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ECOSYSTEM SERVICES IN THEORY AND PRACTICE

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The world has changed dramatically. We no longer live in a world relatively empty of humans and their artifacts. We now live in what some are even calling a new geologic era – the "Anthropocene" (Crutzen, 2002) – a full world where humans are dramatically altering our ecological life support system (Daly, 2005).

Our traditional concepts and models of the economy were developed in the empty world. The conventional view of the "economy" is based on a number of assumptions about the way the world works, what the economy is, and what the economy is for (Table 2.1). In this "empty world" context, built capital – the houses, cars, roads, and factories of the market economy – was the limiting factor. Natural capital – our ecological life support system – and social capital – our myriad relationships with each other – were abundant. It made sense, in that context, not to worry too much about environmental and social "externalities" – effects that occurred outside the market – since they could be assumed to be relatively small and ultimately solvable. It made sense to focus on the growth of the market economy, as measured by Gross Domestic Product (GDP), as a primary means to improve human welfare. It made sense, in that context, to think of the economy as only marketed goods and services and to think of the goal as increasing the amount of the goods and services produced and consumed.

But in the new full world context, we have to think differently about what the economy is and what it is for if we are to create sustainable prosperity. If we seek "improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities", as the UN has recently proclaimed as the primary global goal (UNEP, 2011, p.2), we are going to need a new vision of the economy and its relationship to the rest of the world, one that is better adapted to the new conditions we face.

We have to first remember that the goal of the economy is to sustainably improve human well-being and quality of life. We have to remember that material consumption and GDP are merely means to that end, not ends in themselves. We have to recognize, as both ancient wisdom and new psychological research tell us, that material consumption beyond real need can actually reduce our well-being. We have to better understand what really does contribute to sustainable human well-being (SHW), and recognize the substantial contributions of natural and social capital, which are now the limiting factors to improving SHW in many countries. We have to be able to distinguish between real poverty in terms of low SHW and merely low monetary income.

Table 2.1 Basic characteristics of the current economic model and the 'ecological economics' model

	Current Economic Model: the "Washington Consensus"	*Ecological Economics Model*
Primary policy goal	**More:** economic growth in the conventional sense, as measured by GDP. The assumption is that growth will ultimately allow the solution of all other problems. More is always better.	**Better**: focus must shift from merely growth to "development" in the real sense of improvement in quality of life, recognizing that growth has negative by-products and more is not always better.
Primary measure of progress	GDP	ISEW/GPI (or similar)
Scale/carrying capacity	Not an issue since markets are assumed to be able to overcome any resource limits via new technology and substitutes for resources are always available	A primary concern as a determinant of ecological sustainability. Natural capital and ecosystem services are not infinitely substitutable and real limits exist
Distribution/ poverty	Lip service, but relegated to "politics" and a "trickle down" policy: a rising tide lifts all boats	A primary concern since it directly affects quality of life and social capital and in some very real senses is often exacerbated by growth: a too rapidly rising tide only lifts yachts, while swamping small boats
Economic efficiency/ allocation	The primary concern, but generally including only marketed goods and services (GDP) and institutions	A primary concern, but including both market and non-market goods and services and effects. Emphasizes the need to incorporate the value of natural and social capital to achieve true allocative efficiency
Property rights	Emphasis on private property and conventional markets	Emphasis on a balance of property rights regimes appropriate to the nature and scale of the system, and a linking of rights with responsibilities. A larger role for common property institutions in addition to private and state property
Role of Government	To be minimized and replaced with private and market institutions	A central role, including new functions as referee, facilitator and broker in a new suite of common asset institutions
Principles of Governance	*Laissez faire* market capitalism	Lisbon principles of sustainable governance

Ultimately, we have to create a new vision of what the economy is and what it is for, and a new model of development that acknowledges this new full world context and vision (Table 2.1).

Planetary boundaries

Our planet's ability to provide an accommodating environment for humanity is being challenged by our own activities. The environment – our life-support system – is changing rapidly

from the stable Holocene state of the last 12,000 years, during which we developed agriculture, villages, cities, and contemporary civilizations, to an unknown future state of significantly different conditions – the Anthropocene.

One way to address this challenge is to determine "safe planetary boundaries" based on fundamental characteristics of our planet and to operate within them. "Boundaries" here mean specific points related to a global-scale environmental process beyond which humanity should not go. Identifying our planet's intrinsic, nonnegotiable limits is not easy, but recently a team of scientists have specified nine areas that are most in need of well-defined planetary boundaries. (Rockström *et al.*, 2009). The nine areas they identified as most in need of planetary boundaries are climate change, biodiversity loss, excess nitrogen and phosphorus production, stratospheric ozone depletion, ocean acidification, global consumption of fresh water, change in land use for agriculture, air pollution, and chemical pollution. They estimate that humanity has already transgressed three of these boundaries: climate change, biodiversity loss, and nitrogen production, with several others rapidly approaching the safe boundary.

Clearly, remedial policy responses to date have been local, partial, and inadequate. Early policy discussions and the resulting responses tended to focus on symptoms of environmental damage rather than basic causes, and policy instruments tended to be ad hoc rather than carefully designed for efficiency, fairness, and sustainability. For example, in the 1970s emphasis centered on end-of-pipe pollution control which, while a serious problem, was actually a symptom of expanding populations and inefficient technologies that fueled exponential growth of material and energy throughput while threatening the recuperative powers of the planet's life-support systems.

These problems are all evidence that the material scale of human activity is rapidly approaching, or already exceeds, the safe operating space for humanity on the earth. We are degrading our life-support systems – the ecosystem services provided by our natural capital assets.

Ecosystem services

Ecosystem services are defined as "the benefits people obtain from ecosystems" (Costanza *et al.*, 1997, MA, 2005). These include provisioning services such as food and water; regulating services such as regulation of floods, drought, and disease; supporting services such as soil formation and nutrient cycling; and cultural services such as recreational, scientific, spiritual, and other nonmaterial benefits (Costanza *et al.*, 1997, Daily, 1997, de Groot *et al.* 2002).

This is an appropriately broad and an appropriately vague definition. It includes both the benefits people perceive, and those they do not. The conventional economic approach to "benefits" is far too narrow in this regard, and tends to limit benefits to those that people both perceive and are "willing to pay" for in some real or contingent sense. But the general population's information about the world, especially when it comes to ecosystem services, is extremely limited. We can expect many ecosystem services to go almost unnoticed by the vast majority of people, especially when they are public, non-excludable services that never enter the private, excludable market. Think of the storm regulation value of wetlands (Costanza *et al.*, 2008). How can we expect the average citizen to understand the complex linkages between landscape patterns, precipitation patterns, wetlands, and flood attenuation, when even the best landscape scientists find this an extremely challenging task? We need to remember the definition of ecosystem services (the benefits provided by ecosystems), and acknowledge that the degree to which the public perceives and understands them is a separate (and very important) question. Conventional economic valuation presumes that people have well-formed preferences and enough information about trade-offs that they can adequately

judge their "willingness-to-pay." Since these assumptions do not hold for many ecosystem services we must: (1) inform people's preferences by showing the underlying dynamics of the ecosystems in question using models; (2) allow groups to discuss the issues and "construct" their preferences within a framework to inform the discussions; or (3) use other techniques that do not rely directly on preferences to estimate the contribution to human well-being of ecosystem services (i.e. to directly infer marginal contributions to well-being), such as the use of computer models.

In addition, the benefits one receives from functioning ecosystems do not necessarily depend on one's ability to pay for them in monetary units. For example, indigenous populations with no money economy at all derive most of the essentials for life from ecosystem services but have zero ability to pay for them in monetary terms. To understand the value of these ecosystem services we need to understand the trade-offs involved, and these may be best expressed in units of time, energy, land, or other units not necessarily monetary, remembering that the local population may or may not understand or be able to quantify these trade-offs. Finally, if one can express the tradeoffs (value) in one set of units (numerator) and can express the trade-offs between that numerator and another, then one can convert the trade-offs into the other numerator. For example, if we can express trade-offs in units of time and can estimate the time/money trade-off, we can express the time units in monetary terms.

A second issue is that ecosystem services are, by definition, not ends or goals, but means to the end or goal of sustainable human well-being. This does not imply that ecosystems are not also valuable for other reasons, but that ecosystem services are defined as the instrumental values of ecosystems as means to the end of human well-being. An important, but different, distinction some authors have made is one between intermediate services and final services (Boyd and Banzhaf, 2007). It is certainly true that for the purposes of certain aggregation exercises adding intermediate and final services would be double counting. But that does not imply that intermediate services are not services. Think of the production of tires in an economy. Some tires are sold directly to consumers and are part of final demand, while others are sold to car companies and are intermediate products, sold to consumers as parts of cars. The tires themselves are indistinguishable from each other, the only difference being who buys them. When calculating GDP (which is the aggregate of sales to final demand) it would not be appropriate to count both the tires sold to final demand and the tires sold to car companies, since those tires are already counted as parts of the cars sold to final demand. But tires in both cases, whether intermediate or final products, are means to the end of human well-being and are not ends in themselves. Likewise, ecosystem goods and services, whether intermediate (or "supporting" in the MA typology) services or final services are all contributors to the end of human well-being. Also, ecosystem processes (or functions) and services are not mutually exclusive categories. Some processes or functions are also services, others are not. Some services are intermediate, some are final, and some are partly both.

Ecosystems with embedded humans are complex, dynamic, adaptive systems with nonlinear feedbacks, thresholds, hysteresis effects, etc. (Costanza *et al*. 1993). Ecosystem services are therefore not the product of a linear chain from production (means) to direct benefits by people (ends) with no feedbacks or any of the other complexities of the real world. All ecosystem services are, by definition, means to the end of human well-being. Ecosystem processes or functions can also be services (they are not mutually exclusive categories), and the same services can be both intermediate and final. The real world is complex and messy and our systems of classification and definition of ecosystem services should recognize that and work with it, not ignore it in a misguided attempt to impose unrealistic order and consistency

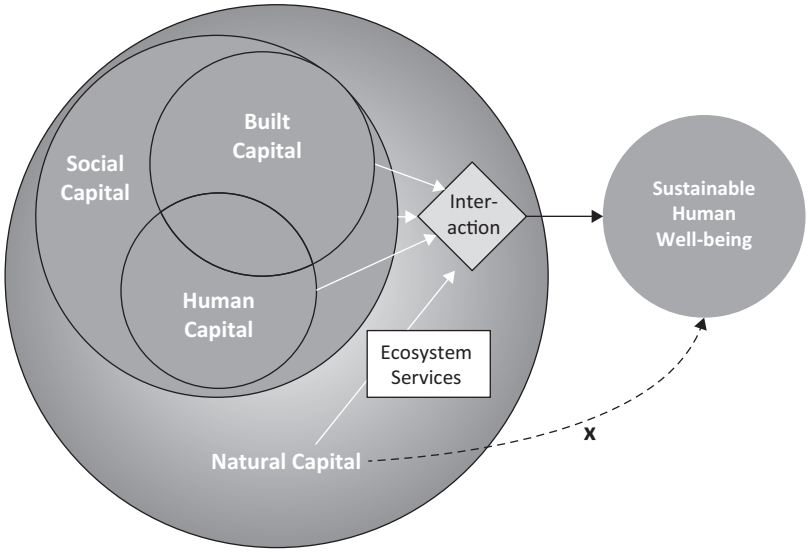

Figure 2.1 Interaction between built, social, human and natural capital required to produce human well-being. Built and human capital (the economy) are embedded in society, which is embedded in the rest of nature. Ecosystem services are the relative contribution of natural capital to human well-being; they do not flow directly. It is therefore essential to adopt a broad, transdisciplinary perspective in order to address ecosystem services.

Source: adapted from Costanza et al., 2014

Natural capital and ecosystem services

The ecosystems that provide the services are referred to as natural capital, using the general definition of capital as a stock that yields a flow of services over time (Costanza and Daly 1992). In order for these benefits to be realized, natural capital (which does not require human activity to build or maintain) must be combined with other forms of capital that *do* require human agency to build and maintain. These include: (1) built or manufactured capital; (2) human capital; and (3) social or cultural capital (Costanza *et al.*, 1997, 2014, see Figure 2.1).

These four general types of capital are all required in complex combinations to produce any and all human benefits. **Ecosystem services thus refer to the relative contribution of natural capital to the production of various human benefits, in combination with the three other forms of capital.** These benefits can involve the use, non-use, option to use, or mere appreciation of the existence of natural capital.

This categorization of services in the MA is a very broad, limited only by the requirement of a contribution to human well-being. Even without any subsequent valuation, explicitly listing the services derived from an ecosystem can help ensure appropriate recognition of the full range of potential impacts of a given policy option. This can help make the analysis of ecological systems more transparent and can help inform decision-makers of the relative merits of different options before them.

To achieve sustainability, we must incorporate natural capital, and the ecosystem goods and services that it provides, into our economic and social accounting and our systems of social choice. In estimating these values we must consider how much of our ecological life-support systems we can afford to lose. To what extent can we substitute manufactured for natural capital,

and how much of our natural capital is irreplaceable? For example, could we replace the radiation screening services of the ozone layer if it were destroyed? Because natural capital is not captured in existing markets, special methods must be used to estimate its value. These range from attempts to mimic market behavior using surveys and questionnaires to elicit the preferences of current resource users (i.e. willingness-to-pay, WTP), to methods based on energy analysis (EA) of flows in natural ecosystems (which do not depend on current human preferences at all). (Farber and Costanza, 1987, Costanza *et al.*, 1989, Costanza, 2004). Because of the inherent difficulties and uncertainties in determining these values we are better off with an intelligently pluralistic approach that acknowledges and utilizes these different, independent approaches.

Valuation of ecological systems and services

The issue of valuation is inseparable from the choices and decisions we have to make about ecological systems. Some argue that valuation of ecosystems is either impossible or unwise. For example, some argue that we cannot place a value on such "intangibles" as human life, environmental aesthetics, or long-term ecological benefits. But, in fact, we do so every day. When we set construction standards for highways, bridges and the like, we value human life – acknowledged or not – because spending more money on construction would save lives. These are statistical lives, however, not particular lives, and one should not confuse the two.

People also often talk about "economic value", "ecological value", and "social value" as if they were separate things. Nothing could be further from the truth. As the discussion above makes clear, the "value" or "benefit" we are talking about here is the contribution to sustainable human well-being. None of these elements (ecological, cultural, economic) can make a contribution to that goal without interacting with the others. What we can ask is: what is the relative contribution of, for example, natural capital to sustainable human well-being, in combination with other forms of capital (built, human, social) in a particular context? We have to look at these things in context and in as part of an integrated, whole system of humans embedded in cultures embedded in the rest of nature.

Another often-made argument is that we should protect ecosystems for purely moral or aesthetic reasons, and we do not need valuations of ecosystems for this purpose. But there are equally compelling moral arguments that may be in direct conflict with the moral argument to protect ecosystems. For example, the moral argument that no one should go hungry. All we have done is to translate the valuation and decision problem into a new set of dimensions and a new language of discourse. So, while ecosystem valuation is certainly difficult, one choice we do not have is whether or not to do it. Rather, the decisions we make, as a society, about ecosystems imply trade-offs and therefore valuations. We can choose to make these valuations explicit or not; we can undertake them using the best available ecological science and understanding or not; we can do them with an explicit acknowledgment of the huge uncertainties involved or not; but as long as we are forced to make choices we are doing valuation. The valuations are simply the relative weights we give to the various aspects of the decision problem. Society can make better choices about ecosystems if the valuation issue is made as explicit as possible. This means taking advantage of the best information and models we can muster and making uncertainties about valuations explicit too. It also means developing new and better ways to make good decisions in the face of these uncertainties. Ultimately, it means being explicit about our goals as a society, both in the short-term and in the long-term.

The point to stress is that the economic value of ecosystems is connected to their physical, chemical, and biological role in the long-term, global system – whether the present generation of individuals fully recognizes that role or not. If it is accepted that each species, no matter

how seemingly uninteresting or lacking in immediate utility, has a role in natural ecosystems (which do provide many direct benefits to humans), it is possible to shift the focus away from our imperfect short-term perceptions and toward the goal of developing more accurate values for long-term ecosystem services. Ultimately, this will involve the collaborative construction of dynamic, evolutionary models of linked ecological economic systems that adequately address long-term responses and uncertainties, like those mentioned above.

Institutions to manage ecosystems and their services

One hears a lot of talk these days about "ecosystem service markets". The problem is, conventional markets are not the right institution for managing many ecosystem services. These services (other than provisioning services) are often "non-rival" and not easily excludable and are therefore best thought of as "public goods" or, more generally, a part of "the commons" (Farley and Costanza, 2010). While we can and should use economic incentives (fees and payments) when appropriate to manage the commons, we need a different institutional form than "markets" within which to do this – something more akin to an "ecosystem trust".

Ruhl *et al*. (2007) document the "anti-ecosystem services bias" prevalent in American property law, regulation, and social norms. One particularly interesting counter-trend to this bias emerges in the "public trust doctrine", an idea that law professor Joseph Sax identified in the 1970s as the only legal doctrine with the breadth and substance to be useful as a comprehensive approach to natural resource (and ecosystem service) management. However, so far the U.S. Supreme Court has declined to take it there. Recent proposals to expand the "commons sector" of the U.S. and global economy by creating "common asset trusts" to manage the atmosphere, water, and other natural capital assets (structured like the Alaska Permanent Fund or the many existing Land Trusts) may be one way of implementing this doctrine (Barnes, 2006, Barnes *et al.*, 2008). For example, a bill has been introduced in the Vermont Senate to create a "Vermont Common Asset Trust", based on the public trust doctrine, to "propertize" (but not privatize) the state's natural and social capital assets in order to better manage them on behalf of their common stakeholders (both living and future). Trusts are widely used and well-developed legal mechanisms designed to protect and manage assets on behalf of specific beneficiaries (Souder and Fairfax, 1996). Extending this idea to the management and protection of whole ecosystems and the services they provide is a new but straightforward extension of this idea. Trusts would define whole ecosystems as common property assets, managed by trustees on behalf of all current and future beneficiaries. Once these common assets are assigned property rights, we can use all the existing property law to manage them more effectively. For example, we can charge fees for damages and make payments for enhancement. This gives Payment for Ecosystem Services (PES) schemes a broader institutional framework within which to operate and can help to drastically reduce transaction costs (see Brouwer, this volume).

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While trusts may not be the only or the best institution for managing ecosystem services, they seem to be a move in the right direction. We need to think much more creatively about the design of institutions that are better suited to the common asset nature of ecosystem services.

The promise of ecosystem services: toward a sustainable and desirable future

A new model of the economy and prosperity consistent with our new full world context (Table 2.1) would be based clearly on the goal of sustainable human well-being. It would use measures of progress that clearly acknowledge this goal (i.e. GPI instead of GDP). It would

acknowledge the importance of ecological sustainability, social fairness, and real economic efficiency.

Ecological sustainability implies recognizing that natural and social capital are not infinitely substitutable for built and human capital, and that real biophysical limits – planetary boundaries – exist to the expansion of the market economy. Climate change is perhaps the most obvious and compelling of these limits.

Social fairness implies recognizing that the distribution of wealth is an important determinant of social capital and quality of life. The conventional development model, while explicitly aimed at reducing poverty, has bought into the assumption that the best way to do this is through growth in GDP. This has not proved to be the case, and explicit attention to distribution issues is sorely needed. As Frank (2007) has argued, economic growth beyond a certain point sets up a "positional arms race" that changes the consumption context and forces everyone to consume too many positional goods (like houses and cars) at the expense of non-marketed, non-positional goods and services from natural and social capital. Increasing inequality of income actually reduces overall societal well-being, not just for the poor, but across the income spectrum (Wilkinson and Pickett, 2009).

Real economic efficiency implies including all resources that affect sustainable human well-being in the allocation system, not just marketed goods and services. Our current market allocation system excludes most non-marketed natural and social capital assets and services, which are huge contributors to human well-being. The current development model ignores this and therefore does not achieve real economic efficiency. A new, sustainable ecological economic model would measure and include the contributions of natural and social capital and could better approximate real economic efficiency.

The new economic model would also acknowledge that a complex range of property rights regimes are necessary to adequately manage the full range of resources that contribute to human well-being. For example, most natural and social capital assets are public goods. Making them private property does not work well. On the other hand, leaving them as open access resources (with no property rights) does not work well either. What is needed is a third way to propertize these resources without privatizing them. Several new (and old) common property rights systems have been proposed to achieve this goal, including various forms of common property trusts.

The role of government also needs to be reinvented. In addition to government's role in regulating and policing the private market economy, it has a significant role to play in expanding the "commons sector", which can propertize and manage non-marketed natural and social capital assets. It also has a major role to play as facilitator of societal development of a shared vision of what a sustainable and desirable future would look like. As Prugh *et al*. (2000) have argued, strong democracy based on developing a shared vision is an essential prerequisite to building a sustainable and desirable future.

The conventional economic model is not working for either the developed or the developing world. It is not sustainable and it is also not desirable. It is based on a now-obsolete empty world vision and it is leading us to disaster.

We need to accept that we now live in a full world context where natural and social capital are the limiting factors. We could achieve a much higher quality of life, and one that would be ecologically sustainable, socially fair, and economically efficient, if we shifted to a new sustainable development paradigm that incorporates these principles.

The problem is that our entire modern global civilization is, as even former President Bush has acknowledged, "addicted to oil", and addicted to consumption and the conventional development model in general. An addictive substance is something one has developed a dependence on, which is either not necessary or harmful to one's longer-term well-being. Fossil fuels (and

excessive material consumption in general) fit the bill. We can power our economies with renewable energy, and we can be happier with lower levels of consumption, but we must first break our addiction to fossil fuels, consumption, and the conventional development model, and as any addict can tell you: "that ain't easy". But in order to break an addiction of any kind, one must first clearly see the benefits of breaking it, and the costs of remaining addicted, facts that accumulating studies like the IPCC reports, the Stern Review (2007), the MA (2005), and many others are making more apparent every day.

What else can we do to help break this addiction? Here are just a few suggestions:

- Create and share a vision of a future with zero fossil fuel use and a quality of life higher than today. That will involve understanding that GDP is a means to an end, not the end itself, and that in some countries today more GDP actually results in less human well-being (while in others the reverse is still true). It will require a focus on sustainable scale and just distribution. It will require an entirely new and broader vision of what the economy is, what it's for, and how it functions
- Convene a "new Bretton Woods" conference to establish the new measures and institutions needed to replace GDP, the World Bank, the IMF, and the WTO. These new institutions would promote:
- Shifting primary national policy goals from increasing marketed economic activity (GDP) to maximizing national well-being (GPI or something similar). This would allow us to see the interconnections between built, human, social, and natural capital, and build real well-being in a balanced and sustainable way.
- Reforming tax systems to send the right incentives by taxing negatives (pollution, depletion of natural capital, overconsumption) rather than positives (labor, savings, investment).
- Expanding the commons sector by developing new institutions that can propertize the commons without privatizing them. Examples include various forms of common asset trusts, like the atmospheric (or sky) trust (Barnes *et al.*, 2008), payments for depletion of natural and social capital, and rewards for protection of these assets.
- Reforming international trade to promote well-being over mere GDP growth. This implies protecting natural capital, labor rights, and democratic self-determination first and then allowing trade, rather than promoting the current trade rules that ride roughshod over all other societal values and ignore non-market contributions to well-being.

We can break our addiction to fossil fuels, overconsumption, and the current development model and create a more sustainable and desirable future. It will not be easy; it will require a new vision, new measures, and new institutions. It will require a directed evolution of our entire society (Beddoe *et al.*, 2009). But it is not a sacrifice of quality of life to break this addiction. Quite the contrary, it is a sacrifice not to.

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