Chapter 17: Ecological Diversity and Resilience

— Eric Zencey

Introduction

Ecological diversity and resilience are definitive qualities of healthy ecosystems, the networks of relations between and among life forms and their physical environment that hold humans in their complex webs and that produce and maintain themselves through their use of nutrients and sunlight. As can be seen in any review of the history of failed civilizations, healthy ecosystems are necessary to the maintenance of human society (Diamond, 2005; Homer-Dixon, 2006). Participation in human society, in turn, is essential to individual human wellbeing and happiness; involuntary separation from fellow humans is always punishment, and it's a very rare individual who manages to survive, let alone thrive, without any social connection or economic interaction with others. Thus, human happiness and wellbeing clearly depend on healthy ecosystems.

That dependence is more than aesthetic (though there are some humans whose happiness and wellbeing are augmented by contemplating or otherwise experiencing life in its manifold variety) and is more than moral (though here too, there are some humans who could not consider themselves well or be happy if their lives depended on the extirpation of other life or the degradation of healthy ecosystems). The dependence of human happiness and wellbeing on ecological resilience and diversity is substantial and fundamental. As water is to a fish—the medium through which it moves, through which it gains sustenance, and into which it excretes its wastes—nature is the ground-of-being for economic life, a context so omnipresent and far-reaching that most economic theory simply ignores it, much as fish never speak to each other of "water."

To ask policy makers to take ecological resilience and diversity into account in their decisions about economic development is to ask them to employ new ways of thinking—a new development paradigm.

Domain description

Ecological diversity describes the variety of different forms of life that are present in a particular ecosystem. Very generally, the more species the better; ecosystems tend to evolve toward maximum feasible use of the energy available to them, and this usually involves the colonization of differentiated energy niches by a variety of differentiated species (Odum and Odum, 1981). A reduction in the number of species can harm the functioning of ecosystems (MEA, 2003). Virtually all of Earth's ecosystems have been dramatically

transformed through human actions, which have become the largest threat to the continued existence of countless species. Changes in human behavior, therefore, are needed to preserve the planet's existing (anthropogenically depleted) stock of genetic diversity (UNEP, 2007).

Resilience in ecological systems can be measured as the time required for an ecosystem to regain capacity to produce biomass and to self-regulate following a disturbance (Dale et al., 2001; Folke et al., 2004). Many factors contribute to ecosystem resilience; diversity of life forms is one such factor, but is by no means the only one.

Humans benefit from healthy ecosystems through the provision of ecosystem services, discussed more fully below. Briefly, these range from the purification and delivery of water, to the recycling of nutrients and the building of soil fertility, to serving as the source of replenishable supplies of food (including protein), lumber and other biologically generated raw materials, and energy. One important group of ecosystem services is the moderation of climate and the effects of weather.

Because humans derive direct benefit from the various services provided by healthy ecosystems, and ecological diversity and resilience are definitive elements of healthy ecosystems, any effort to maximize human happiness and wellbeing has to take account of the contribution that ecological diversity and resilience make.

Existing sub-domains

The Gross National Happiness Index developed and used in Bhutan contains a domain of indicators that aim to do this. The domain holds four sub-indicators, three of which assess subjective perceptions of environmental matters (pollution, urban issues and individual environmentally responsible behavior) and one of which asks respondents to assess an objective condition (crop damage by wildlife).

Levels of pollution are, obviously, a crucial element in any environment's ability to contribute to wellbeing. The GNH instrument asks a series of questions to gather respondents' perceptions about pollution, which are ranked on a four-item scale from "not a concern," through "of some concern" and up to "a major concern."

The environmental responsibility indicator attempts to measure feelings of personal responsibility and care for the environment, and its four-point scale runs from "highly responsible" to "not at all responsible." Information gathered on this item could be used to assess the success of efforts to reinforce

ecologically responsible behavior or to diagnose deterioration in environmental responsibility, though survey results may be subject to inherent problems. Few people consciously and purposely maintain a disjunction between their beliefs and their behavior, and most people want to believe they behave appropriately. Given this, questions that ask for self-assessment of environmentally responsible behavior and attitudes are likely to have a high rate of false or inappropriately positive responses unless the target demographic has a high capacity for critical self-awareness. Ignorance of what constitutes environmentally appropriate behavior may lead to inaccurate self-scoring as well.

Given the tendency of people to avoid dissonance between behavior and belief, and the difficulties individuals face in changing ecologically inappropriate behavior in a built world that assumes a high level of resource use, attempts to promote environmentally responsible behavior through education may have the unintended consequence of encouraging the intended audience to ignore or consciously reject the message--and all additional information about environmental concerns that is consistent with it (Thorgersen, 2004). Thus, a public education campaign may have the perverse effect of encouraging public ignorance.

The Urban Issues sub-indicator is intended to assess the success of policies promoting sustainable urban development, which is one of the major objectives of the Bhutanese government (Ura et al., 2012). It solicits responses about traffic congestion, the quality of urban green spaces, whether streets are pedestrian friendly and the degree of urban sprawl. Rapid urbanisation has both positive and negative impacts on human wellbeing; with city life comes improvement in some areas of wellbeing (such as access to health care and benefits from use of civic infrastructure), but these are to some degree offset by undesirable aspects of urbanized life. Positive impacts of urbanization are collected within other domains of the GNH survey.

The Wildlife indicator collects information on damage to crops, which has been a growing concern in Bhutan, and which can have significant effects on the happiness and wellbeing of people whose lives and livelihoods are closely connected to the success of harvests on small farms. Concern about crop damage can also disrupt sleep patterns and create anxiety and insecurity about economic wellbeing (Ura et al., 2012).

Two questions on the presence and absence of damage and the severity of damage are used to discover whether wildlife damage to crops is a constraint on farming and where the damage falls on a scale ranging from “a lot” to “not at all.” This indicator is specific to rural populations. Its influence in the overall

measurement of Gross National Happiness is complemented by the Urban Issues indicator which applies to urban dwellers.

With these four subindicators forming the total of GNH's assessment of the environmental impacts of economic life (and of human activity in general), GNH as presently structured is incapable of measuring ecologically sustainable happiness or wellbeing. As Ura, Alkire, Zangmo and Wangdi say in an overview of GNH, "Indicators in this domain in particular may be reconsidered for future GNH surveys to better capture the full complexity of the ecological system." (Ura et al., 2012, p.31) Reconsideration and development is desirable on several fronts.

First, the full complexity of ecological systems (and the effects of economic activity on them) would be better captured by disaggregating the category "pollution" into its major constituent elements, defined by the ecological sector they affect. Thus, a more detailed indicator would assess the rates or quantities of disposal of various types of harmful and/or non-biodegradable wastes into the air, into water, and on land. Additionally, the category "pollution" could be expanded to include any unwanted or harmful environmental phenomenon imposed as an externality on innocent others: into this category would go noise pollution, noxious odors, light pollution at night, and perhaps even aesthetically displeasing changes to natural and built environments. This is consistent with the concept of *commons* that provides one readily understandable frame of reference for approaching environmental damage: just as a river or a lake or a clean atmosphere are each a commons from which humans derive benefit, and which can be degraded by the unchecked and self-interested actions of individuals, so too can we think of silence as a commons, of visual access to the night sky as a commons, of a beautiful landscape or scenic viewshed as a commons, etc.

Proposals to use aesthetic criteria in making decisions about development often elicit protestations that ideas of beauty are completely subjective, and that therefore no property owner should be forced to submit to the aesthetic judgment of others. This logic would equally serve the opposite conclusion: because aesthetic judgments are subjective, no individual should be allowed to impose their individual aesthetic judgment on a community without community guidance, input and review. Aesthetic values are one criterion by which proposed development is judged under Vermont's development control law, discussed below.

Second, even with greater detail and expansion of the concept of "commons," measuring pollution levels affecting various kinds of commons would not, alone, give the sum total of humanity's negative impact on ecological processes.

Pollution is a stress on the sink services of the environment; there is also environmental degradation on the source side. These two footprints of the economy become clearer in the modeling of the economy done by ecological economics. Standard economic modeling conceives of the economy as a closed loop in which money circulates between households, businesses and governments in exchange for goods and services. Ecological economics, modeling the economy as a thermodynamic system, emphasizes irreversible throughput: the transformation of low-entropy inputs into high-entropy outputs (or waste), because in planetary and thermodynamic terms, all the physical products that the economy produces are but temporary incorporations of order (low entropy) that must inevitably succumb to rust, rot, decay and disorder. Thus, the two ecological footprints of the economy, on the uptake (source) and output (sink) side (Georgescu-Roegen, 1976; Daly and Farley, 2011).

Deforestation, soil depletion, desertification, loss of biodiversity, overharvesting of commercialized species and other unsustainable practices affect the environment's ability to contribute flows of inputs into the human economy. These "source service" disruptors thereby affect ecosystems' ability to support human happiness and wellbeing. Source-side diminishments should be counted as economic losses -costs -whenever development produces them.

Third, a revision to GNH's reliance on survey research methodology is appropriate in this domain. The achievement of a sustainable relationship between economic activity and ecosystem processes is not a matter of opinion but an objective, either-or condition: water is either clean enough to drink or it isn't, a commercial species either is or isn't harvested at a sustainable rate, energy sources are either sustainable in geologic/ecological time or they aren't. Survey methodology doesn't reveal environmental conditions; it reveals what people think about environmental conditions. (This in itself may be useful information, but it cannot measure the degree to which an economy approaches sustainability.) While it is true that some countries and regions have populations that retain a strong, primarily agricultural link to the ecosystems that support them, and which might therefore be in a position to assess ecosystem health with greater accuracy than other more urbanized populations, in many countries and regions much of the population is able to offer nothing more than uninformed (or media-manipulated) opinion on such matters. Even where survey of the perceptions of well-informed lay populations may lead to acceptably accurate results, the method is not ideal. Any time opinion is used as a proxy for fact the relationship ought to be tested regularly for accuracy, which means in this case that primary data about environmental quality would have to be collected in any case.

Finally, the GNH instrument cannot measure any cumulative, long-term environmental impacts if those impacts are not visible to and tracked by local residents. GNH methodology is not suited to assessment of such large and consequential phenomena as the effects of climate change or the loss of the ozone layer, both of which have the potential to affect human happiness and wellbeing dramatically.

Alternative sub-domains: redefining the problem

An appropriately ambitious set of indicators in this domain can be developed from a redefinition of the problem. The deterioration of the ability of ecosystems to contribute to happiness and wellbeing doesn't arise simply from pollution or from a lack of responsible behavior by individuals or as a problematic interface between farmland and non-cultivated nature, as is implicitly assumed by the sub-domains currently in use in GNH.

The problematic relationship between human culture and nature - the relationship that threatens to diminish the ability of ecosystems to contribute to happiness and wellbeing, even to the point of societal collapse – can be re-defined by using the concept of natural capital and a related concept, natural capital services.

By analogy to built capital (the machinery, tools, and physical wealth humans use to increase the productivity of labor in the production of economic value), healthy ecosystems can be seen as a stock of natural capital that provides a flow of services that contribute to human happiness and wellbeing.

Built capital provides useful productive services without itself being consumed in the process. It does wear out, thanks to the entropy process; this is why maintenance, repair, and replacement of capital investments are necessary, and why owners of such productive resources are well advised to set aside some part of the income they derive from those resources in order to fund restoration of depreciated value.

Natural capital has several advantages over built capital, including one enormous cost saving: a healthy ecosystem will self-repair. The maintenance of any complex system against the depredations of entropy requires the importation into that system of organized matter and energy that are deployed according to some form of design intelligence. Ecosystems resist entropic degradation, create biodiversity, and create biomass by using energy throughput derived from the sun to organize physical nutrients according to the design intelligence coded by evolution into the genes of their constituent elements (Keeling, 1898). Through their economic production humans create

value and wealth, and resist entropic decay in the things they value, in the same way (Zencey, 1985; 2012).

The concept of natural capital allows for a precise definition of what ecological sustainability is--a definition that is a clearer guide to policy than the commonly used Brundtland definition ("meeting the needs of the present without compromising the ability of future generations to meet their needs," (Brundtland and World Commission on Environment and Development, 1987), which is more a description than a definition. Just as no business is sustainable if it consumes its operating capital as income, no economy can sustainably deliver wellbeing and happiness to humans if it steadily consumes the stocks of natural capital on which it relies. Therefore: a measure of the economy's ability to deliver sustainable wellbeing must assess economic activity's net impact on stocks of natural capital and on the flows of ecosystem services we derive from them. Economic activity that reduces stocks of natural capital is in practice borrowing from the future in order that we might spend and consume today. (In the past, economic theory has justified this perpetration of injustice by incorrectly assuming that natural capital and built capital are infinitely substitutable for each other, which would mean that future generations would have no problem developing technologies that would allow them to cope with the reduction of ecosystem services that that our consumption imposes on them; Daly and Farley, 2011). Economic processes that leave natural capital stocks whole and healthy, or even augmented, secure the future happiness and wellbeing of humans.

Alternative subdomains: drawing from GPI

One indicator set that attempts to measure the health of natural capital stocks and flows is the Genuine Progress Indicator, which evolved from the Index of Sustainable Economic Welfare proposed by Daly and Cobb (1989). Specifically, among the elements that GPI measures are:

- Net change in forest acreage
- Net change in farmland acreage
- Net change in water quality
- Net change in wetlands acreage

Because GPI aims to produce a single number that stands as a better representation of economic progress than GDP, each of these changes is assigned a dollar valuation, an amount that is added to or (more often) subtracted from the account. In addition, the GPI measures some other environmental costs:

- Cost of noise pollution
- Cost of air pollution
- Cost of long-term environmental damage
- Cost of non-renewable resource depletion
- Cost of personal pollution abatement

GPI begins with a basic measure that is a component of GDP (Personal Consumption) and corrects it by adding benefits and subtracting costs, including environmental costs that GDP ignores. Because it is a monetized measure, each of its environmental sub-indicators consists of two distinct calculations: an objective variable (acreage of forest or wetland or farmland, linear or square kilometers of waterbodies in various categories of health, ambient decibel level, etc.) and a valuation (an estimate of the monetary value of costs imposed or ecosystem services gained or lost in that category).

While accurate measurement of the variable and meaningfully defensible estimates of the valuations are important to the utility of these measures, GPI retains enormous usefulness for policy guidance even if the monetary valuations attached to ecosystem services are understood to be approximations. GPI can be a valuable, albeit approximate, indicator of change in economic wellbeing as long as the method of approximation is consistent from year to year and region to region. GPI's variables are objective, and accuracy in their measurement is conceptually easy if sometimes costly to achieve. (New technologies, like Geographic Information Systems data from satellite telemetry, can reduce the cost of data collection considerably.) For some of the variables, less expensive proxy measurements can be used, as when "net change in forest cover" is used as a proxy for "net change in forest ecosystem services."

Estimates of valuation have distinct problems that are discussed below in a section on valuation methodology. And the GPI categories themselves could be improved. Briefly:

- "Net change in forest acreage" captures some of the costs of deforestation, but this subindicator would be made more accurate if it was disaggregated into component measures. Forests come in different types - hardwood, softwood, rain forest, etc. - each with characteristic kinds and amounts of various ecosystem services. The economic cost of lost forest acreage would thus vary with type of forest. Also, between "fully forested" and "clear cut" lies a range of forest densities, with a corresponding variation in level and kind of forestry ecosystem services. Appropriately detailed field work combined with inference from GIS data would make this indicator more precise than the either-or condition of forested or not. In such a disaggregation, particular attention might be

paid to the difference in valuation of forest under sustained yield management and forest under other management regimes. Of particular and special interest is the range of variability in carbon sequestration as a forestry ecosystem service; because carbon sequestration is a scarce service globally, we'd expect a forest type that sequesters more carbon to be more economically valuable than one that sequesters less carbon. As our knowledge of the costs of climate change becomes more detailed, valuations of this forest service need to change accordingly.

- Within the GPI, "Net change in farmland" can be seen as a proxy measurement for several valuable conditions, including retention of soil fertility, which can be degraded by natural processes of erosion (which can be hastened, to be sure, by human act) and through practices that amount to soil mining: extraction, through harvest, of the carbon energy stored in fertile soil (Hyams, 1953). Direct measurement of net change in total soil fertility, or the ratio of soils whose fertility is being conserved to those whose fertility is being degraded, would be desirable. And since the world faces a difficult transition to post-petroleum agriculture with the advent and passage of peak oil, a case can be made that fertile farmland that is in organic (post-petroleum) production is more valuable, per acre, than farmland whose productivity is dependent on fossil fuel-based fertilizers and pesticides. Separate valuation of these two types of farmland would increase the accuracy of this subindicator as a measure of sustainable wellbeing.

- "Cost of noise pollution" has conceptual and practical difficulties that require attention. Noise pollution is increasing, as is awareness of the costs, both direct and indirect. A study published in 1995 by the World Health Organization reports that "about half of the EU citizens are estimated to live in zones which do not ensure acoustic comfort to residents" and "more than 30 % are exposed at night to noise levels exceeding 55 dB…which are disturbing to sleep" (Berglund and Lindvall, 1995).

  Much current GPI practice relies on an index of urbanization to estimate noise pollution, on the assumption that noise is mostly a problem in urban areas, and specifically that the noise of vehicular traffic is a good proxy for all other forms of noise pollution. Neither assumption is particularly defensible, and both are unsuited to the experience of noise in relatively less developed countries and in rural areas. Low levels and small amounts of humanly generated sound can spoil the aural tranquillity - the silence that is a shared commons - of rural life. Technological innovation, such as computer applications that allow smart

phones to become GPS-equipped decibel meters, holds out the promise that inexpensive crowd-sourced information on ambient db levels could eventually be strong and sturdy enough to have policy applications (Maisonneuve, Stevens and Steels, 2009). An international project called "Noisetube.net," begun in 2008, collates and maps crowd-sourced noise data on its website.

Even with better data on environmental sound levels, computation of the monetary cost of noise pollution requires a foundation in assumptions and calculations that need articulation, elaboration, debate and consensus. For instance, if a regional economy depends on ecotourism, persistent sound from highways, chainsaws, even distant airplanes may have direct economic costs. Standards for setting valuations will need to be articulated by an appropriate authoritative body, most likely one drawn from the community of practice rather than from governmental organizations.

Many GPI compilations use cost data on noise pollution published in a World Health Organization study from several decades ago, and that study assessed just some of the health costs of chronic exposure to high levels of ambient sound (Cost of Noise Pollution 2012). Studies need to be done on other costs imposed on humans by other levels of noise (Bergund and Lindvall, 1995).

- "Cost of long-term environmental damage" can be used to capture the cost of climate change. Current GPI methodologies are unsatisfactory for this purpose. Insight might be gained from the cost computations made by insurers as they adjust their actuarial tables to the reality of changed weather patterns (Botzen and van den Bergh, 2008; Mills, 2005). The industry uses various climate models to estimate liabilities in our era of changing weather and is strongly motivated to predict those liabilities accurately. But not all costs of climate change are insurable losses. A community that loses its potable water supply to drought and summer heat; local businesses in an agricultural region that de-grows because of drought; increased consumer expense for air-conditioning; homeowner and civic expense to adapt storm water management to emergent realities; all of these represent an imposition of costs that are not in principle insurable. If in some regions and for some types of human development patterns the expected monetary cost of property damage from changing weather patterns could be shown to correlate meaningfully with other, non-insurable costs of climate change, it might be possible to extrapolate that correlation to other similar areas and

regions in order to develop more accurate measures of both the insurable and non-insurable costs of climate change.

- One problem that affects many of the monetary valuations that appear in GPI calculations is rooted in basic economic theory: if the supply of a good diminishes while demand for it remains constant or increases, its monetary (market) price will increase. Thus, scarcity of ecosystem services brings increasing marginal value to successive losses. This means that straight-line projection of the costs of ecosystem degradation is inappropriate; the values should asymptotically rise toward infinity as clean water, clean air, fertile soil, healthy forestland, etc. become increasingly rare—and rarity, here, can be local, regional, or global.

  But neither is a simple logarithmic function appropriate for all environmental costs. The first source of obnoxious sound in an otherwise quiet landscape degrades the silence-as-commons completely; the addition of a second source of sound does not have as large an effect and may in fact have no additional effect at all. But the addition of other sources of sound can eventually cumulate into levels of sound that again compound arithmetically or logarithmically. Similarly, bodies of water can have several different levels of impairment, corresponding to failure to meet standards for different uses: human drinking, human bathing, support of particular species of wildlife, etc. The first contaminant that places a waterbody into a particular impairment category can be conceived as imposing the cost of denial-of-service on humans, while additional units of contamination that do not change the impairment status of the waterbody do not, in principle, impose additional denial of service.

Intrinsic value of the domain

It's a mark of the severity of the ecological crisis facing humanity that it seems necessary to assert, and to offer authoritative citation for the assertion, that biodiversity and human wellbeing are inextricably connected because humans are an integral part of natural ecosystems. Biodiversity sustains the human food supply, supports delivery of the clean air and water that humans need to survive, and increases the possibilities for human adaptive use of nature's time-tested designs, including formulations for compounds and extracts that either serve as or inspire human medicines (Benyus, 2002). Biodiverse regions have greater prospects for economic development and biodiversity contributes to cultural and spiritual enrichment (CBD Health and Biodiversity, 2012).

Ecosystem resiliency allows ecosystems--providers of ecosystem services crucial to humans--to recover from exogenous and endogenous shocks (including the

enormous exogenous shock of climate change, which may bring changes to which the most resilient of ecosystems cannot adapt). Studies suggest that individuals who see the care and restoration of ecosystem resiliency as a social value worth supporting have a generally stronger sense of connection to other humans and stronger sense of their dependency on the land and on local nature. Each of these correlates with better health and higher levels of wellbeing (Forestry commission, 2003). The web of psychic and physical connection between self, other and land is an essential component of many traditional cultures, and helps account for the longevity of those cultures as they are otherwise sorely strained by contact with developed, industrial-commercial cultures. That web of connection is also a shared value that is consciously cultivated in newly developed "ecocultures," such as transition towns, in developed nations (Transition Town network, 2012).

Evidently, it is possible for some humans to experience wellbeing and happiness in isolation from the natural world. Because this is so, whether or not the health of ecosystems can be said to make an intrinsic contribution to human happiness and wellbeing depends on the mindset of the humans involved.

For humans who live their lives distant from nature, who are ecologically illiterate or who accept the mistaken, infinite-planet premises of standard economic theory, much damage to and even loss of ecosystems and their services will not immediately register as a significant decrement to their happiness and wellbeing. The contribution to wellbeing and happiness that ecosystems offer would, for these people, be entirely instrumental and not at all intrinsic.

For those humans who take pleasure in beholding natural forms and systems, who are alive to their own dependence on them, or who see their relationship to other life on the planet in moral and ethical terms, ecosystem health has great intrinsic value. When such people become aware of how those systems are being degraded, damaged and destroyed by human activity, that diminishment of ecosystems and their services is cause for alarm, anxiety, and sorrow.

This diminishment of happiness and wellbeing is even greater for humans who have either transcended or not succumbed to the anthropocentric species narcissism offered by contemporary commercial culture. These humans find intrinsic value in ecosystem health because they embrace a bio-egalitarian view in which every life form has an equal dignity and an equal right to exist, to compete for resources, and to flourish according to its nature. If all life forms are ontologically equal, their preservation has enormous intrinsic value.

Extrinsic value of the domain

It isn't necessary to adopt a bio-egalitarian mindset in order to find value in ecosystem resilience and biodiversity; these qualities have instrumental or extrinsic value for humans.

Meta-macroeconomic value: saving civilization

Traditional economic theory is systematically a-temporal and a-historical (Zencey, 1997). Because of this, it does not offer a level of analysis that allows appreciation of the largest of the benefits that accrue within the domain of Ecological Diversity and Resilience. When a temporal dimension is added to economic analysis by integrating environmental and economic history (an approach that could be called meta-macroeconomic, Zencey, 2008), it becomes obvious that healthy ecosystems are the foundation of civilization. No civilization can survive the loss of its root in nature. Thus, the qualities measured by indicators in this domain ultimately have an extrinsic, or instrumental, value equal to the value of civilization, which many civilized people would peg as infinite.

Macro- and microeconomic value: ecosystem services

At the macro- and microeconomic levels, the instrumental value of healthy ecosystems is obvious and relatively easy to specify. Degradation of ecosystems through pollution and contamination of air, water and land creates human health problems, which can be measured, and imposes defensive and remedial costs, which can be measured. Absence of green space affects human physical and psychological health, which can be measured. Compared to unhealthy ecosystems, healthy ecosystems offer larger contributions, over time, to the production of goods and services that humans seek, such as harvests of lumber, fish, game and agricultural produce and extractions of water from flows and reservoirs and aquifers; all of these can be measured. Ecosystem diversity increases ecosystem resilience, reducing the risk of sudden loss of these contributions to human wellbeing; the diversity of ecosystems can be measured, and the risk of ecosystem collapse can be estimated.

The concept of ecosystem service gives one framework for articulating the instrumental values provided by nature and its ecosystems. Several different schemas exist for classifying ecosystem services, though they do not disagree on the substance of what those services are.

One widely cited and influential paper (Costanza et al., 1997) fixed an approximate value for world ecosystem services, estimating them conservatively at US$ 16 - 54 trillion per year, with an average of US$ 33 trillion per year, compared to a global GNP of around US$ 18 trillion a year. The paper, which synthesized existing studies and reported a few original calculations,

looked at 17 distinct ecosystem goods and services for 16 distinct biomes. The categories:

- Regulation of atmospheric chemical composition
- Regulation of global temperature and climate processes
- Regulation of effects of storms and other natural phenomena
- Regulation of hydrological flows
- Storage and retention of waters in aquifers, reservoirs, soils, etc.
- Erosion control
- Soil formation
- Nutrient cycling
- Waste treatment and storage
- Pollination
- Biological control of plant and animal populations
- Habitat for economically valuable species
- Raw material for extraction (lumber, fuel, fodder)
- Genetic resources
- Recreational opportunities
- Cultural (aesthetic, artistic, educational, spiritual, etc.) opportunities

A Millennium Ecosystem Assessment (MEA) report issued in 2005 groups these services into four categories, which it labels "supporting," "provisioning," "regulating," and "cultural." (MEA, 2005) A suggested revision to the MEA categories by Kumar et al. reduces the possibility of double counting and suggests relabeling "supporting" services as "habitat" services (de Groot and Kumar, 2010).

The monetary valuation of ecosystem services

Setting monetary valuations for ecosystem services is becoming increasingly accepted but remains controversial. Some critics object to the practice on ontological grounds, noting that it is wrong, or at least metaphysically dubious and perhaps ultimately dysfunctional, to extend the valuation systems of the human economy to encompass Nature, of which humans and their economies can only ever be a subset; extending the valuation system of the part to encompass the whole seems like a perpetuation of the problem rather than a path toward a solution. Other critics note that ecosystem service valuation is an inexact science, subject to wide variation and notably different results from different methodologies, and that it cannot successfully value some services. (What, for instance, could possibly be the monetary valuation of an incremental increase or decrease in an ecosystem service that is infinitely valuable, like the protection afforded to all life by the ozone layer?)

Defenders of ecosystem service valuation point out that new methods and new thinking are needed if we are to achieve a new result, the preservation of enough ecosystem services to sustain civilization. The effort to keep nature and its values from being absorbed by commercial and economic systems of valuation by appealing to human altruism (i.e., asking consumers to reject market signals and their own financial self-interest) amounts to a call for something like a religious or at least a moral and ethical transformation of the dominant human culture on the planet. In the decades that environmentalism has been styled as a moral force, it has achieved some successes but has come nowhere close to establishing civilization on a sustainable footing. A call to save civilization (and thereby preserve the possibility of continued enjoyment of high levels of human wellbeing and happiness) through moral transformation is less likely to succeed than a call to "get prices to tell the ecological truth" so that the *economical* choice in any market is also an *ecological* choice. Nature has already been absorbed by commercial culture, the defenders of ecosystem service valuation point out; a refusal to put a monetary value on ecosystem services merely means that the default value will continue to be zero, which is clearly wrong.

In the past, environmentalists and conservationists aimed to put natural values beyond the reach of commercial, monetary considerations; this was the avenue to their preservation. That strategy led to some notable successes in the past century, as some landscapes were preserved from development and some species saved from profit-driven extinction by appeals to morality (i.e., it is wrong to cause other sentient beings pain and suffering or to prevent their kind from sharing the planet with us); to powerful symbolism (e.g., the purity of mothers' milk and the vitality of the US national symbol, the bald eagle, were factors contributing to a US ban on use of DDT); to deeply held religious beliefs (e.g., all of God's creatures deserve an equal chance to live and thrive, even if humans have supposedly been given "dominion" over them for instrumental use). But appeals to such value systems have not succeeded in producing anything like a general respect for the integrity of ecosystems or the voluntary human restraint that would be necessary to achieve a sustainable relationship between humans and nature.

Moneyed interests drive ecosystem damage, and moneyed interests understand the language of money. To preserve ecosystem values it may be necessary to speak the language of the people whose behavior and outlook stand most in need of change.

Metaphysical objections and linguistic concerns aside, as a practical matter ecosystem health is destroyed through human decision-making, and if humans are to make economically rational decisions those decisions must be based on

accurate assessment of expected costs and expected benefits. Ecosystem service valuation allows those decisions to include a category of cost that has not heretofore entered into economic decision making. For better or worse, monetary valuation is a widely shared frame of reference in our increasingly globalized market culture. As another report prepared as part of the UN Millenium Assessment put it:

> Economic valuation offers a way both to value a wide range of individual [ecological] impacts (some quite accurately and reliably, others less so) and, potentially but controversially, to assess well-being as a whole by expressing the disparate components of wellbeing in a single unit (typically a monetary unit). It has the advantage that impacts denominated in monetary units are readily intelligible and comparable to other benefits or to the costs of intervention (DeFries and Pagiola, 2005).

Such valuation, the report notes, "can also be used to provide information to examine distributional, equity, and intergenerational aspects" of the relationship between ecosystem health and human wellbeing.

Interaction of ecology and good governance

One underappreciated extrinsic value of healthy ecosystems is visible in the interaction of variables in this domain with variables in the domain of good governance. Whatever else it is, good governance has to be governance that secures the ongoing existence - the sustainability - of the society that is being governed. Thus, one criterion of good governance on a finite planet is management of public commons for the general benefit of citizens. These commons include not just air and water, but more generally many, if not all, of the ways in which the ecosystems of the planet provide source and sink services for human economic activity. Good governance must come to mean effective, equitable and sustainable administration of the various commons that contribute to wellbeing.

One commons that is not often conceived of as such is the economy, the primary instrument through which humans materially interact with their physical environment.

Conceiving of the economy as a common asset of society that is not essentially different from natural common assets like clean air and clean water helps to bridge the conceptual gap between culture and nature, economy and ecology, by pointing to yet another avenue of their integration. It also helps re-establish the role that government and justice plays in securing the social and political context in which economic activity takes place - a role that is not always

credited in societies that seek to liberalize trade and markets. In an era in which government intervention into the economy has strong ideological opposition, conceiving of the economy as a commons can help justify the intervention of public authority into economic affairs to maintain the common asset while promoting a public good that is not by any means automatically produced by unregulated, "free market" systems: the delivery of the maximum possible sustainable well-being to humans and their communities.

If that avenue of connection between good governance and ecological health is clear, less easily discerned is how that relationship runs the other way: healthy ecosystems are the foundation of our current notions of good governance. But the connection is equally durable and real. The basic conceptual foundations of modern democracy - the egalitarian concepts of the worth and dignity of each individual, and the notion that political, social, economic and cultural freedoms allow humans to achieve the fullest expression of their individual selves and their common humanity - emerged in the eighteenth and nineteenth centuries on a planet significantly different from the one we have today. The notion that individuals have a right to be let alone in any matter that doesn't affect others is a product of a time and a place - and a balance between nature and culture - in which human acts were thought to be incapable of damaging the planet and its ecological systems. Because the human population was small and its economic activity had not yet been amplified by fossil fuel use, the realm in which individuals could exercise prerogative, unregulated choice and freedom of action was large. Since that era, many of the ecological systems of the planet have been destroyed, degraded or distressed by human presence and activity. This represents an existential challenge to the theoretical and physical foundations of western democracy.

To generalize: the human experience of freedom is a dependent function of the distance between what culture takes from and discards into nature, on the one side, and what nature can sustainably give to us and absorb from us, on the other. Our notions of political freedom, along with many of the fundamental elements of our political and economic institutions, trace to a time when the distance between these two things seemed large, because the planet seemed infinitely fecund, infinitely generative, and infinitely absorptive. Today, with a globalized economy that is budgeted up to (and beyond) the absolute limits of sustainable production, that buffer zone in which human freedom flourished has disappeared.

We live now on a Factory Planet, not a Garden Planet. And a Factory Planet offers no room to do anything differently; life in a factory approaches the totalitarian condition in which all behavior that is not compulsory must be

disallowed. A factory is no place to insist on a right to privacy, a right to act on one's own volition, a right to participate in the decisions that affect one's life.

The largest extrinsic value of healthy ecosystems capable of hosting human culture, then, is the potential - not always realized - for civil liberty and democratic government (Zencey, 2012; 2009).

Traditional public policy

Worldwide, environmental policy is often grounded in one or more assumptions that are unsupportable:

Environmental values are one kind of economic value, which societies can purchase in greater amount when they are wealthier.

This is the assumption behind the Environmental Kuznets Curve, a supposedly empirical relationship between levels of pollution and levels of national income. The EKC holds that as national income (as measured by GDP) rises, levels of pollution at first increase, then reach a peak, then decline, as some of the newly created wealth is used to "buy" environmental quality. The idea has "intuitive appeal" for those whose standard economic theory defines environmental values as a subset of all economic values. (Standard economic theory acknowledges that nature has economic value because people will pay to experience it or to use some of its services.) But studies purporting to find the EKC's inverted-U relationship between wealth and pollution are deeply flawed. Most do not isolate and control for "pollution haven" effects—the export of negative environmental impacts from wealthier countries to less developed countries. Most seem to have been undertaken in an effort to prove the validity of the EKC, and manipulate assumptions and data combinations until the resulting curve takes on the foreordained shape. And all of them select proxy measurements (they focus on particular pollutants) rather than measuring ecological degradation in general. Finally, if we accept that green house gases are a pollutant, the EKC leads us to the absurd conclusion that the richest countries that the planet has ever seen in its history are still not wealthy enough to purchase the environmental good called "climate stability," and that more wealth generation (fuelled by something other than fossil energy, presumably) is what is needed to solve the problem (Stern, 2003).

These justifiable criticisms are sufficient to thoroughly discredit the notion that there is an automatic dynamic by which pollution levels at first rise then decline with increasing wealth. Still, the majority of economists have yet to explicitly reject the EKC, and the logic of it remains embedded in much environmental policy. Anytime there is talk of not being able to afford environmental regulation, or of needing to have economic growth first and environmental

quality later, the specter of the EKC is casting its pall of bad economic science on the discussion (Daly and Farley, 2011).

Degradation of common assets (like air or water quality) can be prevented by establishing property rights in the common asset, which gives owners of the asset the incentive to maintain it because preservation and protection of the asset will be in the owners' own economic self-interest.

This is the lesson learned from much human experience, ranging from the Enclosure Acts in England through Unitary Reservoir Management in the U.S. oil industry up to international agreements apportioning tonnages of catch from various blue-water fisheries. It does seem that establishing property rights solves the problem, but, as Daly and Farley (2011) point out, not all commons can be successfully enclosed. (It would be difficult to assign ownership shares in the ozone layer) Often enclosure is accomplished only through extinguishing the claims to usufruct of a significant number of beneficiaries - that is, property rights are established (by claim, seizure, negotiation or grant) for one or a few and others who have legitimate claim to benefit from use of the commons are excluded. Closing commons through establishing property rights regimes has not and probably cannot solve all environmental problems, and depending on how it's done it can create inequity and injustice.

Innovation and technological change are capable of dealing with any environmental limit or problem.

This testament to the faith that "more technology can solve the problems that technology has given us" is not expressed explicitly as frequently as it was in earlier decades but it has been retained through inertia in much economic theorizing and policy practice. It's evident in the effort to devise a technical fix to its carbon-intensive transportation system - automobiles that operate on electricity - rather than developing mass transit and pushing for the kinds of zoning and urban development changes that would make automobile use less necessary. Similarly, proposals to "geo-engineer" our way out of climate change or to genetically engineer crops to survive drought are silent testimony to this faith. (The implicit premise seems to be that nature is more malleable than are the human political systems in which powerful interests maintain their ability to foul the commons.)

Can technology always save us? While innovation and technological change have accomplished a great deal in terms of increasing the efficiency with which humans use resources, and while they have allowed some nations to derive more per-capita economic wealth from smaller per-capita ecological footprints, that process of progressive change is not and cannot be infinite: there are limits to technological development that can't be transcended or engineered into irrelevance. No matter how inventive humans turn out to be, they will never invent their way around the first and second laws of thermodynamics, the laws

that forbid perpetual motion. The failure of the discipline of economics to adopt the thermodynamic model of the economy proposed by Nicholas Georgescu-Roegen (1976), Herman Daly (1977) and others signals the discipline's retention of this assumption, which is crucial to maintaining a faith in the possibility of perpetual economic growth.

Regulatory "tailpipe plugging" can be sufficient to reduce environmental harms to tolerable levels, and tort law is sufficient means of rectifying cases not (yet) covered by regulation.

When the planet seemed large and expansive in relation to human acts and works, environmental policy could be reactive. Demonstrable harms led to legislation or to pursuit of damages through civil law. A thermodynamic model of the economy suggests that these amount to tailpipe plugging: they attempt to regulate the performance of a machine, the economy, by limiting its capacity to exhaust its detrimental wastes. Experience has shown that engines are more effectively and efficiently regulated through metering of inputs rather than choking down outputs, and that insight might yet be applied to the machine that is an economy.

Environmental policy is clearly distinct from monetary and fiscal policy.

The international economy that threatens to render the planet inhospitable to humans is lubricated by a monetary system that allows private banks to create the money supply by creating debt, and this system requires perpetual economic growth in order to maintain even a semblance of stability. The logic: Debt is a claim on the future production of real wealth by the economy. The productive capacity of any economy is subject to physical limits, including resource constraints. Even if the planet were infinite, there would be physical constraints: production takes place in time using matter and energy, and because it is physical, the output of real wealth cannot be expanded as rapidly as can the completely virtual quantity "total debt." When debt grows faster than an economy can grow the means of paying it back, the economy has a structural need for some form of debt repudiation (Daly, 1977; Benes and Kumhof, 2012). Inflation is one sort of debt repudiation, and it is created by governments running budget deficits - in essence, private debt generated by the economy is converted into public debt.

If nations are required to balance their budgets, then the necessary debt repudiation will come as a crisis: foreclosures, defaults, stock market crashes, pension fund wipeouts, the loss of paper assets (expected future real wealth) in any form. (It is worth noting that when government budgets can only be balanced through austerity measures that impose penury on citizens and lead to civil disturbance, the choice is between two paths that lead to social dislocation and crisis.) Loosening environmental regulations can stimulate the rate of growth of the economy, staving off such crises at the cost of compromising the

environment's ability to contribute to present and future human happiness and wellbeing. The better solution to the problem of periodic debt crises is one that preserves the health of the environment, and it consists in bringing the creation of debt under control so that growth in debt doesn't outpace the global economy's ability to grow enough real wealth to pay it back. (And, in a global economy that already uses an unsustainable flow of matter and energy inputs, any sustainable growth must come from the application of the third factor of production, design intelligence. Daly and Farley (2011) call this "development" to distinguish it from foot-print expanding growth.) Fiscal, monetary and environmental policies are thus intimately linked (Dyson et al., n.d.).

Population policy is not a necessary component of environmental policy.

In one commentator's apt phrase, population policy is the third, fourth, and fifth rail of environmental politics; the subject has simply disappeared from public discourse, which seems to operate on a tacit consent that all talk of limiting population growth to ensure a higher standard of sustainable wellbeing for humans on the planet is simply off limits. Several large factors help account for this. First, infinite-planet theorists ranging from free-market enthusiast Julian Simon to socialist Karl Marx succeeded in establishing an elite consensus around the idea that (in Marx's case) labor is the source of all economic value or (in Simon's case) there are no limits to human ingenuity; the two doctrines are functionally identical, and historically led both communist and (supposedly) free-market capitalist powers to oppose population control measures. Second: Catholic Church doctrine continues to define the most effective forms of family planning and birth control as sinful, and other religions and cultures expressly reject family planning methodologies and information campaigns. Third: Among mammals, the determinant of the rate of population growth is what happens in the wombs of fertile females; because a lone male can impregnate many females, the number of males of the species can be - and often is - irrelevant to population growth. Humans have social systems that tend to tie impregnators to impregnated, male to female, but at the biological level, control of population growth for a mammalian species is control of the female reproductive system. To many people, human population policy looks to be an attempt to exert social control over women's bodies.

Other assumptions that underlie much traditional environmental policy have been criticized and are beginning to lose their status as part of the tacit valuations and beliefs behind "the Washington Consensus," the foundation of a globalized world economy. These newly contentious assumptions include:

Because technology can solve any problem that humans create by using technology, the planet is effectively infinite for economic purposes, which means the marginal cost of lost ecosystem services is close to zero, and therefore environmental

externalities are not significant disruptors of the efficiency of market-based allocation systems.

This unspoken assumption is in the process of being questioned and discarded. Increasingly, political processes and policies are taking environmental externalities into account or there is official support for doing so. Thus, in 2010 the President of the World Bank, Robert Zoellick, told a conference on biodiversity that "We need to assist…economic agencies to measure 'natural wealth'…The value of services we derive from ecosystems shouldn't be assumed to be zero," and he went on to call for calculation of the value of lost ecosystem services in making decisions about development (World Bank, 2010). Even so, no western world leader has yet said "perpetual economic growth is impossible."

Economic growth as traditionally defined is always and everywhere a good thing.

It is becoming increasingly obvious that economic growth and development have ecological and social consequences, some of which are costs; as Daly and Farley (2011) have noted, when those costs exceed the expected benefits, economic growth becomes uneconomic growth.

Energy is a commodity like any other, and market forces are capable of resolving energy shortages if given enough time and a loosening of environmental constraint.

In the 2004 edition of their *Principles of Economics,* Robert H. Frank and Ben S. Bernanke (2004) told student readers about the gas crises of the 1970s but reassured them that rising prices eventually cleared the market and led to additional oil prospecting and production: "in short, market forces solved the energy crisis" (p.529). That remarkable conclusion suffers from an ignorance of the laws of thermodynamics and a failure to appreciate a crucial distinction between stock and flow: the market price of oil is determined by supply and demand, and the supply is determined by the rate at which we extract a flow from a fixed stock. A stable or declining price for oil doesn't mean we've solved our economy's energy problem; it simply means that we are pumping a finite stock of stored solar energy out of the ground fast enough to match or overmatch rising demand for it. An appreciation of the economy as a thermodynamic machine and a respect for the laws of thermodynamics leads to the conclusion that energy is not a commodity like any other, but a fundamental factor of production (along with matter and intelligence).

Knowledge of the economic history of humanity, as filtered through this thermodynamic lens, suggests that limited energy supply (usually in the form of solar energy captured from green plants through agriculture and forestry) has in nearly all places and times been the constraining factor to the human production of wealth and enjoyment of wellbeing (Homer-Dixon, 2006; Crosby, 2007; Hall and Klitgaard, n.d.). The contemporary era is defined by the

discovery of comparatively vast quantities of stored solar energy in the form of oil, coal and gas, and by the relatively rapid development of technologies that exploit this energy. These temporarily removed energy from its status as limiting factor, but only a myopic, temporally parochial perspective could mistake the Fossil Fuel Era for the permanent condition of humanity. This mistake on the part of economic theory has been supported by another assumption that is in the process of being challenged and changed:

Nature is an unchanging given, immune from being affected by economic activity, which means economic analysis does not need to include the environmental feedback loop represented by the measurement and valuation of ecosystem services.

Geophysical sciences have known for more than a century that this isn't true (Marsh, 1864). But economics was, and by and large remains, an ahistorical discipline - a discipline that studies dynamic change within relevant social systems but ignores history, the aggregation of all change over time. At best the discipline seems able to grasp a kind of comparative statics, comparing conditions at time "A" to conditions at time "B". (Georgescu-Roegen suggested that this ahistoricity of economics was due to its unwillingness to accept the economic import of the entropy law, for the entropy process is "time's arrow," the only physical law of universal application that is unidirectional in time.) In this, the discipline of economics perpetuates a pre-Darwinian metaphysics; it encodes a vision of nature as lying outside of culture, essentially unchanged, unchanging and unchangeable. The growing use of the concept of ecosystem services represents a subversion of that ahistoricity, for it proceeds from an acknowledgement that the flows of those services can vary with the results of human decision making.

Other major research findings relevant to public policy

The academic literature on valuation of ecosystem services as an element of human wellbeing is vast and growing, and no attempt will be made here to survey or summarize it. An extremely useful survey of the field can be found in DeFries and Pagiola (2005), which characterizes valuation methodologies, giving their appropriate applications, their data requirements and their limitations.

Table 2.6. Main Economic Valuation Techniques (Adapted from Pagiola et al. forthcoming)

Methodology	Approach	Applications	Data Requirements	Limitations
Revealed preference methods				
Change in productivity	trace impact of change in environmental services on produced goods	any impact that affects produced goods	change in service; impact on production; net value of produced goods	data on change in service and consequent impact on production often lacking
Cost of illness, human capital	trace impact of change in environmental services on morbidity and mortality	any impact that affects health (e.g., air or water pollution)	change in service; impact on health (dose-response functions); cost of illness or value of life	dose-response functions linking environmental conditions to health often lacking; underestimates, as it omits preferences for health; value of life cannot be estimated
Replacement cost (and variants, such as relocation cost)	use cost of replacing the lost good or service	any loss of goods or services	extent of loss of goods or services; cost of replacing them	tends to overestimate actual value
Travel cost method	derive demand curve from data on actual travel costs	recreation	survey to collect monetary and time costs of travel to destination; distance traveled	limited to recreational benefits; hard to use when trips are to multiple destinations
Hedonic prices	extract effect of environmental factors on price of goods that include those factors	air quality, scenic beauty, cultural benefits	prices and characteristics of goods	requires vast quantities of data; very sensitive to specification
Stated preference methods				
Contingent valuation (CV)	ask respondents directly their willingness to pay for a specified service	any service	survey that presents scenario and elicits willingness to pay for specified service	many potential sources of bias in responses; guidelines exist for reliable application
Choice modeling	ask respondents to choose their preferred option from a set of alternatives with particular attributes	any service	survey of respondents	similar to CV; analysis of the data generated is complex
Other methods				
Benefits transfer	use results obtained in one context in a different context	any for which suitable comparison studies are available	valuation exercises at another, similar site	can be widly inaccurate, as many factors vary even when contexts seem "similar"

Table 5. ***Main economic valuation techniques***

Most of the work of ecosystem service valuation consists of quantifying biophysical relationships: how, for instance, deforestation diminishes water quality, and how that change affects the health of humans and other species who derive benefit from that water source. Causal chains are traced and data are used to gauge impacts. The assignment of monetary valuation to ecosystem services lost (or, more rarely, gained) is the final step.

Each of the approaches given by DeFries and Pagiola has seen extensive use and a considerable literature exists on their application. They report that many of the valuation studies are cataloged in the Environmental Valuation Reference Inventory Web site maintained by Environment Canada (Environment Canada, n.d.).

The choice of valuation method is in some measure a choice of result, and the range of variation in those results undercuts the implicit claim that ecosystem service valuation is a technical exercise that produces objective results. But

ecosystem service valuation is not, on that account, a completely subjective, arbitrary, or unprincipled practice. As with elements of standardization in the machine age, appropriate standards can be generated by a non-politicized community of practice. The American Society of Mechanical Engineers set screw pitch standards based on tensile strengths and coefficients of friction of metals and the needs of various applications. The choice between metric or "English" standardization was a cultural one, and left-loosen right-tighten was essentially arbitrary. Standardization of valuation methodologies is likely to be accomplished with a similar mix of elements.

Recommendations

What not to do

A variety of actions and policies need to be stopped or modified in order to do ensure contribution of healthy ecosystems to happiness and wellbeing, respectful of all forms of life. These include:

- Do not mistake GDP to be a measure of economic progress, and do not pursue maximum GDP as a policy goal, because GDP fails to take into account the economic benefits that are lost when ecosystems are degraded or destroyed;

- Stop allowing the issuance of private-bank, debt-based money, which allows the sum total of debt in the global economy to grow faster than the economy can grow the real wealth needed to pay it back. This is an ecological issue because the distance between the two values is the primary driver of unsustainable, eco-system damaging economic growth;

- In investment calculations, stop discounting future benefits from resource use, since the practice encourages exploitation of resources in the present and leads to unsustainable exploitation of resources that might be exploited sustainably;

- Stop subsidizing further development of fossil fuel use through extending and improving fossil-fuel-intensive infrastructure. Stop direct subsidies to fossil fuel industries (including the petroleum, coal, highway construction, and automotive industries);

- End the silence on discussion of population policy as a reasonable and necessary component of the effort to achieve and maintain high levels of human happiness and wellbeing;

- End the "race to the bottom" by which developing countries are encouraged to compete with each other for jobs and economic wellbeing by reducing the burden of environmental and worker health and safety regulations.

- Stop hamstringing the development of solar and renewable energy industries by creating a climate of uncertainty through on-again, off-again subsidies and tax credits.

- Stop presuming that of the three factors of production—matter, energy and intelligence—intelligence is the trump that can overrule any resource limit; which is to say, stop presuming that economic development can always eventually become non-zero-sum or "win-win," bringing benefit to all involved.

- End property rights on life in any form, whether human, animal or vegetal.

What to do

The ultimate goal is to build something the world has never seen: an ecologically sustainable human civilization that has a high degree of material wellbeing that is widely and equitably shared. Success requires nothing less than reversing several centuries' worth of momentum that has accumulated behind our current perpetual-growth, infinite-planet economic practice - a belief system and a practice that take for granted humanity's access to low cost (high Energy Return on Energy Invested) energy sources (Hall and Klitgaard, n.d.).
It's a daunting task, but the effort may receive geophysical assistance as supplies of high EROI energy dwindle, forcing on humanity a return to an economy that operates on current solar income. Meanwhile, there are leverage points at which concerted effort for change will have amplified effect. Some of those leverage points are particularly relevant to the domain of "Ecological Diversity and Resilience."

Because our current ecologically unsustainable system is not the accidental product of sound social and economic theory, but the product of infinite-planet thinking in social and economic realms, some of the most powerful leverage points lie not in the concrete realm of policy but in the abstract realm of changing our social capital—the shared understandings and publicly held knowledge that built our infinite-growth economy. Specific policy proposals, then, are keyed to changes in the underlying principle that the policy seeks to enact. The list is by no means comprehensive.

Principle 1. Establish that the purpose of an economy is not the maximum throughput of resources, or even the maximum creation of wealth, but the maximum creation of sustainable human wellbeing and happiness. Establish that the consumption of natural capital as income is unsustainable, anti-social, self-defeating, uneconomic, and just plain stupid.

> *Policy 1.a.* Establish a comprehensive set of indicators of human happiness and wellbeing that assess the health of all the forms of capital that are important to human happiness and wellbeing, and which specifically treats degradation of natural, social and cultural capital as cost items in national accounting systems.
>
> *Policy* 1.b Establish an international body of experts, on the model of the American Society of Mechanical Engineers, to articulate, promulgate, curate, set standards for and as necessary develop and modify the elements of that indicator set.

Principle 2. End the competitive race-to-the-bottom by which nations, regions, and various political subdivisions compete with each other for development that brings employment opportunities.

> *Policy 2a.* Establish minimum standards for worker safety, health, and dignity, along with minimum standards for environmental protection, that are consistent with production of maximum human wellbeing, and which specifically recognize that work with dignity is essential to human well-being.
>
> *Policy 2b.* Enforce these minimum standards through tariffs or outright trade embargoes imposed on countries that fail to meet them.

Principle 3: Establish in national law, international law and as a principle human right the principle that that no person, group of persons, agents, corporations or governments should be allowed to profit from imposing ecological, social, cultural or economic harm, damage or loss on any other humans or groups of humans.

> *Policy 3a:* Support the general adoption of the model offered by Ecuador, which in 2008 adopted a national constitution that specifically acknowledges that nature has the right "to exist, persist, maintain and regenerate its vital cycles, structure, functions and its processes in evolution" and which establishes governmental authority to forbid the private diminution of ecosystem services.

Policy 3b: Establish authoritative administrative systems that use broad criteria to judge development proposals to ensure that proposed development neither seeks nor is likely to allow some humans to profit by imposing harm, damage or loss on others. The criteria should specifically acknowledge that denial of ecosystem services constitutes a loss. Whenever such anticipated externalized losses outweigh the anticipated externalized gains that would be brought to the community by the development proposal, the criteria should require that the proposal be rejected. One model for such a development review process is Act 250 in the US state of Vermont. This law mandates a process of careful review of development proposals (originally, by citizen panels), ensuring that they meet ten distinct criteria. Under those criteria, development must not result in "undue" water or air pollution; must not "unreasonably burden" any existing water supply; must not cause "unreasonable" soil erosion, "unreasonably dangerous or congested conditions" in transportation modes, have an "undue adverse affect" on "scenic beauty, historic sites, or natural areas," or "imperil necessary wildlife habitat or endangered species" (Argentine, 2008). Case law has determined what does and doesn't count as "unreasonable" and "undue." As the administration of the law evolved over several decades, the direction of change points toward (but hasn't fully achieved) this insight: in an ecologically straitened world, it is no longer reasonable to suppose that one individual's pursuit of self interest should be allowed to impose loss of ecosystem services on the community as a whole (Courtney and Zencey, 2012).

Principle 4: Reform those elements of the economy, like our debt-based monetary system, that encode the presumption that infinite economic growth is possible and which push the system toward production of uneconomic growth. Since privately issued, debt-based money is the primary driver of a financial system that demands continual economic growth as a condition of economic stability, establish as a principle the right of public authority to retain sole control over the creation and issuance of money.

Policy 4a: Phase out fractional reserve banking through a series of stepped increases in reserve ratios until the maximu of 100% is reached, and forbid private creation of other instruments of debt-based money.

Policy 4b: Subnational and local governments create local banks and local currencies, capturing seingiorage (the profit that comes from creating a public good, money) for the public treasury.

Principle 5: Policies to protect ecosystem diversity, ecosystem health, and the continued delivery of ecosystem services to humans can no longer be reactive

but must encode the precautionary principle (Daly and Farley, 2011). It is therefore necessary to augment (and eventually to displace) environmental regulation's focus on reactive tail-pipe plugging and tort law with policies designed to address environmental problems at their source: the expansion of the economy's two ecological footprints, on the uptake and on the output side.

> *Policy 5a:* A "green tax shift" from taxing value-added processes (like the income tax on labor) to taxing throughput of scarce resources (including use of the scarce "sink" capacity of ecosystems) exemplifies this approach.

Principle 6: Establish zero population growth as a public policy target.

> *Policy 6a:* worldwide, education of women has the single largest net effect in suppressing birth rates. Support education of women as a civil and social right, and as one means toward achieving sustainability through population stability.

> *Policy 6b:* Because the annual number of unplanned pregnancies is roughly equal to the rate of population increase, support dissemination of birth control technologies and family planning information worldwide.

Principle 7: Establish a 100% renewable energy standard as a desirable public policy goal.

> *Policy 7a:* provide trade privileges and other incentives for nations that make progress toward or achieve this while establishing disincentives for continued reliance on fossil fuel.

> *Policy 7b:* Establish a clear protocol, such as that advocated by Campbell (1996) and Heinberg (2006), for assisting nations in tapering off their use of petroleum, and for equitably apportioning the reduced flow of petroleum among competing national claimants.

Principle 8: Climate change is the largest and most obvious, but by no means the only, environmental externality imposed by our current economic system. This relentlessly unfolding catastrophe requires immediate and far-reaching action.

> *Policy 8a:* Continue to press for an enforceable limit on green house gas emissions, and even in the absence of such an agreement offer incentives and rewards to nations that behave as if such an agreement were in place.

Policy 8b. Design and implement a climate-change knowledge-generation and -dissemination strategy and a climate-change awareness program for all sectors of society (including, but not limited to, early education).

Policy 8c. In the wake of severe weather events (presumably aggravated by climate change), condition relief aid on participation in the principles and practices of the New Economic Paradigm (abandonment of GDP, institution of Green Tax Reform, agreement to the Oil Depletion Protocol, etc.).

For several centuries, political economists of varying stripes have celebrated the mutual reinforcement between free markets and democratic systems and between economic growth on the one side and growth in individual empowerment and civil liberty on the other. Faith in these conjunctions are part of the social capital—the mutual trust, shared valuations, shared perception of reality and publicly held knowledge (Zencey, 2012, adapting Goodwin, Nelson and Harris, 2009)—that characterizes modern democracies and allows them to function. But these conjunctions are conventional and historical, not absolute; they are the product of a particular set of circumstances—cheap fossil energy, small human population, and a relatively untrammelled planet with immense stocks of natural capital—that cannot be replicated in planetary history. In an era of ecological constraint, democracy and unregulated markets tend to be antagonists, not complements, for as a system designed for infinite growth meets environmental limits its dynamics shift from win-win to zero sum, and as damage and loss are imposed on less politically powerful participants elites find ways to insulate their system from popular pressures (Zencey, 2012). Faith in democratic processes is similarly challenged by sustainability, which is an objective condition that is unaffected by the majority's perception of it. Even in the absence of popular support for establishing a sustainable economy, continuation of an unsustainable economy is not an option; by definition, unsustainable systems do not last, but revert to sustainability. To ensure that the sustainable system we eventually achieve is one that retains democratic and participatory forms, several additional imperatives must be met:

Principle 9: To the maximum feasible extent, policies implementing the New Development Paradigm need to be articulated, designed and implemented through broadly inclusive egalitarian consultation and engagement, to help build the social capital that successful adoption will require, and to reflect the role that good governance (including democratic and participatory forms) plays in contributing to human happiness and wellbeing.

Policy 9a: These processes should guarantee that all stakeholders are apprised of objective realities and the newly emergent, ecologically

grounded constraints that establish new criteria for wise statecraft and effective public policy.

Policy 9b: Additional conscious efforts to support the development of the social capital needed to achieve an ecologically sustainable democracy need to be undertaken. This social capital will be at odds with the social capital that supports infinite-planet, infinite growth economic policies; the ability of vested interests to subvert the creation of finite-planet social capital should be curtailed through limits on corporate political and issue advertising, on corporate donations to political campaigns, and on gifts and other valuable conveyances to elected officials. Countries that fail to meet standards for these protections should be sanctioned by the international community.

Policy 9c: In the effort to shape finite-planet social capital and promote sustainability, preference should be given to those strategies whose corollary lessons are compatible with sustainable democracy. Top-down prescription, along with opaque and distant decision-making, tend to teach political passivity; they devalue the role of voter as empowered decision-maker that is central to democratic theory. To support retention of democratic habits, extensive use should be made of participative action forums, co-production of relevant policy solutions (e.g. urban gardens, community bike paths and no-car days), peer-led methodologies, creative strategies (participative theatre, art) and transformative action methodologies. Citizen participation in the administrative processes outlined in policy 3b is necessary to prevent capture of that regulatory process by vested interests.

Policy 9d: Formal and informal communities of interest and other networks should be used to promulgate the shared valuations and publicly held knowledge that is necessary to and supportive of sustainable democracy.

Policy 9e: Ensure the participation in open public policy forums of local stakeholders engaged in the practical search for a sustainable economy, e.g. citizens associated with Transition Town Networks.

Principle 10: No act that imposes harm, damage or loss on others is truly private. On a crowded planet with an economy built out to and beyond its environmental limits, there may be no truly "private property."

Policy 10a: International property laws should be overhauled to harmonise them with the target of healthy ecosystems; where feasible, open access

regimes should be closed through appropriate assignment of property rights.

Principle 11: The knowledge and technical expertise needed by a post-petroleum society will resemble, in crucial ways, the knowledge and technical expertise achieved in non- or pre-petroleum societies. Exchange between practioners in each of these groups should be promoted and facilitated.

Policy 11a: Governments and educational institutions should, through appropriate programming, support the interchange of ideas, information and experience between pre- and post-petroleum cultures. For instance, in Knox County Ohio, Kenyon College's Rural Life Center has promoted job sharing, socialization, and other opportunities for communication between Amish and organic farmers (Rural Life Center, n.d.). Strategies should be developed and implemented to promote the appropriate retention and transmission of knowledge systems that predate the petroleum era.

Barriers to policy adoption

The barriers are many and in some cases formidable.

- Ignorance
- Inertia
- Vested interests with the power to influence political processes and prevent change that would limit their ability to benefit financially by imposing harm and loss on others through private appropriate of common value, e.g. through ecosystem degradation.
- Pressure for austerity in public spending, which militates against increased public staffing to investigate and articulate policies aimed at achieving sustainability. (This pressure is both ideological and geophysical: advocates of smaller central government resist extending the reach of government to encompass new tasks, and as the EROI of oil declines, the economy has less net energy to fuel the creation of goods and services of all kinds, including governmental services.)
- Principles of national and cultural autonomy, which limit the ability to achieve top-to-bottom imposed movement toward a sustainable global economy.

Ignorance and inertia can be met with sustained rational argument. Other barriers have proven more resistant.

A concerted campaign to inform relevant publics, to encourage influential decision makers to re-imagine economic relations along the lines proposed here and to lobby decision makers to adopt elements of the program seems a reasonable strategy. Care should especially be taken to help influential people and decision makers to re-frame their experience in light of the concepts central to this program.

We can expect that the economies of the world will continue to experience the difficulties that come from infinite-planet practices encountering the limits of a finite planet, and those occasions of crisis will afford the opportunity to encourage these people to re-think their fundamental premises and entertain the idea of adopting the policies and outlook advocated here.

The change is facilitated when the alternative paradigm is ready-to-hand to help explain events that are otherwise confusing, unexpected, or inexplicable. In the effort to change the economic vision that currently guides national and international policy, the ecosystems of the planet will continue to be a strong partner, for they will continue to give evidence of the shortcomings of the old way of thinking.

In particular, development of a sturdy and comprehensive indicator set is a logical first step. The failures of GDP as an indicator of economic wellbeing are so obvious that the adoption of better measures can scarcely be resisted. An appropriate set of metrics will, when adopted, provide an inspirational framework for national policy that will drive other positive change.

Data and measurement for policy

Some of the analysis that could be offered under this heading was covered in the section on additional sub-indicators.

Additional data and metrics for measuring human wellbeing and happiness are offered by the Failed State Index, which could usefully be mined for this purpose. The Failed State Index is a production of a respected NGO, The Fund for Peace. Using a set of metrics the FSI evaluates the 177 recognized nations of the world for their levels of stability and capacity, ranking them on a scale from "least failed" to "most failed." The Fund for Peace reports a steady increase in the number of governments that have responded to the rankings by seeking ways to improve their standing or by using it as a component in policy decisions. The FSI is thus functioning as an alternative indicator system for

those governments. The Fund for Peace describes the methodology behind the Index in these terms:

> The Failed States Index is based on The Fund for Peace's proprietary Conflict Assessment Software Tool (CAST) analytical platform. Based on comprehensive social science methodology, data from three primary sources is triangulated and subjected to critical review to obtain final scores for the Failed States Index. Millions of documents are analyzed every year, and by applying highly specialized search parameters, scores are apportioned for every country based on twelve key political, social and economic indicators and over 100 sub-indicators that are the result of years of painstaking expert social science research (The Fund for Peace, n.d.)

The twelve major indicators in the FSI can be grouped into three broad categories: Social, Economic, and Political and Military. As can be seen from boxed text below, the categories and indicators offer significant overlap with GNH and GPI based assessments. This suggests that there is room for fruitful collaboration between the Fund for Peace and the work being done in pursuit of "Happiness and Well-being: Toward a New Economic Paradigm."

Social Indicators

Demographic Pressures — DP

Pressures on the population such as disease and natural disasters make it difficult for the government to protect its citizens or demonstrate a lack of capacity or will.

Includes pressures and measures related to:

- Natural Disasters
- Disease
- Environment
- Pollution
- Food Scarcity
- Malnutrition
- Water Scarcity
- Population Growth
- Youth Bulge
- Mortality

Refugees and IDPs — REF

Pressures associated with population displacement. This strains public services and has the potential to pose a security threat.

Includes pressures and measures related to:

- Displacement
- Refugee Camps
- IDP Camps
- Disease related to Displacement
- Refugees per capita
- IDPs per capita
- Absorption capacity

Group Grievance — GG

When tension and violence exists between groups, the state's ability to provide security is undermined and fear and further violence may ensue.

Includes pressures and measures related to:

- Discrimination
- Powerlessness
- Ethnic Violence
- Communal Violence
- Sectarian Violence
- Religious Violence

Human Flight and Brain Drain — HF

When there is little opportunity, people migrate, leaving a vacuum of human capital. Those with resources also often leave before, or just as, conflict erupts.

Includes pressures and measures related to:

- Migration per capita
- Human Capital
- Emigration of Educated Population

Economic Indicators

Uneven Economic Development — UED

When there are ethnic, religious, or regional disparities, the governed tend to be uneven in their commitment to the social contract.

Includes pressures and measures related to:

- GINI Coefficient
- Income Share of Highest 10%
- Income Share of Lowest 10%
- Urban-Rural Service Distribution
- Access to Improved Services
- Slum Population

Poverty and Economic Decline — ECO

Poverty and economic decline strain the ability of the state to provide for its citizens if they cannot provide for themselves and can create friction between the "haves" and the "have nots".

Includes pressures and measures related to:

- Economic Deficit
- Government Debt
- Unemployment
- Youth Employment
- Purchasing Power
- GDP per capita
- GDP Growth
- Inflation

Table 6. ***The Failed State Index Indicator Set*** **(Fund for Peace, n.d.)**

Monitoring

Progress in the adoption of sound policy in this area can be judged in two main arenas, which can be likened to measuring the performance of an engine by monitoring both its intakes and outputs.

On the output side, progress will consist in choking the exhaust, which can be measured as the increasing adoption of a comprehensive set of metrics that assess the ecological impacts of economic activity as part of its overall measure of happiness and wellbeing. Progress could be charted in reference to the number of nations that adopt such an indicator set; or the percentage of the world's population covered by that indicator set; or (ironically enough) the

percentage of world GDP that is encompassed under the new metric. Just as restricting exhaust flow is not the most effective way to regulate an engine's speed, establishing a comprehensive set of indicators of sustainable wellbeing is no guarantee that policies will be adopted that will maximize the positive elements and minimize the negative elements in that indicator set.

On the intake side, progress will consist in diminishing the forces that drive our economies into uneconomic, ecosystem-degrading economic growth. This will come as a result of the increasing adoption of an appropriate finite-planet financial system, one that no longer allows money to be created through the creation of debt. Here progress could be gauged in a similar manner: number of nations that have agreed to eliminate fractional reserve banking on a published schedule; or the percentage of the world's population who reside in nations that have made that commitment; or percentage of the world's money supply that is government-created rather than issued as debt-based money by the private banking system.

Conclusion

Because the ultimate purpose of an economy is to bring the maximum feasible amount of happiness and wellbeing to its participants, and because happiness and wellbeing depend on healthy ecosystems, an ecologically sustainable economy is not just a practical necessity in the long run but is also the only kind of economy that can achieve an economy's ultimate purpose.

The transition from an infinite-growth, GDP-based model to a steady-state, alternative-indicator-based model will not be an easy one. Vast energies have been employed in developing the current system, and entrenched interests benefit from it. In the past—before the planet reached its capacity to support human economic activity—those interests derived their benefits by meeting the needs and satisfying the wants of consumers. On a finite planet that hosts an economy too large for it, business as usual continues to meet needs and satisfy wants, but increasingly it imposes harm, damage and loss as a necessary element of doing so. The problem is not with markets as such or with ownership of productive resources as such; the problem is that a system designed for infinite expansion has reached real-world limits that were not anticipated and have been too long denied. Effective redesign of the system, adapting it to a finite planet, is needed, and the measures offered here are meant to provide the framework for such a redesign. Those who continue to benefit from business as usual—those who profit from imposing harm, damage and loss on others—are likely to marshall their considerable resources to resist elements of that redesign that cause them financial loss.

If this prospect is disturbing, there is some comfort, if also some additional cause for concern, in the thought that unsustainable systems do not last. We will have a sustainable economy in one form or another, sooner or later. The relevant question is, will we prepare sensibly for it? Implementation of a new development paradigm will minimize the amount of human pain and suffering in the future by securing from further degradation the biological diversity and ecosystem resilience of the planet. Failure to act will bring further reduction in the human carrying capacity of the ecosystems of the planet, condemning future generations to a meaner, mingier, stingier life.

Between a sustainable state and the world we occupy now lies the potential for a great deal of political and social upheaval. Wise statecraft would seek to minimize those upheavals; wise statecraft would adopt a New Development Paradigm.

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