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QuickTime™ and a decompressor are needed to see this picture.

Principles of Ecological Economics

Guidance for a Sustainable Society

Robert Costanza
Gordon and Lulie Gund Professor of Ecological Economics
and Director, Gund Institute of Ecological Economics
Rubenstein School of Environment and Natural Resources
The University of Vermont
Burlington, VT 05405

Gund Institute for Ecological Economics
University of Vermont
www.uvm.edu/giee

Practical Problem Solving Requires the *Integration* of:

- Vision
  - a. How the world works
  - b. How we would like the world to be
- Tools and Analysis
  - appropriate to the vision
- Implementation
  - appropriate to the vision

Full World Anthroposphere

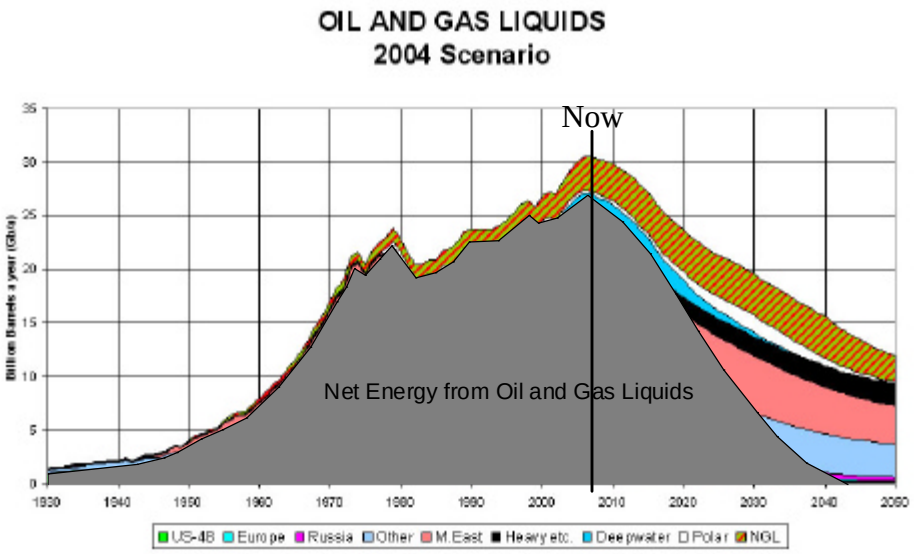
QuickTime™ and a
Cinepak decompressor
are needed to see this picture.

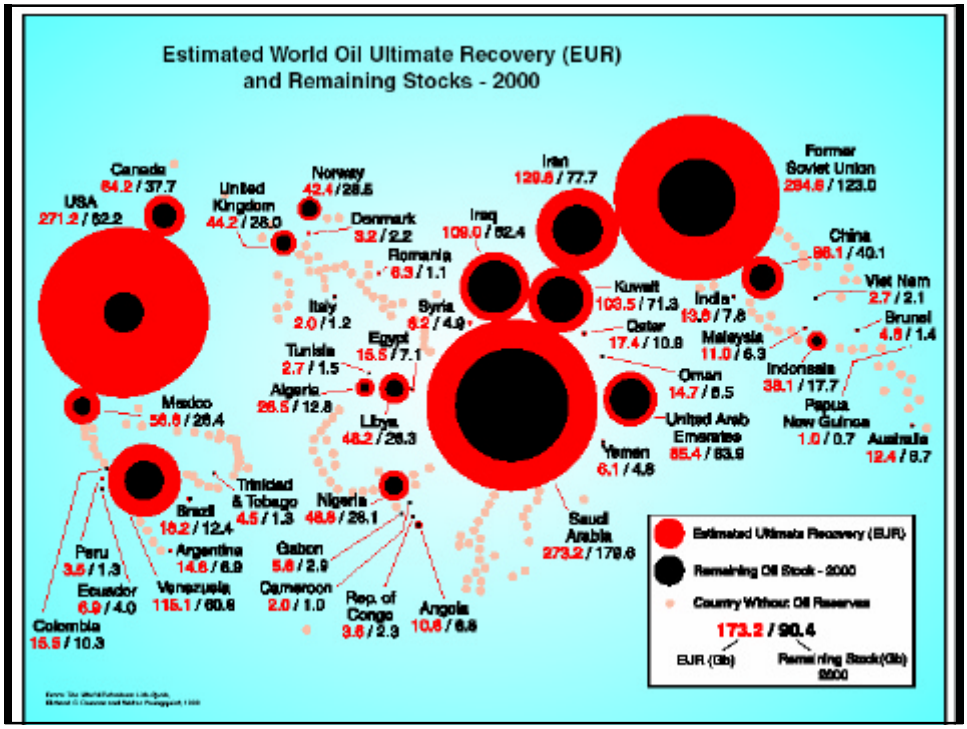
Marc Imhoff

Biospheric Sciences Branch

NASA

OIL AND GAS LIQUIDS 2004 Scenario
Updated by Colin J. Campbell, 2004-05-15





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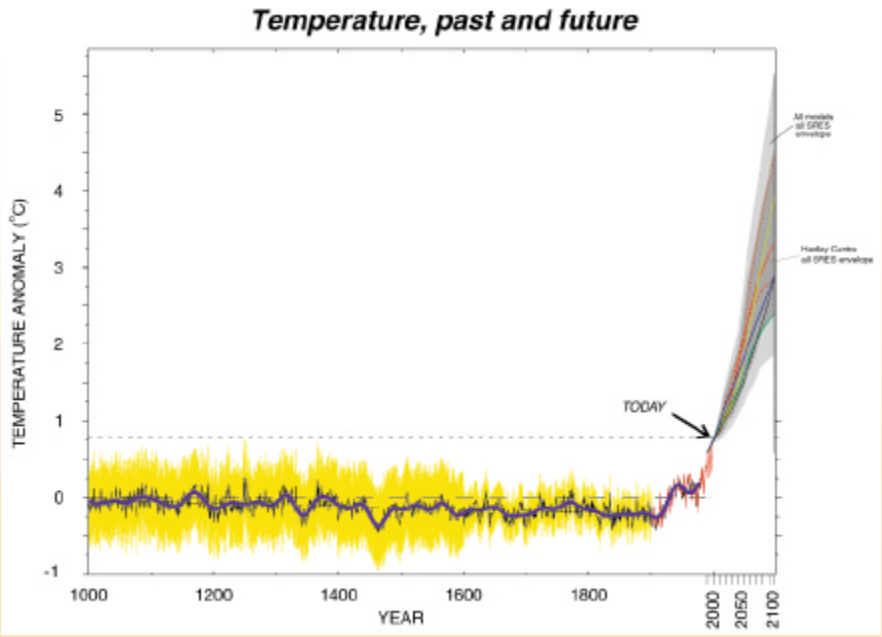
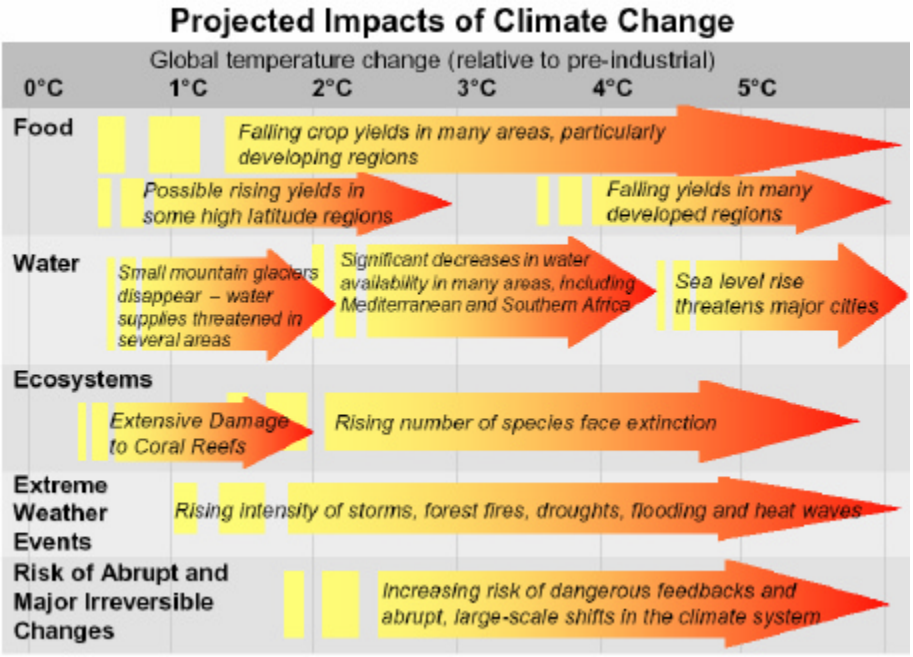
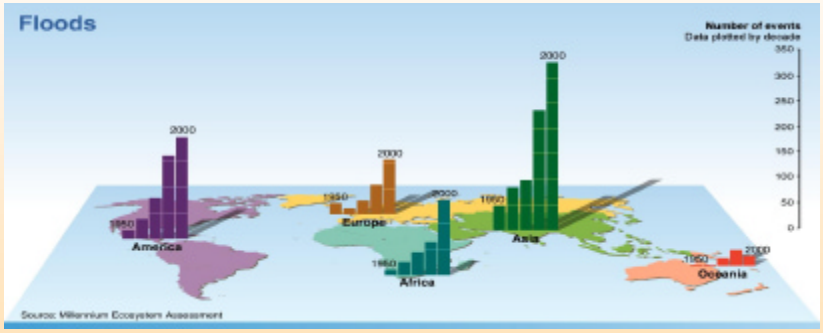


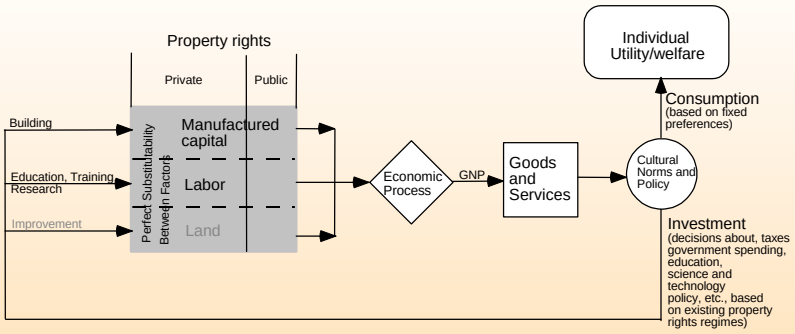


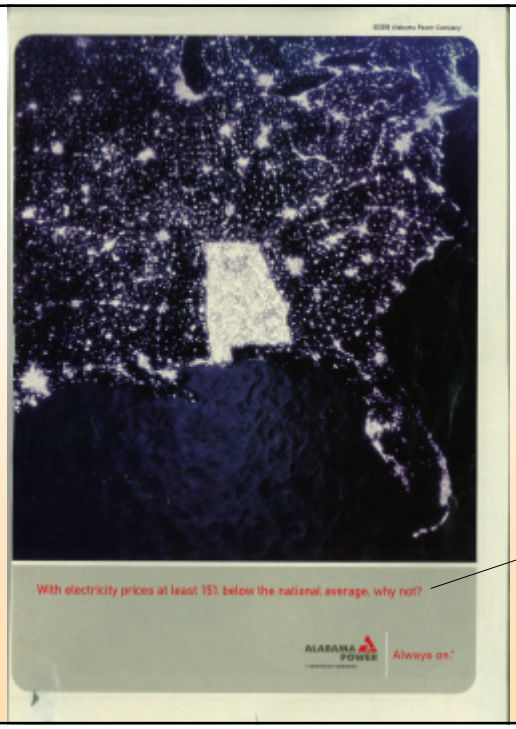
Source: Stern review on the economics of climate change, 2006


Floods
Number of events
Data plotted by decade
350
300
250
200
150
100
50
0
2000
1950
America
Europe
Asia
Africa
Oceania
Source: Millennium Ecosystem Assessment

What is “the economy” and what is it for?

”Empty World" Model of the Economy



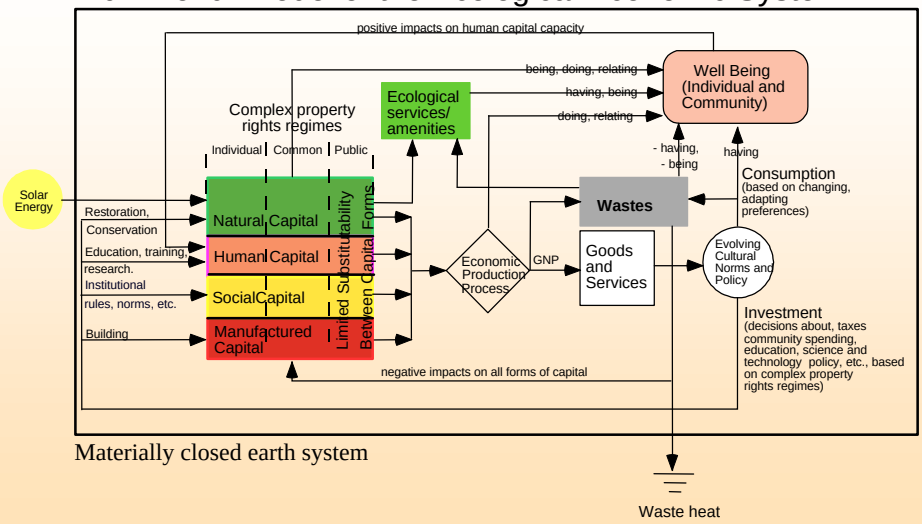


Empty World Energy Planning?

Alabama Power's motto: "Always on"

"With Electricity prices at least 15% below the national average, why not?

"Full World" Model of the Ecological Economic System



Materially closed earth system

From: Costanza, R., J. C. Cumberland, H. E. Daly, R. Goodland, and R. Norgaard. 1997. An Introduction to Ecological Economics. St. Lucie Press, Boca Raton, 275 pp.

Ecological Economics

oikos = "house"
logy = "study or knowledge"
nomics = "management"

Literally: *management of the house (earth) based on study and knowledge of same*

Integrated Questions/Goals:

- Ecologically Sustainable **Scale**
- Socially Fair **Distribution**
- Economically Efficient **Allocation**

Methods:

- Transdisciplinary **Dialogue**
- **Problem** (rather than tools) **Focus**
- **Integrated Science** (balanced synthesis & analysis)
- Effective and adaptive **Institutions**

See: Costanza, R., J. C. Cumberland, H. E. Daly, R. Goodland, and R. Norgaard. 1997. An Introduction to Ecological Economics. St. Lucie Press, Boca Raton, 275 pp.

Some key questions:

- What are humanity's shared goals?
- What is quality of life (QoL) and how do we achieve and sustain it?
- How do natural, social, built and human capital contribute to QoL?
- How do cultures evolve?
- What drives human behavior?
- How do we manage human affairs to achieve our shared goals?

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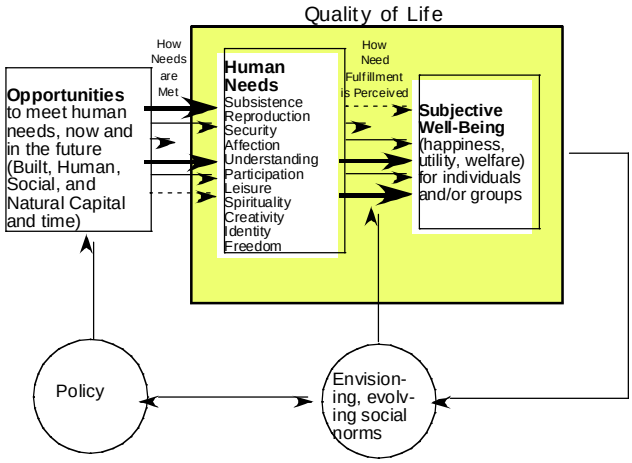
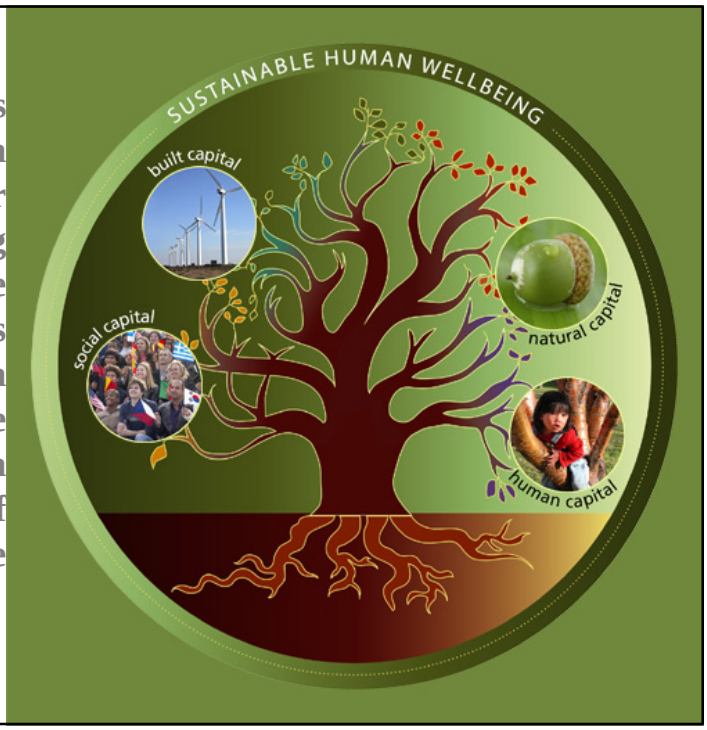
Quality of Life (QOL) as the interaction of human needs and the subjective perception of their fulfillment, as mediated by the opportunities available to meet the needs.



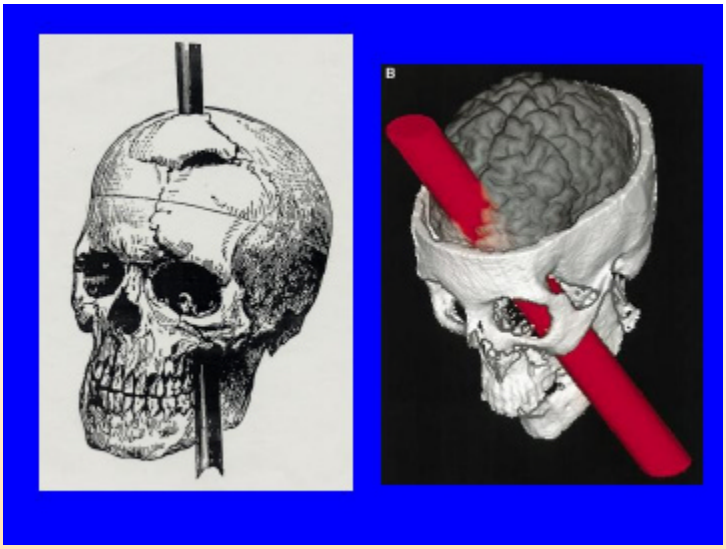
From: Costanza, R., B. Fisher, S. Ali, C. Beer, L. Bond, R. Boumans, N. L. Danigelis, J. Dickinson, C. Elliott, J. Farley, D. E. Gayer, L. MacDonald Glenn, T. Hudspeth, D. Mahoney, L. McCahill, B. McIntosh, B. Reed, S. A. T. Rizvi, D. M. Rizzo, T. Simpatico, and R. Snapp. 2006. Quality of Life: An Approach Integrating Opportunities, Human Needs, and Subjective Well-Being. *Ecological Economics* (in press).

The key is developing a better understanding of the opportunities to create a sustainable future with a high quality of life



More realistic vision of human behavior

- Multiple motivations (personality types, culture, etc.)
- Limited knowledge and "rationality"
- Evolving preferences
- Satisfaction based on relative, rather than absolute, consumption, plus a host of "non-consumption" factors
- Central role of emotions in decision-making and evading social traps
- Embedded in multiscale, complex, adaptive, systems



Phineas Gage

Well-being vs. GDP

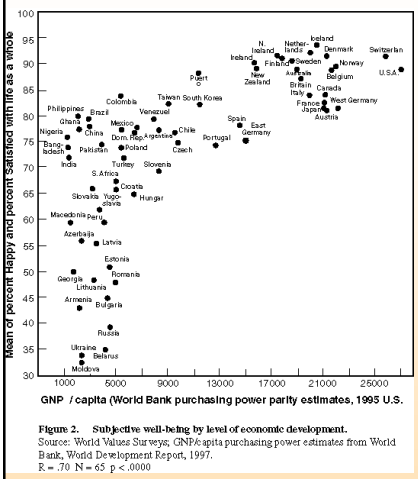
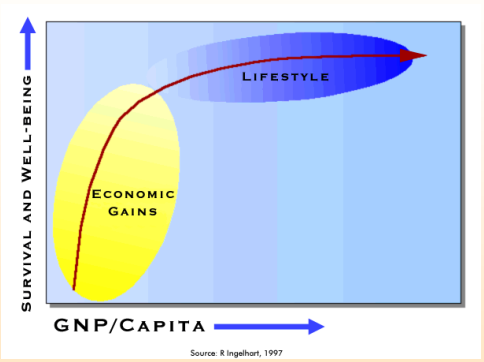
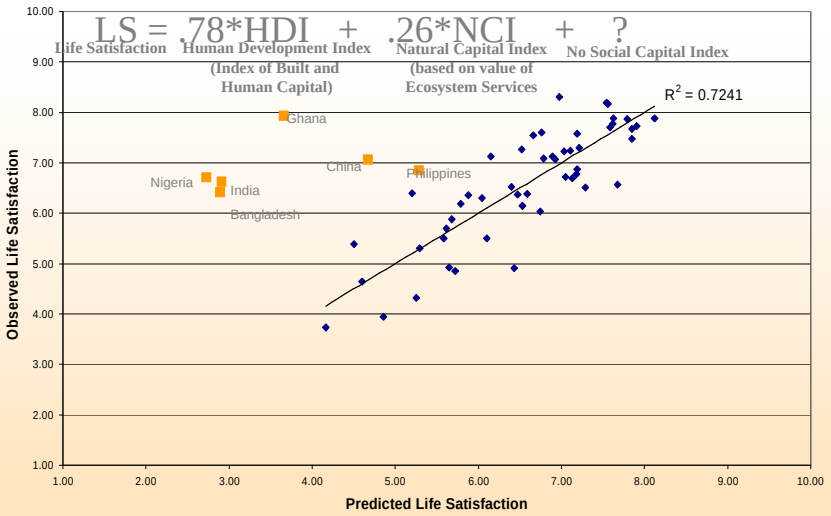


Figure 2. Subjective well-being by level of economic development.
Source: World Values Surveys; GNP/capita purchasing power estimates from World Bank, World Development Report, 1997.
R = .70 N = 65 p < .0000



Observed Life Satisfaction versus Predicted Life Satisfaction



Predicted Life Satisfaction (LS)

From: Vemuri, A. W. and R. Costanza. 2006. The Role of Human, Social, Built, and Natural Capital in Explaining Life Satisfaction at the Country Level: Toward a National Well-Being Index (NWI). *Ecological Economics* (in press).

A range of goals for national accounting and their corresponding frameworks, measures, and valuation methods

Goal	Economic Income: Marketed	Economic Income: Weak Sustainability	Economic Income: Strong Sustainability	Economic Welfare	Human Welfare
Basic Framework	value of marketed goods and services produced and consumed in an economy	1 + non-marketed goods and services consumption	2 + preserve essential natural capital	value of the wefare effects of income and other factors (including distribution, household work, loss of natural capital etc.)	assessment of the degree to which human needs are fulfilled
Non-environmentally adjusted measures	**GNP** (Gross National Product) **GDP** (Gross Domestic Product) **NNP** (Net National Product)			**MEW** (Measure of Economic Welfare)	**HDI** (Human Development Index)
Environmentally adjusted measures	**NNP'** (Net National Product including non-produced assetts)	**ENNP** (Environmental Net National Product) **SEEA** (System of Environmental Economic Accounts)	**SNI** (Sustainable National Income) **SEEA** (System of Environmental Economic Accounts)	**ISEW** (Index of Sustainable Economic Welfare)	**HNA** (Human Needs Assessment)
Appropriate Valuation Methods	Market values	1 + Willingness to Pay Based Values (see Table 2)	2 + Replacement Costs,+ Production Values	3 + Constructed Preferences	4 + Consensus Building Dialogue

From: Costanza, R., S. Farber, B. Castaneda and M. Grasso. 2001. Green national accounting: goals and methods. Pp. 262-282 in: Cleveland, C. J., D. I. Stern and R. Costanza (eds.) The economics of nature and the nature of economics. Edward Elgar Publishing, Cheltenham, England

Genuine Progress Indicator (or ISEW) by Column

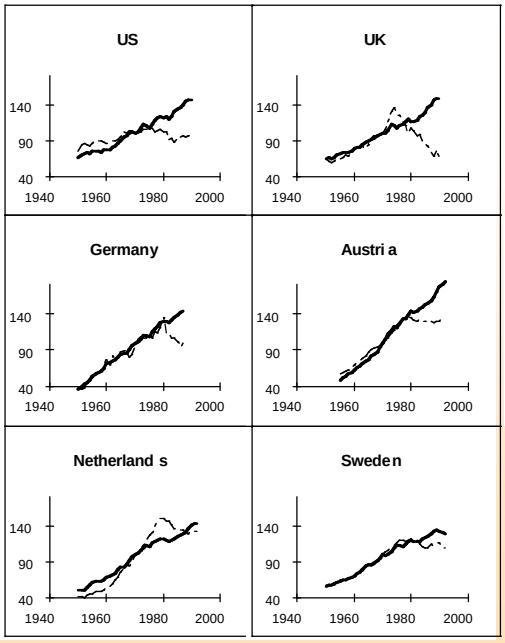
Additions

- Column A: Personal Consumption Expenditures
- Column B: Income Distribution
- Column C: Personal Consumption Adjusted for Income Inequality
- Column D: Value of Household Labor
- Column E: Value of Volunteer Work
- Column F: Services of Household Capital
- Column G: Services Highways and Street

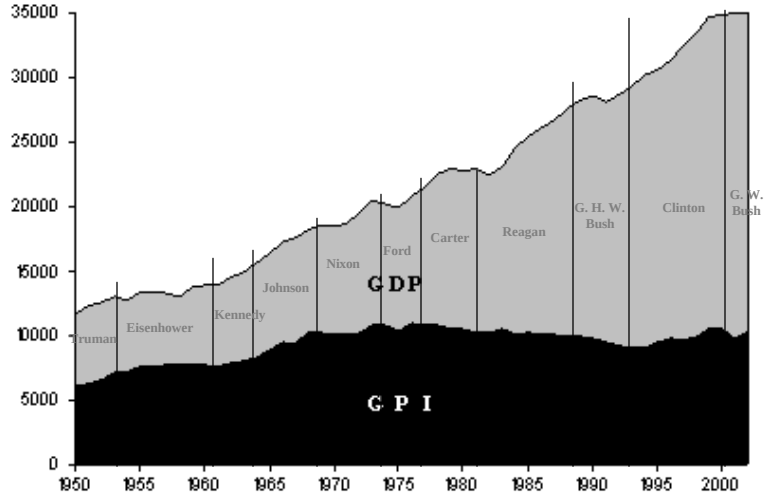
Subtractions

- Column H: Cost of Crime
- Column I: Cost of Family Breakdown
- Column J: Loss of Leisure Time
- Column K: Cost of Underemployment
- Column L: Cost of Consumer Durables
- Column M: Cost of Commuting
- Column N: Cost of Household Pollution Abatement
- Column O: Cost of Automobile Accidents
- Column P: Cost of Water Pollution
- Column Q: Cost of Air Pollution
- Column R: Cost of Noise Pollution
- Column S: Loss of Wetlands
- Column T: Loss of Farmland
- Column U: Depletion of Nonrenewable Resources
- Column V: Long-Term Environmental Damage
- Column W: Cost of Ozone Depletion
- Column X: Loss of Forest Cover
- Column Y: Net Capital Investment
- Column Z: Net Foreign Lending and Borrowing

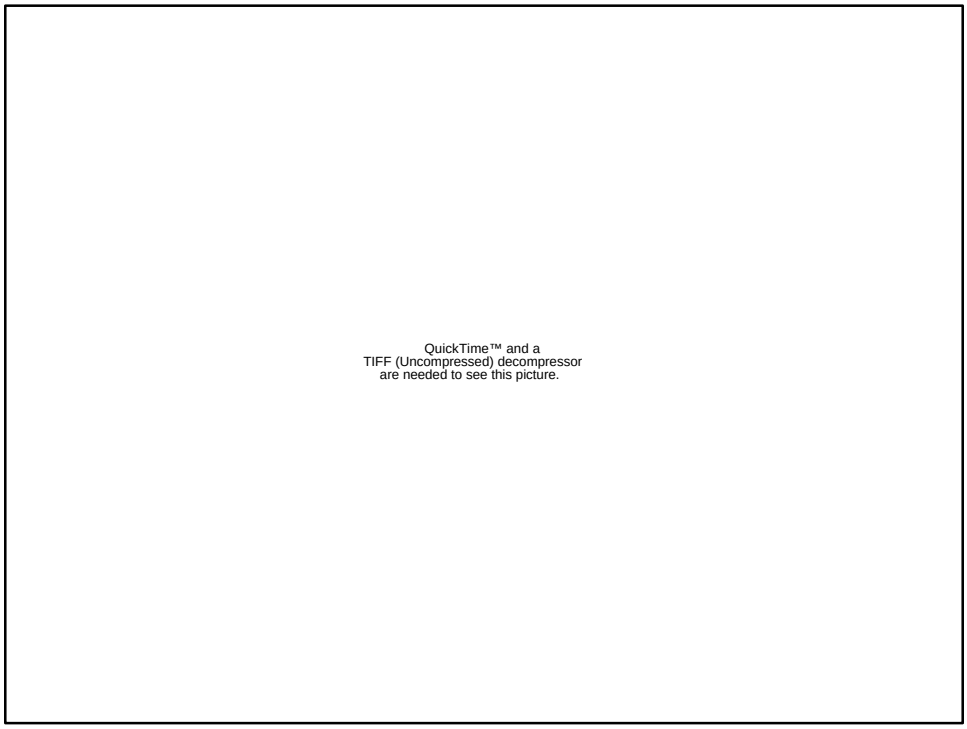
Built Capital
Human Capital
Social Capital
Natural Capital



Indices of ISEW– –
(Index of Sustainable Economic Welfare)
and GDP ——
(1970 = 100)



Gross Production vs. Genuine Progress for the US, 1950 to 2002
(source: Redefining Progress - http://www.rprogress.org)



The Commons

" refers to all the gifts we inherit or create together. This notion of the commons designates a set of assets that have two characteristics:

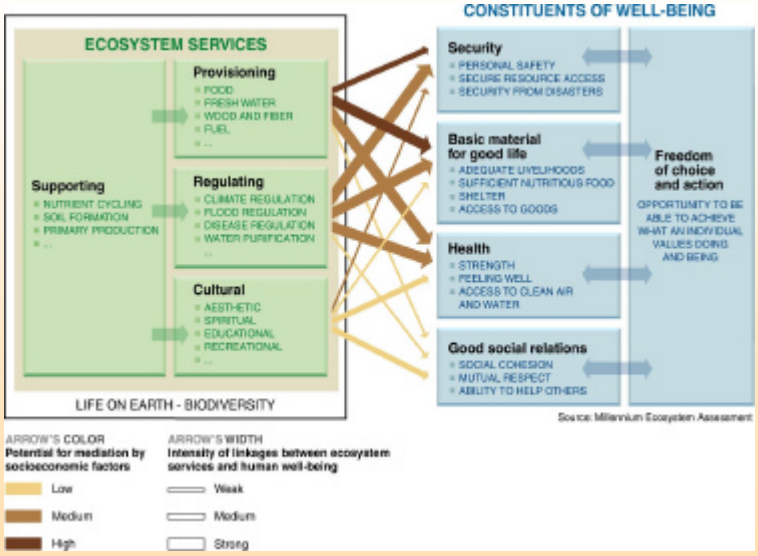
they're all **gifts**, and
they're all **shared**.

A gift is something we receive, as opposed to something we earn.
A shared gift is one we receive as members of a community, as opposed to individually.
Examples of such gifts include air, water, ecosystems, languages, music, holidays, money, law, mathematics, parks, the Internet, and much more".

Peter Barnes, *Capitalism 3.0*

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

Ecosystem Services: the benefits humans derive from ecosystems



Biosphere

QuickTime™ and a
decompressor
are needed to see this picture.

Sea-viewing Wide Field-of-View Sensor (SeaWiFS)
data on marine and terrestrial plant productivity

2nd most cited article in the last 10 years in the Ecology/Environment area according to the ISI Web of Science.

NATURE |VOL 387 | 15 MAY 1997 **253**

article

The value of the world's ecosystem services and natural capital

Robert Costanza*†, Ralph d'Arge‡, Rudolf de Groot§, Stephen Farberk, Monica Grasso†, Bruce Hannon¶, Karin Limburg#, Shahid Naeem, Robert V. O'Neill††, Jose Paruelo‡‡, Robert G. Raskin§§, Paul Suttonkk & Marjan van den Belt¶¶**

** Center for Environmental and Estuarine Studies, Zoology Department, and † Insitute for Ecological Economics, University of Maryland, Box 38, Solomons, Maryland 20688, USA*
‡ Economics Department (emeritus), University of Wyoming, Laramie, Wyoming 82070, USA
§ Center for Environment and Climate Studies, Wageningen Agricultural University, PO Box 9101, 6700 HB Wageninengen, The Netherlands
kGraduate School of Public and International Affairs, University of Pittsburgh, Pittsburgh, Pennsylvania 15260, USA
¶ Geography Department and NCSA, University of Illinois, Urbana, Illinois 61801, USA
 # Institute of Ecosystem Studies, Millbrook, New York, USA
*** Department of Ecology, Evolution and Behavior, University of Minnesota, St Paul, Minnesota 55108, USA*
†† Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee 37831, USA
‡‡ Department of Ecology, Faculty of Agronomy, University of Buenos Aires, Av. San Martin 4453, 1417 Buenos Aires, Argentina
§§ Jet Propulsion Laboratory, Pasadena, California 91109, USA
kkNational Center for Geographic Information and Analysis, Department of Geography, University of California at Santa Barbara, Santa Barbara, California 93106, USA
¶¶ Ecological Economics Research and Applications Inc., PO Box 1589, Solomons, Maryland 20688, USA

The services of ecological systems and the natural capital stocksthat produce them are critical to the functioning of the Earth's life-support system. They contribute to human welfare, both directly and indirectly, and therefore represent part of the total economic value of the planet.We have estimated the current economic value of 17 ecosystem services for 16 biomes, based on published studies and a few original calculations. For the entire biosphere, the value (most of which is outside the market) is estimated to be in the range of US$16–54 trillion ($10^{12}$) per year, with an average of US$33trillion per year. Because of the nature of the uncertainties, thismust be considered a minimum estimate. Global gross national product total is around US$18 trillion per year.

Summary of global values of annual ecosystem services (From: Costanza et al. 1997)

Biome	Area (e6 ha)	Value per ha ($/ha/yr)	Global Flow Value (e12 $/yr)
Marine	**36,302**	**577**	**20.9**
Open Ocean	33,200	252	8.4
Coastal	3,102	4052	12.6
Estuaries	180	22832	4.1
Seagrass/Algae Beds	200	19004	3.8
Coral Reefs	62	6075	0.3
Shelf	2,660	1610	4.3
Terrestrial	**15,323**	**804**	**12.3**
Forest	4,855	969	4.7
Tropical	1,900	2007	3.8
Temperate/Boreal	2,955	302	0.9
Grass/Rangelands	3,898	232	0.9
Wetlands	330	14785	4.9
Tidal Marsh/Mangroves	165	9990	1.6
Swamps/Floodplains	165	19580	3.2
Lakes/Rivers	200	8498	1.7
Desert	1,925		
Tundra	743		
Ice/Rock	1,640		
Cropland	1,400	92	0.1
Urban	332		
Total	51,625		**33.3**

Problems with the *Nature* paper
(as listed in the paper itself)

1. Incomplete (not all biomes studied well - some not at all)
2. Distortions in current prices are carried through the analysis
3. Most estimates based on current willingness-to-pay or proxies
4. Probably underestimates changes in supply and demand curves as ecoservices become more limiting
5. Assumes smooth responses (no thresholds or discontinuties)
6. Assumes spatial homogeneity of services within biomes
7. Partial equilibrium framework
8. Not necessarily based on sustainable use levels
9. Does not fully include “infrastructure” value of ecosystems
10. Difficulties and imprecision of making inter-country comparisons
11. Discounting (for the few cases where we needed to convert from stock to flow values)
12. Static snapshot; no dynamic interactions

Solving any of these problems (except perhaps 6 which could go either way) will lead to larger values

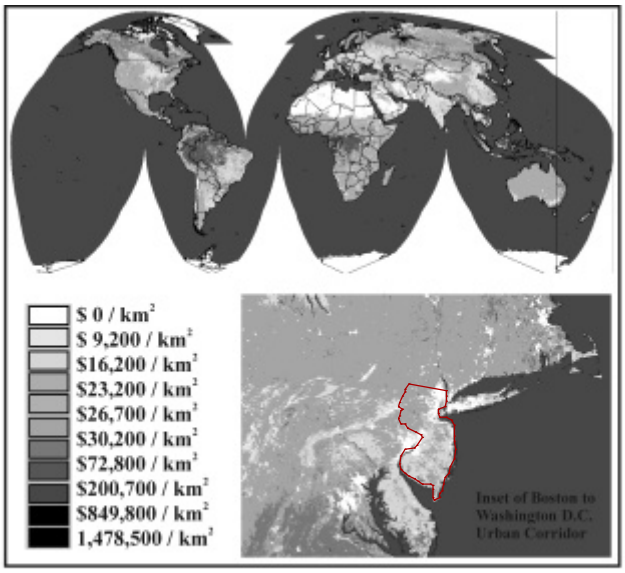
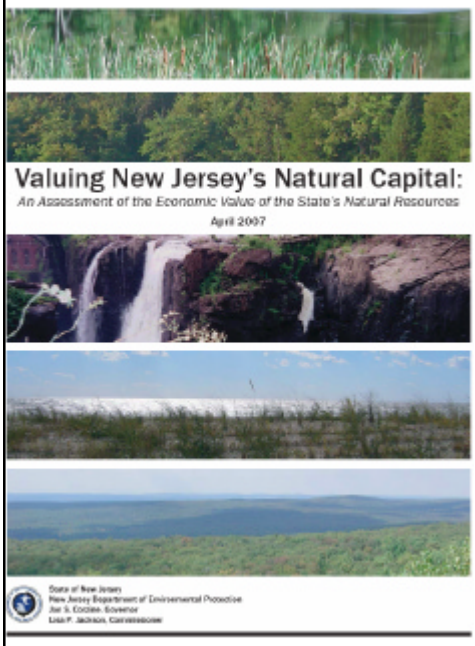
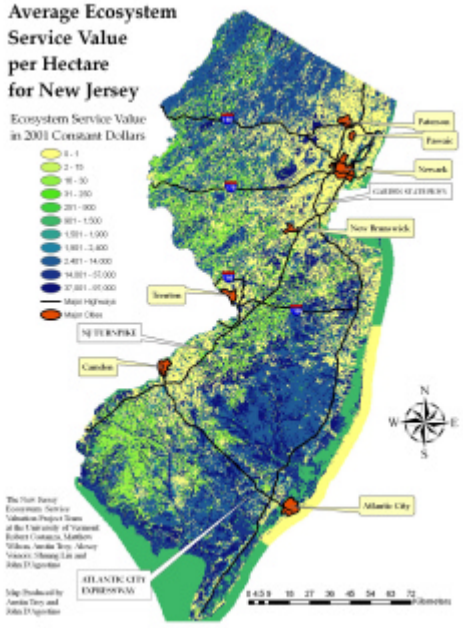


Figure 3: Global Map of Non-Marketed Economic Activity (ESP) arising from Ecosystem Services and derived from Land Cover at 1 km² (For National Totals See Table 1)

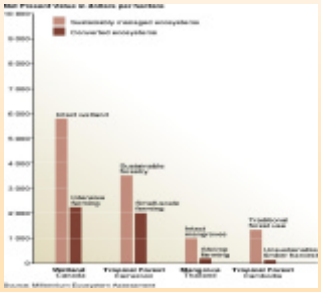
http://www.nj.gov/dep/dsr/naturalcap/





Degradation of ecosystem services often causes significant harm to human well-being

- The total economic value associated with managing ecosystems more sustainably is often higher than the value associated with conversion
- Conversion may still occur because private economic benefits are often greater for the converted system



Economic Reasons for Conserving Wild Nature

Costs of expanding and maintaining the current global reserve network to one covering 15% of the terrestrial biosphere and 30% of the marine biosphere = **$US 45 Billion/yr**

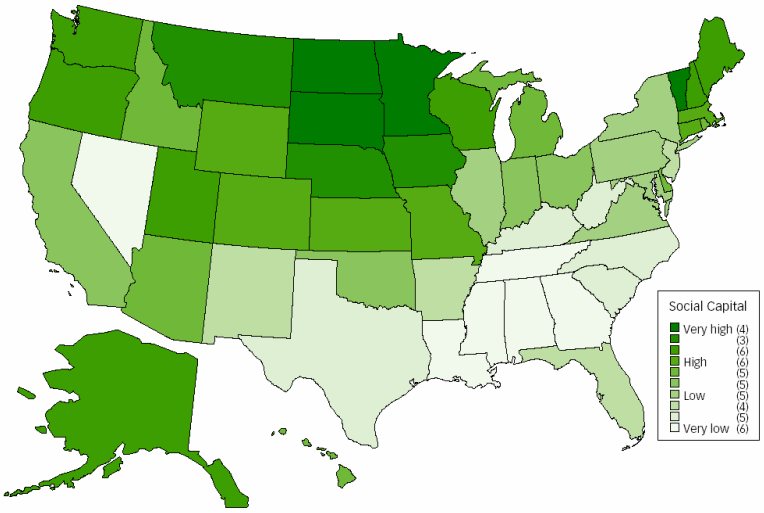
Benefits (Net value* of ecosystem services from the global reserve network) = **$US 4,400-5,200 Billion/yr**

***Net value is the difference between the value of services in a "wild" state and the value in the most likely human-dominated alternative**

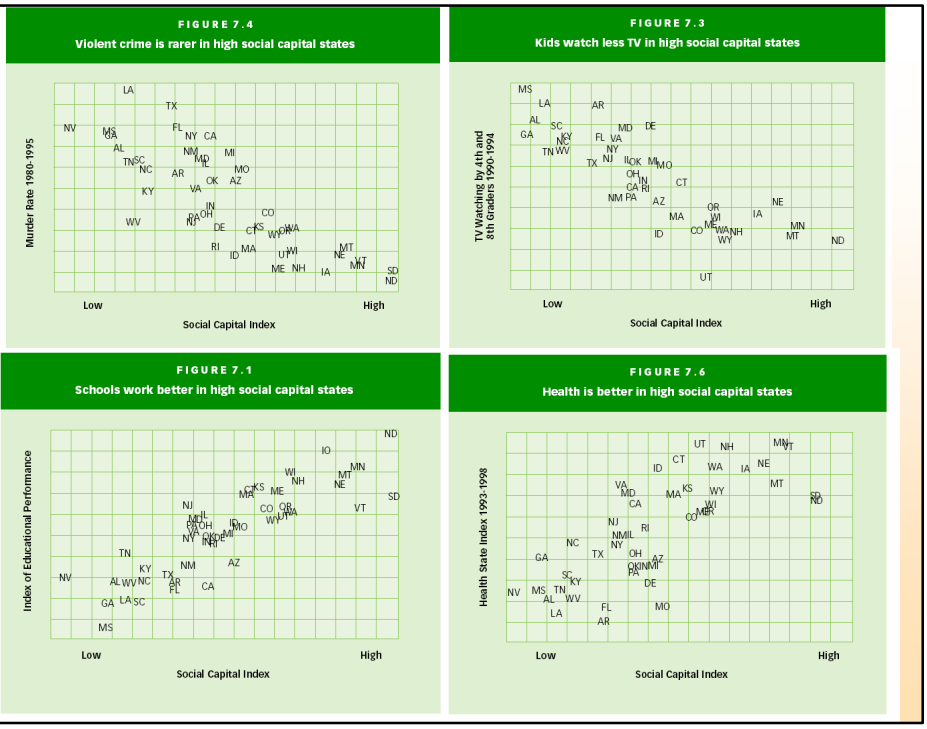
Benefit/Cost Ratio = 100:1

(From: Balmford, A., A. Bruner, P. Cooper, R. Costanza, S. Farber, R. E. Green, M. Jenkins, P. Jefferiss, V. Jessamy, J. Madden, K. Munro, N. Myers, S. Naeem, J. Paavola, M. Rayment, S. Rosendo, J. Roughgarden, K. Trumper, and R. K. Turner 2002. Economic reasons for conserving wild nature. *Science* 297: 950-953)

Social Capital index by State



From: R. Putnam, *Bowling Alone: The Collapse and Revival of American Community* NewYork: Simon and Schuster, 2000).



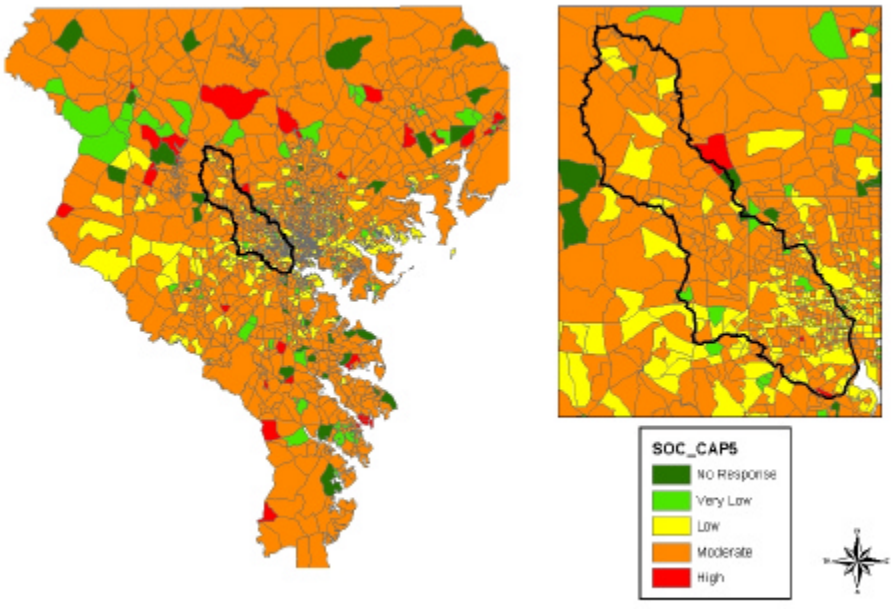
Social Capital Survey Questions

work by: Morgan Grove, Bill Burch, Matt Wilson, and Amanda Vermuri
as part of the Baltimore Ecosystem Study: http://www.ecostudies.org/bes/

- People in the neighborhood are willing to help one another*
- This is a close knit neighborhood*
- People in this neighborhood can be trusted*
- There are many opportunities to meet neighbors and work on solving community problems*
- Churches or temples and other volunteer groups are actively supportive of the neighborhood*
- There is an active neighborhood association
- Municipal (local) government services (such as sanitation, police, fire, health & housing dept) are adequately provided and support the neighborhood's quality

* Included in Social Capital Index; Cronbachs alpha = .7758

Social Capital Index by Census Block Group



Integrated Modeling of Humans Embedded in Ecological Systems

- **Can be used as a Consensus Building Tool in an Open, Participatory Process**
- **Multi-scale in time and space**
- **Acknowledges Uncertainty and Limited Predictability**
- **Acknowledges Values of Stakeholders**
- **Multiple Modeling Approaches, Cross-Calibration, and Integration**
- **Evolutionary Approach Acknowledges History, Limited Optimization, and the Co-Evolution Human Culture and Biology and the Rest of Nature**

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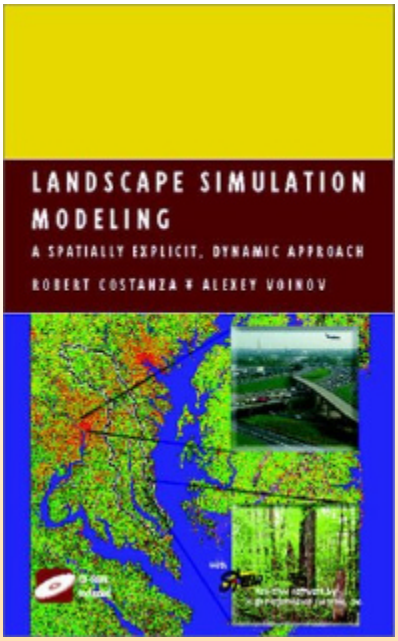

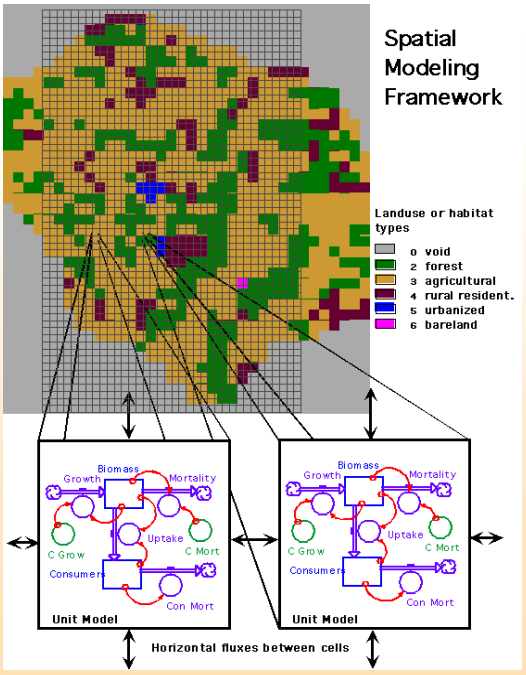

Ecosystem services:
Dynamics, Modeling and Valuation to Facilitate Conservation
Project funded by the Gordon and Betty Moore Foundation
http://www.uvm.edu/giee/?Page=events/ecosystemconference/index.html

Project Goals

Outcome 1. A suite of dynamic ecological economic computer models specifically aimed at integrating our understanding of ecosystem functioning, ecosystem services, and human well-being across a range of spatial scales.

Outcome 2. Development and application of new valuation techniques adapted to the public goods nature of most ecosystem services and *integrated with the modeling work*

Outcome 3. Web-based delivery of the integrated models & results to a broad range of potential users.

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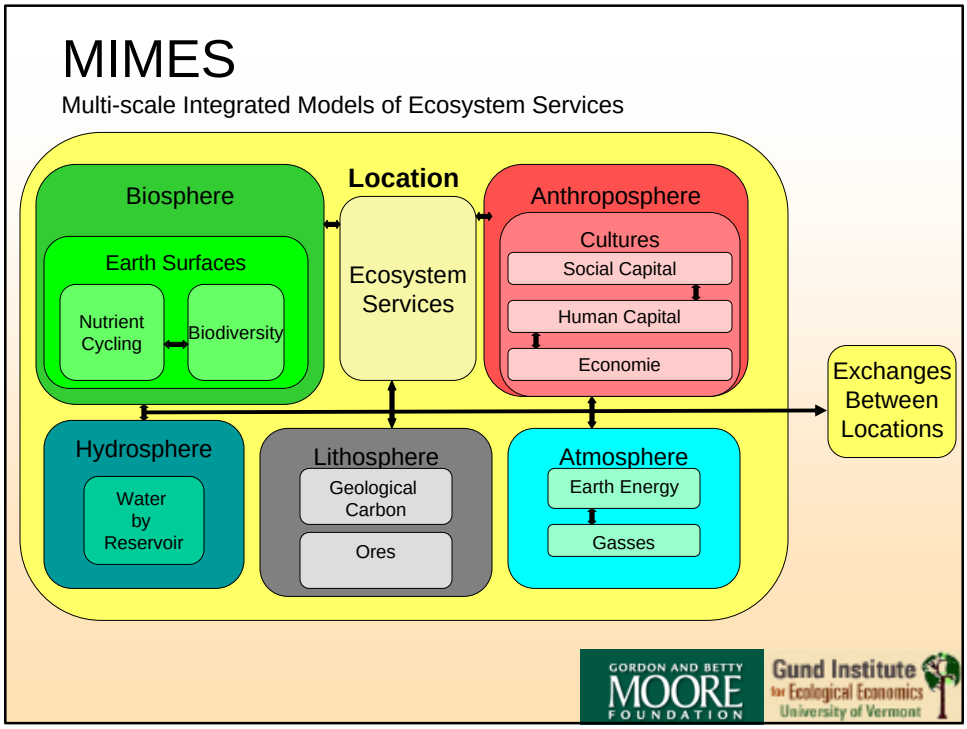
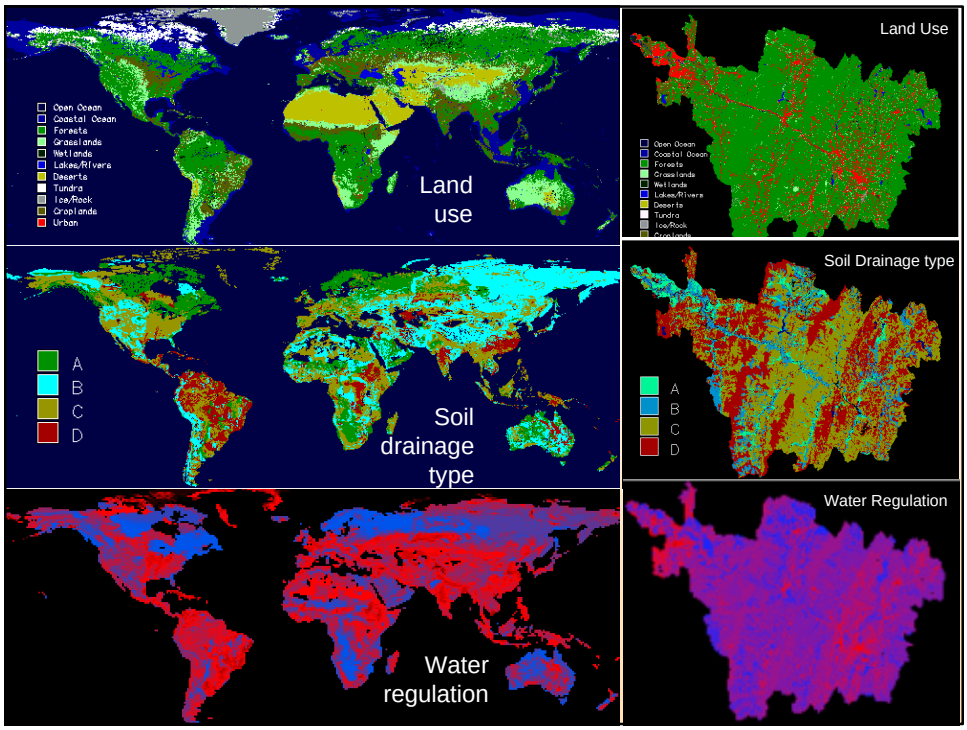
Collaborative Model Development

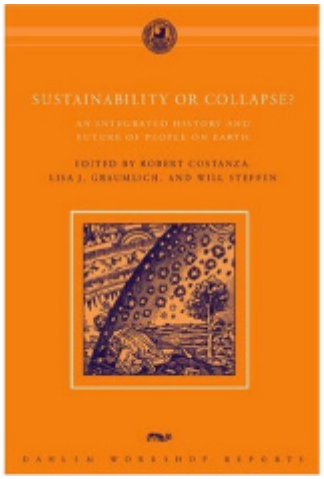

MIMES
Multi-scale Integrated Models of Ecosystem Services
Biosphere
Earth Surfaces
Nutrient Cycling
Biodiversity
Location
Ecosystem Services
Anthroposphere
Cultures
Social Capital
Human Capital
Economie
Exchanges Between Locations
Hydrosphere
Water by Reservoir
Lithosphere
Geological Carbon
Ores
Atmosphere
Earth Energy
Gasses
GORDON AND BETTY MOORE FOUNDATION
Gund Institute for Ecological Economics
University of Vermont


Land use
Soil drainage type
Water regulation
Land Use
Soil Drainage type
Water Regulation
A
B
C
D

SUSTAINABILITY OR COLLAPSE?

AN INTEGRATED HISTORY AND FUTURE OF PEOPLE ON EARTH

EDITED BY ROBERT COSTANZA, LISA J. GRAUMLICH, AND WILL STEFFEN

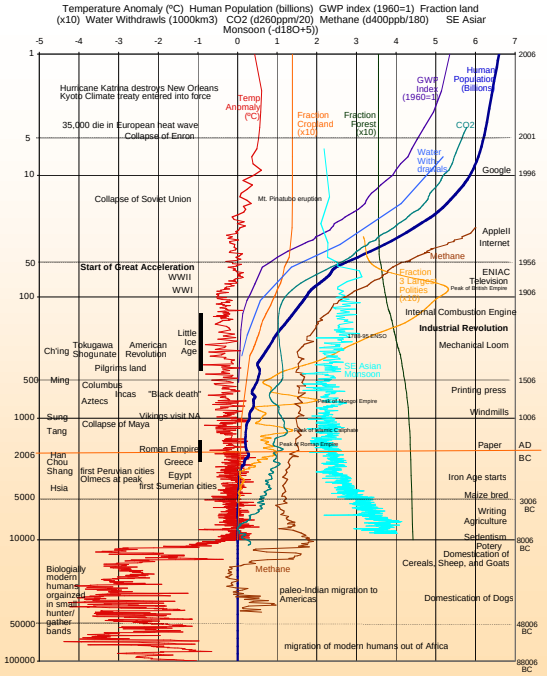


Human history, as written traditionally, leaves out the important ecological and climate context of historical events. But the capability to integrate the history of human beings with the natural history of the Earth now exists, and we are finding that human-environmental systems are intimately linked in ways we are only beginning to appreciate. In *Sustainability or Collapse?*, researchers from a range of scholarly disciplines develop an integrated human and environmental history over millennial, centennial, and decadal time scales and make projections for the future. The contributors focus on the human-environment interactions that have shaped historical forces since ancient times and discuss such key methodological issues as data quality. Topics highlighted include the political ecology of the Mayans; the effect of climate on the Roman Empire; the "revolutionary weather" of El Niño from 1788 to 1795; twentieth-century social, economic, and political forces in environmental change; scenarios for the future; and the accuracy of such past forecasts as *The Limits to Growth*.

"Costanza, Graumlich, and Steffen have assembled an amazing group of scholars from the biophysical and social sciences and the humanities; together, they take a long look back so as to take a better look forward. The resulting book offers a deep understanding of what the future has to offer—both the risks and the opportunities that face humanity."

ELINOR OSTROM
ARTHUR F. BENTLEY PROFESSOR OF POLITICAL SCIENCE AND CO-DIRECTOR OF THE WORKSHOP IN POLITICAL THEORY AND POLICY ANALYSIS, INDIANA UNIVERSITY

ROBERT COSTANZA is Gordon Gund Professor of Ecological Economics and Director of the Gund Institute for Ecological Economics at the Rubenstein School of Environment and Natural Resources at the University of Vermont. **LISA J. GRAUMLICH** is Executive Director of the Big Sky Institute for Science and Natural History and Professor of Land Resources and Environmental Sciences at Montana State University. **WILL STEFFEN** is Director of the Center for Resource and Environmental Studies and Director of the ANU Institute of Environment at the Australian National University and Chief Scientist at the International Geosphere-Biosphere Programme, Stockholm.



Integrated History and future Of People on Earth

From: Costanza, R. L. Graumlich, W. Steffen, C. Crumley, J. Dearing, K. Hibbard, R. Leemans, C. Redman, and D. Schimel. 2007. Sustainability or Collapse: What Can We Learn from Integrating the History of Humans and the Rest of Nature? *Ambio* (in press).

Adaptive Institutions Consistent with the Vision

Lisbon Principles of Sustainable Governance:

1. **Responsibility**
2. **Scale-Matching**
3. **Precaution**
4. **Adaptive Management**
5. **Full Cost Allocation**
6. **Participation**

From: Costanza, R. F. Andrade, P. Antunes, M. van den Belt, D. Boersma, D. F. Boesch, F. Catarino, S. Hanna, K. Limburg, B. Low, M. Molitor, G. Pereira, S. Rayner, R. Santos, J. Wilson, M. Young. 1998. Principles for sustainable governance of the oceans. *Science* 281:198-199.

Making the market tell the truth

In general, privatization is NOT the answer, because most ecosystem services are public goods. But we do need to adjust market incentives to send the right signals to the market. These methods include:

- **Full cost accounting (i.e. www.trucost.org, www.earthinc.org**
- **Ecological tax reform (tax bads not goods, remove perverse subsidies)**
- **Ecosystem service payments (a la Costa Rica)**
- **Impact fees for development tied to real impacts**
- **Environmental Assurance bonds to incorporate uncertainty about impacts (i.e. the Precautionary Polluter Pays Principle - 4P)**
- **Expand the "Commons Sector"**

See:

Bernow, S., R. Costanza, H. Daly, et. Al.. 1998. Ecological tax reform. *BioScience* 48:193-196.

Costanza, R. and L. Cornwell. 1992. The 4P approach to dealing with scientific uncertainty. *Environment* 34:12-20,42.

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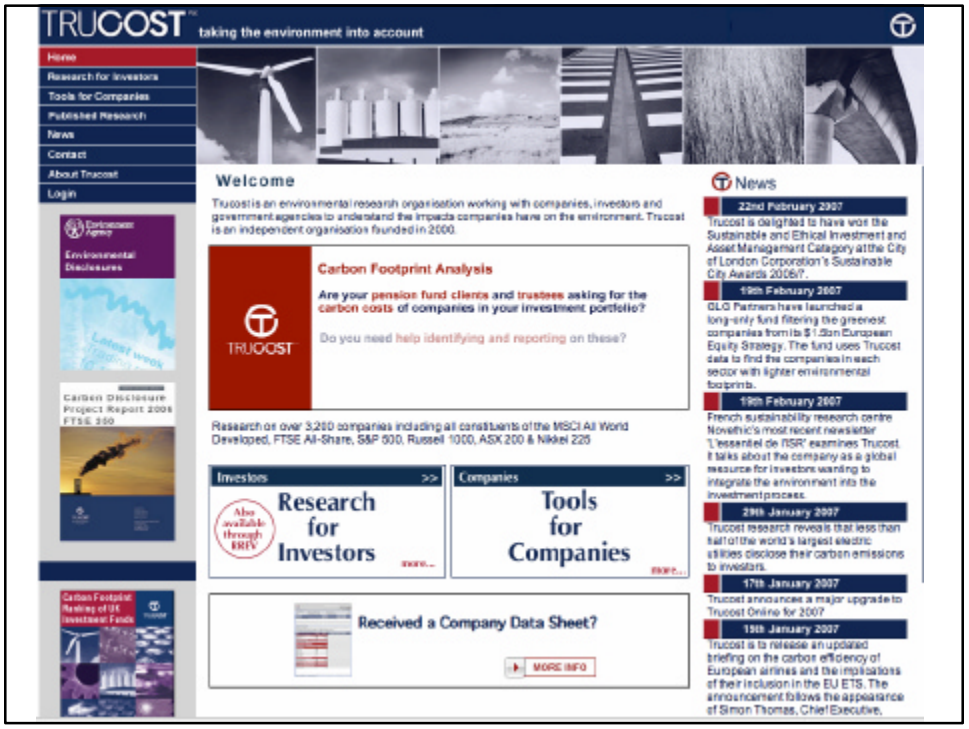


THE NEW COMMONS SECTOR

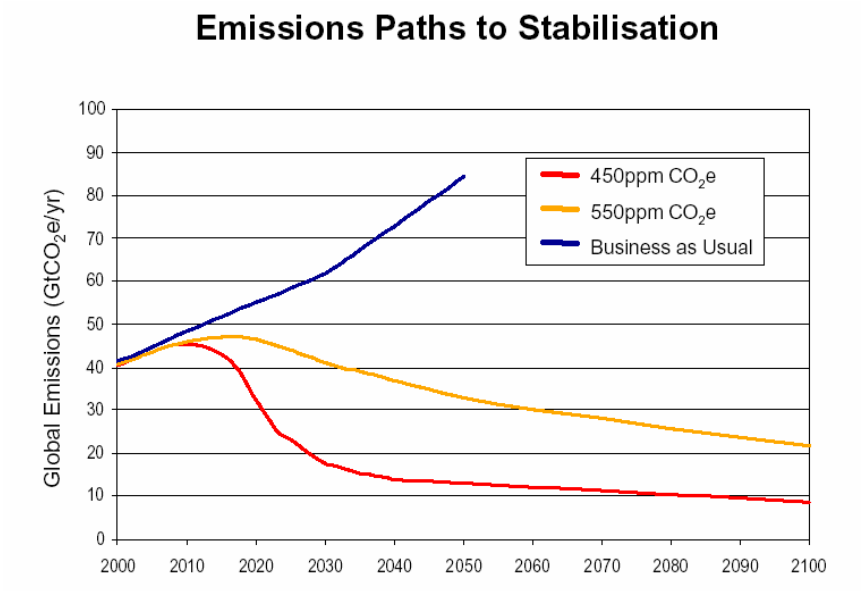
Global
- Earth Atmospheric Trust

National
- American Permanent Fund
- Children's start-up trust
- Universal health insurance
- Copyright royalty fund
- Spectrum trust
- Commons tax credit…

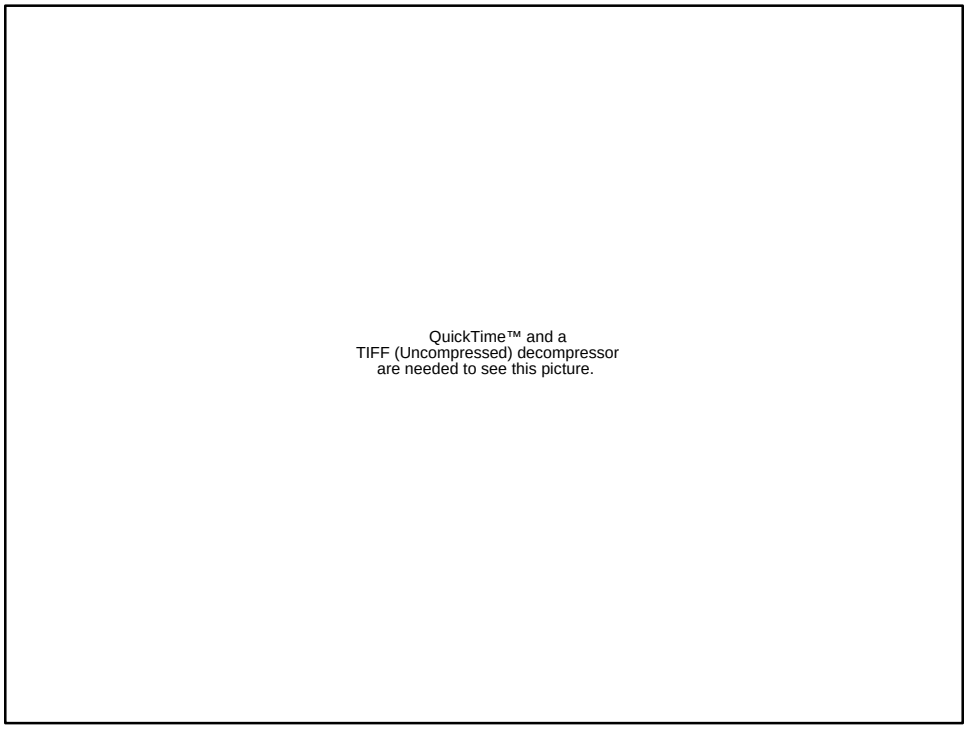
Regional
- Regional watershed trusts
- Regional airshed trusts
- Mississippi basin trust
- Buffalo commons
- Vermont Common Asset Trust…

Local
- Land trusts
- Municipal wi-fi
- Community gardens
- Farmers' markets
- Public spaces
- Car-free zones
- Time banks…

www.
earthinc.
org



Source: Stern review on the economics of climate change, 2006



Creating An Earth Atmospheric Trust:

A system to stop global warming *and* reduce poverty

Peter Barnes, Robert Costanza, Paul Hawken, David Orr, Elinor Ostrom, Alvaro Umaña, and Oran Young

1) **Set up a global cap and trade system** for greenhouse gas emissions – all greenhouse gas emissions from all sources.
2) **Auction off all emission permits** – and allow trading of permits
3) **Gradually reduce the cap to follow the 450 ppm target** (or better). The price of permits will go up and total revenues will increase as the cap is reduced.
4) **Deposit the revenues into a trust fund**, managed by trustees appointed with long terms and a mandate to protect the asset (the climate and atmosphere)
5) **Return a fraction of the revenues to everyone on earth on a per capita basis.** This amount will be insignificant to the rich, and much smaller than their per capita contribution to the fund, but will be enough to lift all the world's poor out of poverty.
6) **Use the remainder of the revenues to enhance and restore the asset.** They could be used to fund renewable energy projects, research and development on renewable energy, payments for ecosystem services such as carbon sequestration, etc.

Special features and cautions
1) Do not allow revenues to go into the general fund of any government
2) Appoint trustees based on their qualifications and understanding of the purposes and details of the trust, not their political affiliations
3) Make all operations and transactions of the trust transparent by posting them open access on the internet
4) Make trustees accountable for their actions and decisions and subject to removal if they are not managing the trust for the benefit of the beneficiaries (all current and future people)


Thank You
Sign on to the Earth Atmospheric Trust at:
www.earthinc.org