Ecological Economics: creating a sustainable and desirable future

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

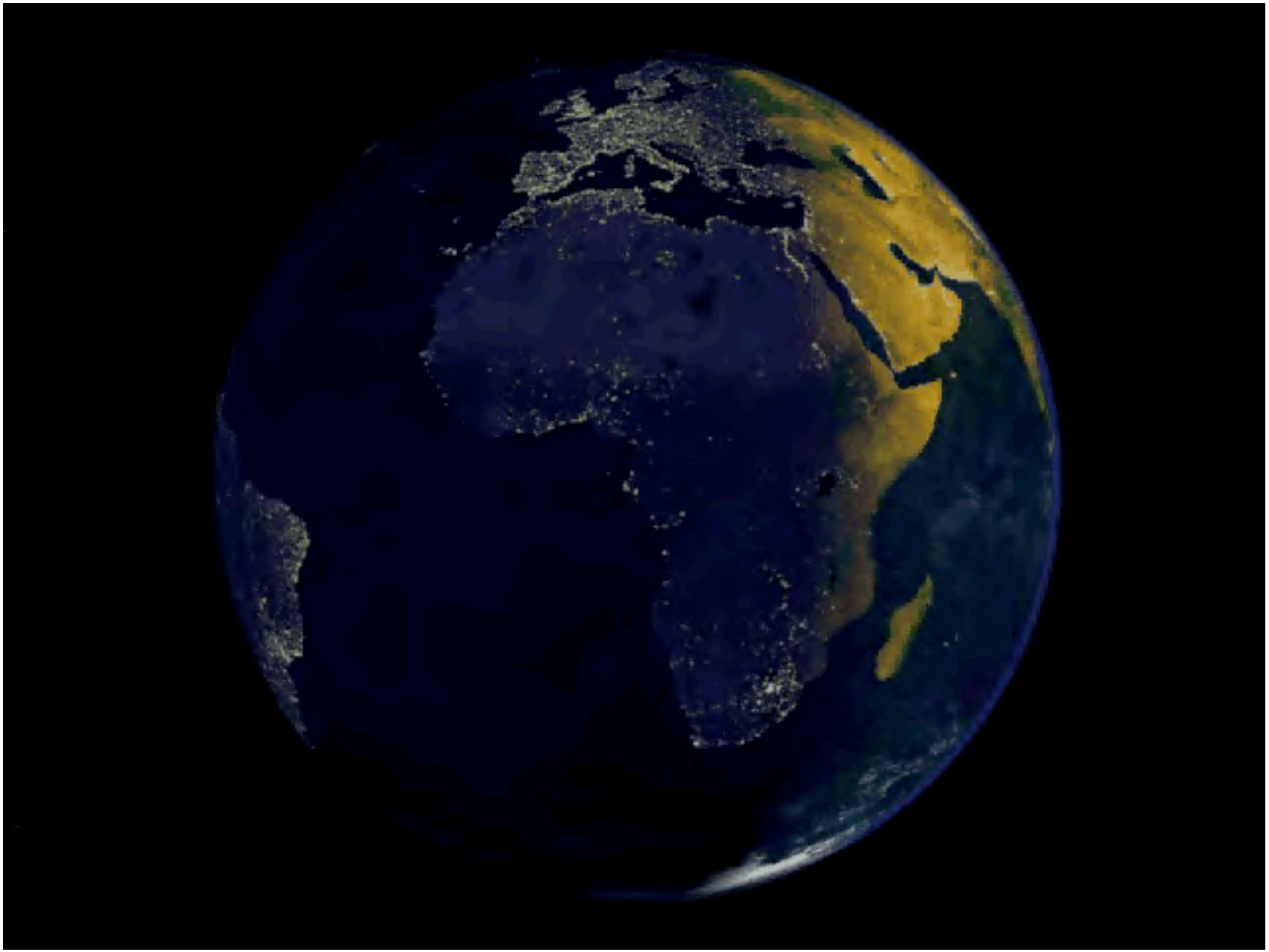
Practical Problem Solving Requires the *Integration* of:

- 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

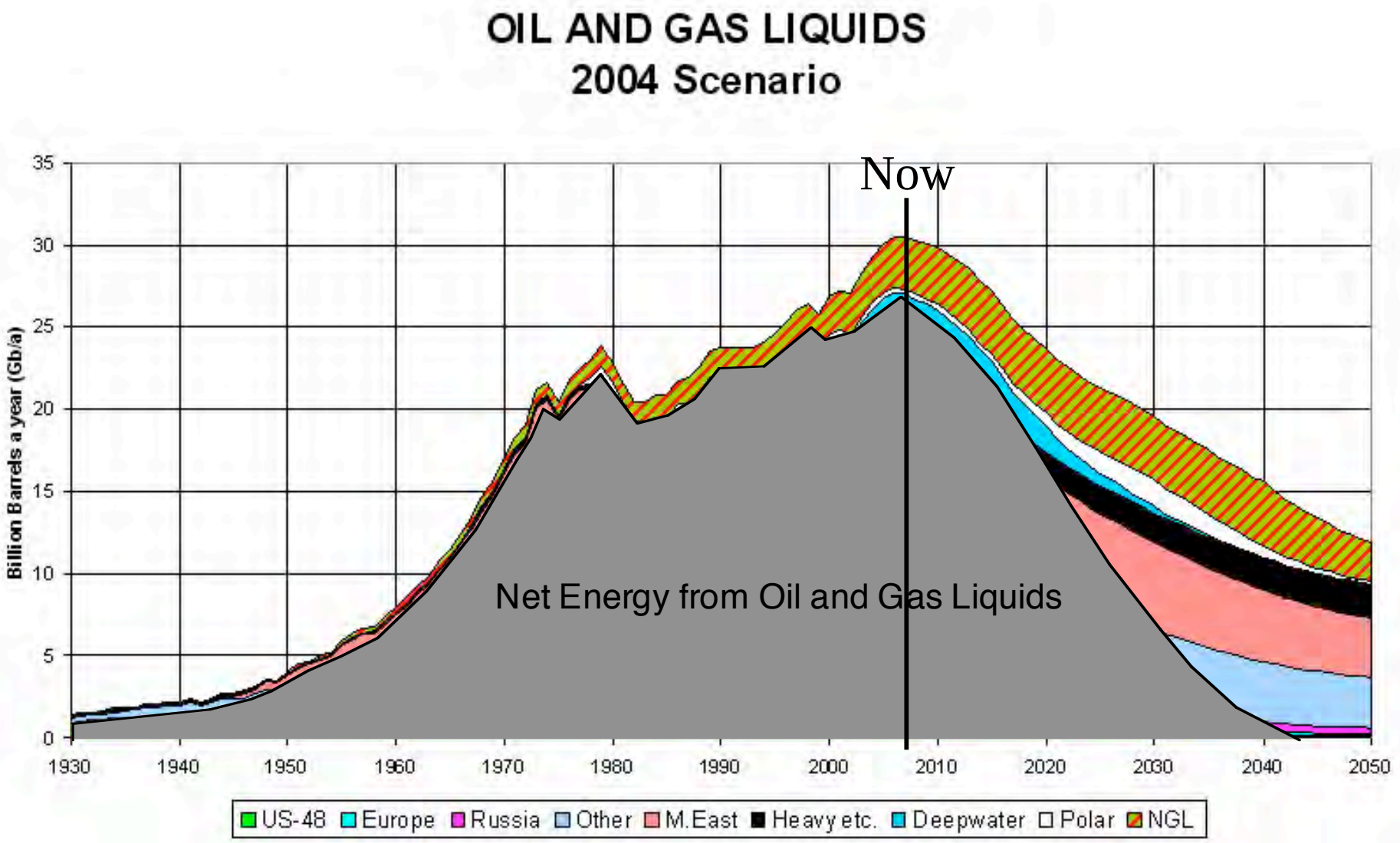


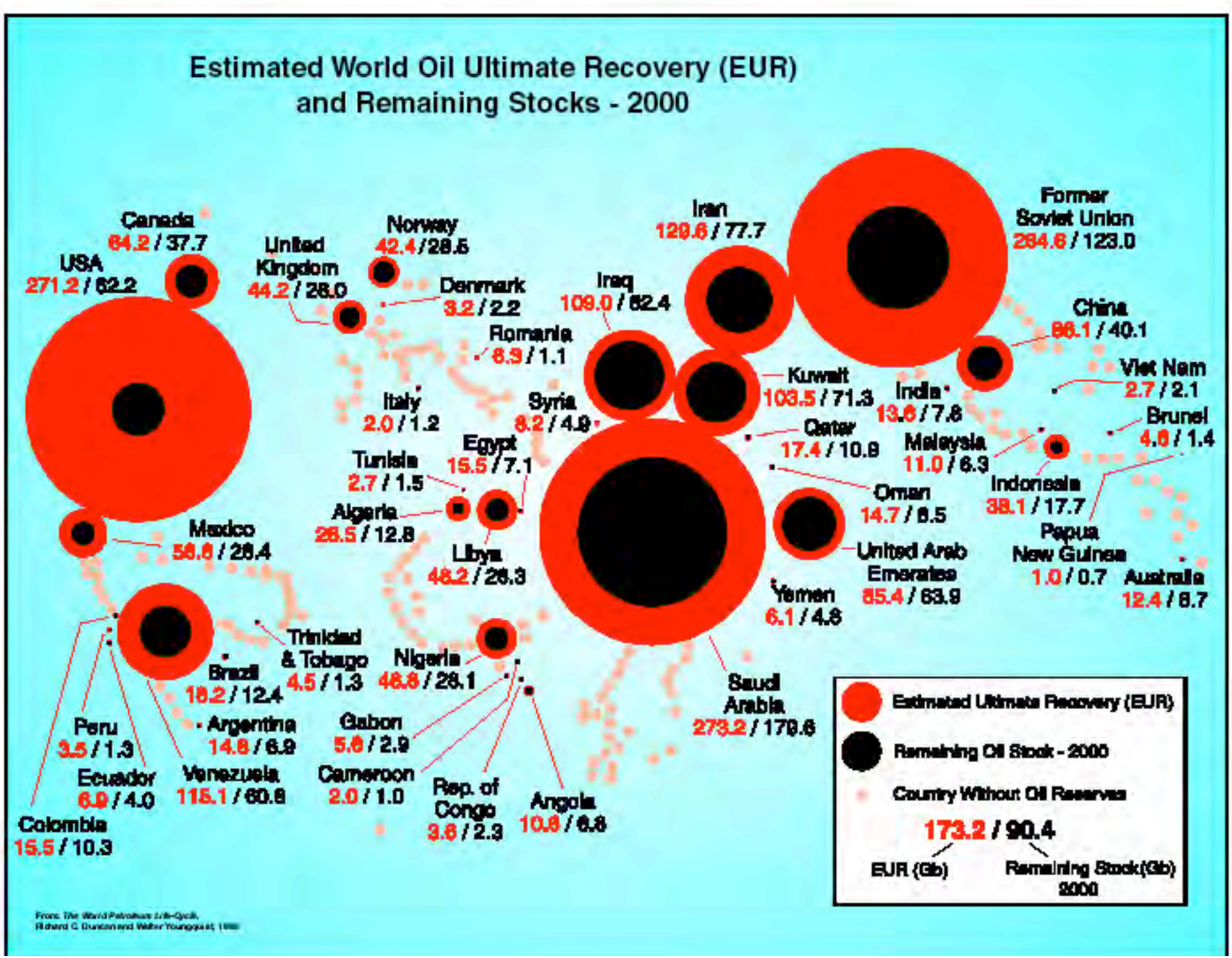
Marc Imhoff

Biospheric Sciences Branch

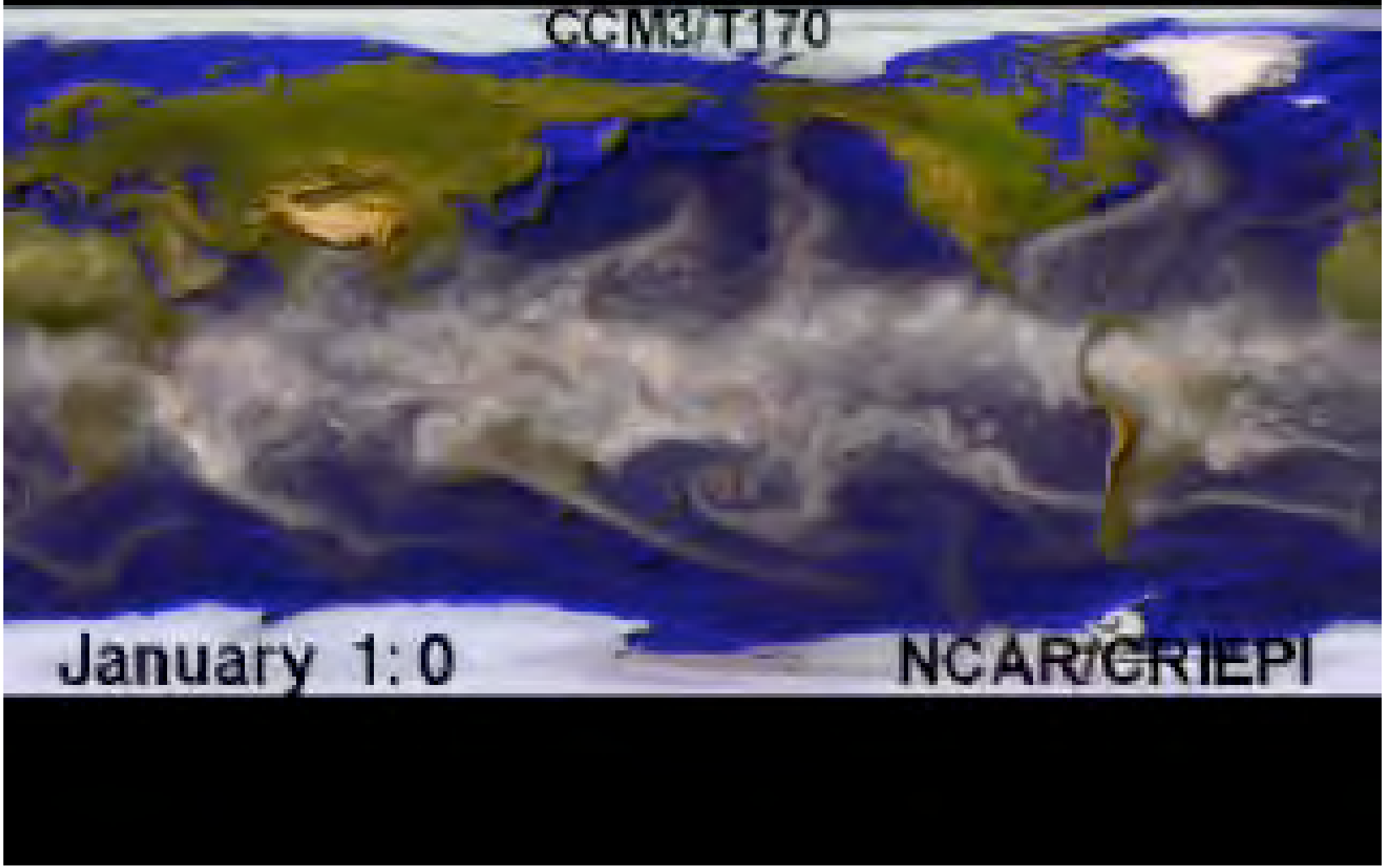
NASA

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

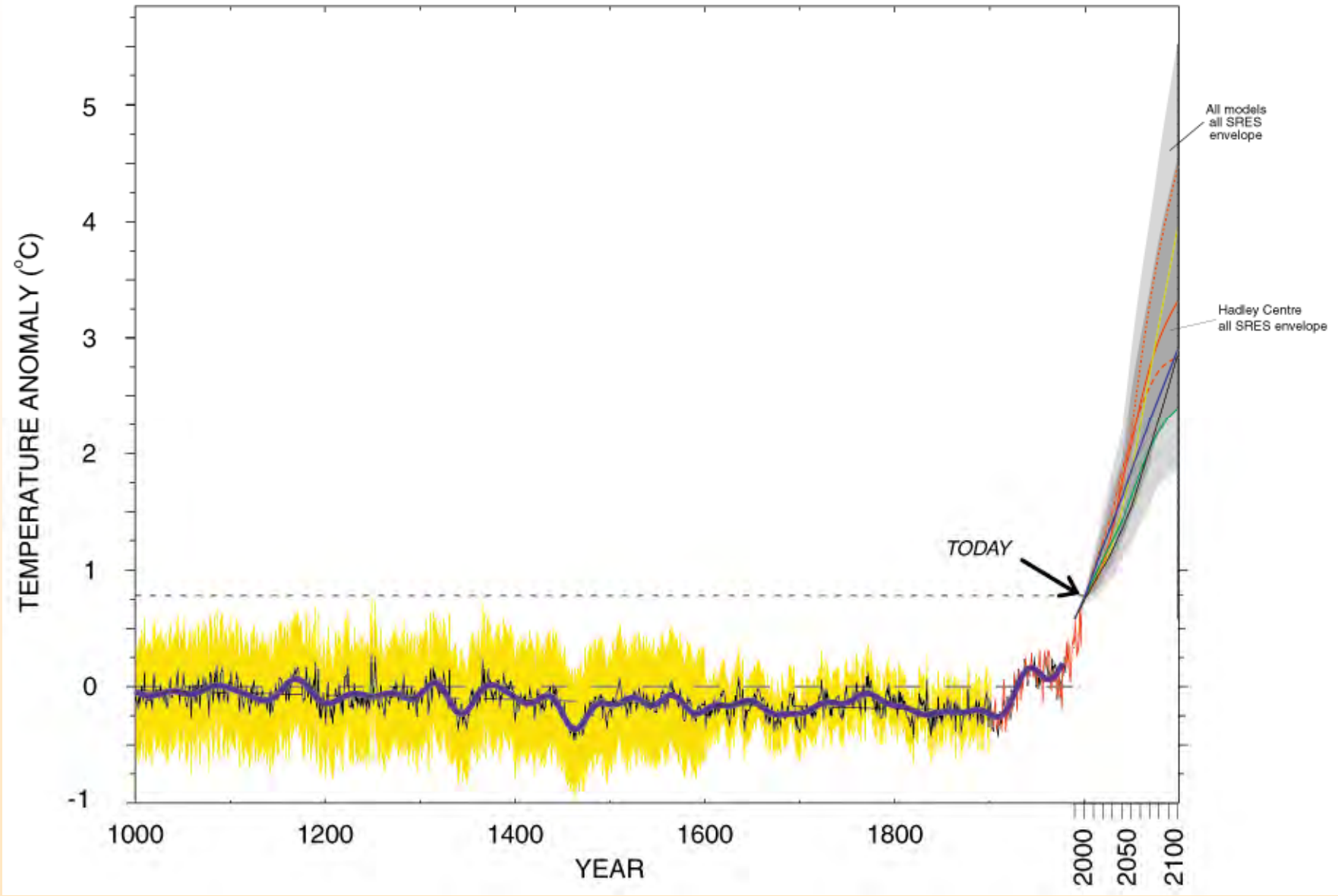


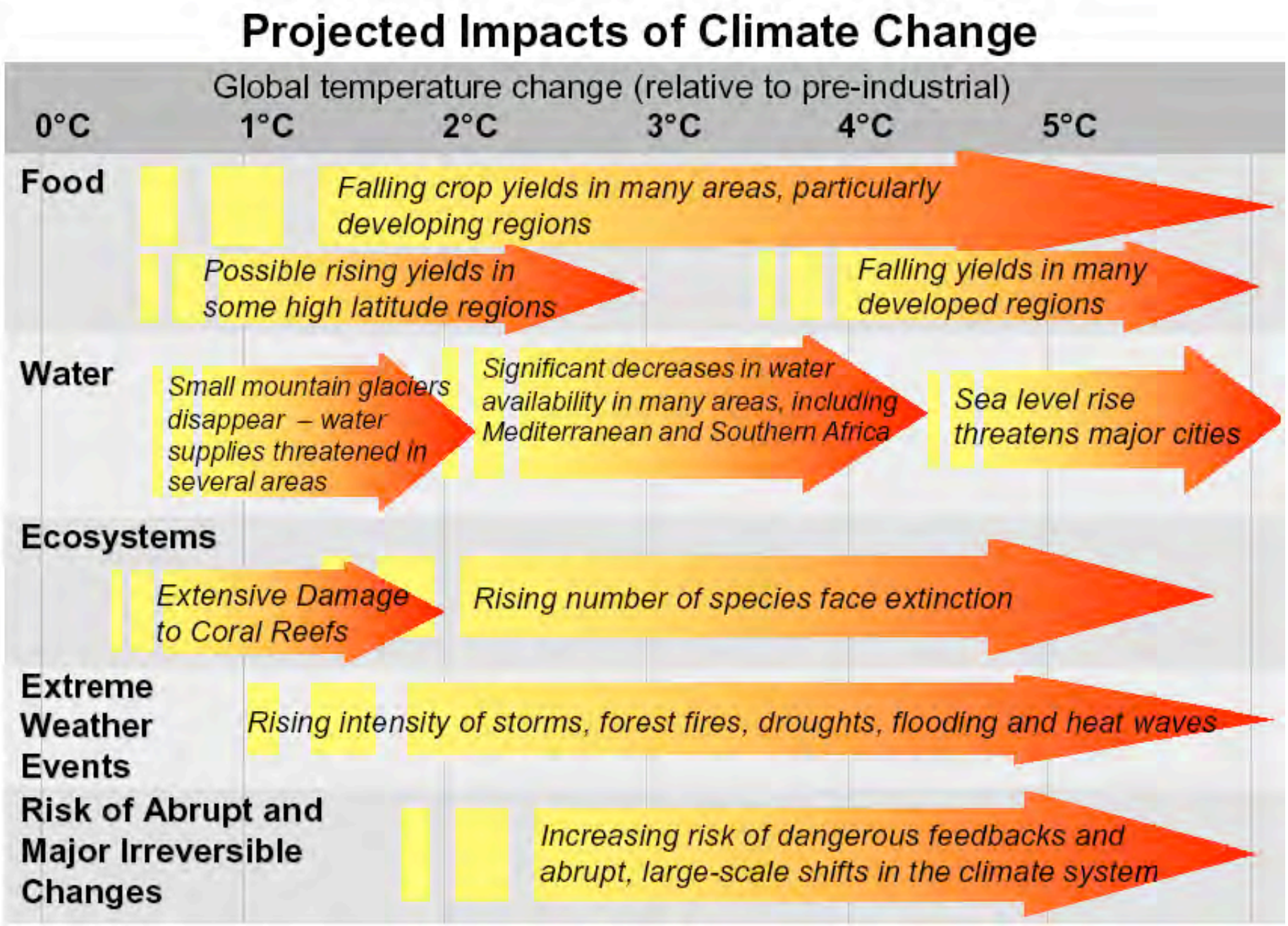

Estimated World Oil Ultimate Recovery (EUR)
and Remaining Stocks - 2000
Canada
64.2 / 37.7
USA
271.2 / 62.2
United Kingdom
44.2 / 28.0
Norway
42.4 / 28.5
Denmark
3.2 / 2.2
Romania
6.9 / 1.1
Italy
2.0 / 1.2
Iran
129.6 / 77.7
Iraq
109.0 / 62.4
Former Soviet Union
284.6 / 123.0
China
66.1 / 40.1
Kuwait
103.5 / 71.3
India
13.6 / 7.6
Viet Nam
2.7 / 2.1
Brunei
4.6 / 1.4
Syria
6.2 / 4.9
Qatar
17.4 / 10.9
Malaysia
11.0 / 6.3
Indonesia
38.1 / 17.7
Egypt
15.5 / 7.1
Tunisia
2.7 / 1.5
Algeria
26.5 / 12.8
Libya
48.2 / 26.3
Oman
14.7 / 6.5
United Arab Emirates
85.4 / 63.9
Yemen
6.1 / 4.8
Papua New Guinea
1.0 / 0.7
Australia
12.4 / 6.7
Mexico
58.6 / 26.4
Trinidad & Tobago
4.5 / 1.3
Nigeria
46.8 / 26.1
Brazil
18.2 / 12.4
Argentina
14.8 / 6.9
Peru
3.5 / 1.3
Ecuador
6.9 / 4.0
Venezuela
115.1 / 60.6
Colombia
15.5 / 10.3
Gabon
5.0 / 2.9
Cameroon
2.0 / 1.0
Rep. of Congo
3.6 / 2.3
Angola
10.8 / 6.8
Saudi Arabia
273.2 / 179.6
Estimated Ultimate Recovery (EUR)
Remaining Oil Stock - 2000
Country Without Oil Reserves
173.2 / 90.4
EUR (Gb)
Remaining Stock(Gb) 2000

Atmosphere



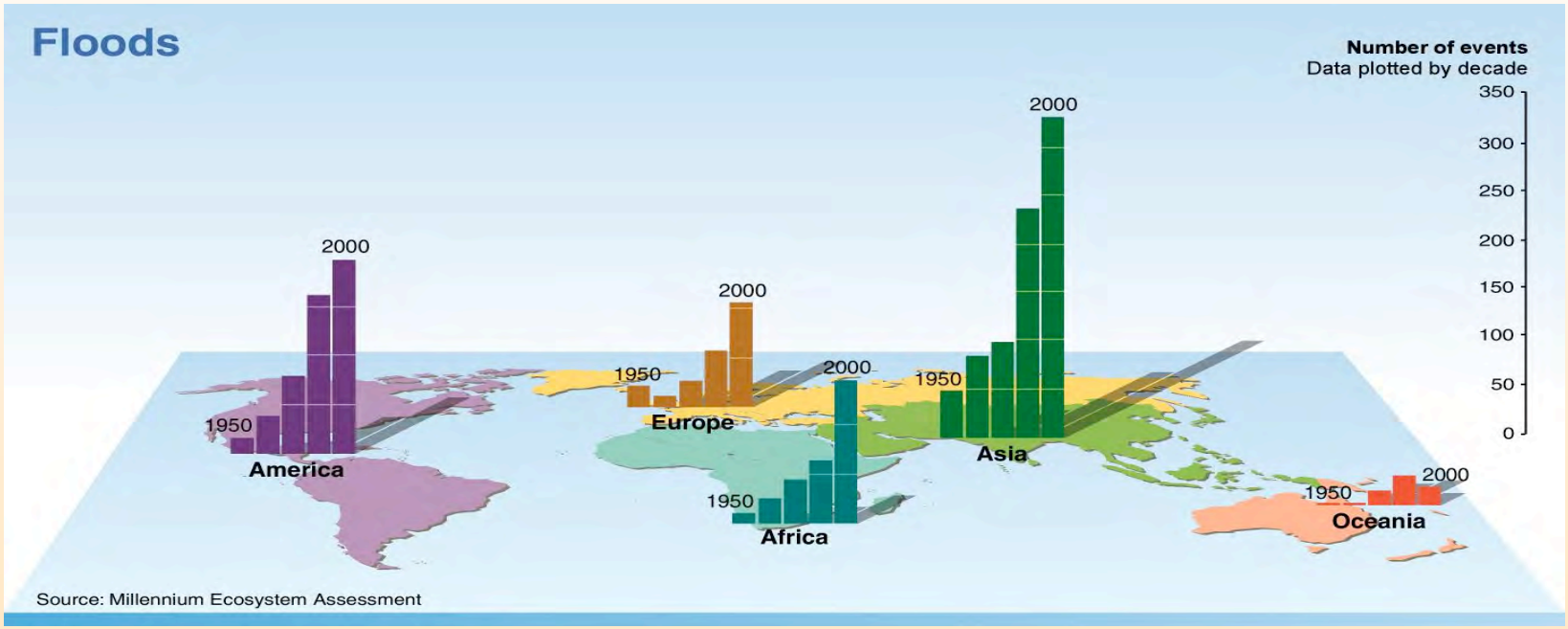
Temperature, past and future





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


NOAA


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

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

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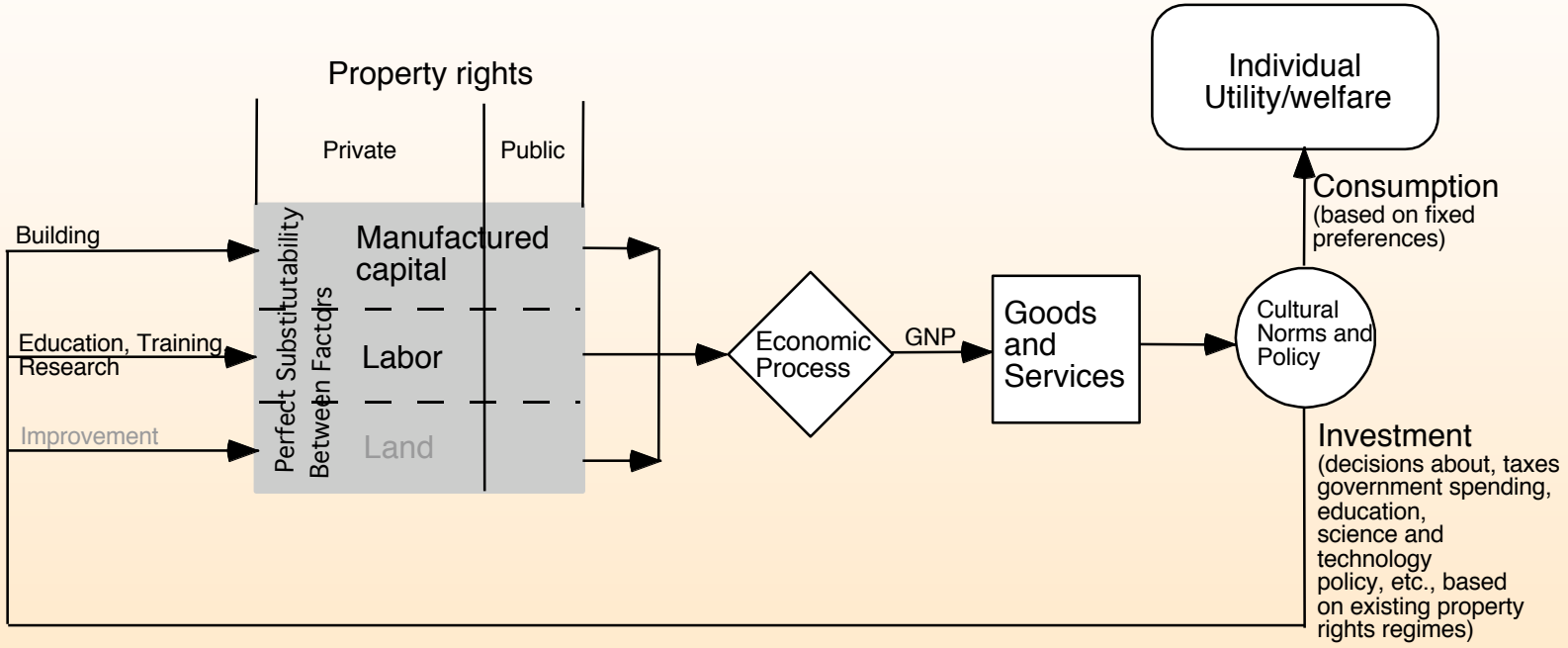
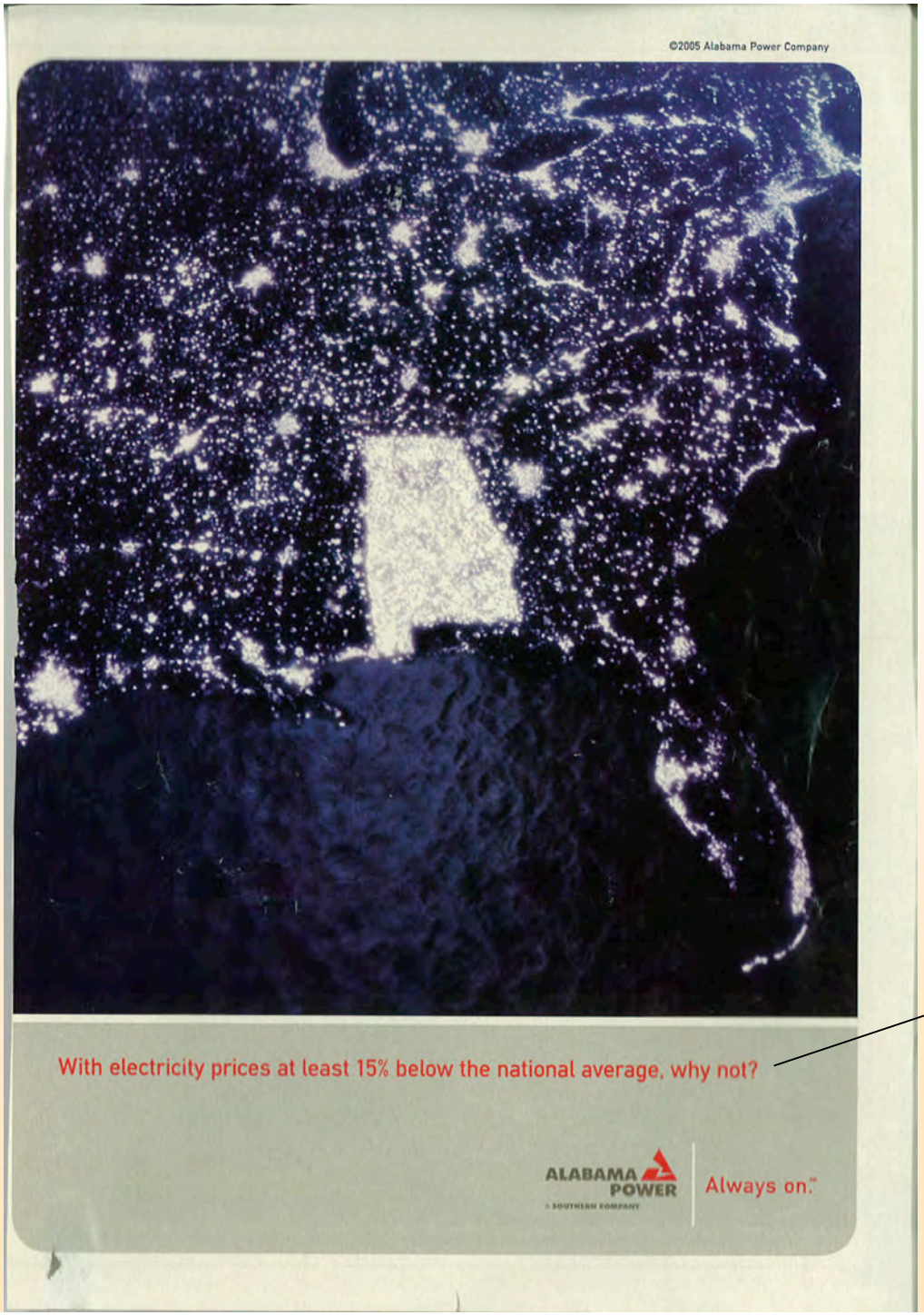
”Empty World" Model of the Economy



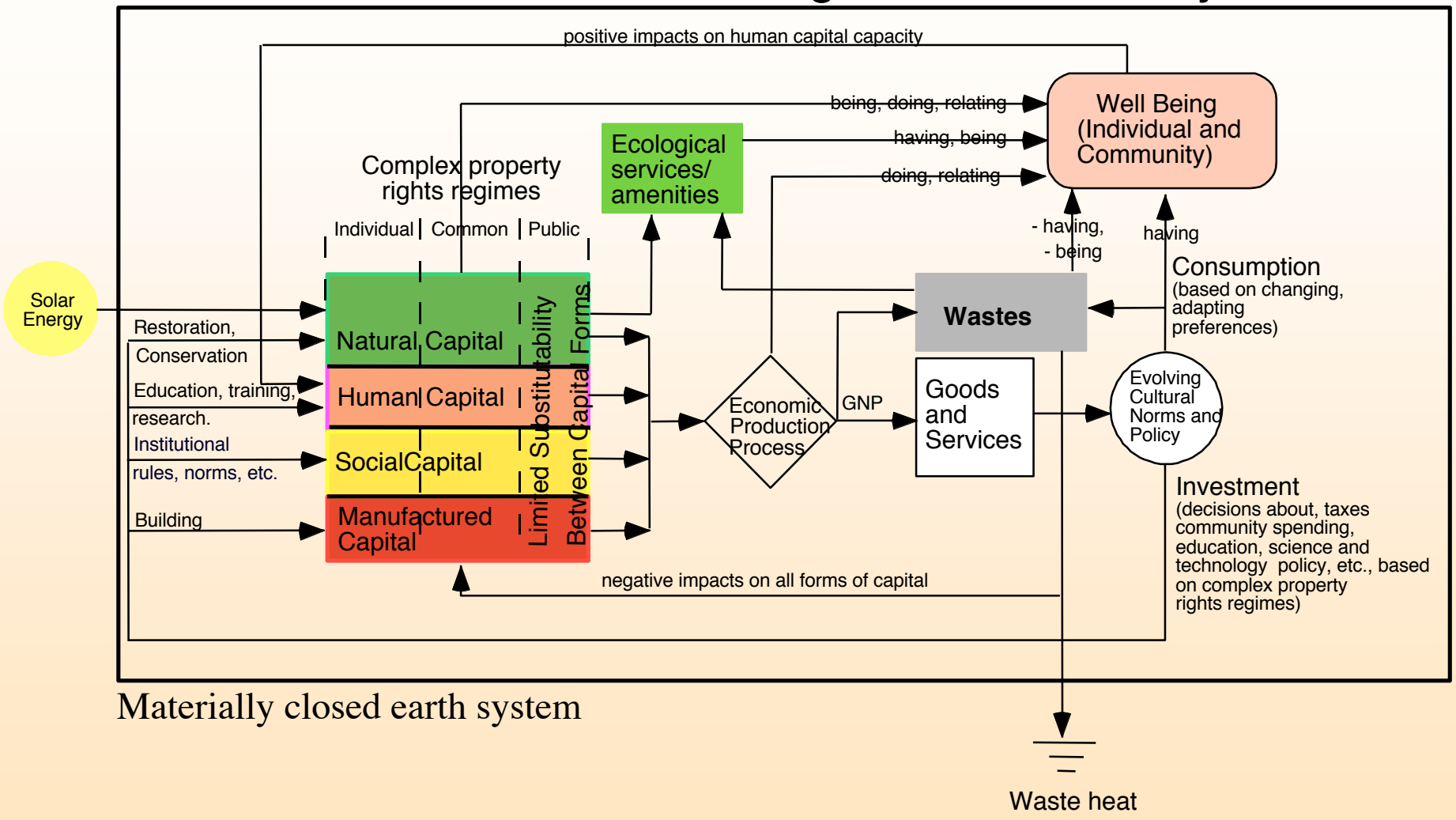


Empty World Energy Planning?

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



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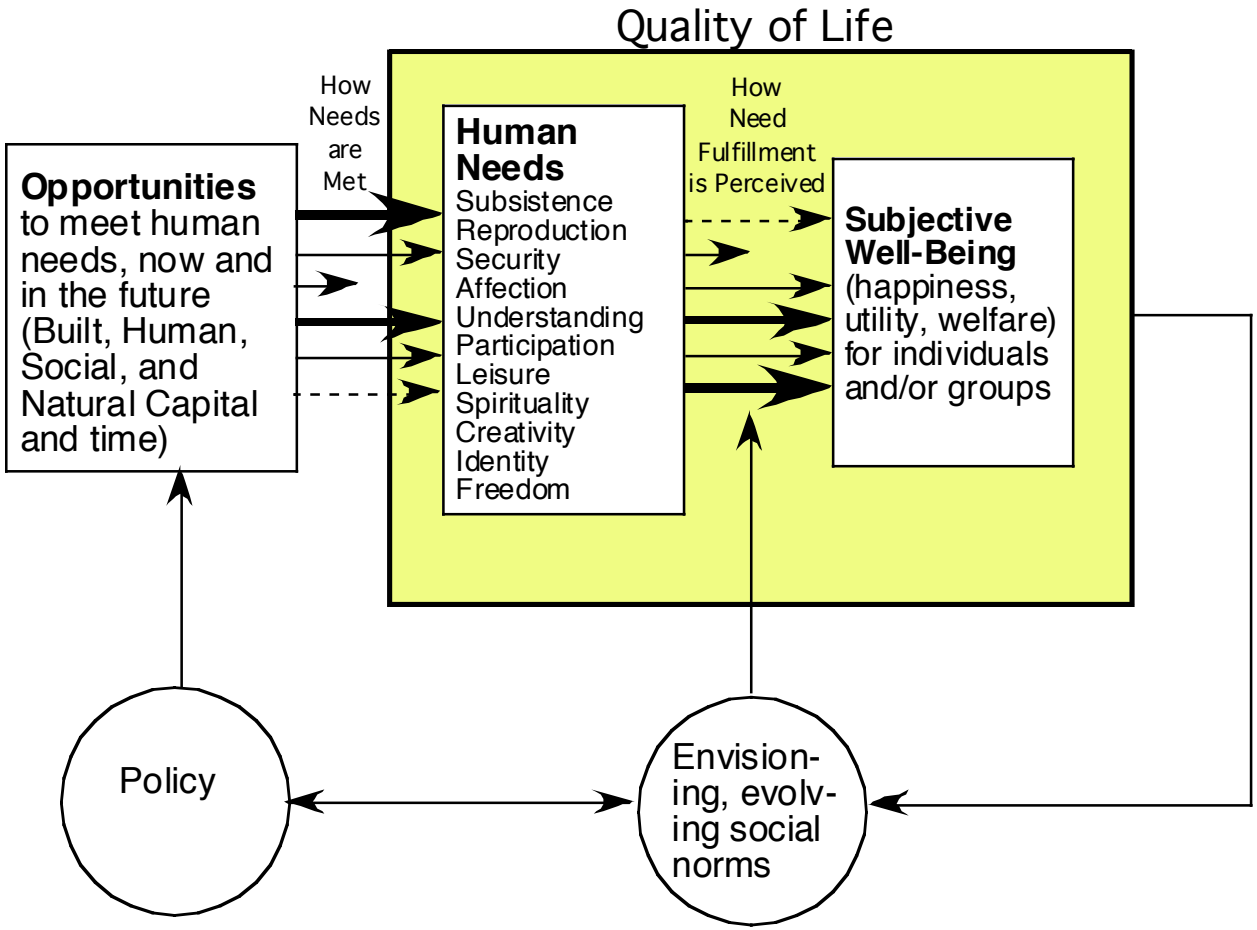
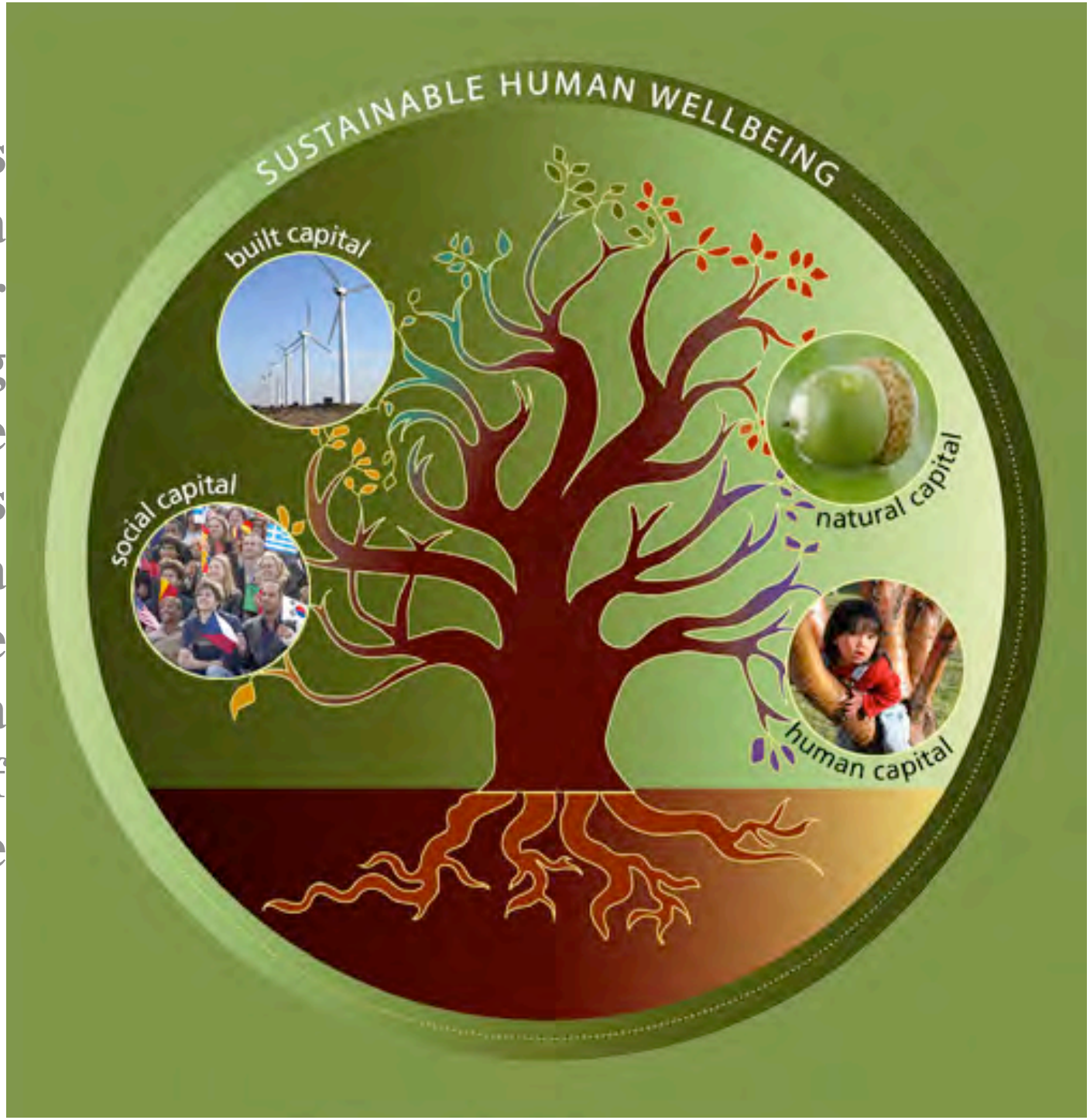
Quality of Life (QOL) as the interaction of human needs and the subjective perception of their fulfillment, as mediated by the opportunities available to meet the needs.



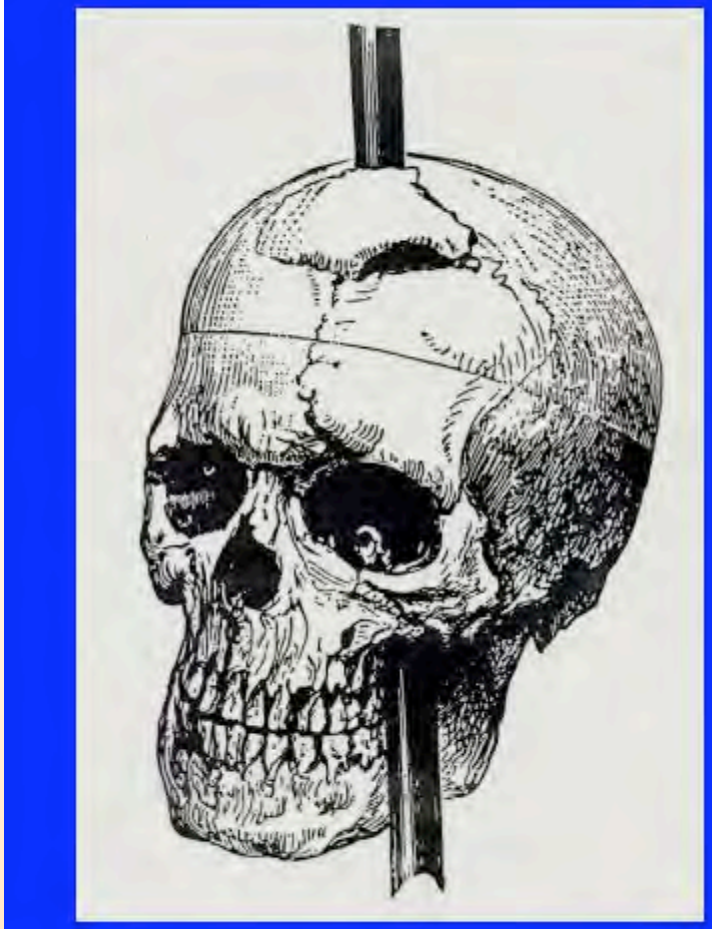
From: Costanza, R., B. Fisher, S. Ali, C. Beer, L. Bond, R. Boumans, N. L. Danigelis, J. Dickinson, C. Elliott, J. Farley, D. E. Gayer, L. MacDonald Glenn, T. Hudspeth, D. Mahoney, L. McCahill, B. McIntosh, B. Reed, S. A. T. Rizvi, D. M. Rizzo, T. Simpatico, and R. Snapp. 2006. Quality of Life: An Approach Integrating Opportunities, Human Needs, and Subjective Well-Being. *Ecological Economics* 61: 267-276

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. GNP

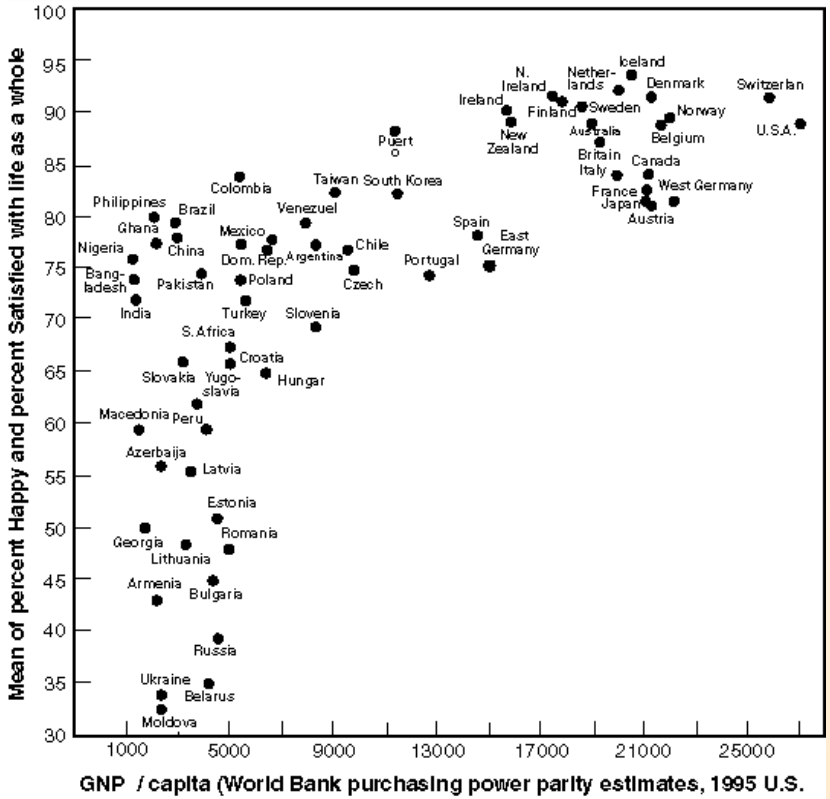
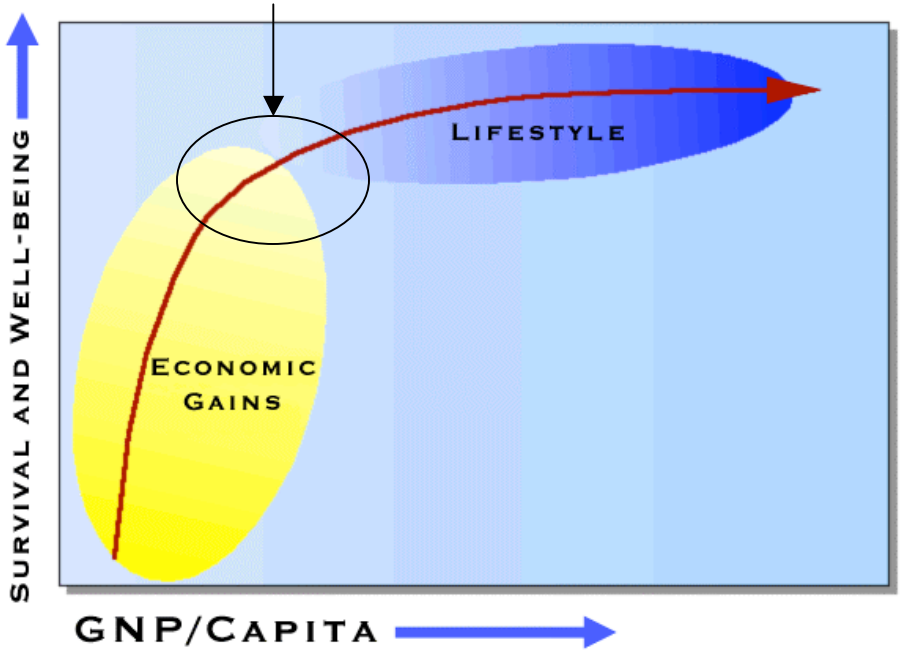


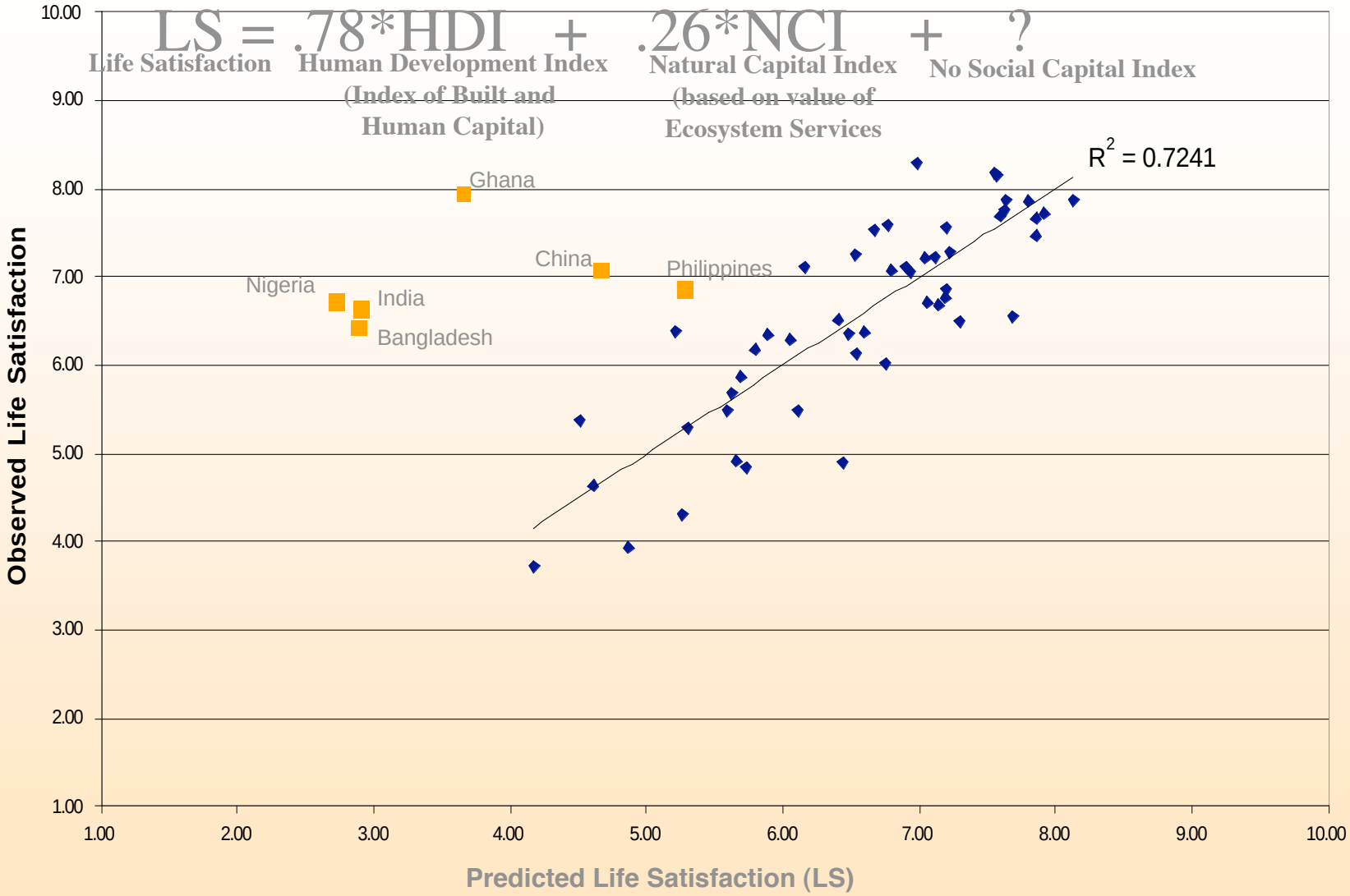
Figure 2. Subjective well-being by level of economic development.
Source: World Values Surveys; GNP/capita purchasing power estimates from World Bank, World Development Report, 1997.
R = .70 N = 65 p < .0000

Convergence zone



Source: R Ingelhart, 1997

Observed Life Satisfaction versus Predicted Life Satisfaction



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	Marketed	**Economic Income** Weak Sustainability	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

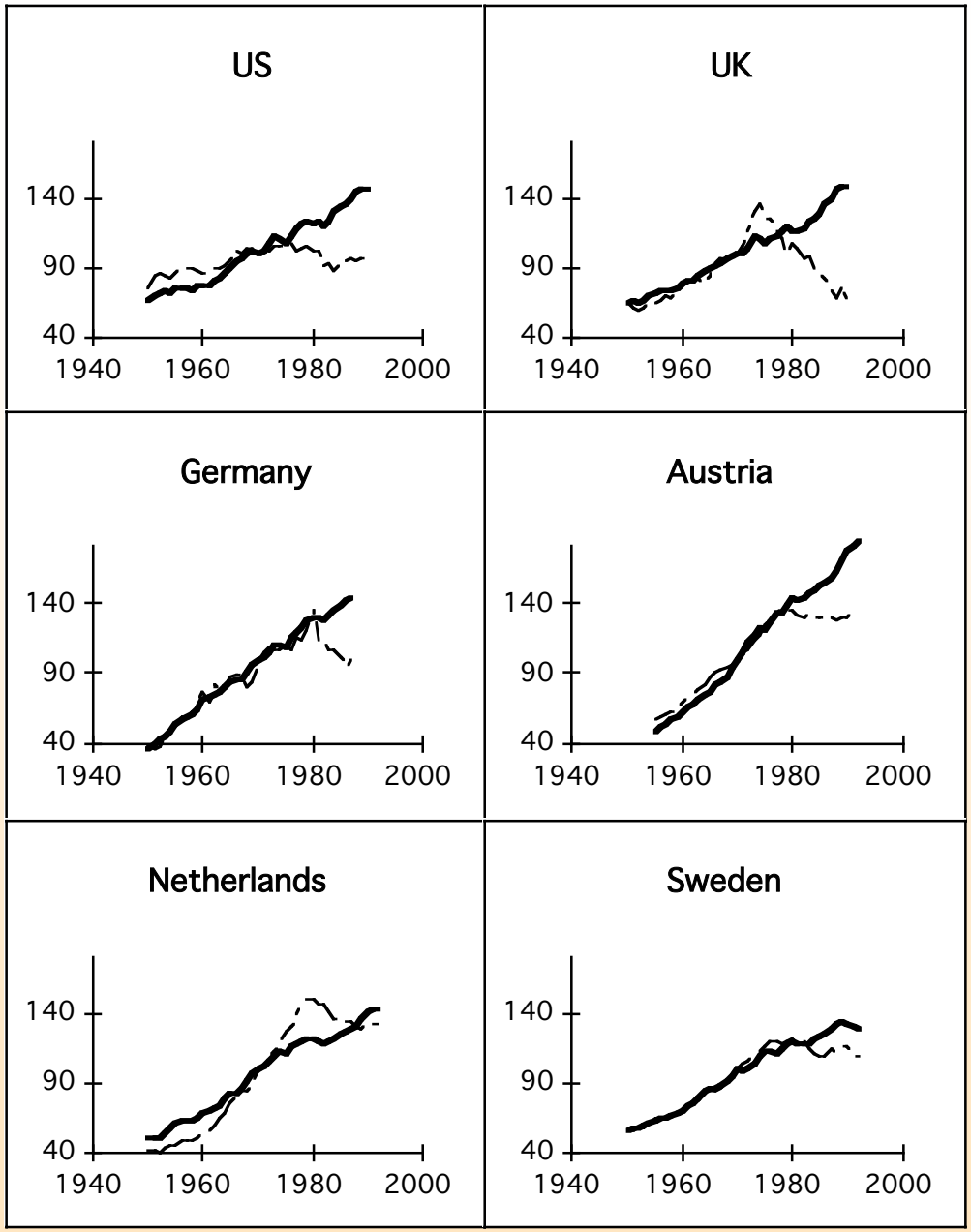
Column A: Personal Consumption Expenditures
Column B: Income Distribution
Column C: Personal Consumption Adjusted for Income Inequality
Column D: Value of Household Labor
Column E: Value of Volunteer Work
Column F: Services of Household Capital
Column G: Services Highways and Street

Subtractions

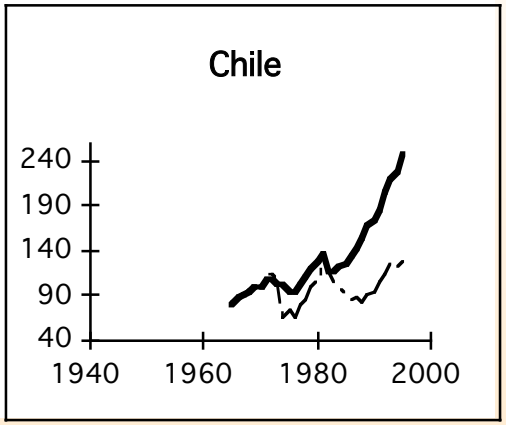
Column H: Cost of Crime
Column I: Cost of Family Breakdown
Column J: Loss of Leisure Time
Column K: Cost of Underemployment
Column L: Cost of Consumer Durables
Column M: Cost of Commuting
Column N: Cost of Household Pollution Abatement
Column O: Cost of Automobile Accidents
Column P: Cost of Water Pollution
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

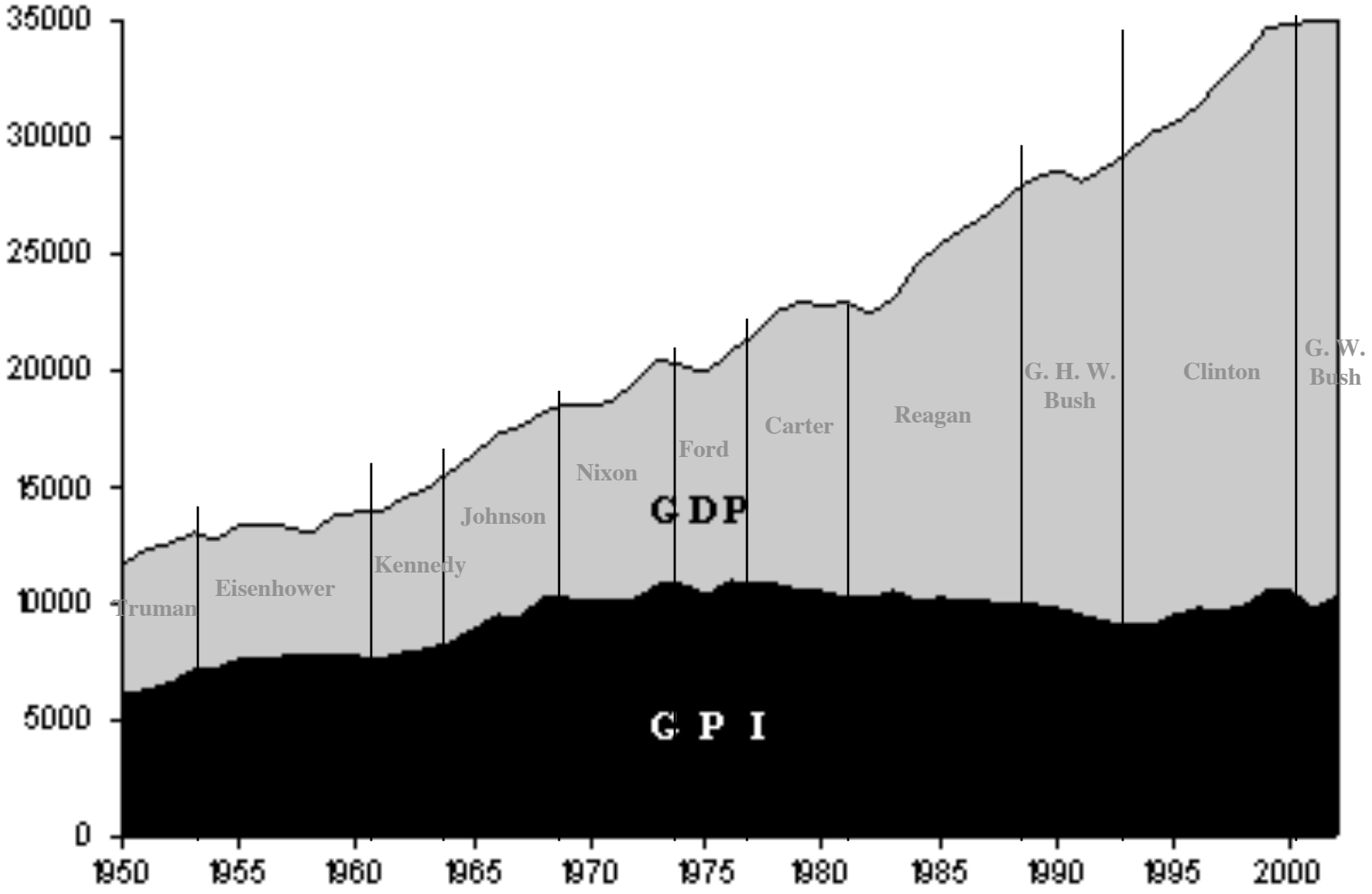
Column Y: Net Capital Investment
Column Z: Net Foreign Lending and Borrowing

Built Capital
Human Capital
Social Capital
Natural Capital



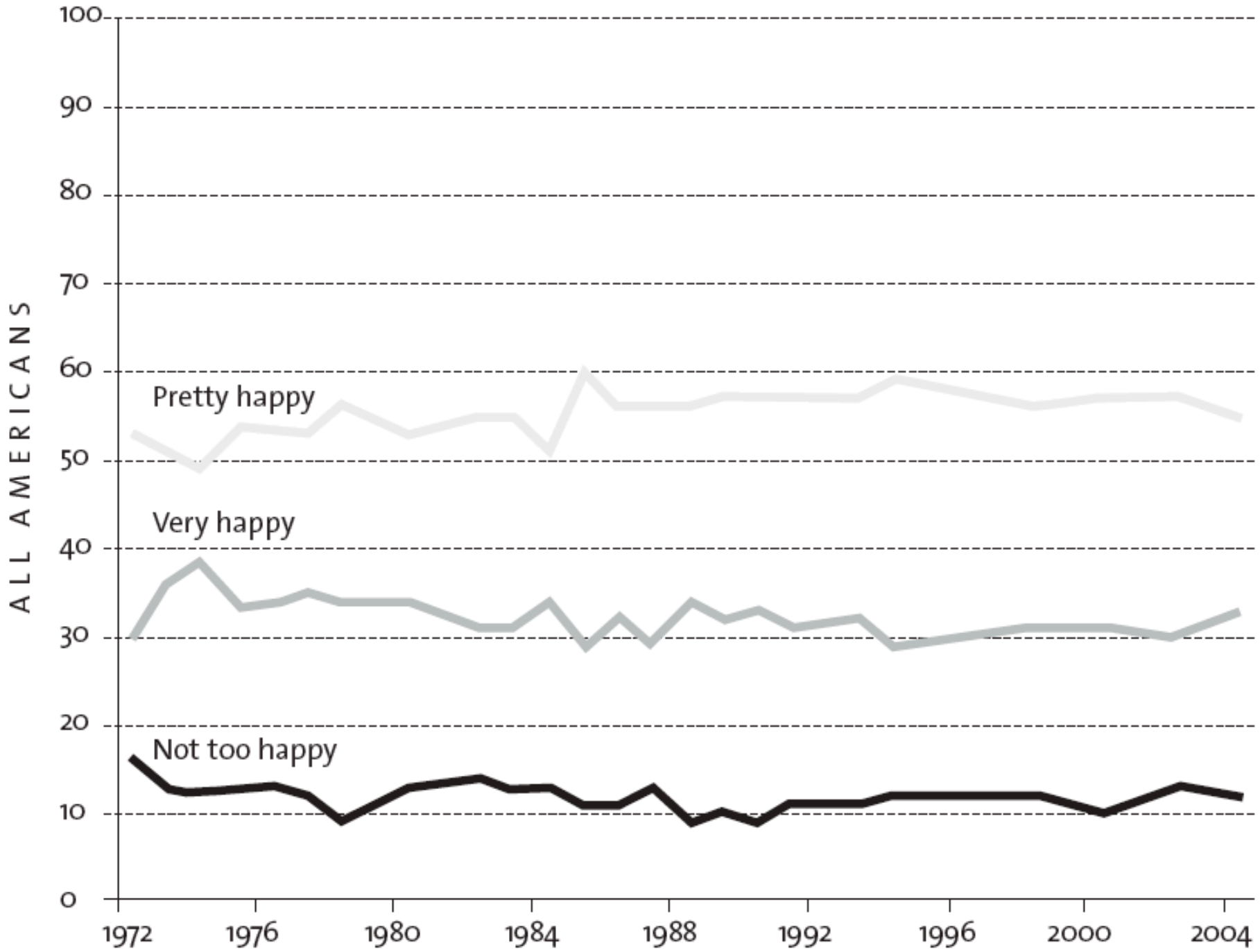
Indices of ISEW– –
(Index of Sustainable Economic Welfare)
and GDP ——
(1970 = 100)





Gross Production vs. Genuine Progress for the US, 1950 to 2002

(source: Redefining Progress - http://www.rprogress.org)


ALL AMERICANS
100
90
80
70
60
50
40
30
20
10
0
Pretty happy
Very happy
Not too happy
1972
1976
1980
1984
1988
1992
1996
2000
2004

The Commons

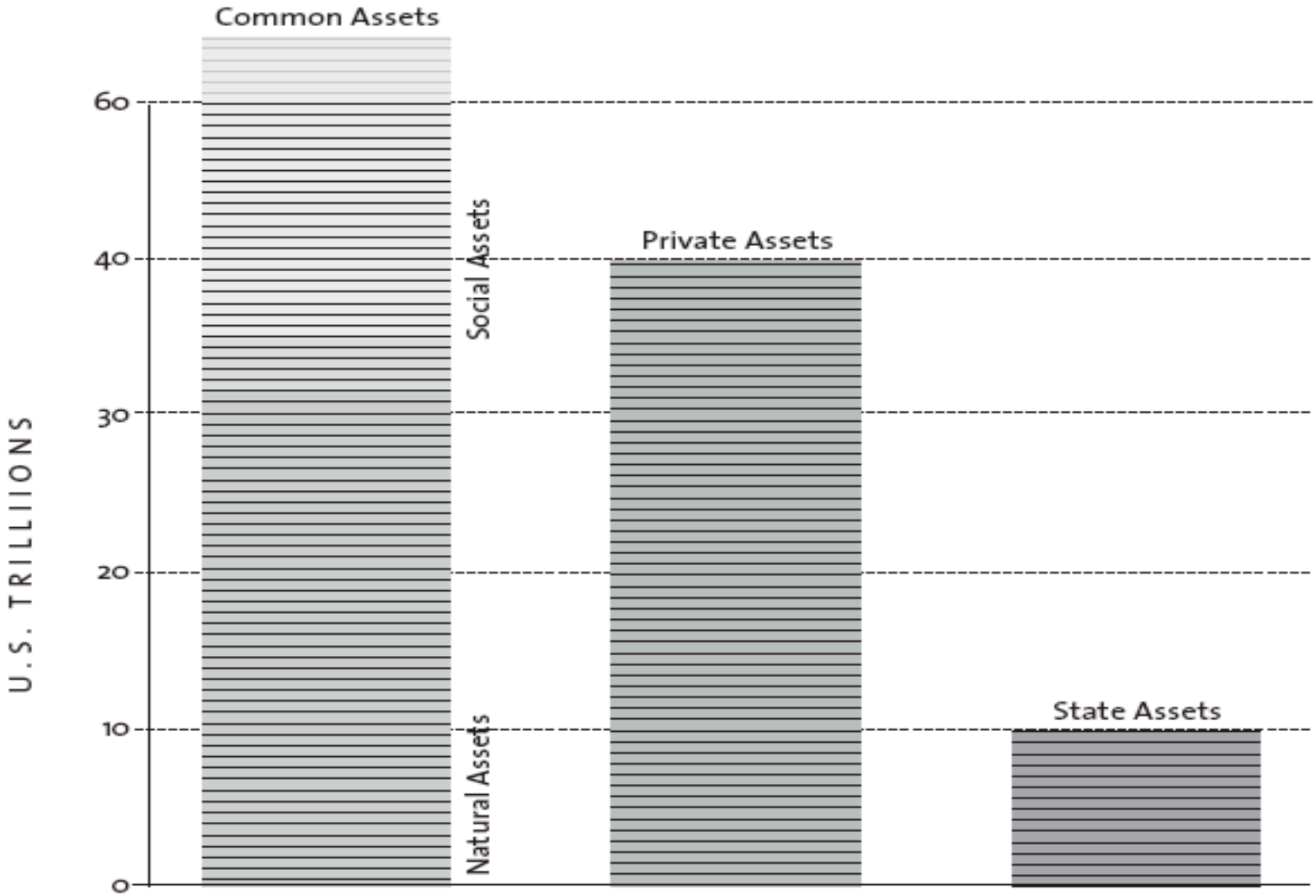
“ refers to all the gifts we inherit or create together. This notion of the commons designates a set of assets that have two characteristics:

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”.

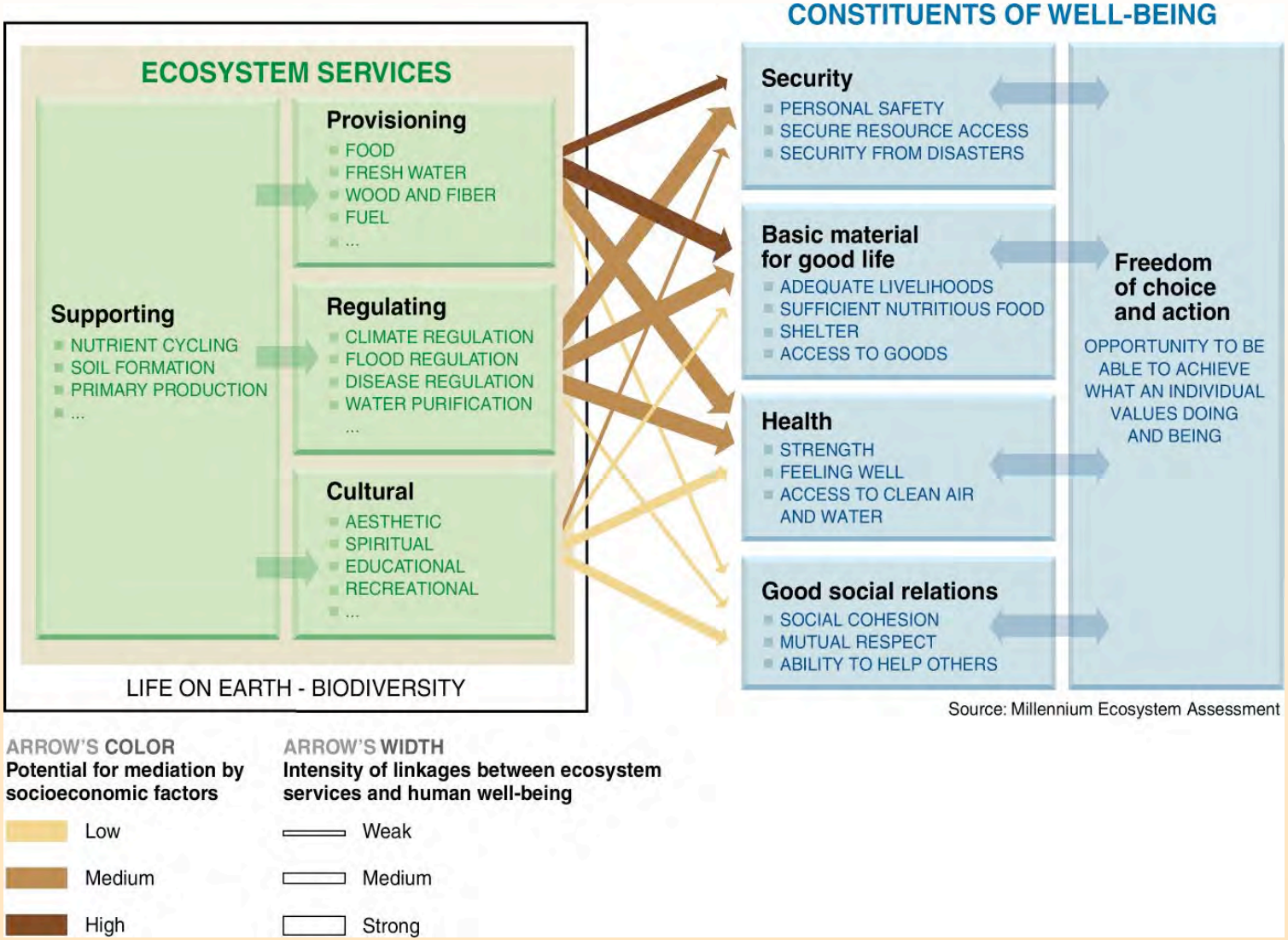
Peter Barnes, *Capitalism 3.0*

Figure 5.1
APPROXIMATE VALUE OF COMMON, PRIVATE, AND STATE ASSETS, 2001 ($ TRILLIONS)

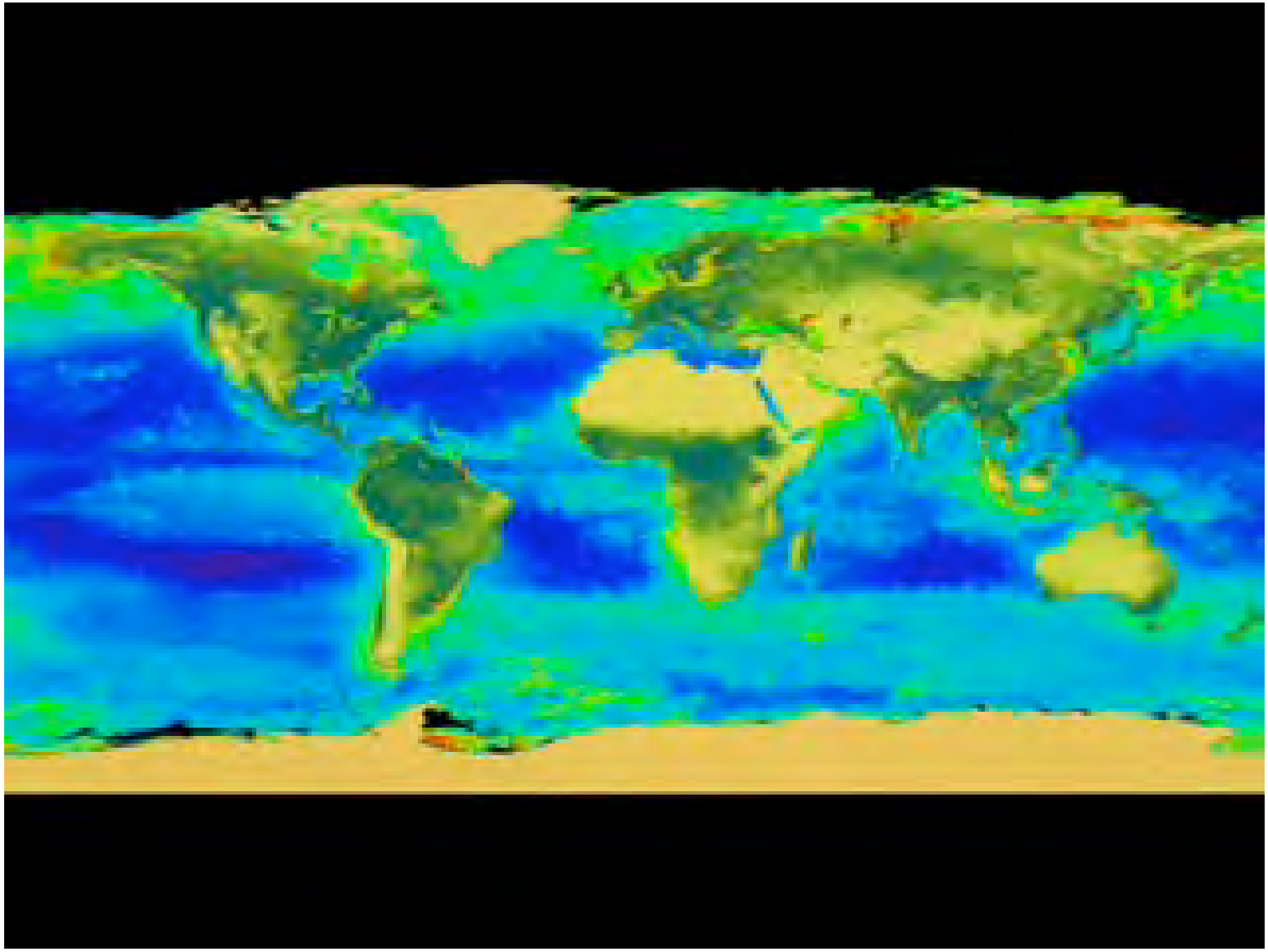


Reflects only quantifiable assets.
Source: Friends of the Commons, *State of the Commons 2003–04*.
http://friendsofthecommons.org/understanding/worth.html. Reprinted with permission.

Ecosystem Services: the benefits humans derive from ecosystems



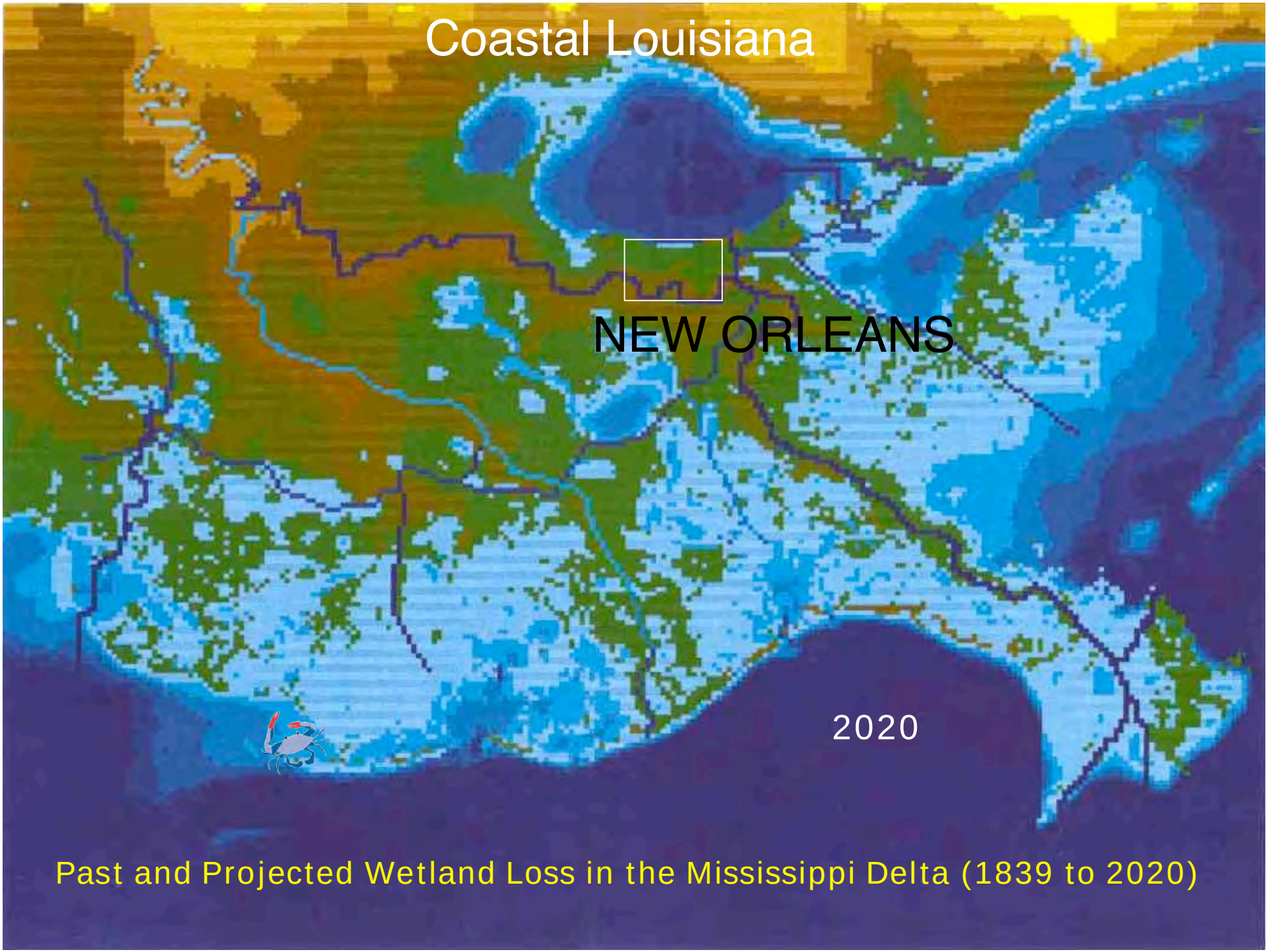
Biosphere



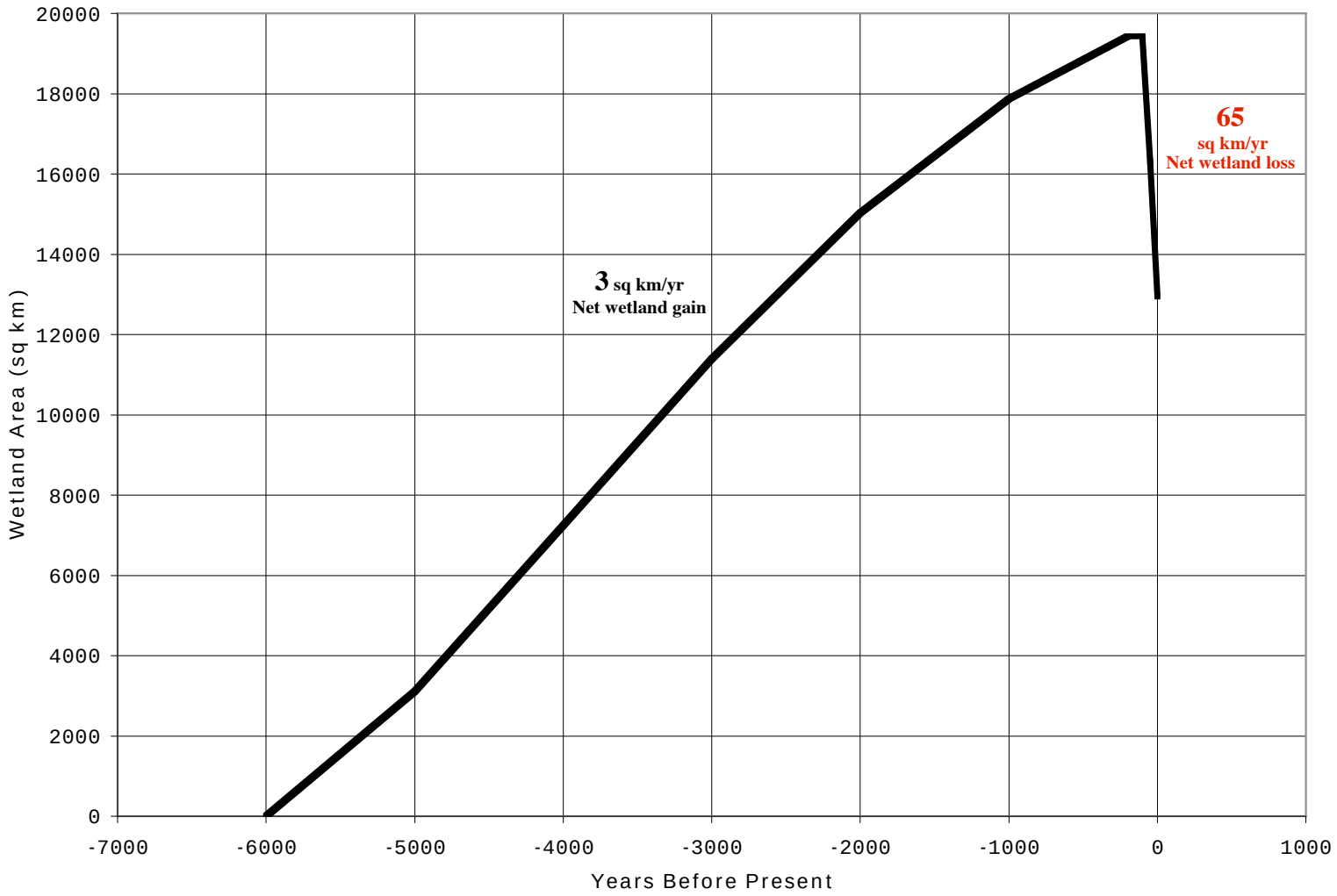
Sea-viewing Wide Field-of-View Sensor (SeaWiFS) data on marine and terrestrial plant productivity


NOAA

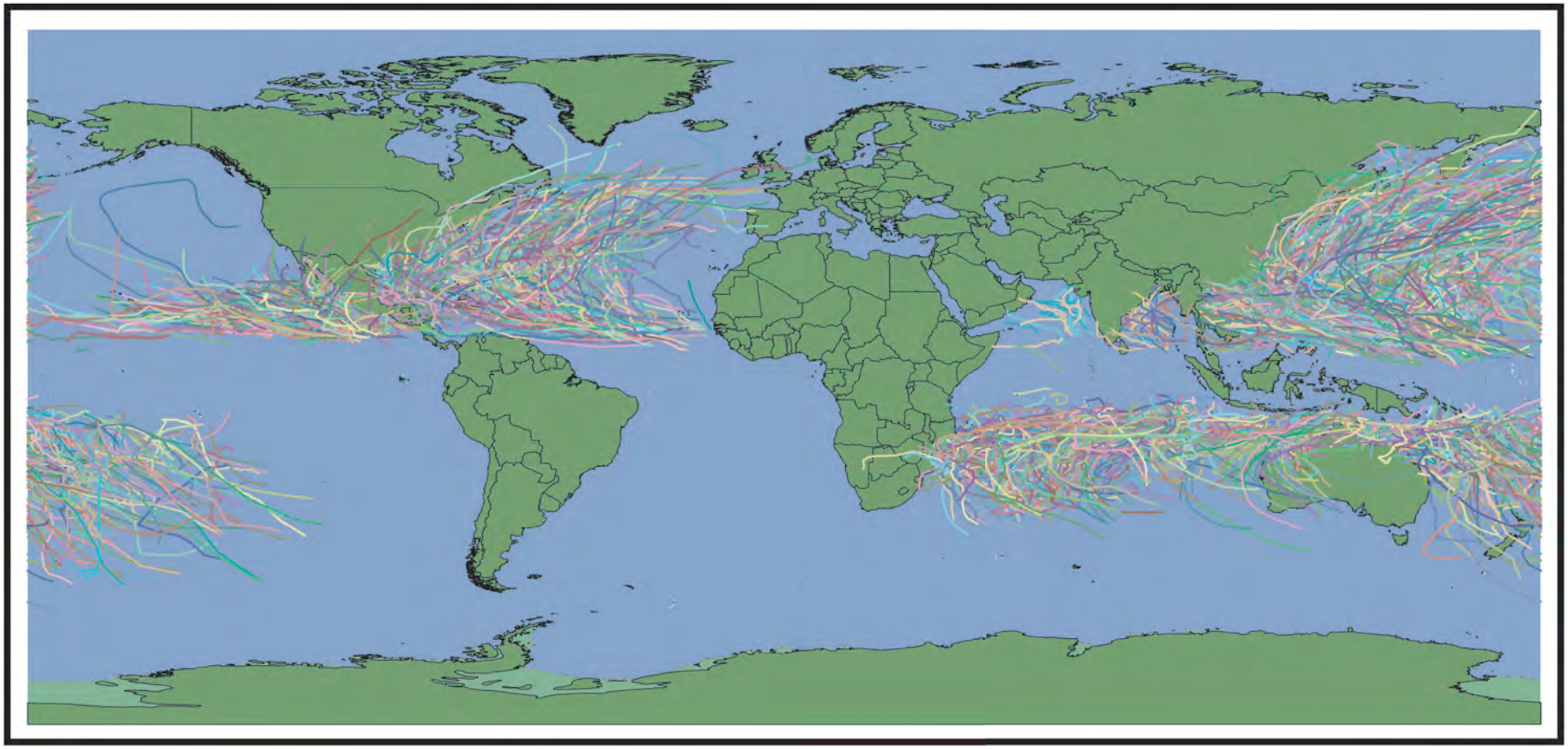
Picture taken by an automatic camera located at an electrical generating facility on the Gulf Intracoastal Waterway (GIWW) where the Route I-510 bridge crosses the GIWW. This is close to where the Mississippi River Gulf Outlet (MRGO) enters the GIWW. The shot clearly shows the storm surge, estimated to be 18-20 ft. in height..



Past and Projected Wetland Loss in the Mississippi Delta (1839 to 2020)



History of coastal Louisiana wetland gain and loss over the last 6000 years, showing historical net rates of gain of approximately 3 km^2/year over the period from 6000 years ago until about 100 years ago, followed by a net loss of approximately 65 km^2/yr since then.



Global Storm Tracks 1980 - 2006

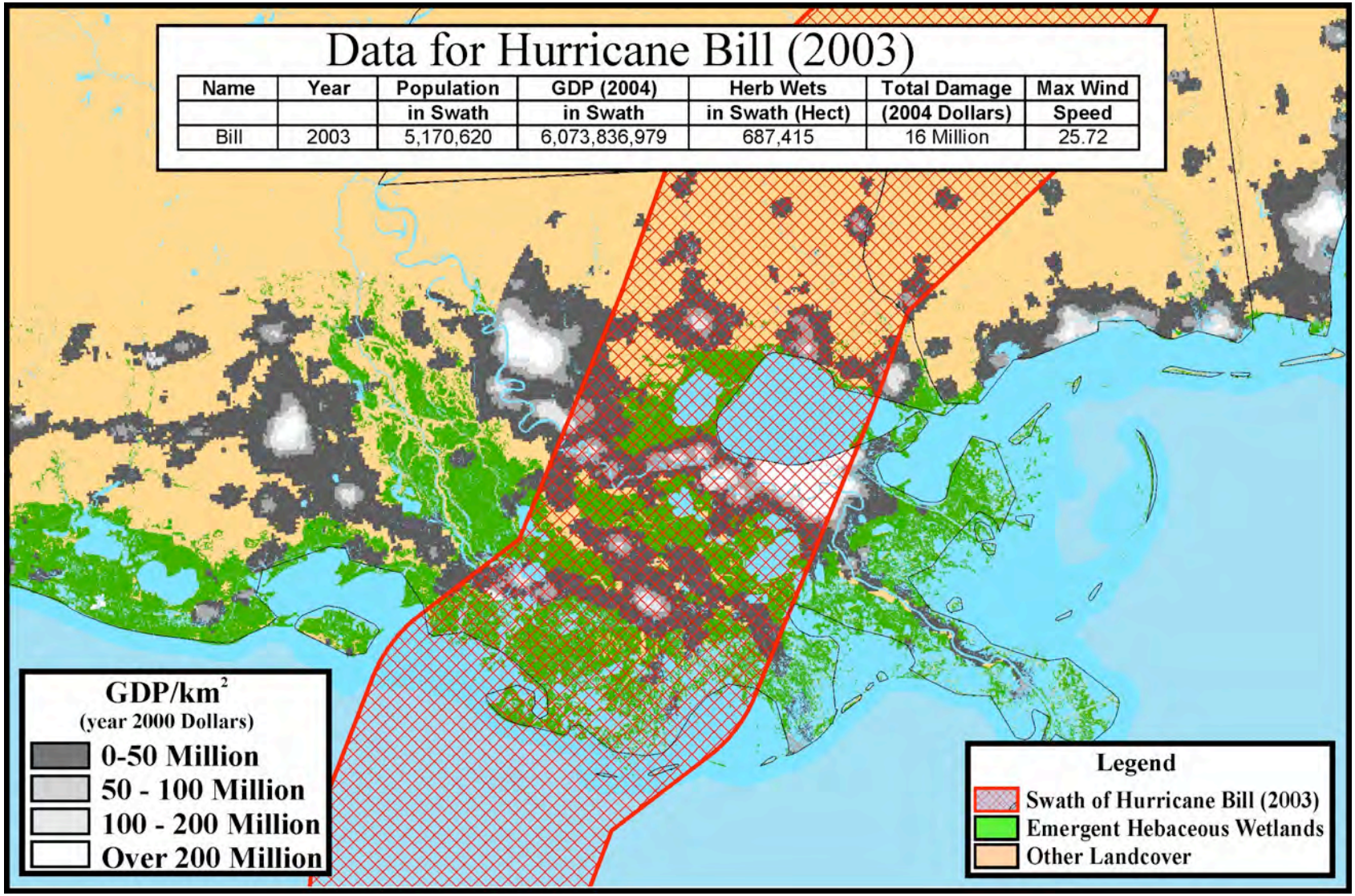


Figure 1. Typical hurricane swath showing GDP and wetland area used in the analysis.

The value of coastal wetlands for hurricane protection

$$\ln (TD_i / GDP_i) = \alpha + \beta_1 \ln(g_i) + \beta_2 \ln(w_i) + u_i \qquad (1)$$

Where:

TD_i = total damages from storm i (in constant 2004 $US);

GDP_i = Gross Domestic Product in the swath of storm i (in constant 2004 $US). The swath was considered to be 100 km wide by 100 km inland.

g_i = maximum wind speed of storm i (in m/sec)

w_i = area of herbaceous wetlands in the storm swath (in ha).

u_i = error

Predicted total damages from storm *i*

$$TD_i = e^{\alpha} * g_i^{\beta_1} * w_i^{\beta_2} * GDP_i$$

Avoided cost from a change of 1 ha of coastal wetlands for storm *i*

$$\Delta TD_i = e^{\alpha} * g_i^{\beta_1} * \left((w_i - 1)^{\beta_2} - w_i^{\beta_2} \right) * GDP_i$$

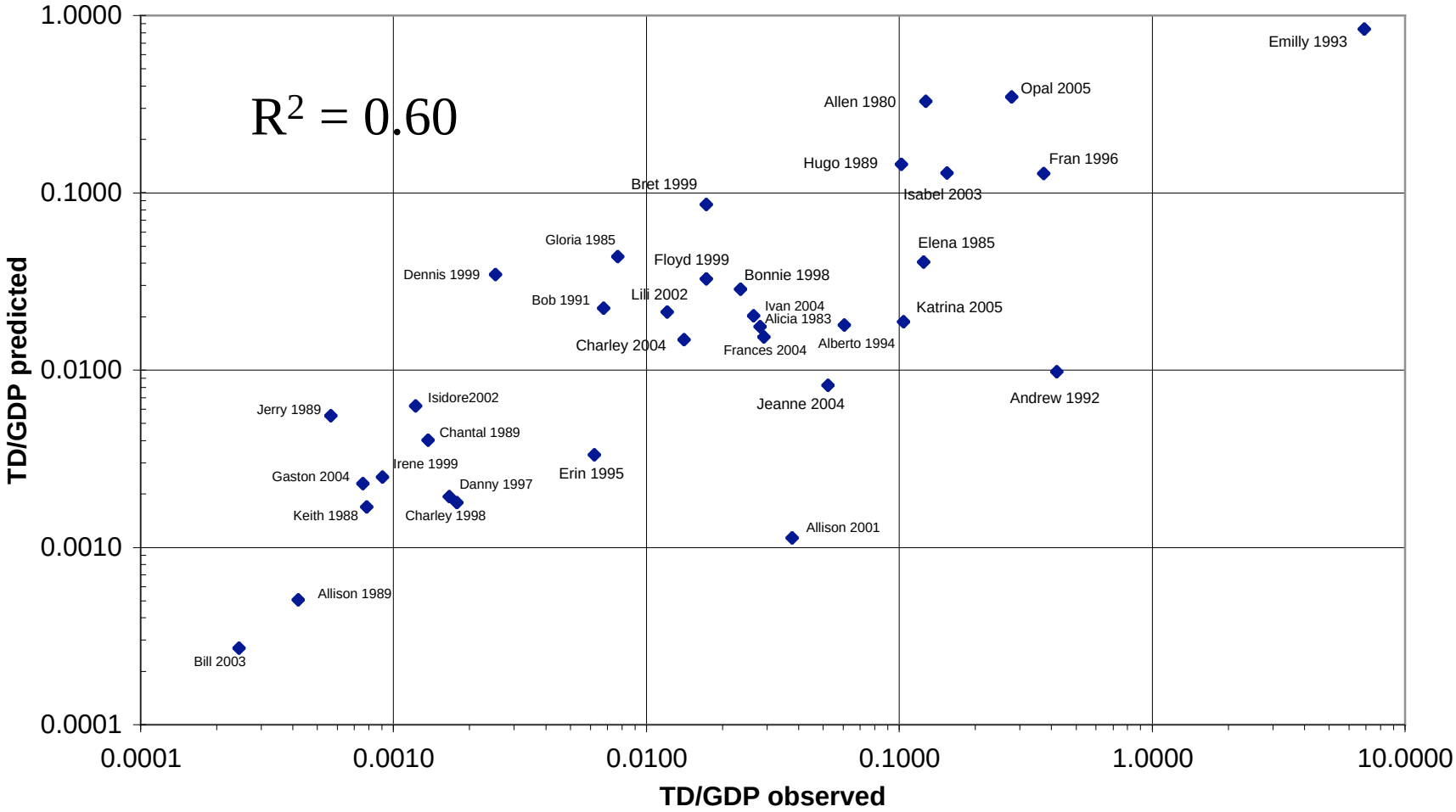


Figure 2. Observed vs. predicted relative damages (TD/GDP) for each of the hurricanes used in the analysis.

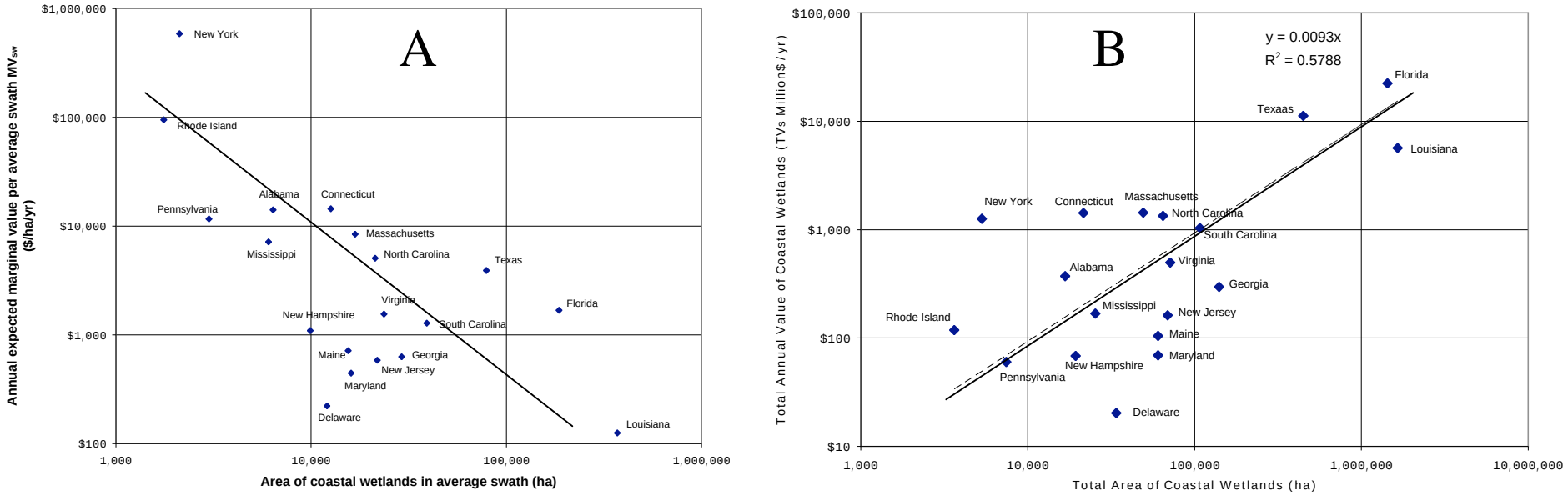
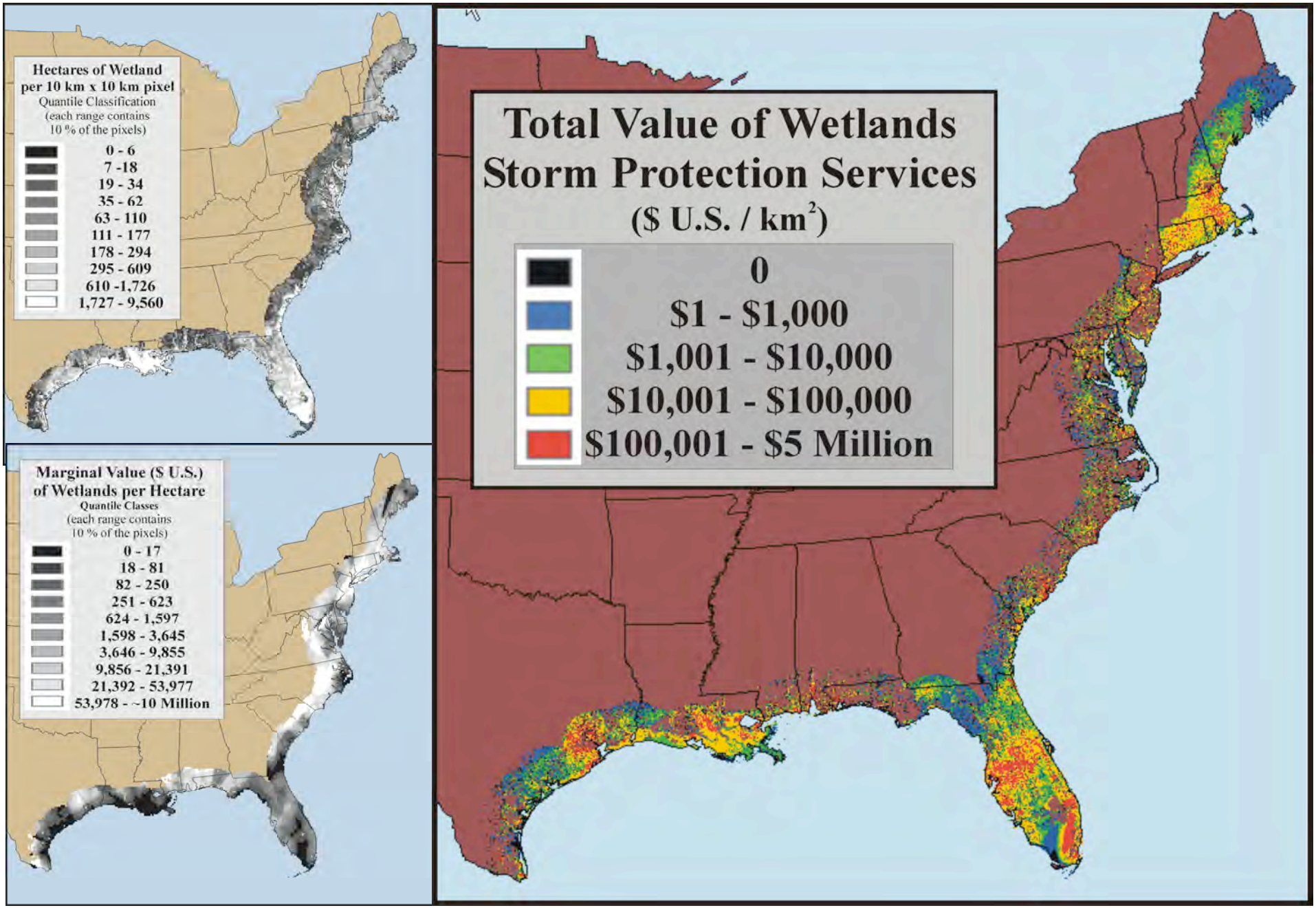


Figure 3. Area of coastal wetlands (A) in the average hurricane swath vs. the estimated marginal value per ha (MV_{sw}) and (B) in the entire state vs. the total value (TV_s) of coastal wetlands for storm protection.


Hectares of Wetland
per 10 km x 10 km pixel
Quantile Classification
(each range contains
10 % of the pixels)
0 - 6
7 -18
19 - 34
35 - 62
63 - 110
111 - 177
178 - 294
295 - 609
610 -1,726
1,727 - 9,560
Marginal Value ($ U.S.)
of Wetlands per Hectare
Quantile Classes
(each range contains
10 % of the pixels)
0 - 17
18 - 81
82 - 250
251 - 623
624 - 1,597
1,598 - 3,645
3,646 - 9,855
9,856 - 21,391
21,392 - 53,977
53,978 - ~10 Million
Total Value of Wetlands
Storm Protection Services
($ U.S. / km²)
0
$1 - $1,000
$1,001 - $10,000
$10,001 - $100,000
$100,001 - $5 Million

•A loss of 1 ha of wetland in the model corresponded to an average $33,000 (median = $5,000) increase in storm damage from specific storms.

•Taking into account the annual probability of hits by hurricanes of varying intensities, the annual value of coastal wetlands ranged from $250 to $51,000/ha/yr, with a mean of $8,240/ha/yr (median = $3,230/ha/yr)

• Coastal wetlands in the US were estimated to currently provide $23.2 Billion/yr in storm protection services.

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#ı, 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

k*Graduate 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

kk*National 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

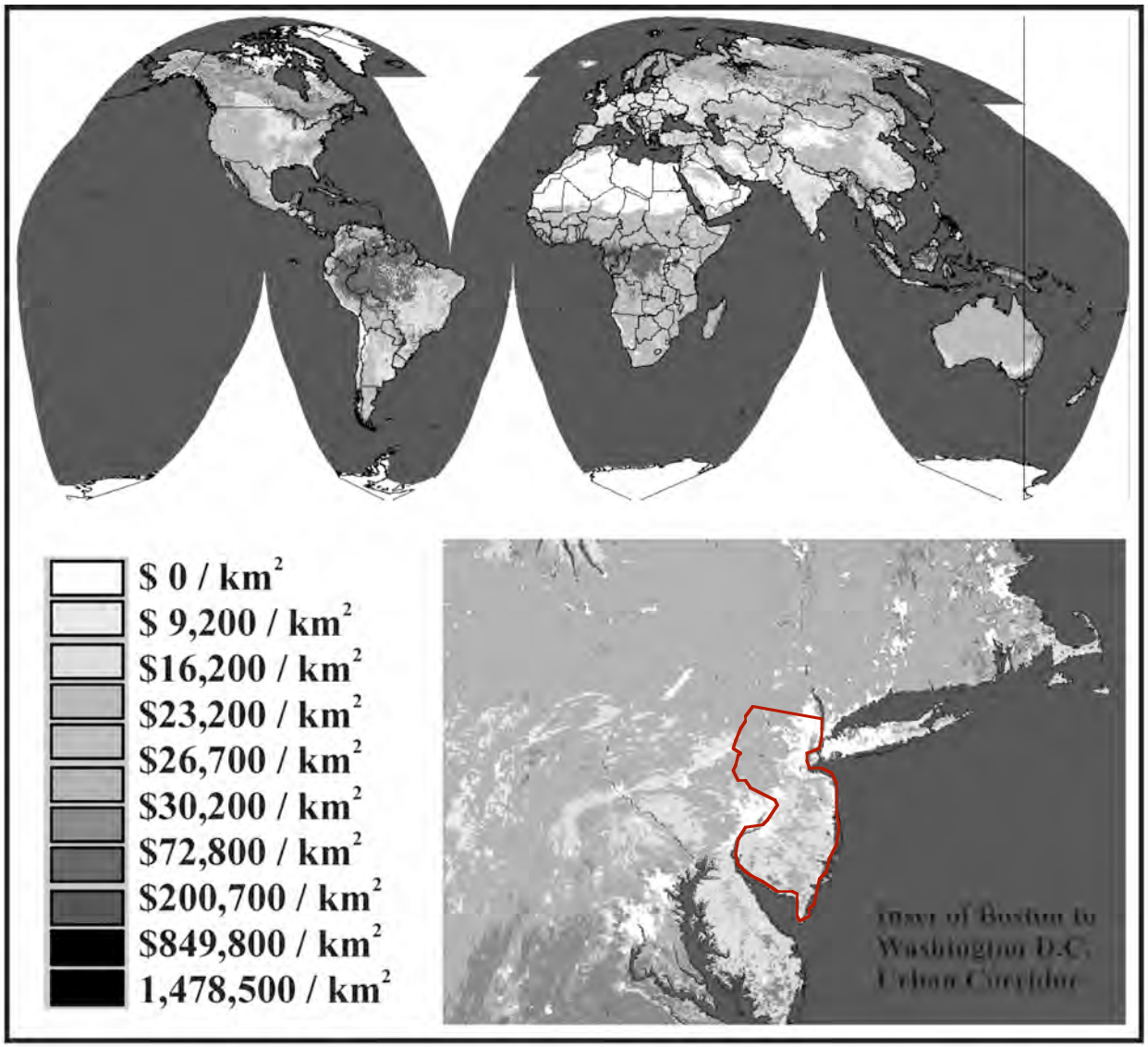


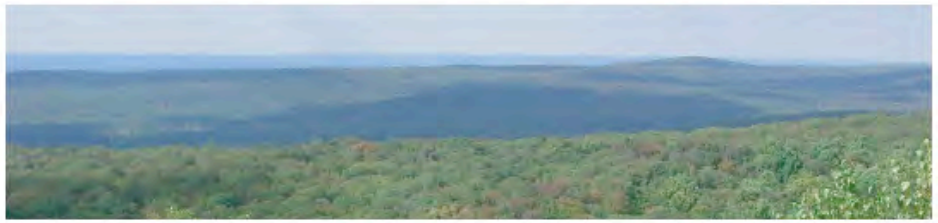
Figure 3: Global Map of Non-Marketed Economic Activity (ESP) arising from Ecosystem Services and derived from Land Cover at 1 km^2 (For National Totals See Table 1)

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

Valuing New Jersey's Natural Capital:

An Assessment of the Economic Value of the State's Natural Resources

April 2007



State of New Jersey
New Jersey Department of Environmental Protection
Jon S. Corzine, Governor
Lisa P. Jackson, Commissioner

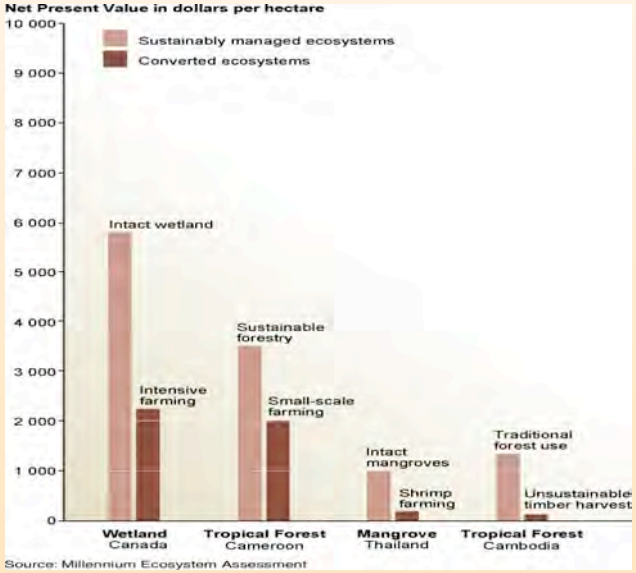
Average Ecosystem Service Value per Hectare for New Jersey

The New Jersey Ecosystem Service Valuation Project Team at the University of Vermont: Robert Costanza, Matthew Wilson, Austin Troy, Alexey Voinoiv, Shuang Liu and John D'Agostino

Map Produced by Austin Troy and John D'Agostino

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**

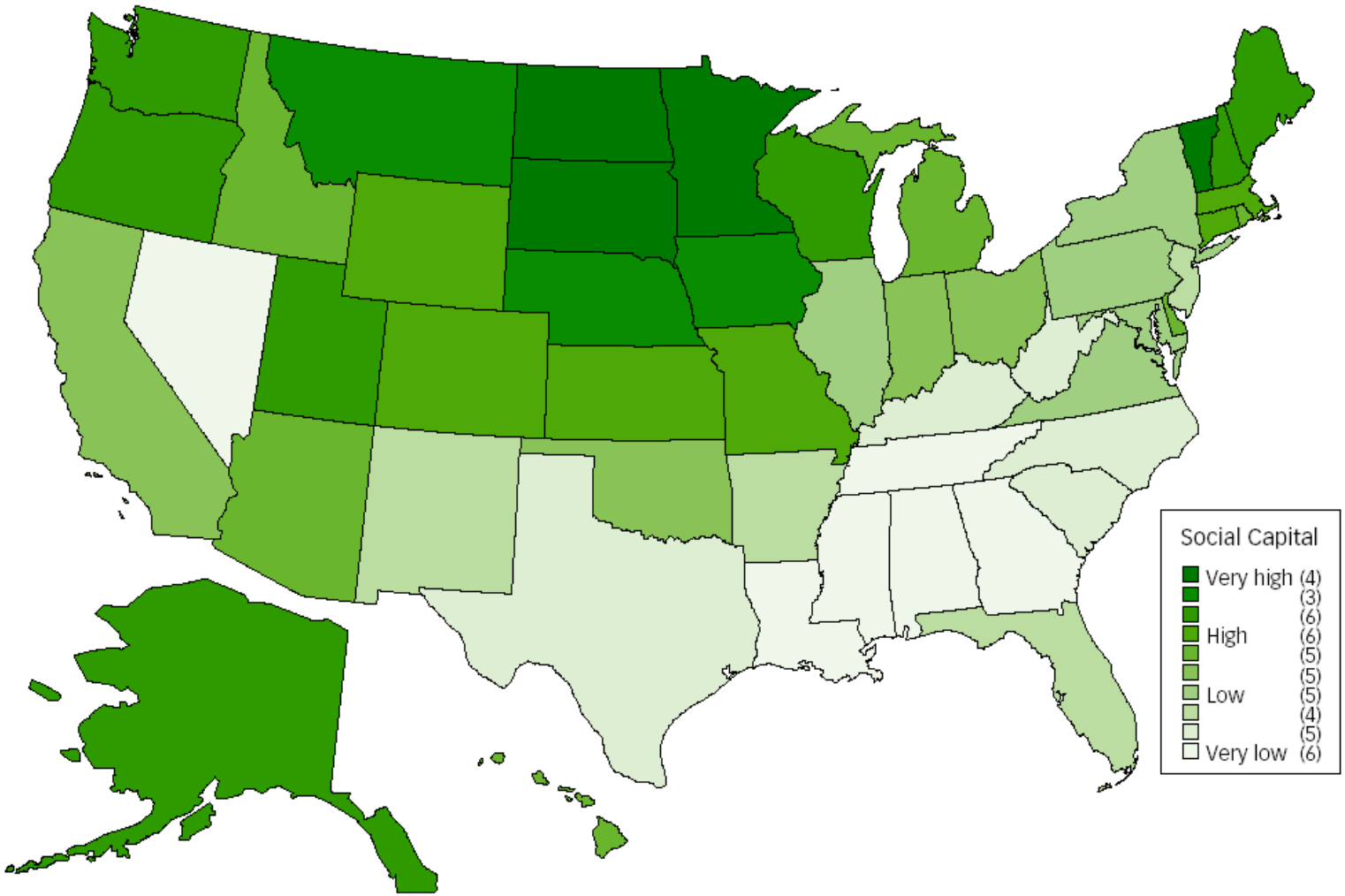
Benefits (Net value* of ecosystem services from the global reserve network) = **$US 4,400-5,200 Billion/yr**

***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).

FIGURE 7.4

Violent crime is rarer in high social capital states

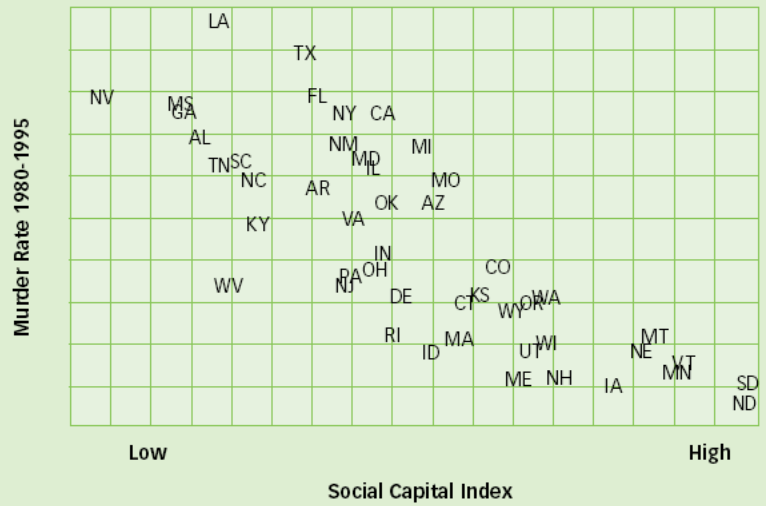


FIGURE 7.3

Kids watch less TV in high social capital states

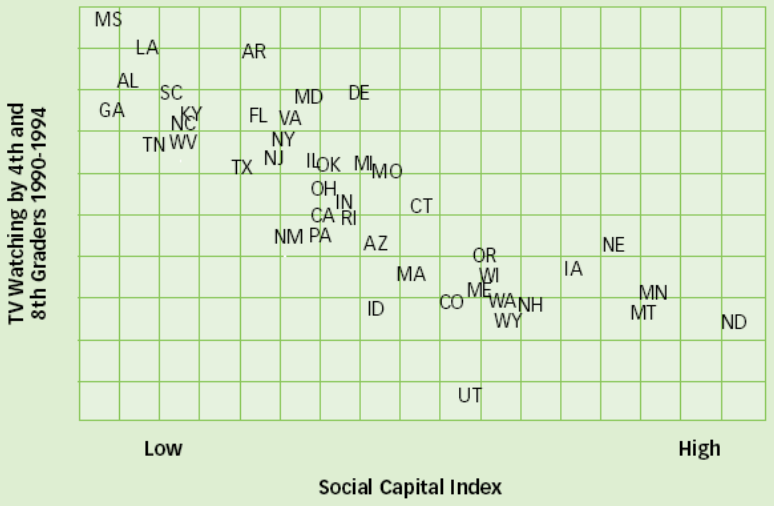


FIGURE 7.1

Schools work better in high social capital states

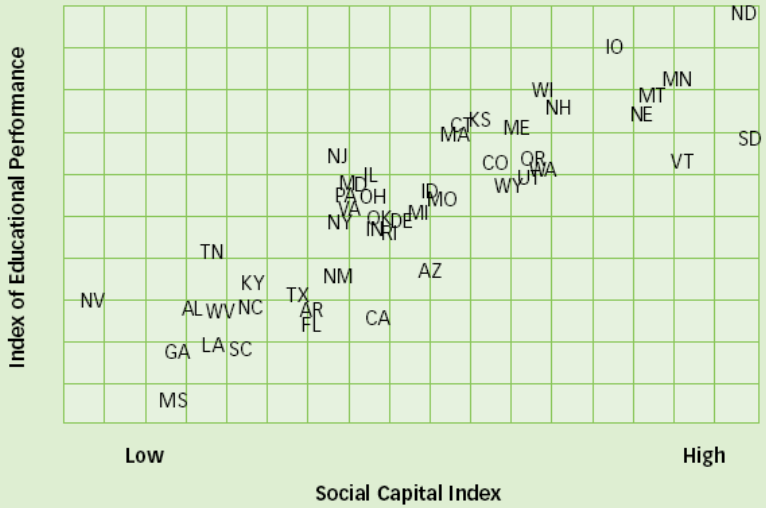
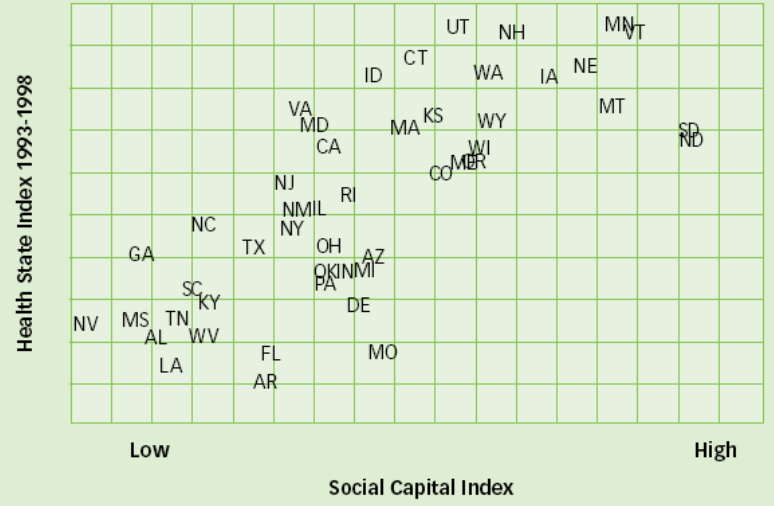


FIGURE 7.6

Health is better in high social capital states



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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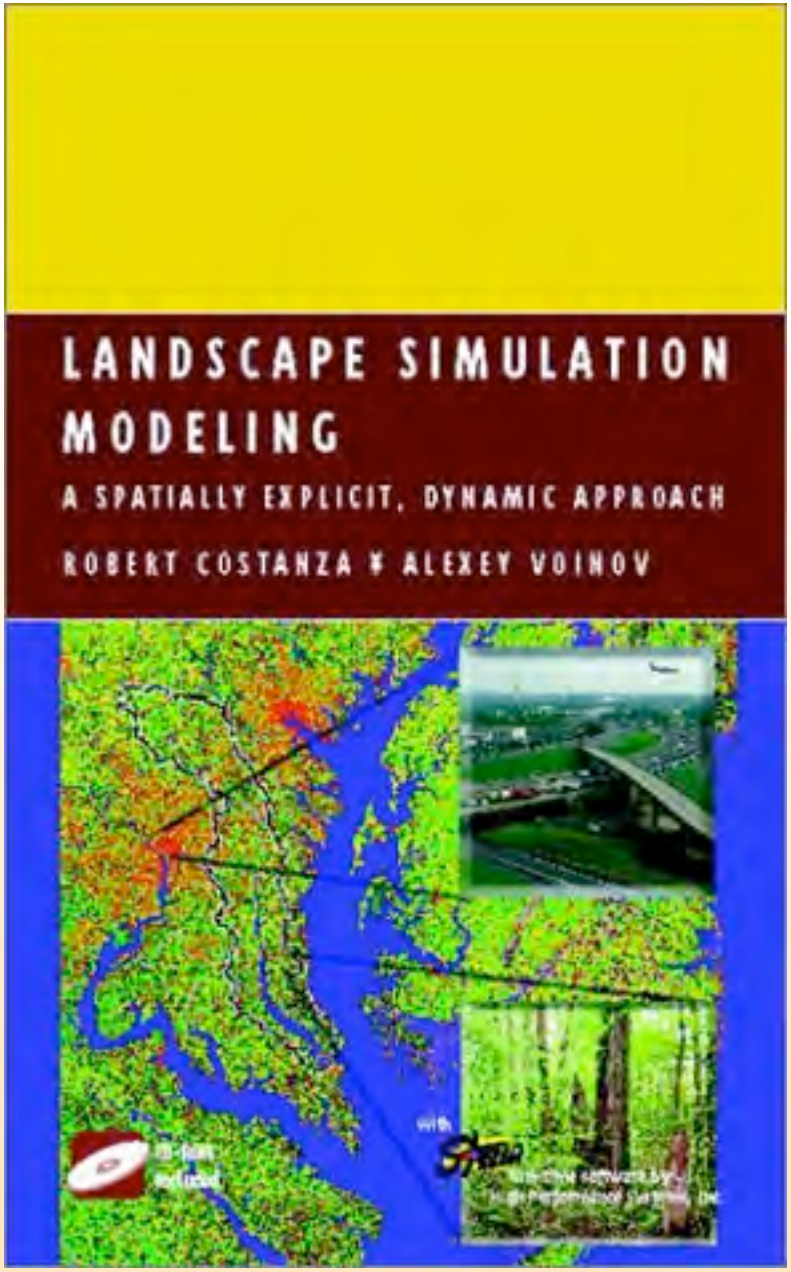
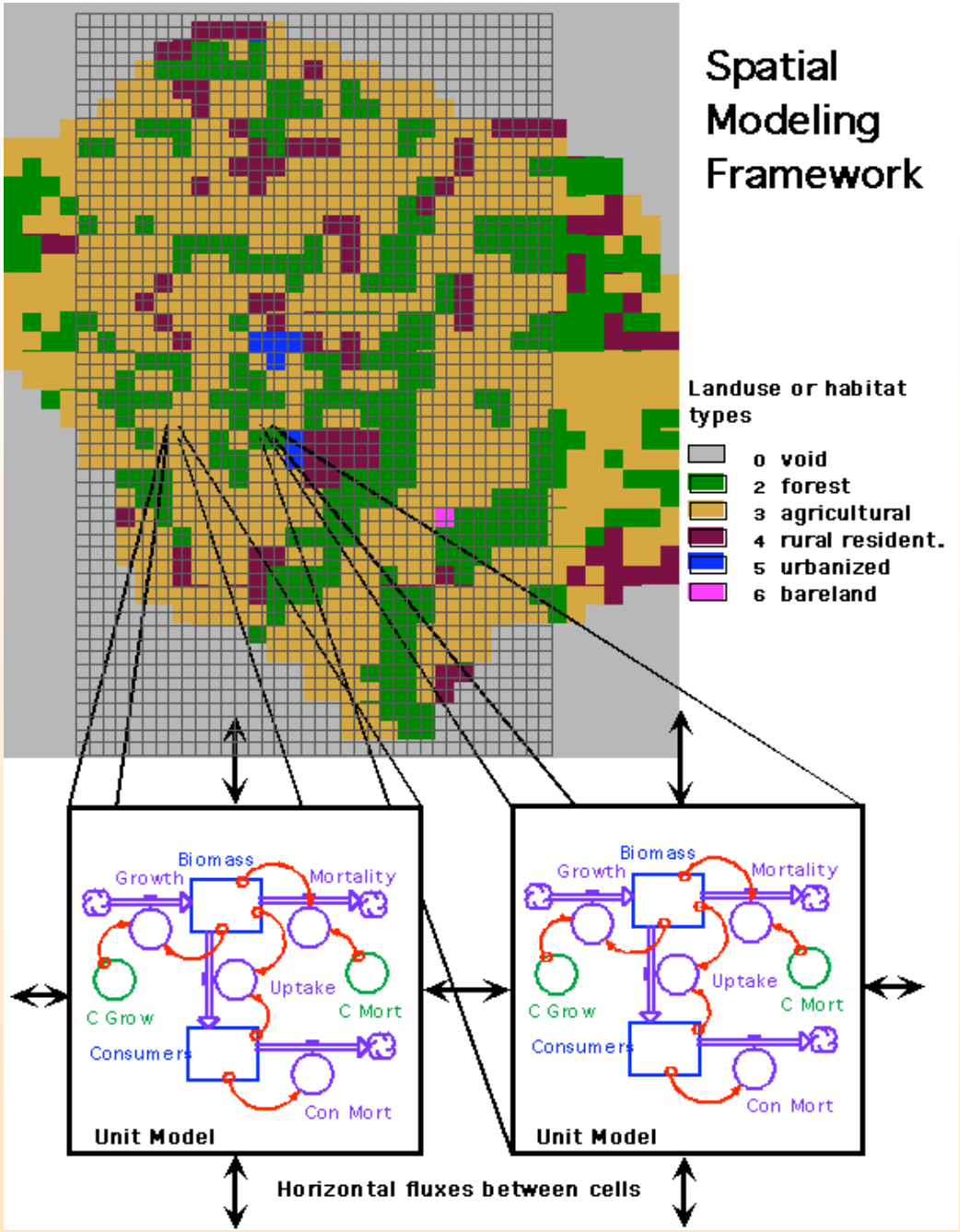
University of Vermont


LANDSCAPE SIMULATION MODELING
A SPATIALLY EXPLICIT, DYNAMIC APPROACH
ROBERT COSTANZA * ALEXEY VOINOV


Spatial Modeling Framework
Landuse or habitat types
0 void
2 forest
3 agricultural
4 rural resident.
5 urbanized
6 bareland
Biomass
Growth
Mortality
Uptake
C Grow
C Mort
Consumers
Con Mort
Unit Model
Unit Model
Horizontal fluxes between cells

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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Major Accomplishments:

- **Global network** of collaborators (> 100, 14 countries)
- **Collaborative development of models** (MIMES) including biophysical dynamics and valuation
- **Initial results and ongoing applications** at calibration sites (Global, Vermont, Amazon, PNW, Mexico, Marine)
- **Web sites** for collaboration, education, and model delivery
- **Publication of results** in multiple venues
- **Commitments for applications** to multiple sites around the world

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Collaborative Model Development

EcoServices classified according to spatial characteristics

1. Global-Non Proximal (does not depend on proximity)

1&2. Climate Regulation

Carbon sequestration (NEP)

Carbon storage

17. Cultural/Existence value

2. Local Proximal(depends on proximity)

3. Disturbance Regulation/ Storm protection

9. Waste Treatment

10. Pollination

11. Biological Control

12. Habitat/Refugia

3. Directional Flow-Related: flow from point of production to point of use

4. Water regulation/flood protection

5. Water supply

6. Sediment regulation/Erosion control

8. Nutrient regulation

4. In situ (point of use)

7. Soil formation

13. Food production/Non-timber forest products

14. Raw materials

5. User movement related: flow of people to unique natural features

15. Genetic resources

16. Recreation potential

17. Cultural/Aesthetic

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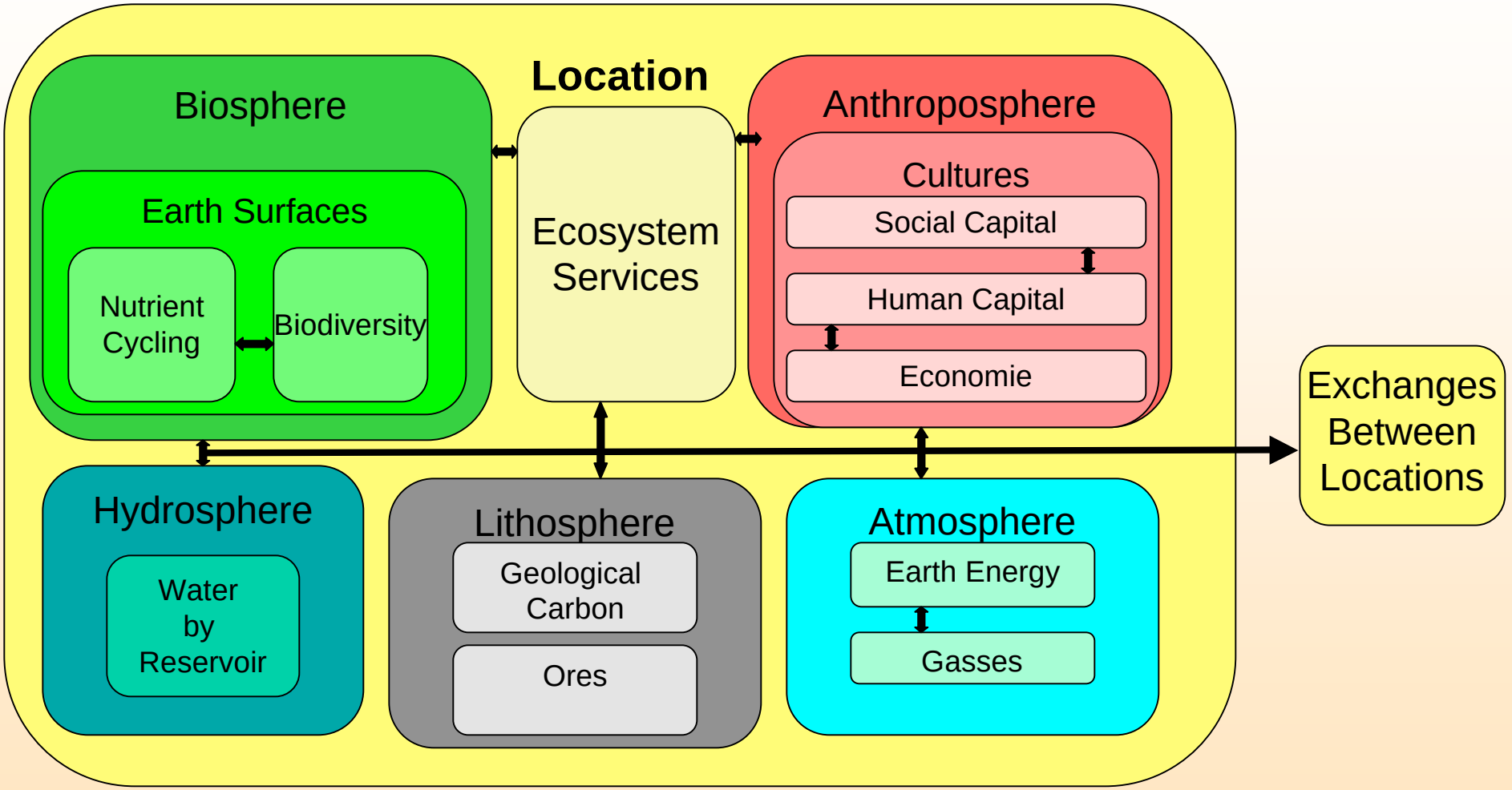
MIMES

Multi-scale Integrated Models of Ecosystem Services



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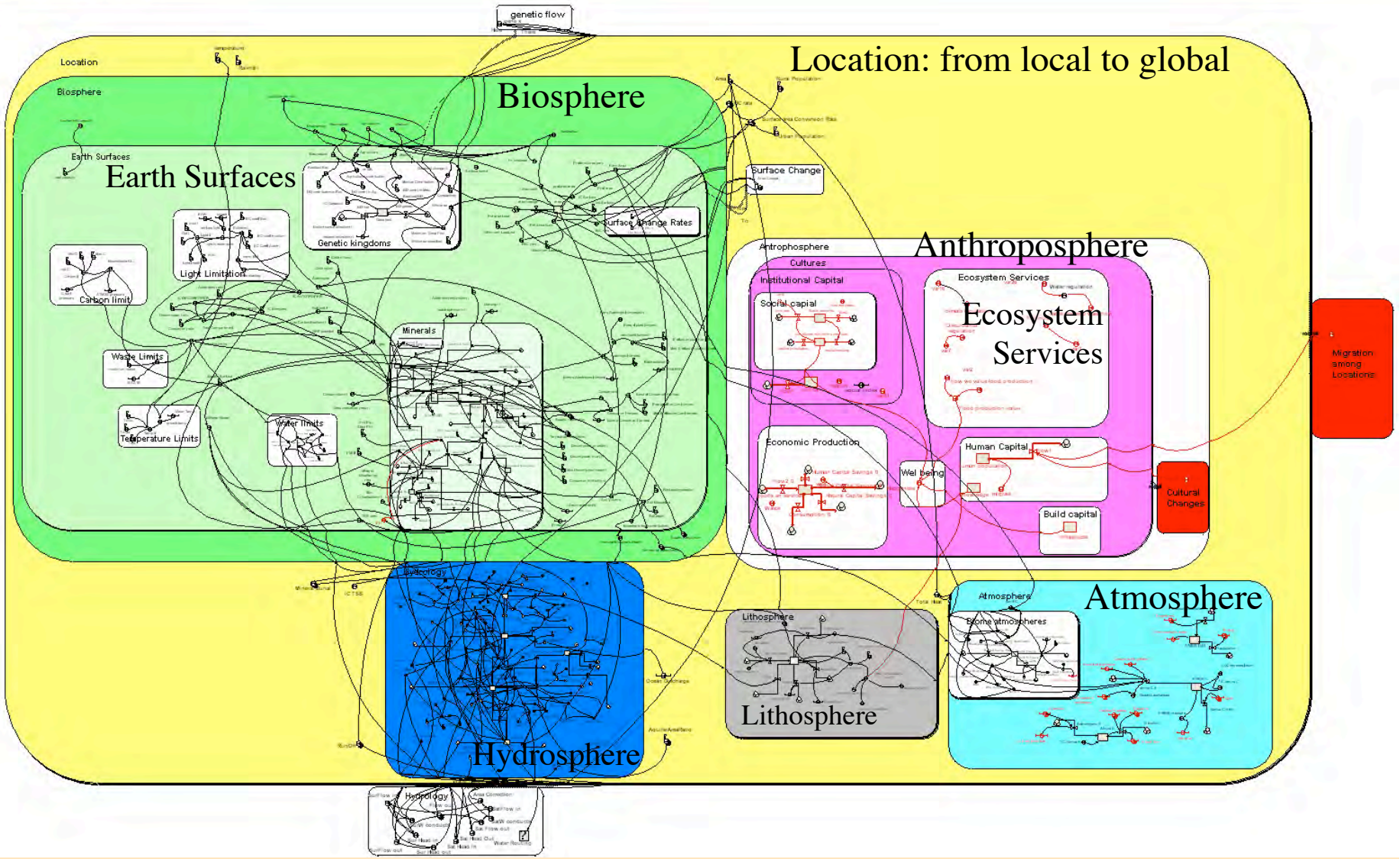
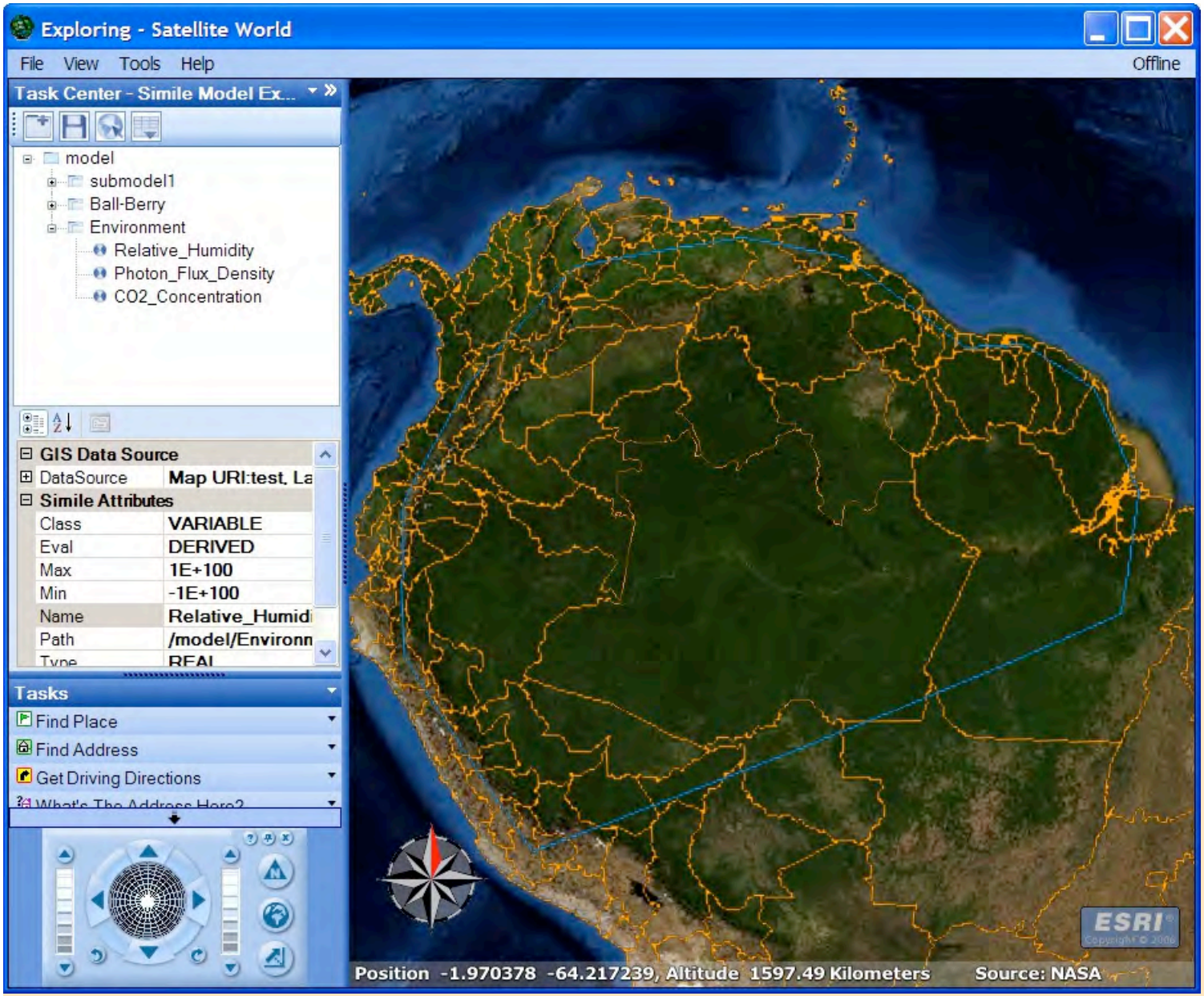
MIMES Multiscale Integrated Models of Ecosystem Services)



Ability to select specific areas to model at variable spatial and temporal resolution, in their global and regional context



A range of calibration sites used by project partners to test model applicability and performance. These include in the first phase: Amazon, Pacific northwest, Winoski watershed, Vermont, and Global

Three complementary and synergistic ways to include humans in models and modeling:

1. **As "stakeholders" and active participants in the model conceptualization, development, construction, testing, scenario development, and implementation processes.**

2. **As "players" of the models where the model is used as both a decision aid and as a research tool to better understand human behavior in complex valuation and decision processes.**

3. **As "agents" programmed into the model based on better understanding of their goals and behavior gleaned through 1 and 2.**

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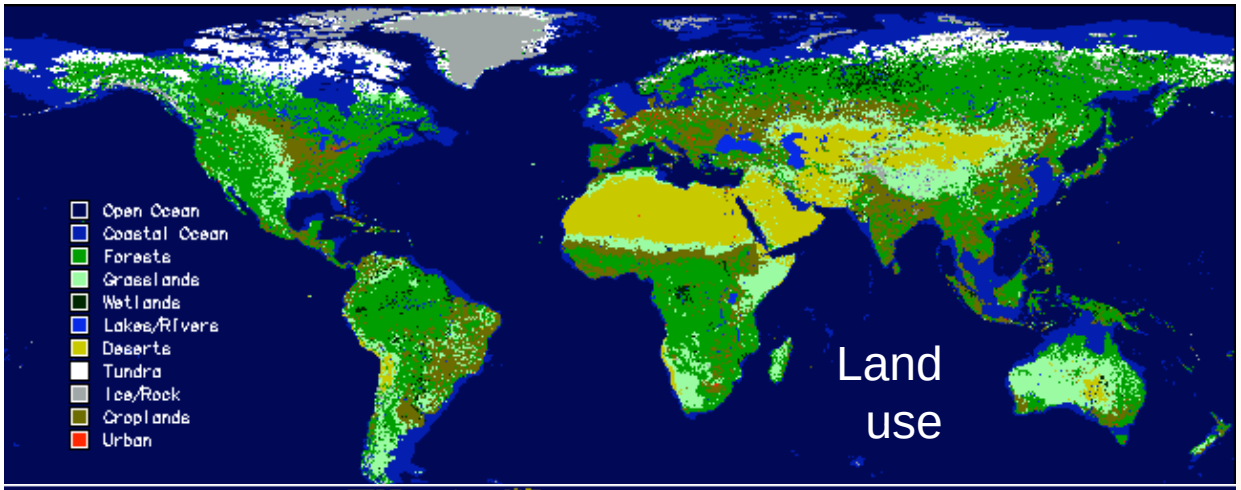
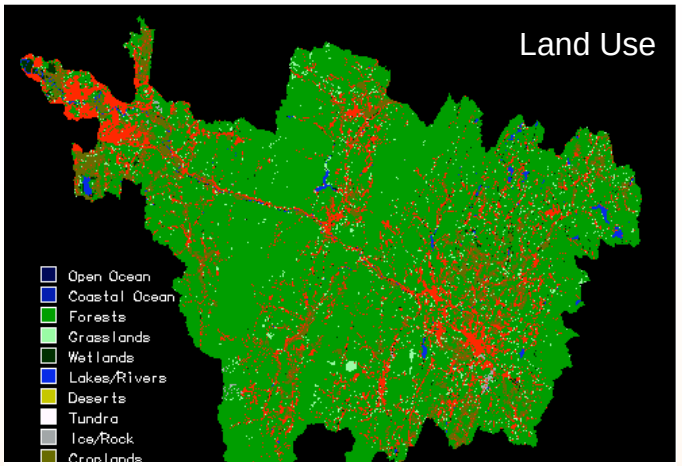

Open Ocean
Coastal Ocean
Forests
Grasslands
Wetlands
Lakes/Rivers
Deserts
Tundra
Ice/Rock
Croplands
Urban
Land use


Land Use
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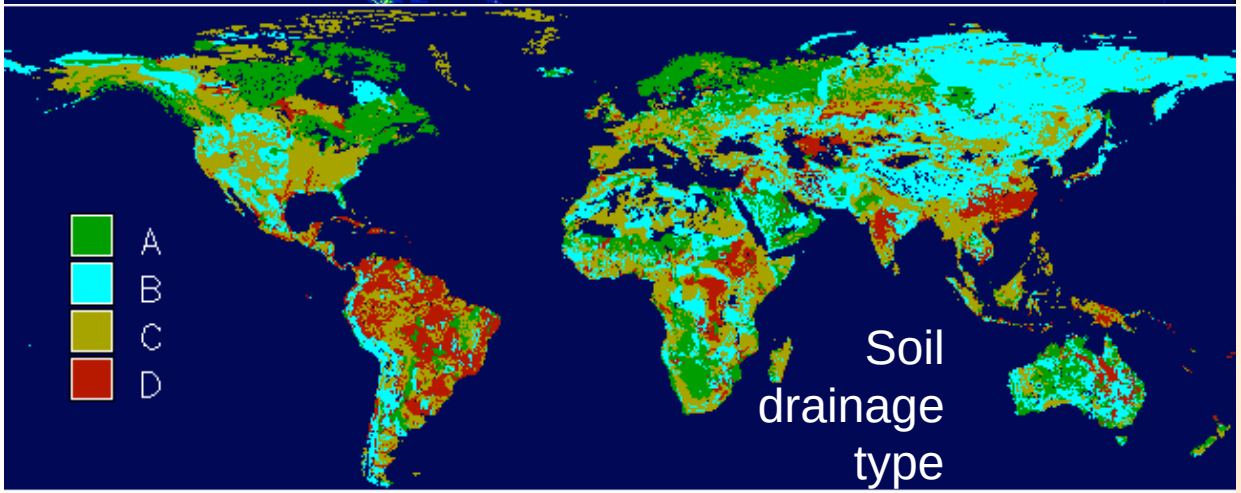
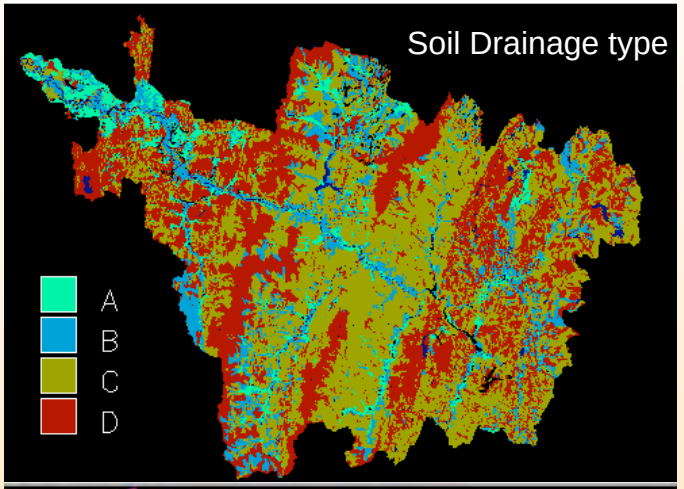
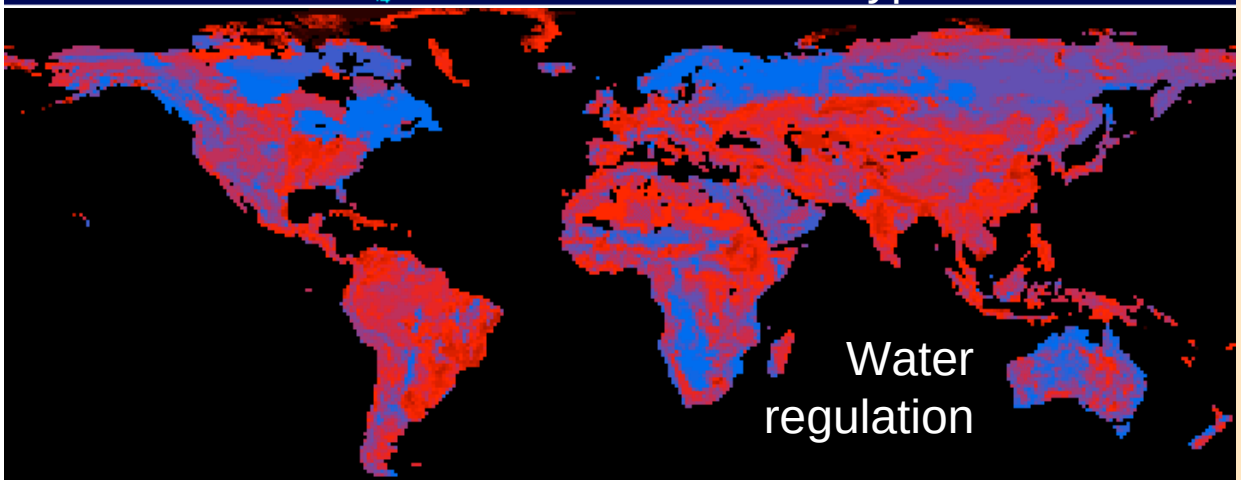
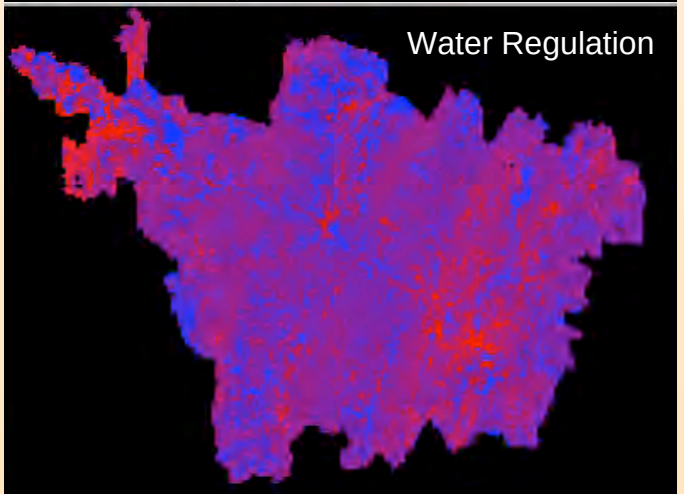
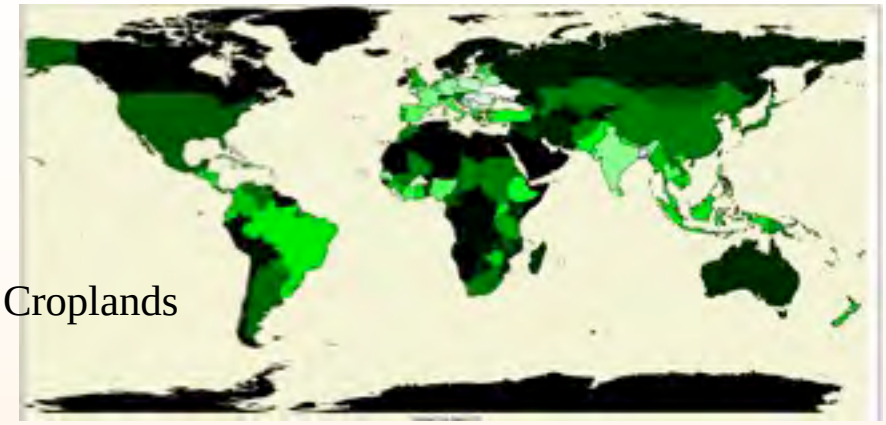

A
B
C
D
Soil drainage type

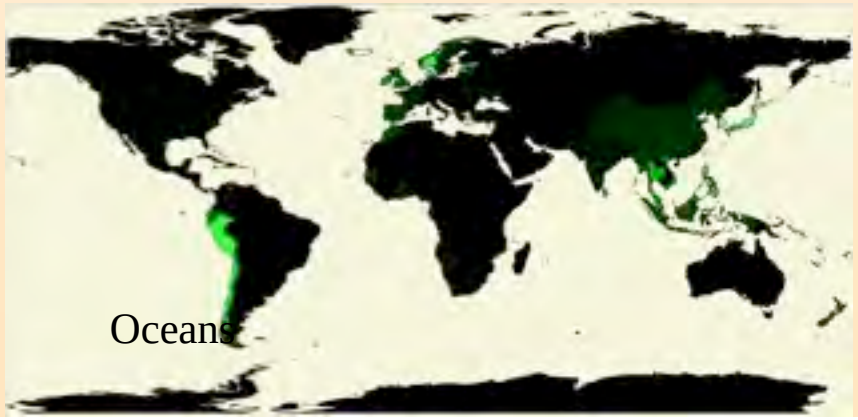

Soil Drainage type
A
B
C
D


Water regulation

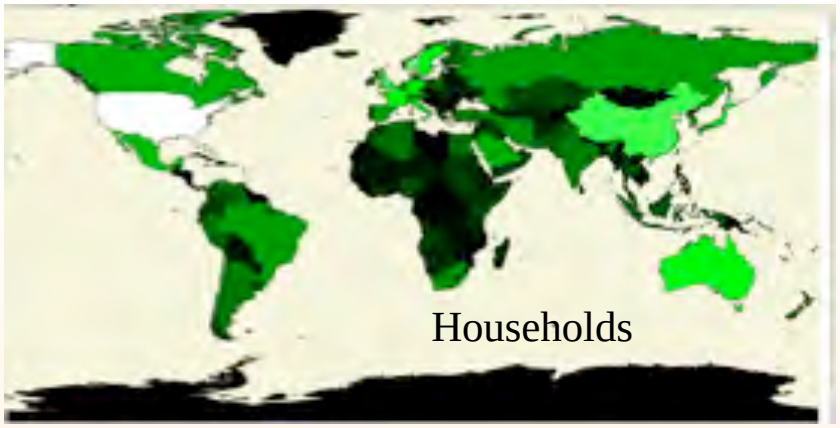

Water Regulation

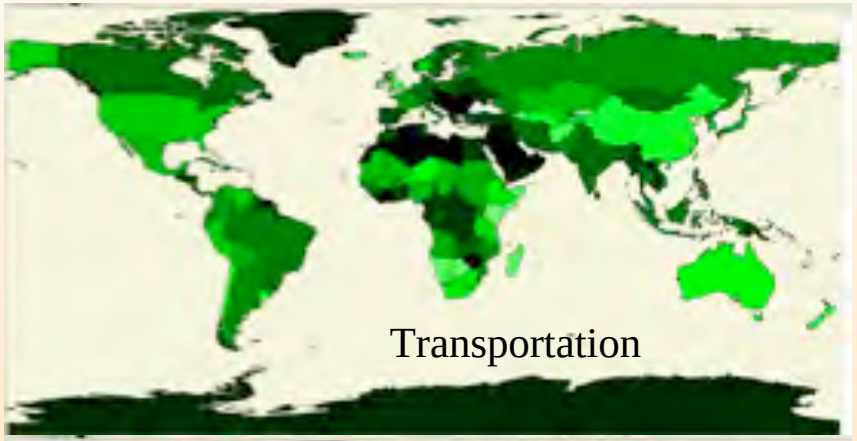
Ecosystems (% Area)

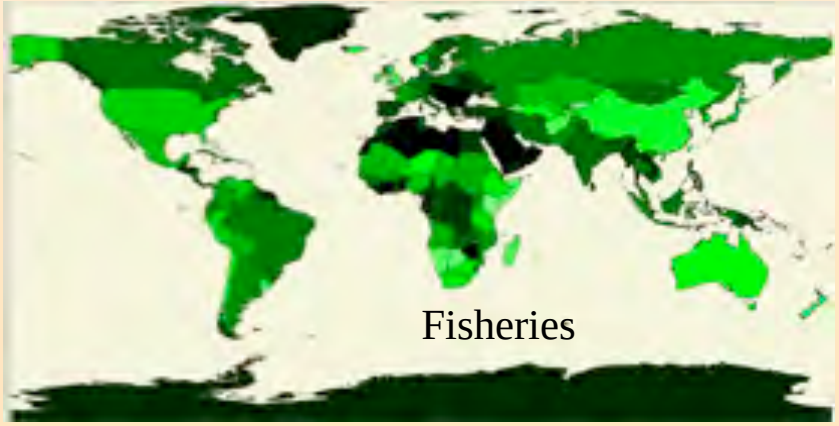




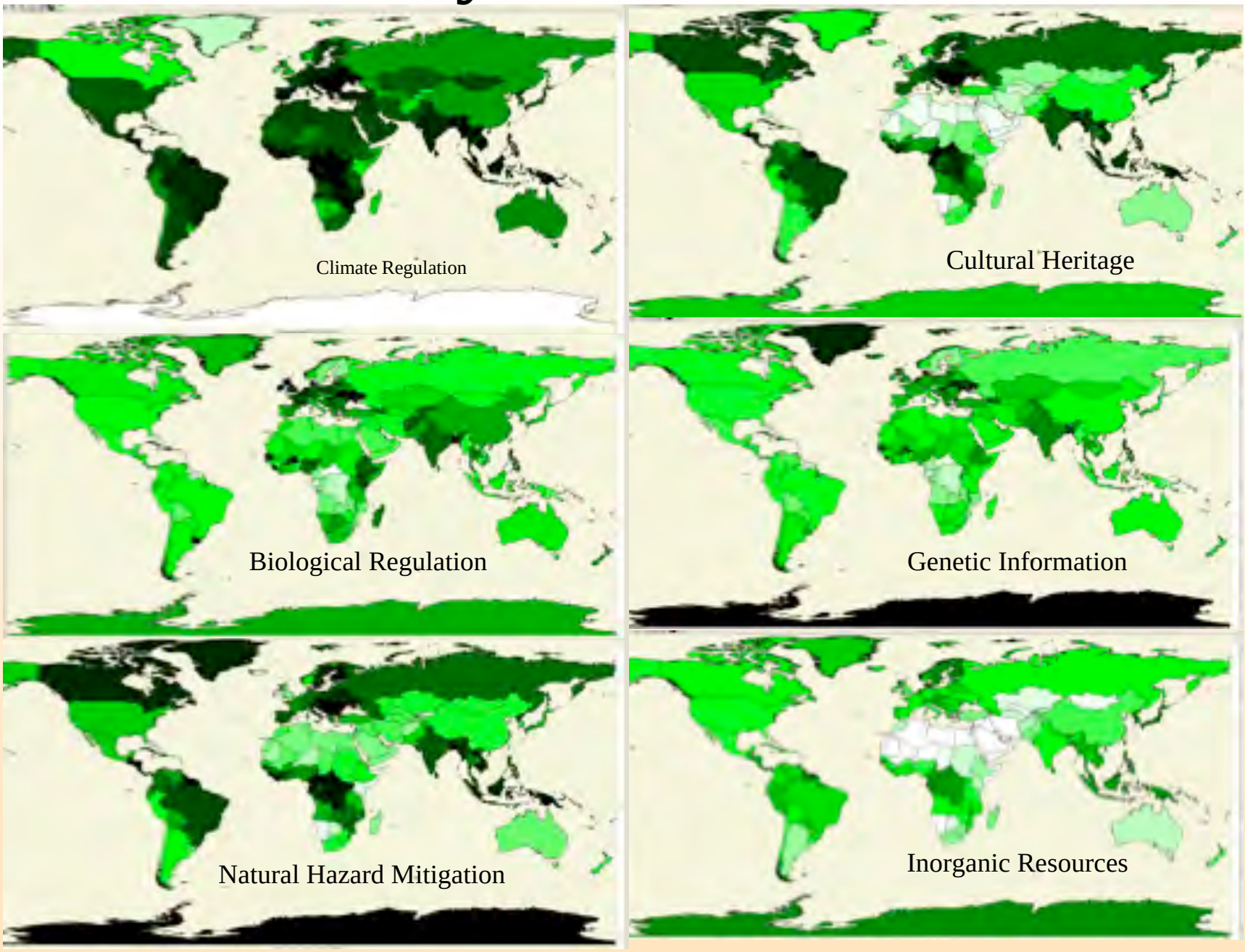
1990 economic production in $ PPP by country







Ecosystem Services



Next Steps:

1. Further development and testing of MIMES

2. Application to a large number of sites around the world in support of conservation, PES systems, carbon trading, national accounting, etc. in collaboration with local partners (including those in the Moore portfolio)

3. make MIMES the most widely used and trusted system for ecosystem service modeling and evaluation in the world

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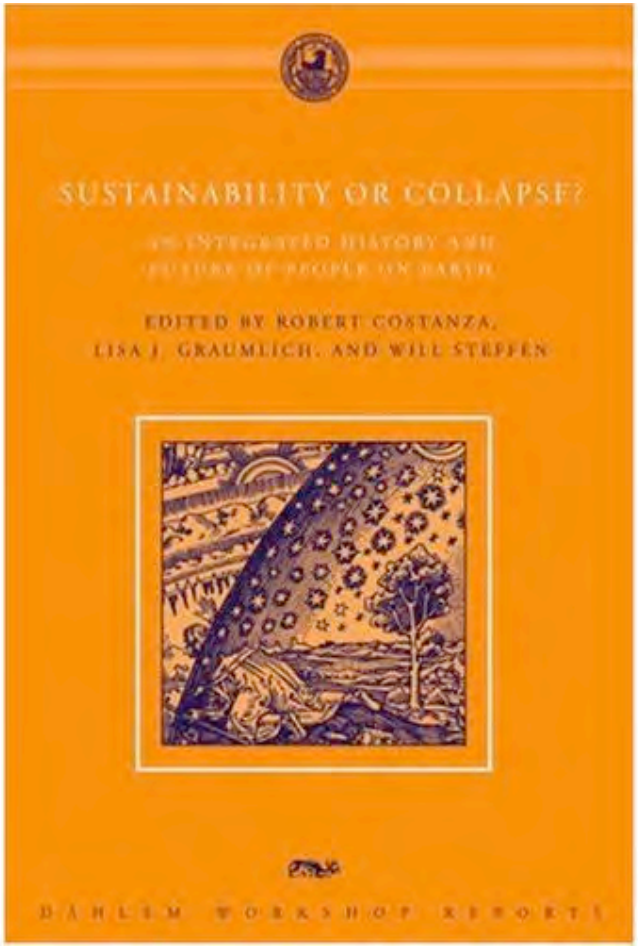
SUSTAINABILITY OR COLLAPSE?

AN INTEGRATED HISTORY AND FUTURE OF PEOPLE ON EARTH

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

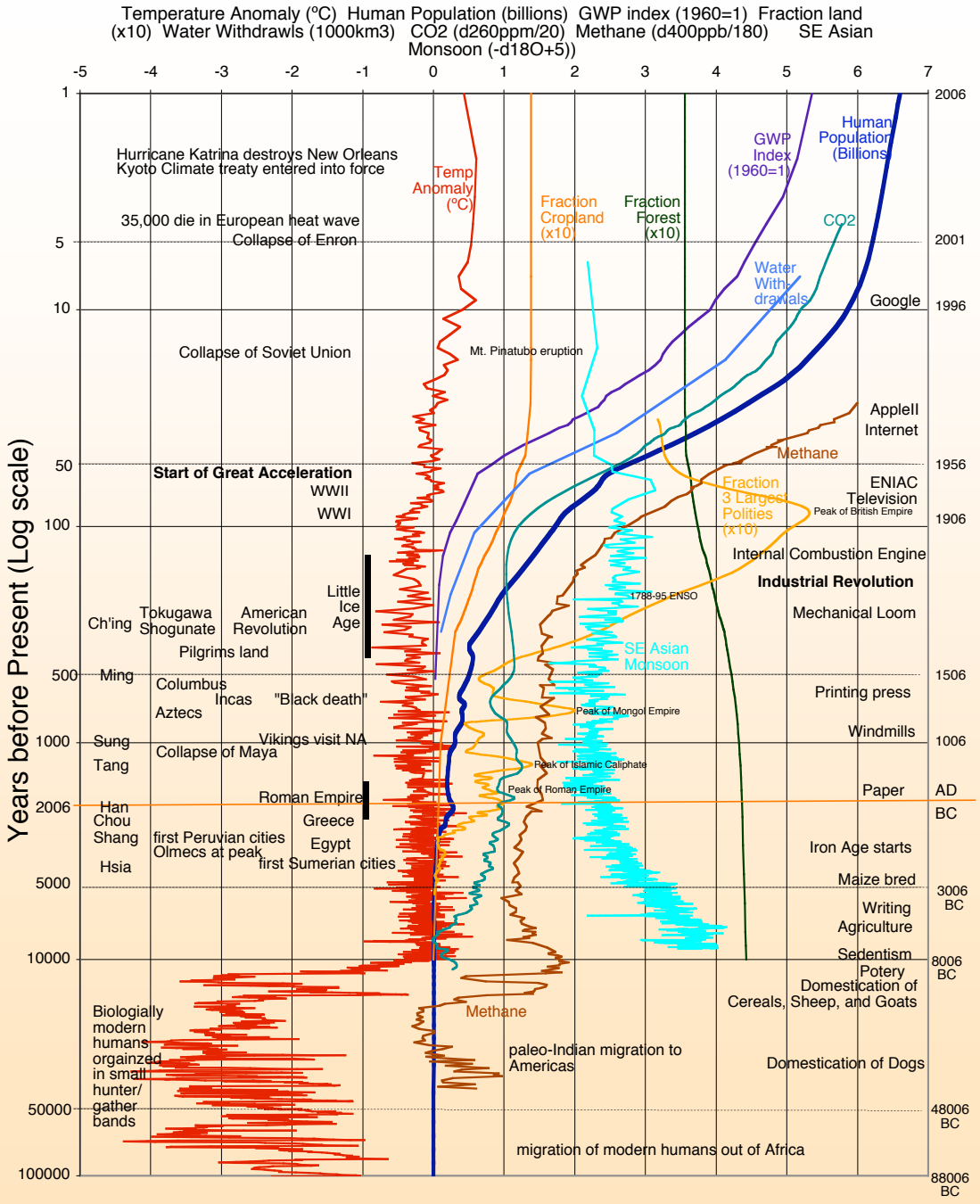


Human history, as written traditionally, leaves out the important ecological and climate context of historical events. But the capability to integrate the history of human beings with the natural history of the Earth now exists, and we are finding that human-environmental systems are intimately linked 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* 36:522-527

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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Environment Agency
Environmental Disclosures

Carbon Disclosure Project Report 2006 FTSE 350

Welcome

Trucost is an environmental research organisation working with companies, investors and government agencies to understand the impacts companies have on the environment. Trucost is an independent organisation founded in 2000.

TRUCOST

Carbon Footprint Analysis

Are your pension fund clients and trustees asking for the carbon costs of companies in your investment portfolio?

Do you need help identifying and reporting on these?

Research on over 3,200 companies including all constituents of the MSCI All World Developed, FTSE All-Share, S&P 500, Russell 1000, ASX 200 & Nikkei 225

Investors >>

Also available through RREV

Research for Investors

more...

Companies >>

Tools for Companies

more...

Received a Company Data Sheet?

MORE INFO

News

22nd February 2007

Trucost is delighted to have won the Sustainable and Ethical Investment and Asset Management Category at the City of London Corporation's Sustainable City Awards 2006/7.

19th February 2007

GLG Partners have launched a long-only fund filtering the greenest companies from its $1.5bn European Equity Strategy. The fund uses Trucost data to find the companies in each sector with lighter environmental footprints.

19th February 2007

French sustainability research centre Novethic's most recent newsletter 'L'essentiel de l'ISR' examines Trucost. It talks about the company as a global resource for investors wanting to integrate the environment into the investment process.

29th January 2007

Trucost research reveals that less than half of the world's largest electric utilities disclose their carbon emissions to investors.

17th January 2007

Trucost announces a major upgrade to Trucost Online for 2007

15th January 2007

Trucost is to release an updated briefing on the carbon efficiency of European airlines and the implications of their inclusion in the EU ETS. The announcement follows the appearance of Simon Thomas, Chief Executive,

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…

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participate!

Earth Inc.

The Earth is our business and your business too. Most people have a basic understanding of how a business works. If you own part of the business, then you're entitled to a share of the profits. As an owner you'll want to take good care of the assets of the business and to plan for the future so your business doesn't collapse. You'll also want to maximize your profit, or in other words, the benefit you receive from the business. Imagine the Earth as a business and you're a shareholder. We're all shareholders. Future generations are entitled to a share too. How do we maximize the benefit every shareholder receives from the Earth? How do we maximize human wellbeing? Earth, Inc. helps answer this most important question.

Board of Directors

- Robert Costanza
- Crea Lintilhac
- Shuang Liu
- Matt Sayre

Advisory Board

- Peter Barnes
- Paul Hawken
- John Kassel
- David Orr

The amount of water impounded behind dams quadrupled since 1960, and three to six times as much water is held in reservoirs as in natural rivers.

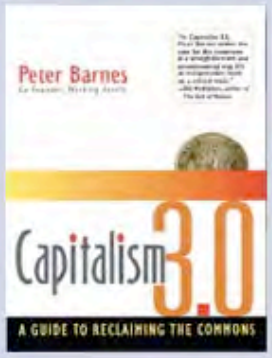
Earth News

Protecting our common asset: The Earth
an article by Dr. Robert Costanza in the Rutland Herald. More >

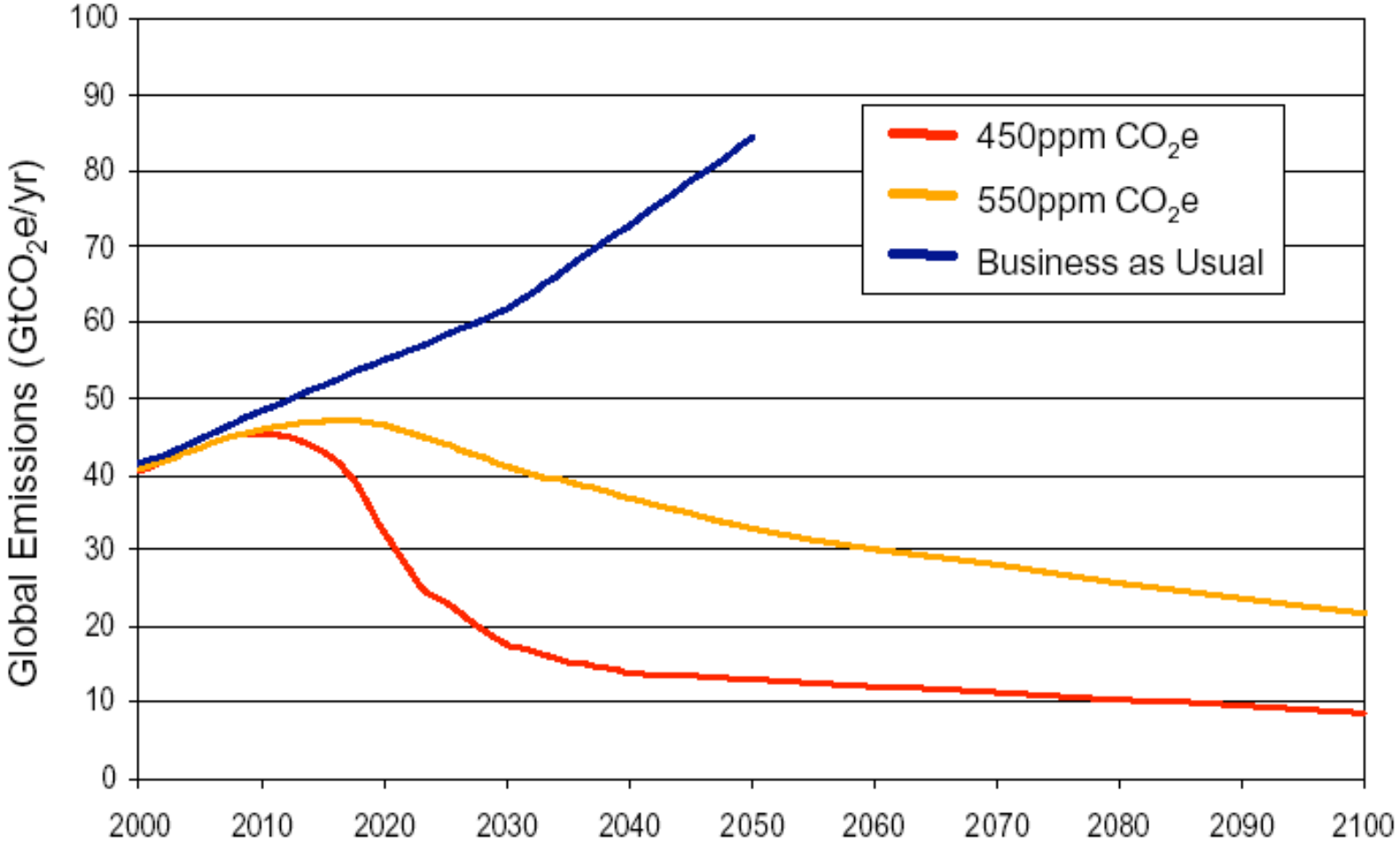
An Earth Atmospheric Trust: A proposal to stop global warming and end poverty
Internationally renowned experts call for the creation of the Earth Atmospheric Trust. More >

Ecosystem Goods and Services Series: Valuation 101

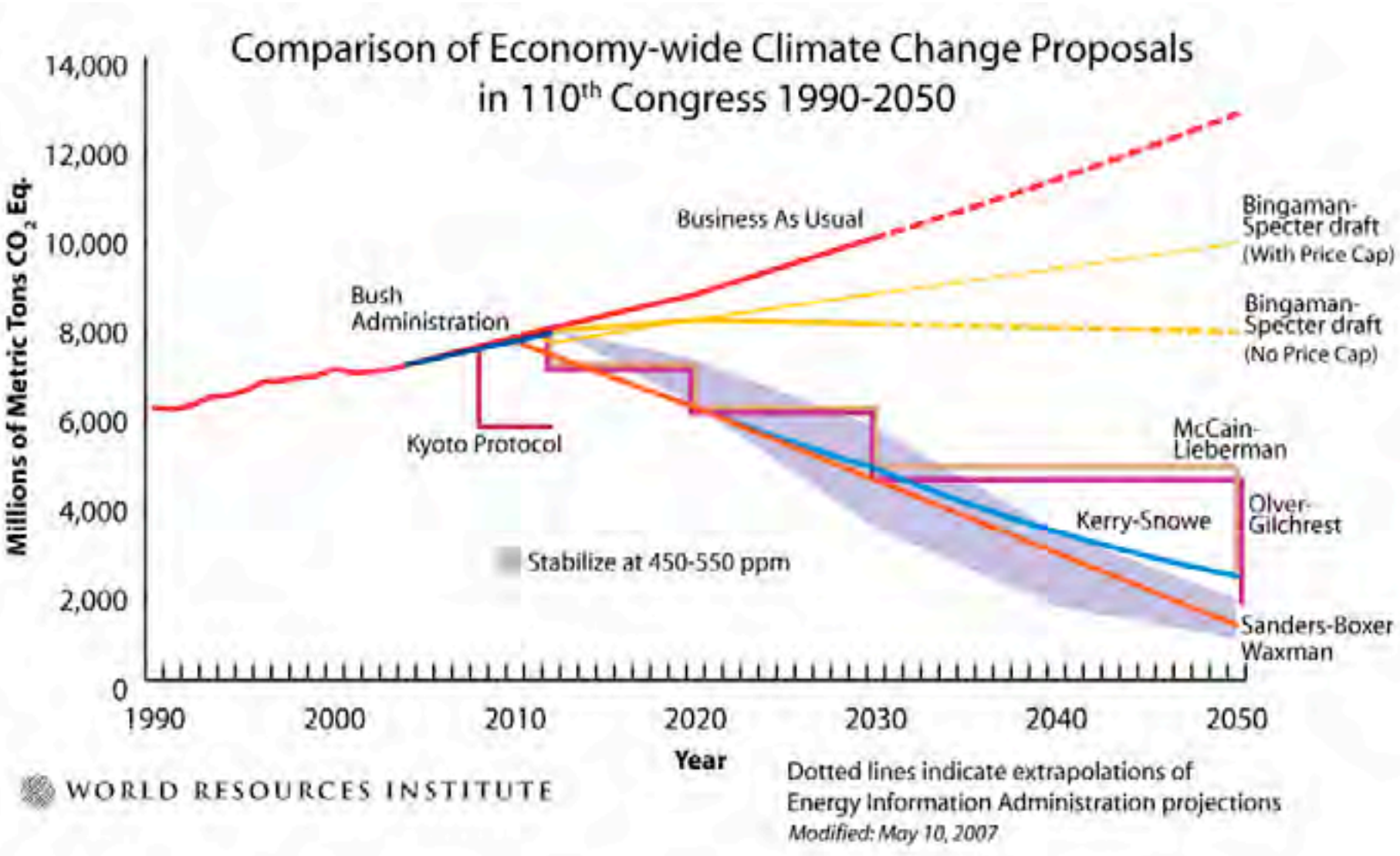
How much is a pristine lake worth? A clean atmosphere? An oil field? More >



Emissions Paths to Stabilisation



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


Comparison of Economy-wide Climate Change Proposals in 110th Congress 1990-2050
Millions of Metric Tons CO_2 Eq.
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1990
2000
2010
2020
2030
2040
2050
Year
Business As Usual
Bush Administration
Kyoto Protocol
Bingaman-Specter draft (With Price Cap)
Bingaman-Specter draft (No Price Cap)
McCain-Lieberman
Olver-Gilchrest
Kerry-Snowe
Stabilize at 450-550 ppm
Sanders-Boxer
Waxman
WORLD RESOURCES INSTITUTE
Dotted lines indicate extrapolations of Energy Information Administration projections
Modified: May 10, 2007

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. *Science (Feb 8, 2008, in press*)

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
Papers mentioned in this talk available at:
www.uvm.edu/giee/publications
Sign on to the Earth Atmospheric Trust at:
www.earthinc.org