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A GPI-Based Critique of "The Economic Profile of the Lower Mississippi River: an Update"

Eric Zencey
University of Vermont

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Eric Zencey, Ph.D.[1]

The Genuine Progress Indicator, or GPI, is an alternative economic indicator that seeks to measure net economic welfare—the economic welfare that is gained by economic activity after the costs of producing that welfare (such as the costs of air pollution, water pollution, resource depletion, climate change, and the like) are deducted. From a GPI perspective, the economy of the LMR Corridor is not nearly as robust as traditional modes of economic analysis would suggest. There are clear paths to increasing GPI (and human economic wellbeing) that have implications for environmental and river-management policy.

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[1] Fellow, Gund Institute for Ecological Economics; Coordinator, Vermont GPI Project; Adjunct Research Associate Professor, Political Science, University of Vermont; Visiting Lecturer, Environmental Studies, Washington University in St. Louis

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Introduction

The recently released report, "The Economic Profile of the Lower Mississippi River: an Update," prepared by Industrial Economics, Incorporated and Dominika Dziegielewska-Parry (hereinafter "the Report" or "LMR Report") is an ambitious, detailed, and thoroughly referenced treatment of its subject matter.[2] Within the confines of traditional economic analysis, the Report is well suited to fulfilling its goal of informing the public and policy makers about the relative significance of key sectors of the (human) economy of the Lower Mississippi River (LMR) Corridor—the counties along and through which the main stem of the Lower Mississippi River passes.

But human economic behavior based on traditional modes of economic analysis has not been kind to the Lower Mississippi River. A few facts illustrate the troubled state of the river's present condition:

- According to a 1998 report prepared by the US Geological Survey, "Evidence is mounting that the cumulative effects of human activities [along the Mississippi River] have already exceeded the ecosystem's assimilative capacity."[3]
- Problems documented by the USGS report include the decline and loss of native species, the rise of invasive species, and the irony that "sediment deficiency is aiding in habitat destruction in Louisiana's coastal zone" while "sediment deposition is threatening to destroy aquatic habitats in the

[2] Industrial Economics, Incorporated and Dominika Dziegielewska-Parry, "The Economic Profile of the Lower Mississippi River: An Update," commissioned by the Lower Mississippi River Conservation Committee, February 2014, accessed October 3, 2015 from http://www.lmrcc.org/wp-content/uploads/2014/02/LMR_Economic_Profile_February2014.pdf

[3] Mac, M. J., P. A. Opler, C. E. Puckett Haecker, and P. D. Doran. 1998. Status and trends of the nation's biological resources. 2 vols. U.S. Department of the Interior, U.S. Geological Survey, Reston, Va. Retrieved from http://www.nwrc.usgs.gov/sandt/SNT.pdf

impounded Upper Mississippi River." None of these conditions has met with successful resolution since this diagnosis.

- While agriculture in the river's fertile bottom lands is, as the LMR Report notes, the third largest revenue-producing sector in the LMR Corridor's human economy, and while "arguably the most important factor" in the success of that agriculture is the richness of the alluvial soil deposited by the river (Report, p. 6-1), dams and locks have diminished the amount of soil-building sediment transported by the River by more than 70 percent since 1850. Sediment loss and flood prevention have starved soils (and the non-human economy of the LMR Corridor in general) of needed nutrients and building material. Agriculture must thus rely on unsustainably sourced fertilizer or on unsustainable draw-down of soil fertility (a.k.a. "soil mining").[4]
- A 2010 assessment of the toxins transported by the Mississippi River found that 12.7 million pounds of toxic chemicals (including nitrates, arsenic, benzene and mercury) were dumped into the river that year.[5]
- Every day the Mississippi River delivers 140,000 pounds of soap-sourced chemical surfactants into the Gulf of Mexico—coincidentally, the amount that BP sprayed daily on the oil slicks created by the Deepwater Horizon blowout—with an unknown but certainly detrimental effect.[6]
- Decades of ecologically oblivious management of the river have brought the river's delta, and the coastal ecosystems dependent on it, to the brink of ecological collapse.[7] Sediment deprivation has contributed to the loss of 2,300 square miles of deltaic ecosystem since 1930. Louisiana continues to lose land at the estimated rate of one football field per hour. This loss imposes costs and risks on humans that traditional modes of economic analysis rarely point to and cannot systematically register.[8]

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[4] The term "soil mining" to describe the practice by which carbon energy and/or necessary nutrients are taken out of the soil through harvest faster than natural processes can replace them was coined by Edward Hyams in his classic work *Soil and Civilization* (1952, Thames and Hudson, London).

[5] Blythe Bernhard, "Mississippi River is second-most polluted U.S. waterway," *St. Louis Post Dispatch,* March 22, 2012. Accessed 10/21/15 at http://www.stltoday.com/lifestyles/health-med-fit/health/health-matters/mississippi-river-is-second-most-polluted-u-s-waterway/article_bce8579e-7449-11e1-9b27-001a4bcf6878.html

[6] Mark Schleifstein, "Mississippi River pours as much dispersant into the Gulf of Mexico as BP," *The Times Picayune,* New Orleans, August 5, 2010, retrieved October 14, 2015 from http://www.nola.com/news/gulf-oil-spill/index.ssf/2010/08/mississippi_river_pours_as_muc.html

[7] "Army Corps of Engineers 'Actively Managing Collapse' of Mississippi River Delta Ecosystem," 2009, Press release by National Wildlife Federation and Environmental Defense Fund Staff, retrieved October 10, 2015 from https://www.nwf.org/News-and-Magazines/Media-Center/News-by-Topic/Wildlife/2009/11-23-09-Army-Corps-of-Engineers-Actively-Managing-Collapse-of-Mississippi-River-Delta-Ecosystem.aspx

[8] Kenneth J. Bagstad, Kevin Stapleton, and John R. D'Agostino, "Taxes, Subsidies, and Insurance as Drivers of United States Coastal Development," *Ecological Economics*, Ecological Economics of Coastal

- Coastal wetlands provide storm protection, absorbing storm surges at a rate approximating one foot of absorbed surge per 2.7 miles of wetlands.[9] Had coastal Louisiana not lost a 50-mile-wide band of bayou from sediment deprivation and ecologically oblivious development, Hurricane Katrina's 14-foot storm surge would have been diminished considerably before its arrival at New Orleans. Katrina caused approximately 1000 deaths and did an estimated $82 billion in damage in New Orleans alone. In none of the economic development plans (public or private) that led to the loss of coastal wetlands were their storm protection services considered. Ironically, as storm damage (a cost) is repaired, the GDP of the affected area goes up, showing the loss as a benefit.
- As noted, in the absence of soil replenishment by annual flooding, agricultural productivity in the LMR Corridor is maintained through large-scale application of unsustainably sourced (fossil-fuel-based) fertilizers.[10] Production of this fertilizer contributes to climate change, which imposes costs on society—including many costs not counted by traditional economic analysis. Again ironically, traditional modes of economic analysis register increased use of fertilizer as a gain, since the costs of producing and shipping the fertilizer contribute to GDP. For instance, the Report specifically mentions (9-6, fn.) that increased fertilizer shipments are partially responsible for record-setting cargo volumes in the ports of South Louisiana—economic activity that registers in the Report as a benefit, not a cost.
- Intensive fertilizer use in the UMR and LMR Corridors is the main contributor to the development and growth of a hypoxic dead zone in the Gulf of Mexico.[11] The National Oceanic and Atmospheric Administration estimates that this seasonal dead zone, which this year exceed the size of the state of Connecticut, costs the nation's seafood and tourism industries $82 million a year, nearly certainly an underestimate.[12] No part of this cost is reflected in traditional modes of economic analysis. If and when money is spent to remediate it, the cost will register as a gain in the region's GDP.

DisastersCoastal Disasters Special Section, 63, no. 2–3 (August 1, 2007): 285–98, doi:10.1016/j.ecolecon.2006.09.019.

[9] Corps of Engineers, US Army Engineer District, New Orleans, Interim Survey Report, Morgan City, Louisiana and Vicinity, serial no. 63, US Army Engineer District, New Orleans, LA (November 1963).

[10] William E. Rees, "The Eco-Footprint of Agriculture: A Far-from-(Thermodynamic) Equilibrium Interpretation," accessed October 21, 2015, http://nabc.cals.cornell.edu/Publications/Reports/nabc_16/16_3_2_Rees.pdf.

[11] "Gulf of Mexico Dead Zone | The Nature Conservancy," accessed October 18, 2015, http://www.nature.org/ourinitiatives/regions/northamerica/areas/gulfofmexico/explore/gulf-of-mexico-dead-zone.xml.

[12] Contributing Op-Ed columnist, "Louisiana Shrimp Season Threatened by US Ethanol Policy: Larry McKinney," *NOLA.com*, June 16, 2014, http://www.nola.com/opinions/index.ssf/2014/06/louisiana_shrimp_season_threat.html.

Clearly, something is bedeviling us, generating paradox. Some parts of the LMR Corridor economy appear to be systematically poisoning, degrading, even annihilating the foundation of other parts of that economy. Expenses that should be counted as costs are ignored or mistakenly counted as benefits. By standard measures the economy of the LMR Corridor is apparently healthy, even setting historical records, yet the river itself is disturbingly sick.

Diagnosing Paradox

Policy based on a continuation of the economic thinking that produced these paradoxes is unlikely to achieve its intended object, the maintenance of a thriving human economy grounded in an ecologically healthy LMR Corridor. Life and earth sciences tell us the river is in crisis. If that crisis is ignored or handled ineffectively, the continued deterioration of the river's ecosystems will lead to a further loss in their ability to provide ecosystem services to the human economy. Those losses, however incremental, are likely to arrive at various tipping points, points at which gradual deterioration becomes sudden and traumatic loss. Such losses of ecosystem function would have a large and detrimental effect on the human economy of the LMR Corridor.

Policy based on a continuation of the economic thinking of the past is unlikely to achieve its intended object, the maintenance of a thriving human economy grounded in an ecologically healthy LMR Corridor.

Three factors explain the paradoxes that rise to the surface from within the LRM report.

First, as ecologists have long noted, time lags between ecological degradation and the impact of that degradation on human economies make diagnosis of ecological crisis difficult.[13] It is indeed possible to have a thriving human economy that degrades the ecosystems that are its foundation; this is the very definition of an unsustainable economy, an economy that cannot last. In the history of unsustainable economies, our petroleum-fuelled version stands out for being more intensely (and therefore more briefly) unsustainable than others.[14] Many observers see the transition-crisis happening well within the lifetimes of those alive today. [15]

[13] Raudsepp-Hearne et al., "Untangling the Environmentalist's Paradox: Why is Human Well-being Increasing as Ecosystem Services Degrade?" 2010. *BioScience* 60:8, 576-589.
[14] Jared M Diamond, *Collapse: How Societies Choose to Fail or Succeed* (New York: Viking, 2005).
[15] Among the numerous sources elaborating this point of view, see Ehrlich and Ehrlich, 2013, "Can a collapse of global civilization be avoided?", *Proceedings of the Royal Society,* 280:1754, March, retrieved from http://rspb.royalsocietypublishing.org/content/280/1754/20122845.short ; Richard Heinberg, 2010. *Peak Everything: Waking Up to a Century of Declines*. New Society Publishers.

On the positive side, the time lag between ecological degradation and its economic impact provides human members of ecosystems the opportunity to begin to react appropriately before the full onset of economic crisis.

Second, although the Report describes itself as "evaluating the economic significance of ten key 'river-related' economic sectors" (ES-1), it does not in fact describe the riparian economy of the LMR Corridor. Instead, it describes the human economy of the counties through which the Lower Mississippi River happens to pass. This is no mere semantic quibble. While some economic activity detailed in the Report can be seen as benefitting directly from ecosystem services provided by the river (transport by barge, river-related recreation and tourism, etc.), and while the Report does acknowledge the existence of ecosystem services related to the river, much of the economic activity described in the Report has little to nothing to do with the river. Farming, for instance, is accomplished in a wide variety of places in the world, and if farming in the LMR Corridor doesn't benefit from the replenishment of soil fertility that the river once afforded—if instead it is dependent on artificial fertilizers--it is in that regard a placeless activity that could be happening anywhere. As long as petroleum is available in sufficient amounts, a placeless, petroleum-dependent agriculture that abuts a major river can thrive even as the river and its ecosystems sicken unto death.

Third, and most importantly, the Report analyzes the human economy in the LMR Corridor according to traditional measures and metrics that are incomplete, misleading, and just plain wrong-headed. The chief problem is the Report's reliance on Gross Domestic Product, GDP, as the primary measure by which economic activity is assessed.

The remainder of this document will elaborate this criticism.

Gross Domestic Product and its Shortcomings

In 1991, the U.S. Department of Commerce's Bureau of Economic Analysis started compiling GDP, Gross Domestic Product, a measure of the dollar value of all goods and services produced in the United States within a given time period. GDP replaced GNP, Gross National Product, which measured the dollar value of all goods and services produced by American citizens no matter where they resided. (GDP is conceptually cleaner as a measure of the size of the domestic economy.) GNP, in turn, dates to the Depression, when policy makers found themselves at a loss to know the scope of the economic problem they faced, since there were no macroeconomic statistics available at all. (Research economist William Nordhaus has said that economists were reduced to counting boxcar loadings to estimate the level of economic activity in a region.[16]) Congress authorized Simon Kuznets, a

[16] Jon Gertner, "The Rise and Fall of the G.D.P.," *New York Times Magazine,* May 30, 2010. accessed October 20, 2015, http://www.nytimes.com/2010/05/16/magazine/16GDP-t.html.

prominent economist, to lead an ad hoc group of economists and statisticians in the development of an indicator of economic activity.

The group produced the first concrete measure of the size of the U.S. economy and inaugurated the field of national income accounting. Its chief accomplishment, GDP (nee GNP) has been widely adopted around the world. But in his first report of the Gross National Product to Congress, Kuznets issued this caution about misuse of the statistic: "The welfare of a nation [can] scarcely be inferred from a measure of national income." Kuznets knew what most businesspeople know: as a gauge of economic wellbeing, income alone is worthless. To judge economic wellbeing you have to look at net gains, not gross revenues. GNP and GDP are, as their names clearly indicate, measures of gross economic activity, not net economic benefit. Neither is in any sense an approximation of general economic welfare. Most economics textbooks acknowledge this and most include something like Kuznets' caution about misusing GDP.

Non-economists, too, have expressed reservations about over-reliance on GDP as a metric describing our wellbeing (see text box).

GDP measures everything -- "except that which makes life worthwhile."

Our Gross National Product...counts air pollution and cigarette advertising, and ambulances to clear our highways of carnage. It counts special locks for our doors and the jails for the people who break them. It counts the destruction of the redwood and the loss of our natural wonder in chaotic sprawl. It counts napalm and counts nuclear warheads and armored cars for the police to fight the riots in our cities..., Yet the Gross National Product does not allow for the health of our children, the quality of their education or the joy of their play. It does not include the beauty of our poetry or the strength of our marriages, the intelligence of our public debate or the integrity of our public officials. It measures neither our wit nor our courage, neither our wisdom nor our learning, neither our compassion nor our devotion to our country. It measures everything, in short, except that which makes life worthwhile. And it can tell us everything about America except why we are proud that we are Americans.

Robert F. Kennedy, speech at the University of Kansas, March 18, 1968

Nevertheless, on the implicit assumption that consumers get what they pay for, and in the absence of alternatives, the gross amount of consumer spending, as measured by GDP or its state equivalent, Gross State Product, was soon taken to be a good measure of the success of an economy in delivering economic welfare or well-being.

Those textbooks that echo Kuznets' warning usually go on to offer chapter after chapter of analysis and theory that take GDP as an approximation of economic welfare.[17]

Simply tallying price-times-quantity of private goods and services misses many dimensions of our economic welfare. And this accounting mistake encourages choices about production and consumption that are narrowly "economic"—the choice brings more in benefit to the individual consumer than it imposes on that consumer in cost—but which are uneconomic for the economy as a whole. This happens when the full cost of production and consumption are not being paid by producers and consumers. When hydrocarbon fuels are burned, for instance, the burning uses part of the planet's carbon absorption capacity—a scarce ecosystem service that, when over-used, imposes on all of us the considerable costs of climate change.

Thus, when prices and other metrics do not accurately reflect social and ecological costs, behavior that is individually economic will not necessarily be economic at the macro level.

This problem affects policy decisions about river management. GDP-based analysis of economic activity in the LMR Corridor gives a flawed account of the costs and benefits of that economic activity. Such analysis can't help but lead to less-than-optimal policy choices. Sometimes such analysis will mistakenly justify policy choices that are not just suboptimal (producing far less than the maximum possible sustainable wellbeing that could be achieved at the same cost) but downright uneconomic (i.e., those choices impose more costs on humans than they bring in benefits).

[17] Steven Mark Cohn in *Reintroducing Macroeconomics* (Routledge; New York, 2015) gives a survey of this paradoxical feature of most standard economics textbooks. See especially Chapter 7.

Faults and flaws of GDP include:

- failure to tally damage to air and water quality as costs of economic activity;
- failure to count as a cost the "negative inventory growth," or depletion, of non-renewable resources;
- failure to count as a cost the draw-down of stocks of renewable resources (like soil fertility, timber, fish, water held in aquifers and reservoirs);
- failure to count damage to the ozone layer and the global climate system as an economic cost;
- failure to count as an economic loss the degradation or loss of farms, forests and wetlands;
- failure to count the opportunity cost of working longer hours to earn larger incomes, a cost that is paid as time away from family, community, or leisure;
- failure to count as an economic cost the value of income and production lost when human labor is idle or not fully employed;
- failure to count as an economic benefit the positive externalities of education;
- denial, at the macro scale, of a basic concept essential to economic analysis at the micro scale, namely, marginal utility analysis, which holds that at some point consumption of additional units of a good thing brings diminishing returns at the margin;
- Encouraging "churn" of resources, as new purchases are included in annual GDP totals but last year's purchases are presumed to offer no consumer value or satisfaction whatsoever;
- Miscounting as positive contributions to our wellbeing the defensive and remedial expenditures we make to
    - Deter and remediate crime,
    - Clean up or isolate ourselves from pollution,
    - replace broken and worn-out items,
    - repair roads and highways damaged by storm and flood,
    - duplicate for two households the material standard of living enjoyed by a family prior to divorce, as divorcing parents establish two residences.

Within the past few decades, a growing body of economic theory has questioned the continued dependence on GDP as a guidepost for economic development. Editorials and newspaper articles have reflected this change, questioning the relevance of 20th century indicators and policies to guide 21st century economies.[18] The experience of China—a country achieving notoriety for its high levels of air and water pollution—illustrates the danger of taking GDP growth as the only marker of successful economic policy.[19] High-level national and international meetings have called for new economic paradigms to address the integrated challenges of persistent poverty,

[18] David J. Rothkopf, "G.D.P. Doesn't Measure Happiness," accessed October 19, 2015, http://www.nytimes.com/2011/10/09/opinion/sunday/gdp-doesnt-measure-happiness.html.

[19] Eric Zencey, "China's Infinite-Growth Haze," *The Daly News,* April 9, 2013, at http://steadystate.org/chinas-infinite-growth-haze/

environment degradation, and social unrest.[20] And policy-makers are turning to a burgeoning literature in macroeconomics for guidance on implementing new metrics of success. One such metric, the Genuine Progress Indicator, has made the leap from theory into practice and is emerging as a strong candidate for becoming a new standardized measure of net economic wellbeing.

History and Methodology of the GPI

The methodology for the GPI evolved over several decades, as economists developed various alternatives to GDP and responded to criticism and discussion of those alternatives. Key points in the lineage of GPI are the work of economists William Nordhaus and James Tobin (1972) on the Measure of Economic Welfare (MEW), and the modification of their methodology proposed by Herman Daly and John Cobb (1989) in their Index of Sustainable Economic Welfare (ISEW). Both efforts consisted of monetized adjustments to GDP that deducted environmental costs of consumption. The methodology evolved into something close to its current form in the work of Cobb et al. 1995, who gave their measure the name Genuine Progress Indicator, or GPI (Cobb et al. 1995). The elements of GPI are shown in graphic form in Figure 1 and are listed in Table 1. A complete account of the methodology, including notes on how each element of the indicator set could be strengthened, can be found on the website of the Vermont GPI Project.[21]

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[20] See "Defining a New Economic Paradigm: The Report of the High-Level Meeting on Wellbeing and Happiness .:. Sustainable Development Knowledge Platform," accessed October 20, 2015, https://sustainabledevelopment.un.org/index.php?page=view&type=400&nr=617&menu=35. See also Stiglitz, Sen and Fitoussi, "Report by the Commission on the Measurement of Economic Performance and Social Progress," published by the Institut Nationale de la Statistique et des Etudes Economique at http://www.insee.fr/fr/publications-et-services/default.asp?page=dossiers_web/stiglitz/documents-commission.htm
See also the material on the OECD's High Level Expert Group on the Measurement of Economic Performance and Social Progress at http://www.oecd.org/statistics/measuring-economic-social-progress/

[21] The report starts with an overview at http://vtgpi.org/indicators/index.html. Each sub indicator has a webpage that reports the variable, the value, the data sources and related computations, and also offers "room for improvement."

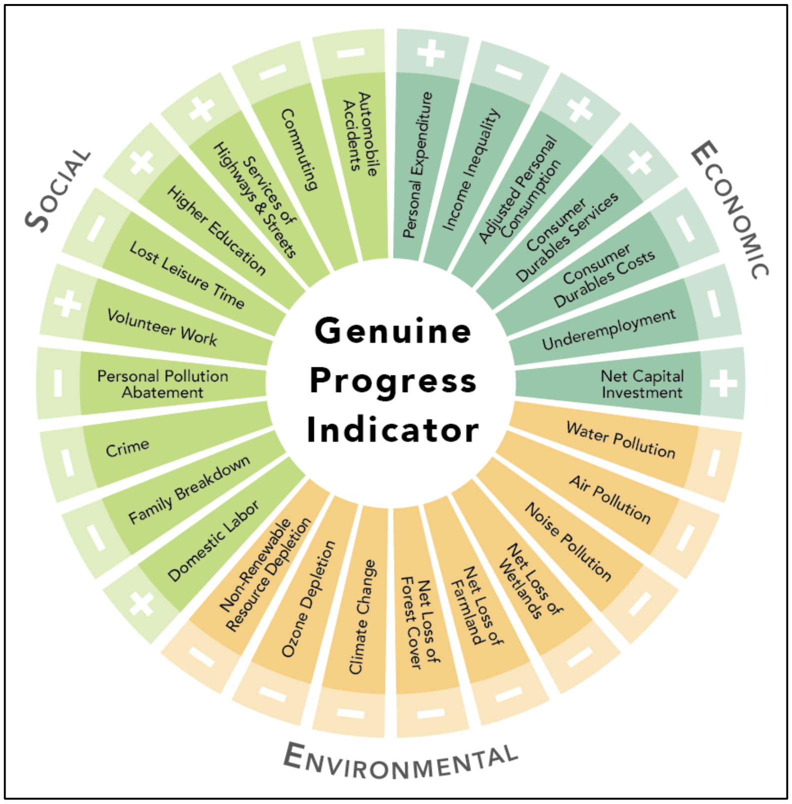

Figure 1: Elements of GPI

A significant literature has developed that is advancing both the theory behind GPI and the application of the indicator set to public policy

With minor variations, the GPI has been estimated in over 20 countries (Kubiszewski et al. 2013),[22] including the U.S. (Cobb et al. 1995; Anielski and Rowe 1999; Talberth et al. 2007).[23] A significant literature has developed that is advancing both the theory behind GPI and the application of the indicator set to public policy (e.g. Neumayer 2000; Lawn 2003; Lawn 2005; Clarke and Lawn 2008).[24] Sub-national or state-level compilations of GPI are increasingly common, having begun with Vermont in 2004 (Costanza et al.).[25] Other published sub-national or state-level studies include those for Maryland (McGuire et al. 2011), Ohio (Bagstad and Shammin 2012), Utah (Berik et al. 2011), Massachussetts (Erickson, Zencey et al. 2013) and Northern Forest counties (Bagstad and Ceroni 2008).[26]

At present, two states have officially endorsed the compilation of GPI for policy use: by executive order in Maryland (where the indicator's compilation is coordinated by the state's Agency of Natural Resources) and through legislation signed into law in Vermont (which has commissioned the Gund Institute for Ecological Economics to

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[22] Kubiszewski, Ida, et al. "Beyond GDP: Measuring and Achieving Global Genuine Progress," *Ecological Economics*, 93, 57-68, 2013.

[23] Cobb, C., Halstead, T. and J. Rowe, "The Genuine Progress Indicator," Redefining Progress, San Francisco, CA, 1995; Anielski, M., and J. Rowe, J., *The Genuine Progress Indicator – 1998 Update*, Redefining Progress, San Francisco, CA, 1999; Talberth, J., C. Cobb, and N. Slattery, "The Genuine Progress Indicator 2006," Redefining Progress, Oakland, CA, 2007.

[24] Neumayer, E., "On the Methodology of ISEW, GPI and Related Measures: Some Constructive Suggestions and Some Doubt on the 'Threshold' Hypothesis," *Ecological Economics*, 34(3), 347-361, 2000; Lawn, P.A., "A Theoretical Foundation to Support the Index of Sustainable Economic Welfare (ISEW), Genuine Progress Indicator (GPI), and Other Related Indexes," *Ecological Economics*, 44(1), 105-118, 2003; Lawn, P.A., "An Assessment of the Valuation Methods used to Calculate the Index of Sustainable Economic Welfare (ISEW), Genuine Progress Indicator (GPI), and Sustainable Net Benefit Index (SNBI)," *Environment, Development and Sustainability*, 7(2), 185-208, 2005; Clarke, M., and P. Lawn, "A Policy Analysis of Victoria's Genuine Progress Indictor," *Journal of Socio-Economics*, 37(2), 864-879, 2008.

[25] Costanza, R., Erickson, J.D., et al. "Estimates of the Genuine Progress Indicator (GPI) for Vermont, Chittenden County and Burlington, from 1950 to 2000," *Ecological Economics*, 51(1), 139-155, 2004.

[26] McGuire, S., S. Posner, and H. Haake, "Measuring Prosperity: Maryland's Genuine Progress Indicator," *Solutions*, 3, 50-58, 2012; Bagstad, K.J., and M.R. Shammin, M.R., "Can the Genuine Progress Indicator Better Inform Sustainable Regional Progress?—A Case Study for Northeast Ohio," *Ecological Indicators*, 18, 330-341, 2012; Berik, G., Gaddis, E., Bagstad, K., and J. Lowry, *The Utah Genuine Progress Indicator (GPI), 1990 to 2007*, Utah Population and Environment Coalition, Salt Lake City, UT, 2011; Erickson, J., Zencey, E., et al., "The Bay State's Genuine Economy: A report on the Massachussetts Genuine Progress Indicator, 1060-2011," a report prepared for the Demos Foundation, available from the author; Bagstad, K. J., and M. Ceroni, "The Genuine Progress Indicator: a New Measure of Economic Development for the Northern Forest," *Adirondack Journal of Environmental Studies*, 15(1), 2008.

compile and report the number biennially). A June 2013 "GPI in the States" summit organized by the non-profit foundation Demos and convened in Baltimore by the Governor of Maryland brought together 18 states with GPI accounts under development or consideration. The GPI compilers in attendance constituted themselves as the National GPI Technical Advisory Committee—a standards-setting group that will be the arbiter of proposed changes to GPI methods and practices. This has two desirable results: it insulates the indicator's methodology from political influence, and it ensures that GPI compilations will be readily comparable between states.

In the summer of 2015, Vermont became the first state to articulate an economic development goal in terms of the new indicator. Reflecting the legislature's intention that GPI serve as an additional (but not sole) metric for assessing the economy, the state did not break completely with the traditional "jobs and GDP" approach to goal-setting for economic policy. The Comprehensive Economic Development Strategy (CEDS) produced and issued by the state's Agency of Commerce and Community Development announced that in addition to seeking an increase in the number of jobs available to Vermonters, and an increase in per capita Gross State Product (GSP), the state's development program would seek to increase the state's GPI by 5% by 2020.[27] The CEDS identifies reductions in environmental charges against the economy, including particularly costs of long-term environmental damage and the cost of depletion of non-renewable energy resources, as strategies for achieving this goal. A graphic presentation of the Vermont GPI 1962-2012 is offered in Figure 2.

[27] "Vermont 2020 - VT 2020 CEDS.pdf," accessed October 20, 2015, http://accd.vermont.gov/sites/accd/files/VT%202020%20CEDS.pdf.

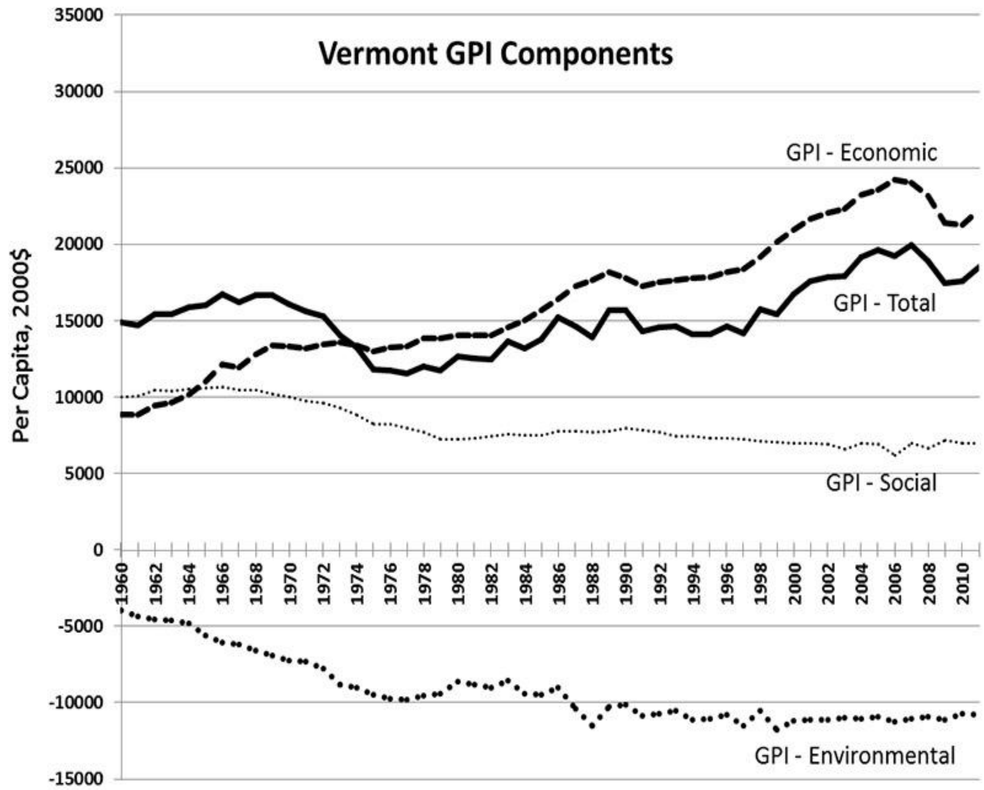

Figure 2: The Vermont GPI, 1960 to 2012, showing the summed performance of the three component categories of indicators.

Table 1. Missouri GPI results, 2000 and 2010

Monetary figures in year 2000 $, in billions except per capita amounts. This table is based on work done by students that has not been published in a peer reviewed journal.

	2000	2010	% change
Gross State Product	**180.967**	**194.930**	7.72%
per capita	32,343	32,548	0.63%
Genuine Progress Indicator	**98.066**	**84.006**	-14.34%
Per capita	17,527	14,027	-19.97%
Economic			
Personal Consumption Expenditures	123.19	145.66	18.24%
Income Inequality Adjustment	-15.62	-22.47	43.85%
Adjusted Personal Consumption	107.57	118.13	9.82%
Services of Consumer Durables	22.22	25.90	16.56%
Cost of Consumer Durables	-1.84	-1.67	-9.24%
Cost of Underemployment	-2.70	-6.74	149.63%
Net Capital Investment	15.81	2.78	-82.42%
Environmental			
Cost of Water Pollution	-0.31	-0.39	25.81%
Cost of Air Pollution	-1.37	-1.19	-13.14%
Cost of Noise Pollution	-0.14	-0.16	14.29%
Cost of Net Wetland Change	-12.64	-20.32	60.76%
Cost of Net Farmland Change	-0.03	0.32	-1166.67%
Cost of Net Forest Cover Change	4.46	4.93	10.54%
Cost of Climate Change	-10.73	-14.92	39.05%
Cost of Ozone Depletion	-9.50	-9.29	-2.21%
Cost of Nonrenwb. Energy Resource Depl.	-39.78	-42.53	6.91%
Social			
Value of Housework	31.13	30.13	-3.21%
Cost of Family Changes	-0.63	-1.99	215.87%
Cost of Crime	-1.20	-1.64	47.31%
Cost of Personal Pollution Abatement	-0.93	-1.58	25.13%
Value of Volunteer Work	1.99	2.49	25.13%
Cost of Lost Leisure Time	-8.46	-9.57	13.12%
Value of Higher Education	12.72	19.81	55.74%
Services of Highways and Streets	3.36	5.60	66.67%
Cost of Commuting	-4.56	-7.57	66.01%
Cost of Motor Vehicle Crashes	-6.36	-5.87	-7.70%

Compilation of the GPI builds from national income accounting and involves multiple methods to estimate a level and value for each of two dozen sub-indicators, each of which represents a category of cost or benefit not included in GDP (see Figure 1). The starting point is the figure for Personal Consumption from GDP, which is then adjusted for income distribution. Such an adjustment implies no value judgment about income inequality, but merely reflects the truism that economic gains in consumption that fall to a narrow segment of an economy's population cannot be said to increase general economic welfare within that population. (If Personal Consumption expenditures were to increase by 1%, but all of that increase was due to an increase in Bill Gates' income, we could hardly conclude that Americans in general are better off.) The adjustment to Personal Consumption is made based on a standard measure of income distribution, the Gini Coefficient.

GPI methodology then proceeds through a series of additions and subtractions. Subtracted are costs of economic activity that GDP ignores or miscounts. Additions are made for economically valuable but non-market benefits that GDP ignores. Each of the subindicators is comprised of a raw figure (e.g. number of acres of forest; total number of hours worked by volunteers) multiplied by a dollar value (e.g. value of ecosystem services of forestland per acre; average hourly wage rate).

GPI's development from theoretical exercise to practical public policy tool has sharpened interest in making the indicator set more accurate.

GPI's development from theoretical exercise to practical public policy tool has sharpened interest in making the indicator set more accurate. The current methodology, known as the "Maryland-Vermont Model," evolved through close collaboration between GPI compilers in the two states. The National GPI Technical Advisory Committee has before it a proposal for "GPI 2.0," a revision in methodology that would bring greater consistency in GPI compilation and greater utility for the measure as a public policy tool.[28] In general, improvements to the methodology will fall into three broad categories as outlined in the text box.

As was the case for the GNP in its early days, GPI is in many of its constituent parts a blunt measure. The example of farmland is illustrative. Current GPI methodology registers the loss of farmland as a cost and the gain of farmland as a benefit to overall economic wellbeing. (If farmland is gained from conversion of forest, a loss is recorded in another sub-indicator, Net Change in Forestland. Whether the change is net positive or negative depends on the relative valuations of ecosystem services from the two kinds of land use.) At present, GPI methodology looks merely at net change in acreage of farmland. A more accurate measure would be derived by

[28] Kenneth J. Bagstad, Günseli Berik, and Erica J. Brown Gaddis, "Methodological Developments in US State-Level Genuine Progress Indicators: Toward GPI 2.0," *Ecological Indicators* 45 (October 2014): 474–85, doi:10.1016/j.ecolind.2014.05.005.

Three categories of anticipated improvements in GPI methodology

1) **Improved data**: information that is more timely, more detailed, more comprehensive
2) **Improved valuations**: ecosystem service valuations that are more particularized to the biome under consideration. For instance, instead of taking a single dollar value as its estimate of the economic value of ecosystem services from a forested acre, a GPI compilation could reflect differences in types of forest acreage (hardwood, softwood, recently harvested, old growth, etc.) each with its own appropriate valuation-per-acre.
3) **Conceptual changes and clarifications**, such as
    a) developing protocols for assigning ecological costs appropriately when those costs are generated and imposed across state lines or other jurisdictional boundaries and
    b) including net change in ecosystem service valuations from additional biomes such as on- and offshore marine environments, desert scrub, and tundra; and
    c) deducting from GPI's bottom line other categories of expenses that GDP counts as beneficial that are more properly seen as costs, such as
        i) money spent on remedial (as opposed to preventative) health care;
        ii) money spent on cigarettes, illicit drugs and other addictive consumables;
        iii) money spent on advertising.

assessing net change in farmland soil fertility. Under such a metric, the practice of soil mining would show as a cost. Since soil fertility is a capital stock from which a flow of service is derived, soil mining should be treated as a cost, just as standard accounting practice treats degradation, loss or depreciation of any other capital stock.

As with almost all efforts to gather and use data, increased precision entails increased cost. The GPI will continue to gain in precision (and thus to gain utility as a public policy tool) as additional resources are dedicated to its compilation, extension, and improvement. Even as a blunt instrument, however, the GPI offers useful insight into public policy problems and can be used to recognize and structure (if not yet precisely calibrate) many of the trade-offs that economic and environmental policies face.

GPI and the LMR Corridor Economy

While an extended analysis of the LMR Corridor economy based on GPI would be a useful exercise, it is beyond the scope of the present work. What's offered here is a brief sketch of what such an analysis would take into consideration, done as a sector-by-sector annotation of the Report. Additional insight into the nature of a GPI compilation for the LMR Corridor can be drawn from the compilation of the Missouri GPI for 2000 and 2010 done by graduate students at Washington University in St. Louis under the direction of the current author, as reported in a public presentation at the Sam Fox School of Design and Visual Arts in April of 2013. A summary of the results of that compilation is offered in Table 1.

- **Commercial harvest of natural resources**. Against the positive income generated in this category must be charged the loss of ecosystem services that comes from remaking ecosystems in order to maximize the offtake of the harvested resource. In some (if not most) instances this loss of ecosystem services is an ongoing expense. If, for instance, wetlands are converted to timber production (or indeed to agriculture or urban development), GPI treats the annual service value of those wetlands as a lost benefit—a cost--in each succeeding year. In Missouri alone the annual service value of lost wetlands is estimated by standard GPI methodology to be $20.32 billion in year 2000 dollars (see Table 1).

  An accurate accounting of the value of the harvested offtake must distinguish between offtake that comes from sustainable harvesting (harvest that takes no more than that year's annual growth) and unsustainable draw-down of the resource stock. This distinction applies to renewable and replenishable resources like timber and forest products, seafood, fish, alligators, and agricultural produce (in which the relevant stock is soil fertility). Conceptually, the GPI can support acknowledging the important difference between stock diminishment and flow harvest, a distinction crucial to the development of a sustainable natural resource economy. As a practical matter, though, the methodology has not yet matured enough to do full justice to this distinction. The problem is complex, because (as is acknowledged in timber and wildlife management practice) under some conditions a draw-down of stock—thinning--will increase the growth rate and hence the size of the sustainable offtake of the resource in succeeding years. In the past, commercial harvest of natural resources done without regard to rates of regeneration and growth, and hence the size of the

  > **Conceptually, the GPI can support recognition of the important difference between stock diminishment and the harvest of annual flow, a distinction crucial to the development of a sustainable natural resources economy.**

sustainable yield, has been responsible for driving commercial species into extinction and near extinction.

Accounting against such standards does not always produce bad news. The Report tells us that "The forests of the LMR corridor produced over 375 million cubic feet of timber each year, valued at $290 million in annual revenues" in year 2011 dollars (p. 2-4). This sizable flow was extracted from 16 million acres of forest stock, for an extraction rate of 23.4 cubic feet per acre. (But at page 11-2 the report says there are 11 million acres of forested land in the LMR Corridor; this would give an extraction figure of 34.1 cubic feet per acre.) This offtake is well below the 52 cubic feet per acre annual net growth for U.S. forests that is posited by a 2007 USDA report.[29] Thus, if timber growth in the LMR Corridor approaches the U.S. average, timber harvest in the region appears to be sustainable.

Timber harvest in the region appears to be sustainable.

- **Outdoor Recreation.** The 38 million trips that generate $1.3 billion in expenditures, increasing the GDP of the LMR Corridor (Report, p. ES-3), have cost consequences that would register in several GPI categories (particularly the Cost of Non-Renewable Resource Depletion, the Cost of Climate Change, the Cost of Automobile Accidents, and The Cost of Commuting). The methodology of the Report treats all of these costs as benefits.

Here, the GDP-based methodology of the Report treats transportation-related costs as benefits.

- **Tourism.** GPI registers costs here similar to those for Outdoor Recreation. An additional consideration: the Report notes that New Orleans lost an estimated $2 billion in tourism expenditures in the 12 months after Hurricane Katrina. If, as GPI methodology acknowledges, storm surge protection is one ecosystem service provided by wetlands, then this $2 billion loss needs to be added to the estimates of the direct damage done by the storm to New Orleans. Like that larger figure

The $2 billion loss in New Orleans' tourism industry in the year after Hurricane Katrina needs to be factored into the cost of losing the coastal wetlands that used to protect the city from storm surges.

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[29] Roger C. Conner and Michael T. Thompson, "Timber Growth, Mortality and Change," in *Forest Resources of the United States – 2007,* U.S. Forest Service Department of Agriculture, p. 65), http://www.fs.fed.us/rm/pubs_other/wo_gtr078_064_066.pdf

this cost must be expensed against the economic development (including dam and lock construction, oil production and oil rig movement) that led to the loss of coastal wetlands.

- **Water Supply.** This section of the Report deals with withdrawals of water from the river for various purposes, but in what counts as a major oversight the Report offers no data whatsoever on the condition of the water when it finds its way back to the river. Use of the river for withdrawals of water is an obvious economic benefit and is appropriately detailed in the report. But the river is also used as a sink for several categories of water-borne waste, including thermal waste generated by power stations (the largest single category of water withdrawal at 58% of all use) and nitrogen pollution from fertilizer runoff transported by rainfall and irrigation water. The sink services of the river are generally free (unpriced), though their overuse imposes costs on residents of the LMR Corridor through various forms of ecosystem degradation, including hypoxia that diminishes the offtake of commercial fish and seafood harvests downstream. GPI methodology captures these costs as a charge against the economy's bottom line.

  While the Report documents water withdrawals crucial to the LMR Corridor economy, in what counts as a major oversight it offers no data whatsoever on the condition of the water when it finds its way back to the river.

  Sewage treatment is part of the cost of avoiding water pollution, and GPI methodology treats it as such. The Report folds the cost of sewage treatment into its survey of economic activity in this section, implicitly counting this expense as a benefit. ("The water supply and sewerage sector in the LMR Corridor employs roughly 650 people and generates an estimated $385 in revenues…," p. 5-6.) Degraded water quality that is unremediated also counts as a cost in GPI methodology. This is not the case in the Report, which (in one of its few mentions of water quality) notes only that "poor water quality may force manufacturers to perform expensive treatment on water before it can be used" (10-9). No mention is made of how poor water quality affects wildlife or human life. The Report follows traditional economic thinking in assigning a cost to this externality not when the cost is imposed, but only when the pollution is remediated (and apparently only when the remediation is done by a corporation).

- **Agriculture.** Farming is the systematic harvesting of a natural resource, the solar energy that falls onto green plants, which the plants capture and convert into harvestable food energy. Consistency in classification would place agriculture in "Natural Resource Harvests." The scale of agricultural activity and its distinctive cultural importance, however, justify disaggregating it from other natural resource harvests to be considered separately, as is done in the LMR Report.

GPI methodology values farmland differently than does the Report. The Report values farmland at market prices. In GPI valuation, farmland values are not market based but reflect the value to humans of the variety of unpriced but economically valuable ecosystem services that farmland provides.

For most of human history, agriculture was the primary sector through which usable energy entered the human economy. Unfortunately, as an energy - capture system petroleum-based agriculture is net negative: food calories cost us more in energy than they deliver to us in return.

Net change in farmland is one subindicator in the current GPI methodology (the Maryland-Vermont model). As noted above, GPI methods are evolving toward treating loss of soil fertility (rather than simple loss of farmland acreage) as a cost charge. Once this change has been adopted, increases in soil fertility would tend to raise GPI while soil mining would decrease the GPI.

A cogent argument can be made for treating fertilizer, pesticide and irrigation expense as costs rather than GDP-enhancing benefits, though there are at present no proposals to this effect before the National GPI Technical Advisory Committee. Currently the production of fossil-fuel based fertilizers registers as a cost in two GPI categories (Climate Change and Non-Renewable Resource Depletion). The methodology charges these costs to the state in which the fertilizer is manufactured, not the state in which it is used.

Ecological economics suggests an entirely new approach to determining the economic value of agriculture. American culture has always had a soft spot for agriculture for a variety of reasons, including the nation's ongoing appreciation of the heritage and influence of small-town farming life, its appreciation of (and nostalgia for) the rural values that emerge from that life, and the benefits derived from the sturdy stock of social capital (mutual trust, shared understanding, common valuations and publicly held knowledge) that small town, face-to-face communities can enjoy.[30] But ecological economics gives additional importance to agriculture within the its theoretical foundation, which sees the economy as a thermodynamic enterprise, a set of processes and institutions that use energy to shape matter in order to produce economic value that improves the human quality of life.[31] When economic processes are seen this way, agriculture emerges as one of the few sectors of the economy with the potential to be consistently and sustainably net-positive. In effect, agriculture is a broad net thrown by humans that can capture the planet's current solar income in usable form. (Note that a necessary but not sufficient condition for a sustainable economy is that it operate on current solar income rather than fossil fuels.) Unfortunately, as an energy-delivery system fossil-fuel based agriculture is net negative: industrial agriculture invests more energy in agricultural processes than those processes return to us as food energy.[32] This is because agricultural productivity receives an energy subsidy from oil. Because oil is finite, sooner or later our society will make a transition to a post-petroleum economy, including a post-petroleum agriculture. Just as the true cost of nuclear power must include the cost of the eventual decommissioning of the reactor, the true cost of fertilizer use in the LMR Corridor properly includes an appropriately discounted estimate of the future costs of this transition. (Some of those costs will be easy to recognize as dollar amounts, as when food prices increase. Other costs—social dislocation, malnutrition, food insecurity—will be harder to calibrate but no less real.) Attempts to estimate this cost would vary widely, for the cost we eventually experience will

Future costs to the economy are increased by continued failure to plan for a post-petroleum agriculture in which soil fertility within the LMR Corridor is replenished by natural processes, including sediment deposition by flooding.

[30] These are themes I explore in various parts of *The Other Road to Serfdom and the Path to Sustainable Democracy* (University Press of New England, Hanover, 2012).
[31] The fundamental precepts and assumptions of ecological economics, including the credence the discipline gives to the laws of energy, have been codified in the textbook by Herman Daly and Joshua Farley, *Ecological Economics: Principles and Applications* (Island Press, 2nd edition 2012).
[32] Eric Garza, "The Energy Return on Energy Invested of US Food Production," *Resilience*, September 9, 2013. Accessed October 21, 2015, http://www.resilience.org/stories/2013-09-09/the-energy-return-of-energy-invested-of-US-food-production.

depend on policy actions taken in the very near term. Risk analysis might be used to assign probabilities to various paths and outcomes. We can expect such analysis to show that the probability of a high-cost transition is increased by continued failure to plan for a post-petroleum agriculture in which soil fertility within the LMR Corridor is replenished by natural processes, including replenishment with flood-borne sediment.

While current GPI methodology does not support the inclusion of such costs, they could be accommodated through bringing greater precision to the subindicator Net Change in Farmland. Every acre of farmland dedicated to post-petroleum agriculture, and every acre of farmland whose soil fertility is replenished naturally, contributes to the reduction of the future cost of making the transition to a post-petroleum economy.

Some part of the cost of how fertilizers are currently used is also the economic cost of dead zones and algal blooms. This cost is captured in GPI through the category Cost of Water Pollution. Solving the problems generated by fertilizer runoff would thus tend to raise GPI. Under a consistent GPI methodology, some portion of the cost of the Gulf of Mexico's Dead Zone would be charged to agriculture within the LMR Corridor.

- **Mineral Resources and Energy Production:** Fossil fuel extraction is included as a cost in GPI under Non-Renewable Resource Depletion and Climate Change, though (again) the charge is made to the GPI of the economy that uses the fuel, not the GPI of the region that extracts it. Energy production from fossil fuels in the LMR Corridor shows up in GPI as both a benefit that raises the regional GPI (people use part of their Personal Consumption expenditures on energy) and a cost that lowers the regional GPI. GPI methodology does not at this point take separate account of depletion of non-energy minerals and ores, and thereby implicitly uses Non-Renewable Energy Resource Depletion as a proxy for all Non-Renewable Resource Depletion. (There is discussion among GPI theorists about sharpening this measure, but conceptual and practical difficulties stand in the way of assigning an appropriate depletion cost to non-energy mineral resources.)

Energy production from fossil fuels in the LMR Corridor shows up in GPI as both a benefit that raises the indicator and a cost that decreases the indicator.

- **Commercial Navigation.** Against the GDP benefits generated by commercial navigation in the LMR Corridor must be charged the considerable costs of lost ecosystem services from the river's channelization and control. These costs register in GPI primarily as lost wetlands, and the cost is perennial. Future iterations of GPI methodology may

The river has been heavily managed to promote navigability at the cost of significant loss of ecosystem services. We cannot know whether the benefits of past policy are net positive or net negative unless costs and benefits are scrupulously counted and appropriately credited.

include an item that specifically measures the cost of the risk associated with denying rivers access to their floodplains. Fellows at the Gund Institute of Ecological Economics have done conceptual and practical work in this field, finding that in one flood episode alone the relatively small Otter Creek floodplain in Vermont provided $2.3 million in flood mitigation services to the town of Middlebury.[33]

Note that a recent estimate of the GPI for Missouri found that the loss of ecosystems services from converted wetlands totaled $20.23 billion in 2010 in year 2000 dollars (see Table 2). New thinking about hydrology holds that channelization and levy building amplify the severity of flooding when it does occur.[34] If this is the case, then the levy-and-channelization program's contribution to the considerable costs of flooding (which reached $16 billion in the Mississippi River basin in just one event in 1993), prorated as a contribution to the expected annual *risk* of flooding, must be deducted from the economic benefits brought by commercial navigation. This is not to say that channelization and control of the river has no net benefit; it's to say that we cannot know whether or not the benefits of past policy are net positive or net negative unless costs and benefits are scrupulously counted and appropriately credited.

To the extent that the economic benefits of current river management policy are captured in GDP methodology, they are also reflected in GPI through the latter's foundation in GDP's major component, Personal Consumption.

- **Natural Resource Services not Reflected in the Commercial Economy.** From a GPI perspective, the inclusion of this item in the Report is a large step in the right direction. But the inclusion of non-market ecosystem services here serves to highlight their absence elsewhere. Nowhere does the Report mention, let alone assign a value to, the ecosystem services that were lost as a result of decisions made about river management and economic development within the LMR Corridor. The Report notes that "coastal marshes of Louisiana serve as nurseries for numerous marine organisms" and that "coastal marshes and barrier islands also provide a physical barrier against strong winds and hurricanes" (ES-4), giving the positive side of the ledger on ecosystem services. If wetlands bring us non-market but

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[33] Bryan, Keri, Rickets, Taylor, Galford, Gillian, Polasky Steve, Dunne O'Niel Jarlath. "Economic valuation of the flood mitigation services provided by the Otter Creek wetlands to Middlebury, VT." The University of Vermont, Gund Institute of Ecological Economics and the Spatial Analysis Labratory, The University of Minnesota, Department of Applied Economics and Department of Ecology, Evolution and Behavior, 2014. Under review for publication. See the presentation at http://www.conference.ifas.ufl.edu/aces/presentations/Dec%2010%20Wednesday/6%20Session%205F/Bryan%20%20Keri%20.pdf

[34] Nicholas Pinter, "One Step Forward, Two Steps Back on U.S. Floodplains," *Science* 308, no. 5719 (April 8, 2005): 207–8.

economically valuable ecosystem services, it must follow as a matter of logic that the loss of these wetlands—a loss that continues apace, as coastal marshes continue to be denied the sedimentary deposition they need in order to continue to exist—constitutes an economic loss. This is the kind of loss that GPI was designed to account for. As a methodology for calculating national income, GPI brings the principles of double-entry bookkeeping to the economy as a whole.

The inclusion of non-market ecosystem services here serves to highlight their absence elsewhere. The LMR Corridor Report includes only the positive contribution of these services and makes no mention of their loss where development or river management practices have deprived LMR Corridor residents of them.

Further iterations of GPI methodology will become more sophisticated in assessing its constituent costs and benefits as time and effort are invested in the work. Of particular interest to those concerned with the economy of the LMR Corridor will be the incorporation into GPI methodology of estimates of the ecosystem service value of flood plains (and, on the other side of the ledger, the costs associated with denying the river access to its historical floodplains).

Conclusion

Good policy has to be based on accurate information. The standard modes of economic analysis used in the LMR Corridor Economic Profile don't give policy makers accurate information. Not only does the GDP-based analysis offered in the Report push to the margins any consideration of the real but non-market economic value the human economy gains from ecosystem services, when these services are mentioned at all in the Report they are present only as an entry on one side of the cost-versus-benefit ledger.

A full and accurate accounting of all economically relevant costs and benefits is needed to illuminate the path to optimal policy in the LMR Corridor as elsewhere. Because it remains rooted in standard GDP-based accounting of economic benefits, the LMR Corridor Economic Profile does not give such an accounting. The Genuine Progress Indicator offers an alternative methodology that, while in a relatively early stage of development, is a marked improvement on GDP based economic analysis.

In effect, GPI brings the principles of double-entry bookkeeping to the economy as a whole.

This critique of a GDP-based review of the economy of the LMR Corridor is not a full accounting of the GPI of the LMR Corridor, but is meant to point up how the shortcomings of traditional GDP accounting are present in the LMR Corridor Economic Profile, and to illustrate the benefits of thinking about the economy of the LRM Corridor in GPI's more realistic, more accurate, more inclusive accounting methodology. Genuine economic progress comes when the benefits of economic activity exceed the costs of that activity. The GPI was specifically designed to determine whether and when that happens.