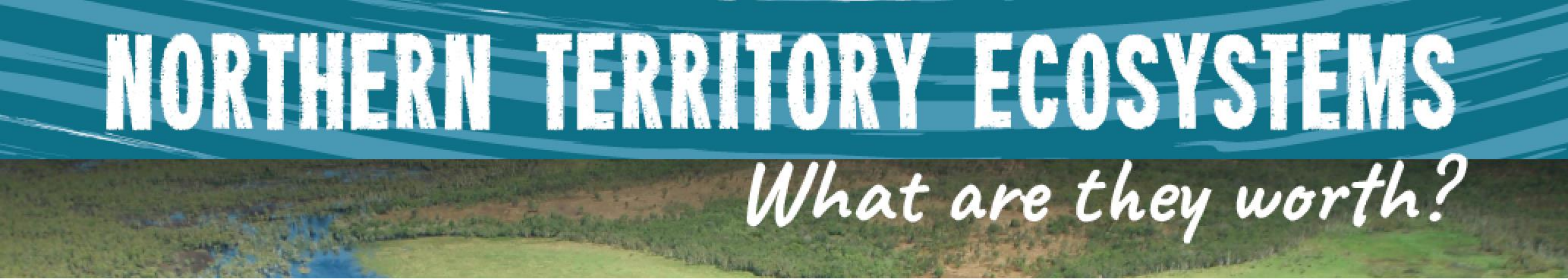


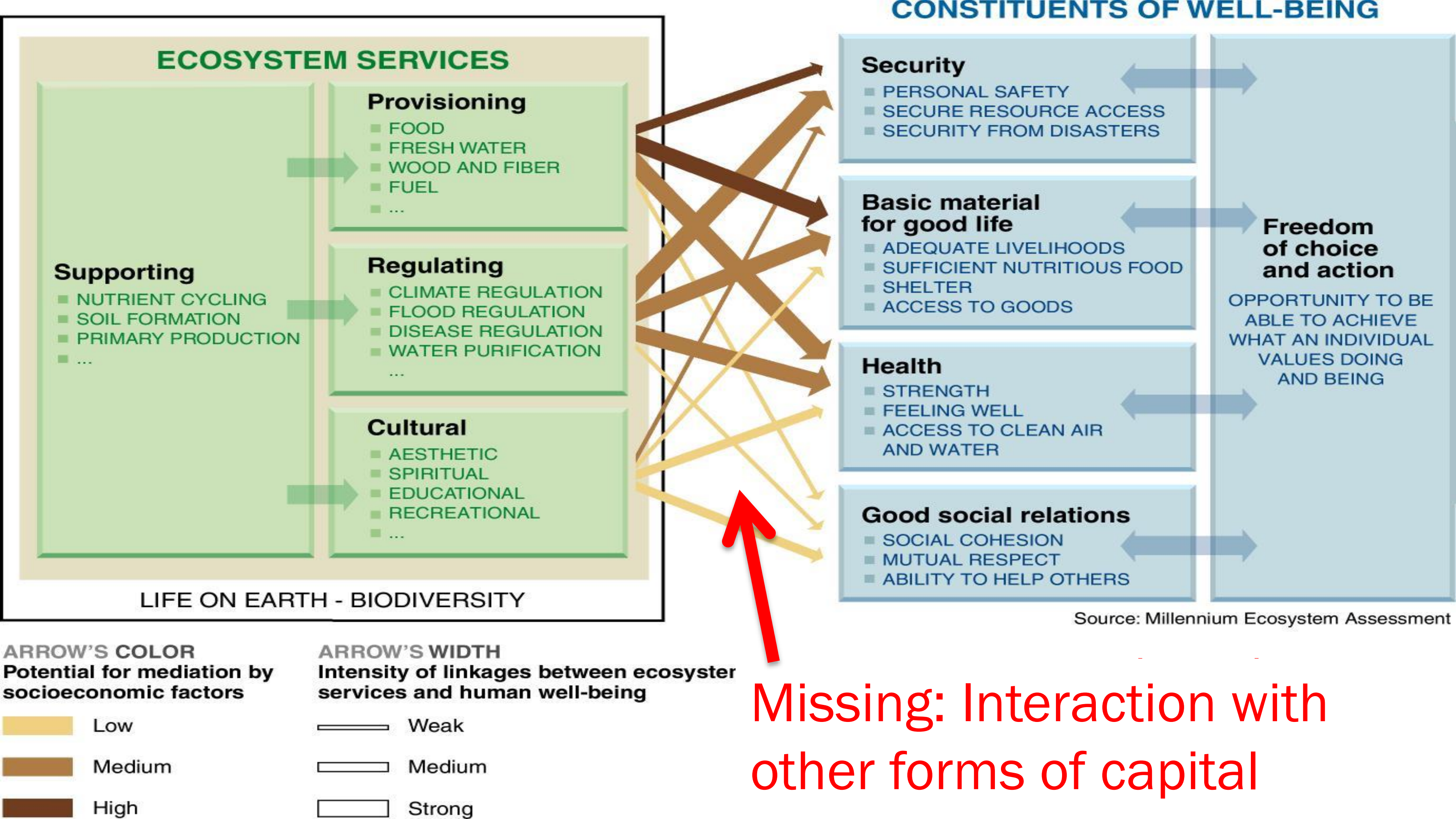
Overview of ecosystem evaluation opportunities

Robert Costanza

- Professor and Chair in Public Policy
  Crawford School of Public Policy
  Australian National University
  Canberra ACT 2601, Australia
- Editor in Chief, *Solutions* (www.thesolutionsjournal.org)

Australian National University

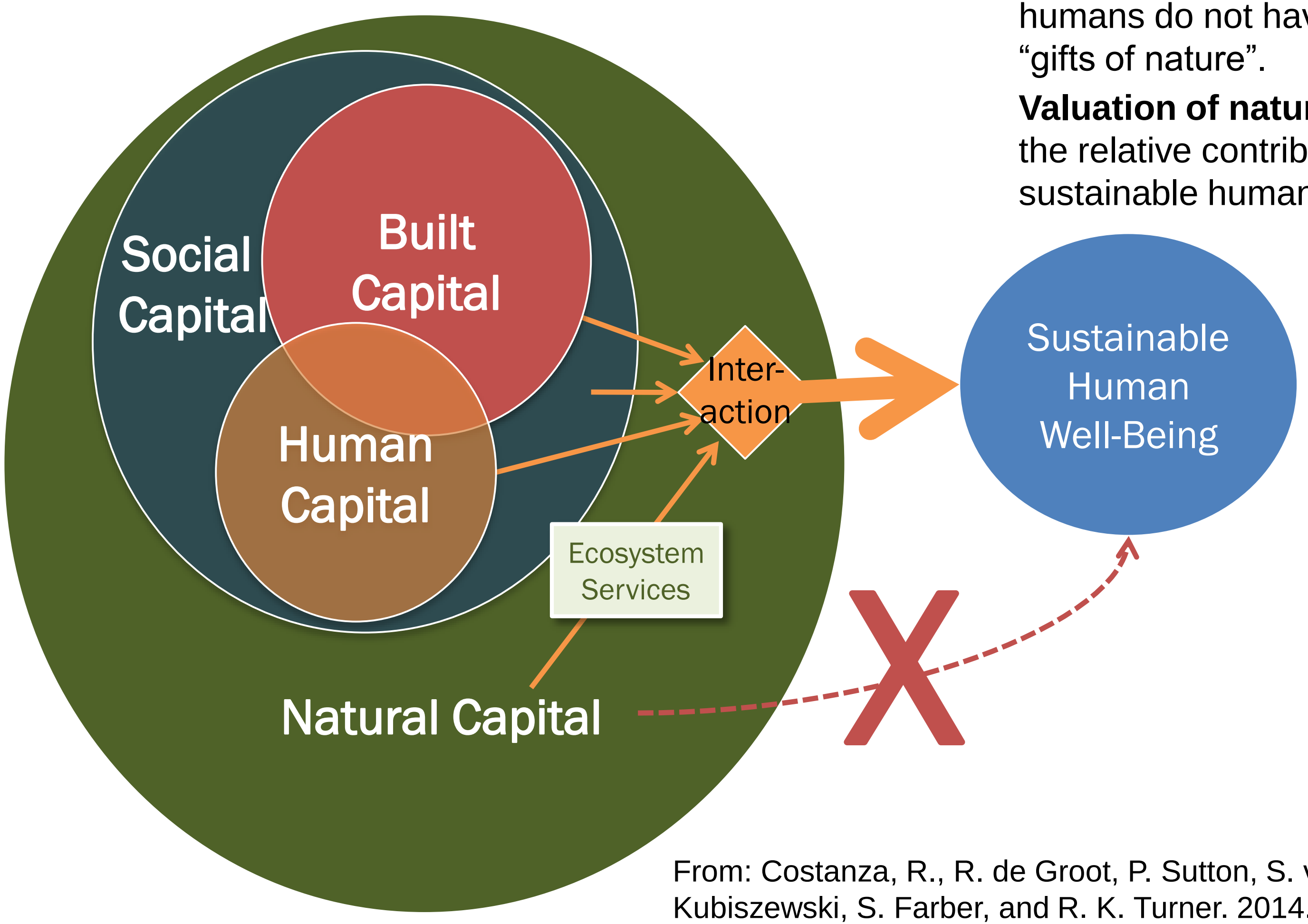
CRAWFORD SCHOOL OF PUBLIC POLICY



Missing: Interaction with other forms of capital

Natural Capital is everything in the world that humans do not have to produce or maintain – the "gifts of nature".

Valuation of natural capital is about assessing the relative contributions of natural capital to sustainable human well-being.

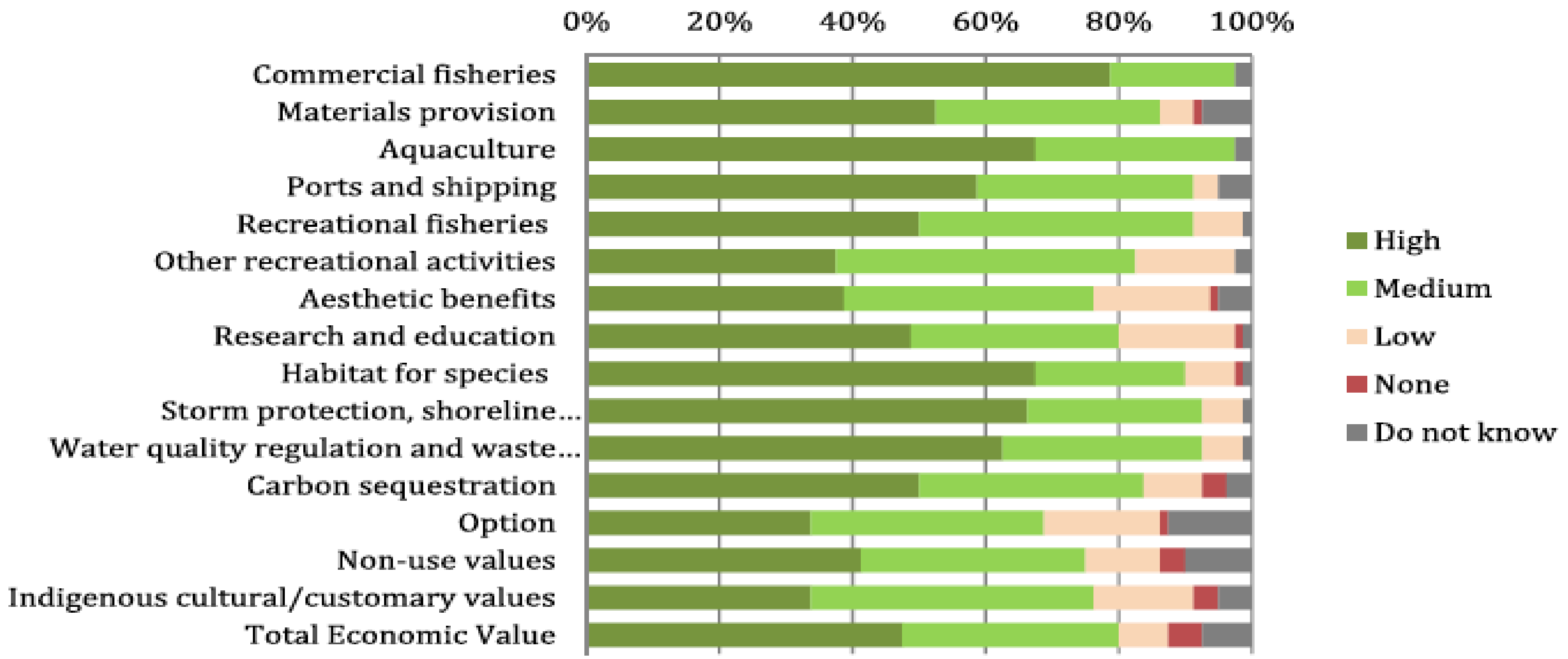


From: Costanza, R., R. de Groot, P. Sutton, S. van der Ploeg, S. Anderson, I. Kubiszewski, S. Farber, and R. K. Turner. 2014. Changes in the global value of ecosystem services. *Global Environmental Change* 26:152-158.

Some mistaken identities concerning ecosystem services and valuation

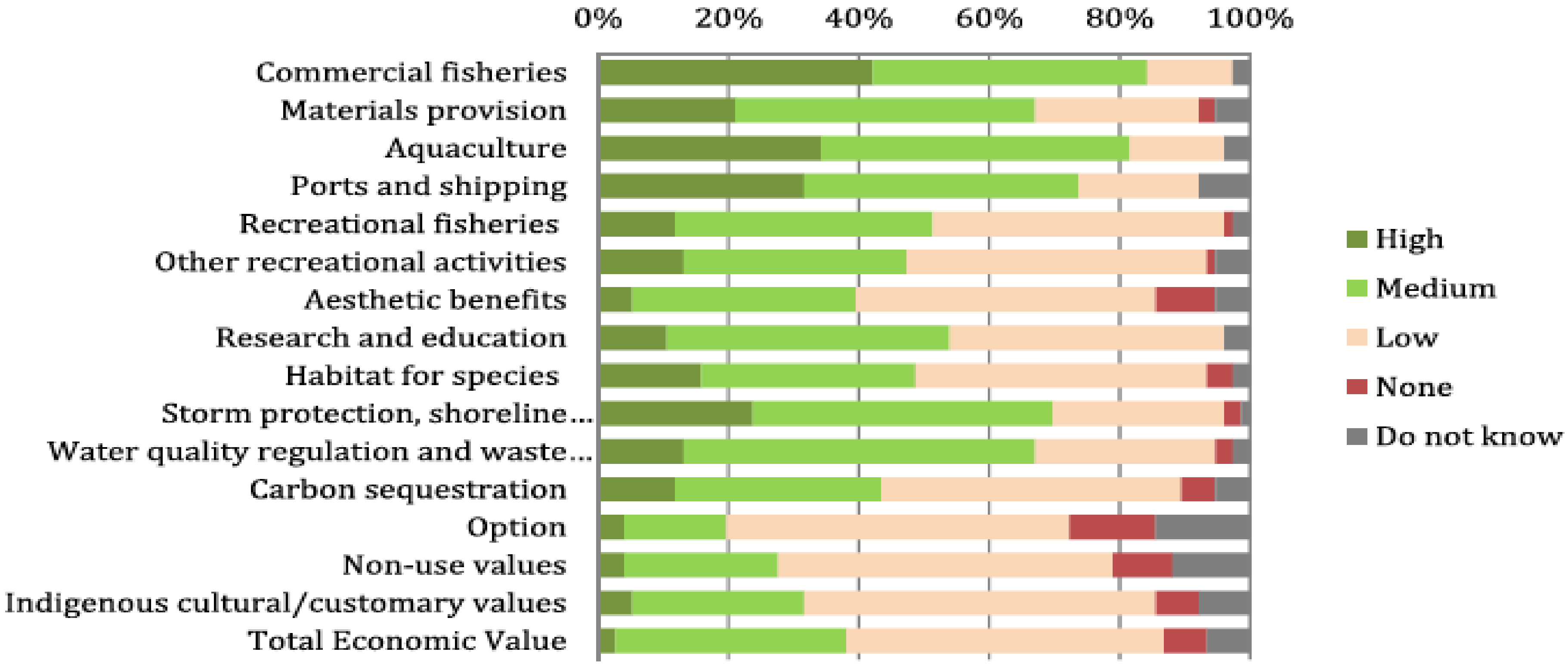
- **Economics ≠ "the Market"**
- **Valuation ≠ Privatization, Commodification, or Trading**
- **Expressing values in monetary units ≠ Market or exchange values**

Also, we cannot avoid valuation:
decisions about ecosystem are implicit valuations



Importance of Valuation (n=80)

Source: Marre et al. 2016. Is economic valuation of ecosystem services useful to decision-makers? Lessons learned from Australian coastal and marine management. *Journal of Environmental Management* 178:52-62



Trust in Value Estimates (n=80)

Source: Marre et al. 2016. Is economic valuation of ecosystem services useful to decision-makers? Lessons learned from Australian coastal and marine management. *Journal of Environmental Management* 178:52-62

Table 3. Valuation of ecosystem services based on the three primary goals of efficiency, fairness, and sustainability (Costanza and Folke 1997)

Goal or Value Basis	Who Votes	Preference Basis	Level of Discussion Required	Level of Scientific Input Required	Specific Methods
Efficiency	*Homo economius*	Current individual preferences	Low	Low	Willingness to pay
Fairness	*Homo communicus*	Community preferences	High	Medium	Veil of ignorance
Sustainability	*Homo naturalis*	Whole system preferences	Medium	High	Modeling with precaution

Range of uses for ecosystem services valuation

Use of Valuation	Appropriate values	Appropriate spatial scales	Precision Needed
Rising awareness and interest	Total values, macro aggregates	Regional to global	Low
National income and well-being accounts	Total values by sector and macro aggregate	National	Medium
Specific policy analysis	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

From: Costanza, R., R. de Groot, P. Sutton, S. van der Ploeg, S. Anderson, I. Kubiszewski, S. Farber, and R. K. Turner. 2014. Changes in the global value of ecosystem services. *Global Environmental Change* 26:152-158.

EcoServices Classified According to Rivalness and Excludability

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

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

Elinor Ostrom’s 8 Principles for Managing a Commons

1. Define clear group boundaries.
2. Match rules governing use of common goods to local needs and conditions.
3. Ensure that those affected by the rules can participate in modifying the rules.
4. Make sure the rule-making rights of community members are respected by outside authorities.
5. Develop a system, carried out by community members, for monitoring members’ behavior.
6. Use graduated sanctions for rule violators.
7. Provide accessible, low-cost means for dispute resolution.
8. Build responsibility for governing the common resource in nested tiers from the lowest level up to the entire interconnected system.

IPBES
IPBES negotiations
IUCN's support to the IPBES process
News and Events
Contacts

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

www.es-partnership.org

EU Biodiversity Strategy to 2020

Our life insurance, our natural capital

The protection, conservation and enhancement of the Union's natural capital is one of the 9 priority objectives of the **7th General Union Environment Action Programme to 2020** 'Living well, within the limits of our planet'.

The EU Biodiversity Strategy stipulates in Target 2, Action 5 that the member states must map and assess the state of the ecosystems and their services and promote the integration into the reporting systems at the EU and national level by 2020.

Target 2 – Maintain and Restore Ecosystems and their Services

By 2020, ecosystems and their services are maintained and enhanced by establishing green infrastructure and restoring at least 15 % of degraded ecosystems.

Action 5) Member States, with the assistance of the Commission, will map and assess the state of ecosystems and their services in their national territory by 2014, assess the economic value of such services, and promote the integration of these values into accounting and reporting systems at EU and national level by 2020.

Ken Henry on advancing Australia's Natural Capital

Share 31 Tweet G+1 0

http://www.thefifthestate.com.au/articles/ken-henry-on-advancing-australias-natural-capital/82531

Ken Henry: natural capital needs to be considered by all stakeholders

"We all know that farmers go through dry and wet times. There will be drought. But when the drought breaks:

- if you have invested in your built capital – your pumps will be working,
- if you've invested in your human capital, you'll have staff to operate your machinery and the know-how to run your business commercially,
- and if you've taken care of your natural capital – managed your weeds, your water retention and your soil health – you will be well positioned to take advantage of future commercial opportunities.

Natural capital is not a footnote in a business plan, it is a core asset on the balance sheet. That's true for an individual business; and it is true also for the nation."

Creating an “ecological civilization”

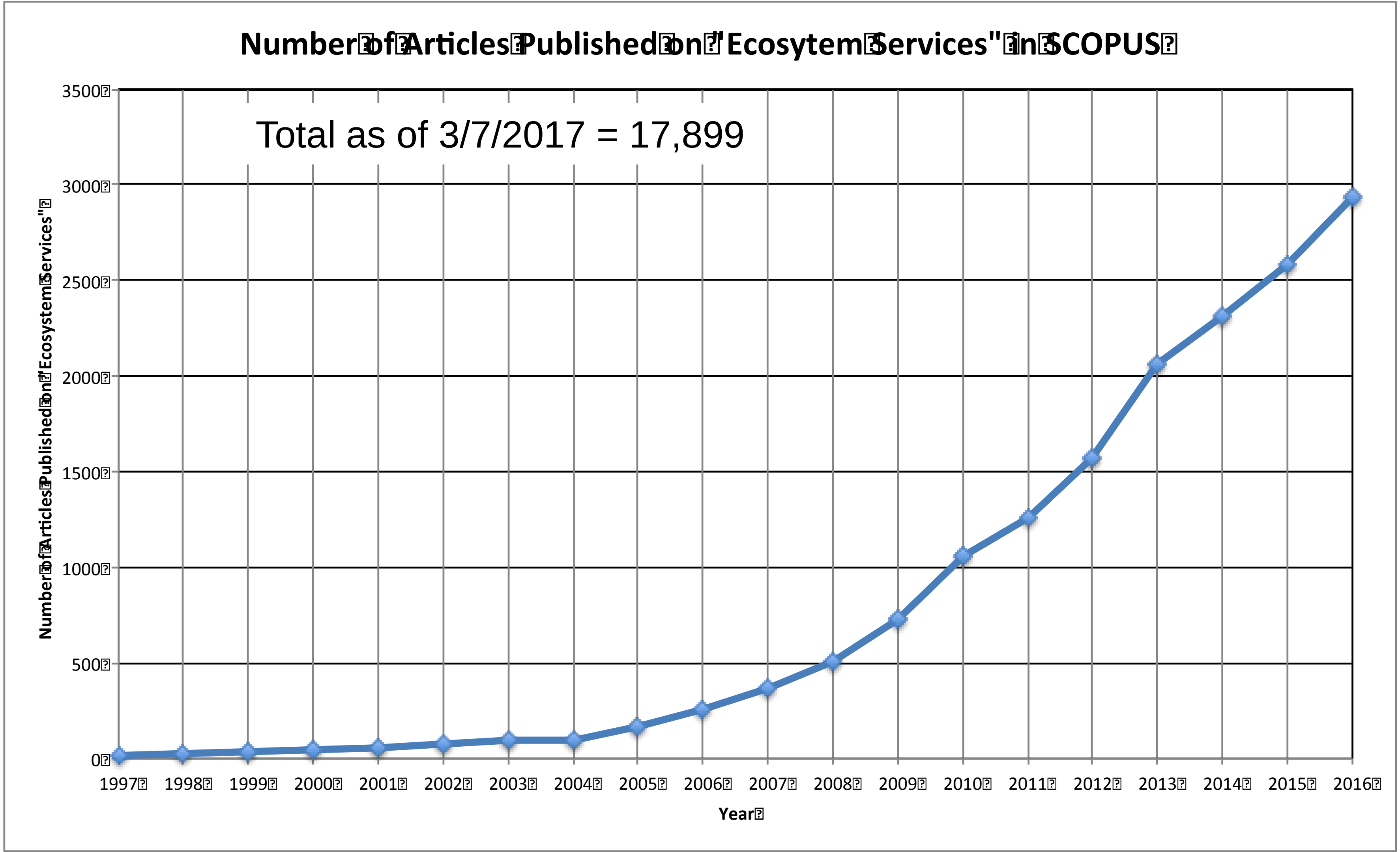
“A good ecological environment is the most universal common good, the most universal aspect of people’s wellbeing”

“We would rather have clear water and green mountains than mountains of silver and gold”

President Xi Jinping

In a word, businesses profit by calculating and paying only a fraction of the costs involved. Yet only when “the economic and social costs of using up shared environmental resources are recognized with transparency and fully borne by those who incur them, not by other peoples or future generations”, can those actions be considered ethical.

Pope Francis, ENCYCLICAL LETTER LAUDATO SI’ - ON CARE FOR OUR COMMON HOME


Number of Articles Published on "Ecosytem Services" in SCOPUS
Total as of 3/7/2017 = 17,899
3500
3000
2500
2000
1500
1000
500
0
Number of Articles Published on "Ecosystem Services"
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Year

NATURE VOL 387 15 MAY 1997

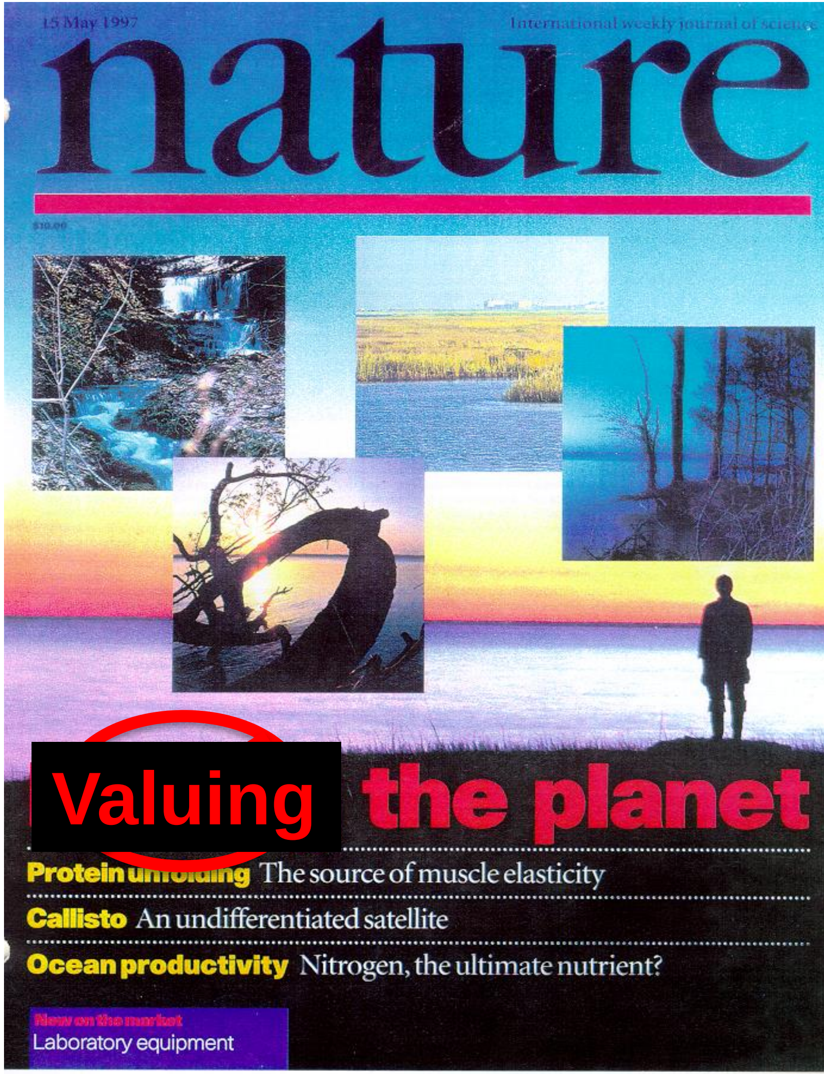
The value of the world's ecosystem services and natural capital

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**

*..

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 per year, with an average of US$33 trillion per year.

2nd most cited article in the Ecology/Environment area according to the ISI Web of Science with more than 7500 citations – which puts it in the top 0.01% of all papers ever published.



Ecosystem Services 1 (2012) 50–61

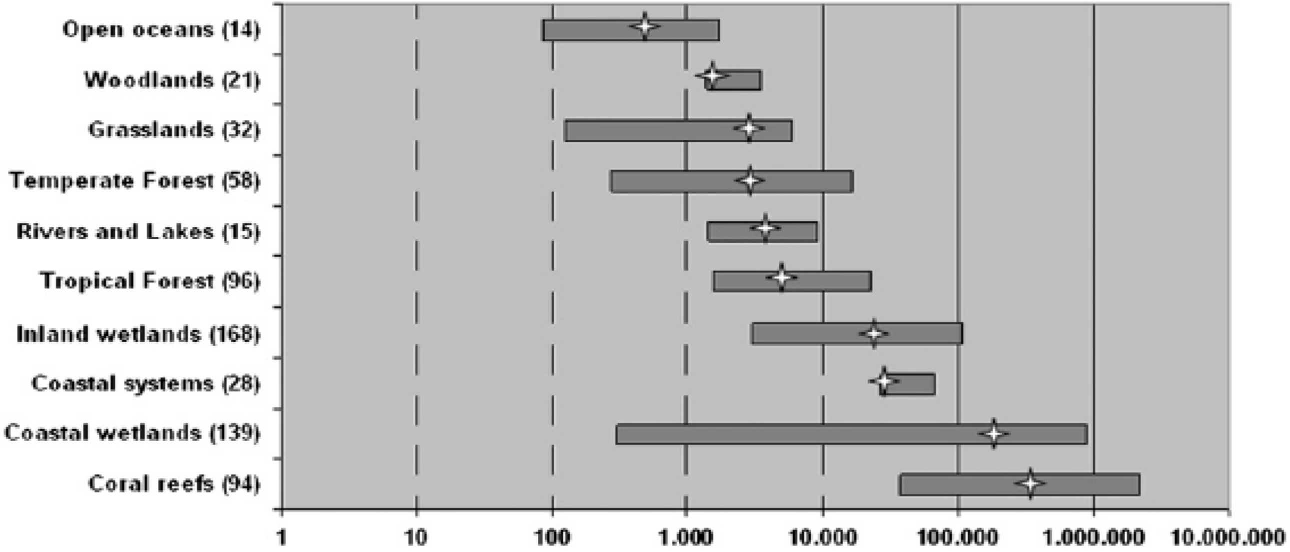
Contents lists available at SciVerse ScienceDirect

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]



Global Environmental Change 26 (2014) 152–158

Contents lists available at ScienceDirect

Global Environmental Change

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

Changes in the global value of ecosystem services

Robert Costanza[a,*], Rudolf de Groot[b], Paul Sutton[c,d], Sander van der Ploeg[b], Sharolyn J. Anderson[d], Ida Kubiszewski[a], Stephen Farber[e], R. Kerry Turner[f]

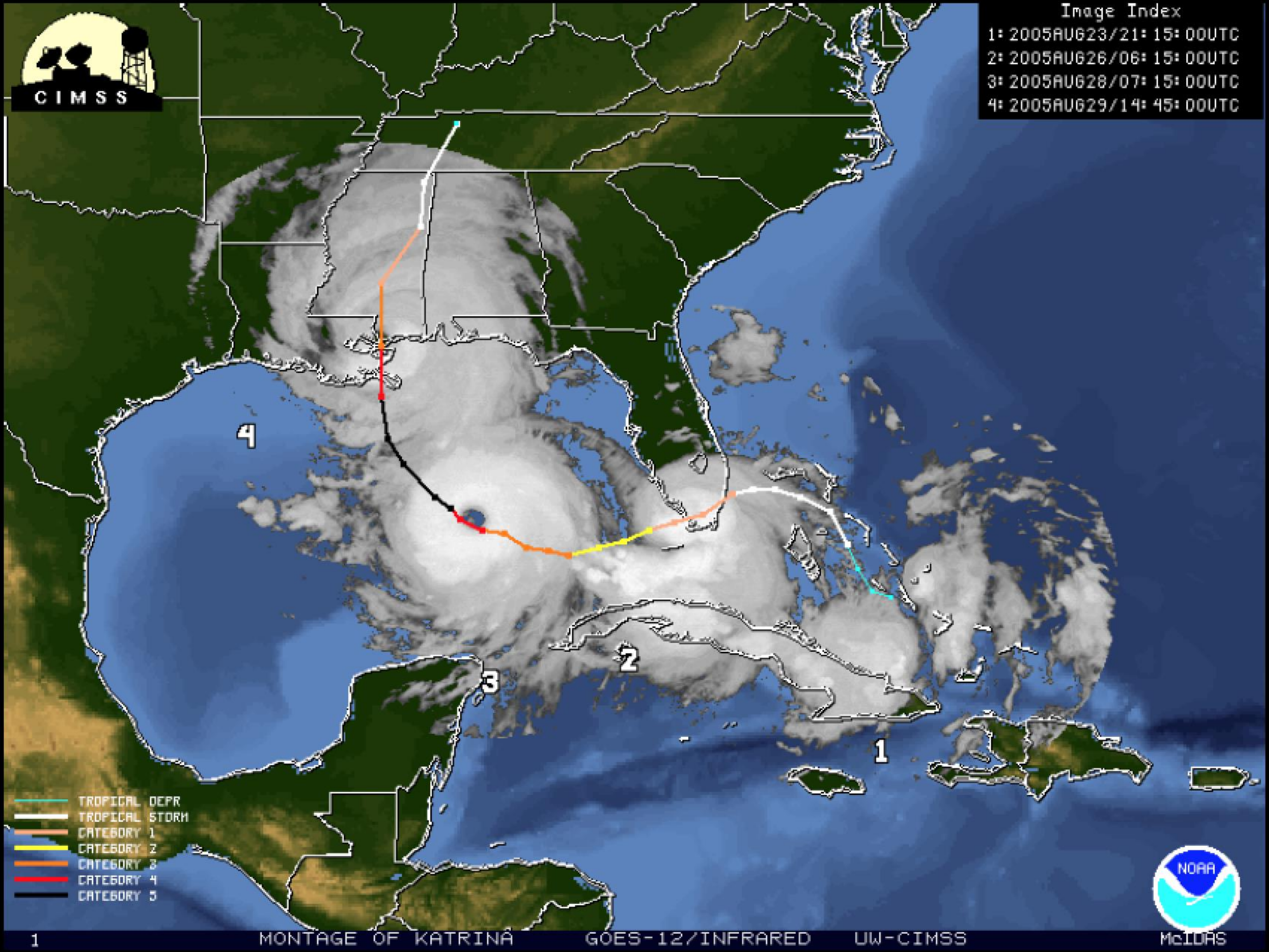
[a] *Crawford School of Public Policy, Australian National University, Canberra, Australia*
[b] *Environmental Systems Analysis Group, Wageningen University, Wageningen, The Netherlands*
[c] *Department of Geography, University of Denver, United States*
[d] *Barbara Hardy Institute and School of the Natural and Built Environments, University of South Australia, Australia*
[e] *University of Pittsburgh, United States*
[f] *University of East Anglia, Norwich, UK*

…we estimated the loss of eco-services from 1997 to 2011 due to land use change at

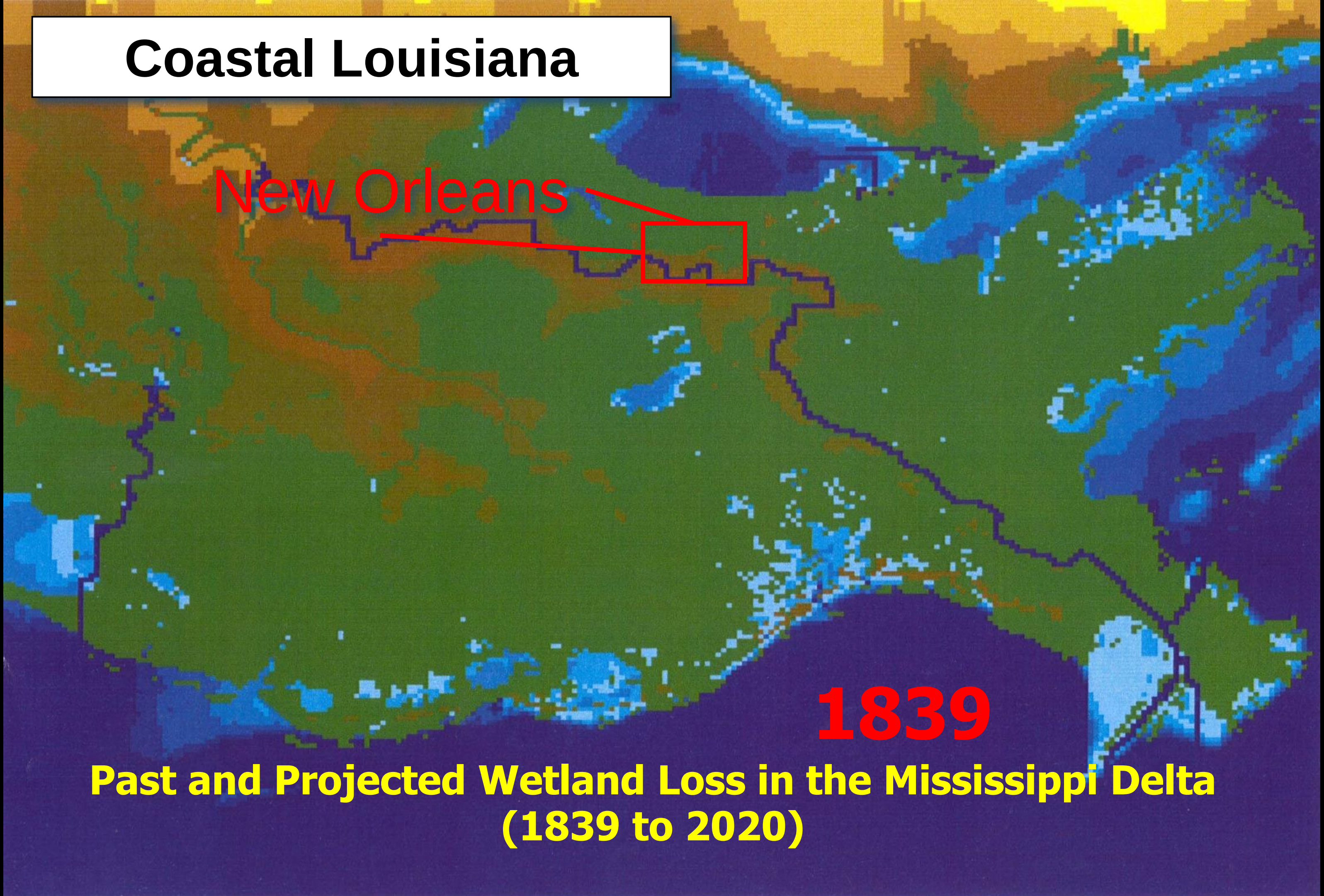
\$4.3–20.2 trillion/yr.

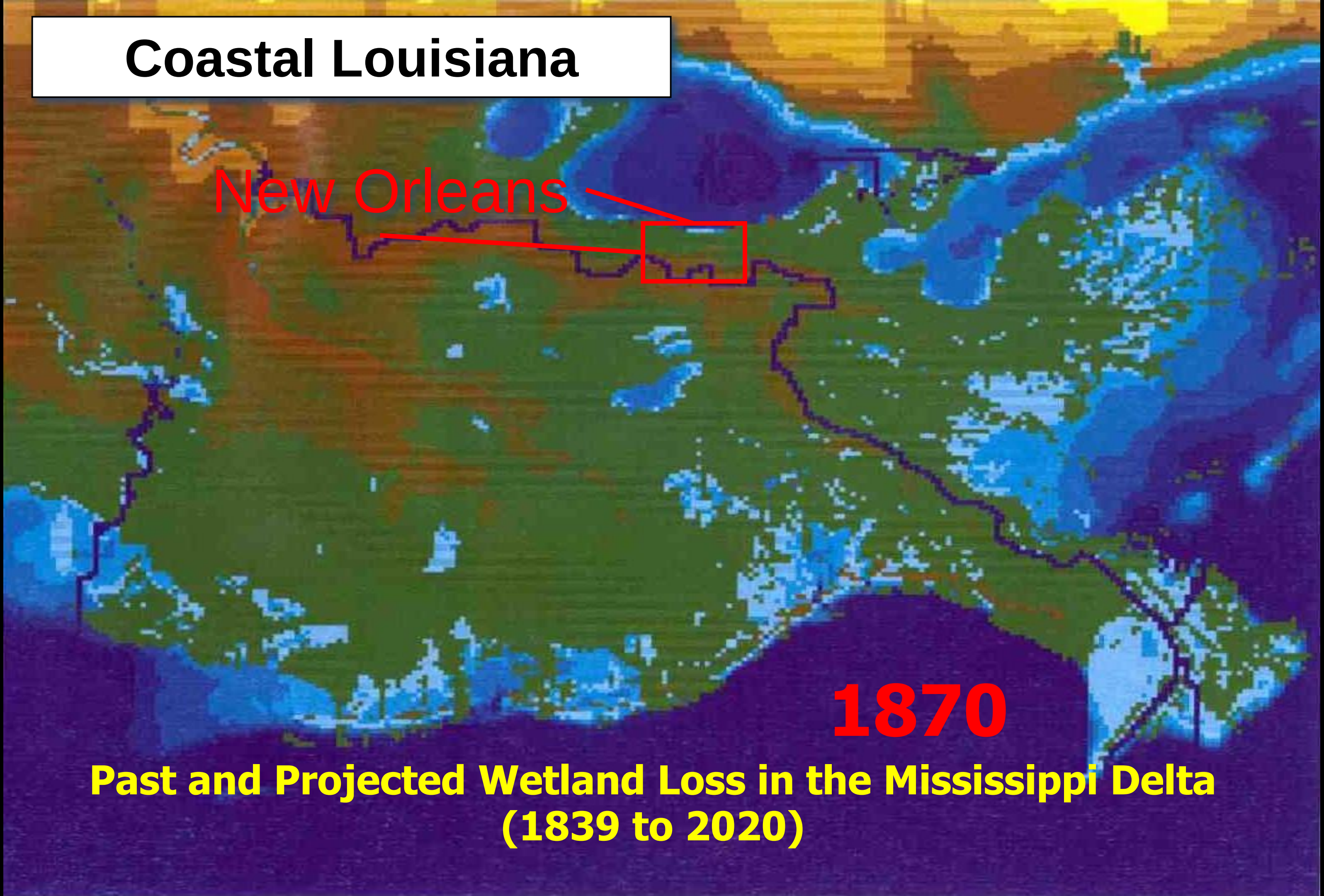
Table 2. Four levels of ecosystem service value aggregation (Kubiszewski and Costanza 2013)

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

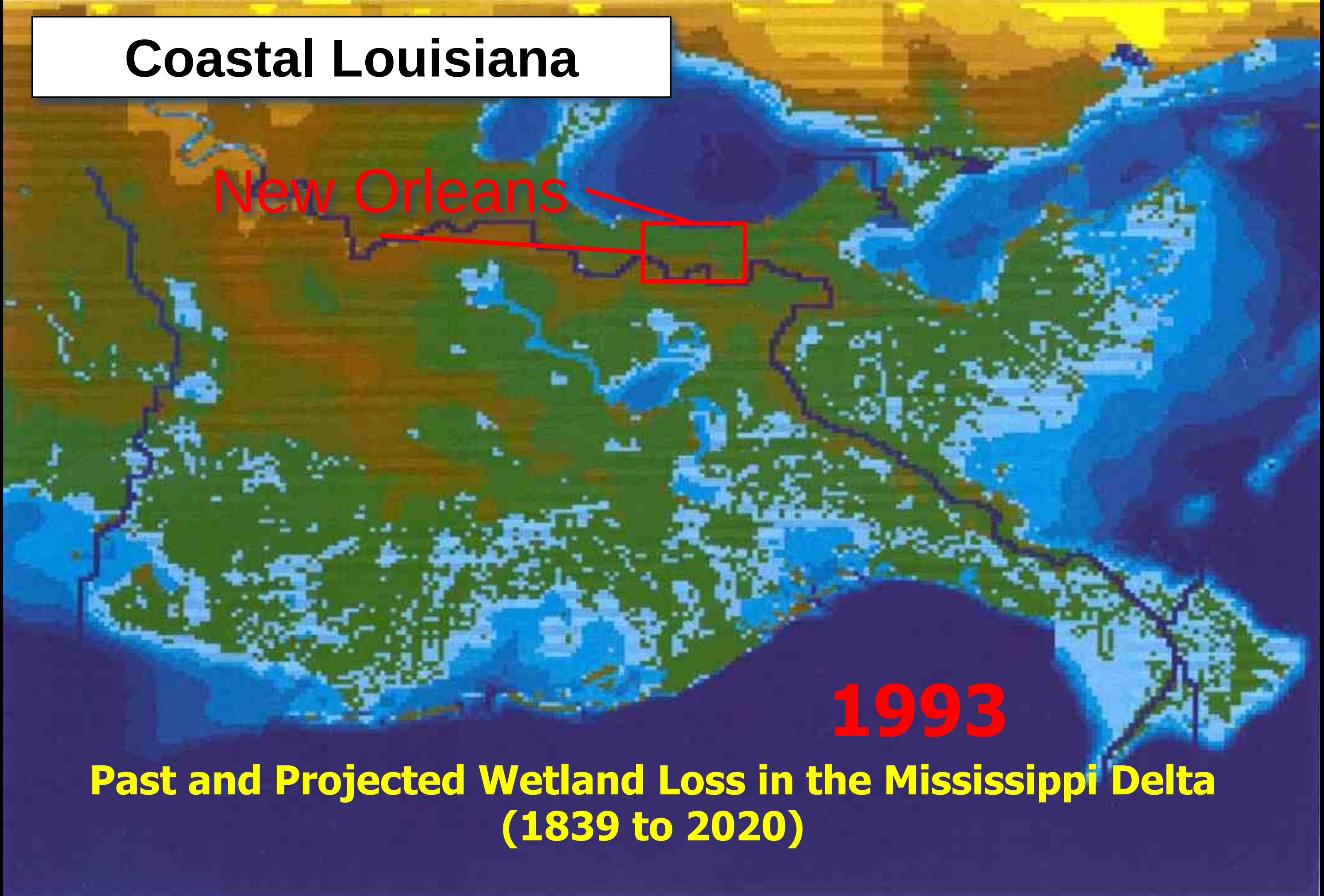


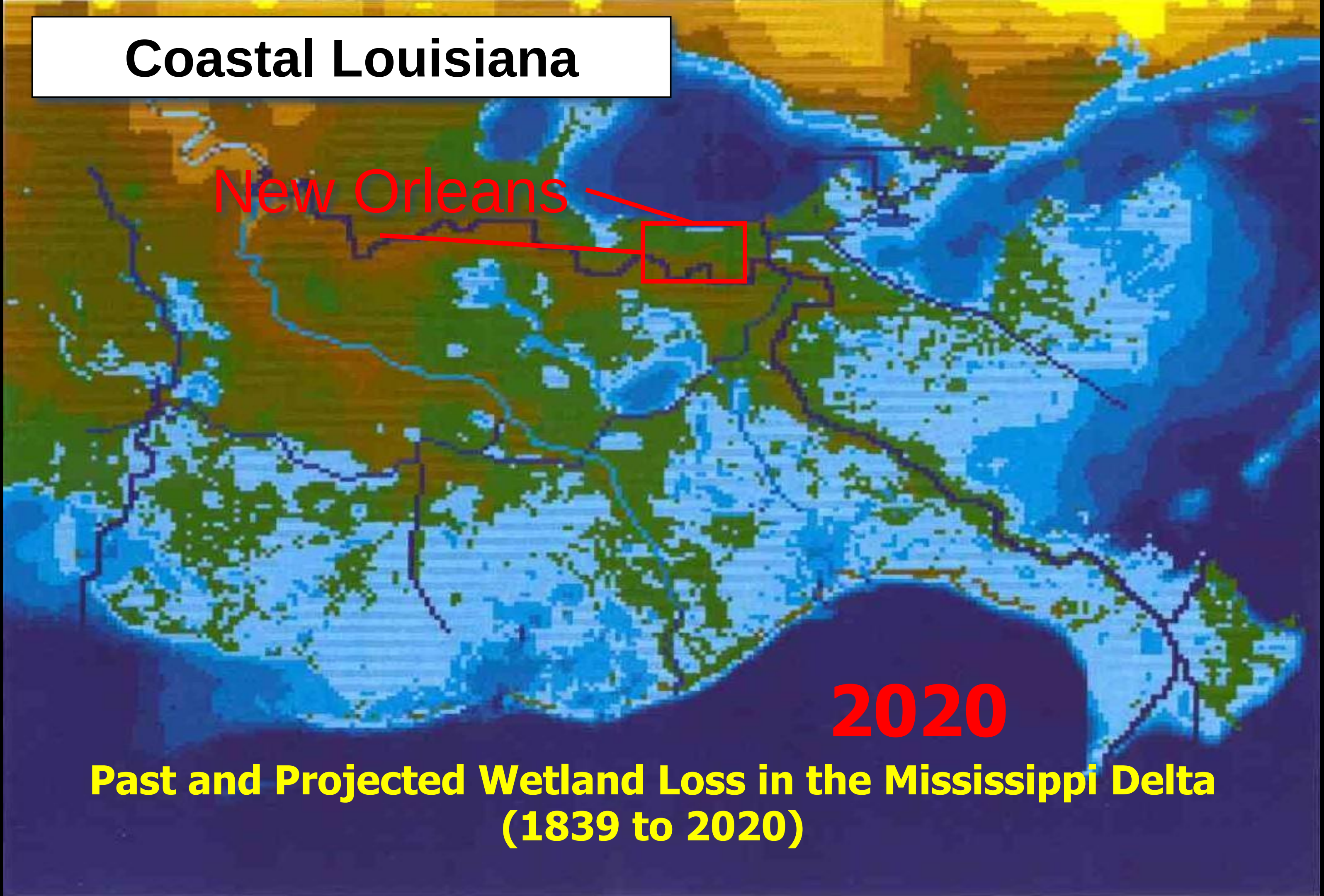
Track of Hurricane Katrina, August 23-29, 2005, showing spatial extent and storm intensity along its path (Source: NOAA)


Coastal Louisiana
New Orleans
1839
Past and Projected Wetland Loss in the Mississippi Delta
(1839 to 2020)

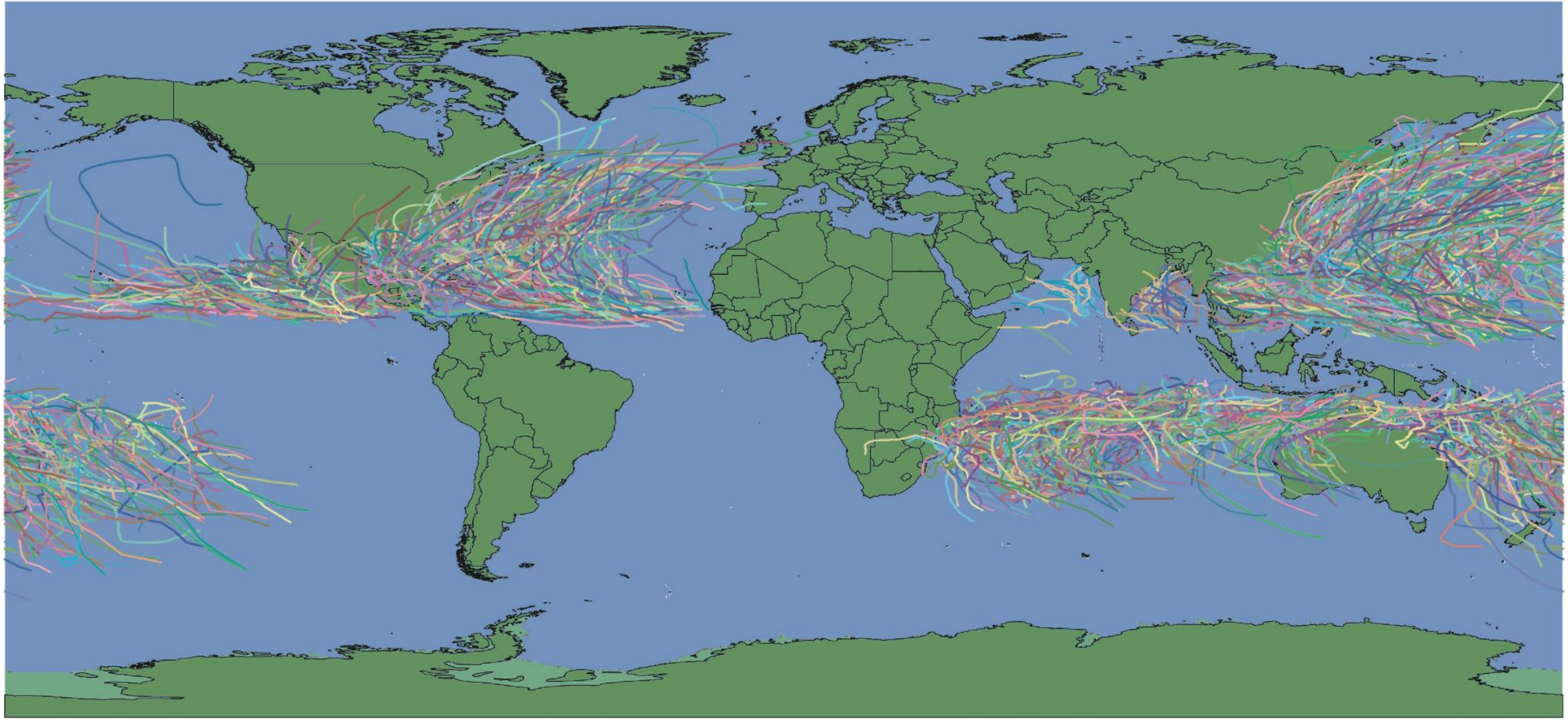


Past and Projected Wetland Loss in the Mississippi Delta (1839 to 2020)


Coastal Louisiana
New Orleans
1993
Past and Projected Wetland Loss in the Mississippi Delta
(1839 to 2020)


Coastal Louisiana
New Orleans
2020
Past and Projected Wetland Loss in the Mississippi Delta
(1839 to 2020)

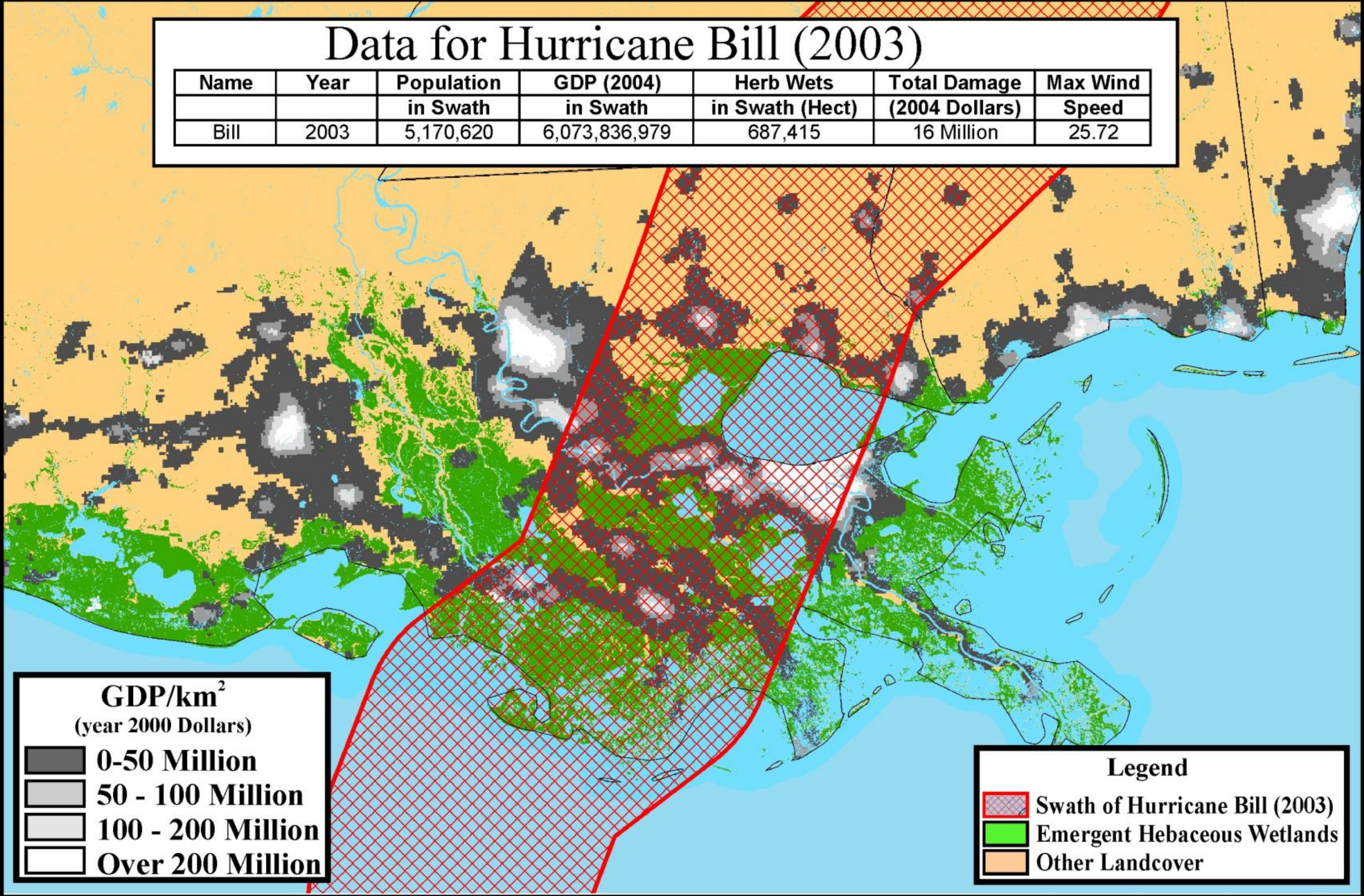
Picture taken by an automatic camera located at an electrical generating facility on the Gulf Intracoastal Waterway (GIWW) where the Route I-510 bridge crosses the GIWW. This is close to where the Mississippi River Gulf Outlet (MRGO) enters the GIWW. The shot clearly shows the storm surge, estimated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



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).

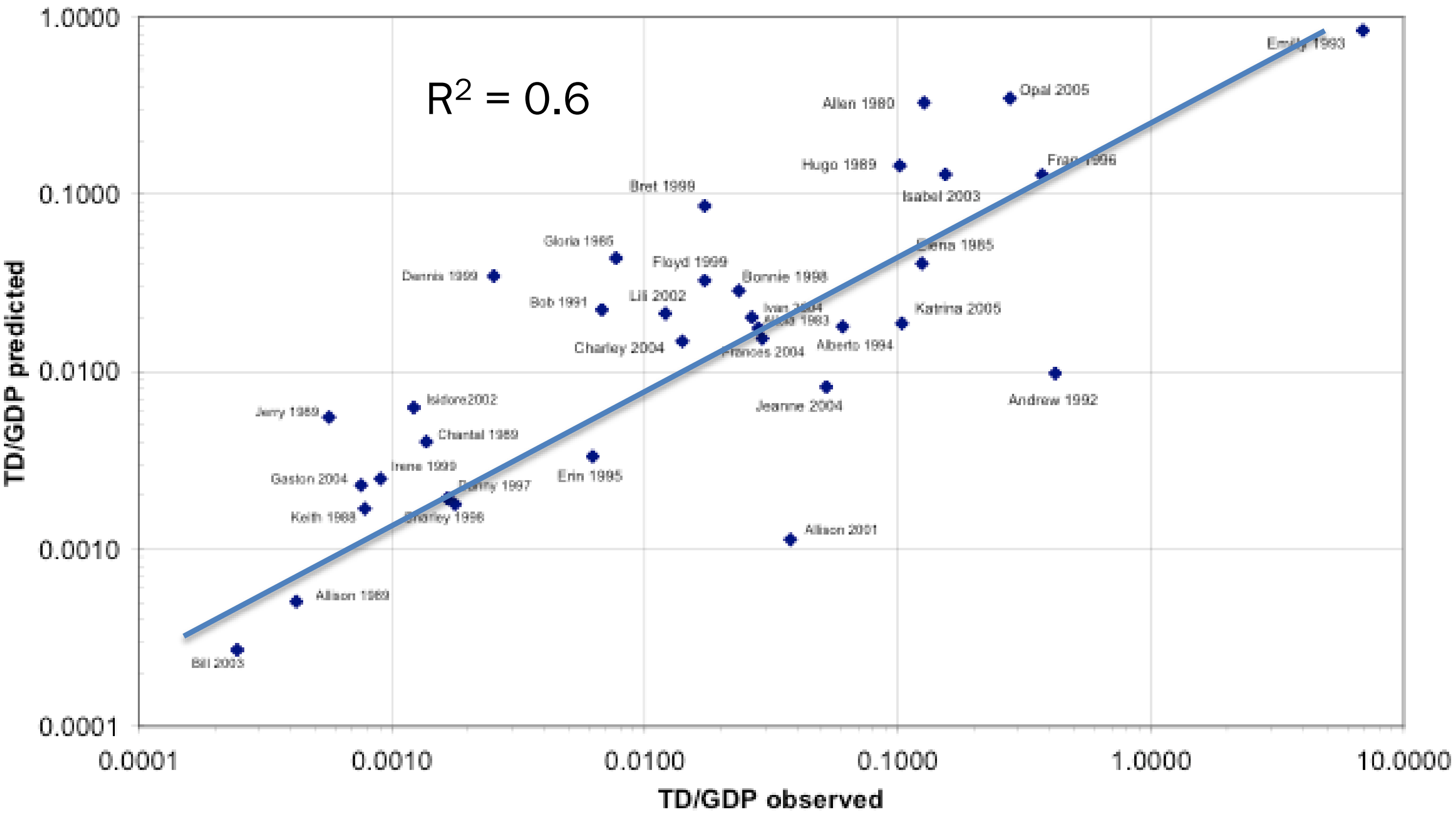
u_i = error

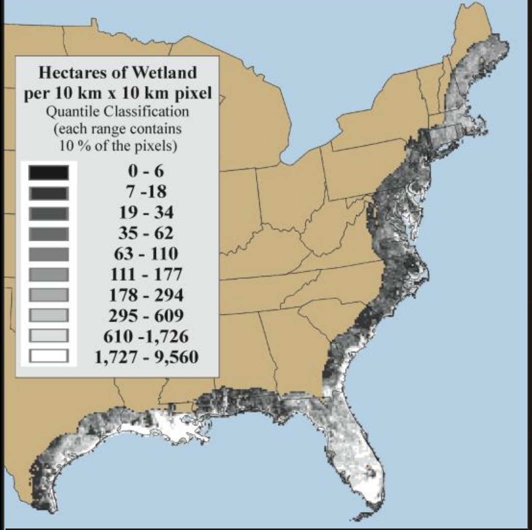
Predicted total damages from storm *i*

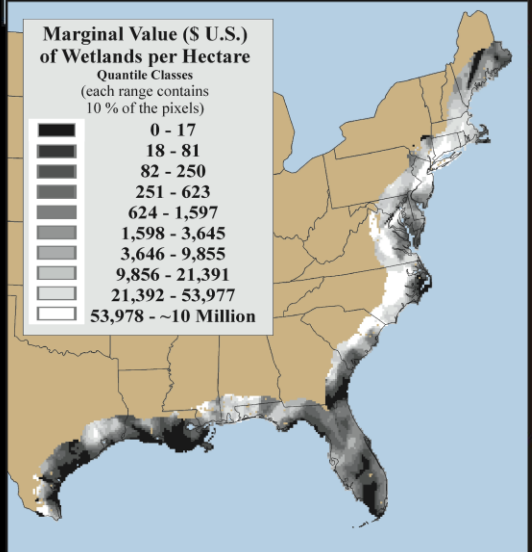
$$TD_i = e^{\alpha} * g_i^{\beta_1} * w_i^{\beta_2} * GDP_i$$

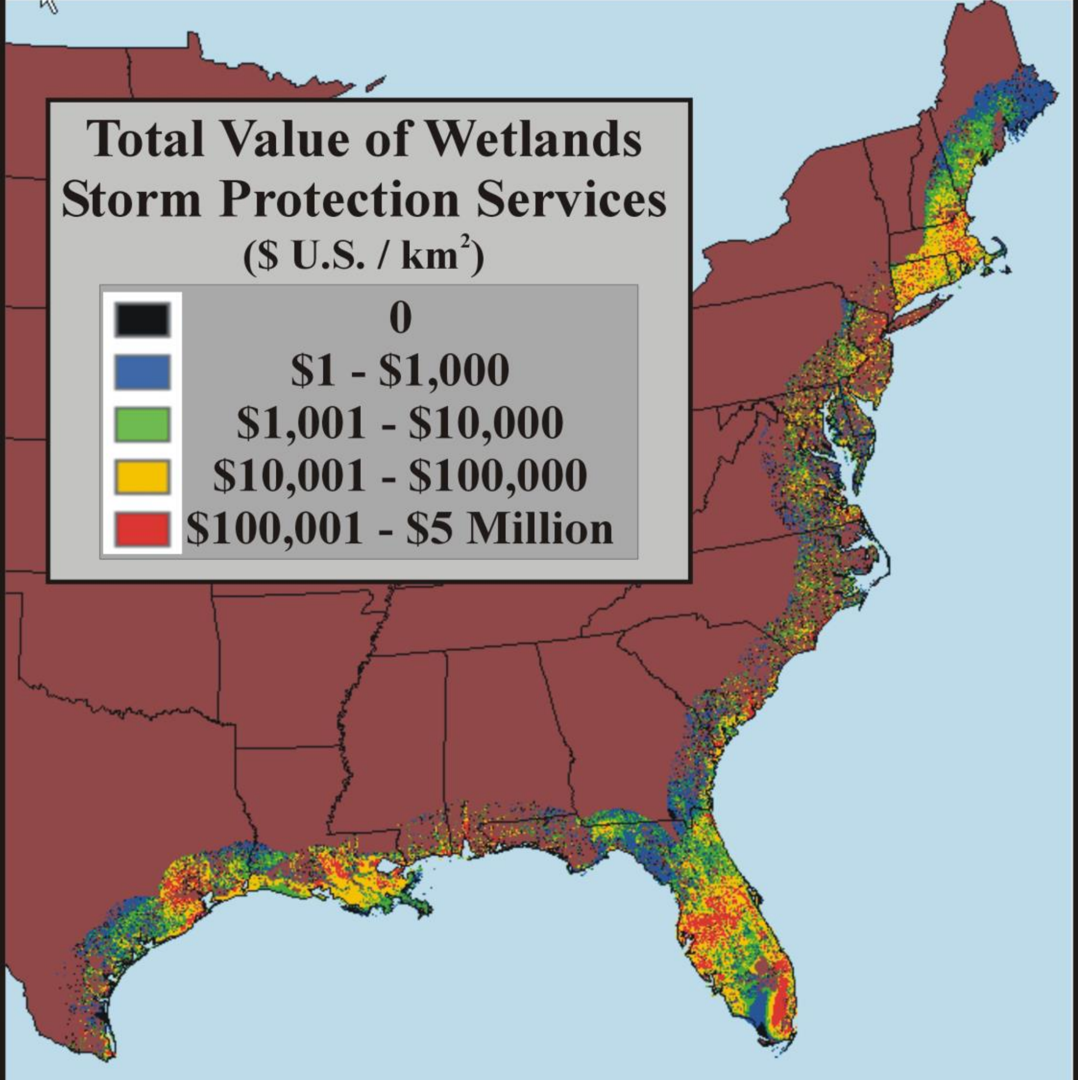
Avoided cost from a change of 1 ha of coastal wetlands for storm *i*

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


R² = 0.6
TD/GDP predicted
TD/GDP observed
1.0000
0.1000
0.0100
0.0010
0.0001
0.0001
0.0010
0.0100
0.1000
1.0000
10.0000
Allen 1980
Opal 2005
Hugo 1989
Isabel 2003
Bret 1999
Gloria 1985
Floyd 1999
Bonnie 1998
Dennis 1999
Lili 2002
Bob 1991
Katrina 2005
Alberto 1994
Charley 2004
Frances 2004
Jeanne 2004
Andrew 1992
Isidore2002
Jerry 1989
Chantal 1989
Irene 1999
Gaston 2004
Erin 1995
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

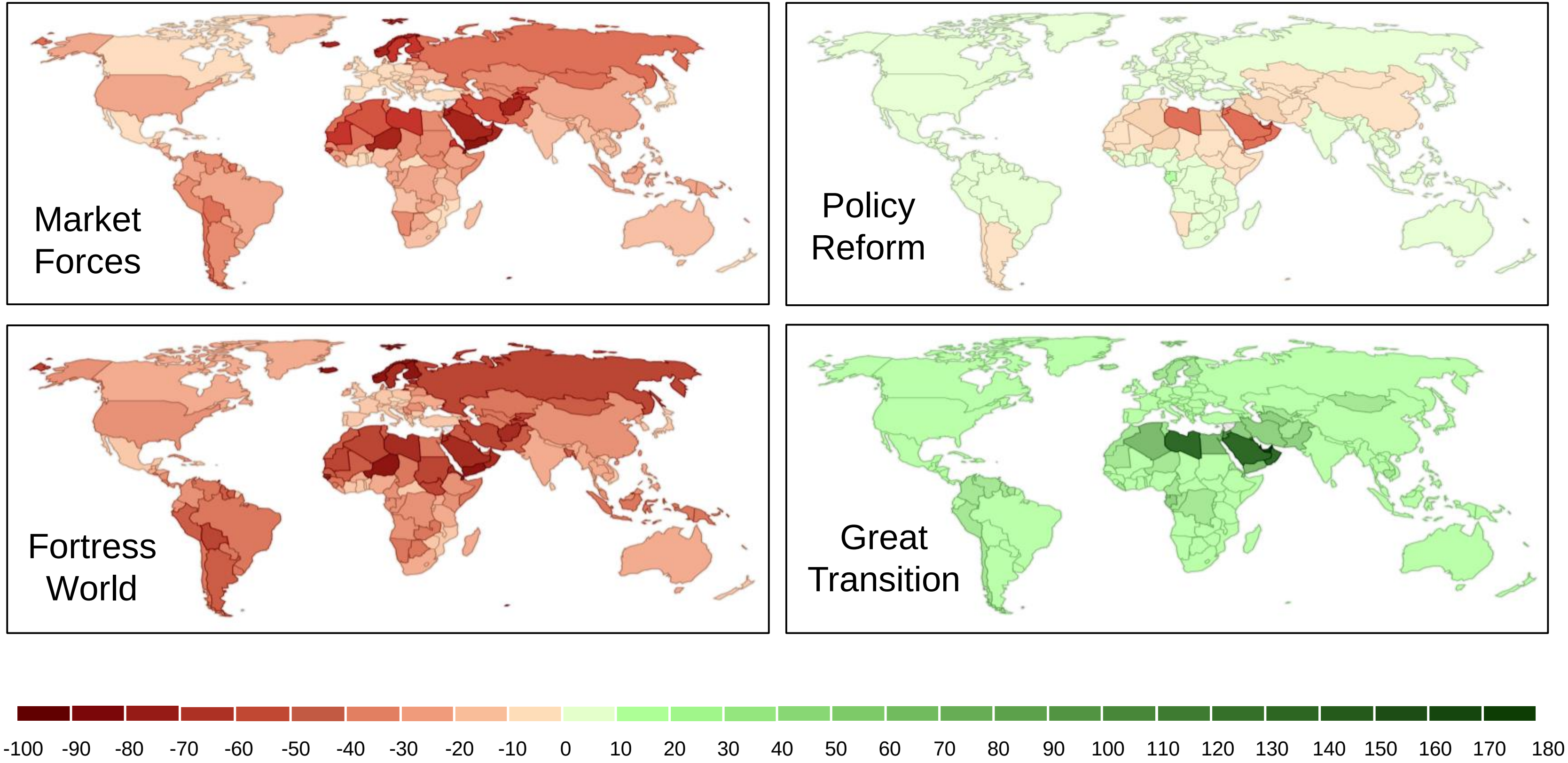

Total Value of Wetlands
Storm Protection Services
($ U.S. / km2)
0
$1 - $1,000
$1,001 - $10,000
$10,001 - $100,000
$100,001 - $5 Million

- **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)**

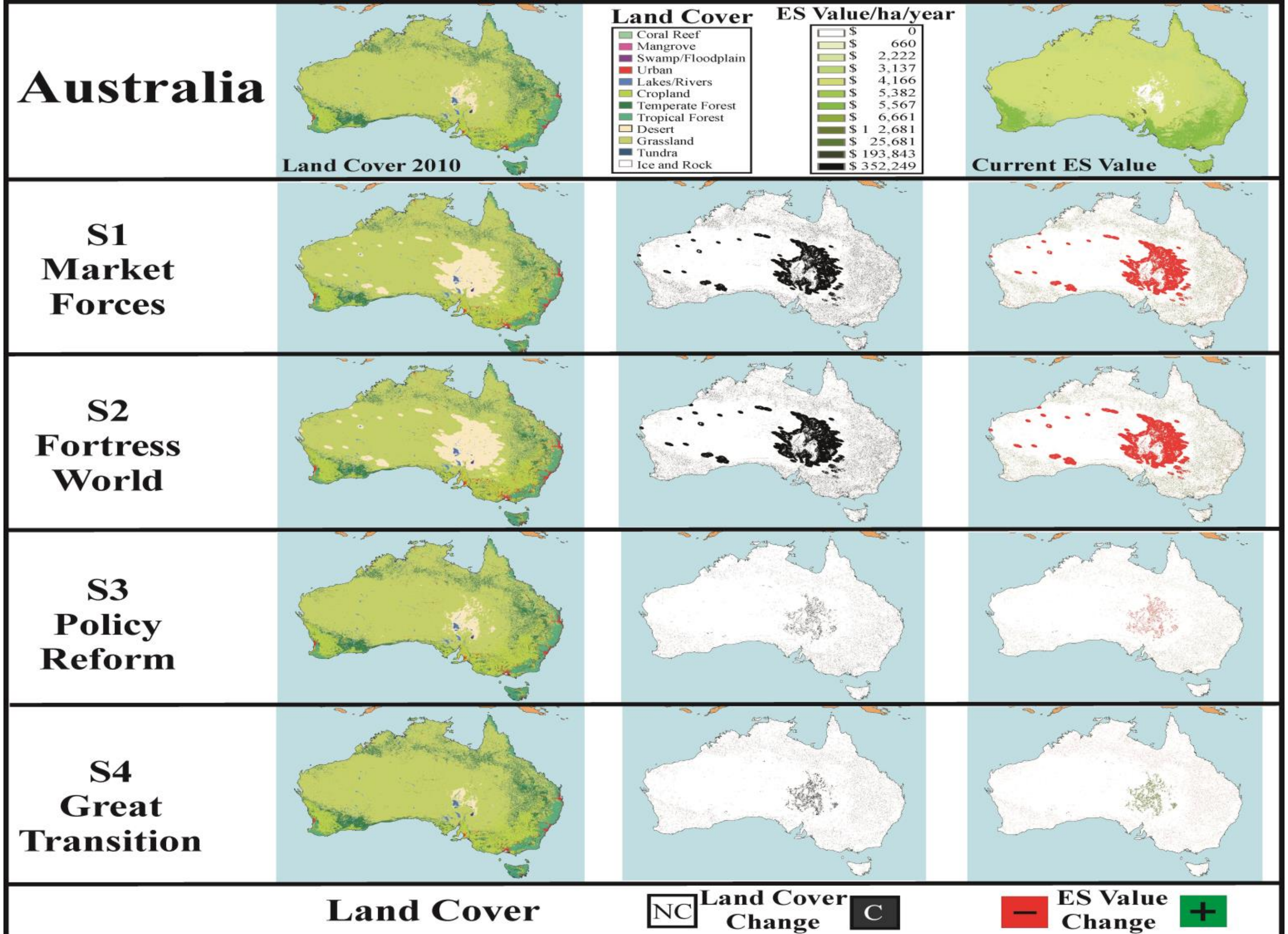
- **Coastal wetlands in the US were estimated to currently provide $23.2 Billion/yr in storm protection services.**

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.



Percent Change in 2050 from 2011 Ecosystem Service Values

From: Kubiszewski, Costanza, Anderson, and Sutton. (2017). The Future of Ecosystem Services: Global Scenarios and National Implications. *Ecosystem Services.* 26:289-301.


Australia
Land Cover 2010
Land Cover
Coral Reef
Mangrove
Swamp/Floodplain
Urban
Lakes/Rivers
Cropland
Temperate Forest
Tropical Forest
Desert
Grassland
Tundra
Ice and Rock
ES Value/ha/year
$ 0
$ 660
$ 2,222
$ 3,137
$ 4,166
$ 5,382
$ 5,567
$ 6,661
$ 12,681
$ 25,681
$ 193,843
$ 352,249
Current ES Value
S1
Market
Forces
S2
Fortress
World
S3
Policy
Reform
S4
Great
Transition
Land Cover
NC
Land Cover
Change
C
−
ES Value
Change
+

Economic Values of the Northern Territory Marine and Coastal Environments

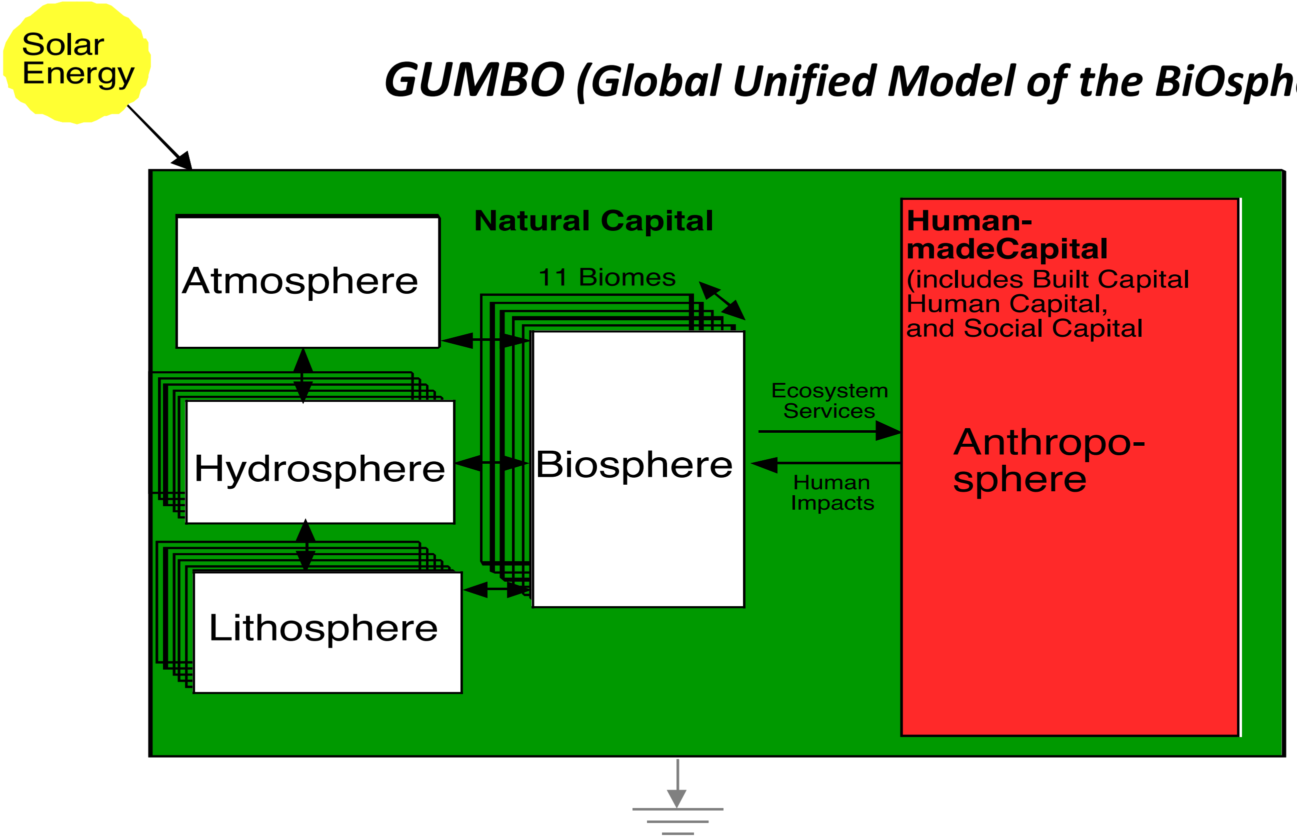
Neville D. Crossman[1], Natalie Stoeckl[2], Kamaljit K. Sangha[3] and Robert Costanza[4]

[1]University of Adelaide, Adelaide, SA
[2]Stoeckl Consultants, Townsville, QLD
[3]Charles Darwin University, Darwin, NT
[4]Australian National University, Canberra, ACT

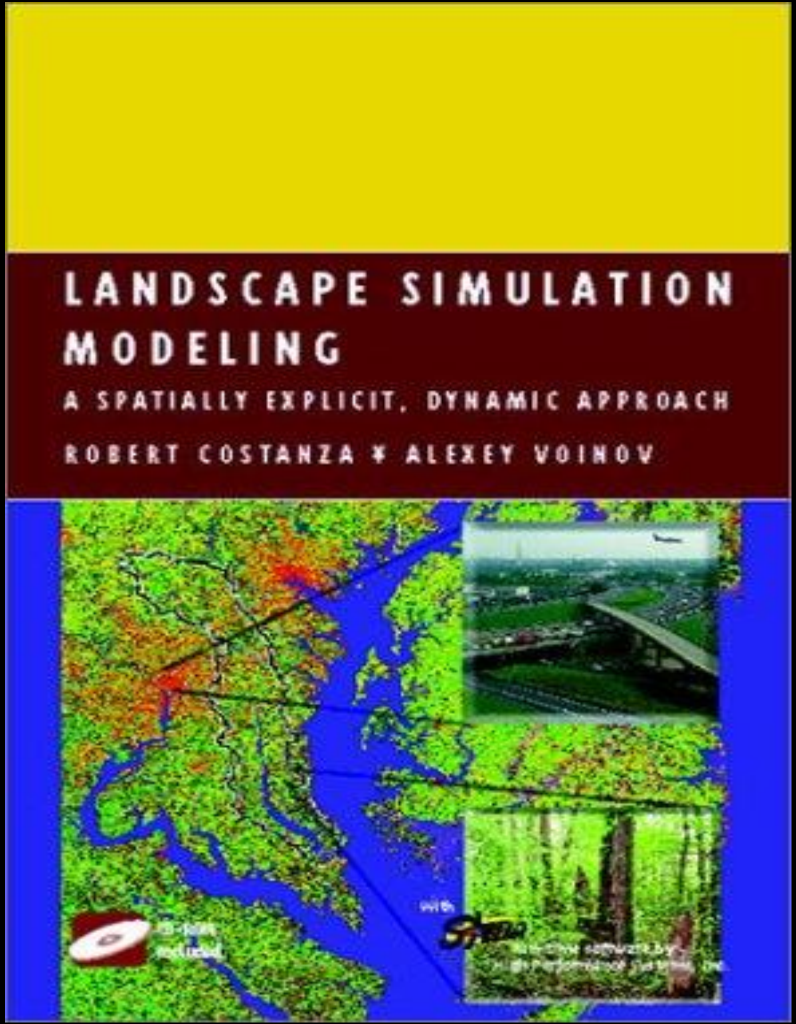
Integrated Modeling of Humans Embedded in Ecological Systems

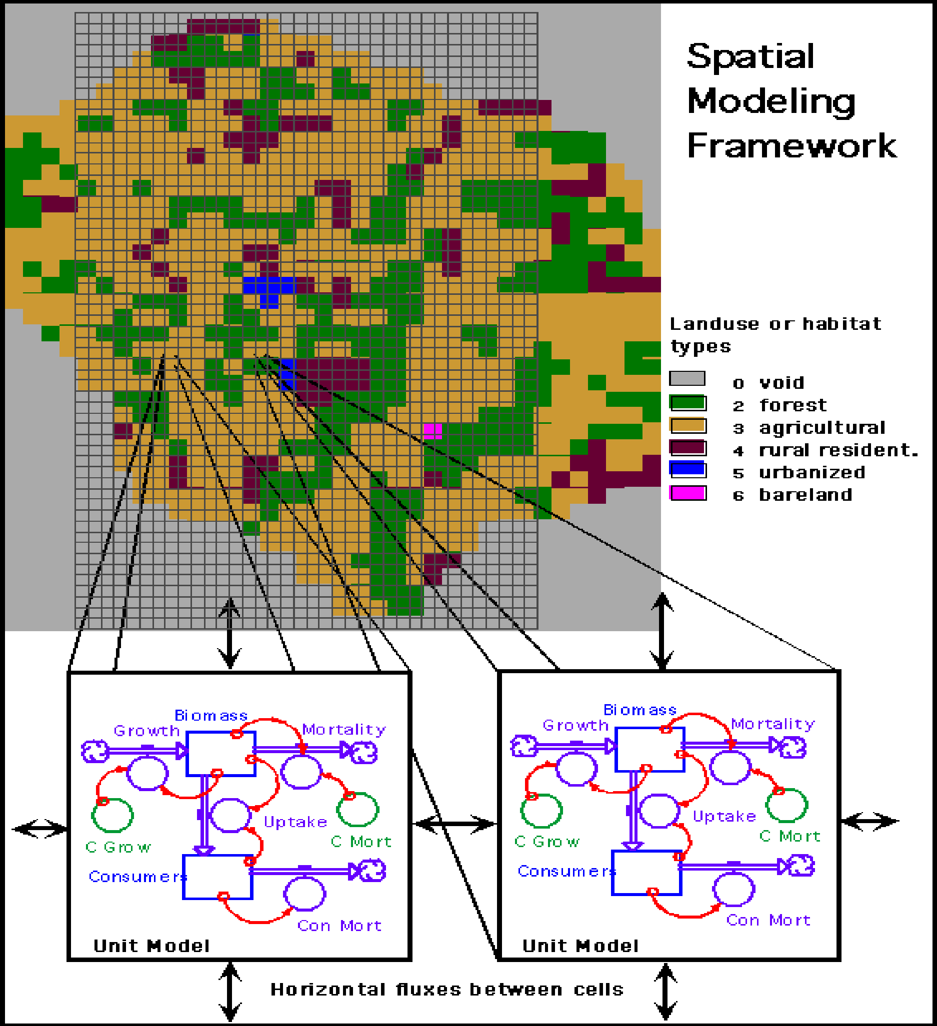
- Intelligent Pluralism (Multiple Modeling Approaches), Testing, Cross-Calibration, and Integration
- Multi-scale in time, space, and complexity
- Can be used as a Consensus Building Tool in an Open, Participatory Process
- Acknowledges Uncertainty and Limited Predictability
- Acknowledges Values of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

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


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
Biomass
Growth
Mortality
Uptake
C Grow
C Mort
Consumers
Con Mort
Unit Model
Horizontal fluxes between cells

Population Density, Forest Condition, Settlement Trade Strength, and Soil Degradation for the Simulated Landscape at 800-Year Intervals

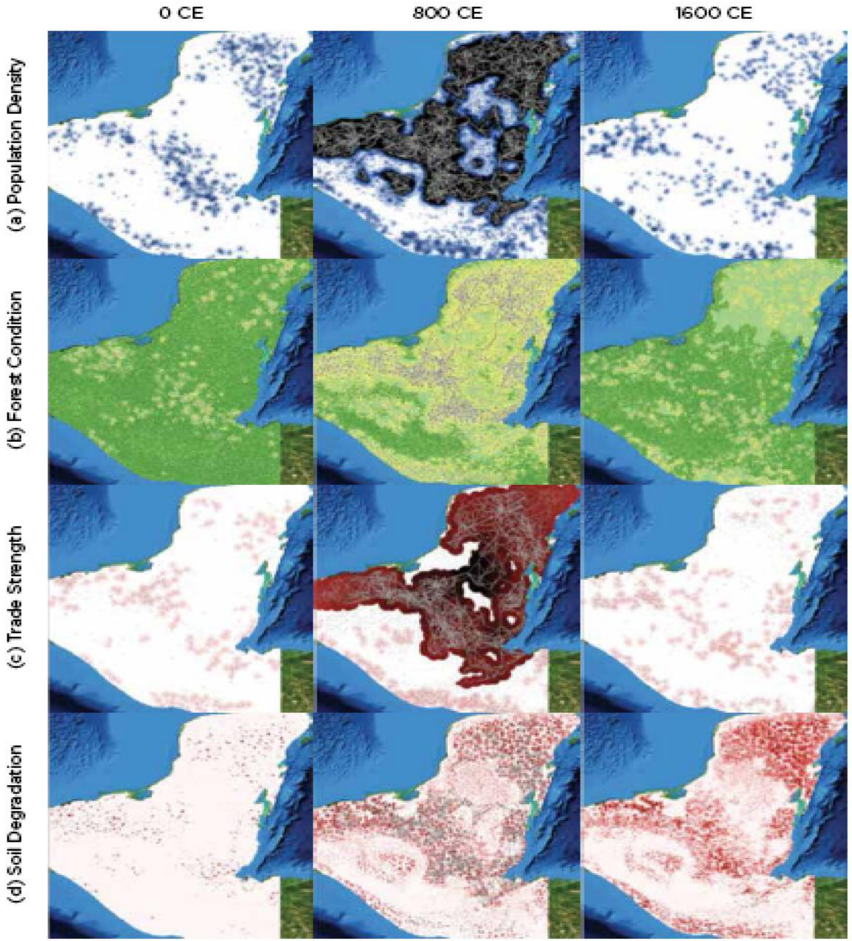


Figure 1. Darker colouring shows increased a) population density (blue), b) forest condition (three states of cleared/cropped cells) (yellow), secondary regrowth (light green) and climax forest (dark green), c) trade strength (red), and d) soil degradation (red).

Achieving Sustainable Societies: Lessons from Modelling the Ancient Maya

by Scott Heckbert, Robert Costanza, and Lael Parrott, *Solutions*, 5(5), 2014

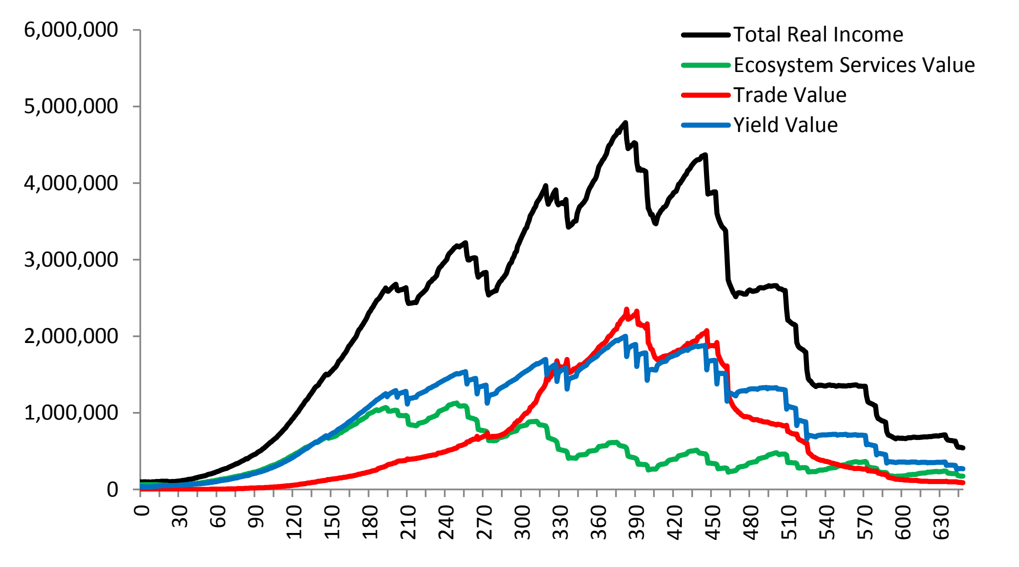
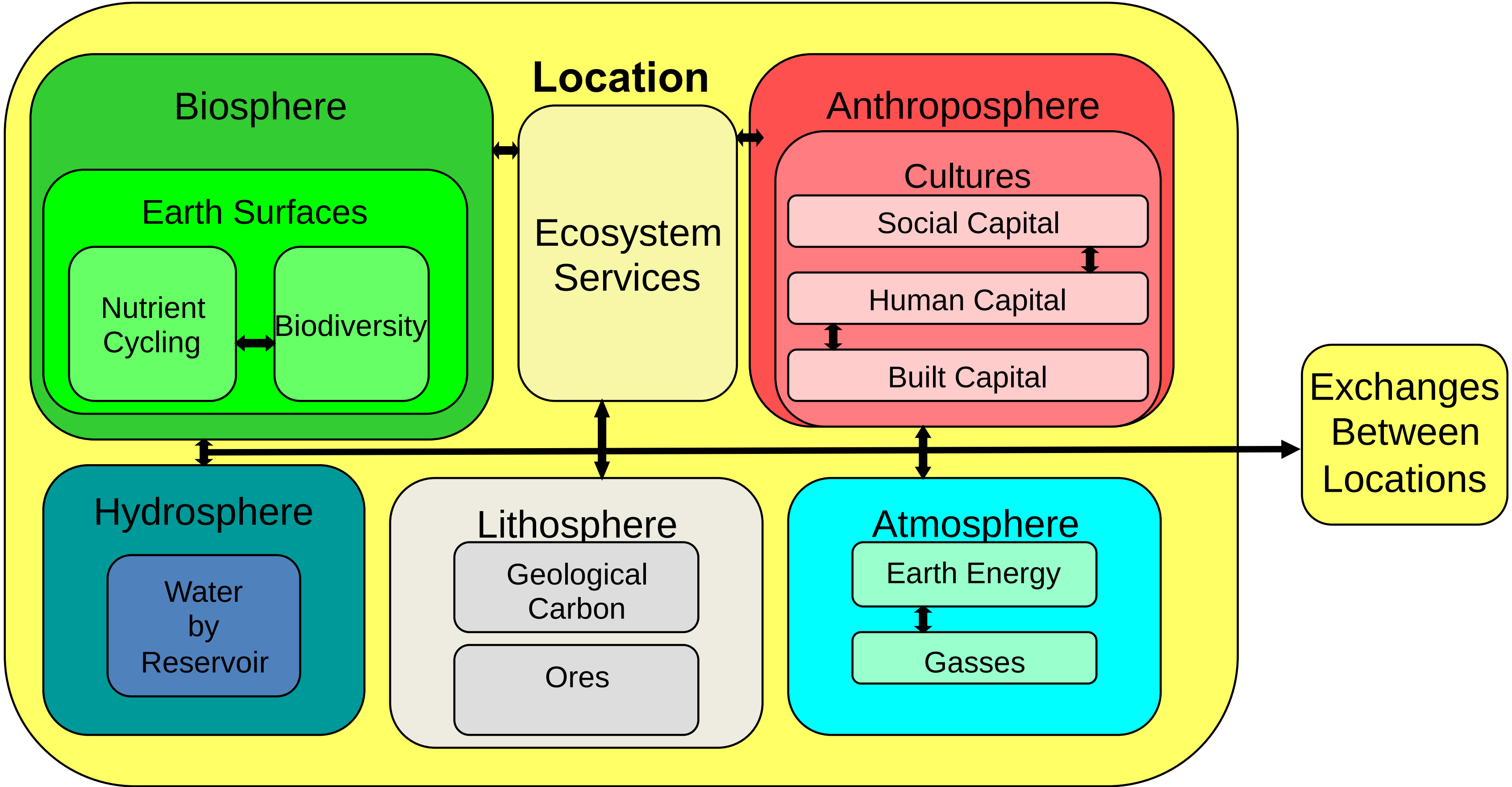


Figure 6: Real income of all simulated settlements over time by contributions from agriculture, ecosystem services, and trade value. Ecosystem services is eventually superceded by agriculture, and both by trade around time step 350.

MIMES

Multi-scale Integrated Models of Ecosystem Services



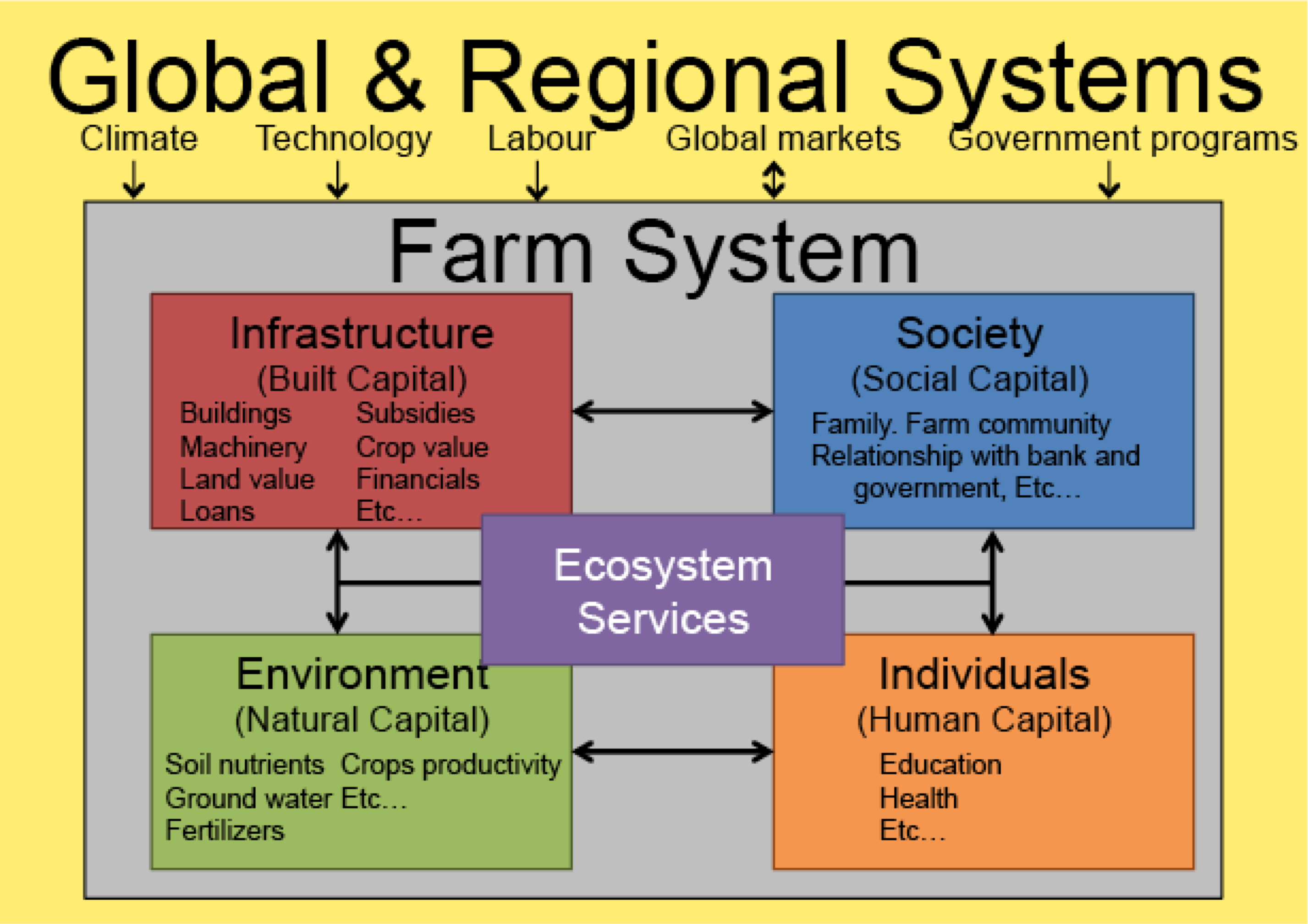
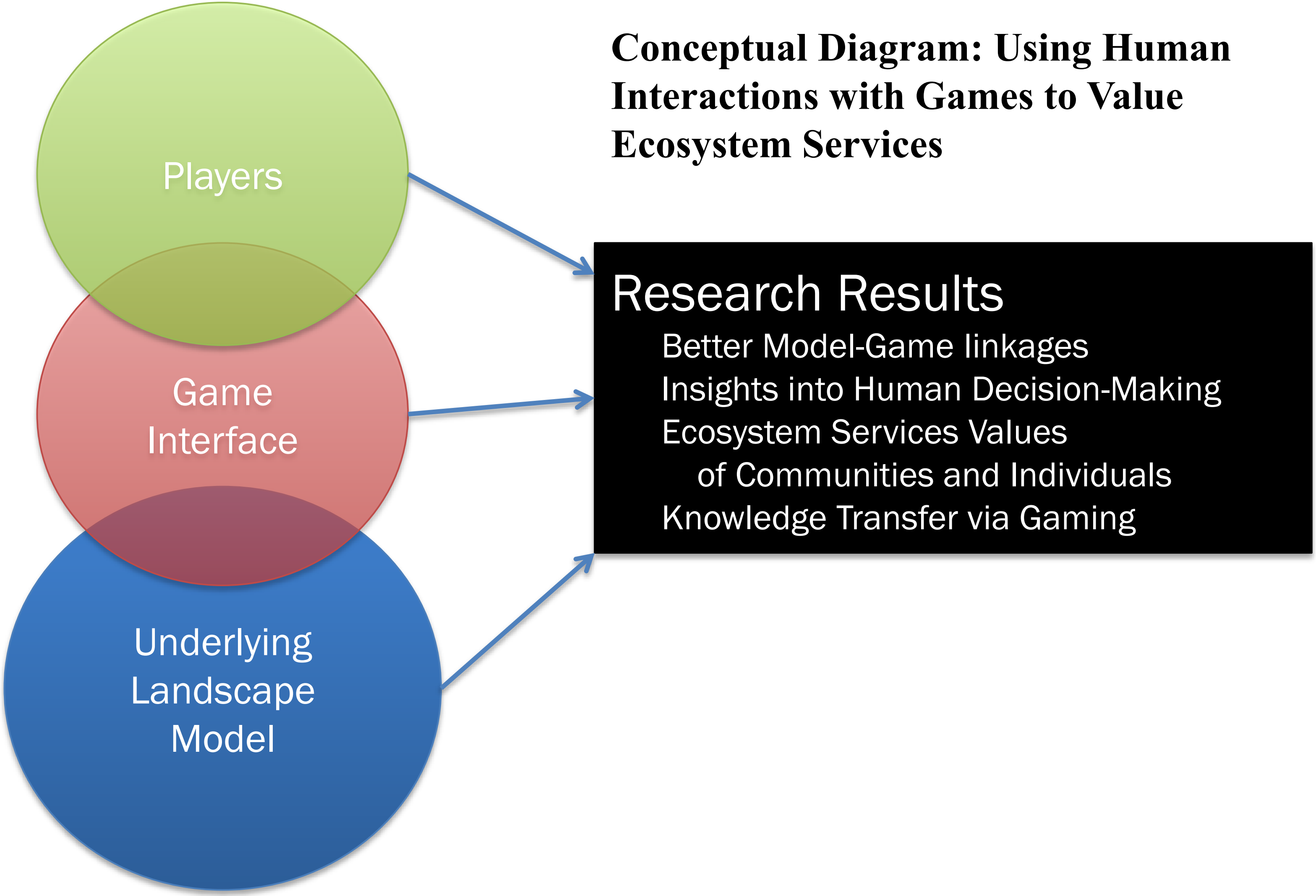


Figure 1. Overview of the integrated systems model components.

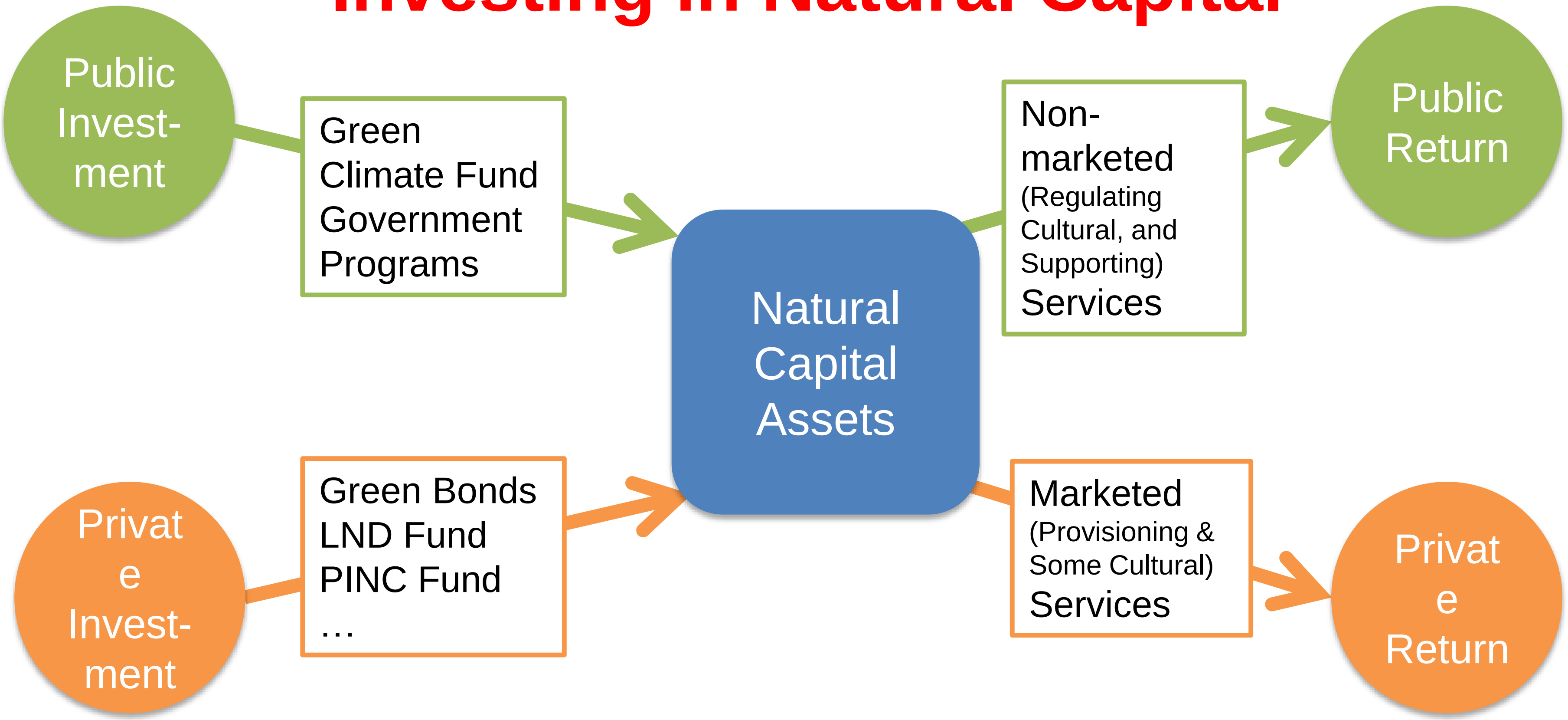
Conceptual Diagram: Using Human Interactions with Games to Value Ecosystem Services



Uses of Games

Costanza, R., K. Chichakly, V. Dale, S. Farber, D. Finnigan, K. Grigg, S. Heckbert, I. Kubiszewski, H. Lee, S. Liu, P. Magnuszewski, S. Maynard, N. McDonald, R. Mills, S. Ogilvy, P. L. Pert, J. Renz, L. Wainger, M. Young and C. Richard Ziegler. (2014). Simulation games that integrate research, entertainment, and learning around ecosystem services. Ecosystem Services 10: 195-201.

Public-Private Partnerships for Investing in Natural Capital



Thank You

Papers mentioned in this presentation
can be downloaded from:

www.robertcostanza.com

From: Bateman et al. 2013. Bringing Ecosystem Services into Economic Decision-Making: Land Use in the United Kingdom. *Science* 341:45-50

Table 2. Summary of land-use change scenarios. [Details in (*13*).]

Scenario	Environmental regulation and planning policy relative to current	Spatial focusing of changes
Go with the flow (GF)	**Similar:** Policy and regulatory regime as today. Existing patterns of countryside protection relaxed only where economic priorities dominate.	**Unfocused:** Similar spatial constraints on land-use change as today. No expansion of the protected area network.
Nature at work (NW)	**Stronger:** Policy and planning emphasize multifunctional landscapes and the need to maintain ecosystem function.	**Focused:** Greening of urban and peri-urban areas to enhance recreation values.
Green and pleasant land (GPL)	**Stronger:** Agri-environmental schemes strengthened with expansion of stewardship and conservation areas.	**Focused:** Increased extent of existing conservation areas. Creation of functional ecological networks where possible.
Local stewardship (LS)	**Stronger:** Agri-environmental schemes strengthened with expansion of stewardship and conservation areas.	**Unfocused:** No strong spatial component to changes but protection of areas of national significance continues.
National security (NS)	**Weaker:** Emphasis on increasing UK agricultural production. Environmental regulation and policy is weakened.	**Unfocused:** Some land-use conversion into woodland occurs in areas of lower agricultural values
World markets (WM)	**Weaker:** Environmental regulation and policy are weakened unless they coincide with improved agricultural production.	**Focused:** Losses of greenbelt to urban development, which results in loss of recreational values. Weaker protection of designated sites and habitats.

Table 1. Summary of the ecosystem service related goods considered in the analysis. [Metrics, data, modeling and valuation are fully documented in (*13*).]

Ecosystem service–related good	Metrics (in year specified)	Main data and sources	Model	Valuation
Agricultural production	Proportion and output of land use in each 2-km grid square	Land use, soils and physical environment, climate, digital mapping, etc. (*31–33*)	Environmental-econometric regression analysis of land-use decisions as a function of the local physical environment, prices, costs and policies, based on (*34*)	Market values (*35*)
Greenhouse gases	Net metric tons of CO_2, CH_4, and N_2O per 2-km grid square	Land-use predictions, GHG responses (*36–38*)	Process models for CO_2, CH_4, and N_2O; conversion to metric tons of CO_2 equivalent ($MTCO_2Eq$) based on insulation factors	Official UK values per $MTCO_2Eq$ (*39*)
Recreation	Visitors per 2-km grid square	National survey of >40,000 households, census (*40, 41*)	Regression model of visit count from outset to destination as a function of characteristics of both locations, population socioeconomics, etc.	Meta-analysis of 300 ecosystem-specific valuation estimates
Urban green-space amenity	Distance to green space from each 2-km grid square	Digital mapping census (*32, 41*)	Regression model linking distance from households to green-space sites, their size and quality	Meta-analysis of prior literature examining changes in value with respect to distance
Wild bird–species diversity	Wild bird diversity (*20*) per 2-km grid square	*Breeding Bird Survey* (*42*)	Regression model linking wild bird diversity to land use and location.	Not valued; analysis uses the opportunity cost of avoiding declines

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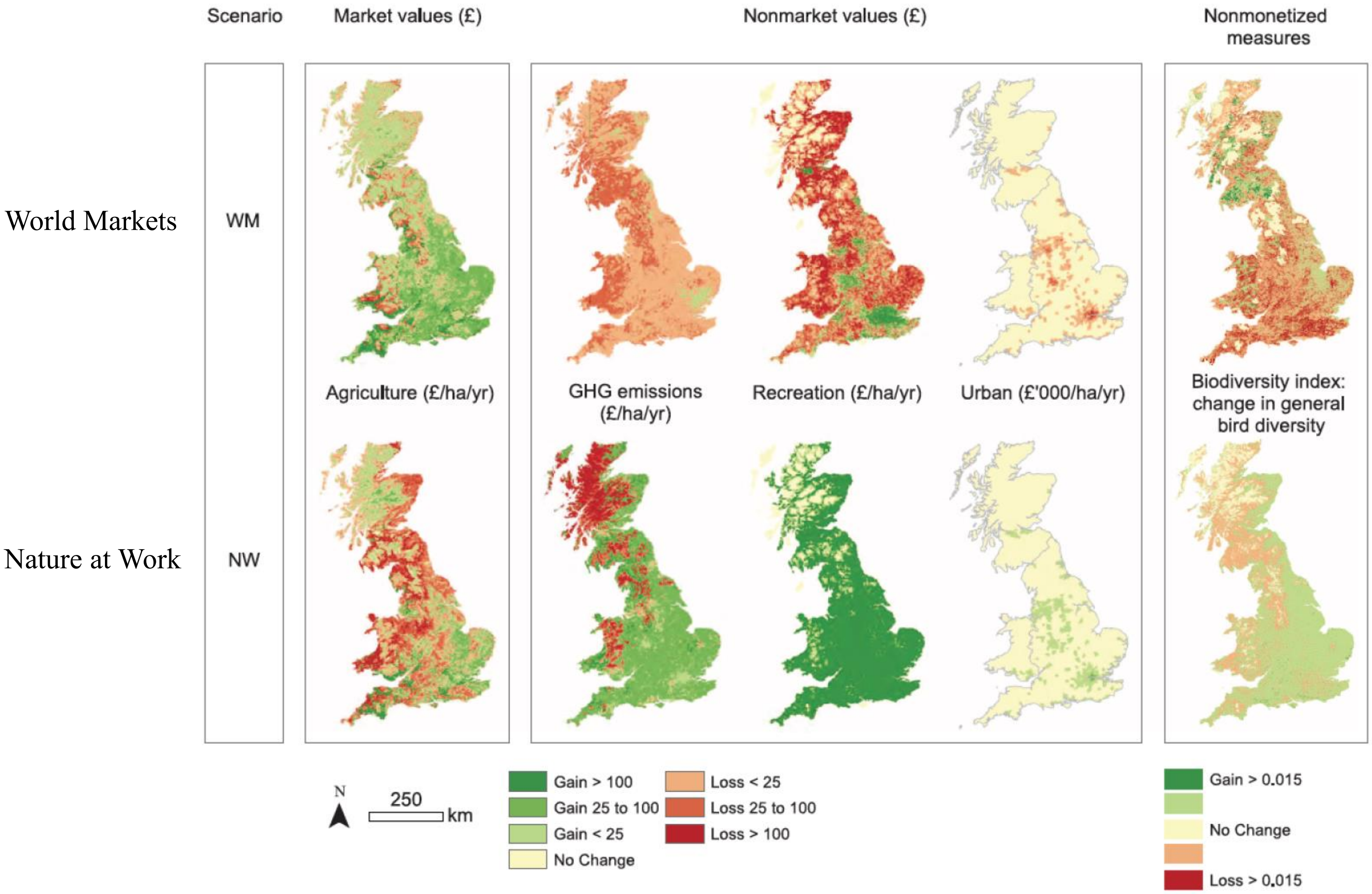

Example scenario analyses including non-market ecosystem services values

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Table 3. Change in values across Great Britain from the present day (2010) to 2060 achieved by the targeting of policy options under three decision rules. (Millions of £s per annum; real values in £2010; UK Climate Impacts Programme low-emission scenario throughout.)

Decision component	Maximize market (agricultural) values only (Fig. 3, A and B)	Maximize all monetary values (Fig. 3, C and D)	Maximize all monetary values with biodiversity constraint (Fig. 3, E and F)
Market agricultural value	971	−448	−455
Nonmarket GHG emissions	−109	1,517	1,510
Nonmarket recreation	2,550	13,854	12,685
Nonmarket urban green space	−2,520	4,683	4,352
All monetary values	892	19,606	18,092

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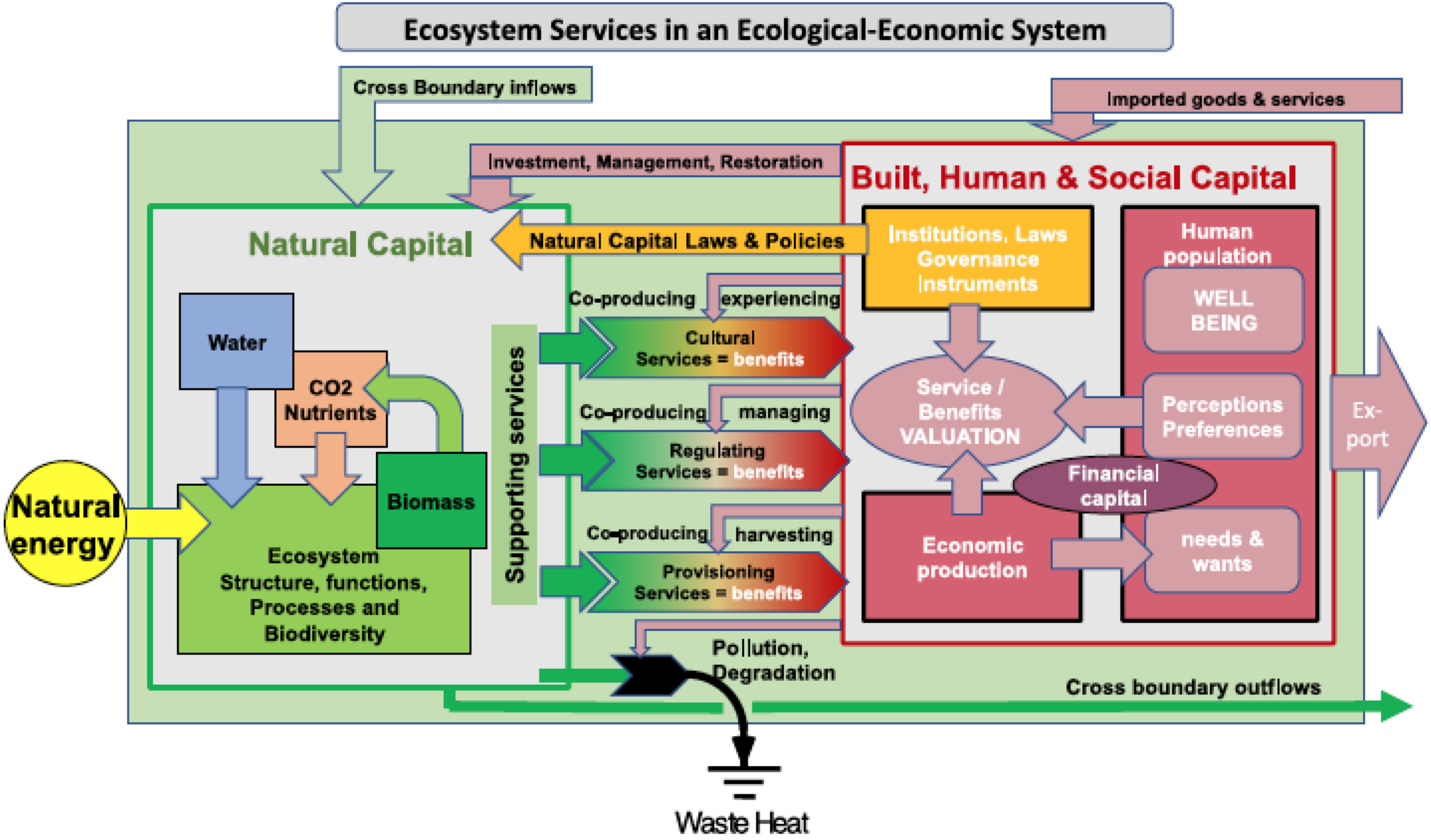
Ecosystem Services in an Ecological-Economic System
Cross Boundary inflows
Imported goods & services
Investment, Management, Restoration
Built, Human & Social Capital
Natural Capital
Natural Capital Laws & Policies
Institutions, Laws Governance Instruments
Human population
WELL BEING
Co-producing
experiencing
Cultural Services = benefits
Water
CO2 Nutrients
Service / Benefits VALUATION
Perceptions Preferences
Ex-port
Co-producing
managing
Regulating Services = benefits
Supporting services
Biomass
Natural energy
Financial capital
Co-producing
harvesting
Provisioning Services = benefits
Economic production
needs & wants
Ecosystem Structure, functions, Processes and Biodiversity
Pollution, Degradation
Cross boundary outflows
Waste Heat

Green Water Credits