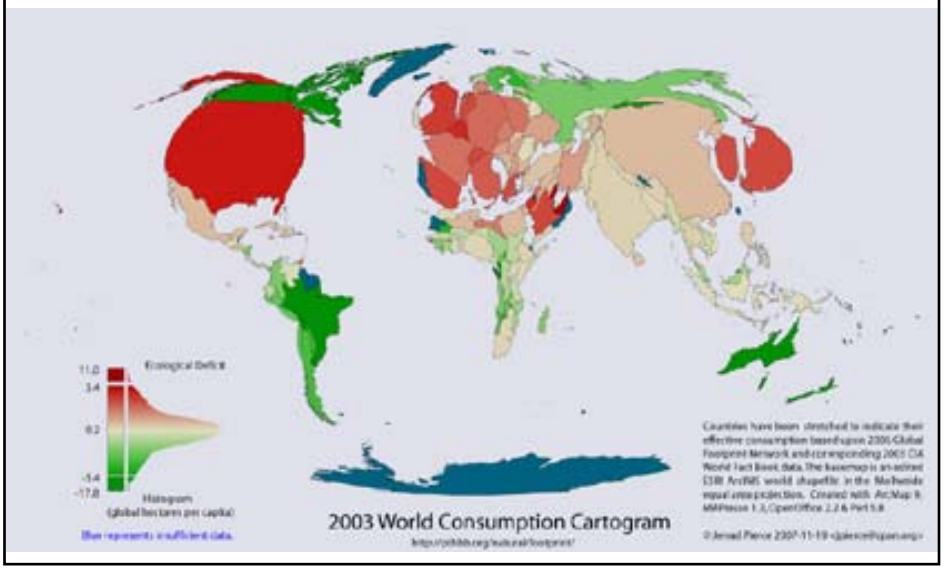


Image by MIT OpenCourseWare.

Ecological Footprint by Region



Courtesy of Jerrad Pierce. Used with permission.

S-Lab Spring 2008 Footprints

CATEGORY (Now)	Low	Median	Mean	High
FOOD	1.00	5.00	**4.87**	7.00
MOBILITY	1.00	2.00	**3.35**	9.00
SHELTER	1.00	4.00	**4.60**	13.00
GOODS/SERVICES	2.00	5.00	**6.29**	17.00
TOTAL FOOTPRINT	9.00	17.00	**19.22**	42.00
IF EVERYONE LIVED LIKE YOU, WE WOULD NEED THIS MANY PLANETS.	2.00	4.00	**4.38**	9.00
CATEGORY (Future)				
FOOD	1.00	4.00	**3.77**	7.00
MOBILITY	-	4.00	**3.92**	8.00
SHELTER	1.00	3.00	**3.48**	9.00
GOODS/SERVICES	-	6.00	**6.27**	18.00
TOTAL FOOTPRINT	4.00	17.00	**17.52**	40.00
IF EVERYONE LIVED LIKE YOU, WE WOULD NEED THIS MANY PLANETS.	1.00	4.50	**4.54**	10.00

My Footprint: No Flying, 2.4; With Flying, 4.7

How much is enough?

How much would you need to spend each year to be happy? That is, how much consumption would be enough to satisfy you?

Consumption spending here means expenditure to provide for the lifestyle you wish to have, including food, clothing, shelter, travel, entertainment, and all other expenditures on goods and services.

Consumption does not include charitable giving, but only what you spend on yourself and your immediate family.

Consumption does not include saving or investment (for example to build future income for retirement).

Consumption does not include payment of income taxes, but only the cost of the goods and services you purchase.

Choose one of the following options:

A. $_____ per year is enough.

B. At least $_____ per year, but more is always better.

How much is enough?
S-Lab Students Spring 2008

	Low	Median	Mean	High
Class Average	$ 5,000	$ 60,000	$ 102,542	$ 750,000
- 1yr MBA	$ 20,000	$ 60,000	$ 100,478	$ 750,000
- 2yr MBA	$ 30,000	$ 50,000	$ 104,000	$ 500,000
- 1yr LFM	$ 5,000	$ 50,000	$ 62,571	$ 200,000
- 2yr LFM	$ 40,000	$ 77,500	$ 98,750	$ 200,000
- Fellows	$ 50,000	$ 165,000	$ 170,000	$ 300,000
- non-Sloan	$ 50,000	$ 50,000	$ 62,000	$ 100,000

GDP/Capita (PPP$/capita, 2004)		**Class Mean/ Average**
US	**$39,676**	**2.62**
High Human Development Nations	**$26,568**	**3.91**
World	**$8,838**	**11.63**
Low Human Development Nations	**$1,113**	**92.33**

(source:UNDP Human Development Report 2006; http://hdr.undp.org/statistics/data/)

More is always better: 58%

Our global civilization is not sustainable

- We depend on nonrenewable resources
- We consume renewable resources faster than they regenerate
- We generate wastes faster than they can be absorbed and rendered harmless
- We have pushed the ecosystems of the planet into new regimes in which we have no experience and do not understand

Growth Is Ending

- **Growth is rapidly deepening our unsustainability**
  - Population (but demographic transition)
  - Economic growth
- **Growth will stop.**
  - Question is not if, but how, when;
  - Voluntarily and peacefully or involuntarily and convulsively?

Innovation,Technology & Markets

- Powerfully *increase* environmental degradation
  - By enabling growth
  - Through unanticipated side effects
- Essential in creating a sustainable world
  - Moderating our impact on the global carrying capacity
  - Repairing the damage we've already done

BUT

There is no purely technological solution to the challenge of creating a sustainable society.

Next Time

What can we do?

What are the barriers to action?

- *Please read:*
  - Repenning and Sterman (2001) Nobody ever gets credit for fixing problems that never happened.
  - Repenning et al. (2001) Past the Tipping Point: The Persistence of Firefighting in Product Development.
  - **In Many Communities, It's Not Easy Going Green, *New York Times* 7 Feb 2008 (on the MIT server) ***NEW*****
- *Please think about the following questions:*
  - Have you ever worked for an "overloaded" organization that was stuck in the "firefighting trap"? Why were you stuck? Did the organization recover? If so, how?
  - What are the major barriers to "going green" inside a for profit corporation? How can they best be overcome?