Public Land Acquisition & Management Partnership Conference

December 3-5 2008 • Hyatt Regency, Jacksonville Florida

Paying for Themselves: Proving the Worth of Conservation Lands with Ecosystem Services Values

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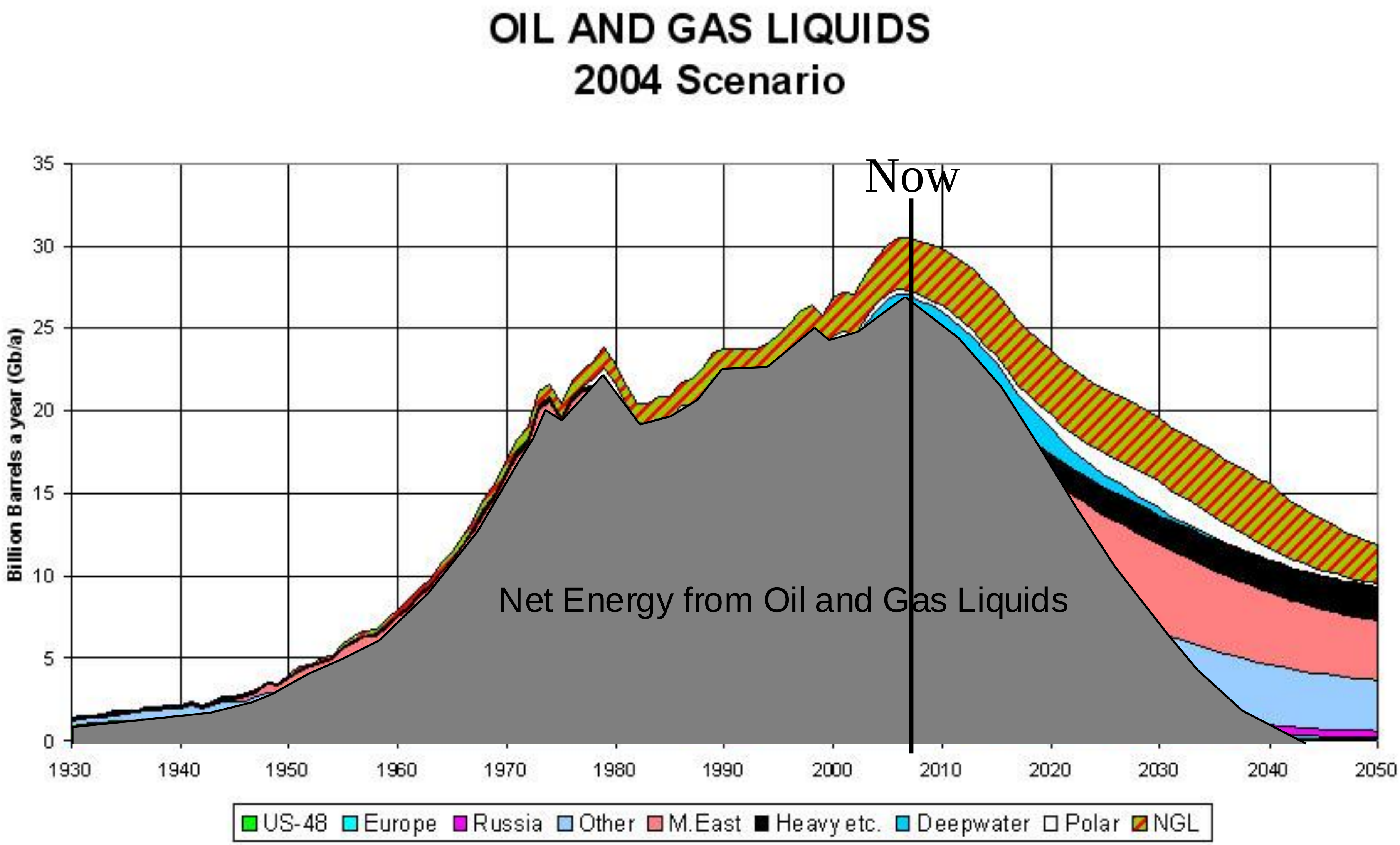
Full World Anthropospher
A "no analog" world.

Marc Imhoff

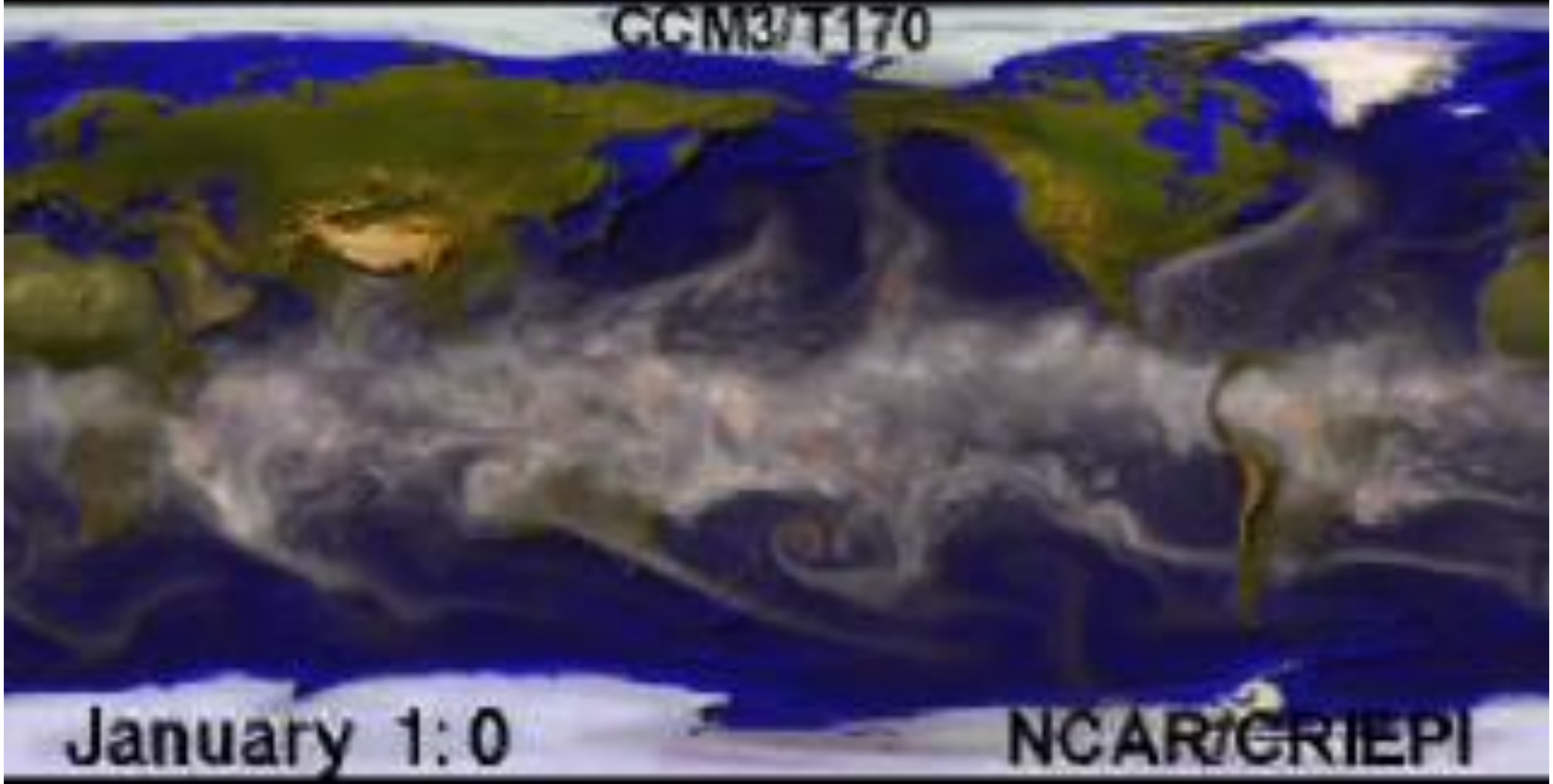
Biospheric Sciences Branch

NASA

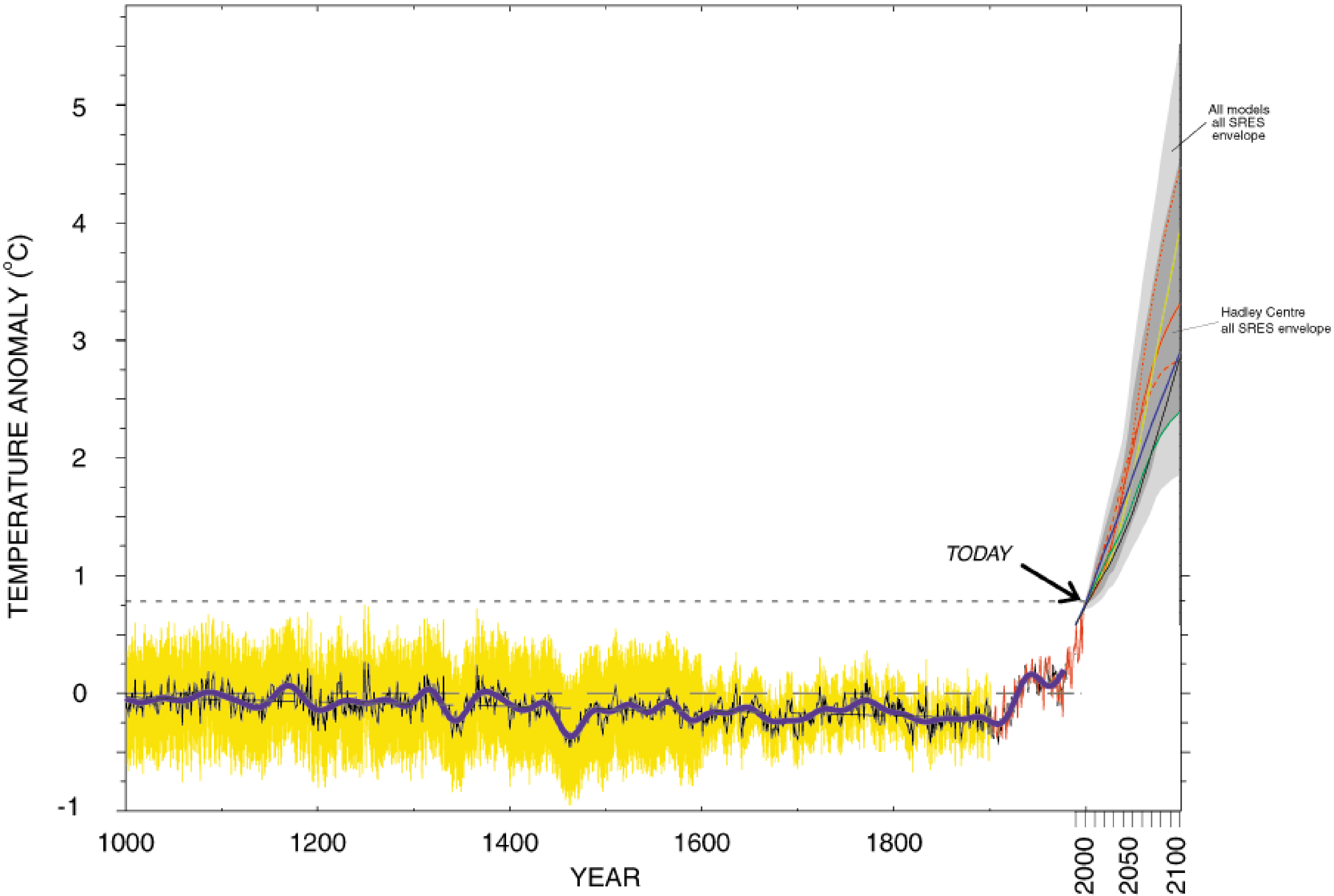
OIL AND GAS LIQUIDS 2004 Scenario
Updated by Colin J. Campbell, 2004-05-15



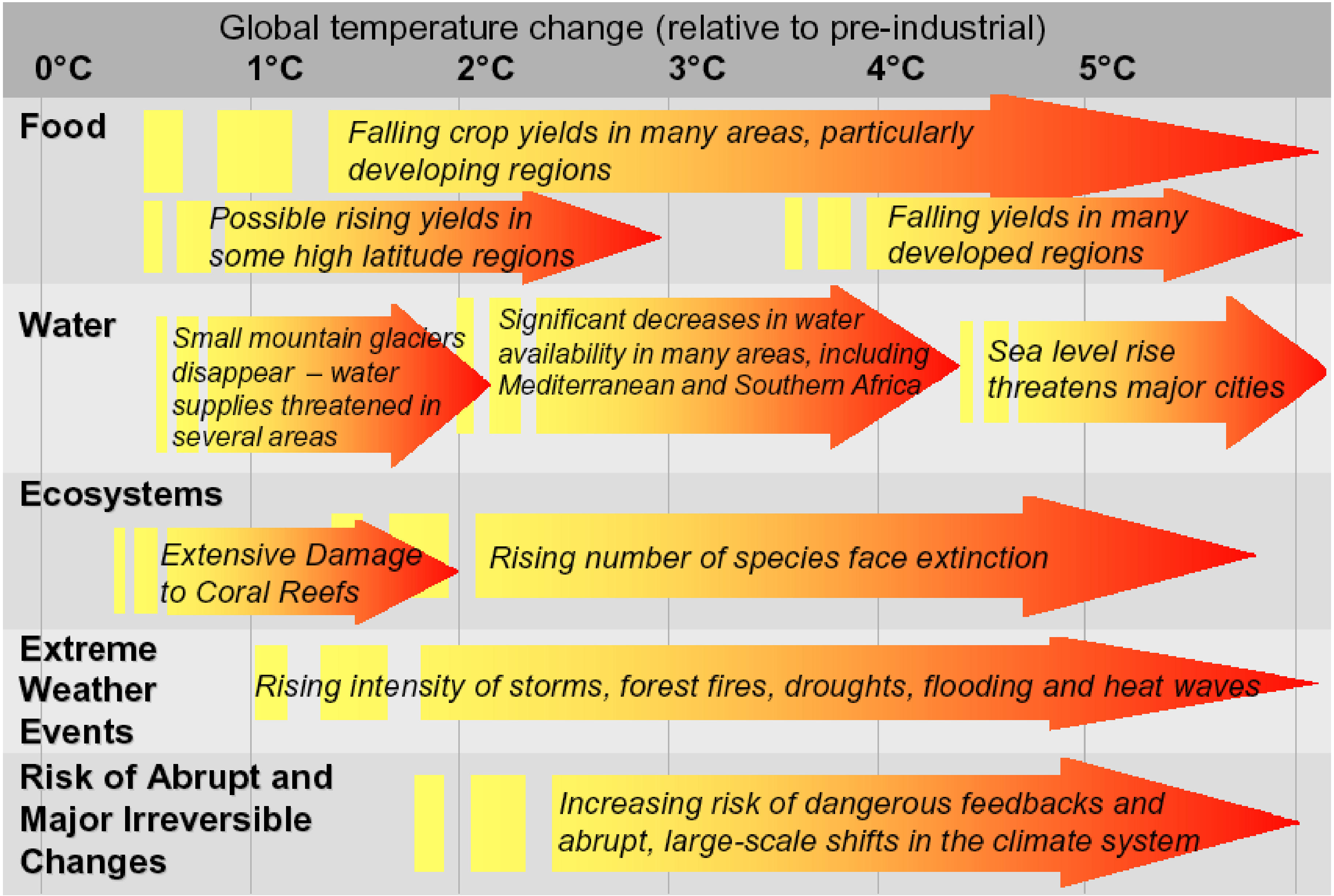
Atmosphere



Temperature, past and future

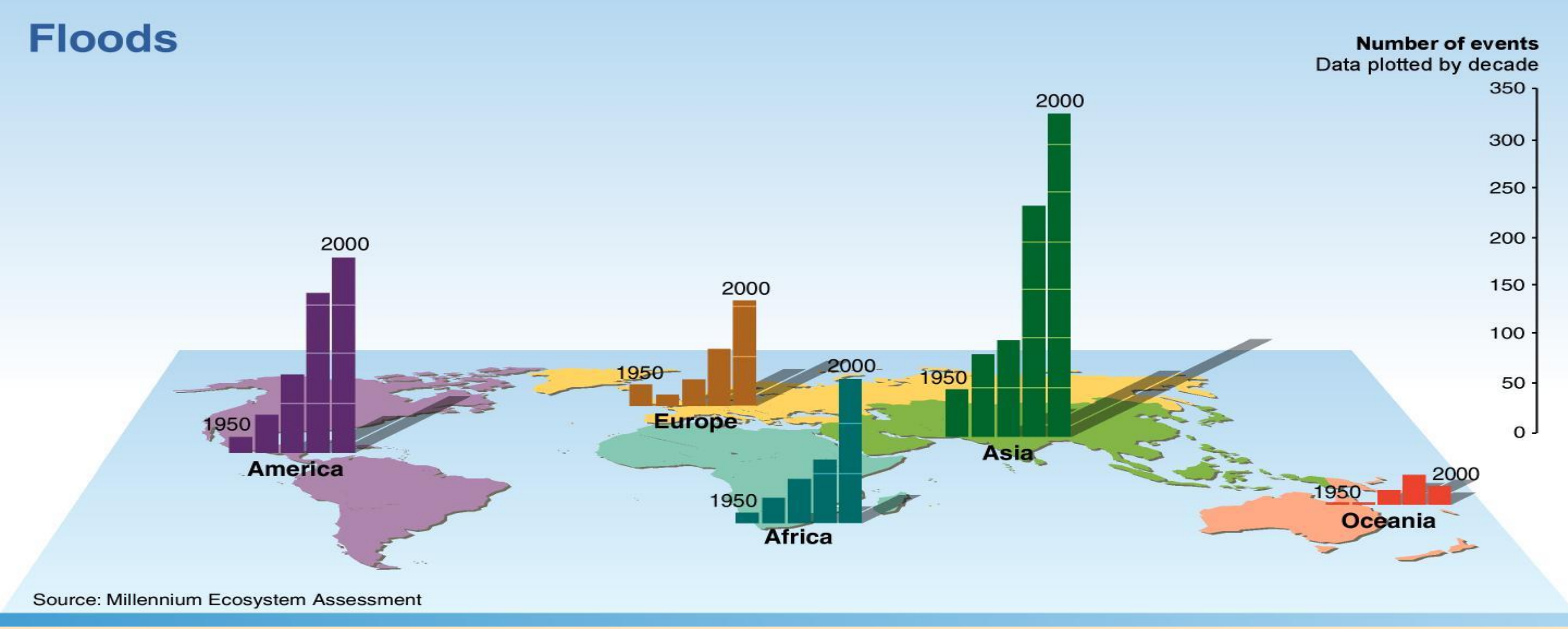


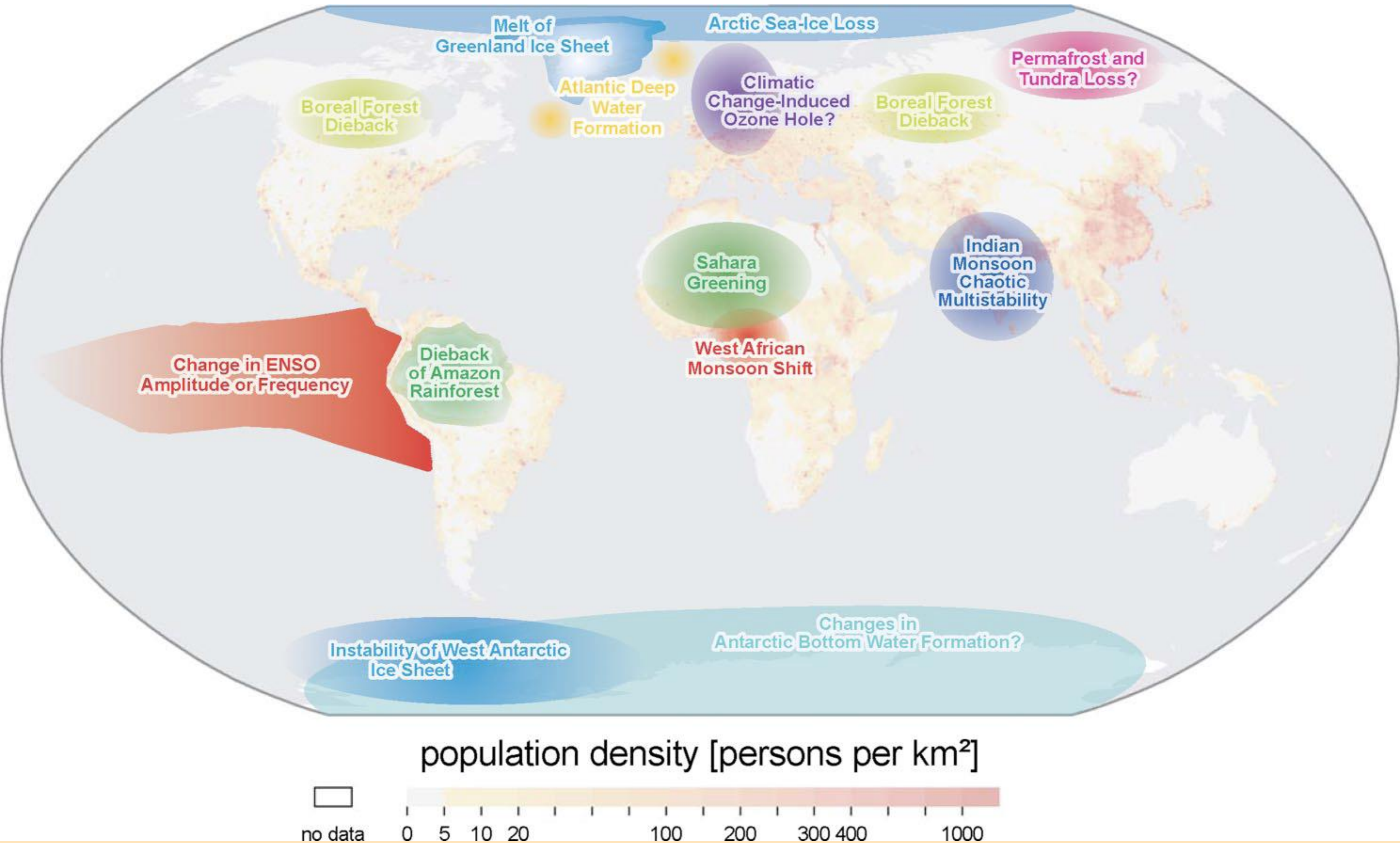
Projected Impacts of Climate Change



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

Increasing number of flood events



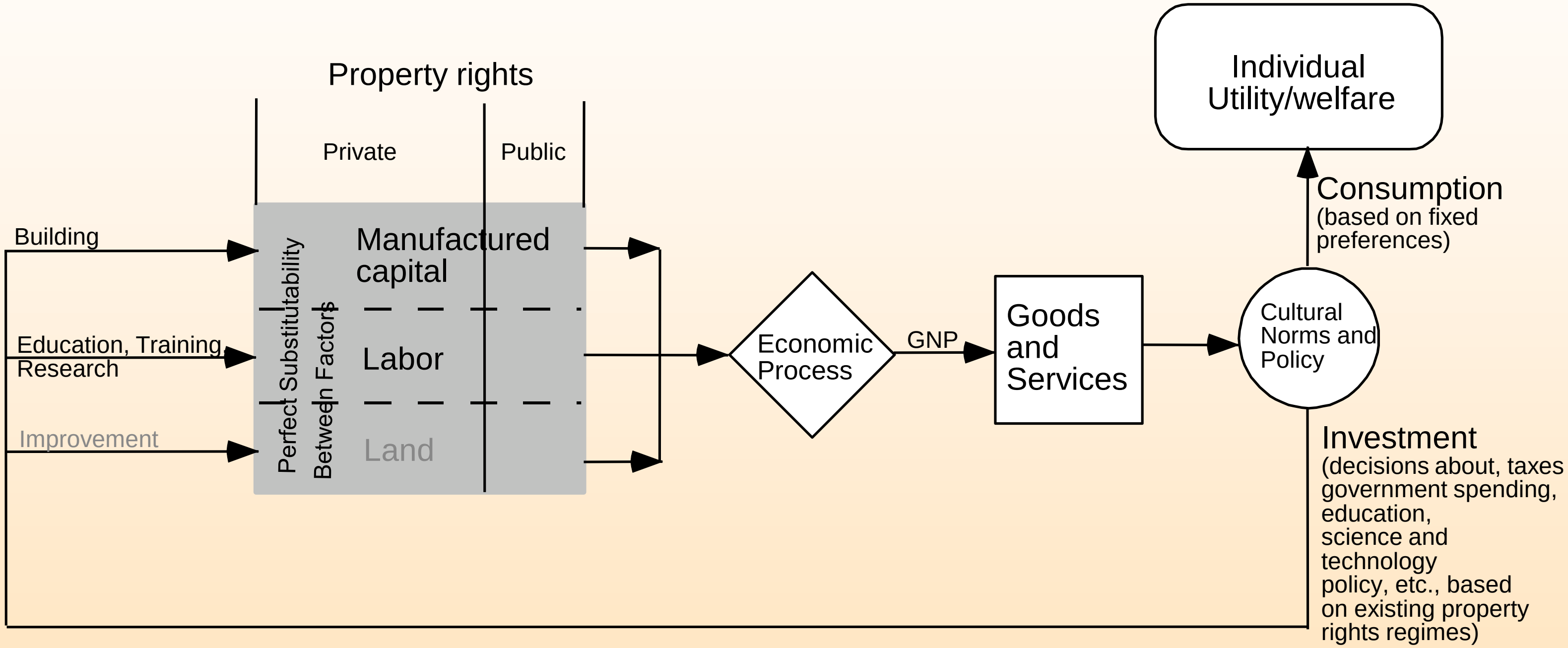


Potential "tipping elements" in the climate system.

(from Lenton et al. 2008)

In a full world context, what is "the economy" and what is it for?

”Empty World" Model of the Economy

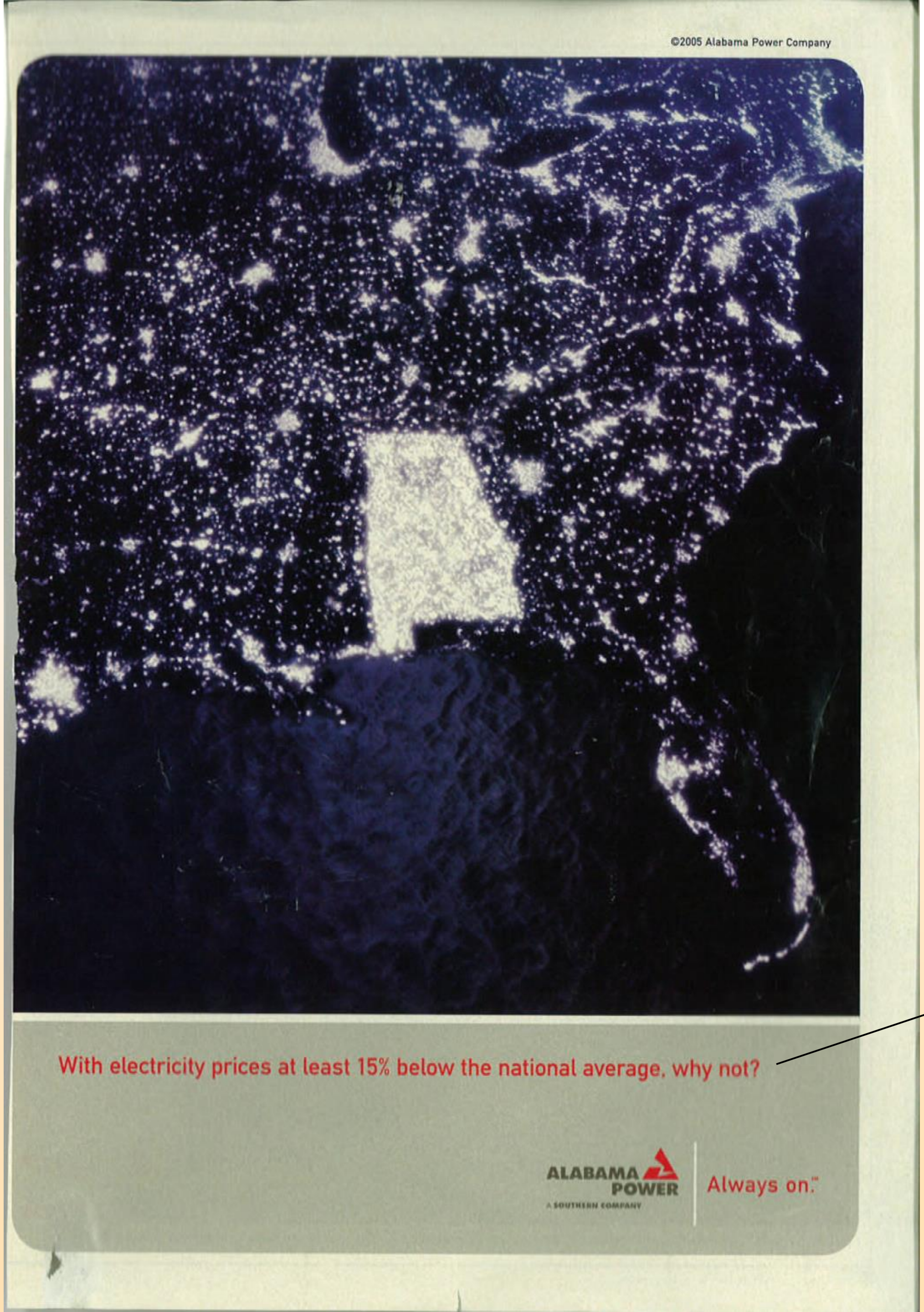


Basic premises:

More is always better

The economy can grow forever

Private property is always best

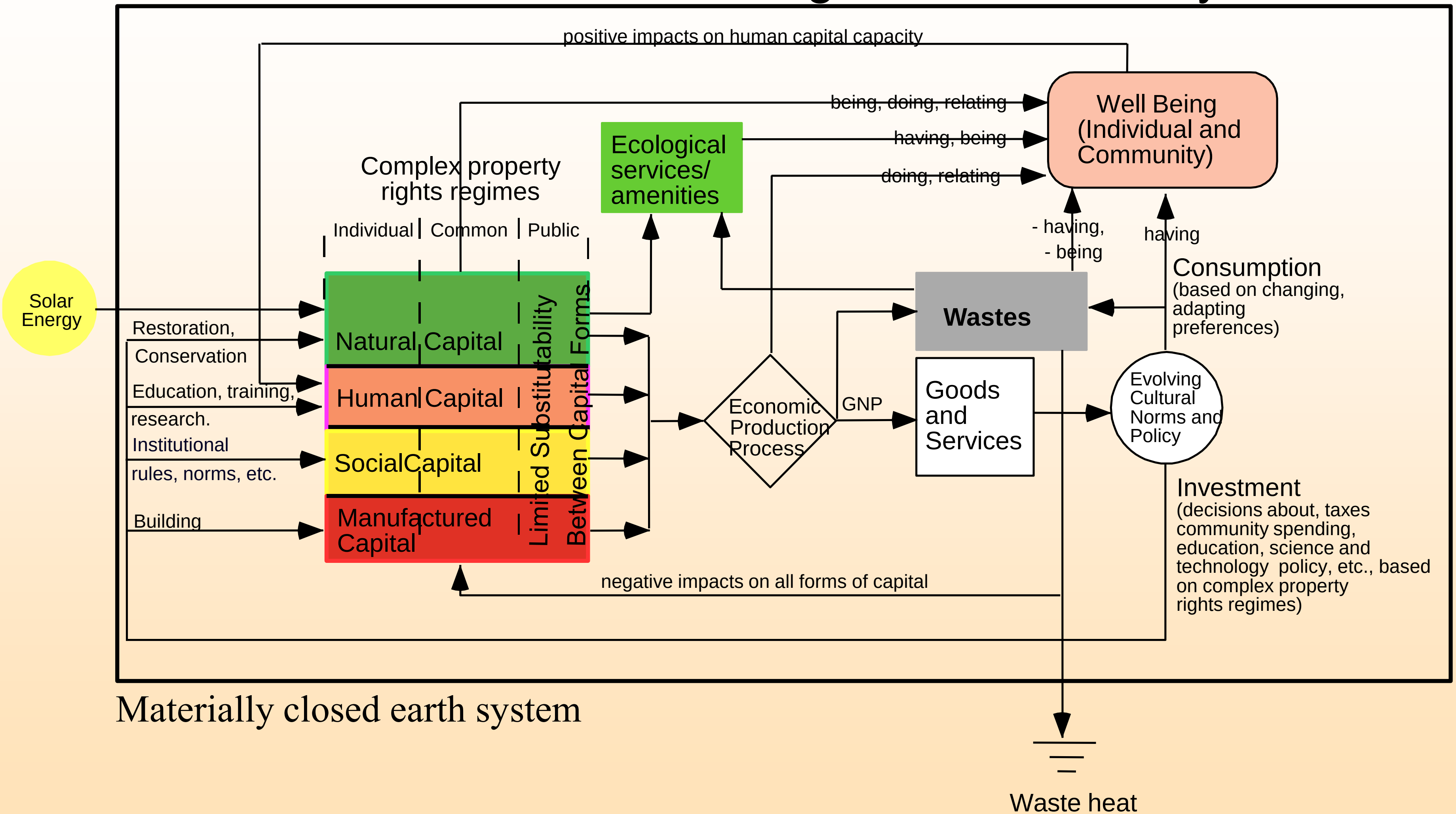


Empty World Energy Planning?

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.

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

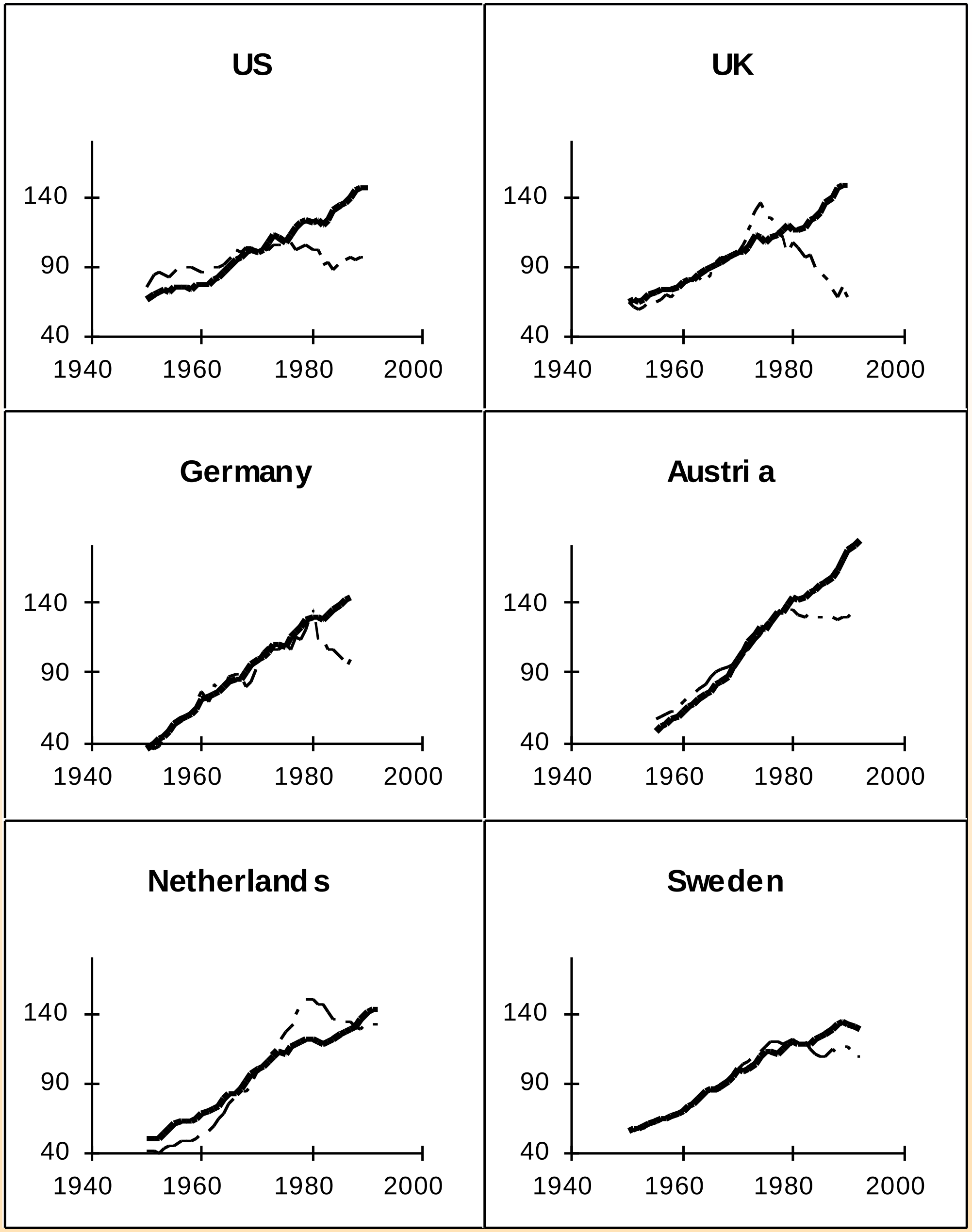
Subtractions

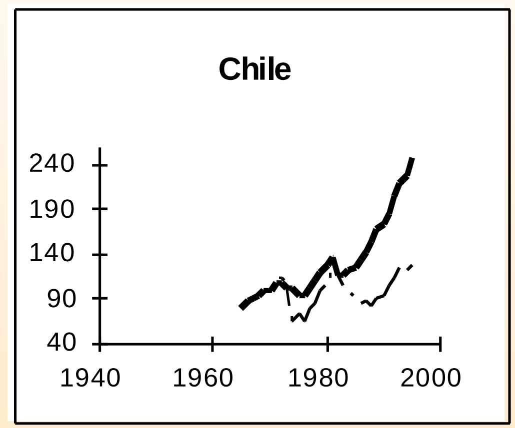
Column H: Cost of Crime
Column I: Cost of Family Breakdown
Column J: Loss of Leisure Time
Column K: Cost of Underemployment
Column L: Cost of Consumer Durables
Column M: Cost of Commuting
Column N: Cost of Household Pollution Abatement
Column O: Cost of Automobile Accidents
Column P: Cost of Water Pollution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

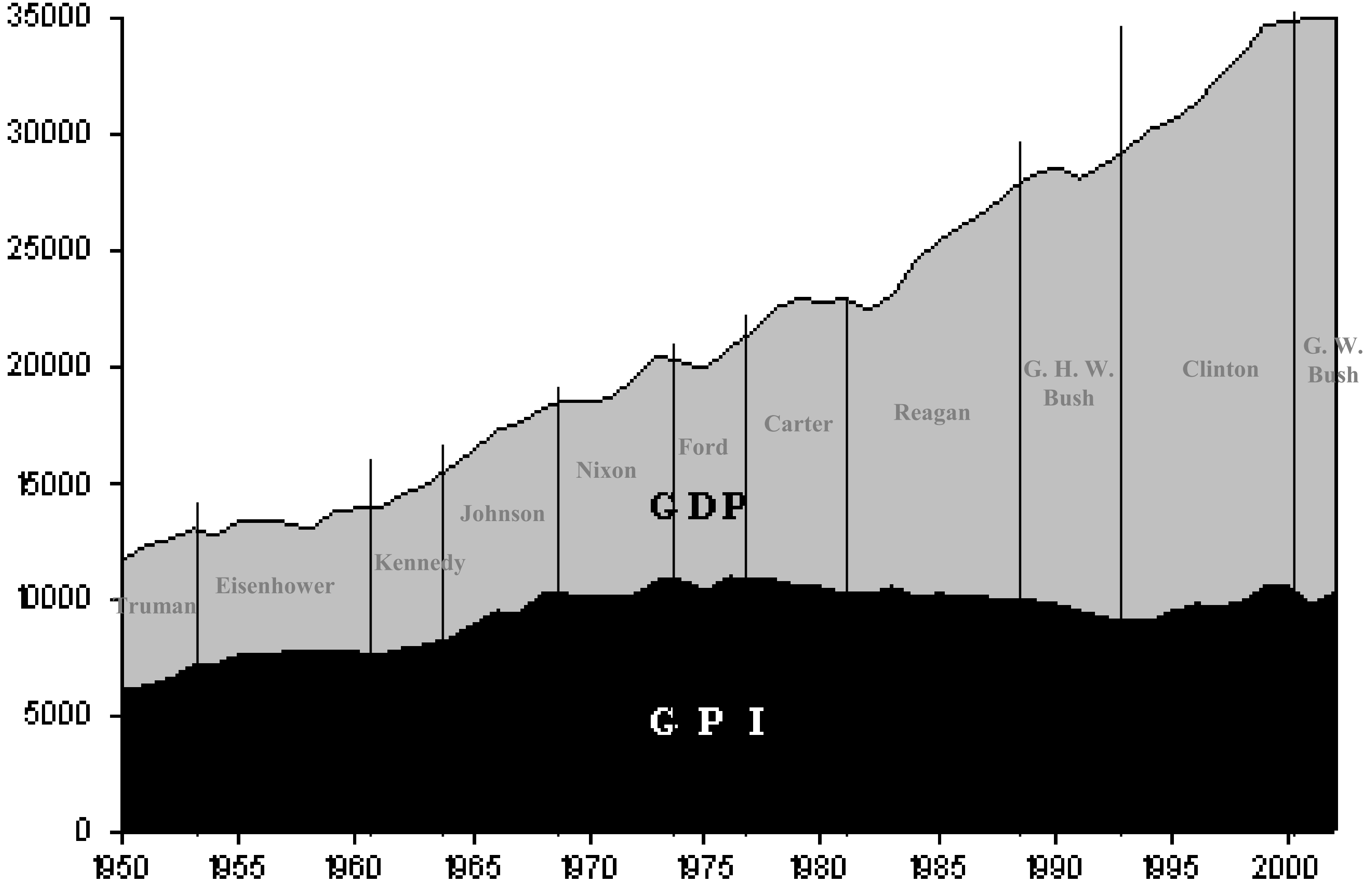
Column Y: Net Capital Investment
Column Z: Net Foreign Lending and Borrowing

- Built Capital
- Human Capital
- Social Capital
- Natural Capital

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

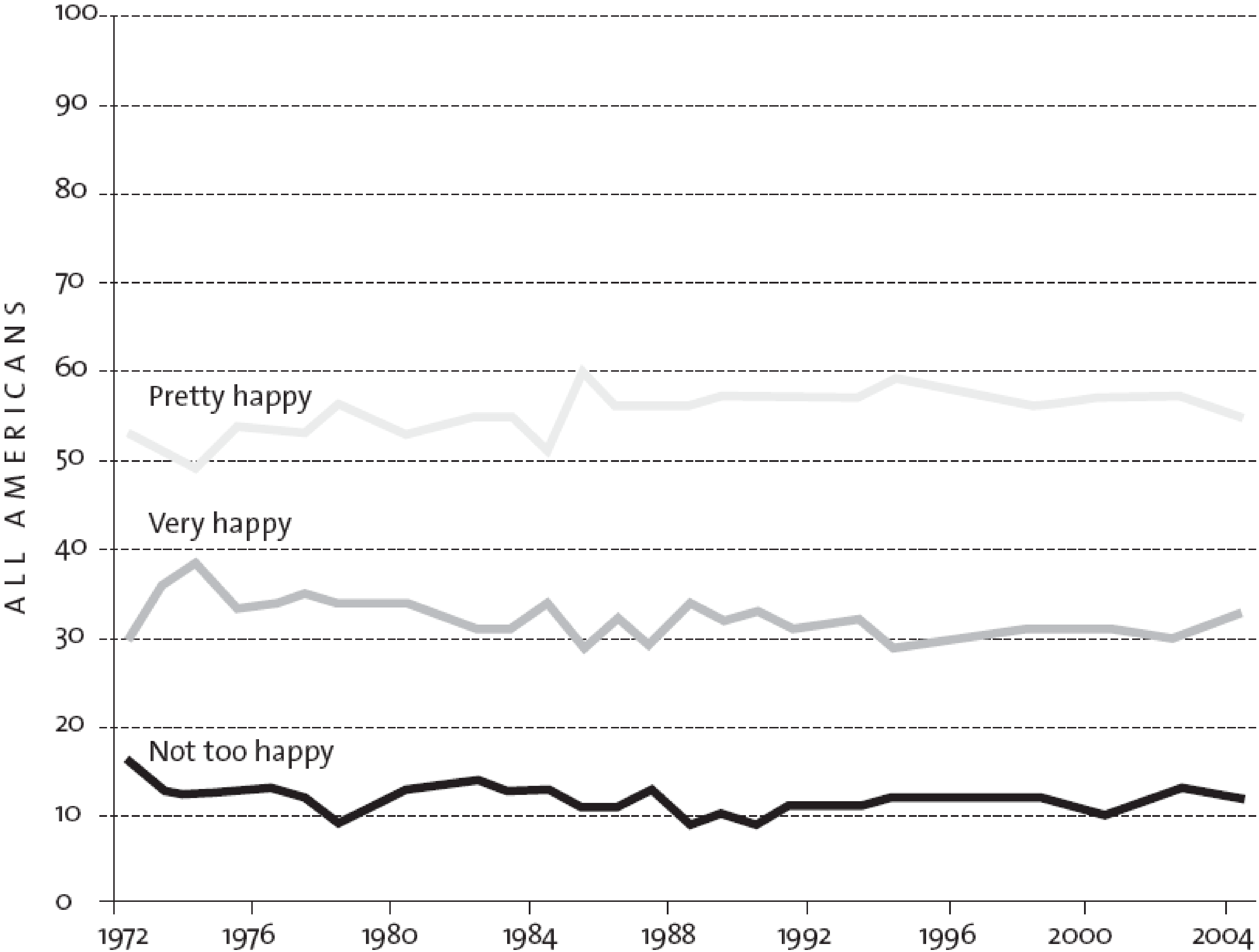






Gross Production vs. Genuine Progress for the US, 1950 to 2002

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


100
90
80
70
60
50
40
30
20
10
0
ALL AMERICANS
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:

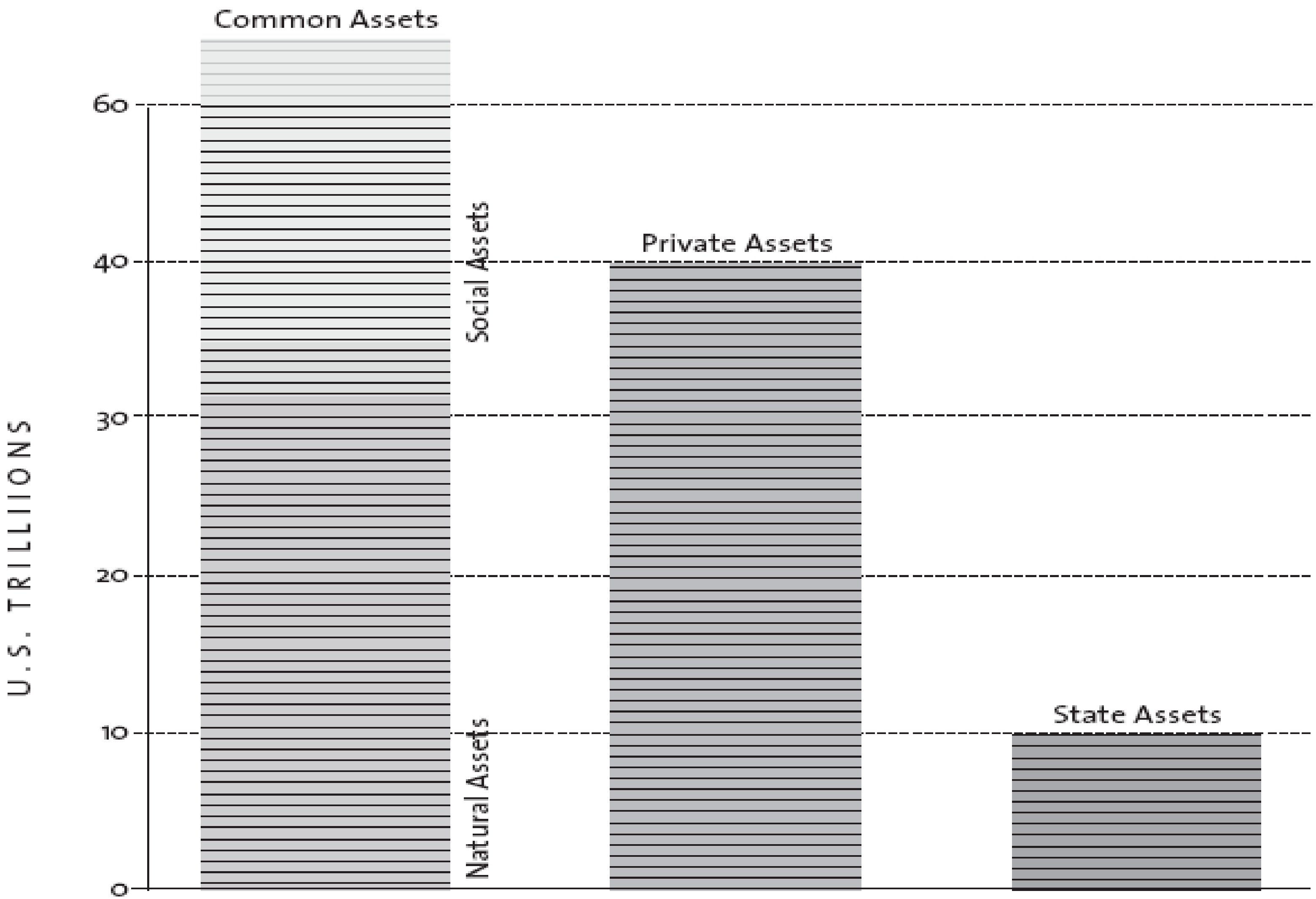
they’re all **gifts**, and
they’re all **shared**.

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: a guide to reclaiming the commons*

Figure 5.1

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



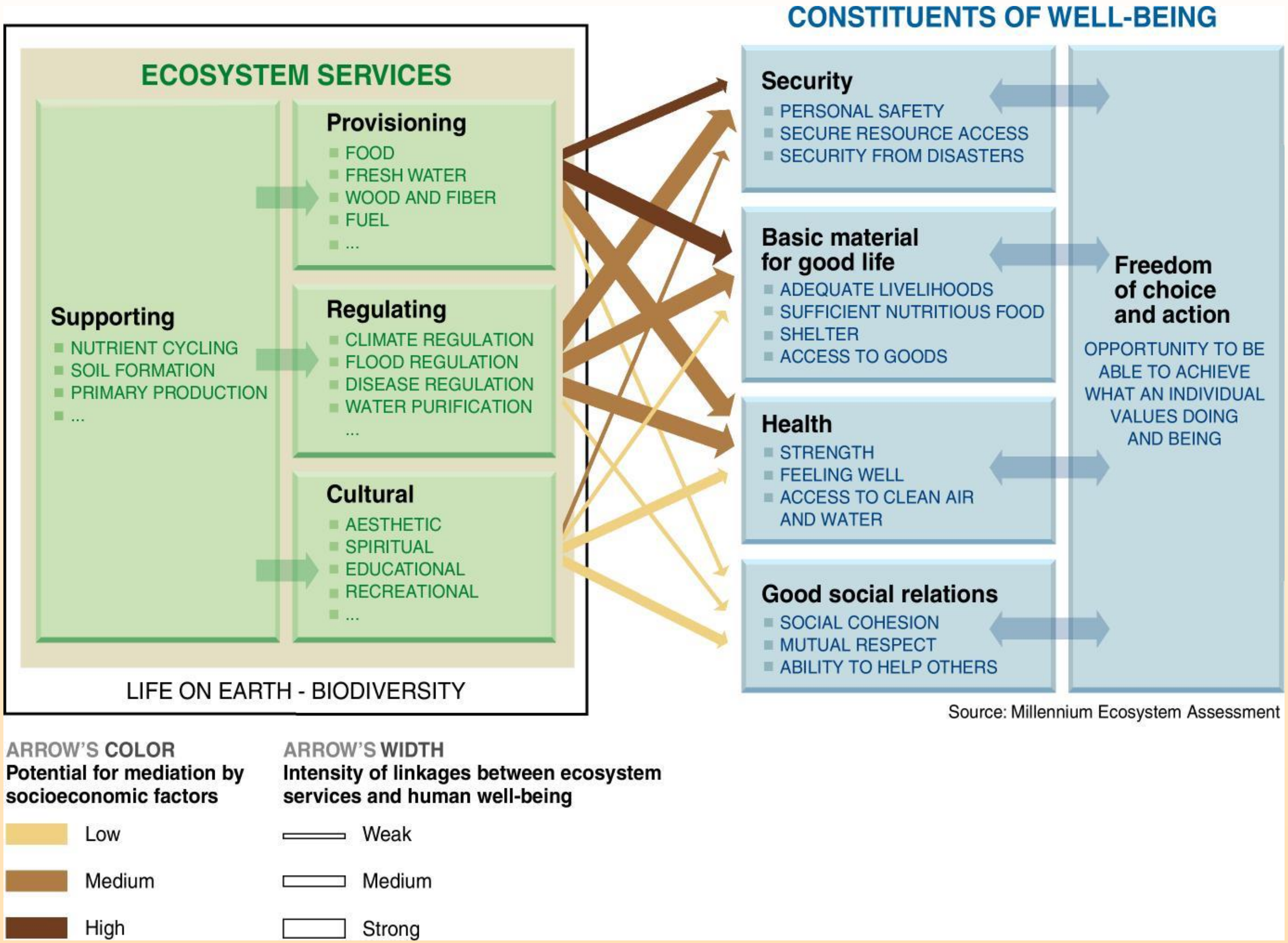
Reflects only quantifiable assets.
Source: Friends of the Commons, *State of the Commons 2003–04*.
http://friendsofthecommons.org/understanding/worth.html. Reprinted with permission.

Ecosystem services are the benefits humans derive from ecosystem functioning

ECOSYSTEM SERVICES	ECOSYSTEM FUNCTIONS
Gas regulation	Regulation of atmospheric chemical composition.
Climate regulation	Regulation of global temperature, precipitation, and other biologically mediated climatic processes at global, regional, or local levels.
Disturbance regulation	Capacitance, damping and integrity of ecosystem response to environmental fluctuations.
Water regulation	Regulation of hydrological flows.
Water supply	Storage and retention of water.
Erosion control and sediment retention	Retention of soil within an ecosystem.
Soil formation	Soil formation processes.
Nutrient cycling	Storage, internal cycling, processing, and acquisition of nutrients.
Waste treatment	Recovery of mobile nutrients and removal or breakdown of excess or xenic nutrients and compounds.
Pollination	Movement of floral gametes.
Biological control	Trophic-dynamic regulations of populations.
Refugia	Habitat for resident and transient populations.
Food production	That portion of gross primary production extractable as food.
Raw materials	That portion of gross primary production extractable as raw materials.
Genetic resources	Sources of unique biological materials and products.
Recreation	Providing opportunities for recreational activities.
Cultural	Providing opportunities for non-commercial uses.

From: Costanza, R. R. d'Arge, R. de Groot, S. Farber, M. Grasso, B. Hannon, S. Naeem, K. Limburg, J. Paruelo, R.V. O'Neill, R. Raskin, P. Sutton, and M. van den Belt. 1997. The value of the world's ecosystem services and natural capital. *Nature* 387:253-260

Ecosystem Services: the benefits humans derive from ecosystems



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

Gund Institute for Ecological Economics University of Vermont

EcoServices Classified According to Rivalness and Excludability

	Excludable	**Non-Excludable**
Rival	Market Goods and Services (most provisioning services)	Open Access Resources (some provisioning services)
Non-rival	Congestable Services (some recreation services)	Public Goods and Services (most regulatory and cultural services)

Example Valuation Techniques

•**Avoided Cost** (AC): services allow society to avoid costs that would have been incurred in the absence of those services; flood control provided by barrier islands avoids property damages along the coast.

•**Replacement Cost** (RC): services could be replaced with man-made systems; nutrient cycling waste treatment can be replaced with costly treatment systems.

•**Factor Income** (FI): services provide for the enhancement of incomes; water quality improvements increase commercial fisheries catch and incomes of fishermen.

•**Travel Cost** (TC): service demand may require travel, whose costs can reflect the implied value of the service; recreation areas attract distant visitors whose value placed on that area must be at least what they were willing to pay to travel to it.

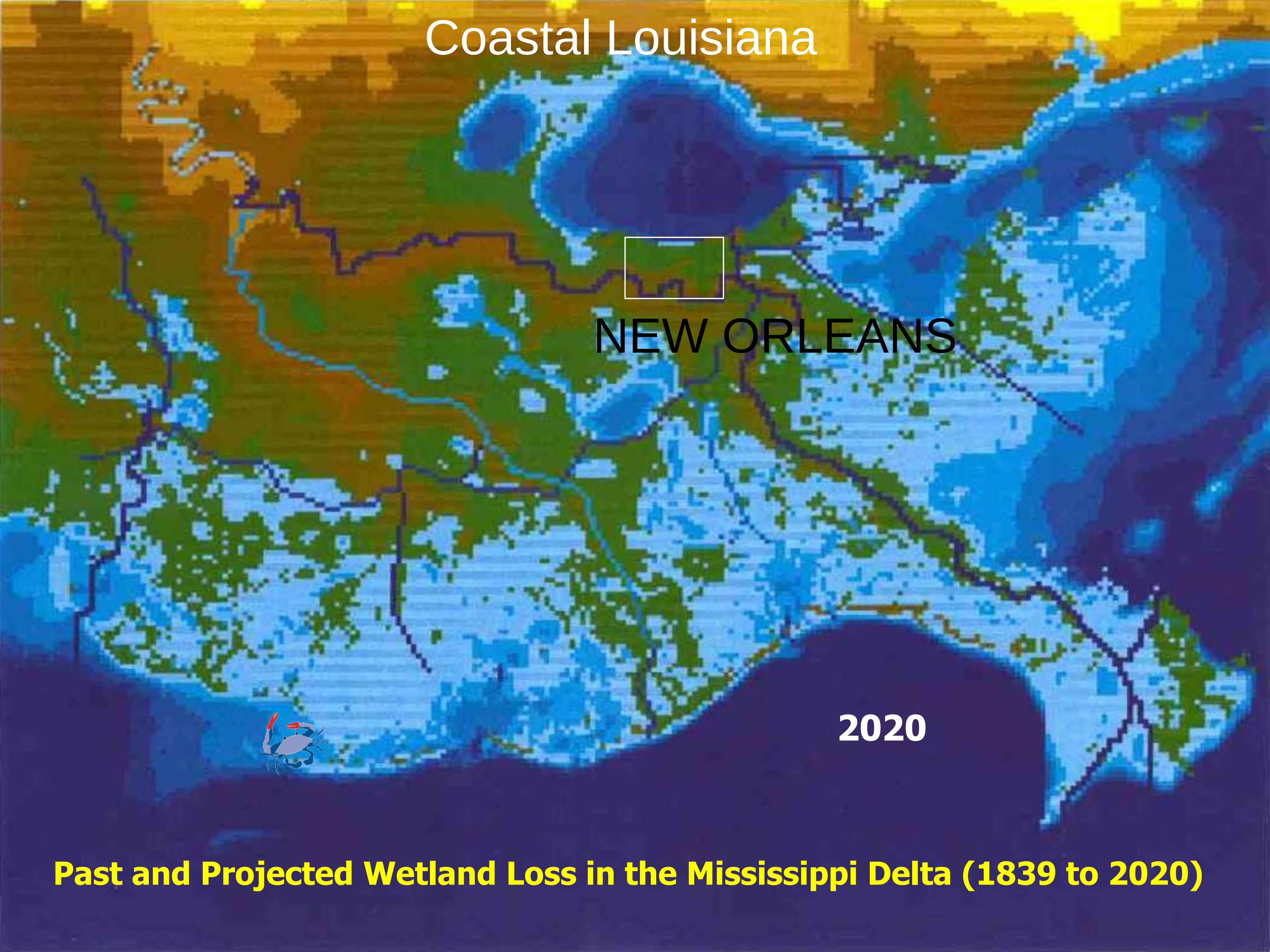
• **Hedonic Pricing** (HP): service demand may be reflected in the prices people will pay for associated goods: For example, housing prices along the coastline tend to exceed the prices of inland homes.

•**Contingent Valuation** (CV): service demand may be elicited by posing hypothetical scenarios that involve some valuation of alternatives; people would be willing to pay for increased preservation of beaches and shoreline.

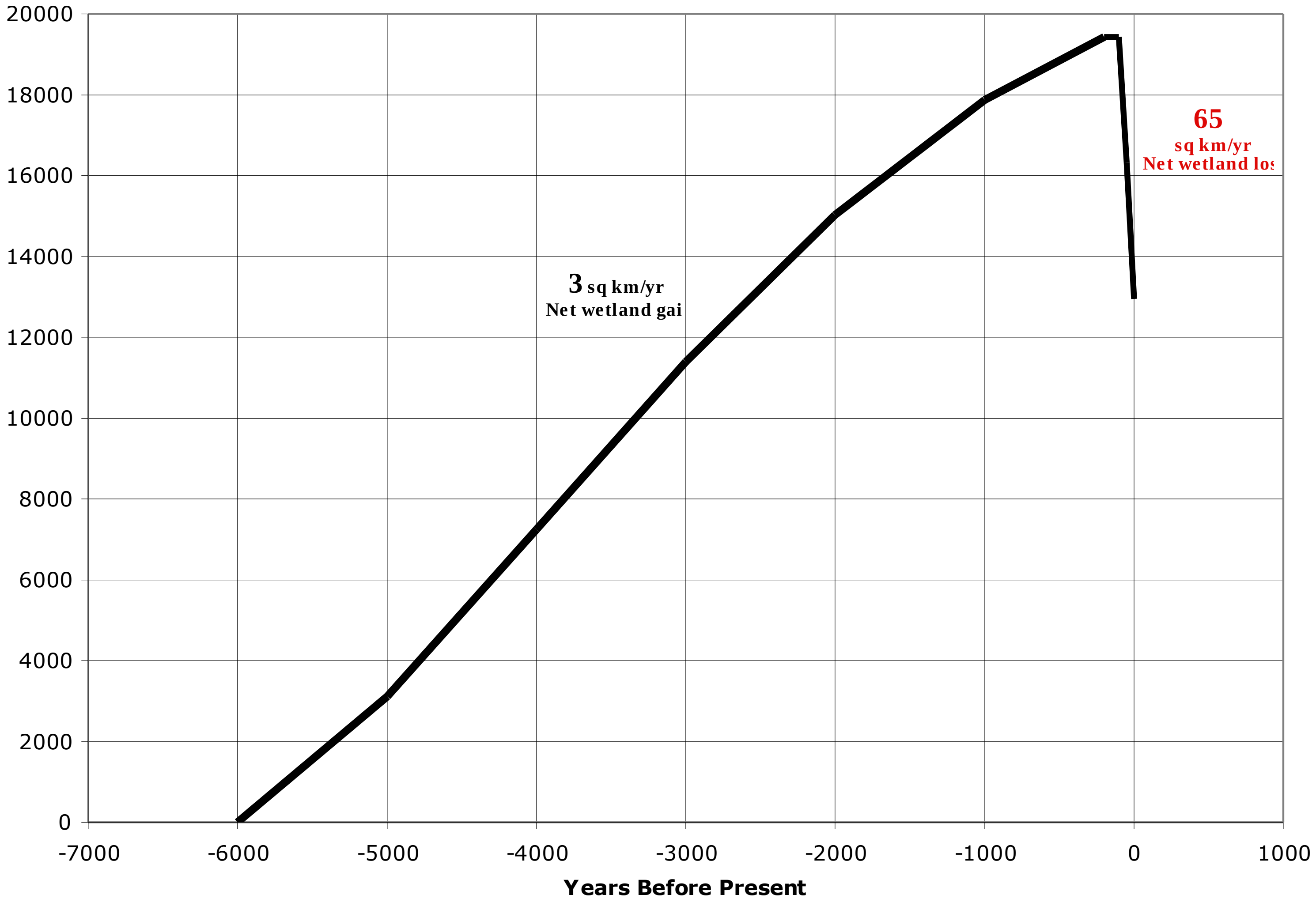
•**Group Valuation** (GV): This approach is based on principles of deliberative democracy and the assumption that public decision making should result, not from the aggregation of separately measured individual preferences, but from *open public debate.*

•**Marginal Product Estimation** (MP): Service demand is generated in a dynamic modeling environment using production functions (i.e., Cobb-Douglas) to estimate value of output in response to corresponding inputs.

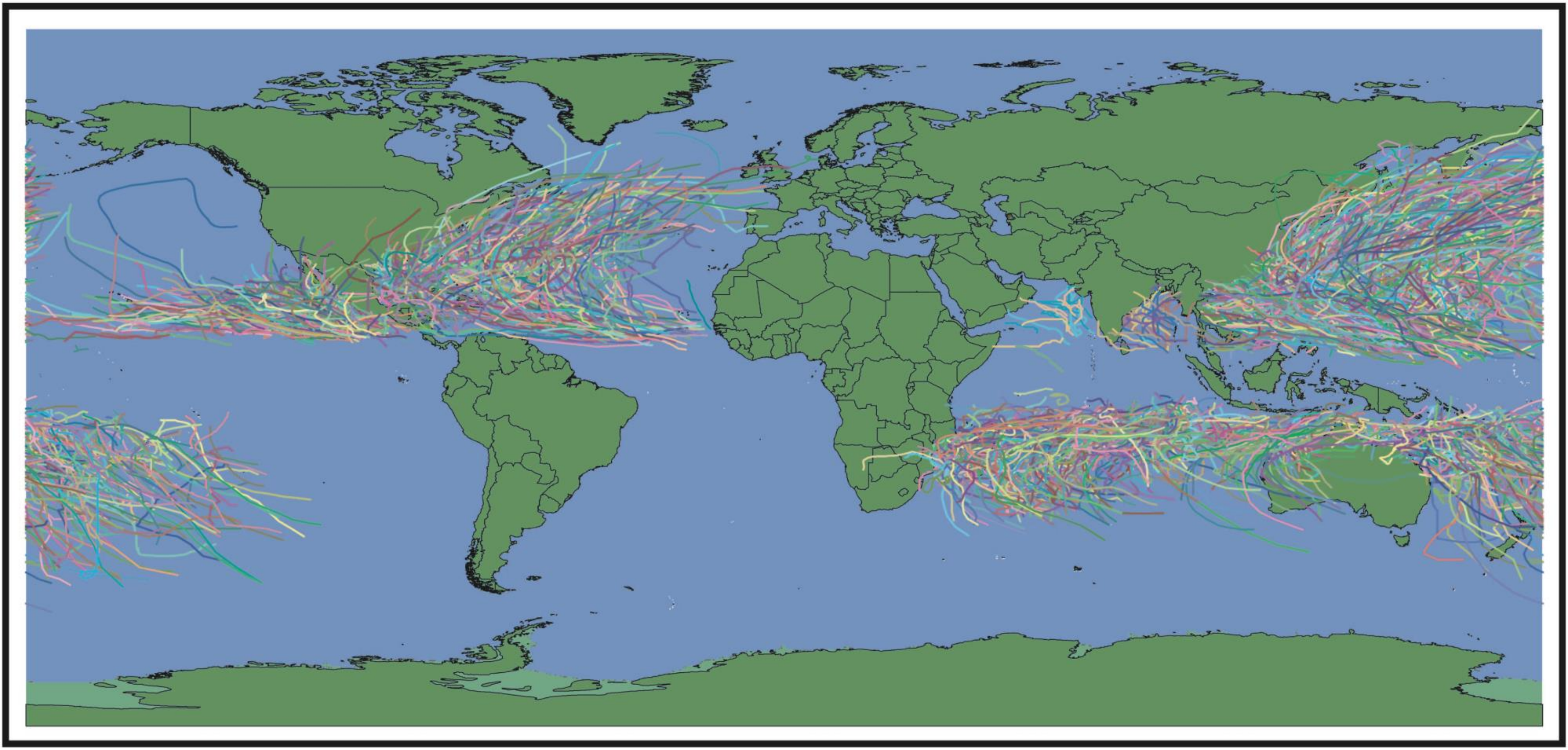
Picture taken by an automatic camera located at an electrical generating facility on the Gulf Intracoastal Waterway (GIWW) where the Route I-510 bridge crosses the GIWW. This is close to where the Mississippi River Gulf Outlet (MRGO) enters the GIWW. The shot clearly shows the storm surge, estimated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

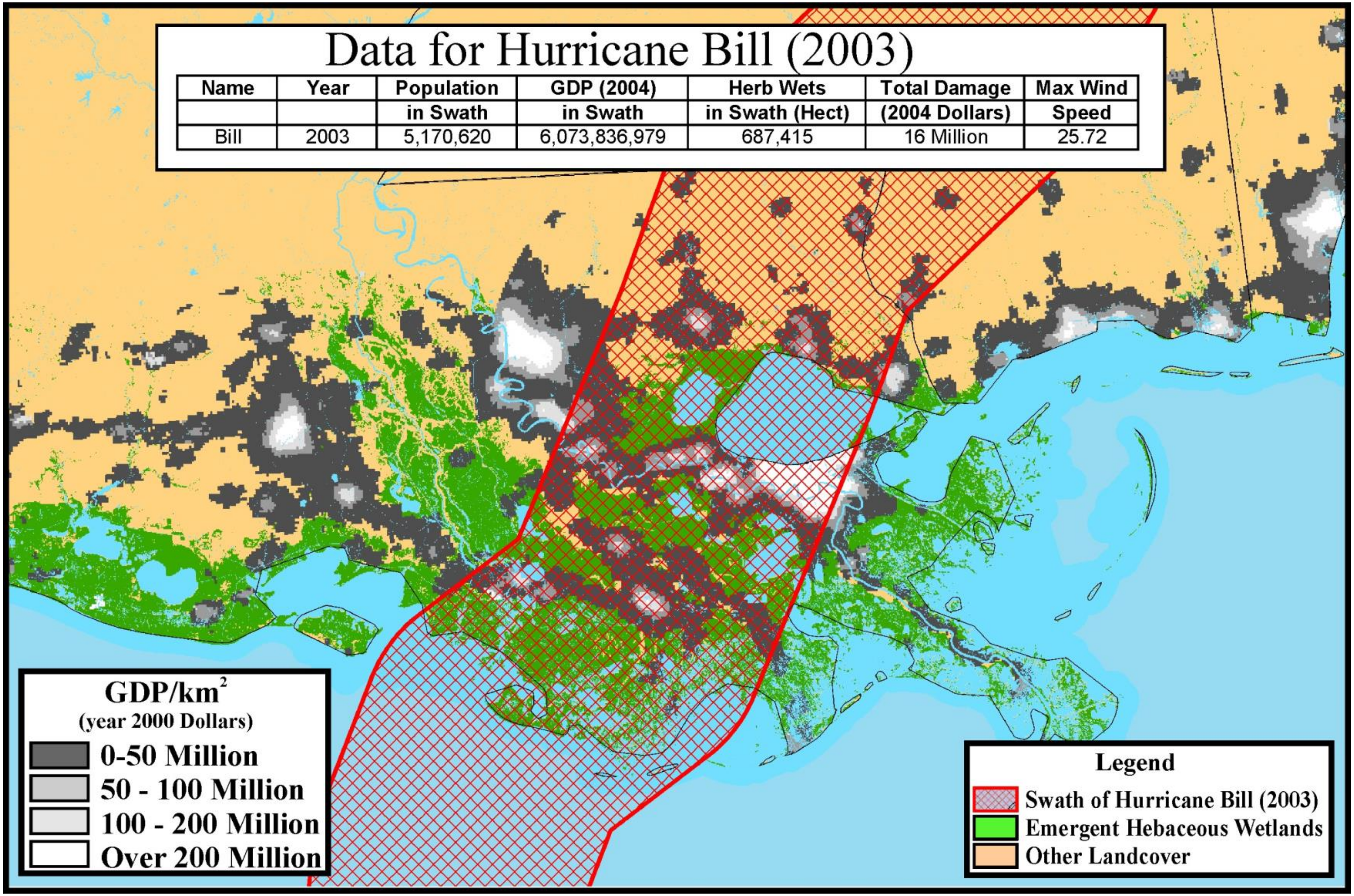


Figure 1. Typical hurricane swath showing GDP and wetland area used in the analysis.

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*

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

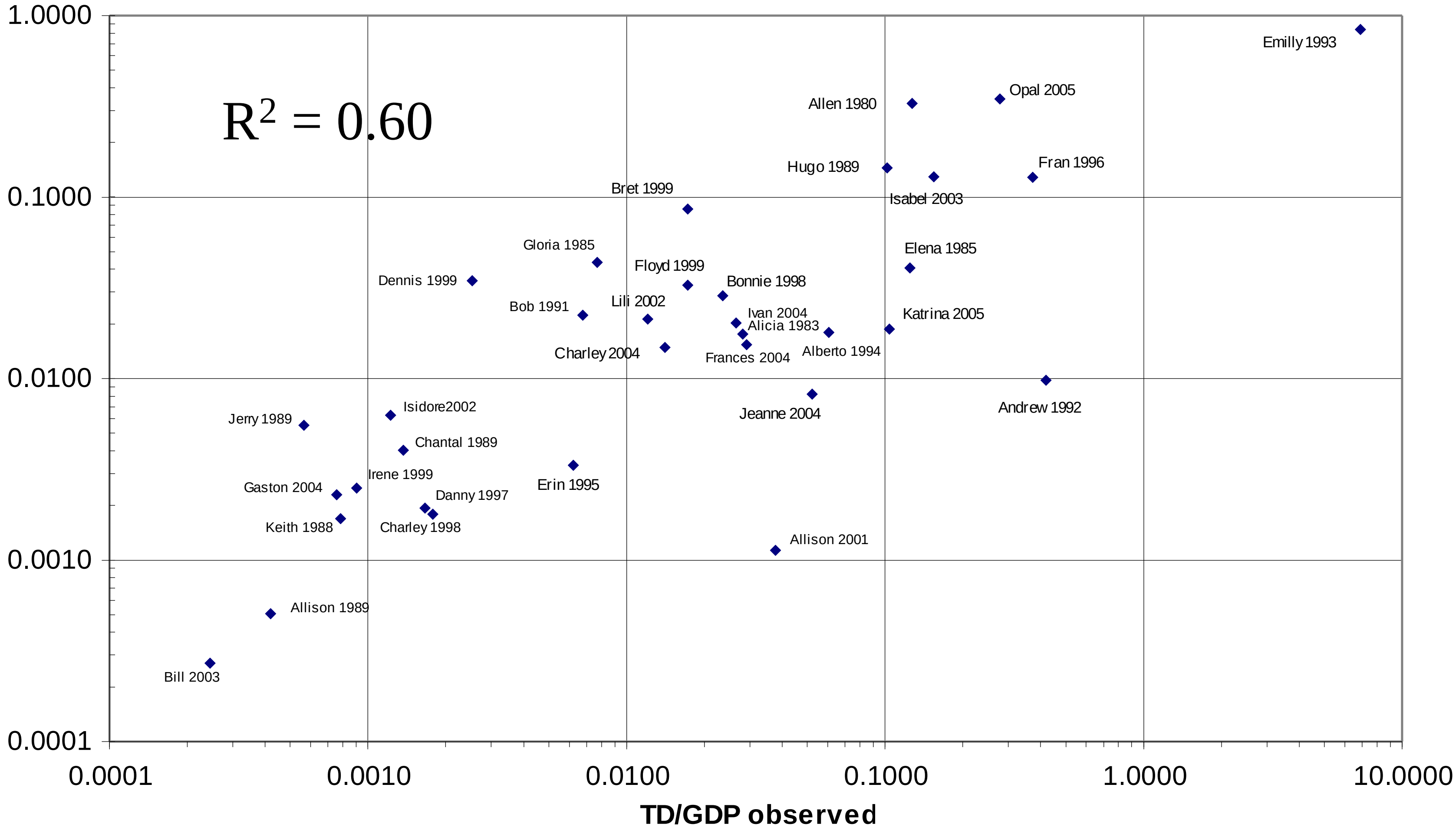
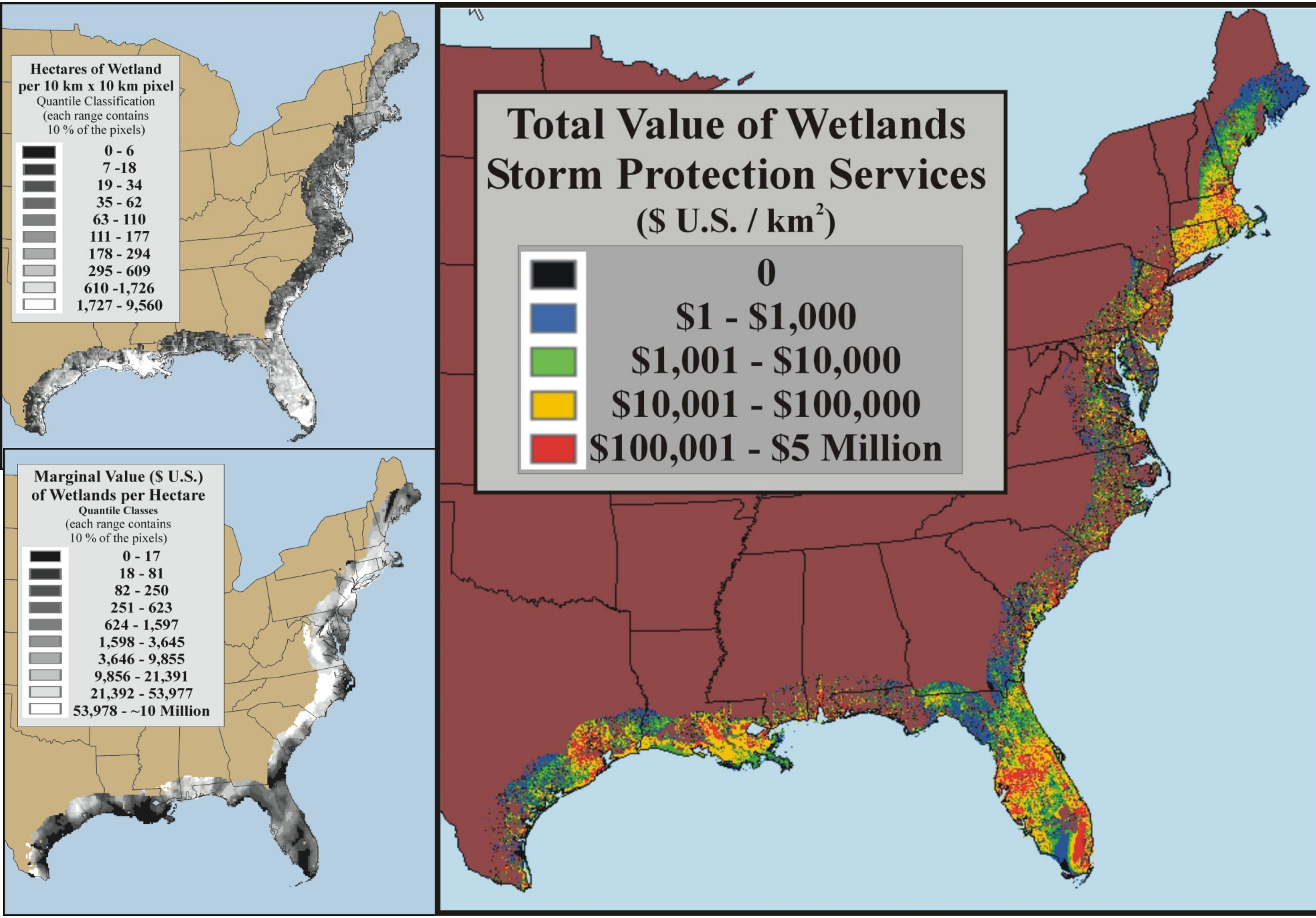


Figure 2. Observed vs. predicted relative damages (TD/GDP) for each of the hurricanes used in the analysis.



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.

From: Costanza, R., O. Pérez-Maqueo, M. L. Martinez, P. Sutton, S. J. Anderson, and K. Mulder. 2008. The value of coastal wetlands for hurricane protection. *Ambio* 37:241-248

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 Farber, Monica Grasso, Bruce Hannon, Karin Limburg, Shahid Naeem, Robert V. O'Neill, Jose Paruelo, Robert G. Raskin, Paul Sutton & Marjan van den Belt

*

The services of ecological systems and the natural capital stocks that 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, this must 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**

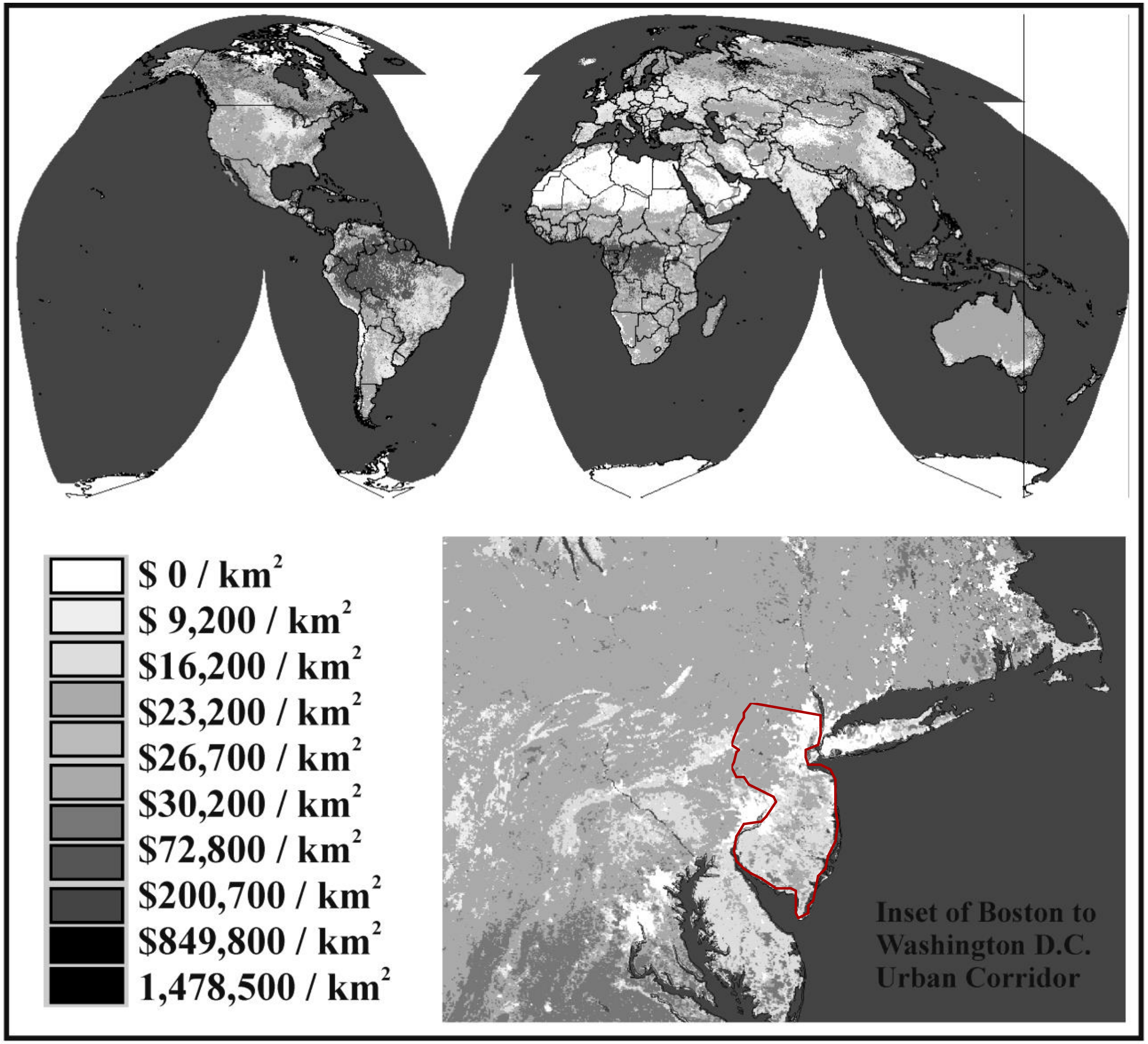


Figure 3: Global Map of Non-Marketed Economic Activity (ESP) arising from Ecosystem Services and derived from Land Cover at 1 km^2 (For National Totals See Table 1)

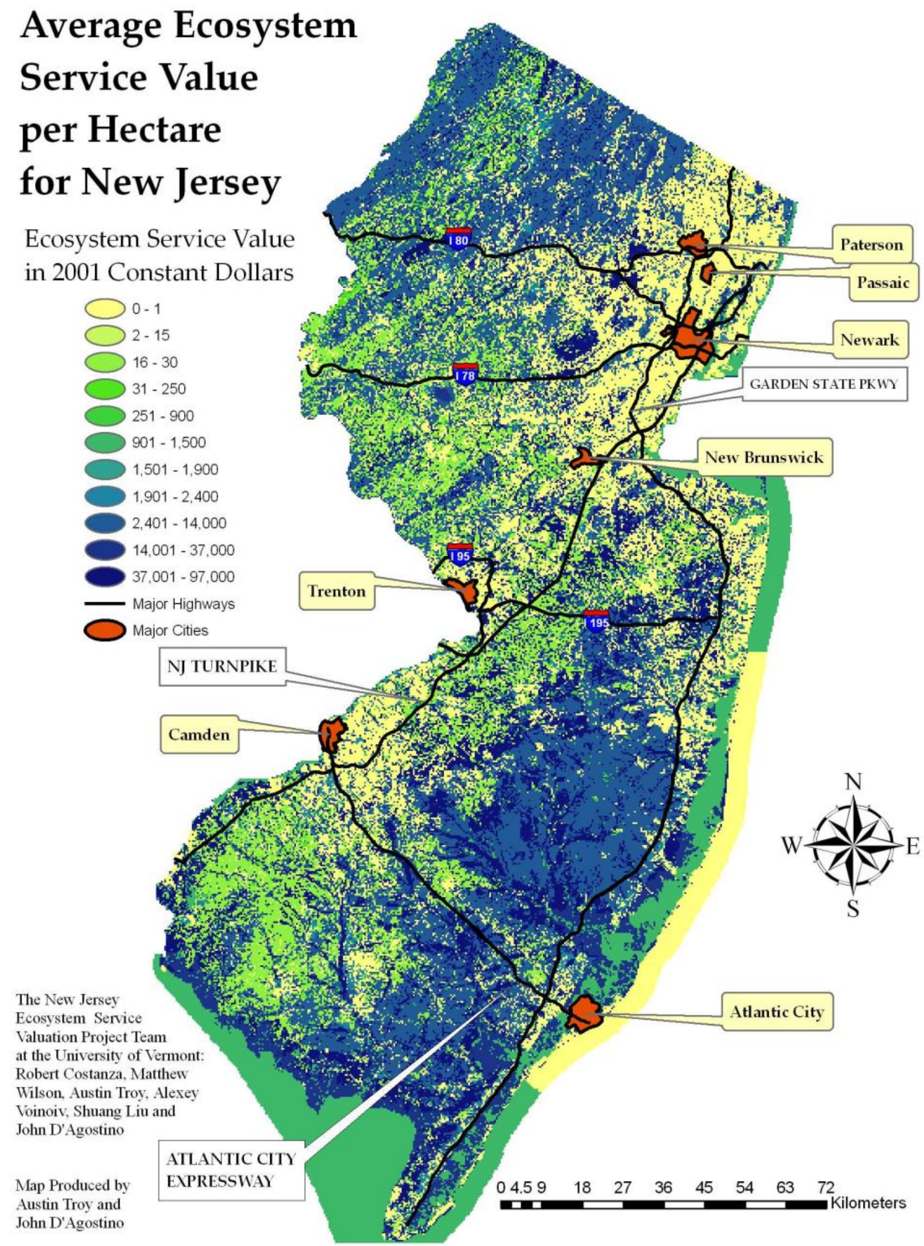
http://www.nj.gov/dep/dsr/naturalcap/

Valuing New Jersey's Natural Capital:

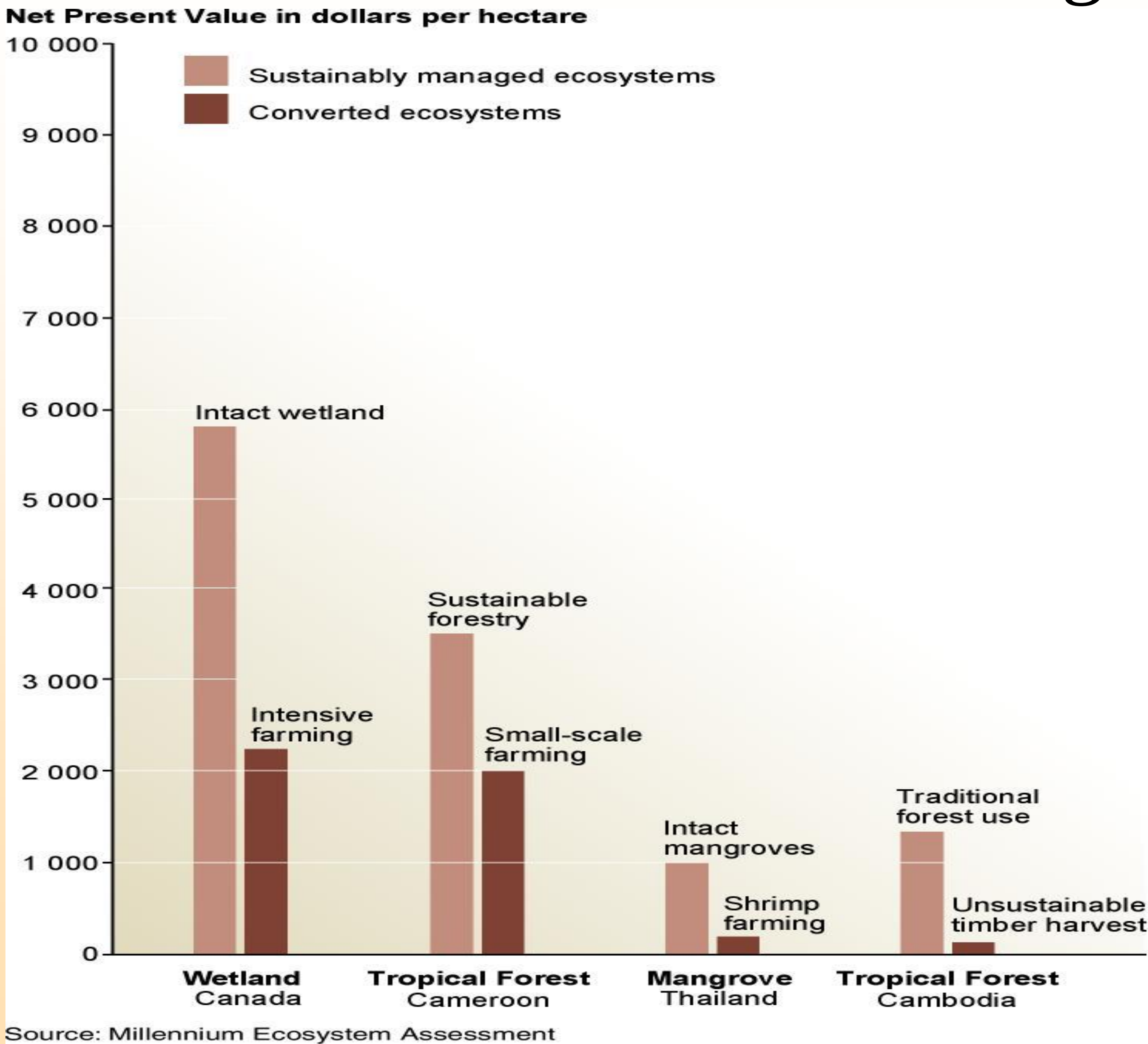
An Assessment of the Economic Value of the State's Natural Resources

April 2007

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



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)

Integrated Modeling of Humans Embedded in Ecological Systems

- **Intelligent Pluralism (Multiple Modeling Approaches), Testing, Cross-Calibration, and Integration**

- **Multi-scale in time, space, and complexity**

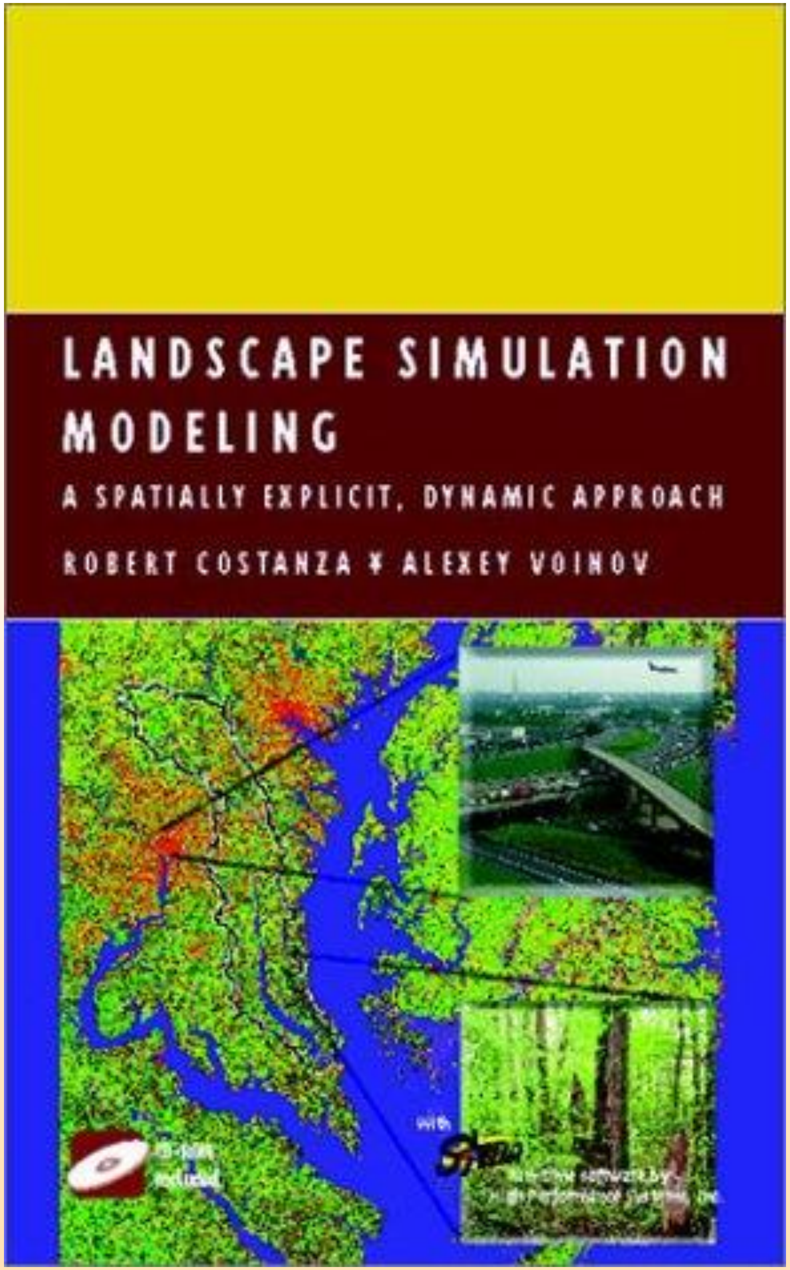
- **Can be used as a Consensus Building Tool in an Open, Participatory Process**

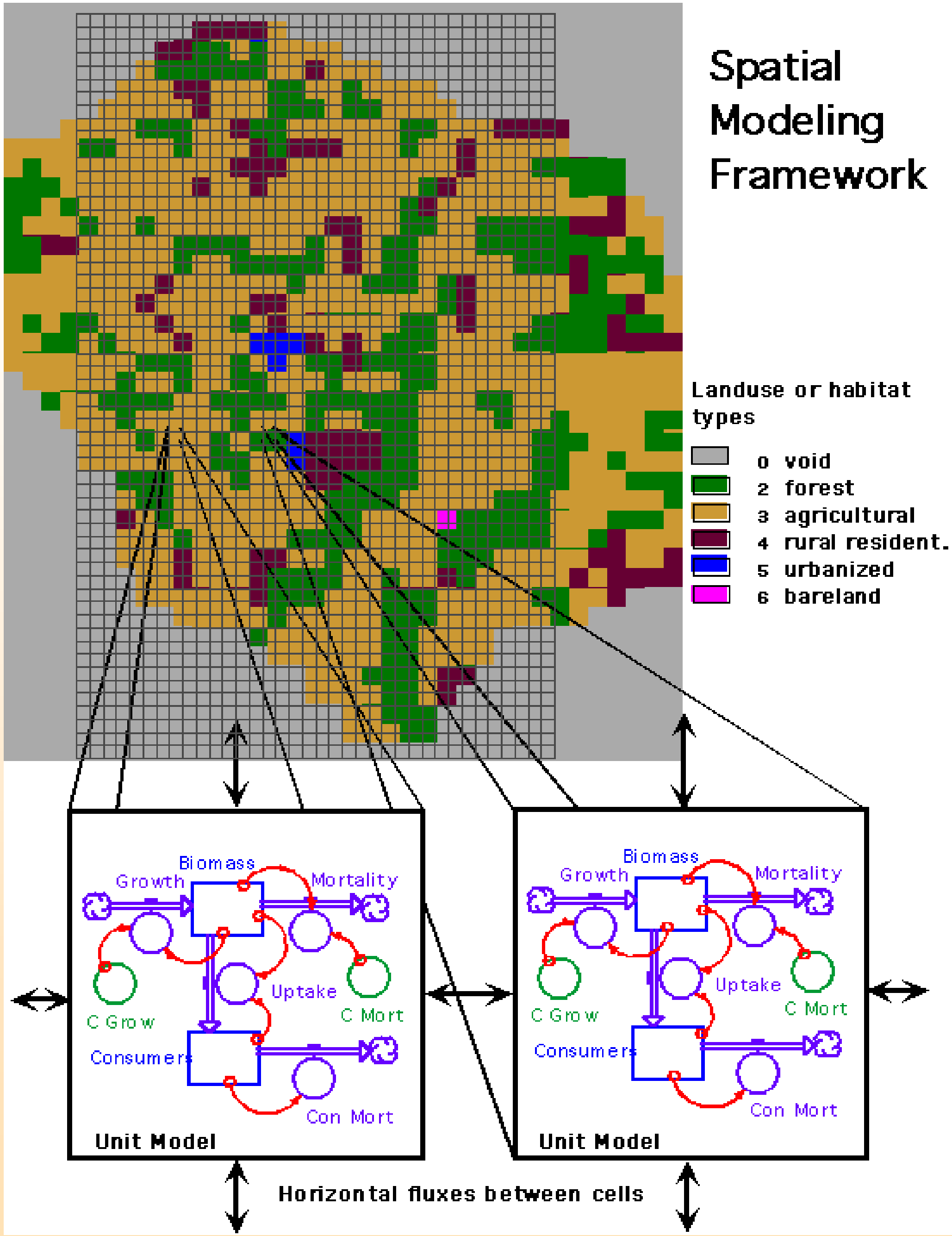
- **Acknowledges Uncertainty and Limited Predictability**

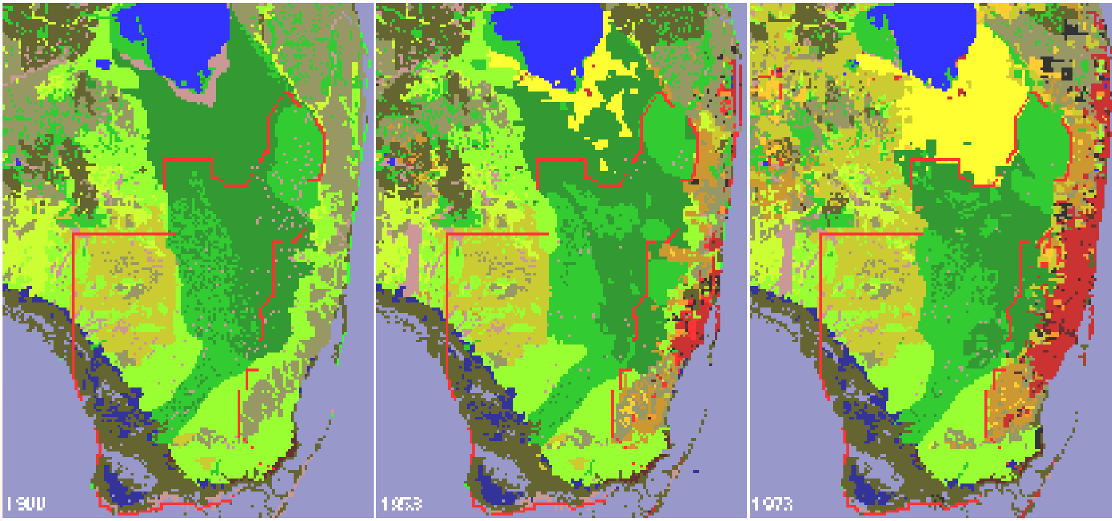
- **Acknowledges Values of Stakeholders**

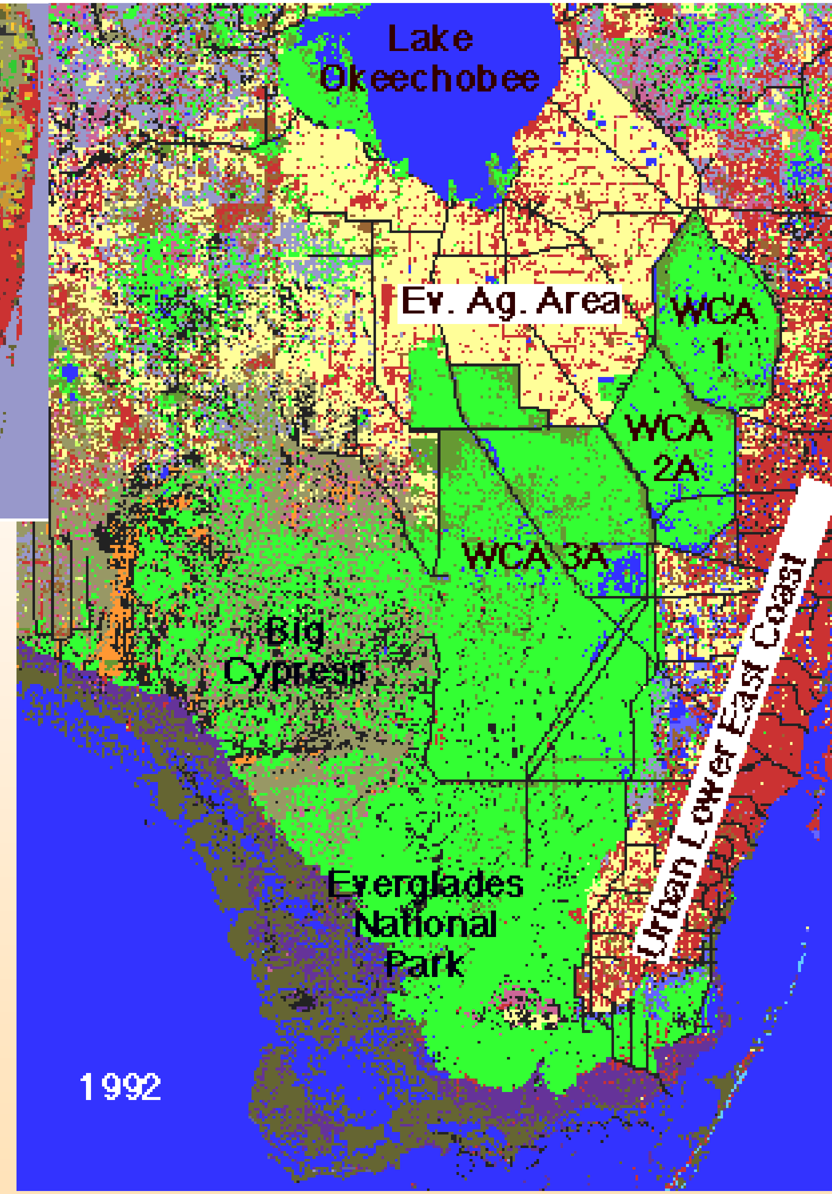
- **Evolutionary Approach Acknowledges History, Limited Optimization, and the Co-Evolution of Human Culture and Biology with the Rest of Nature**

Spatial Modeling Framework









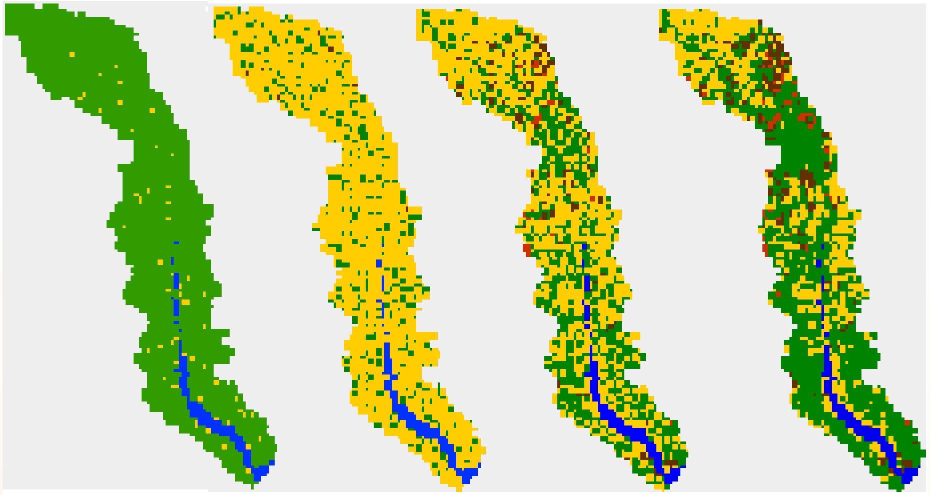
The Everglades Landscape Model (ELM v2.1)

http://www.sfwmd.gov/org/erd/esr/ELM.html

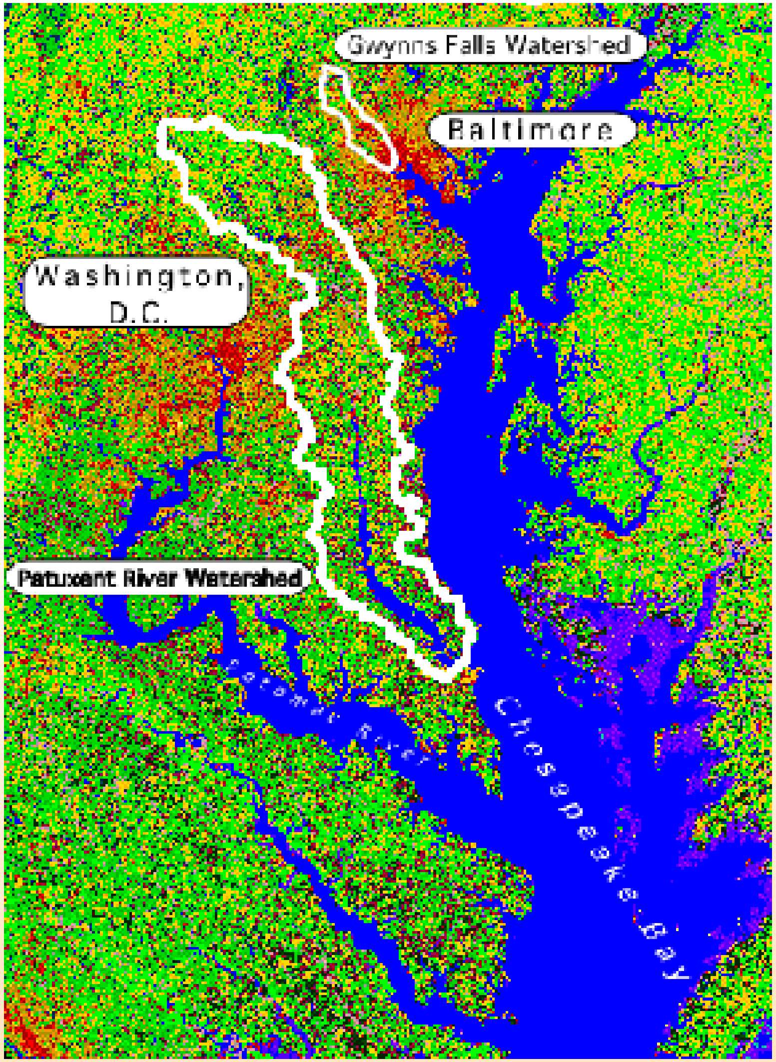
The ELM is a regional scale ecological model designed to predict the landscape response to different water management scenarios in south Florida, USA. The ELM simulates changes to the hydrology, soil & water nutrients, periphyton biomass & community type, and vegetation biomass & community type in the Everglades region.

Current Developers
South Florida Water Management District
H. Carl Fitz
Fred H. Sklar
Yegang Wu
Charles Cornwell
Tim Waring

Recent Collaborators
University of Maryland, Institute for Ecological Economics
Alexey A. Voinov
Robert Costanza
Tom Maxwell
Florida Atlantic University
Matthew Evett



	1700	1850	1953	1972
Forest	2386	348	911	1391
Residential	0	7	111	195
Urban	0	0	28	56
Agro	56	2087	1391	800



The Patuxent and Gwynns Falls Watershed Model s (PLM and GFLM)

http://www.uvm.edu/giee/PLM

This project is aimed at developing integrated knowledge and new tools to enhance predictive understanding of watershed ecosystems (including processes and mechanisms that govern the interconnect - ed dynamics of water, nutrients, toxins, and biotic components) and their linkage to human factors affecting water and watersheds. The goal is effective management at the watershed scale.

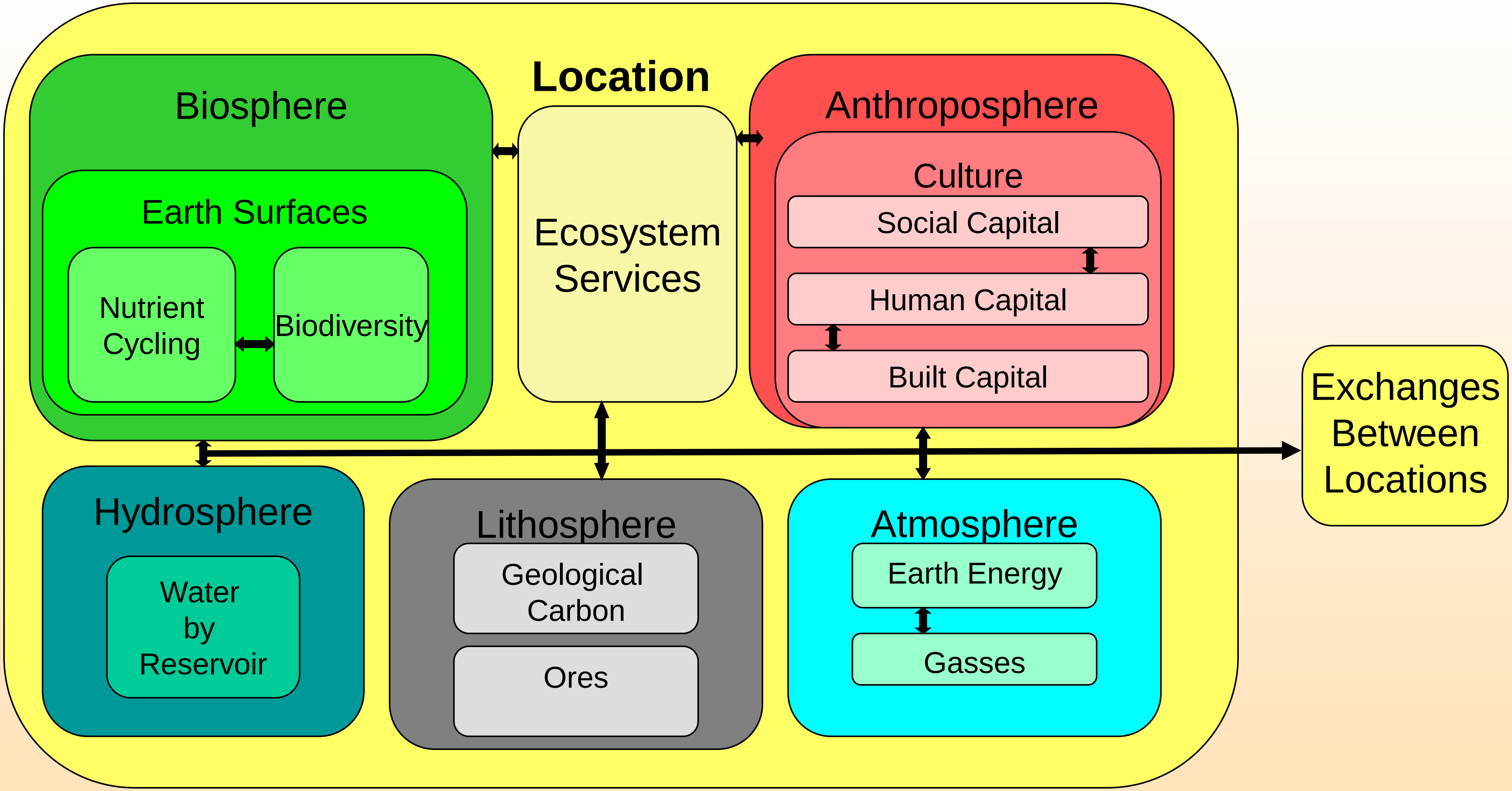
Participants Include:

Robert Costanza
Roelof Boumans
Walter Boynton
Thomas Maxwell
Steve Seagle
Ferdinando Villa
Alexey Voinov
Helena Voinov
Lisa Wainger

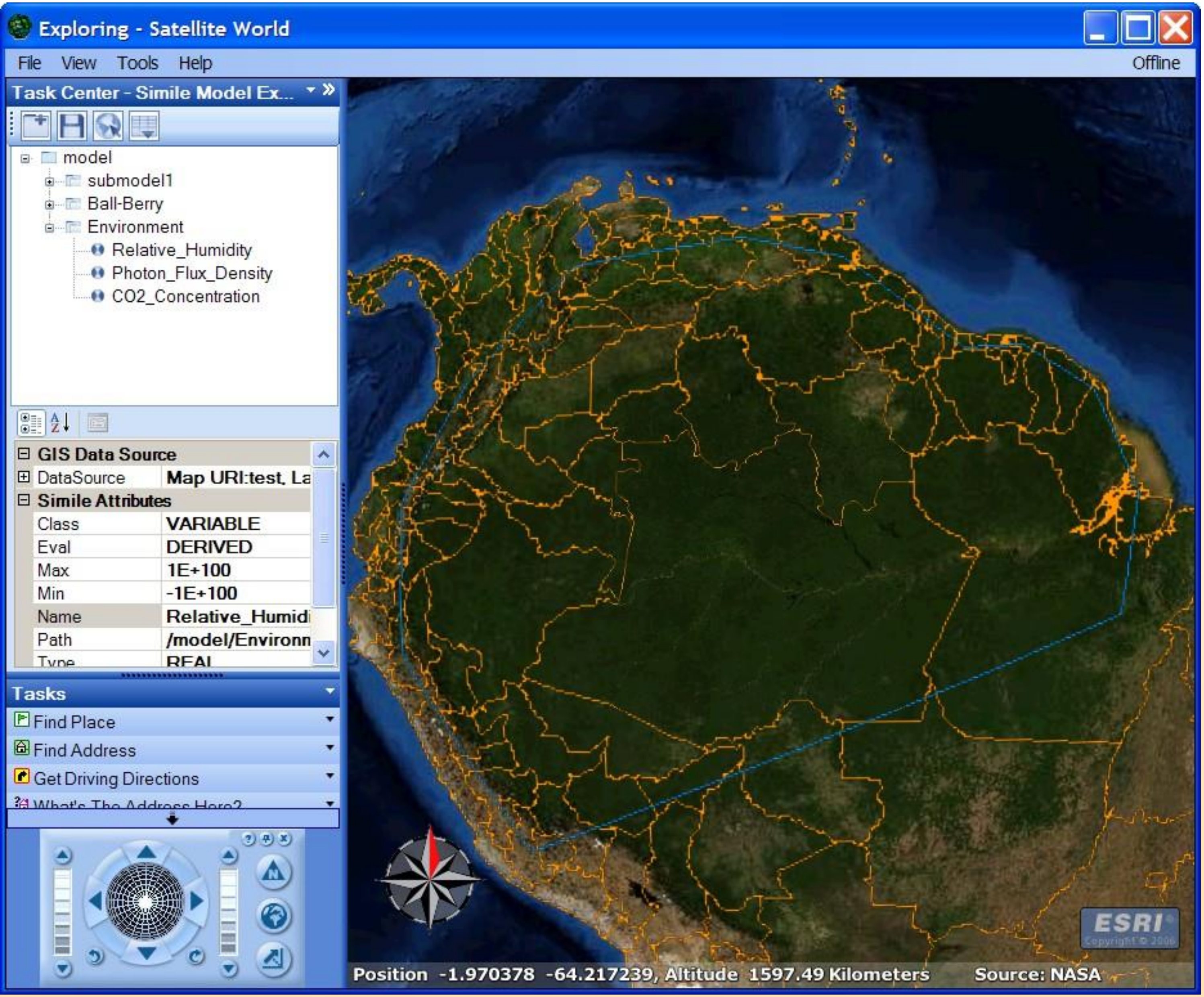
Costanza, R., A. Voinov, R. Boumans, T. Maxwell, F. Villa, L. Wainger, and H. Voinov. 2002. Integrated ecological economic modeling of the Patuxent River watershed, Maryland. *Ecological Monographs* 72:203-231.

MIMES

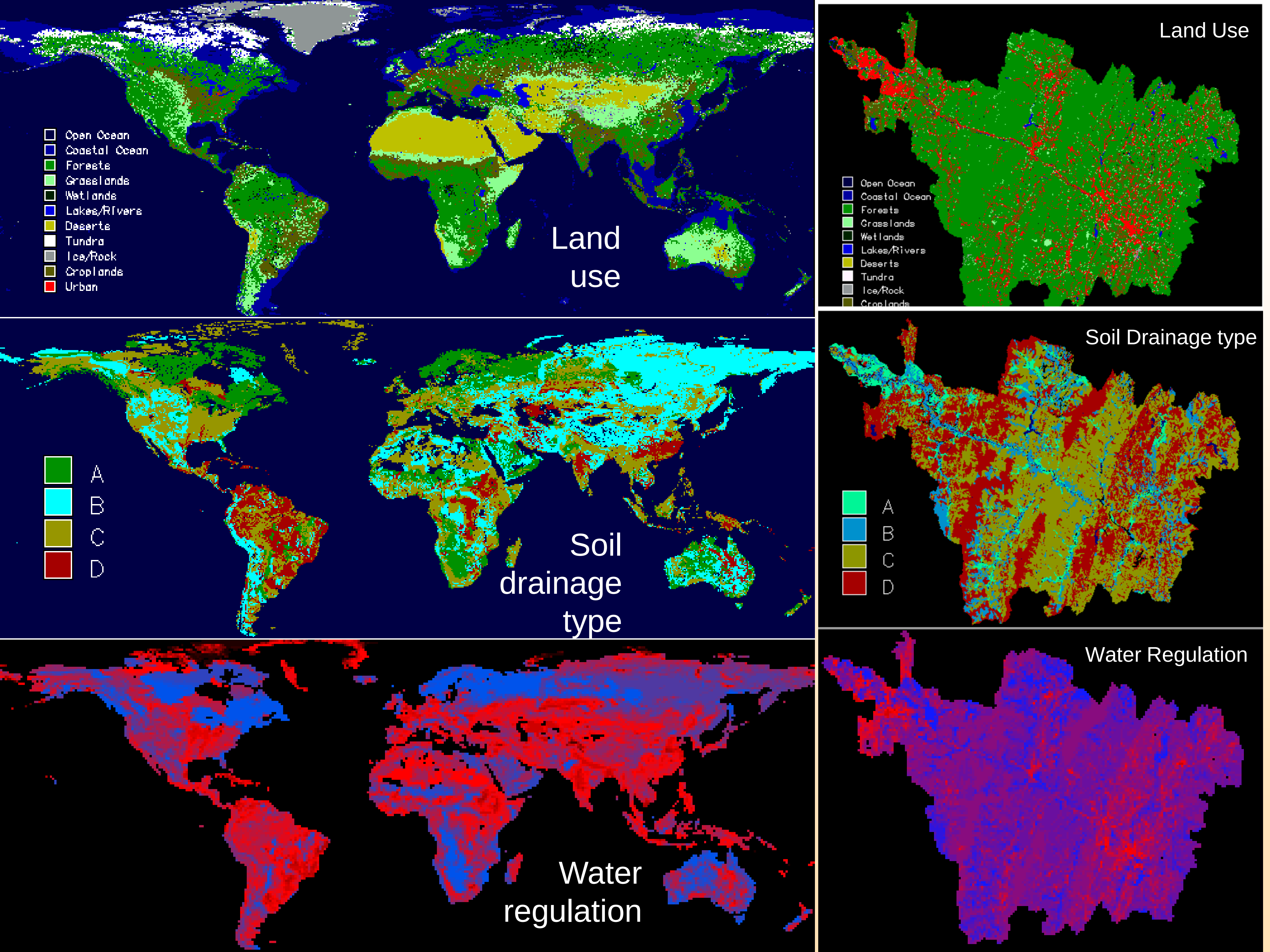
Multi-scale Integrated Models of Ecosystem Services



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



Open Ocean
Coastal Ocean
Forests
Grasslands
Wetlands
Lakes/Rivers
Deserts
Tundra
Ice/Rock
Croplands
Urban
Land use
A
B
C
D
Soil drainage type
Water regulation
Land Use
Open Ocean
Coastal Ocean
Forests
Grasslands
Wetlands
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Tundra
Ice/Rock
Croplands
Soil Drainage type
A
B
C
D
Water Regulation

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.

TRUCOST PLC taking the environment into account

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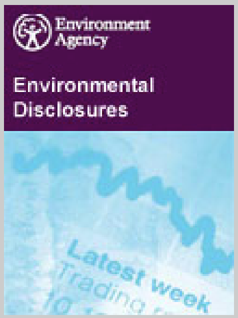

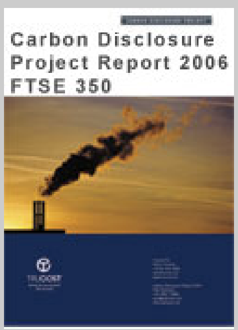

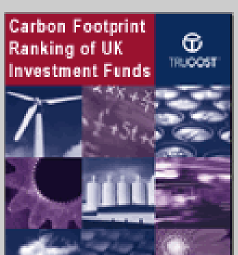

Welcome

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

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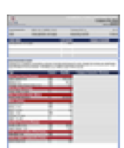


Received a Company Data Sheet?

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…

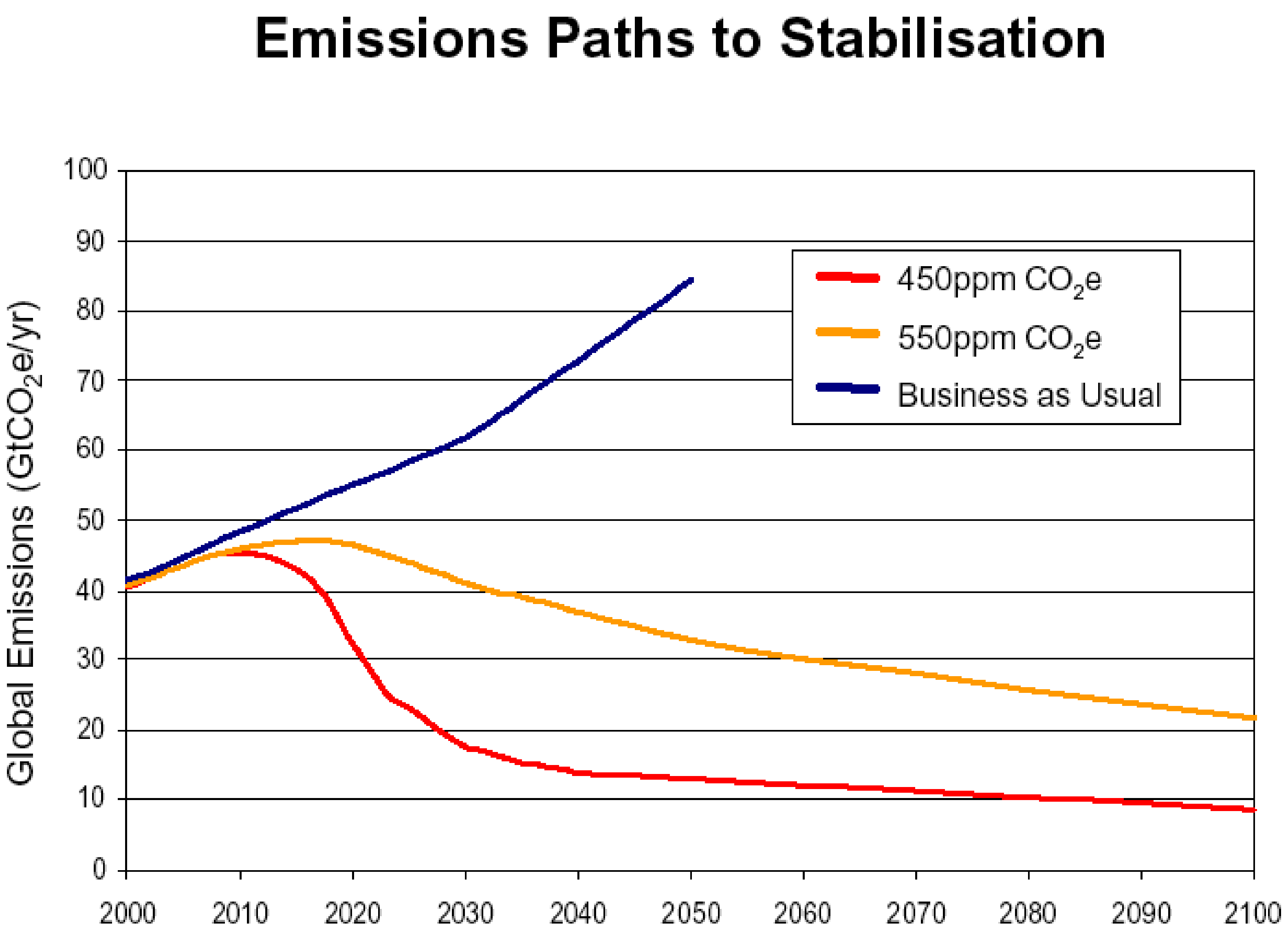
Regional

- 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…

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. *Science*. 319:724 (2008)

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)

SOLUTIONS

FOR A SUSTAINABLE AND DESIRABLE FUTURE

FIRST ISSUE, 2009

A New Publication for a Sustainable and Desirable Future

Solutions is both an online and print journal, a hybrid between a peer-reviewed journal and popular magazine.

Solutions synthesizes the best of our knowledge and creativity, driven by a vision of a future with a globally higher quality of life. It is intended for practitioners of design sciences, as well as for a broad audience that reaches beyond traditional academic journals to the informed public. It will provide a much-needed forum, devoted exclusively to whole-system solutions and the design of an integrated human and natural world.

Founding Editors

Editorial Board

Solutions uses a much more constructive, transdisciplinary review process than typical journals. We encourage collaboration and co-authorship between original authors and reviewers.

This constructive review process improves the quality of articles and enables the development of innovative, integrative, and whole-system solutions. It allows for broader, more transdisciplinary perspectives on a topic, creating articles that appeal to a larger community, with a stronger chance of being implemented.

Call for Contributions

We are soliciting articles and ideas for articles describing solutions for a sustainable and desirable world. These solutions should employ whole-system thinking, be at the appropriate spatial and temporal scales, and address, but not be hobbled by, the institutional and cultural changes that may be required. A solution does not have to solve all problems, but it should recognize what problems it can solve, and what other problems it might cause.

For more information or submissions please contact:

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Burlington, VT 05406-4619

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