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ESP
Ecosystem Services Partnership

**Jacksonville,
Florida
December 5-
9, 2016**

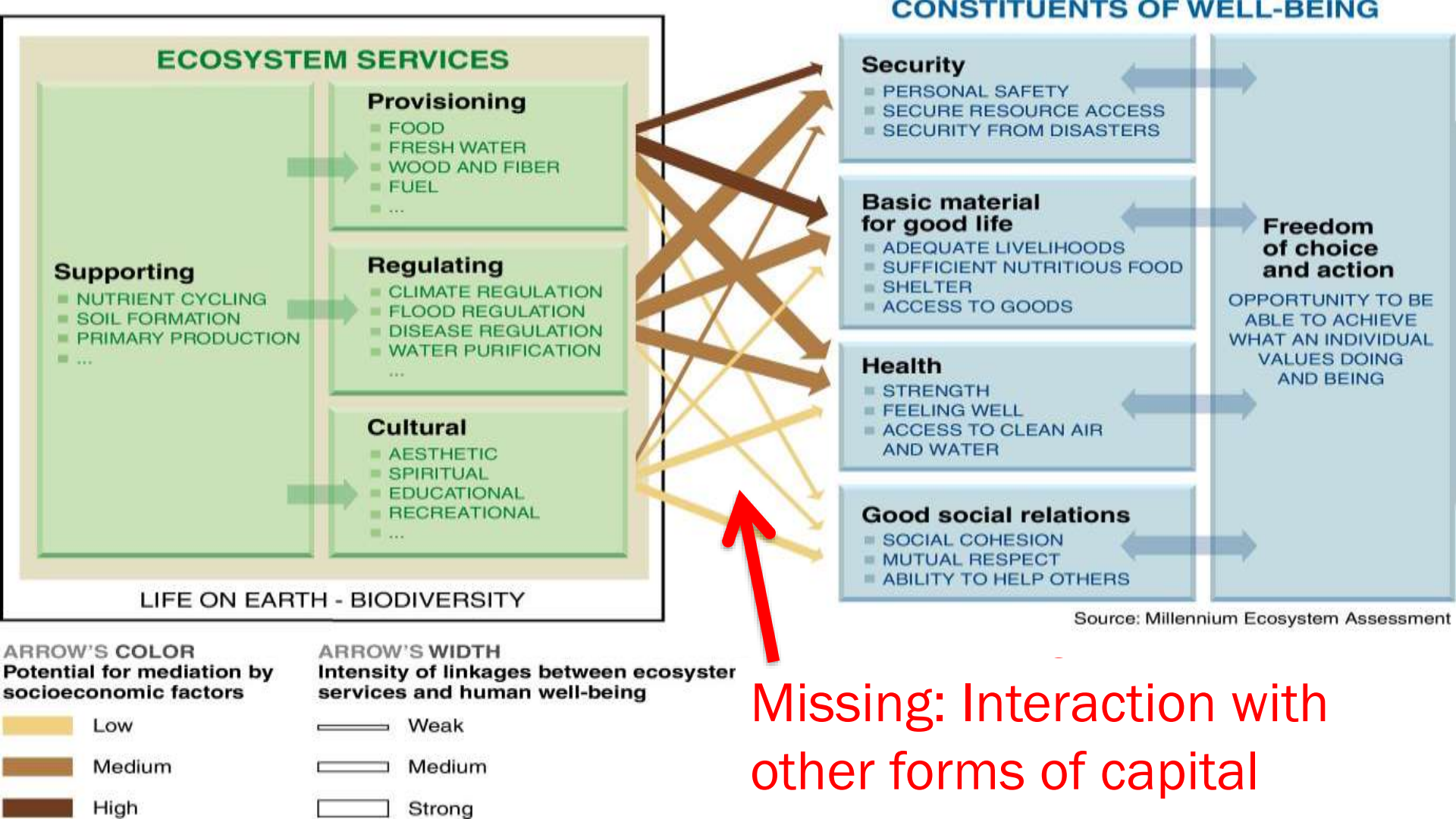
Spatially explicit modelling and gameification of ecosystem services

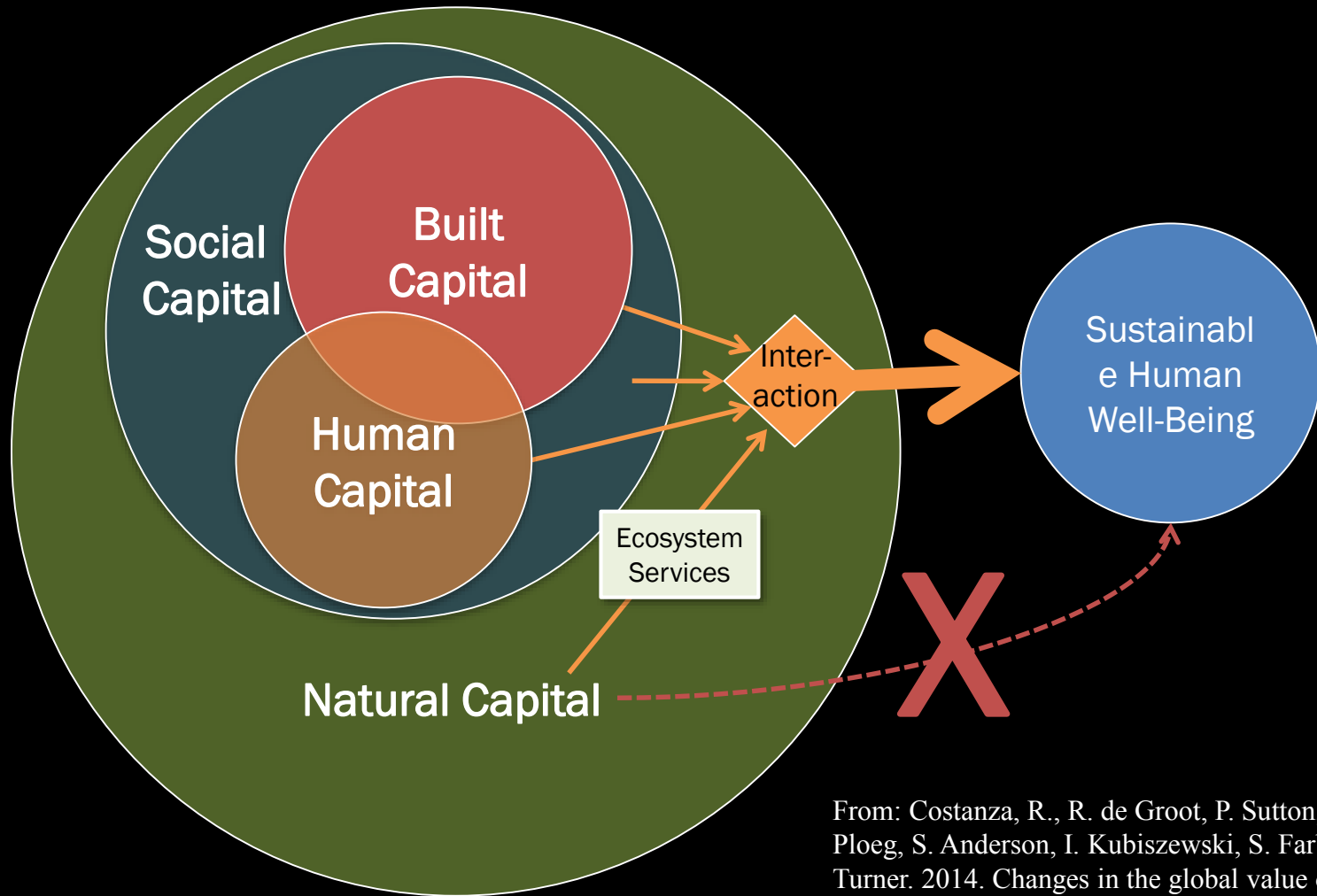
Robert Costanza

- Professor and VC's Chair in Public Policy
Crawford School of Public Policy
Australian National University
Canberra ACT 2601, Australia
- Co-Chair, Ecosystem Services Partnership (ESP)
- Editor in Chief, *Solutions* (www.thesolutionsjournal.org)



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OF PUBLIC POLICY**



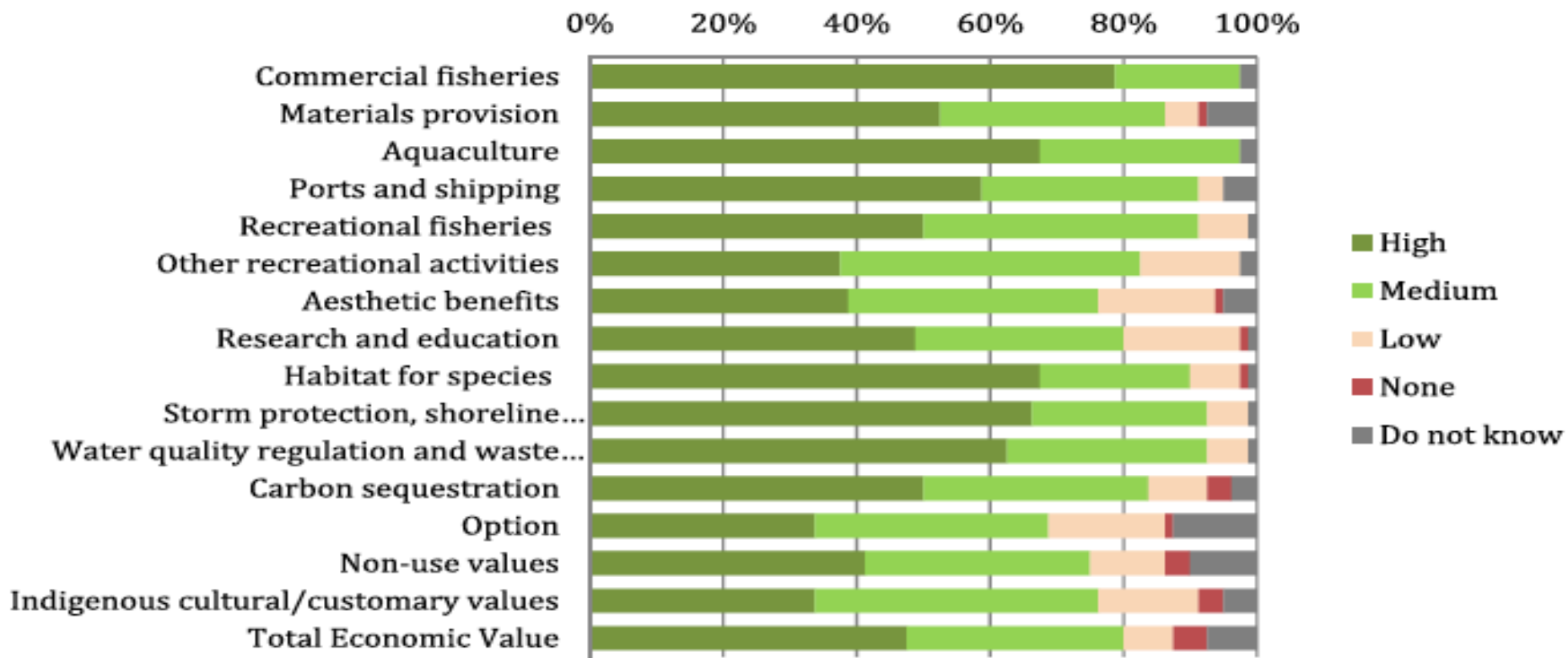


From: Costanza, R., R. de Groot, P. Sutton, S. van der Ploeg, S. Anderson, I. Kubiszewski, S. Farber, and R. K. Turner. 2014. Changes in the global value of ecosystem services. *Global Environmental Change* 26:152-158.

Range of uses for natural capital and ecosystem services valuation

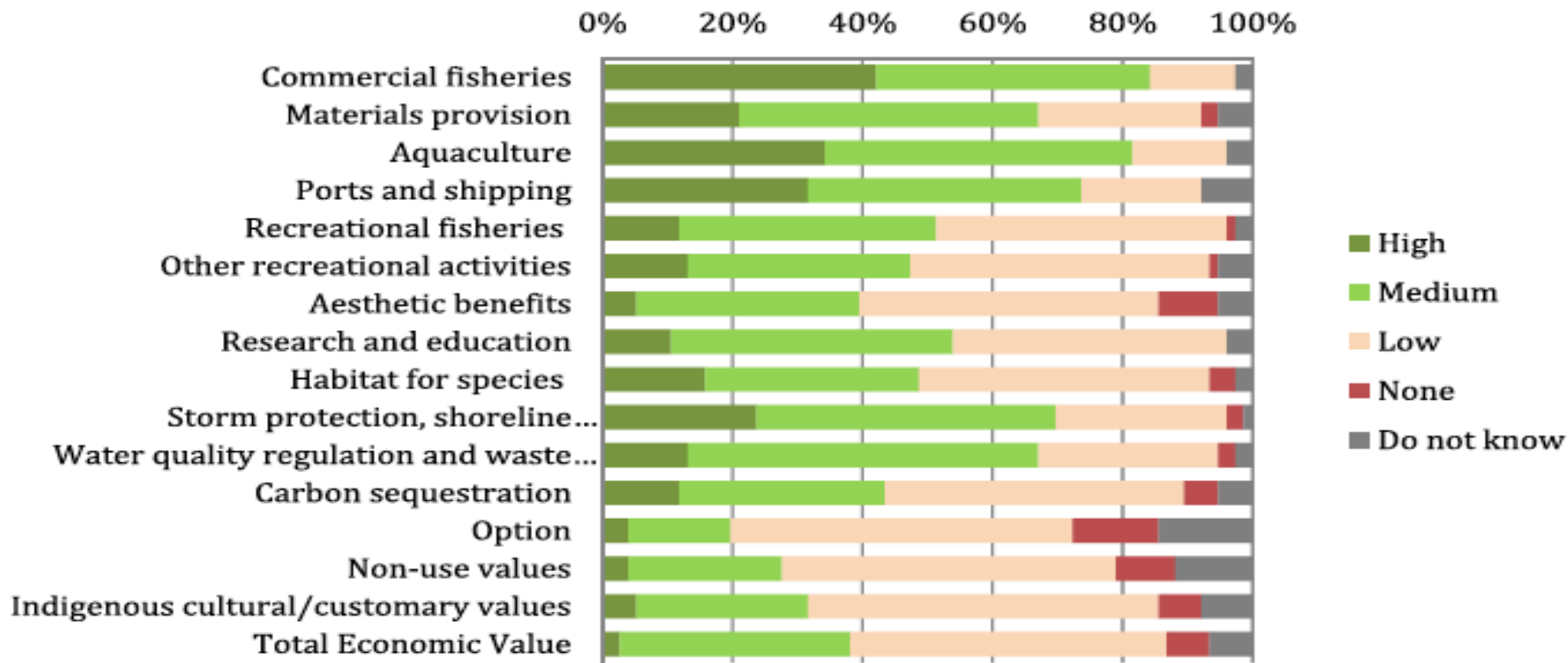
Use of Valuation	Appropriate values	Appropriate spatial scales	Precision Needed
Rising awareness and interest	Total values, macro aggregates	Regional to global	Low
National income and well-being accounts	Total values by sector and macro aggregate	National	Medium
Specific policy analysis	Changes by policy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



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 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

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**



Contents lists available at ScienceDirect

Ecological Modelling

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



Review

A review of methods, data, and models to assess changes in the value of ecosystem services from land degradation and restoration



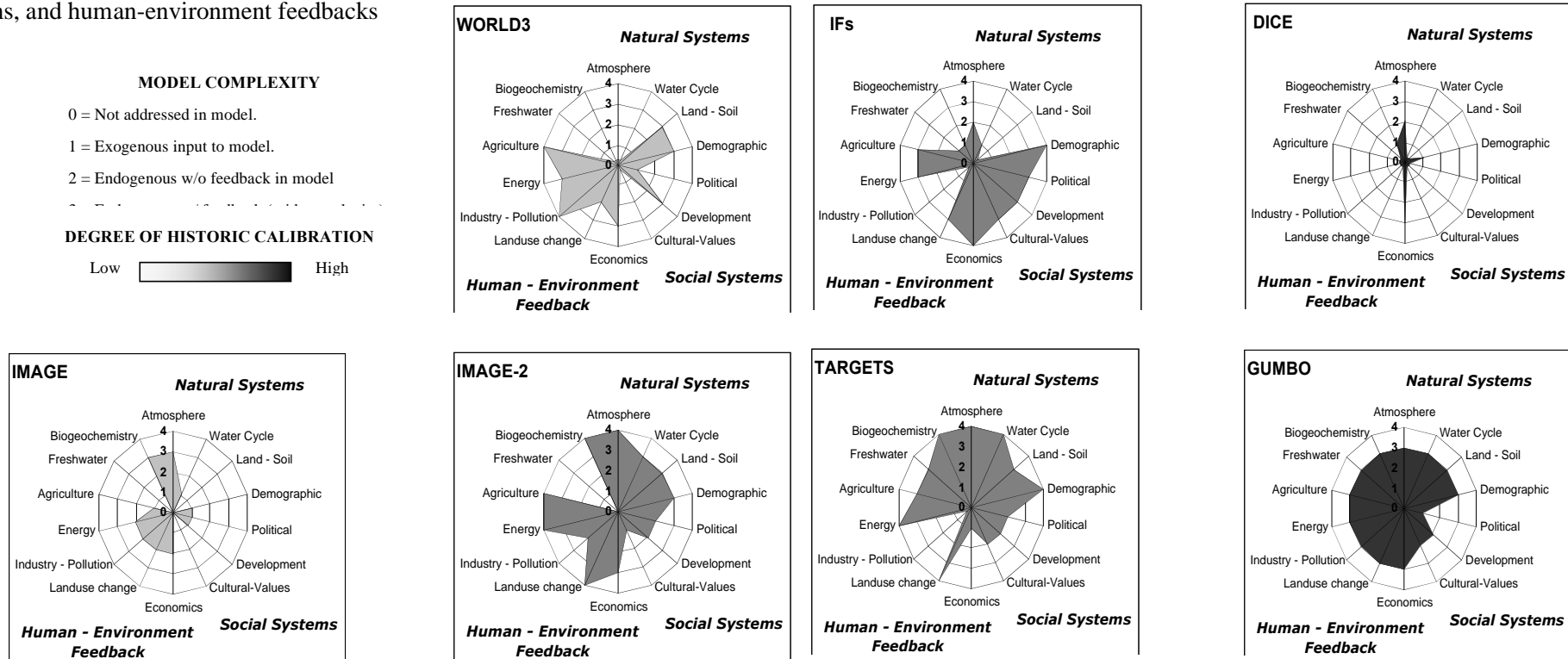
Katrine Grace Turner^{a,b,*}, Sharolyn Anderson^c, Mauricio Gonzales-Chang^d, Robert Costanza^e, Sasha Courville^f, Tommy Dalgaard^a, Estelle Dominati^g, Ida Kubiszewski^e, Sue Ogilvy^e, Luciana Porfirio^h, Nazmun Ratna^d, Harpinder Sandhuⁱ, Paul C. Sutton^c, Jens-Christian Svenning^b, Graham Mark Turner^j, Yann-David Varennes^d, Alexey Voinov^k, Stephen Wratten^d

Model	Scale	Type
CropSyst	Field	Process based model
DNDC	Plot to field	Biogeochemistry computer simulation model in agro-ecosystems
APSIM	Field to farm	Agro-ecosystem process based model
CENTURY	Field to farm	Agro-ecosystem process based model
EPIC	Field to farm	Agro-ecosystem model
APEX	Watershed	Landscape model
DSSAT	Farm to regional	Cropping system model (CSM) Software application program
STICS	Plot to regional	Process based model
LPjml	Global	Dynamic global vegetation models process based
ORCHIDEE	Local to global	Dynamic global vegetation models process based
CARAIB	Regional	Dynamic global vegetation models process based
World3	Global	Integrated global model
IMAGE	Global	Integrated global model
IF	Regional	Integrated global model
TARGETS	Global	Integrated global model
GUMBO	Global	Integrated global model

Representative selection of models to evaluate the effects of sustainable land management. Divided by scale and type.

From: Turner, K. G. et al. 2016. A review of methods, data, and models to assess changes in the value of ecosystem services for land degradation and restoration. Ecological Modelling 319:190–207

Figure 1. Diagram of complexity with which IGMs capture socioeconomic systems, natural systems, and human-environment feedbacks



From: Costanza, R., R. Leemans, R. Boumans, and E. Gaddis. 2007. Integrated global models. Pp 417-446 in: R. Costanza, L. Graumlich, and W. Steffen (eds.). Sustainability or Collapse? An Integrated History and future Of People on Earth. MIT Press. Cambridge, MA.

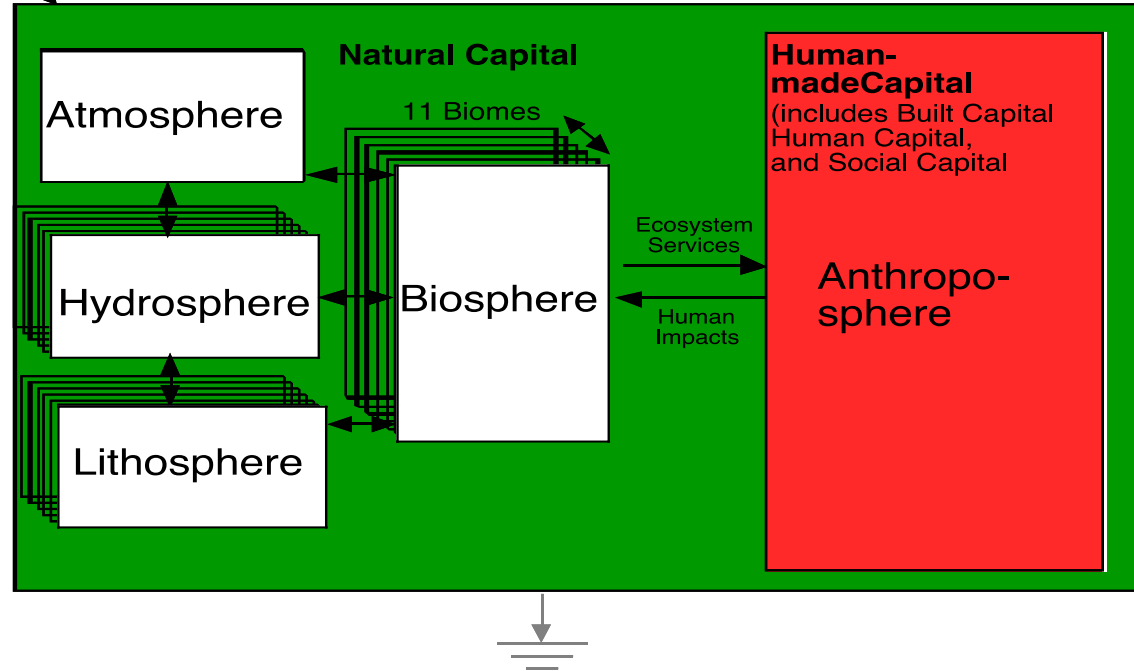
Table 5

A survey of ecosystem services tools (adapted from Bagstad et al., 2013).

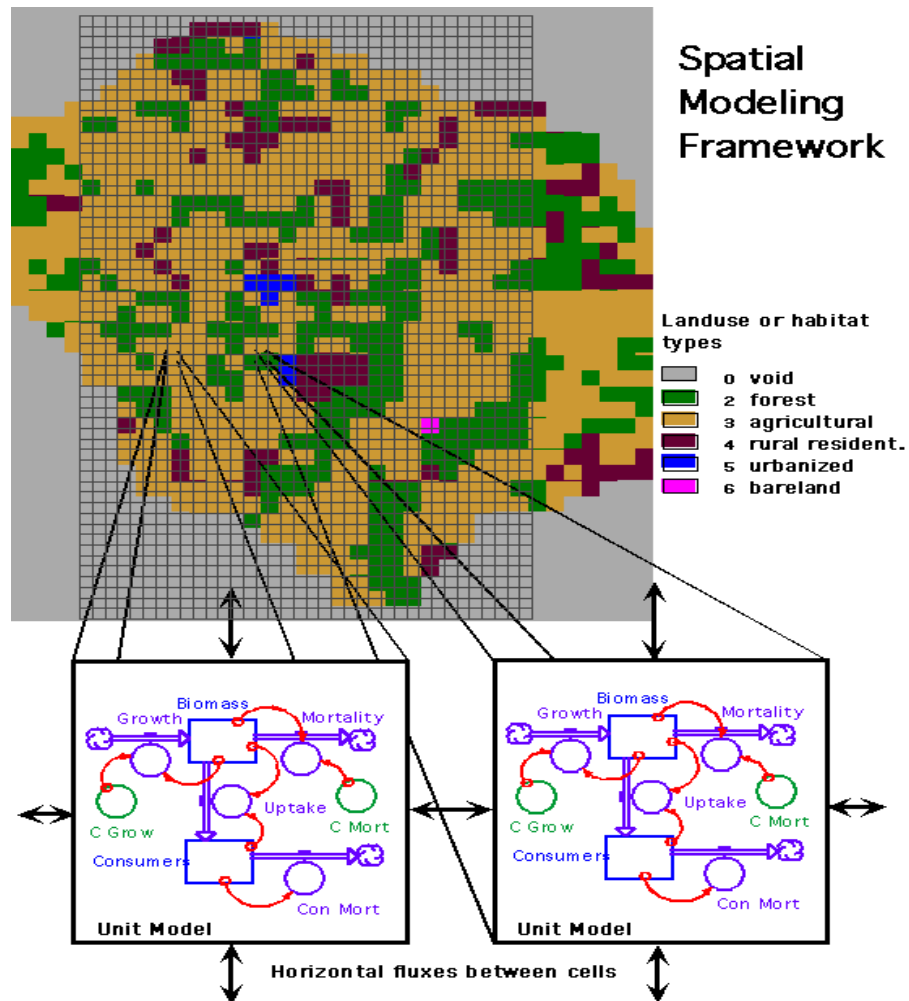
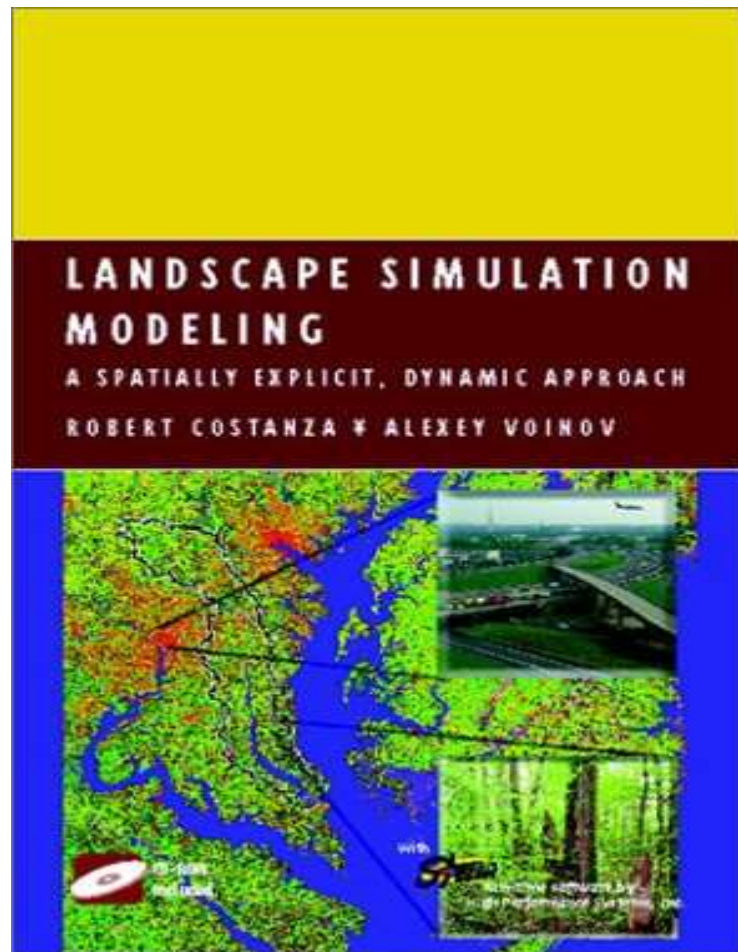
Name	Tool, URL, and references	Brief description
Ecosystem Services Review (ESR)	http://www.wri.org/ , (World Resources Institute (WRI), 2012)	Publicly available, spreadsheet-based process to qualitatively assess ecosystem services impacts
Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST)	http://www.naturalcapitalproject.org , (Kareiva et al., 2011; Tallis et al., 2013)	Open source ecosystem service mapping and valuation models accessed through ArcGIS
Artificial Intelligence for Ecosystem Services (ARIES)	http://www.ariesonline.org (Bagstad et al., 2013; Villa et al., 2011)	Open source modeling framework to map ecosystem service flows; online interface and stand-alone web tools under development
LUCI (formerly Polyscape)	http://www.polyscape.org (Jackson et al., 2013)	Open source GIS toolbox to map areas providing services and potential gain or loss of services under management scenarios
Multiscale Integrated Models of Ecosystem Services (MIMES)	http://www.afordablefutures.org	Open source dynamic modeling system for mapping and valuing ecosystem services
EcoServ	Feng et al. (2011)	Web-accessible tool to model ecosystem services
CoSting Nature	http://www1.policysupport.org/cgi-bin/ecoengine/start.cgi?project=costingnature	Web-accessible tool to map ecosystem services and conservation priority areas
Social Values for Ecosystem Services (SoIVES)	http://solves.cr.usgs.gov (Sherrouse et al., 2011)	ArcGIS toolbar for mapping social values for ecosystem services based on survey data or value transfer
Envision	http://envision.bioe.orst.edu , (Guzy et al., 2008)	Integrated urban growth-ecosystem services modeling system; has used external models, including InVEST, or created new ecosystem service models as appropriate
Ecosystem Portfolio Model (EPM),	http://geography.wr.usgs.gov , (Labiosa et al., 2013)	Web-accessible tool to model the impacts of alternative land uses on economic, environmental, and quality of life
InFOREST	http://inforest.frec.vt.edu/	Web-accessible tool to quantify ecosystem services in Virginia
EcoAIM	Waage et al. (2011)	Proprietary tool for mapping ecosystem services and stakeholder preferences
ESValue	Waage et al. (2011)	Proprietary tool for mapping stakeholder preferences for ecosystem services
EcoMetrix	http://www.parametrix.com (Parametrix, 2010)	Proprietary tool for measuring ecosystem services at site scales using field surveys
Natural Assets Information System (NAIS)	http://www.sig-gis.com , (Troy and Wilson, 2006)	Proprietary valuation database paired with GIS mapping of land-cover types for point transfer
Ecosystem Valuation Toolkit	http://www.esvaluation.org (Ecosystem Valuation Toolkit, 2012)	Subscription-based valuation database paired with GIS mapping of land-cover types for point transfer
Benefit Transfer and Use Estimating Model Toolkit	http://www.defenders.org (Loomis and Rosenberger, 2006)	Publicly available spreadsheets, use function transfer to value changes in ecosystem services in the U.S.

Solar
Energy

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



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

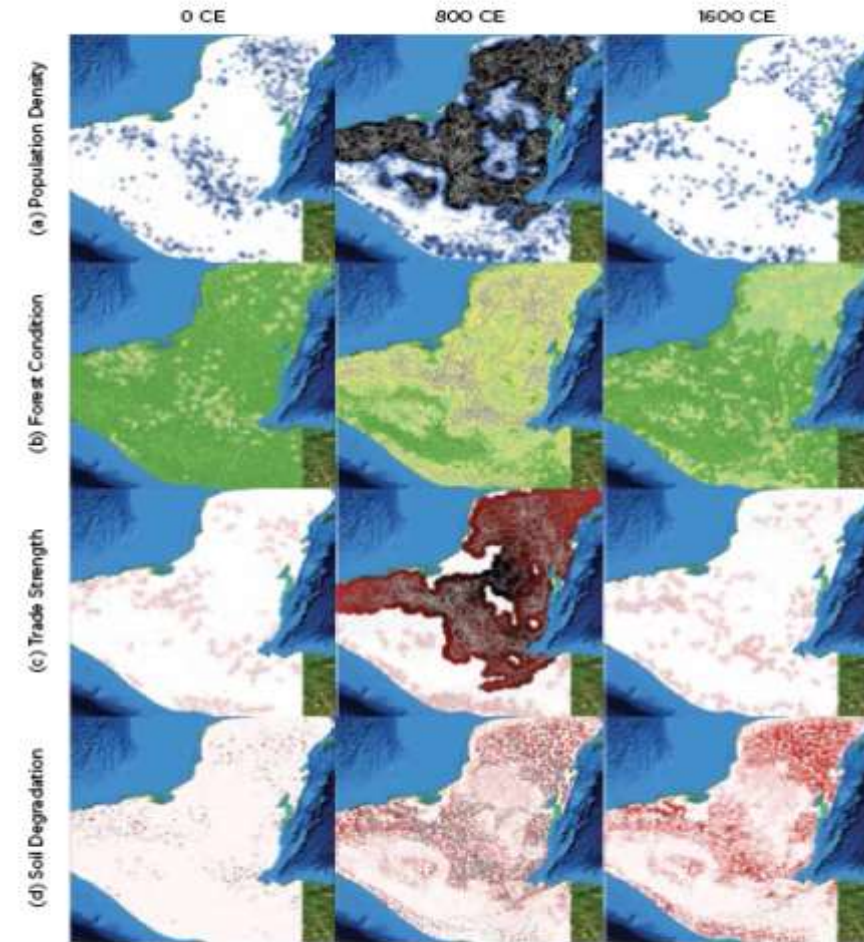
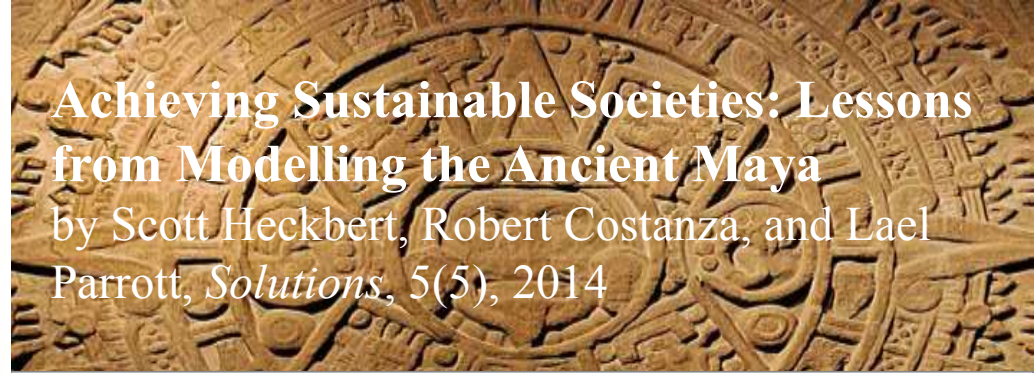


Figure 1. Darker colouring shows increased a) population density (blue), b) forest condition (three states of cleared/cropped (yellow), secondary regrowth (light green) and climax forest (dark green), c) trade strength (red), and d) soil degradation (red).



Achieving Sustainable Societies: Lessons from Modelling the Ancient Maya

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

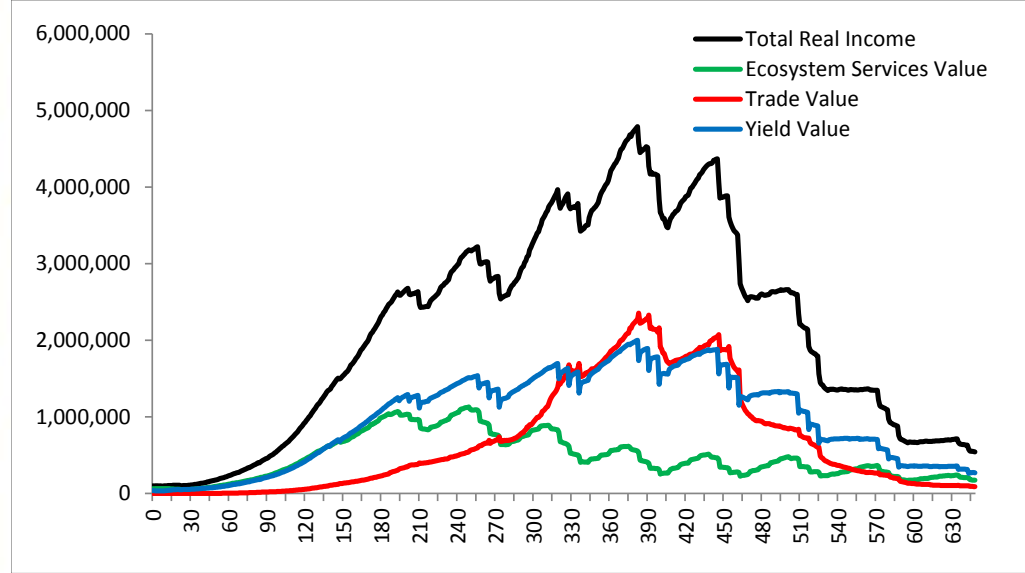
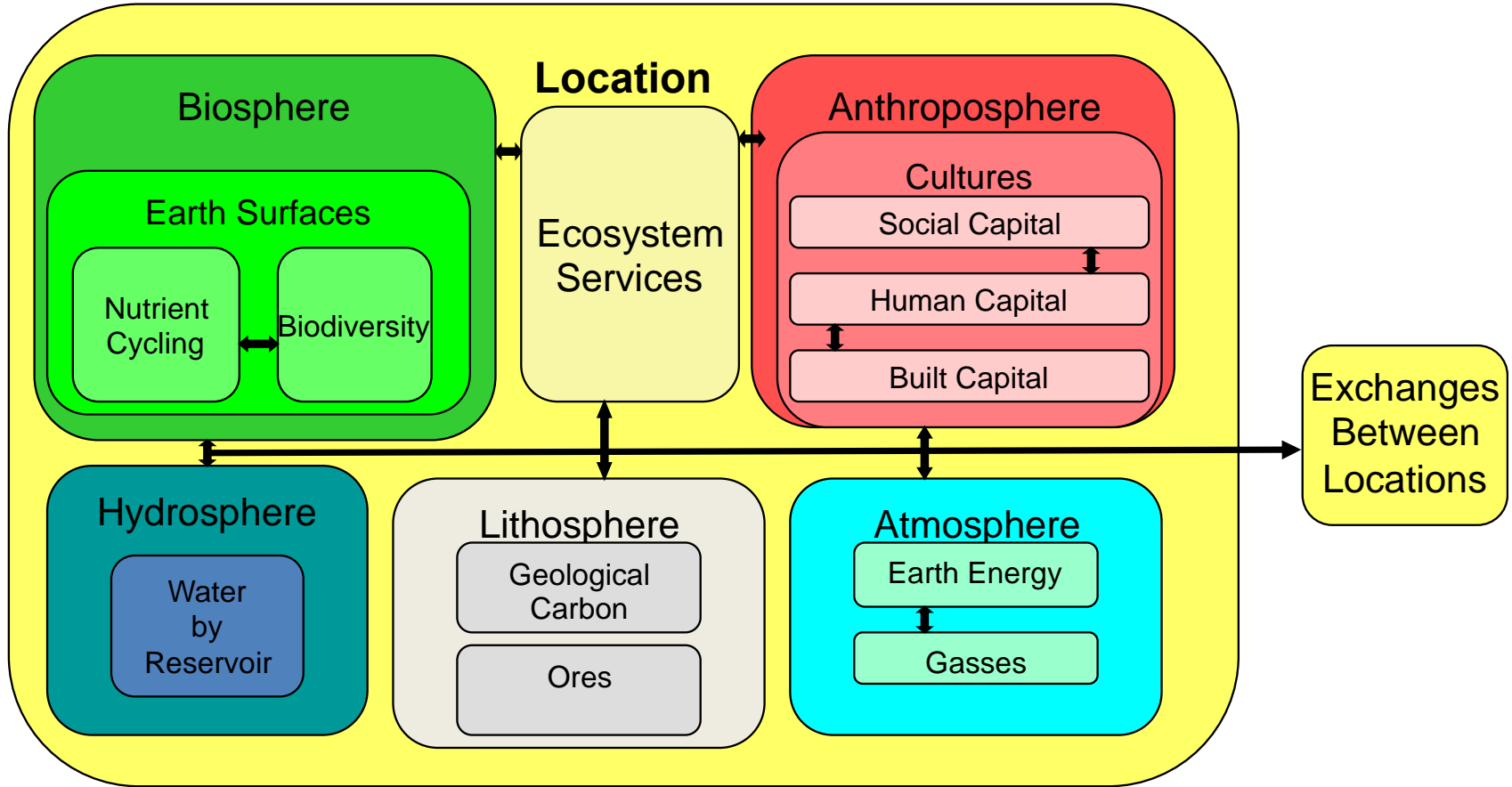


Figure 6: Real income of all simulated settlements over time by contributions from agriculture, ecosystem services, and trade value. Ecosystem services is eventually superseded by agriculture, and both by trade around time step 350.

MIMES

Multi-scale Integrated Models of Ecosystem Services





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Natural value



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What is Natural Value?

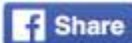
Ecosystems are made up of billions of living plant, animal and microbe species interacting with each other and their environment (e.g. air, water, mineral soil). They're important to humans because they:

- Provide food, fibre and fuel (such as from biomass);
- Regulate climate and rainfall;
- Purify water, control soil erosion and regulate natural hazards,;
- Provide recreation, tourism and educational services; and
- Provide the conditions for photosynthesis, nutrient and water cycling and other processes

All companies are dependent on ecosystem services, either through their supply chains, around their operating sites or via their customers. There is a growing global recognition of the importance of natural capital to the health and wellbeing of the economy.

Part of managing natural capital involves putting an economic value on ecosystem services and the natural environment. In other words, recognising the impacts and dependencies of biodiversity and ecosystem services and accounting for them within traditional business frameworks. In light of this growing recognition, we reviewed our Environmental Agenda in 2011 and added a third pillar, Natural Value - our term for considering the value of natural capital,

Ken Henry on advancing Australia's Natural Capital



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

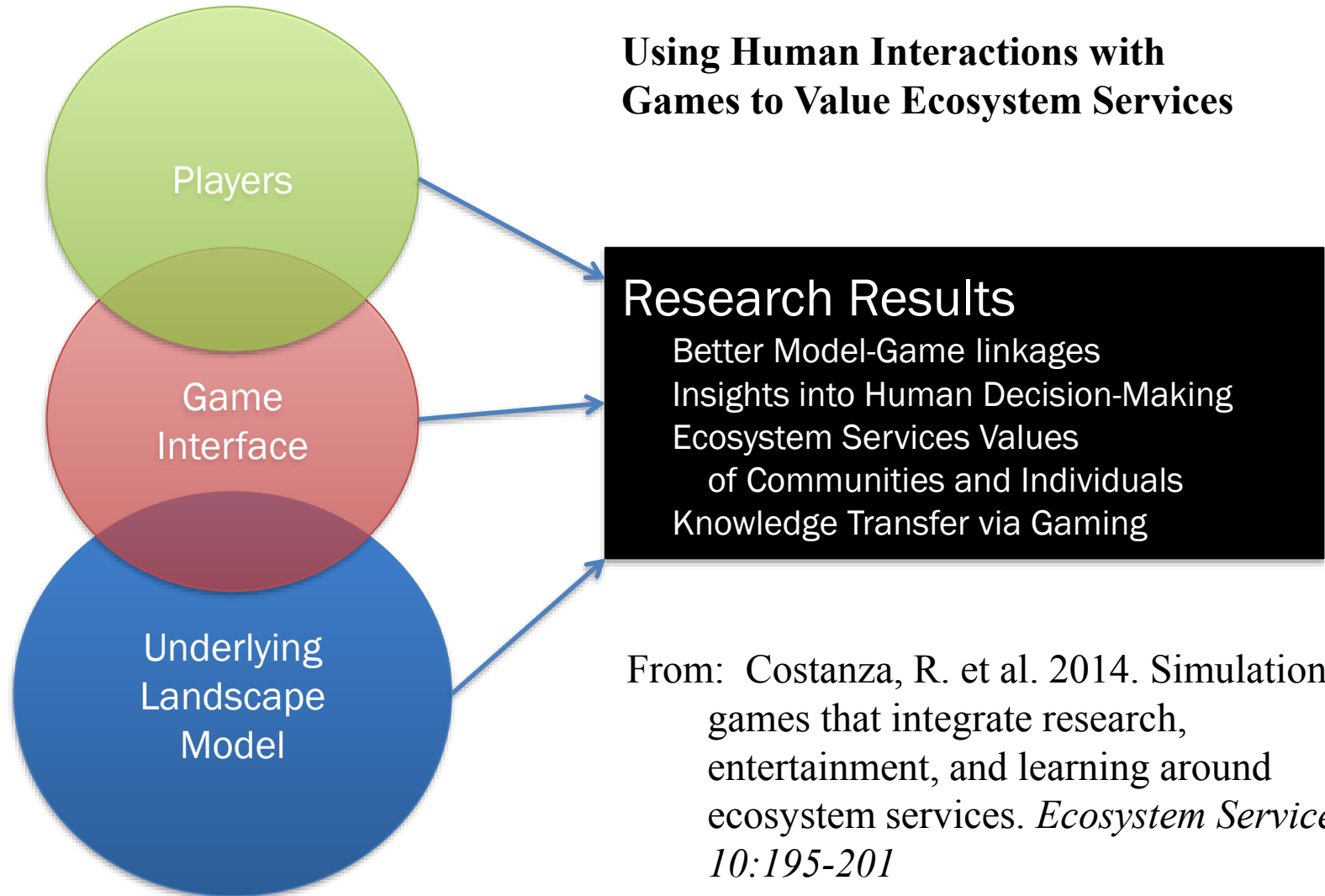
- if you have invested in your built capital – your pumps will be working,
- if you've invested in your human capital, you'll have staff to operate your machinery and the know-how to run your business commercially,
- and if you've taken care of your natural capital – managed your weeds, your water retention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

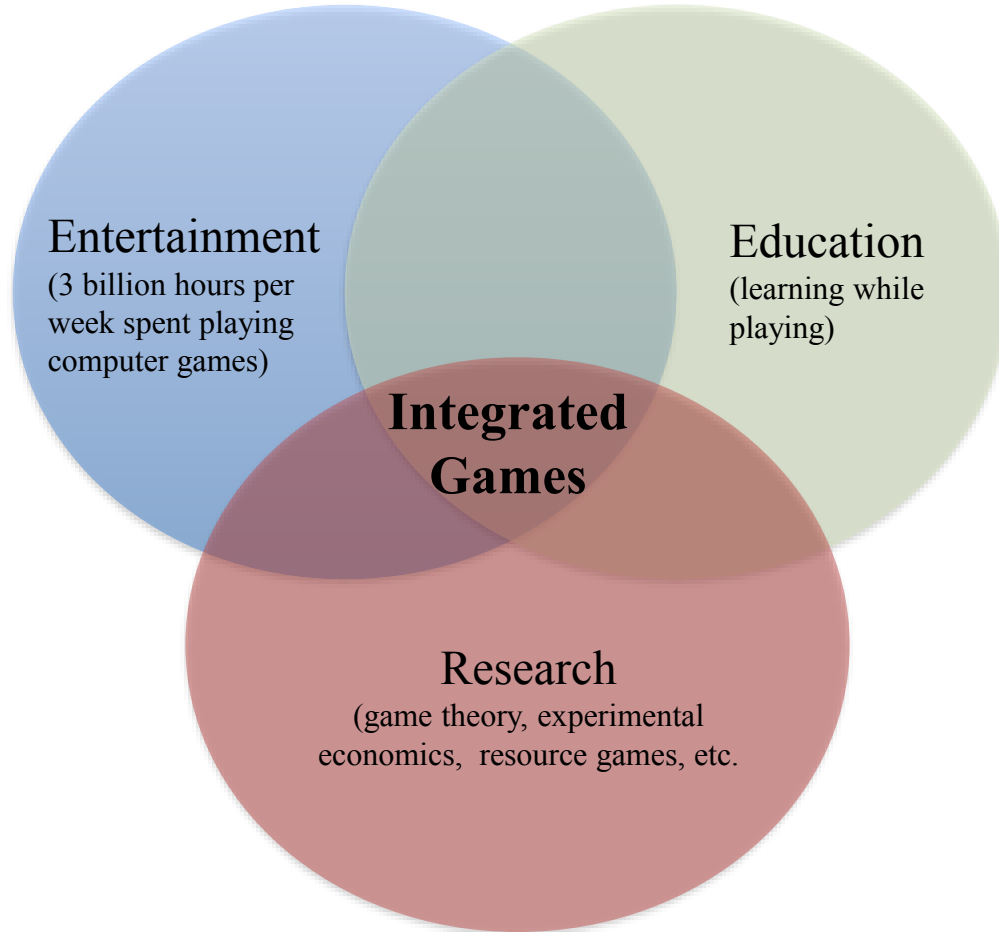
Natural capital is not a footnote in a business plan, it is a core asset on the balance sheet. That's true for an individual business; and it is true also for the nation."

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

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

Using Human Interactions with Games to Value Ecosystem Services





Uses of Games

From: Costanza, R. et al.
2014. Simulation
games that integrate
research,
entertainment, and
learning around
ecosystem services.
Ecosystem Services
10:195-201



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Planetary Boundaries—Governing Emerging Risks and Opportunities

Volume 7 | Issue 3 | Page 45-52 | May 2015

By Victor Galaz, Aart de Zeeuw, Hideaki Shirokuma, Debbie Tripley

The notion of planetary boundaries attempts to define a safe operating space within which humanity can flourish. The boundaries relate to climate change, change in biosphere integrity (i.e. biodiversity loss and species extinction), stratospheric ozone depletion, ocean acidification, biogeochemical flows, land-system change, freshwater use, ...

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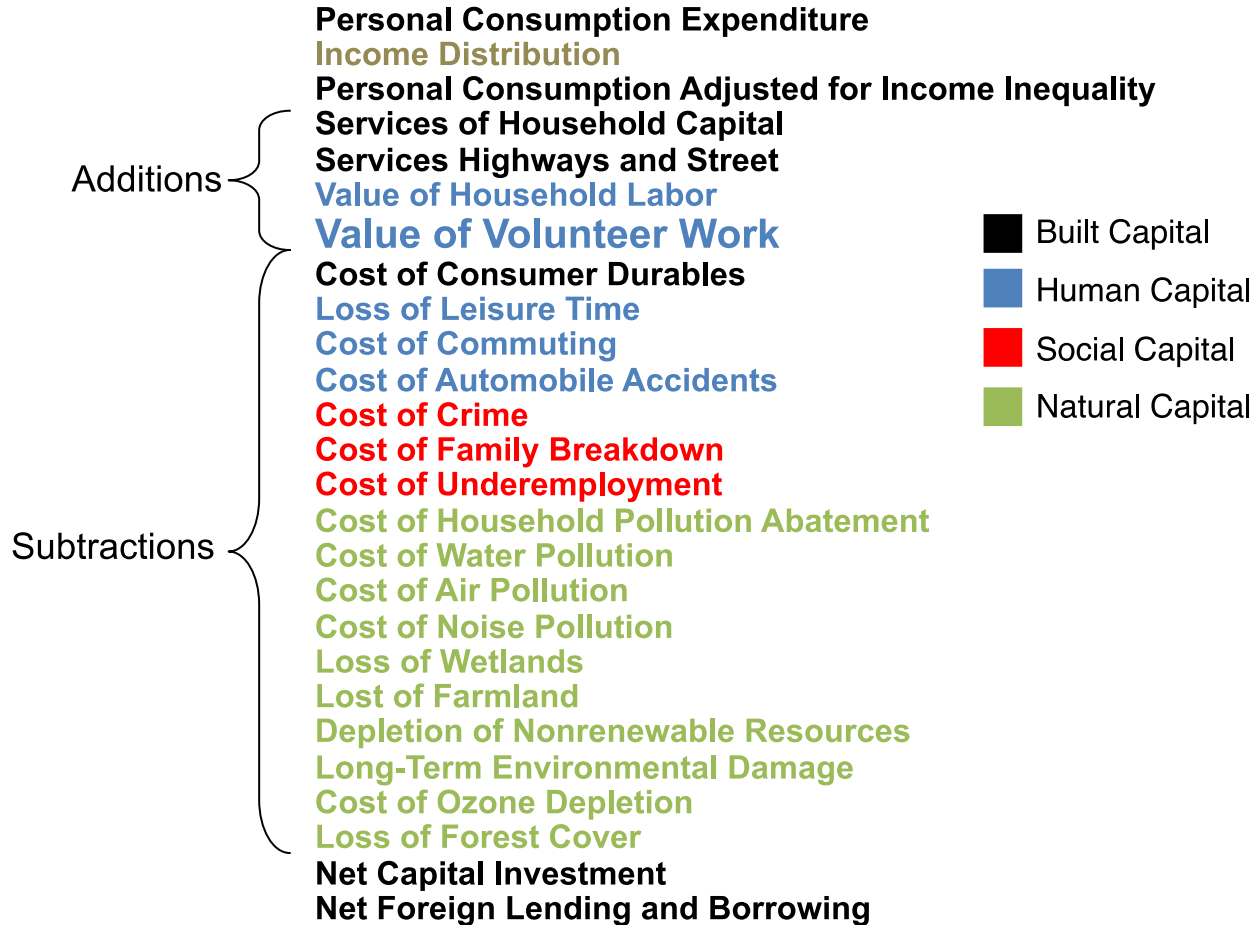




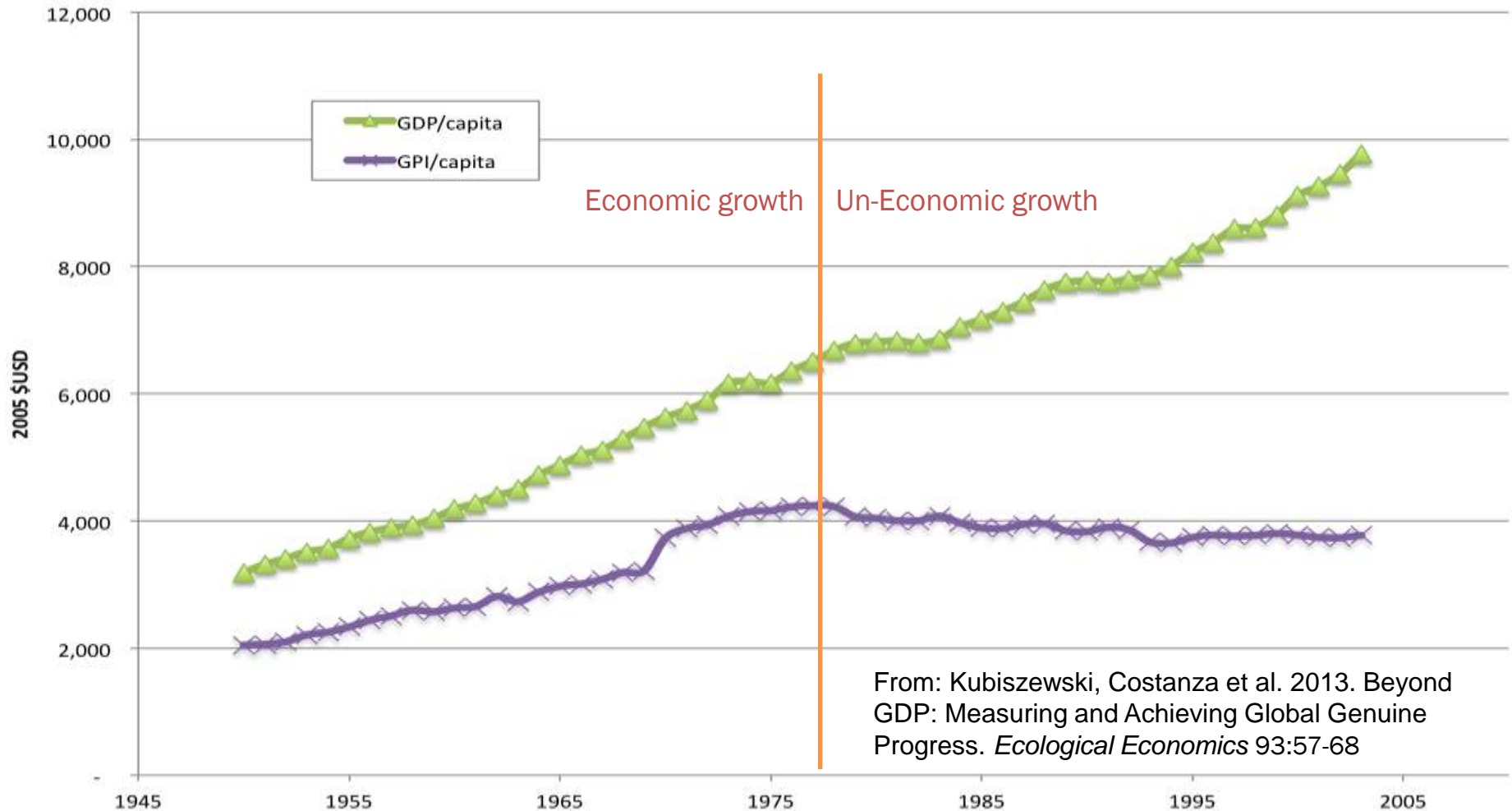
Time to leave GDP behind

Gross domestic product is a misleading measure of national success. Countries should act now to embrace new metrics, urge **Robert Costanza** and colleagues.

Genuine Progress Indicator (or ISEW) by Component



Global GPI/capita & GDP/capita



GPI 2.0

<u>Economic Categories</u>	<u>Environmental Categories</u>	<u>Social Categories</u>
Household Budget Expenditures	Services from natural capital	Services from human capital
Defensive Expenditures	Depletion of natural capital	Services from social capital
Household Investments	Costs of pollution	Social costs of economic activity
Income Inequality		
Public Provisioning		
Services from built capital		



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