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Valuing Our Ecosystems

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  Canberra ACT 0200, Australia
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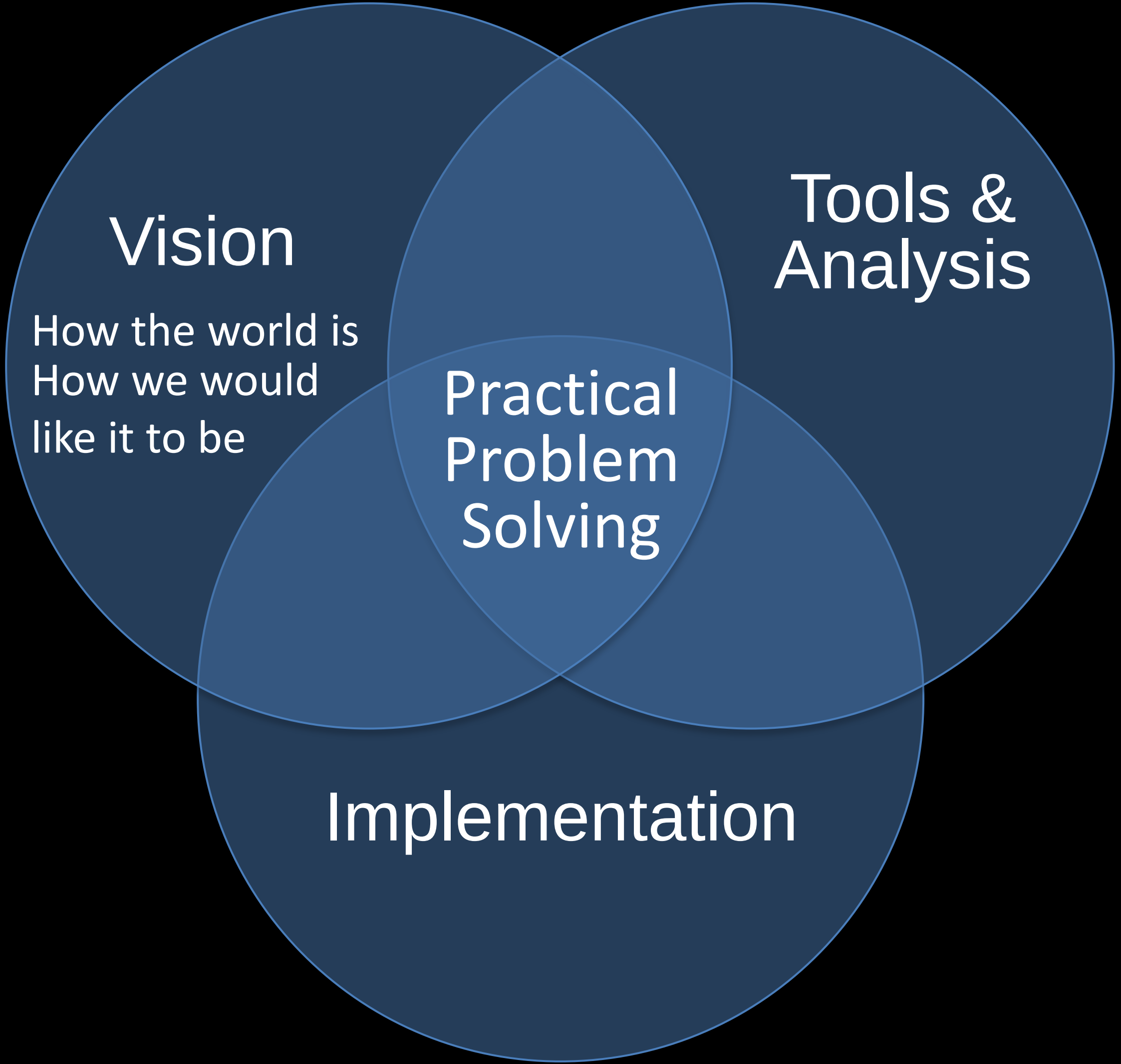
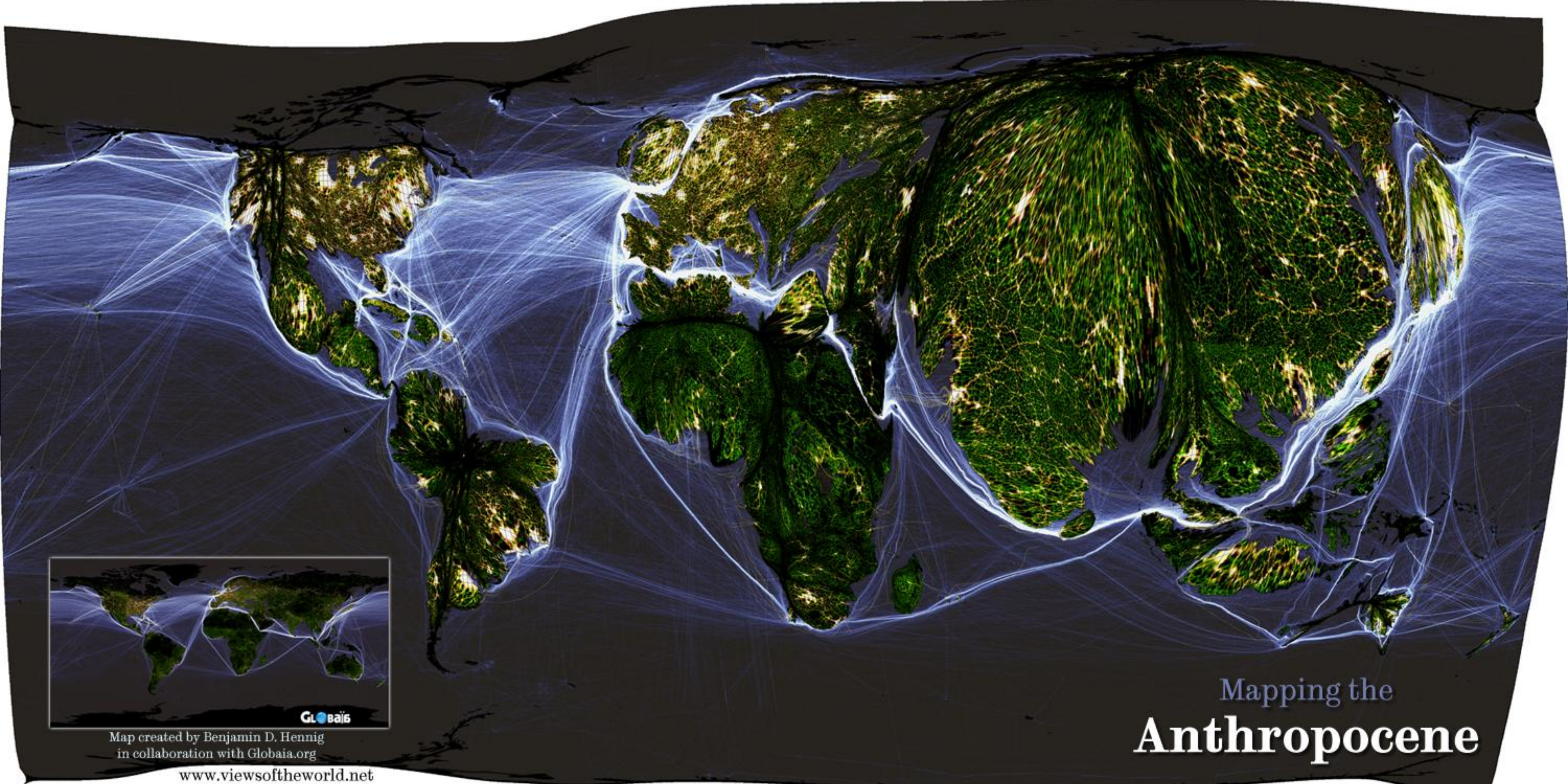
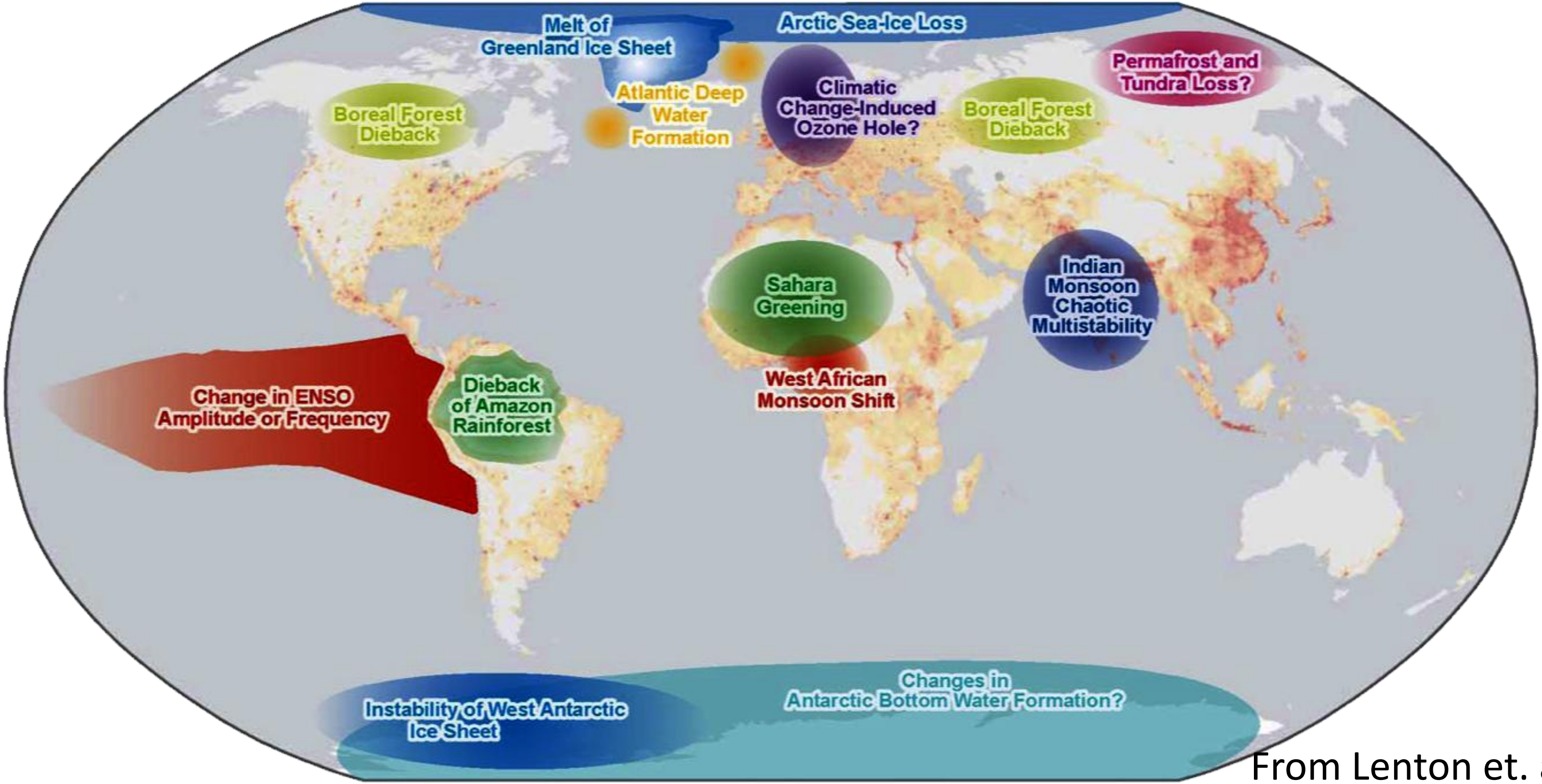
Australian National University


Vision
How the world is
How we would
like it to be
Tools &
Analysis
Practical
Problem
Solving
Implementation

Human influence on the earth system is now so large, that a new geologic era (*the Anthropocene*) has begun. We now live in a “Full World”

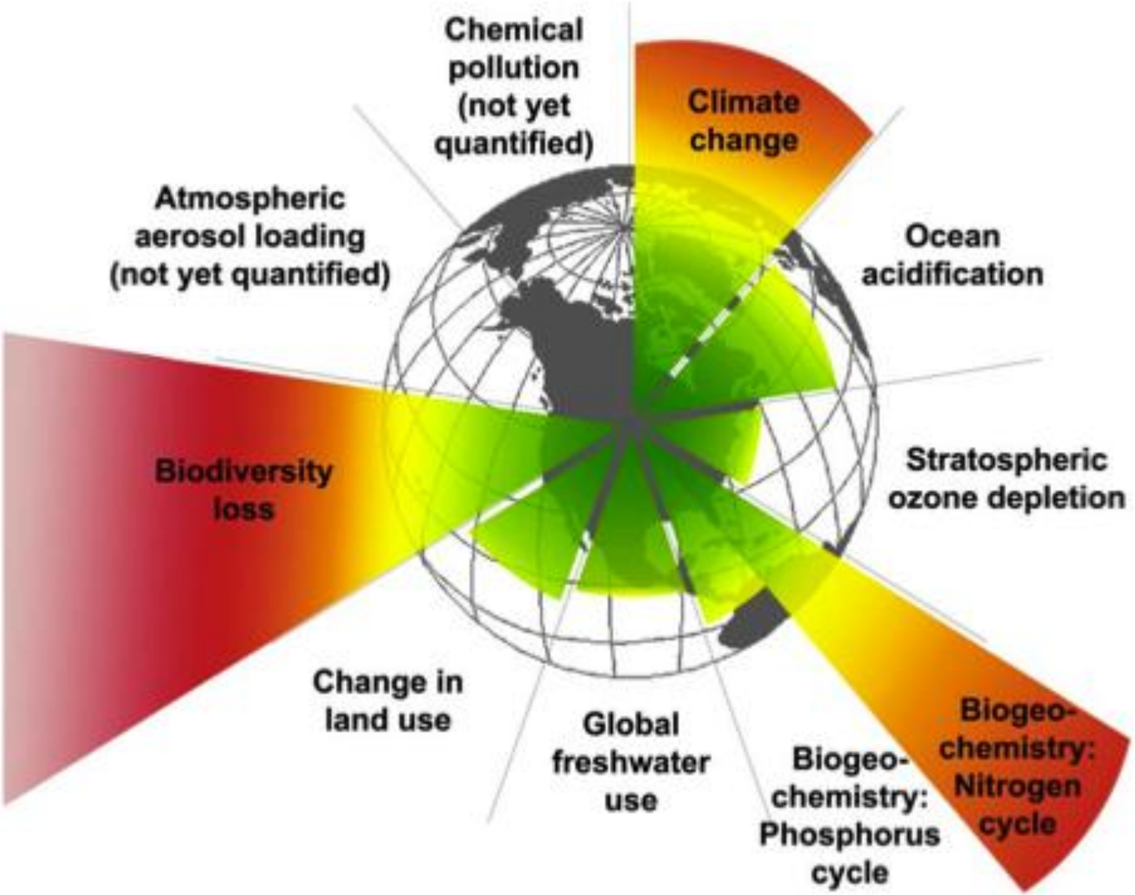


The world is a complex, non-linear, adaptive system, with thresholds, tipping points, and surprises



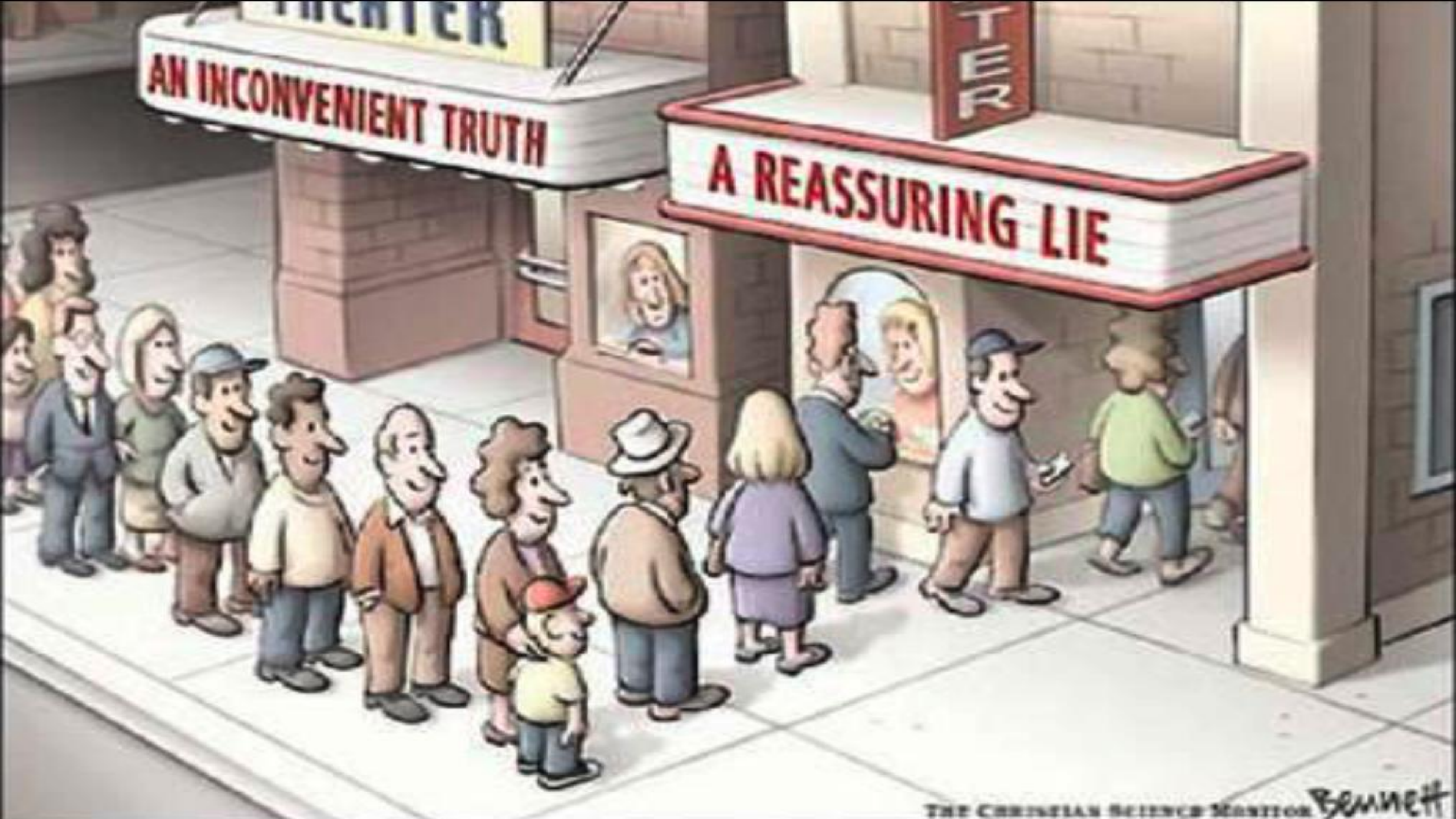
From Lenton et. al. 2008

THERE ARE FUNDAMENTAL *Planetary Boundaries*



Rockström, J., et al. 2009. **A safe operating space for humanity. *Nature* 461:472-475**

Steffen, W., J. Rockström, and R. Costanza. 2011. **How Defining Planetary Boundaries Can Transform Our Approach to Growth. *Solutions*. Vol 2, No. 3, May 2011**


AN INCONVENIENT TRUTH
A REASSURING LIE
THE CHRISTIAN SCIENCE MONITOR
Bennett

We need a ***third*** *movie…*

*We need a **third** movie…*

A sustainable and desirable economy-in-society-in-nature

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- Options for a technology facilitation mechanism - follow-up to the UNCSD outcome

Building a Sustainable and Desirable Economy-in-Society-in-Nature,

by: *United Nations Department of Economic and Social Affairs (UNDESA)*

This report is a synthesis of ideas about what a new economy-in-society-in-nature might look and how we might get there. The report argues that now is the right time for the transition to a new economic paradigm. It lays out a vision, objectives and concrete policies that could underpin a new model of the economy based on the worldview and principles of "ecological economics," including sustainable scale, equitable distribution and efficient allocation ? a model where GDP growth is not the ultimate goal. The report makes a case for a greatly expanded commons sector of the economy and new common asset institutions to adequately deal with natural and social capital assets.

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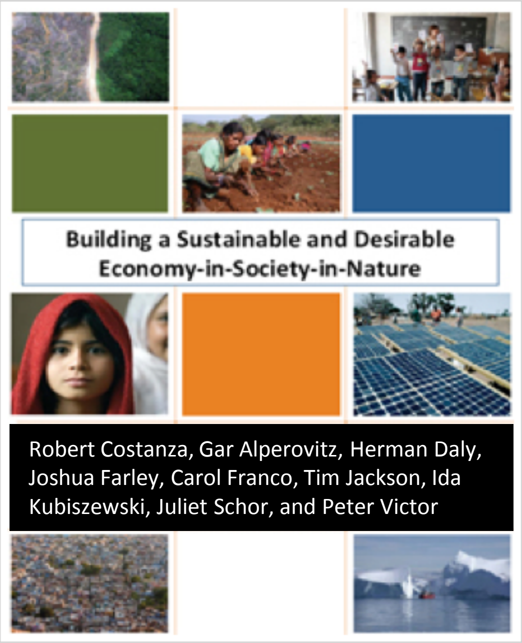
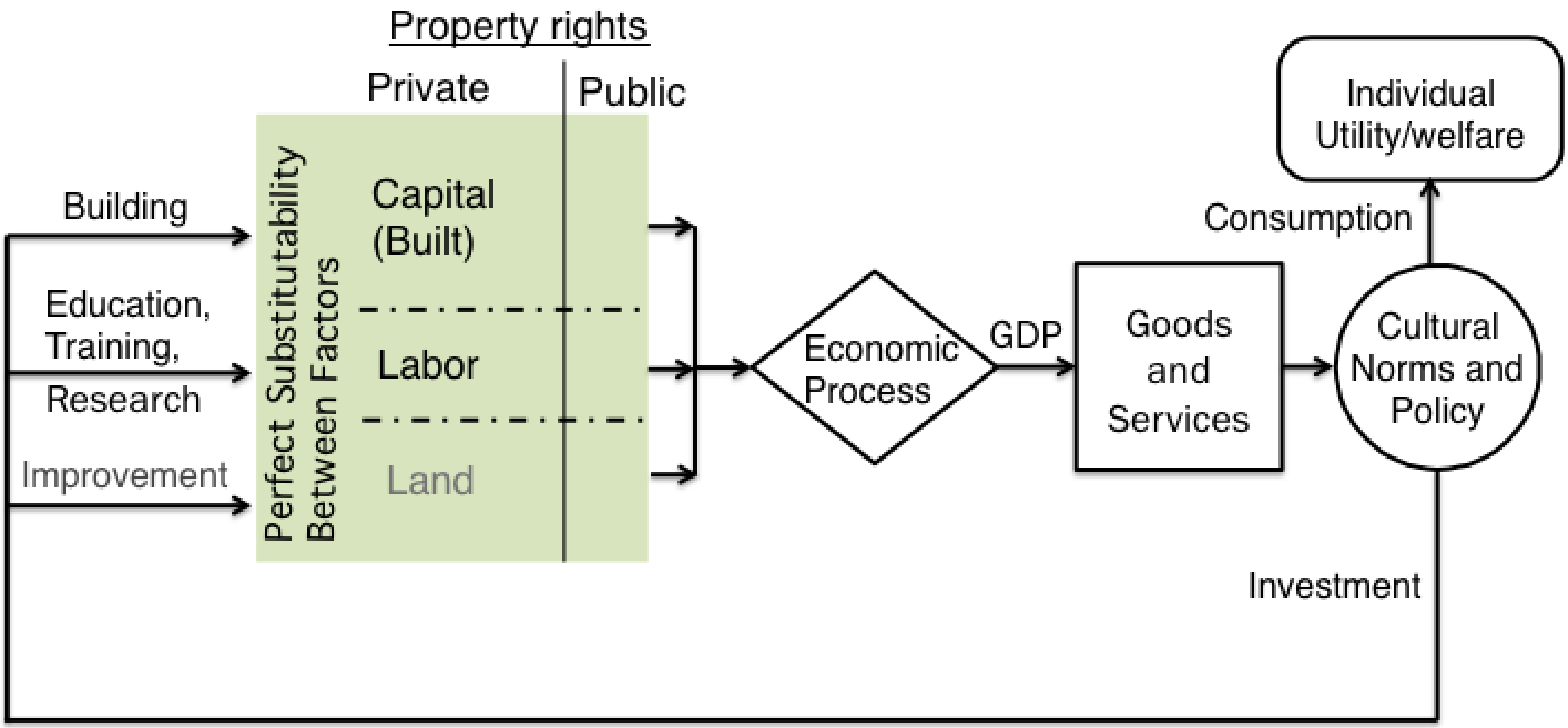


http://sustainabledevelopment.un.org/index.php?page=view&nr=627&type=400&menu=35

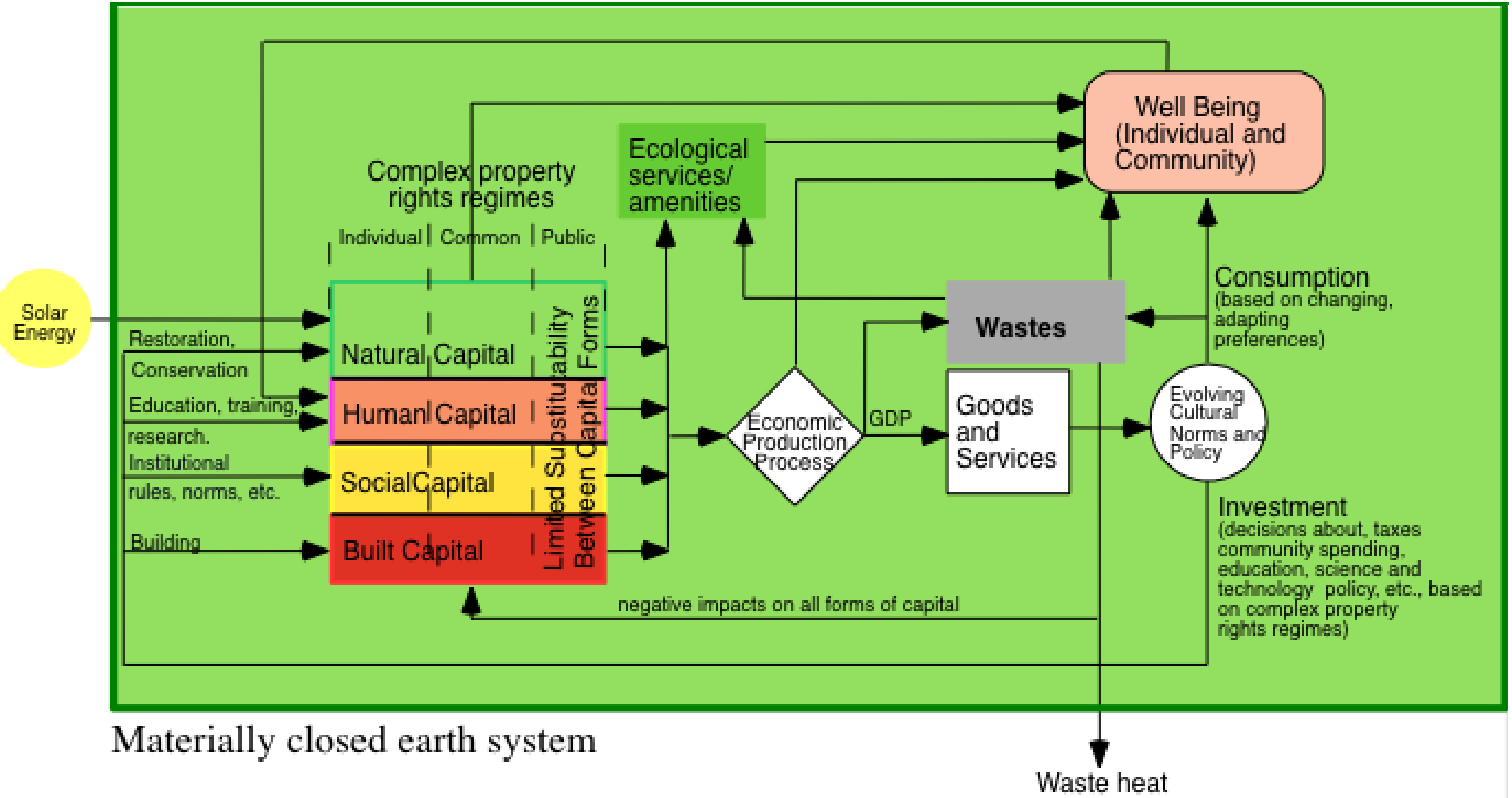
KEY POINTS:

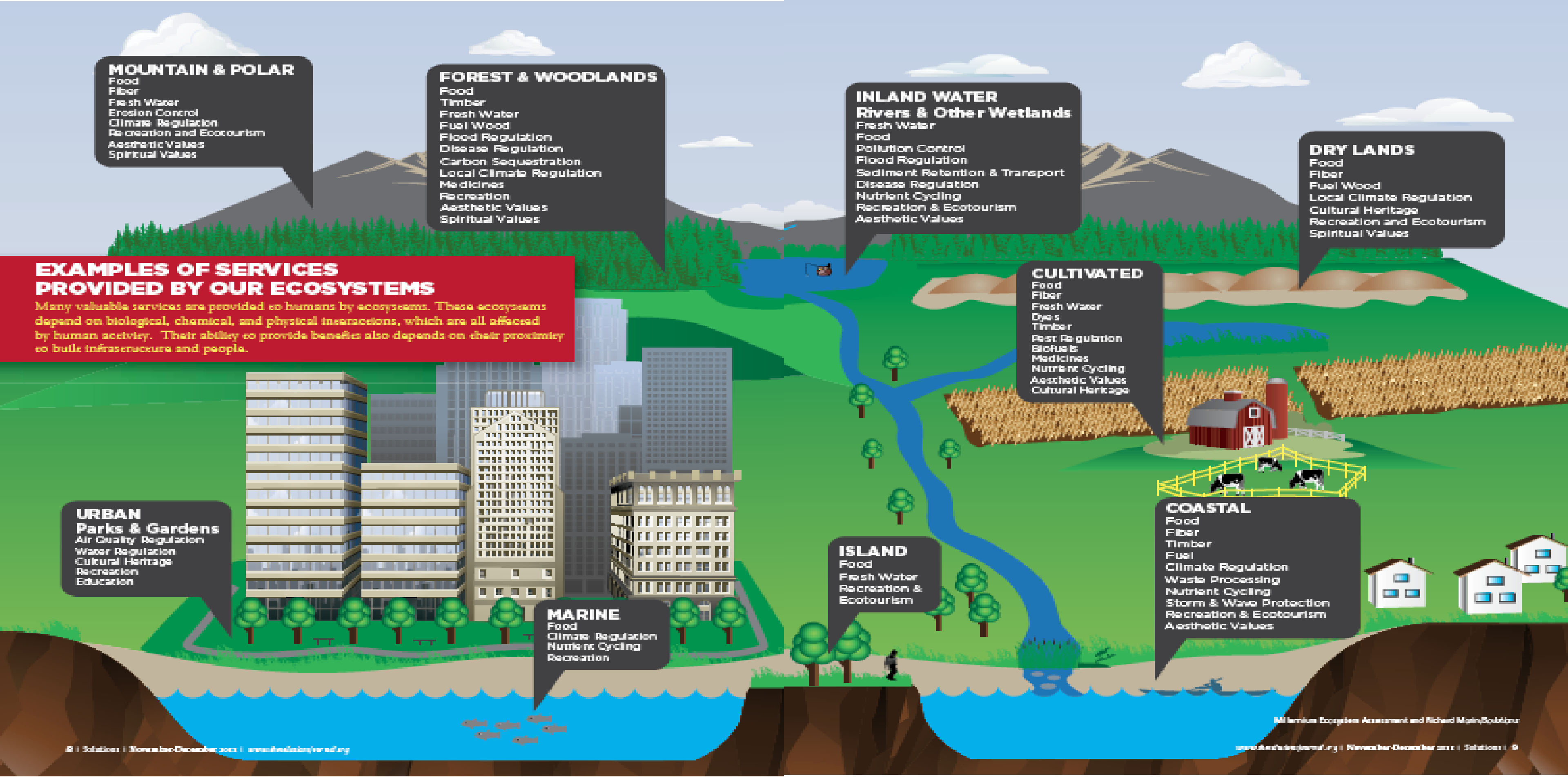
- Growth in material consumption is unsustainable: there are fundamental planetary boundaries.
- Growth in material consumption beyond a threshold already reached by many is undesirable: it has negative effects on social and natural capital and in overdeveloped economies does not increase well-being.
- Viable alternatives exist that are both sustainable and desirable, but they require a fundamental change of worldview and redesign of the entire “regime.”

“Empty World” Vision of the Economy

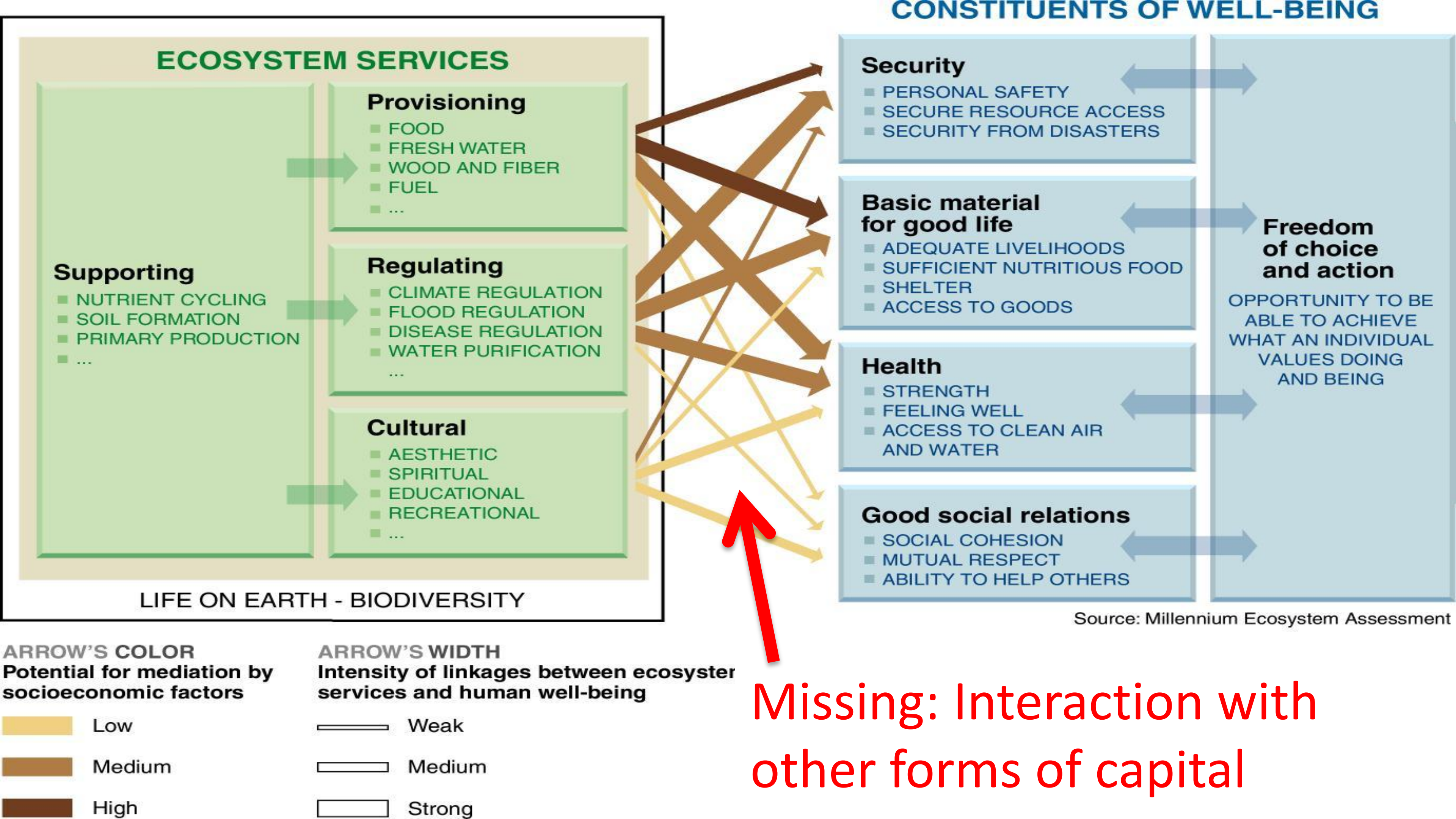


“Full World” Vision of the Whole System

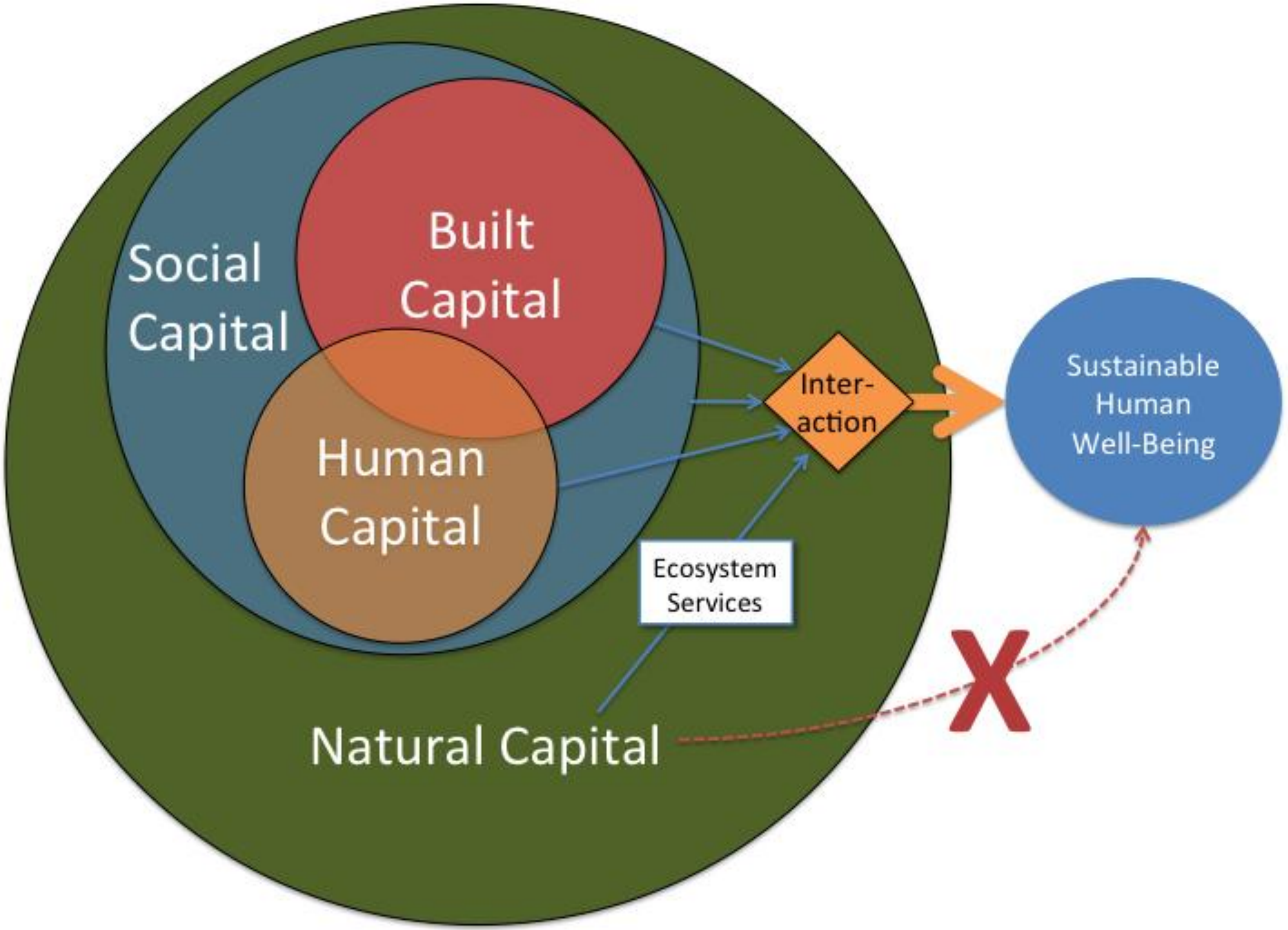




Ecosystem Services: the benefits people derive from functioning ecosystems



Missing: Interaction with other forms of capital


Social
Capital
Built
Capital
Human
Capital
Inter-
action
Sustainable
Human
Well-Being
Ecosystem
Services
Natural Capital
X

IPBES
- IPBES negotiations
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Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES)

What is IPBES?

The "Intergovernmental Platform on Biodiversity and Ecosystem Services" is a mechanism proposed to further strengthen the science-policy interface on biodiversity and ecosystem services, and add to the contribution of existing processes that aim at ensuring that decisions are made on the basis of the best available scientific information on conservation and sustainable use of biodiversity and ecosystem services. IPBES is proposed as a broadly similar mechanism to the Intergovernmental Panel on Climate Change (IPCC).

What is the science-policy interface?

Science-policy interfaces are social processes which encompass relations between scientists and other actors in the policy process, and which allow for exchanges, co-evolution, and joint construction of knowledge with the aim of enriching decision-making at different scales. This includes 2 main requirements:

a) that scientific information is relevant to policy demands and is formulated in a way that is accessible to policy and decision makers; and

b) that policy and decision makers take into account available scientific information in their deliberations and that they formulate their demands or questions in a way that are accessible for scientists to provide the relevant information. Click here for a graphic showing the cycle of

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ESP The Ecosystem Services Partnership

Worldwide Network to enhance the Science and practical Application of ecosystem services assessment

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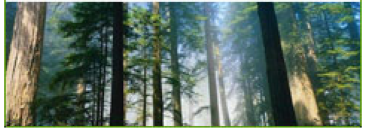
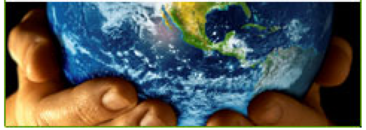


- National ESP Networks



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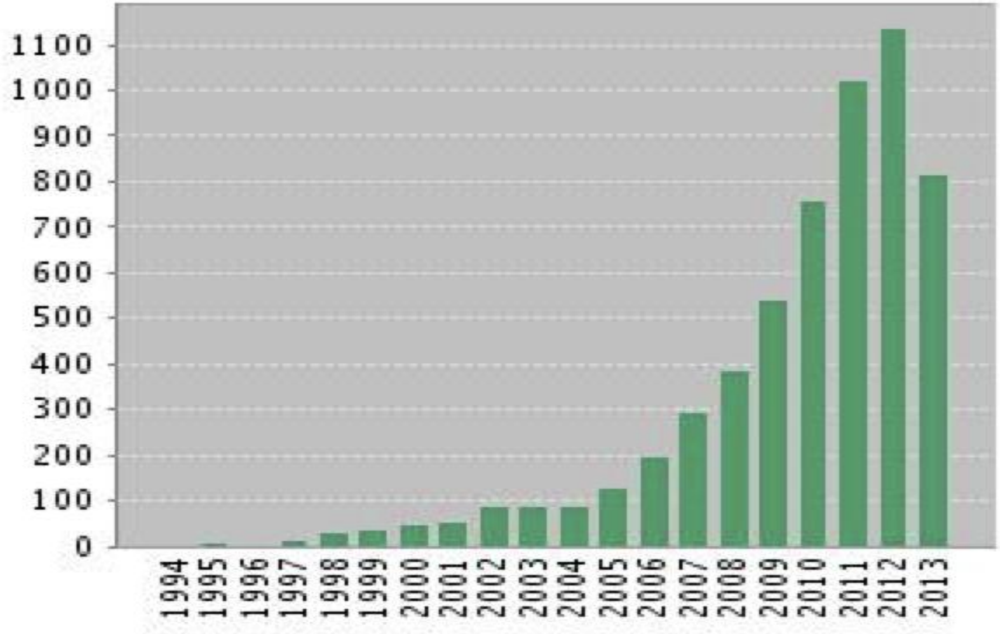

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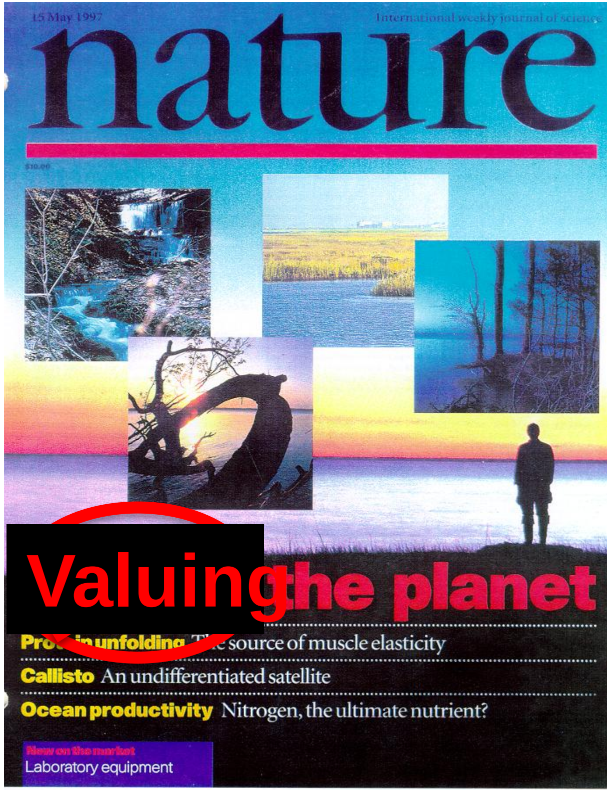
NATURE VOL 387 15 MAY 1997

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.

2nd most cited article in the Ecology/Environment area according to the ISI Web of Knowledge with more than 4000 citations



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**

Ecosystem Services 1 (2012) 50–61

Contents lists available at SciVerse ScienceDirect

Ecosystem Services

journal homepage: www.elsevier.com/locate/ecoser

Global estimates of the value of ecosystems and their services in monetary units

Rudolf de Groot[a,*], Luke Brander[b,1], Sander van der Ploeg[a], Robert Costanza[c], Florence Bernard[d], Leon Braat[e], Mike Christie[f], Neville Crossman[g,h], Andrea Ghermandi[i], Lars Hein[a], Salman Hussain[j], Pushpam Kumar[k], Alistair McVittie[j], Rosimeiry Portela[l], Luis C. Rodriguez[g,h], Patrick ten Brink[m], Pieter van Beukering[b]

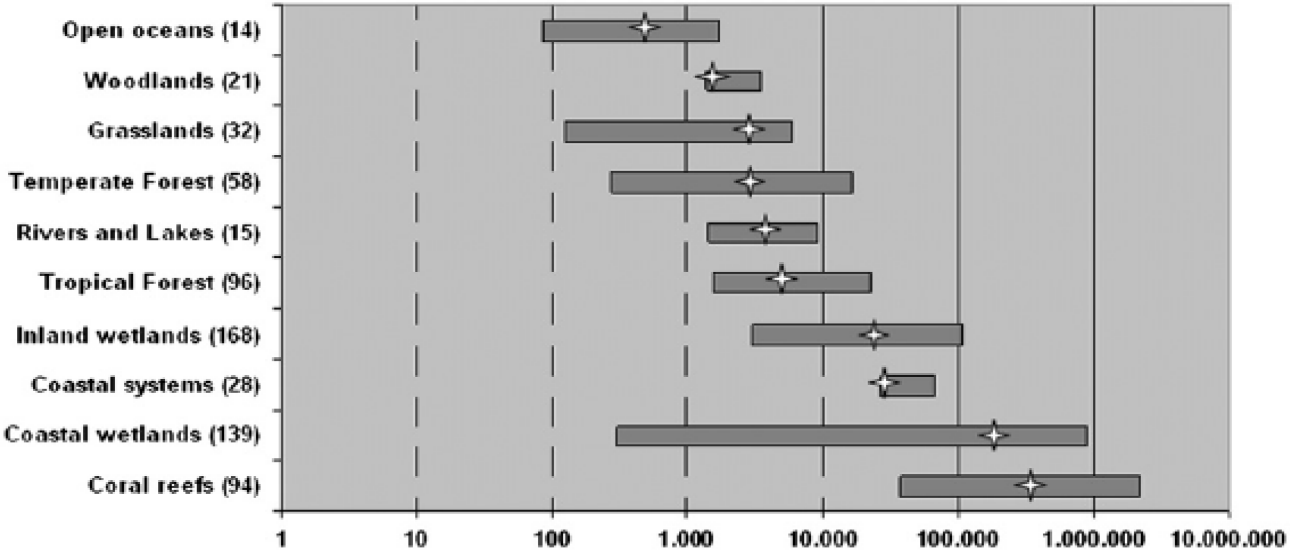
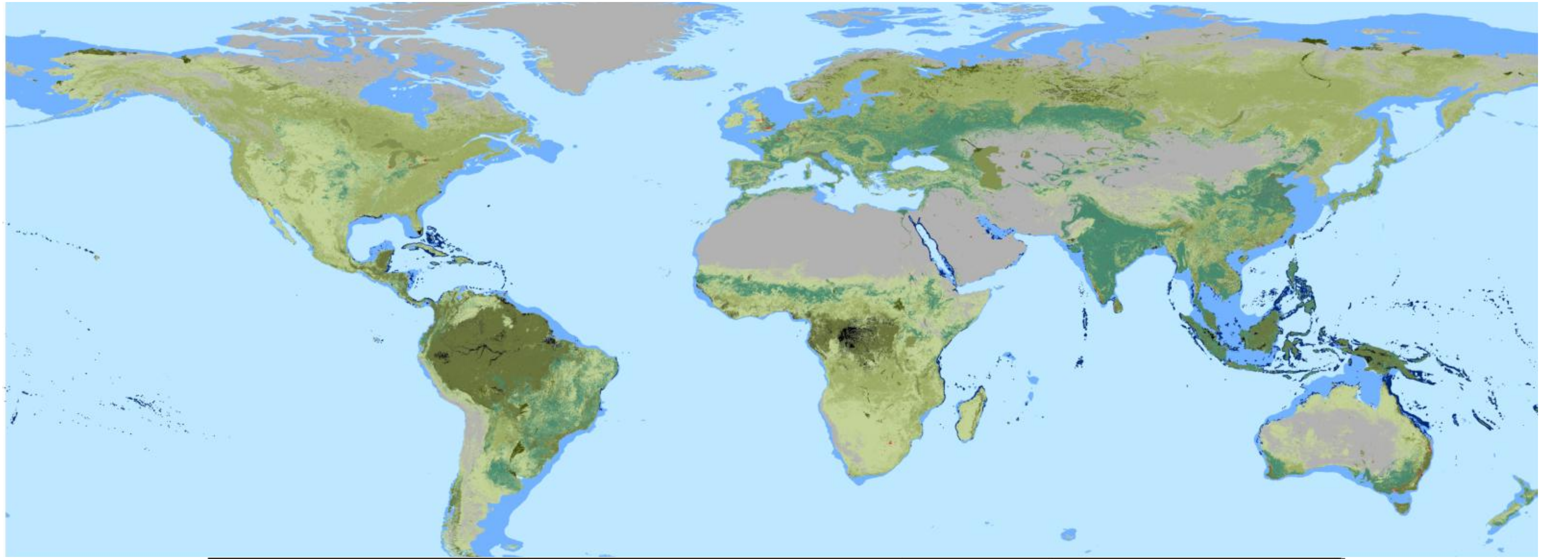


Figure S1. Map of global annual ecosystem services based on 2011 land areas and 2011 unit values



LandCover	Flow Value per Hectare per year	Legend	Area (millions of hectares)
Desert	$0		2159
Tundra	$0		433
Ice/Rock	$0		1640
Open Ocean	$491		33200
Marine Shelf	$2,222		2660
Grass/Rangelands	$2,871		4418
Temperate/Boreal Forest	$3,013		3003
Lakes/Rivers	$4,267		200
Tropical Forest	$5,264		1258
Cropland	$5,567		1672
Urban	$6,661		352
Swamps/Floodplains	$25,682		60
Tidal Marsh/Mangroves	$193,845		128
Coral Reefs	$352,249		28

Table 3. Changes in area, unit values and aggregate global flow values from 1997 to 2011 (green are values that have increased, red are values that have decreased)

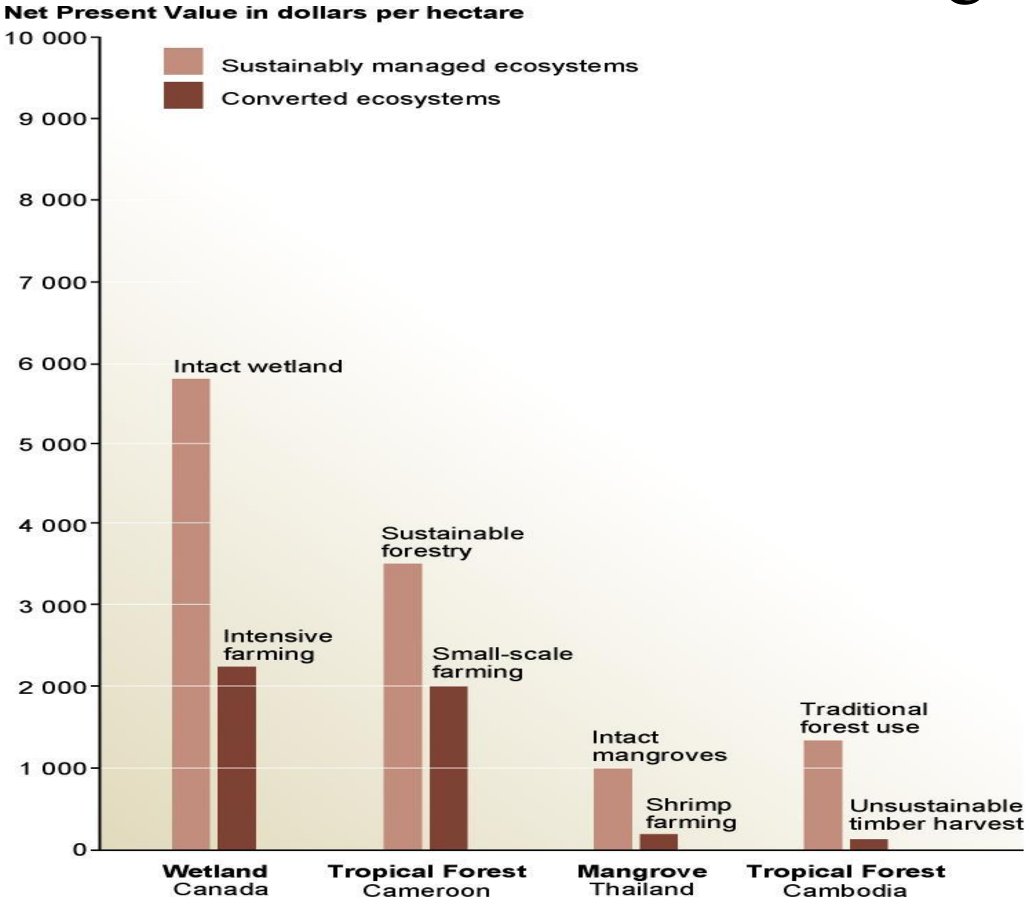
Biome	Area (e6 ha)		Change	Unit values 2007$/ha/yr		Change	Aggregate Global Flow Value e12 2007$/yr			
							A. Original Assuming 1997 area and 1997 unit values	**B.** Change unit values only Assuming 1997 area and 2011 unit values	**C.** Change area only Assuming 2011 area and 1997 unit values	**D.** Change both unit values and area Assuming 2011 area and 2011 unit values
	1997	**2011**	2011-1997	**1997**	**2011**	2011-1997	**1997**	**2011**	**2011**	**2011**
Marine	**36,302**	**36,302**	0	796	1,368	572	**28.9**	**60.5**	**29.5**	**49.7**
Open Ocean	**33,200**	**33,200**	0	348	660	312	11.6	21.9	11.6	21.9
Coastal	**3,102**	**3,102**	0	5,592	8,944	3,352	17.3	38.6	18.0	27.7
Estuaries	180	**180**	0	31,509	28,916	-2,593	5.7	5.2	5.7	5.2
Seagrass/Algae Beds	200	**234**	34	26,226	28,916	2,690	5.2	5.8	6.1	6.8
Coral Reefs	62	**28**	-34	8,384	352,249	343,865	0.5	21.7	0.2	9.9
Shelf	2,660	**2,660**	0	2,222	2,222	0	5.9	5.9	5.9	5.9
Terrestrial	**15,323**	**15,323**	0	1,109	4,901	3,792	**17.0**	**84.5**	**12.1**	**75.1**
Forest	**4,855**	**4,261**	-594	1,338	3,800	2,462	6.5	19.5	4.7	16.2
Tropical	1,900	**1,258**	-642	2,769	5,382	2,613	5.3	10.2	3.5	6.8
Temperate/Boreal	2,955	**3,003**	48	417	3,137	2,720	1.2	9.3	1.3	9.4
Grass/Rangelands	**3,898**	**4,418**	520	321	4,166	3,845	1.2	16.2	1.4	18.4
Wetlands	**330**	**188**	-142	20,404	140,174	119,770	6.7	36.2	3.4	26.4
Tidal Marsh/Mangroves	165	**128**	-37	13,786	193,843	180,057	2.3	32.0	1.8	24.8
Swamps/Floodplains	165	**60**	-105	27,021	25,681	-1,340	4.5	4.2	1.6	1.5
Lakes/Rivers	**200**	**200**	0	11,727	12,512	785	2.3	2.5	2.3	2.5
Desert	**1,925**	**2,159**	234	-	-	0	-	-	-	-
Tundra	**743**	**433**	-310	-	-	0	-	-	-	-
Ice/Rock	**1,640**	**1,640**	0	-	-	0	-	-	-	-
Cropland	**1,400**	**1,672**	272	126	5,567	5,441	0.2	7.8	0.2	9.3
Urban	**332**	**352**	20	-	6,661	6,661	-	2.2	-	2.3
Total	**51,625**	**51,625**	0				**45.9**	**145.0**	**41.6**	**124.8**

-4.3

-20.2

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



Source: Millennium Ecosystem Assessment

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)

Table 1. Range of Uses for Ecosystem Service Valuation

Use of Valuation	Appropriate values	Appropriate spatial scales	Precision Needed
Raising Awareness and interest	Total values, macro aggregates	Regional to global	low
National Income and Well-Being Accounts	Total values by sector and macro aggregates	National	medium
Specific Policy Analyses	Changes by policy	Multiple depending on policy	medium to high
Urban and Regional Land Use Planning	Changes by land use scenario	Regional	low to medium
Payment for Ecosystem Services	Changes by actions due payment	Multiple depending on system	medium to high
Full Cost Accounting	Total values by business, product, or activity and changes by business, product, or activity	Regional to global, given the scale of international corporations	medium to high
Common Asset Trusts	Totals to assess capital and changes to assess income and loss	Regional to global	medium

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What we do

Trucost helps organisations measure and manage the environmental impacts associated with their own operations, supply chains and investment portfolios. Key to our approach is that we not only quantify environmental impacts, but we also put a price on them, helping organisations understand environmental risk in business terms.

In this way, Trucost helps its customers manage financial risk from environmental issues such as climate change regulation and natural resource dependency, meet environmental reporting requirements, demonstrate robust environmental credentials and drive cost and efficiency improvements through their operations.

How Trucost can help

Over the last 10 years, Trucost has collected, standardised and validated the world's most comprehensive data on corporate environmental impacts, including carbon, water, waste, metals and chemicals. This provides Trucost's clients with:

- The most efficient approach to measuring carbon and wider environmental impacts across organisations, supply chains and investment portfolios
- Clear identification of focus areas for reducing material environmental impacts
- Validation of source data, including completion of gaps in data which are currently not being tracked or reported on

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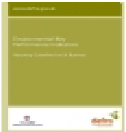
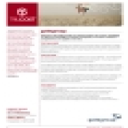
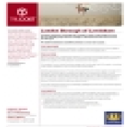
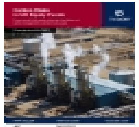
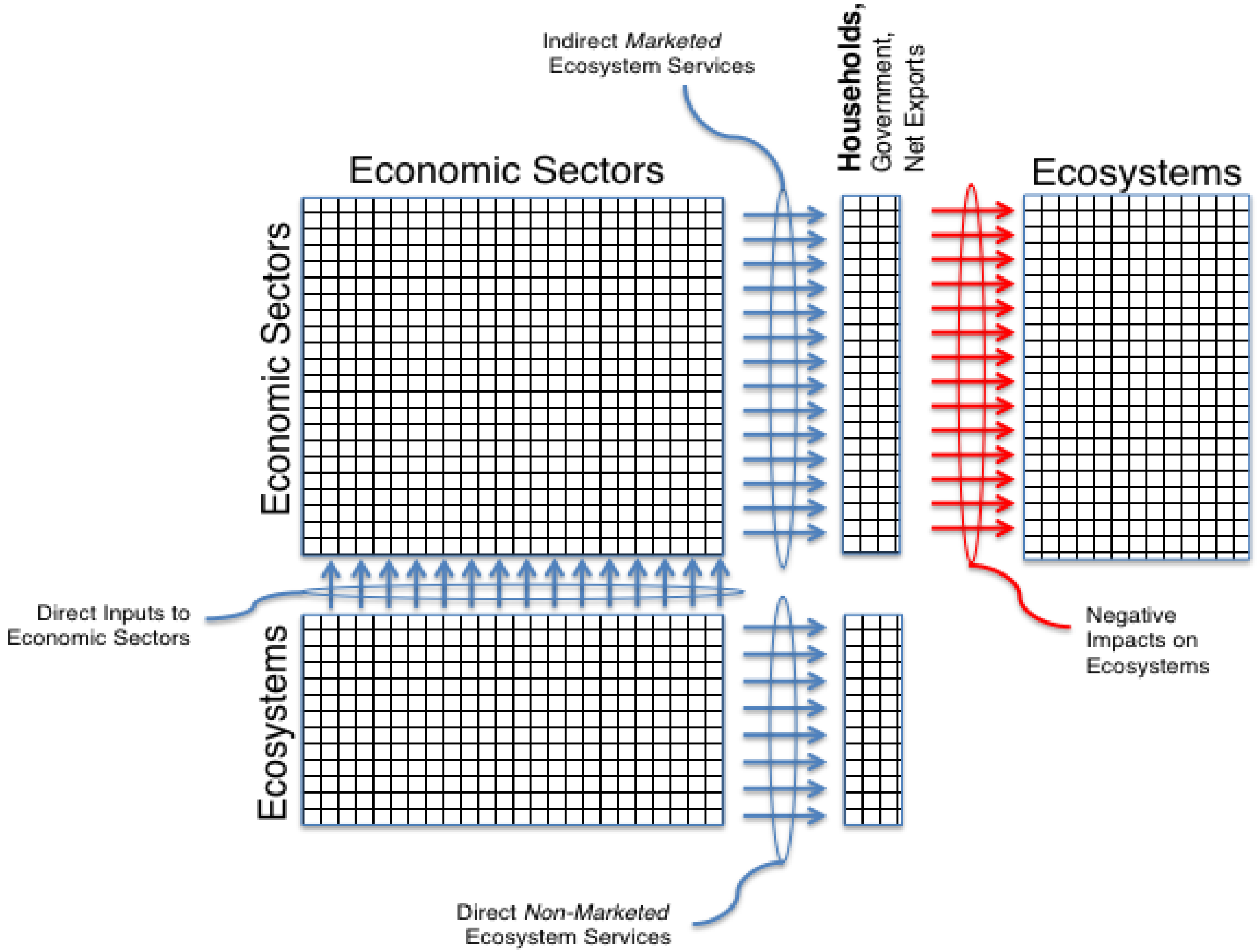





Input-Output Framework for Classifying, Measuring and Valuing Ecosystem Services



Dozen Companies to Join Puma EP&L Coalition; Firm Now Reporting at Product Level

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Puma Researching Compostable Shoes

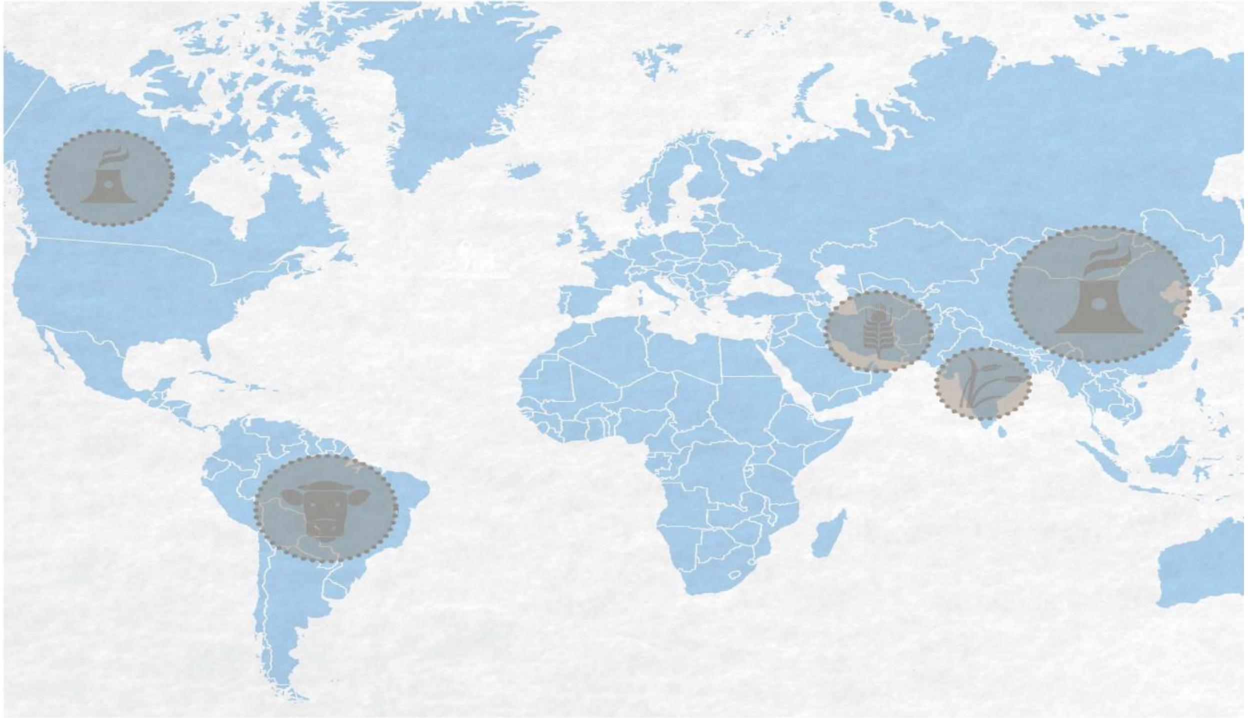
Sportswear company Puma has followed its environmental profit and loss (EP&L) process down to the product level, and is planning an industry coalition to broaden adoption of the sustainability accounting method.

The company will soon launch the InCycle collection of biodegradable and recyclable shoes, apparel and accessories, and has released EP&L results showing that the Puma InCycle Basket sneaker and a Puma InCycle shirt have 31 percent less environmental impact than their conventional counterparts.

The EP&L statement revealed that it takes 31 trucks with a load capacity of 13,000 kg to clear the waste that 100,000 pairs of conventional Puma suede sneakers cause during production, consumer life and disposal. In comparison, 12 trucks are needed to clear the waste that 100,000 pairs of biodegradable Puma InCycle Baskets cause, until they end up in an industrial composting facility system.

The environmental impacts of the InCycle Basket add up to €2.95 ($3.82) per pair, 31 percent lower than that of the conventional Puma Suede at €4.29 per pair, the company said.

Speaking to the Guardian, Puma chairman Jochen Zeitz compared the product EP&Ls to nutritional labeling on cereal boxes. “Many of our customers do care about the environment but they may be confused by lots of labels, but this will change once we have standardized the calculation and put a tag on every product,” he said.



THE PRIMARY PRODUCTION AND PRIMARY PROCESSING SECTORS ANALYZED IN THIS STUDY ARE ESTIMATED TO HAVE UNPRICED NATURAL CAPITAL COSTS TOTALLING US$7.3 TRILLION, WHICH EQUATES TO 13% OF GLOBAL ECONOMIC OUTPUT IN 2009.

NATURAL CAPITAL AT RISK:

THE TOP 100 EXTERNALITIES OF BUSINESS

Table 1 – EcoServices classified according to their 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

From: Costanza, R., 2008. Ecosystem Services: Multiple classification systems are needed. *Biological Conservation* 141:350-352

Table 2. Four levels of ecosystem service value aggregation (Kubiszewski and Costanza 2013)

Aggregation method	Assumptions/approach	Examples
1. Basic value transfer -	assumes values constant over ecosystem types	Costanza et al. 1997, Liu et al. 2010
2. Expert modified value transfer	adjusts values for local ecosystem conditions using expert opinion surveys	Batker et al. 2010,
3. Statistical value transfer	builds statistical model of spatial and other dependencies	Liu and Stern 2008, deGroot et al. 2013
4. Spatially Explicit Functional Modeling	Builds spatially explicit statistical or dynamic systems models incorporating valuation	Boumans et al. 2002 Costanza et al. 2008 Nelson et al. 2009

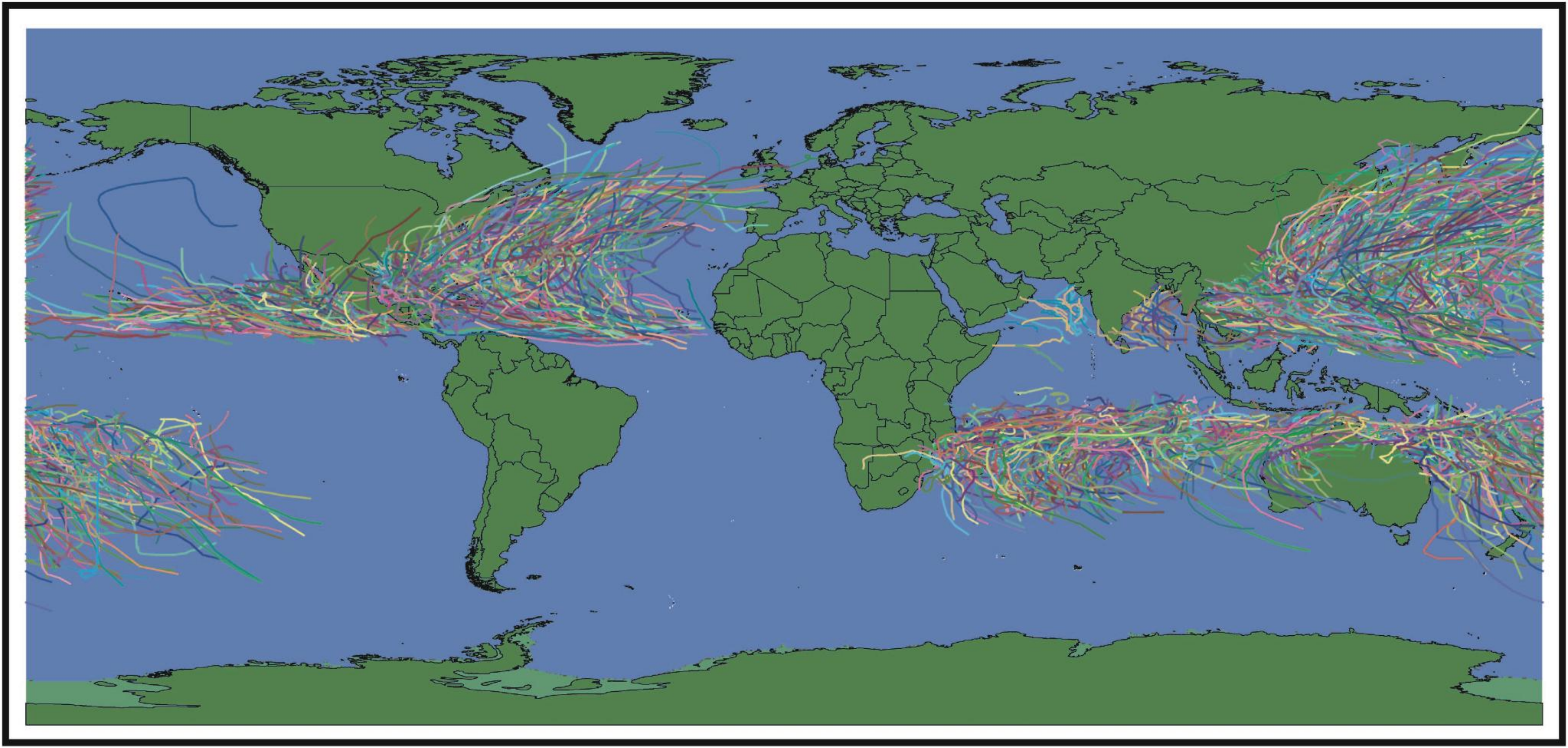
Table 4
Meta-regression value function for inland wetlands.

Variable	Variable definition	Coeffs	Std. error
Dependent constant	Natural log of US$/ha/annum	1.386	1.890
Study site area	Natural log of the study site area (ha)	−0.321***	0.055
Freshwater marsh	Dummy (1=freshwater marsh; 0=other)	0.576	0.443
Wooded marsh	Dummy (1=wooded marsh; 0=other)	0.681**	0.303
Salt-brackish marsh	Dummy (1=salt/brackish marsh; 0=other)	1.489***	0.480
GDP per capita	Natural log of country level GDP per capita (PPP USD 2007)	0.37*****	0.118
Population	Natural log of population within 50 km radius of study site	0.339***	0.093
Wetland abundance	Natural log of area of wetlands within 50 km radius of study site	−0.203***	0.047
Lake and river abundance	Natural log of area of lakes and rivers within 50 km radius of study site	0.092	0.077
Hedonic pricing	Dummy (1=hedonic pricing; 0=other)	−1.219	1.112
Travel cost	Dummy (1=travel cost; 0=other)	−1.658***	0.426
Replacement cost	Dummy (1=replacement cost; 0=other)	−0.567	0.403
Net factor income	Dummy (1=net factor income; 0=other)	−1.355***	0.495
Production function	Dummy (1=production function; 0=other)	−1.298**	0.635
Market price	Dummy (1=market price; 0=other)	−1.391***	0.392
Opportunity cost	Dummy (1=opportunity cost; 0=other)	−0.726	0.804
Choice experiment	Dummy (1=choice experiment; 0=other)	−0.573	0.832
$N=244$	Adjusted $R^2=0.442$		

** Indicates statistical significance at the 5 percent levels.
*** Indicates statistical significance at the 1 percent levels.

From: de Groot, R., L. Brander, S. van der Ploeg, **R. Costanza**, F. Bernard, L. Braat, M. Christie, N. Crossman, A. Ghermandi, L. Hein, S. Hussain, P. Kumar, A. McVittie, R. Portela, L. C. Rodriguez, P. ten Brink, and P. van Beukering. 2012 Global estimates of the value of ecosystems and their services in monetary units. *Ecosystem Services.* 1:50-61

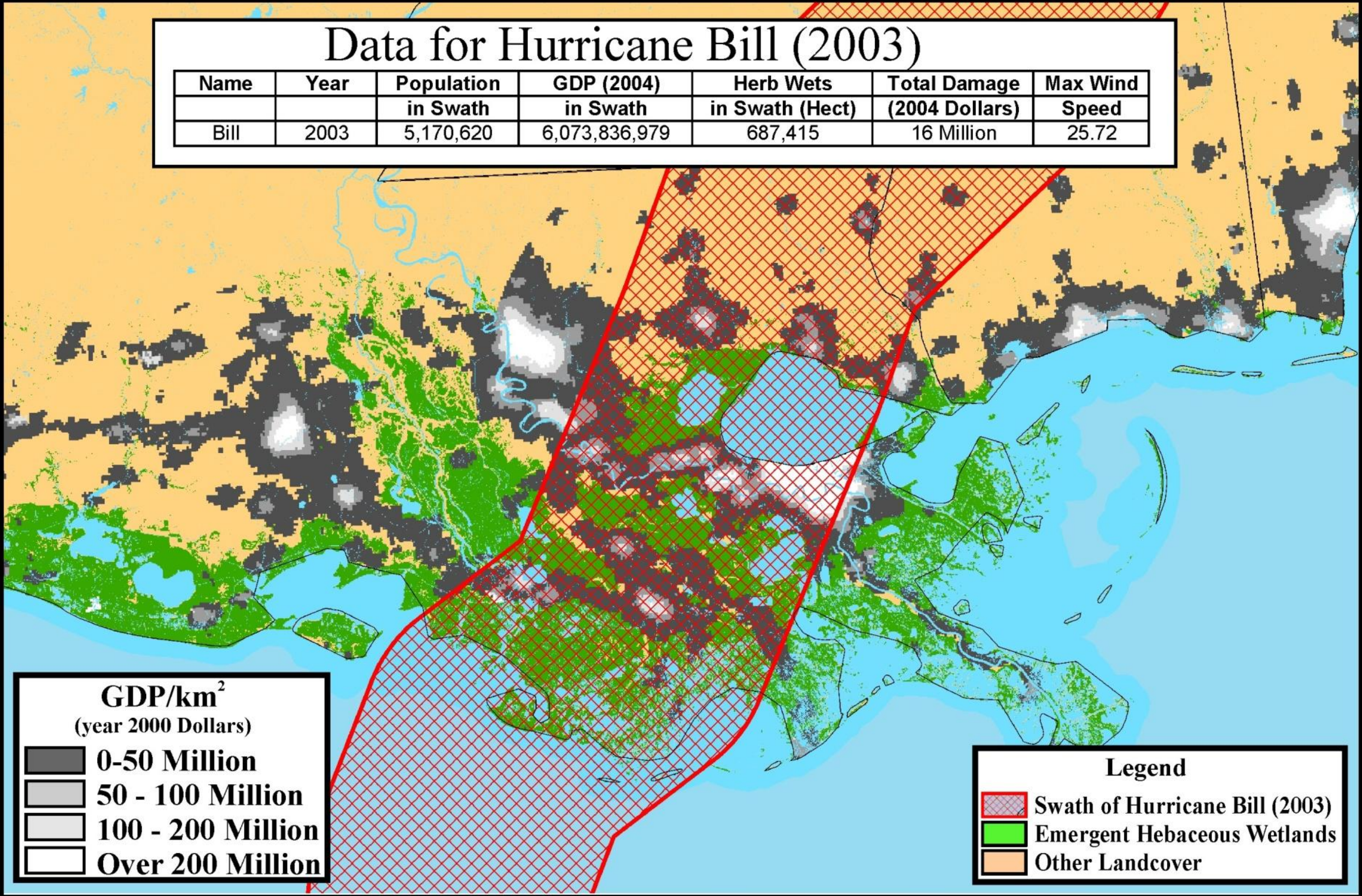

NOAA



Global Storm Tracks 1980 - 2006

Data for Hurricane Bill (2003)

Name	Year	Population in Swath	GDP (2004) in Swath	Herb Wets in Swath (Hect)	Total Damage (2004 Dollars)	Max Wind Speed
Bill	2003	5,170,620	6,073,836,979	687,415	16 Million	25.72



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).

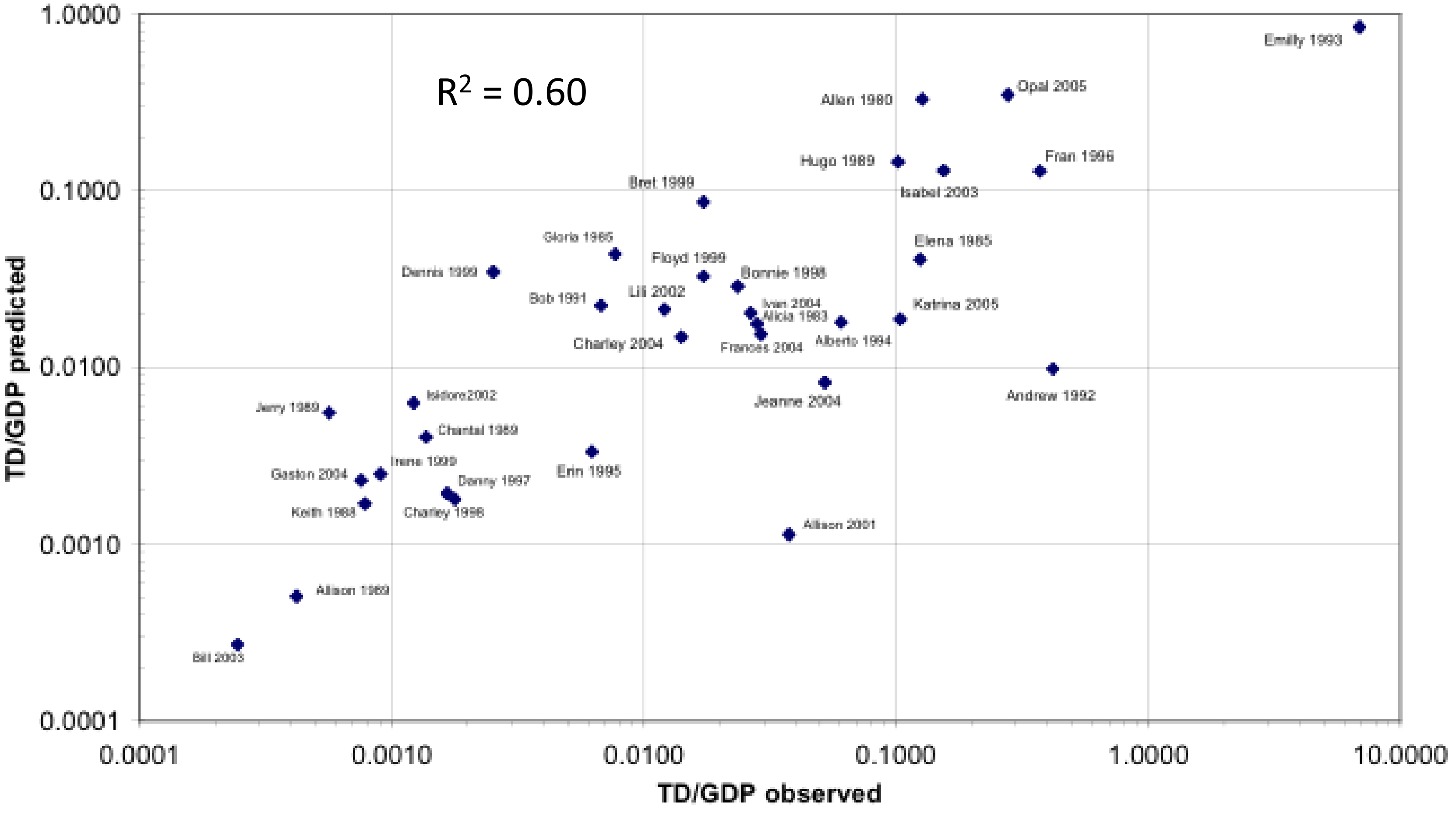
u_i = error

Predicted total damages from storm *i*

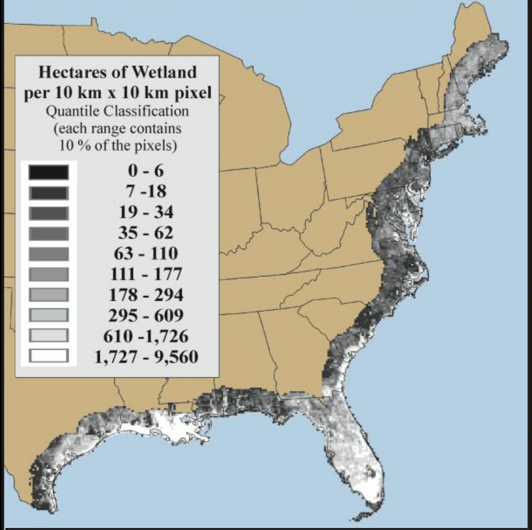
$$TD_i = e^{\alpha} * g_i^{\beta_1} * w_i^{\beta_2} * GDP_i$$

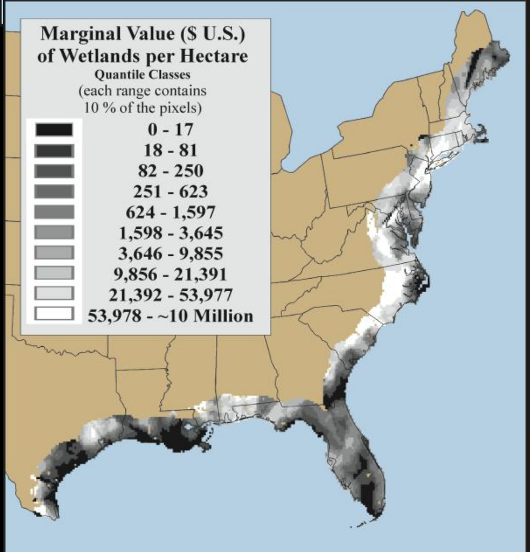
Avoided cost from a change of 1 ha of coastal wetlands for storm *i*

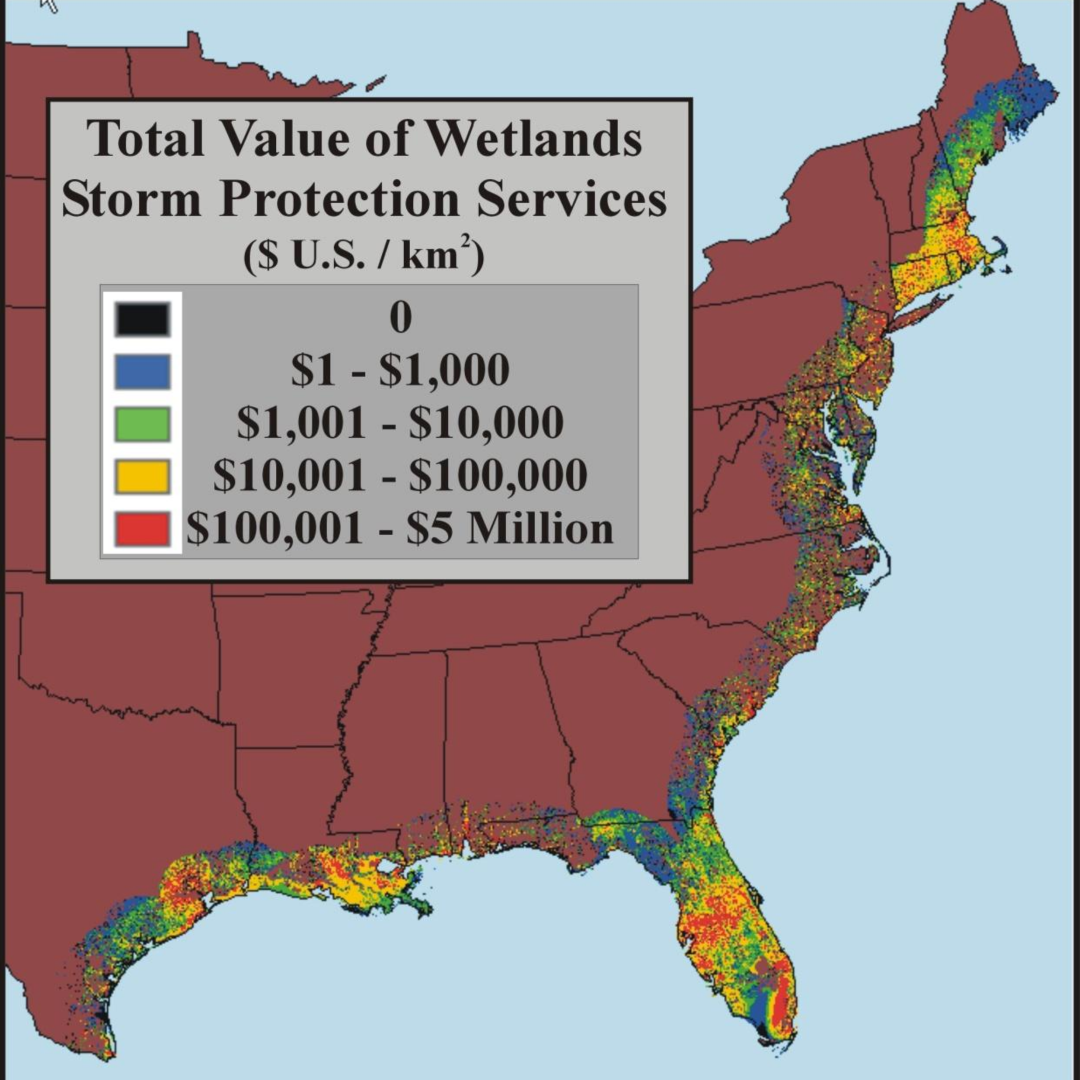
$$\Delta TD_i = e^{\alpha} * g_i^{\beta_1} * \left((w_i - 1)^{\beta_2} - w_i^{\beta_2}\right) * GDP_i$$



$R^2 = 0.60$
TD/GDP predicted
TD/GDP observed
1.0000
0.1000
0.0100
0.0010
0.0001
10.0000
Emily 1993
Allen 1980
Opal 2005
Hugo 1989
Fran 1996
Isabel 2003
Bret 1999
Gloria 1985
Elena 1985
Floyd 1999
Dennis 1999
Bonnie 1998
Lili 2002
Bob 1991
Ivan 2004
Katrina 2005
Alicia 1983
Charley 2004
Frances 2004
Alberto 1994
Andrew 1992
Jeanne 2004
Isidore2002
Jerry 1989
Chantal 1989
Irene 1999
Gaston 2004
Erin 1995
Danny 1997
Keith 1988
Charley 1998
Allison 2001
Allison 1989
Bill 2003


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. / km^2)
0
$1 - $1,000
$1,001 - $10,000
$10,001 - $100,000
$100,001 - $5 Million

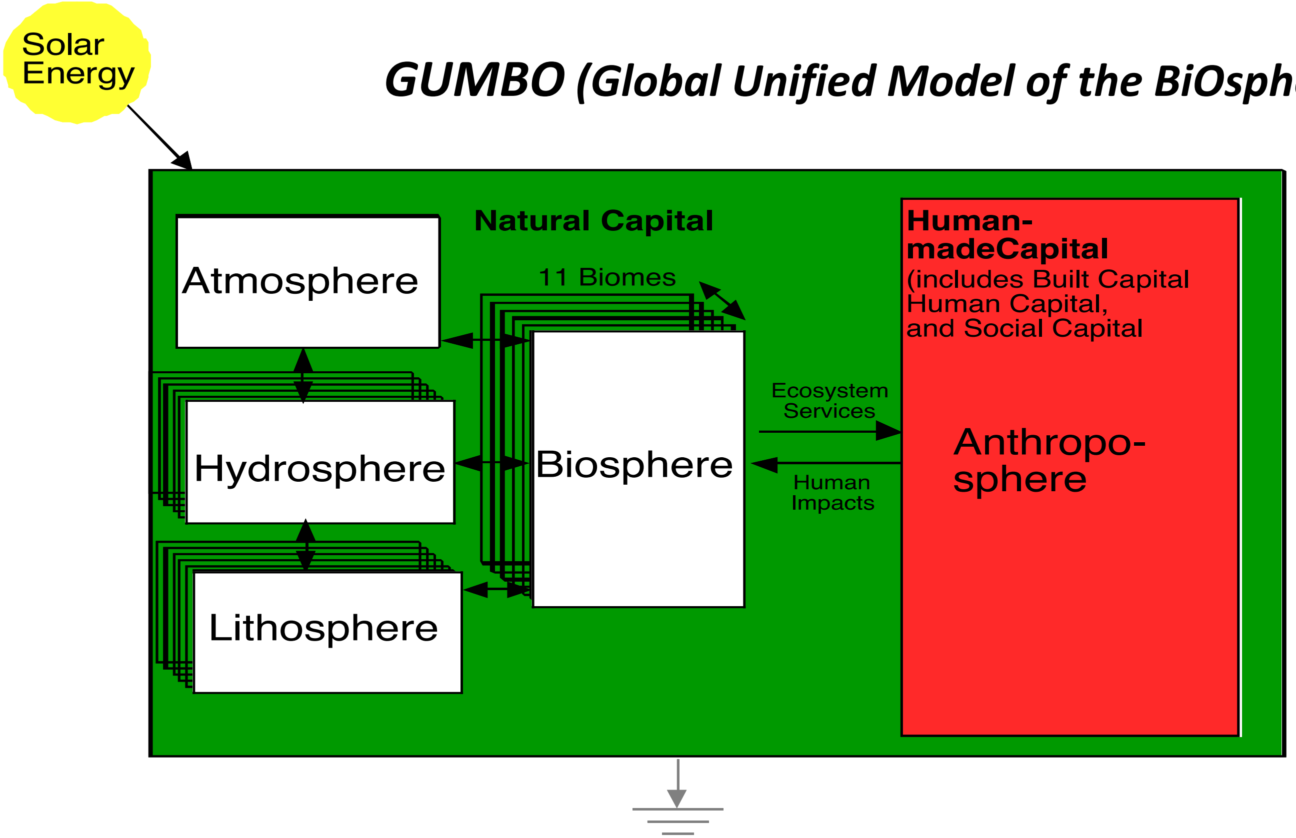
•A loss of 1 ha of wetland in the model corresponded to an average $33,000 (median = $5,000) increase in storm damage from specific storms.

•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)

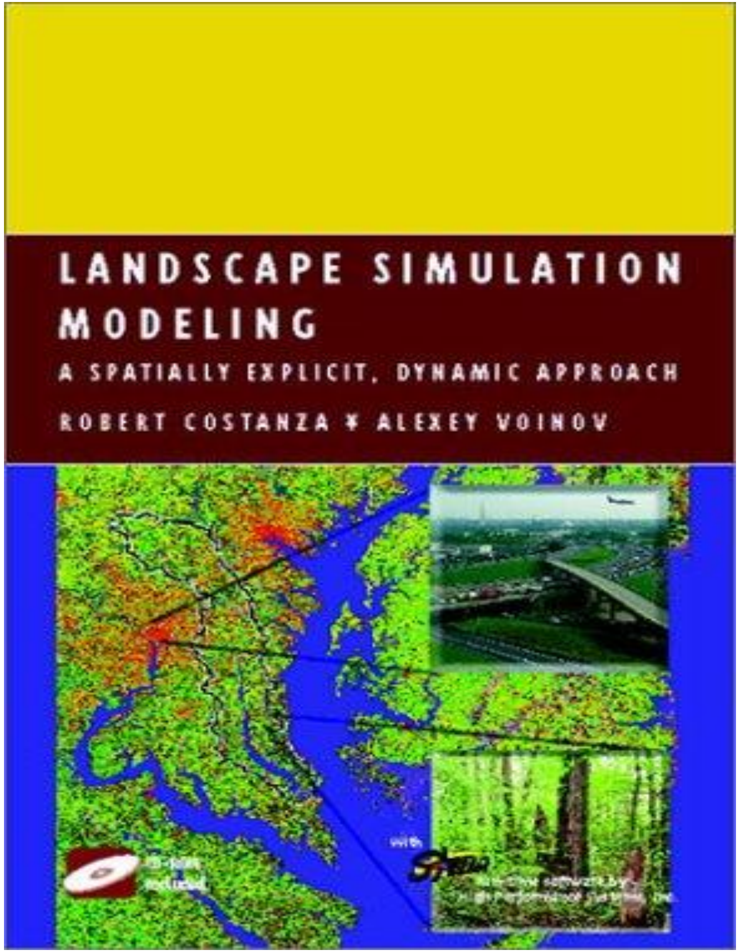
• Coastal wetlands in the US were estimated to currently provide $23.2 Billion/yr in storm protection services.

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.

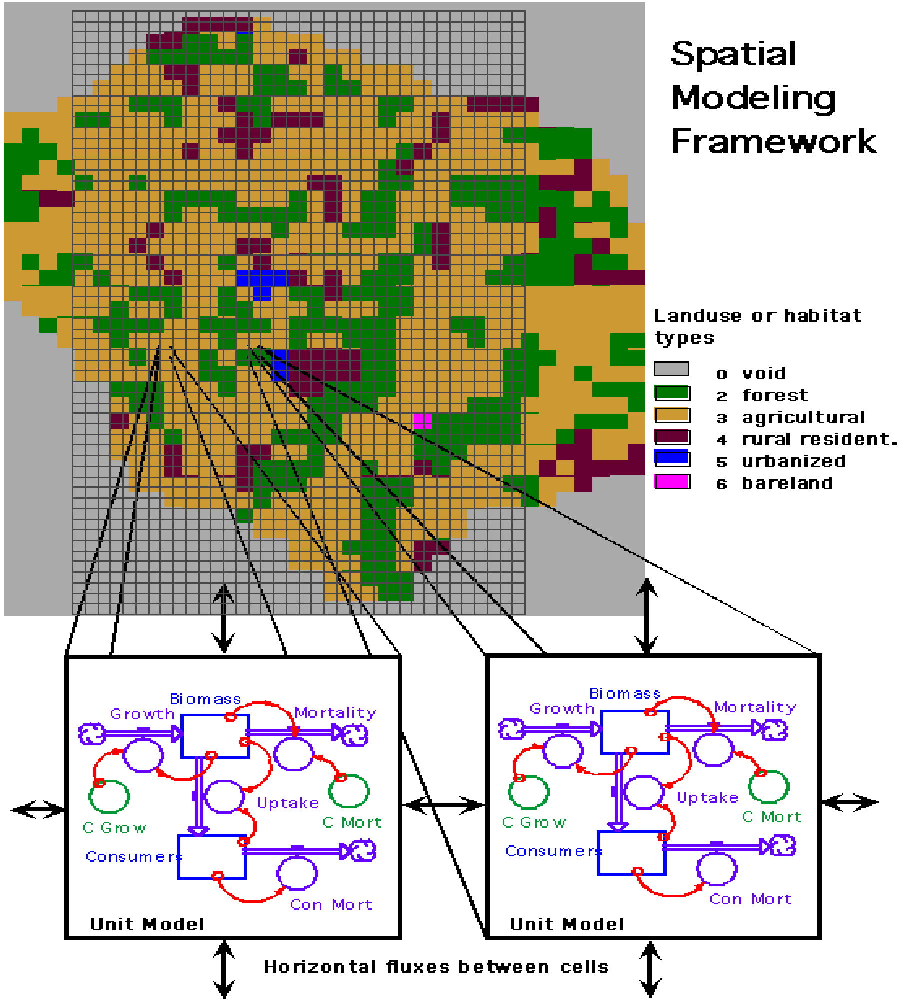
GUMBO (Global Unified Model of the BiOsphere)



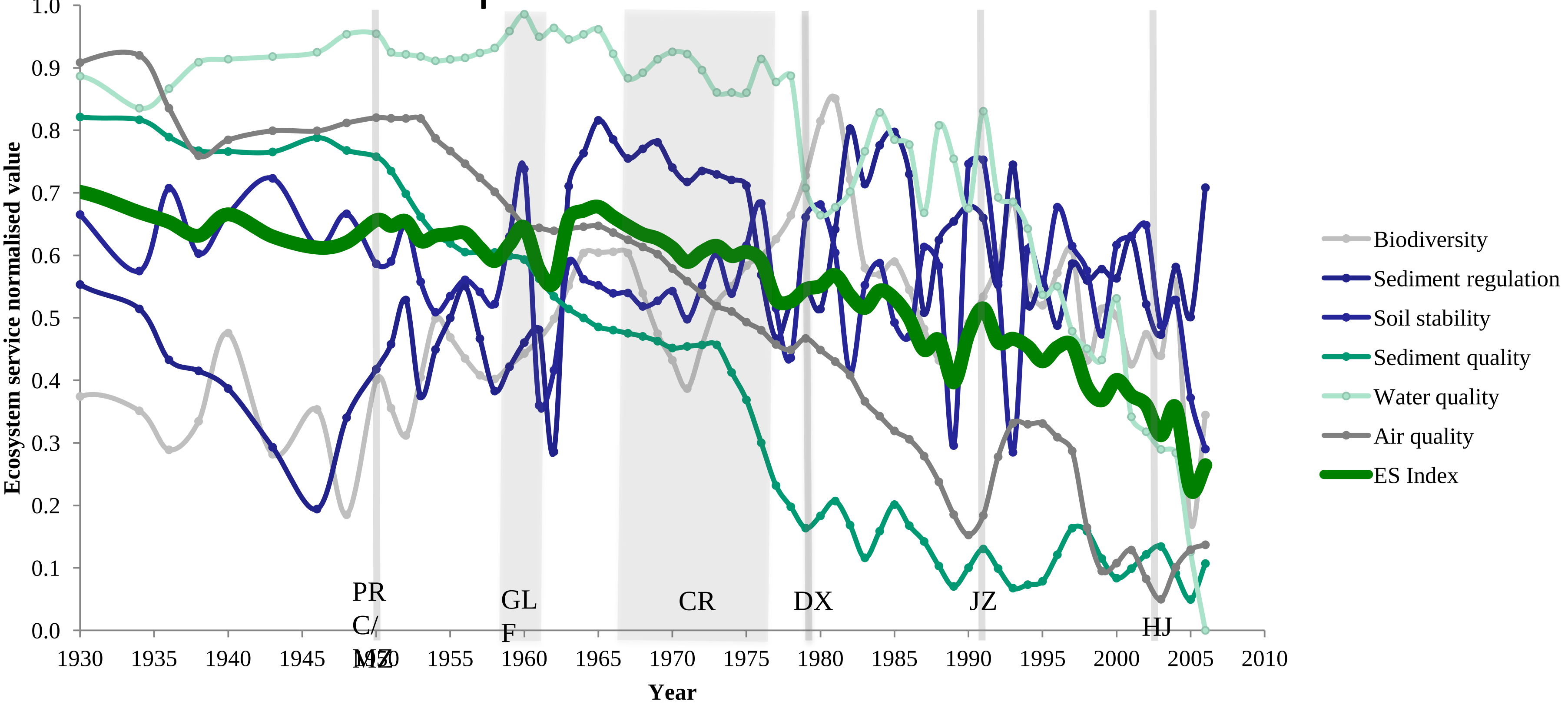
From: Boumans, R., R. Costanza, J. Farley, M. A. Wilson, R. Portela, J. Rotmans, F. Villa, and M. Grasso. 2002. Modeling the Dynamics of the Integrated Earth System and the Value of Global Ecosystem Services Using the GUMBO Model. *Ecological Economics* 41: 529-560



Spatial Modeling Framework



Reconstruction of Ecosystem Services in the Lower Yangtze basin 1930-2000 from paleo records.



Source: John A. Dearing et al.. 2012. Extending the timescale and range of ecosystem services through paleoenvironmental analyses: the example of the lower Yangtze basin. *PNAS*

Growing the ancient Maya social-ecological system from the bottom up

Scott Heckbert, Christian Isendahl, Joel Gunn, Simon Brewer, Vernon Scarborough, Arlen F. Chase, Diane Z. Chase, Robert Costanza, Nicholas Dunning, Timothy Beach, Sheryl Luzzadder-Beach, David Lentz and Paul Sinclair

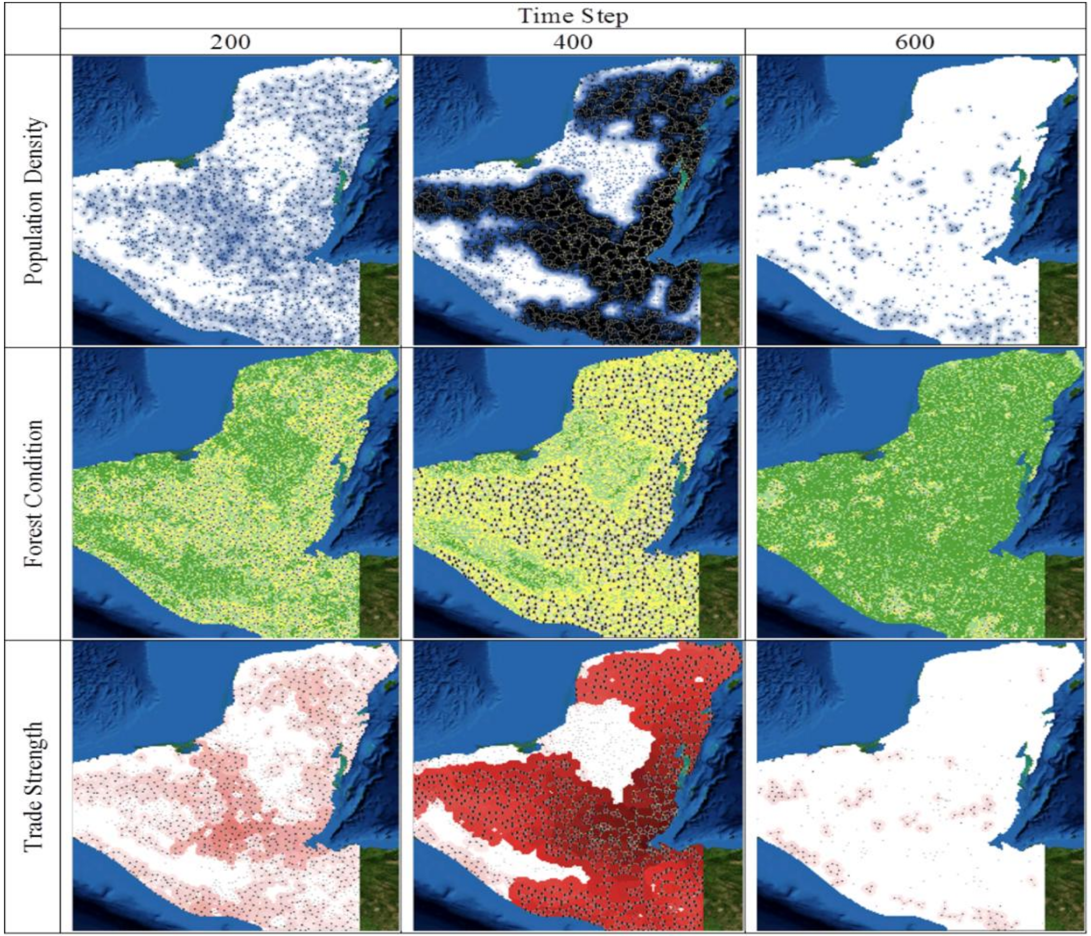


Figure 4: Spatial model results for the scenario where trade is enabled. Population density, forest condition, and settlement trade strength is shown at time step 200, 400, and 600. Darker colouring shows increased population density (blue) and trade strength (red), and forest condition depicts three states of cleared / cropped cells (yellow), secondary regrowth (light green), and climax forest (dark green).

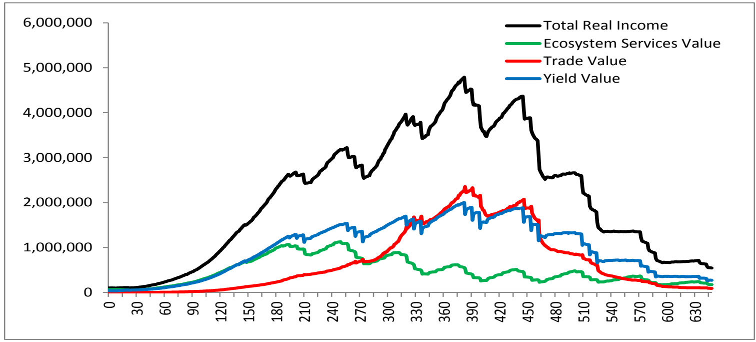
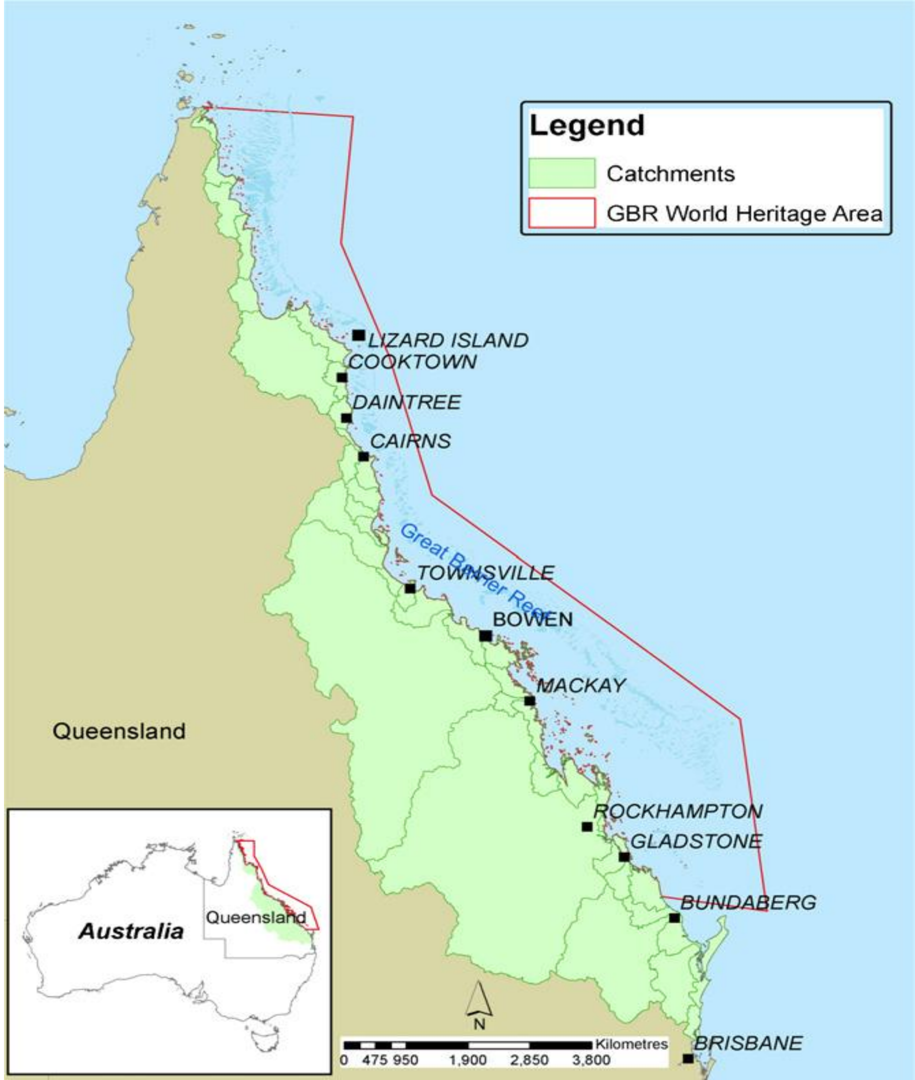
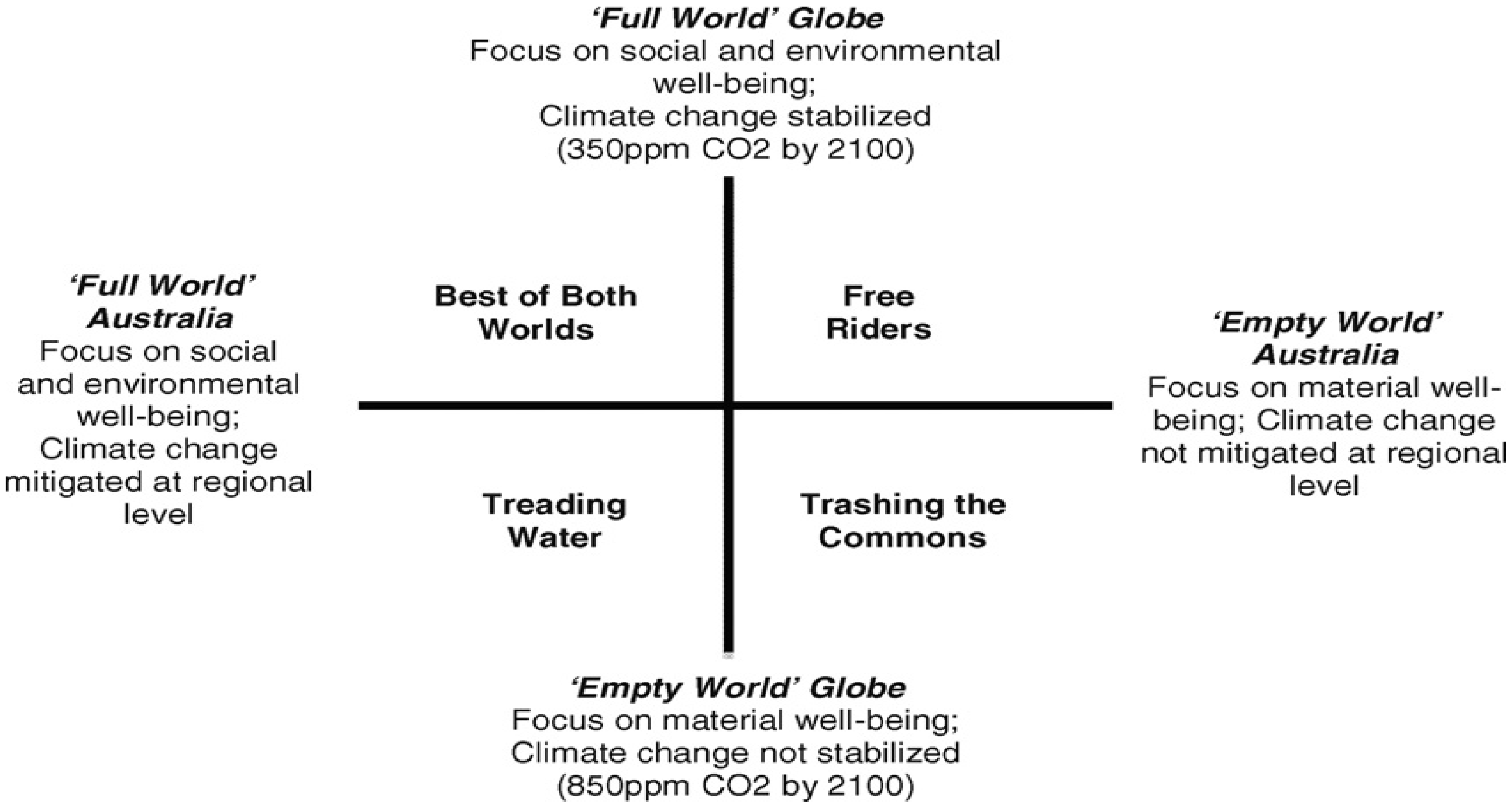


Figure 6: Real income of all simulated settlements over time by contributions from agriculture, ecosystem services, and trade value. Ecosystem services is eventually superceded by agriculture, and both by trade around time step 350.



Catchment **A**nd **R**eef **E**cosystem **S**ervices



Bohensky, E. L., J. Butler, R. Costanza, I. Bohnet, A. Delisle, K. Fabricius, M. Gooch, I. Kubiszewski, G. Lukacs, P. Pert, E. Wolanski. 2011. Future makers or future takers? A scenario analysis of climate change and the Great Barrier Reef. *Global Environmental Change* 21: 876-893

	Capitals	Trashing the Commons	Free Riders	Treading Water	Best of Both Worlds
ES	Supporting	↓ ↓ ↓ ↓	↓ ↓ ↓	↓ ↓ ↓	↑ ↑
	Regulating	↓ ↓ ↓ ↓ ↓	↓ ↓ ↓	↓ ↓ ↓	↑ ↑ ↑
	Provisioning	↓ ↓	↓	↓	↑ ↑
	Cultural	↓ ↓ ↓ ↓ ↓	↓	↓ ↓ ↓	↑ ↑
Human well-being	Equity	↓ ↓ ↓ ↓	↓ ↓	↑	↑ ↑ ↑
	Participation	↓ ↓	↑	↑ ↑	↑ ↑ ↑
	Security/safety	↓ ↓ ↓	↔	↑ ↑	↑ ↑ ↑
	Democracy	↓ ↓ ↓	↓ ↓ ↓	↑ ↑	↑ ↑ ↑
	Networks	↑ ↓	↑ ↓	↑ ↓	↑
	Culture	↓	↓	↑	↑ ↑ ↑
	Institutions	↑ ↓	↑ ↓	↑	↑ ↑ ↑ ↑
	Education	↓ ↓	↓	↑	↑ ↑ ↑
	Health	↓ ↓	↓	↑	↑ ↑ ↑ ↑ ↑
	Professional skills	↑	↑	↔	↑
	Job security	↓	↔	↑	↑ ↑
	Population	↑ ↑ ↑ ↑	↑ ↑ ↑	↑ ↑ ↑	↑ ↑
BE	Quantity	↑ ↑ ↑ ↑	↑ ↑ ↑	↑ ↑ ↑	↔
	Quality	↓ ↓ ↓ ↓	↓ ↓	↑	↑ ↑
	Well-being Indicator	-29	-10	9	44
	Economic Indicator (Pop. + Built Quantity)	8	6	6	2

Genuine Progress Indicator (or ISEW) by Component

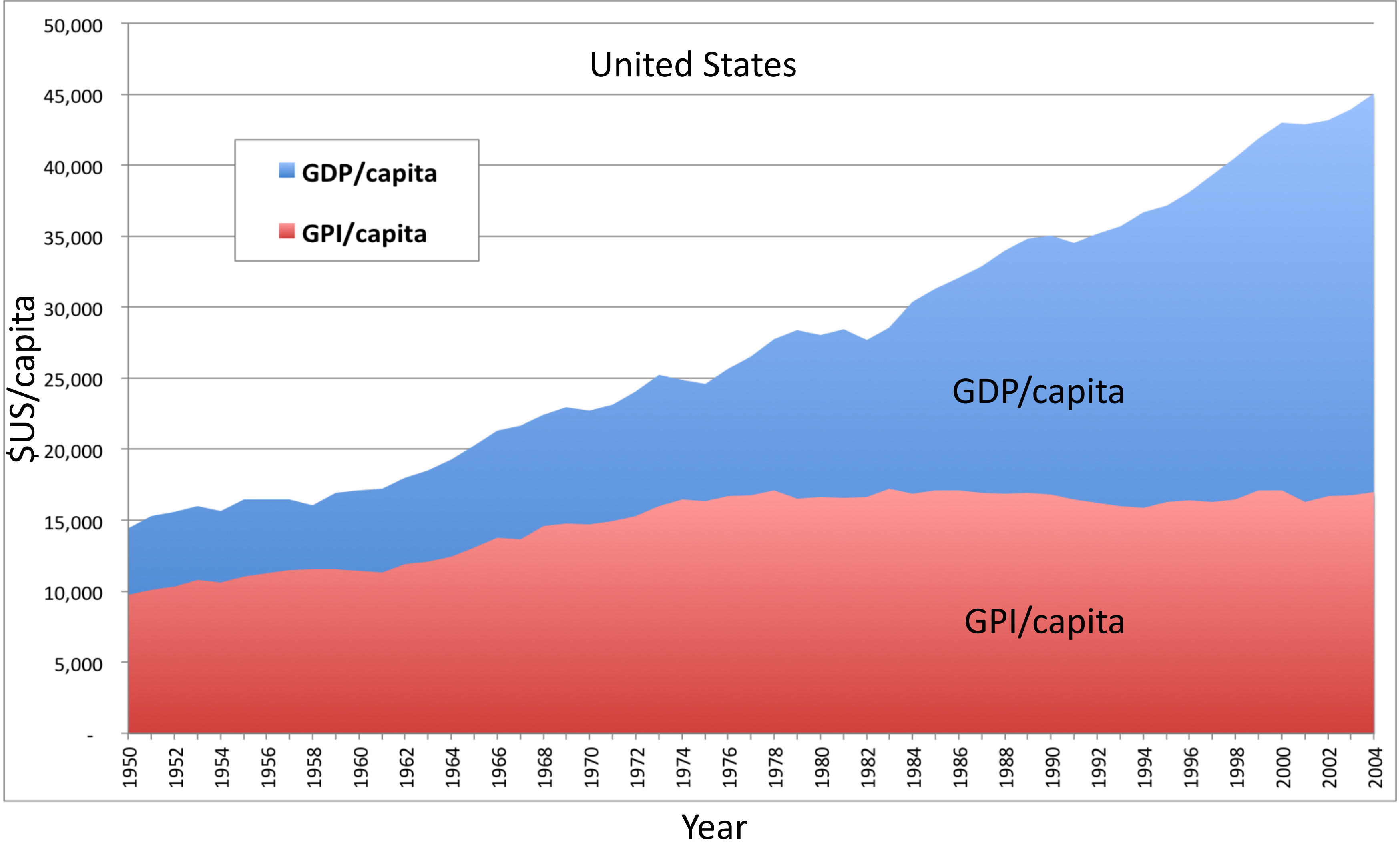
Personal Consumption Expenditure
Income Distribution
Personal Consumption Adjusted for Income Inequality

Additions
Services of Household Capital
Services Highways and Street
Value of Household Labor
Value of Volunteer Work

Subtractions
Cost of Consumer Durables
Loss of Leisure Time
Cost of Commuting
Cost of Automobile Accidents
Cost of Crime
Cost of Family Breakdown
Cost of Underemployment
Cost of Household Pollution Abatement
Cost of Water Pollution
Cost of Air Pollution
Cost of Noise Pollution
Loss of Wetlands
Lost of Farmland
Depletion of Nonrenewable Resources
Long-Term Environmental Damage
Cost of Ozone Depletion
Loss of Forest Cover

Net Capital Investment
Net Foreign Lending and Borrowing

Built Capital
Human Capital
Social Capital
Natural Capital


United States
GDP/capita
GPI/capita
GDP/capita
GPI/capita
$US/capita
50,000
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
-
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
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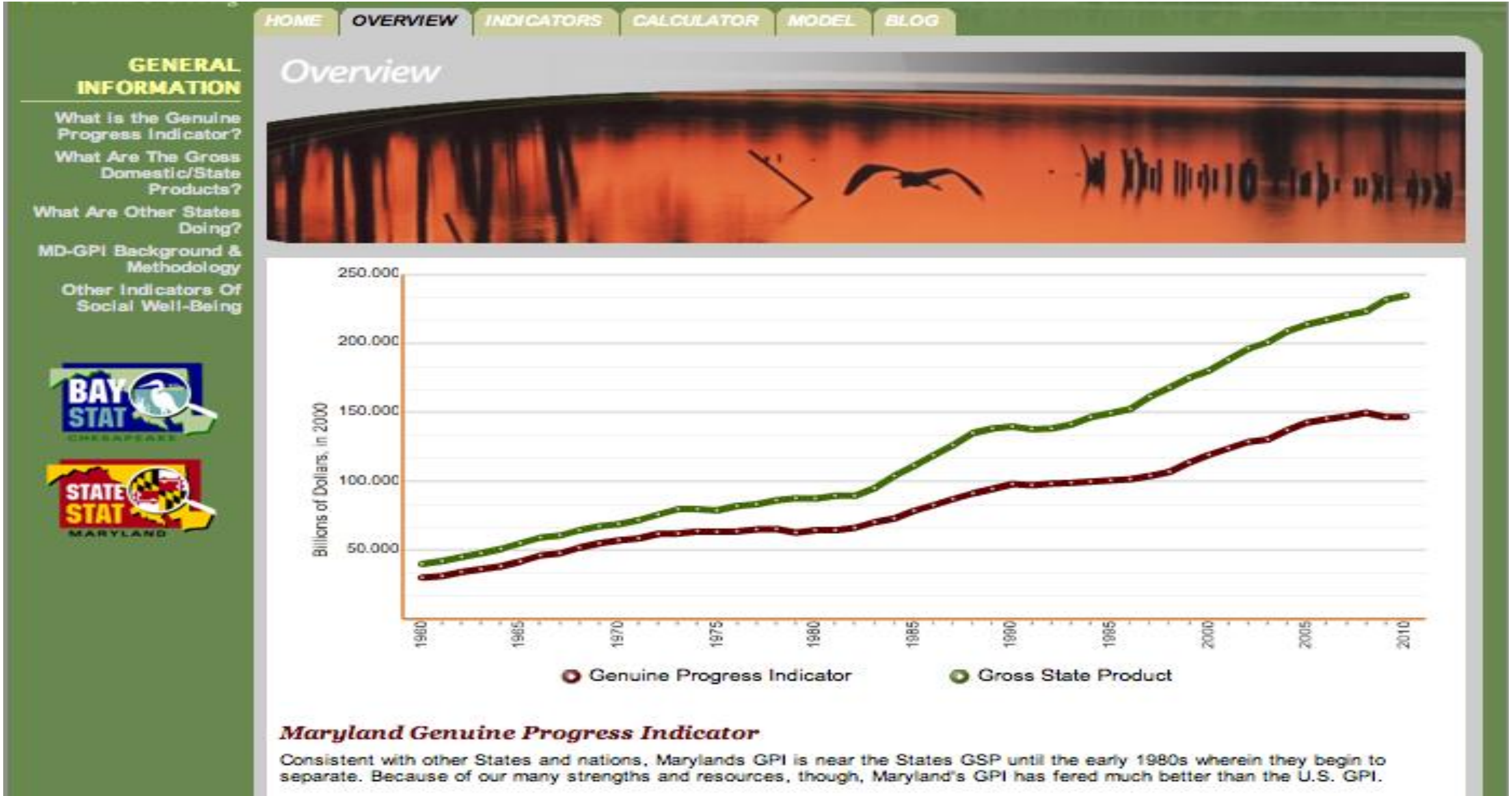
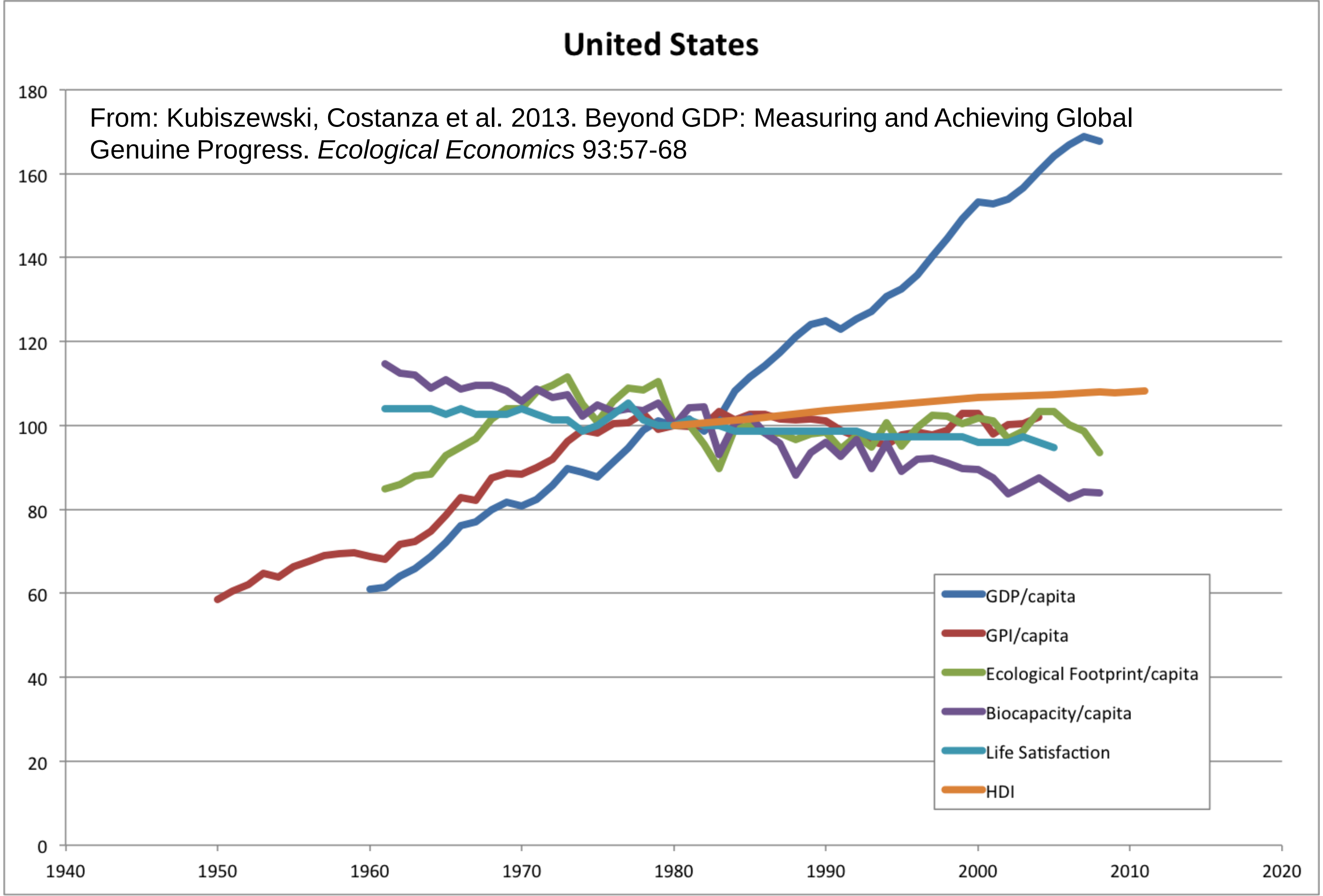
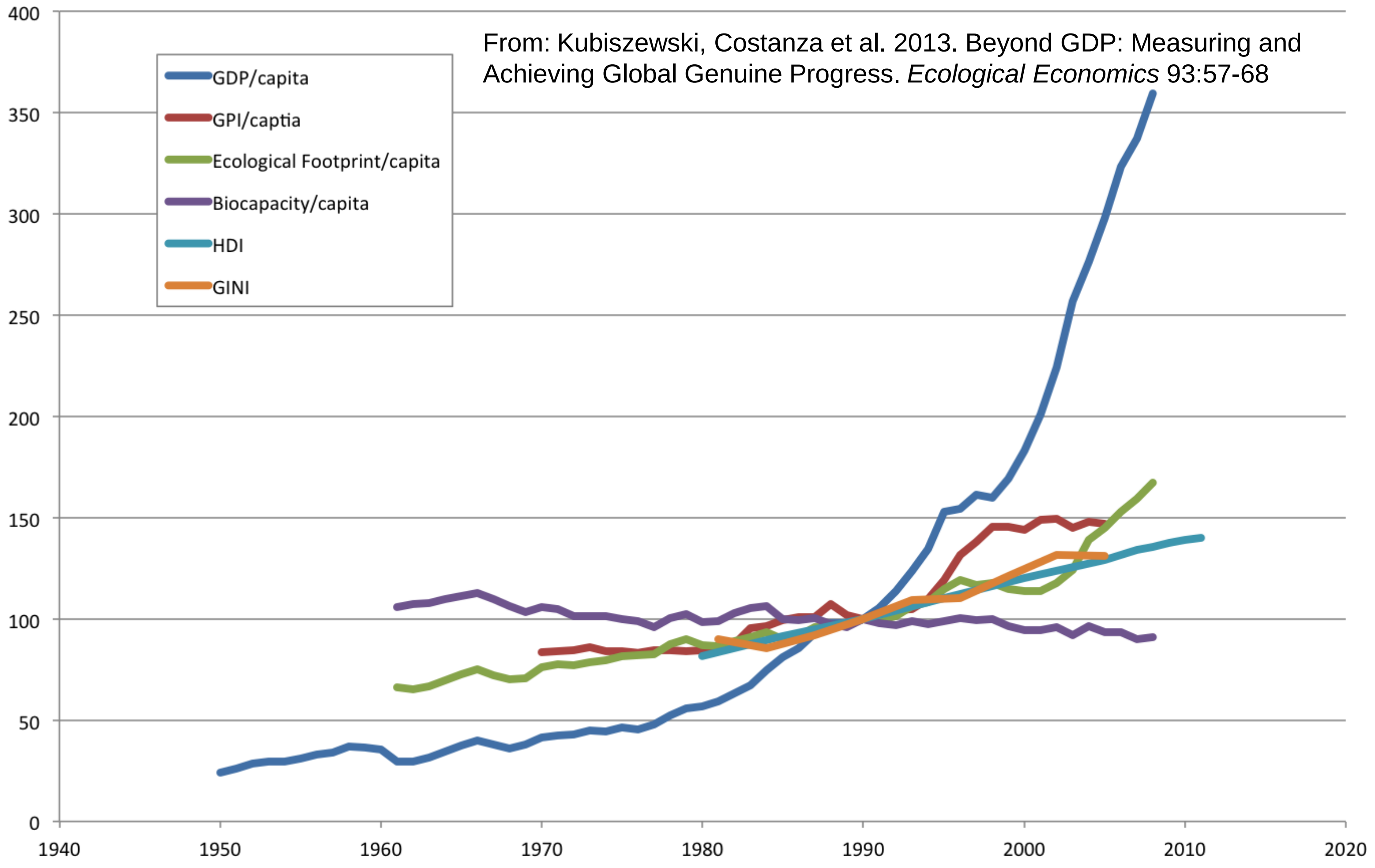
2002
2004
Year

www.green.maryland.gov/mdgpi/




United States
From: Kubiszewski, Costanza et al. 2013. Beyond GDP: Measuring and Achieving Global Genuine Progress. *Ecological Economics* 93:57-68
180
160
140
120
100
80
60
40
20
0
1940
1950
1960
1970
1980
1990
2000
2010
2020
GDP/capita
GPI/capita
Ecological Footprint/capita
Biocapacity/capita
Life Satisfaction
HDI

China



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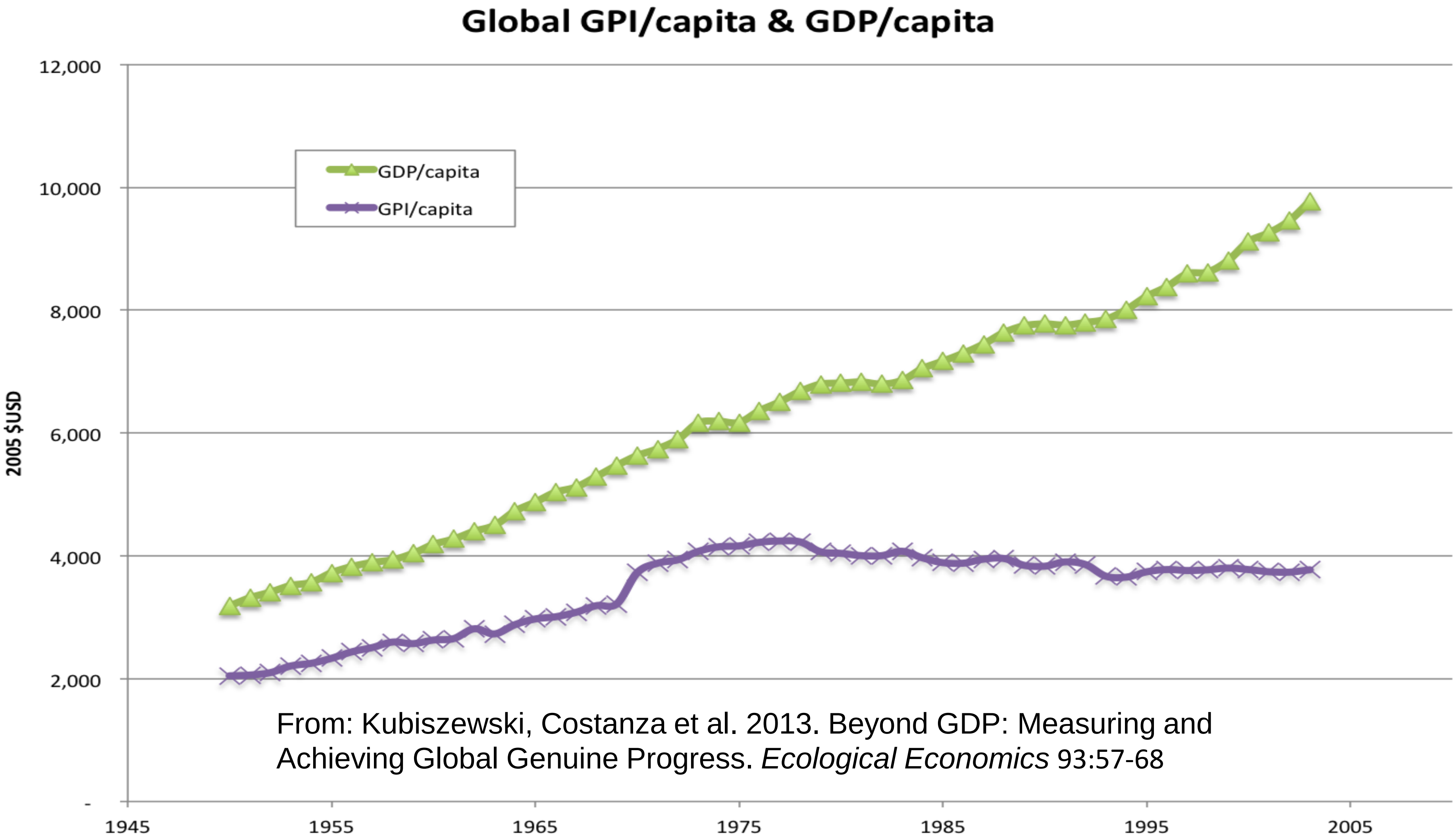

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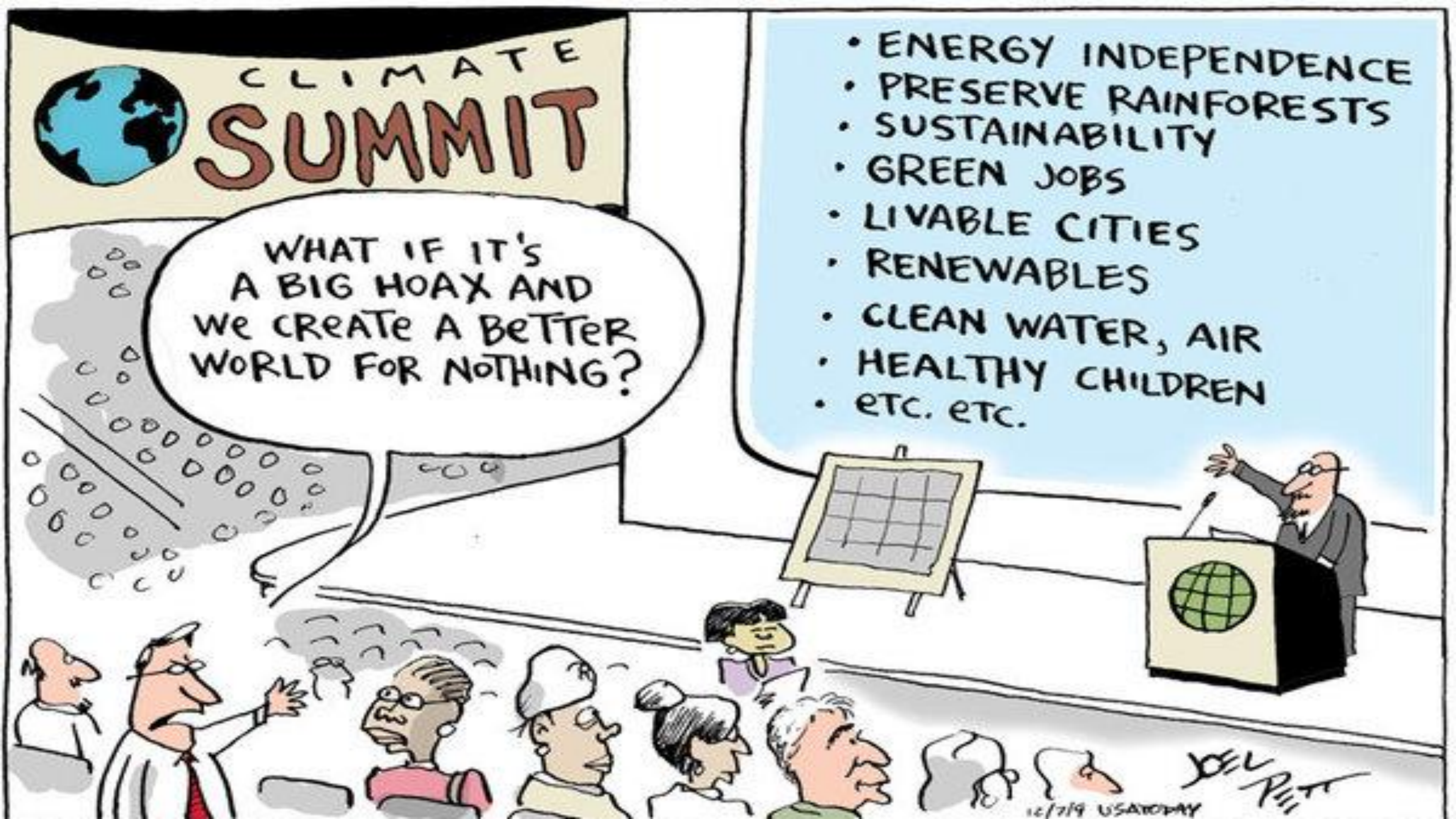
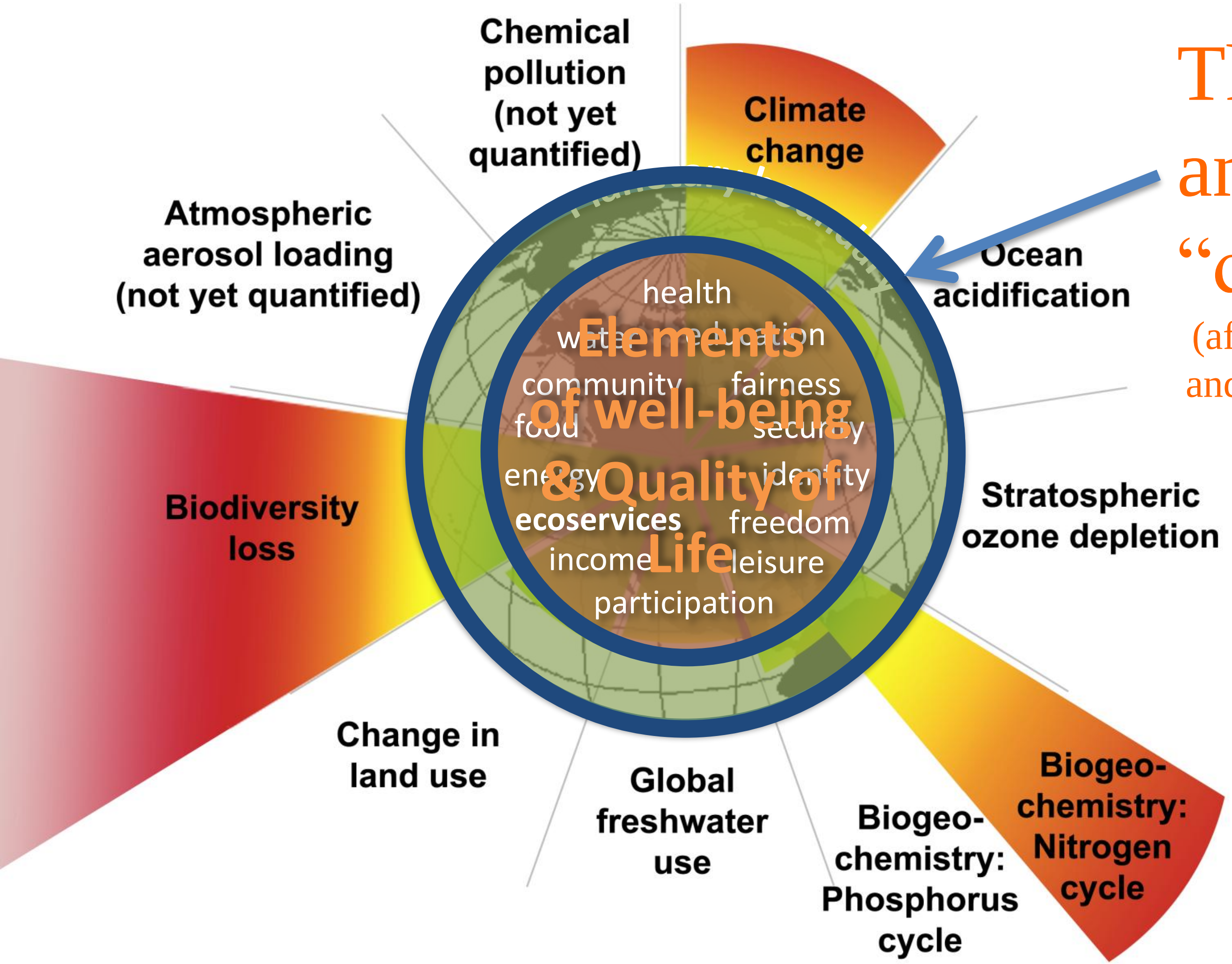

CLIMATE SUMMIT
WHAT IF IT'S A BIG HOAX AND WE CREATE A BETTER WORLD FOR NOTHING?
• ENERGY INDEPENDENCE
• PRESERVE RAINFORESTS
• SUSTAINABILITY
• GREEN JOBS
• LIVABLE CITIES
• RENEWABLES
• CLEAN WATER, AIR
• HEALTHY CHILDREN
• etc. etc.
JOEL PETT
12/7/9 USATODAY

The Sustainable and Desirable "doughnut"

(after: K. Raworth. 2012. A safe and just space for humanity: can we live within the doughnut? Oxfam International)



To create a sustainable and desirable economy-in-society-in-nature requires:

- Breaking our ***addiction*** to the "growth at all costs" economic paradigm, to fossil fuels, and to over-consumption

- Envisioning a more sustainable and desirable future that focuses on quality of life, recognizing the contributions of natural and social capital.

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Thank you