Sustainable Scale In Environmental Education: Three Rules, Two Perspectives, One Overriding Policy Objective, And Six Cultural Shifts

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Abstract:

How does one know if development activities are ecologically sustainable rather than simply less degrading of the environment than current practices? The concept of scale in ecological economics provides a conceptual and practical tool for approaching this issue. Scale is defined as the physical size of the economy relative to the containing and sustaining ecosystems.

The concept of scale has several strengths in terms of defining and operationalizing sustainability, and is thus central to environmental education. It highlights the relationship between economic activities and the ecosystems upon which they depend, connecting some of the most fundamental laws of science, with economic activity. To be sustainable, any economic or development activities must remain within these scientific limits.

The paper highlights the basic lesson of scale, rules, policies and perspectives for applying the concept, and identifies current activities supporting the integration of scale in development activities – priority areas for environmental education concerned with genuine sustainability.

Introduction: Educating for Ecological Sustainability.

Are educational activities designed to improve the environment good enough to achieve ecological sustainability? Is any marginal, environmental improvement necessarily a step toward sustainability? Might some activities genuinely intended to improve the environment, even those that actually make a contribution, be unsustainable? Ecological sustainability is critical not only to preserve the environment, but also for a just distribution of wealth (Daly and Cobb, 1994), thus any contribution to ecological sustainability also contributes to social justice, a necessity for a sustainable future.

Jevons (1865, p 140) noted that " It is wholly a confusion of ideas to suppose that the economical use of fuels is equivalent to a diminished consumption. The very contrary is the truth. As a rule, new modes of economy will lead to an increase of consumption according to a principle recognized in many parallel instances." This phenomenon, called Jevons' Paradox, is a powerful reminder that apparent improvements may actually make things worse from a sustainability perspective. There are many examples since the Industrial Revolution. Global energy and material consumption, despite radically improved efficiencies, have far outstripped population growth and fulfillment of basic human needs (McNeil, 2000; Ponting, 1991). Rudin (1999, p 2) captured this relationship between relative savings and absolute levels of consumption by noting that "our environment does not respond to miles per gallon; it responds to gallons [of gasoline]." The amount of matter or energy used in every production-consumption cycle is referred to as throughput; understanding throughput is central to understanding sustainability (Daly and Farley, 2004; The Scale Project, 2005).

Sustainability has often been sacrificed to marginal environmental improvement, and educational activities can identify the potential traps. For example, the target for greenhouse gas (GHG) emissions set by the Intergovernmental Panel on Climate Change (Watson et al, 2001) is a negotiated political target many times lower than that recommended by scientists concerned about climate stability. The United States' attempt to shift from GHG remediation based on absolute concentrations of atmospheric emissions to emission densities per GDP, commits the same error of seeking a reduction in rates of emissions while allowing absolute levels to rise (National Wildlife Federation, 2003;Office of the Press Secretary, 2002).

Environmental economics seeks to internalize environmental costs to improve the environment (Pearce and Turner, 1990). Even if all critical externalized costs could be captured, *price manipulations cannot substitute for throughput quantity*. If absolute level of throughput determines sustainability of an economic activity, then setting prices to achieve a sustainable quantity will be imperfect and require frequent adjustment, even if the sustainable quantity is known. The sustainable quantity is rarely even estimated. If the target is unknown, any environmental improvement via adjusting prices cannot tell us how close the intervention has brought us to the goal (Daly and Farley, 2004). It is therefore impossible to determine the effectiveness of such price adjustments' contributions to sustainability.

Sustainability issues can be subtle. The Ecological Footprint (Wackernagel and Rees, 1996) is one of the most useful tools to examine the global, regional or local amount of sustainable throughput, by indexing total throughput at the designated level (www.ecofoot.net). However, it fails to capture the toxic quality of the throughput.

Economic arguments of high cost or reduction in quality of life are the most frequent obstacles limiting throughput to sustainable levels. The United States (ENS, 2001) made this argument regarding the Kyoto Protocol, without adequately considering the costs of increasing GHG concentrations, or the benefits of alternative, no-regrets, remediation strategies.

A refined version of this "too costly" argument is the appeal to the Environmental Kuznets Curves –whereby environmental degradation and economic growth are said to be related in an inverted U function (Stern, et al, 1996). This is likely false (Czech, et al 2003), and alternatives to economic development without increasing levels of material throughput exist (Weisacker et al, 1999). Why continue outdated policies and practices that permit continued environmental degradation when significantly better alternatives are available?

The Basic Lesson

Increasing levels of throughput reflected in the expanding Gross World Product pose the greatest threat to ecological sustainability. The most basic lesson for environmental education is *setting absolute limits to material throughput compatible with ongoing ecosystem functioning capable of supporting human well-being*. Environmental educational that ignores this fundamental truth runs the risk of encouraging further environmental degradation, the opposite of the goal.

What approaches enhance the opportunity for environmental educational to encourage genuine sustainability? Most important is a clear concept of ecological sustainability. The notion of scale from ecological economics (Daly and Cobb, 1994; Daly and Farley, 2004; The Scale Project, 2005) provides a powerful conceptual and practical tool to understand and implement sustainable practices and policies.

The concept of scale addresses the proportions between two entities - the physical size of the economy and the containing and sustaining ecosystem. What proportion is possible for sustainability? What proportion is most desirable?

Scale is defined as the physical size of the economy relative to the containing and sustaining ecosystem. This definition recognizes that all economic activities involve throughput; that economic activities are wholly dependent on ecosystem services and natural processes; and that financial capital cannot substitute for natural capital.

All economic activity involves throughput: extracting materials from the earth, transforming them in a manufacturing process, using them, and finally discarding them as waste. Energy is consumed at each stage, from source to sink. The more economic activity there is, the greater the throughput which impacts the environment. Throughput is necessary for providing goods and services for human well-being, although well-being requires more than throughput (Lane, 2000). Scale recognizes the importance of economic activities, but seeks to ensure that throughput is limited to a sustainable level.

Throughput has biophysical limits, determined by the laws of thermodynamics, and the unique biological production limits of the specific ecosystems affected by the economic process. These limiting factors are ultimately determined by laws of nature, not supply and demand, prices or market dynamics. Mainstream economic theory largely ignores contributions from nature; the scale concept clarifies that without natural resources and ecosystem services, there can be no economy. The scale concept demonstrates that the economy is a wholly contained and dependent subsystem of the environment, a reality ignored by mainstream economic theory and practice. Acceptance that nature is critical to economic activities clarifies that financial capital is not a substitute for natural capital, but rather complementary with it (Daly and Cobb, 1994; Daly and Farley, 2004; The Scale Project, 2005).

If sustainable scale is about limits to throughput, and thus economic activity, then what are the limits? How do we identify them? How do we ensure our economic and development activities are ecologically sustainable, and educate others to plan and design for sustainability?

Three Rules for Ensuring Sustainable Scale

The question of limits can be answered by ensuring our activities allow us to live off the income from natural capital, rather than drawing down the stock of natural capital itself. How do we do this?

The **first rule** to ensure sustainable scale is that we *harvest renewable resources below the natural regeneration rates of all critical ecosystem services associated with the specific throughput activities*[1].

[1] The throughput associated with a specific economic activity not only involves the specific resource stock of economic interest (eg lumber), but also the entire flow of fund services of which the stock is a part (Daily, 1997; Costanza et al, 1997). A forest, for example, not only provides lumber (of economic interest), but also a range of ecosystem services, many of which are non-market goods or services but relevant to human well-being (eg. water retention and flood control; soil protection; habitat for biodiversity, etc). Each of these life supporting ecosystem services has regeneration rates different from that of lumber. Yet the lumber extraction will have a direct impact on their ability to regenerate. Therefore, the regeneration rates of all critical natural capital (see Ekins, 2003) needs to be considered when determining the appropriate scale for the resource of economic interest, lumber harvesting in this example.

When a forest or marine ecosystem produces lumber or fish, their harvest should remain below the rate at which the lumber or fish are regenerated by these ecosystems. If the throughput, or harvest, exceeds the regeneration rate, we are exceeding sustainable scale and are decreasing the natural capital upon which our harvest depends – the forest or fish stock, respectively. Continued drawdown of natural capital will eventually degrade the ecosystem's capacity to regenerate at the rate needed to maintain human needs, and result in deforestation or collapse of fisheries, as has happened around the world. Just how much below the regeneration rate the harvest should be is an issue of optimal scale and is discussed below.

Another example of throughput exceeding regeneration is industrial agriculture. The energy inputs involved to produce food greatly exceed the energy outputs available from the food (Pimentel and Pimentel, 1995). Clearly, this process is unsustainable, yet we continue to invest in industrial agriculture, unsustainably converting natural capital into financial capital, in the misguided belief that the financial capital is as good as natural capital.

The **second rule** of sustainable scale is that *we maintain our rate of throughput so that their emissions or wastes do not exceed the rates that can be absorbed or broken down by natural processes in a meaningful time span*.

The most serious examples of unsustainable scale are the result of violating this rule. Wastes from industrial agriculture exceed sustainable scale for many local and regional sinks. Emission of ozone depleting compounds very rapidly resulted in destruction of the protective atmospheric ozone layer. Anthropogenic emission of greenhouse gases increased the concentration of these substances to levels unprecedented over the course of human civilization (Watson et al, 2001; Schneider, 1997), threatening the climate stability our civilization depends on.

Many other examples of throughput exceeding the absorptive capacities of ecosystems exist: anthropogenic nitrogen fixation now exceeds the natural rate (Vitousek, et al 1997; Persistent Organic Pollutants are found even in arctic communities; plutonium, mercury, dioxins and many other novel, man-made toxic wastes are increasing in volume and dispersion (Speth, 2004, pgs 46-52). For highly toxic substances, and elements that never break down (e.g. mercury) or break down over extremely long periods (e.g. plutonium), the ecosystem's absorptive capacity is zero. Therefore the only sustainable throughput level is also zero.

The **third rule** has to do with non-renewable resources: *any use of non-renewable resources should be coupled with investment in replacing the non-renewable resource with renewable alternatives, or coupling the non-renewable usage with a renewable offset* (Daly, 1990). Examples might be using wood instead of plastics, or tree-planting for carbon sequestration, respectively.

This rule recognizes our civilization's dependence on non-renewable resources, and the challenges involved in reducing, and if possible eliminating, their use. Many of these substances are toxic or damaging in use (eg fossil fuels), or their extraction destroys habitat and erodes biodiversity (Czech, et al 2000). There is also a moral concern – if we use up valuable non-renewable substances, then we foreclose their use by future generations. We have an obligation to restrict use of valuable non-renewable resources and minimize their waste. Yet mainstream economics encourages rapid exploitation of these resources, relying on the substitutability of financial capital for natural capital after resource exhaustion.

Keeping these three rules in mind would certainly go a long way to ensure ecological sustainability. Less certain is how to identify the actual biophysical limits of ecosystems, which are required to implement these rules. Ecosystem science is a new field. Several large international studies are underway to provide more scientific information about basic ecosystem dynamics (Millennium Assessment, 2003; see Meadows et al (2003) p304, footnote 16 for list). It would indicate wisdom and humility to acknowledge our ignorance of the ecosystems upon which we depend. Altering them before we sufficiently understand them is foolish and dangerous.

We have learned that ecosystems are incredibly complex, dynamic, interdependent, and under threat (Daily, 1997; World Resources, 2000): atmospheric ozone depletion has mitigated some of the impact of increased greenhouse gas concentrations on climate change (UNEP/WMO, 2002); biodiversity loss and nutrient flows may be increased by global warming (Smil, 2002); increased UV radiation may affect the base of the ocean food chain (UNEP/WMO, 2002). Surprises in ecosystem dynamics are common, and if ecological limits are exceeded an ecosystem's equilibrium state can be altered, and rapidly.

Economic activities are pushing ecosystem boundaries in ways that may be irreversible (Odum and Odum, 2001; Meadows, et al 2003; Schneider1997; Speth, 2004; Smil, 2002). We have learned that ecosystems have enormous resilience (Gunderson and Holling, 2002) and are not likely to be destroyed by human activities. The issue is not whether ecosystems will survive, but whether they can continue to provide levels of service for humanity to comfortably survive. Disrupting global ecosystems is unlikely compatible with this goal. Our hubris makes it difficult to accept that we may not know the throughput levels at which this could happen. Nor can we be certain of avoiding serious harm, or inventing a technical fix. Humble acceptance of our ignorance likely has greater survival value, especially if we adopt a precautionary approach to economic growth.

Two Perspectives for Sustainability: Precaution and Prevention

Adoption of the Precautionary Principle (Science and Environmental Health Network, 2004; Rachel's Environment and Health News, 2002) is an essential step for ecological sustainability. This principle is included in international environmental treaties and national policies, but short-term economic considerations often block its implementation. Educating future environmentalists regarding its importance, and how to implement, is critical.

Major threats to ecological sustainability were taken seriously only after costly disasters, despite prior warnings. Global environmental problem solving has been end-of-pipe, and symptom-focused, rather than proactive, preventive, and design focused. A *focus on prevention* is critical to ensuring all new economic and development activities subscribe to the preceding three rules[2].

An Overriding Policy Objective: Optimal Scale

The above rules and perspectives for ecological sustainability target the goal of optimal scale, the key policy objective for sustainability. **Optimal scale** identifies what is desirable. It is defined as an ecologically sustainable level of material throughput where the increasing marginal environmental and social costs of further throughput are equal to the declining marginal benefits of that additional throughput (Daly and Farley, 2004)[3]. Included in the assessment of increasing marginal environmental and social costs are those concerning justice for current populations, future generations, other species, and the safety margin desired to avoid the consequences of exceeding sustainable scale. Sustainable scale is a biophysical limit, imposed by the laws of nature. Optimal scale defines desirable socio-political limits within these biophysical limits, taking into account moral and ethical boundaries, and boundaries of risk-management with regard to exceeding sustainable scale.

Many levels of material throughput are ecologically sustainable. The closer these levels of throughput are to the unsustainable boundary, the higher the risk that some unforeseen event(s) will trip the ecosystems involved toward unsustainable functioning. The more we restrict the level of throughput within the sustainable range, the less likely we may be to provide the goods and services required for a satisfying and meaningful life for the world's people. Optimal scale requires setting the desirable level of throughput which balances the risk of exceeding sustainable scale against the risk of inadequately meeting human needs. Optimal scale recognizes the biophysical limits of economic activities, thereby forcing attention to fairly sharing the limited goods and services available. By way of contrast, mainstream economics offers the impossible solution of continuous growth to achieve just distribution.

Optimal scale is therefore the major macroeconomic policy objective for a comfortably sufficient, just and ecologically sustainable society. But do we have the tools to achieve, or at least move toward such a desirable goal?

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[2] The rules apply to both existing and new economic activities. It is generally more difficult to convert existing infrastructure (eg transportation systems, housing) to sustainable operations. At a minimum we should be designing new and replacement infrastructure to reflect the sustainability rules, and seek continuous improvement in their applications.

[3] Continued economic expansion beyond this point is actually "uneconomic" in the sense that costs outweigh benefits. This biophysical and social reality is not considered by mainstream economics, which not only allows such uneconomic growth to occur, but actually encourages it. Note that optimal scale also requires social justice.

Cultural Shifts Deserve Support

Cultural shifts toward new theories, values, policies, practices and lifestyles are already underway. Innovative, transdisciplinary, problem-based educational approaches have been developed (Farley, Erickson and Daly, 2004), and it is critical that environmental education efforts support such shifts as:

1. Understanding the Determinants of Human Happiness and Well-Being. Evidence indicates that material throughput (whether measured in terms of GDP, eg Daly and Cobb, 1994, or in terms of energy consumption per capita, eg. Smil, 2003, pgs 97-105) is important to a point, beyond which more material throughput is unrelated to human well-being; material throughput beyond this point is at best wasteful, at worst a major contributor to significant environmental degradation and social inequity.
2. Value Orientation. A resurgence of stewardship is occurring in many major religions as they explore the role between human activities and the environment (Gardner, 2002). Responsibility for creation is accepted as a core value, and frugality as a virtue to be pursued.
3. Public Policy Design Principles have been articulated, and specific policy preferences identified which support ecological sustainability (Daly, 2002a, and 2002b; Daly and Farley, 2004). A remaining challenge is the evolution of institutions to address the global nature of sustainable scale.
4. Alternative Economic Theories. Mainstream economic theories and practices, dominated by market dynamics, encourage ever increasing amounts of material throughput which degrade the environment. Until such theories and practices are altered, attempts at environmental remediation will continue to be rear-guard actions, avoiding the source of the problem. Ecological economics (Daly and Farley, 2004) relies on both market and non-market approaches to provide comprehensive and workable alternatives[4].
5. Sustainable Business Practices. While increased efficiencies and resource productivity alone will not solve the sustainability problem, they are important components to achieving ecological sustainability. Such practices are increasingly sophisticated and demonstrate the many opportunities to change the design of business operations and contribute to significant reductions in material throughput while better meeting human needs (Prahalad and Hart, 2002; Weiszacker, et al 1998).
6. Lifestyle Changes toward "sustainable consumption" patterns, as well as toward reduced consumption, are occurring (Cohen and Murphy, 2001). While the number of people turning towards these goals of frugality and away from excess material consumption is still small, they are growing and should be encouraged (Czech, 2000).

[4] For example, the level of sustainable throughput should be set on the basis of ecosystem science and the precautionary principle, not on the basis of market manipulations; that is, scale should be price determining rather than price determined (see Daly and Farley, 2004).

Taken together, these cultural shifts are important precursors of a sustainable society. Environmental educational activities which support an understanding of these phenomena and the opportunities they offer will make a significant contribution to ecological sustainability and social justice.

The most fundamental lesson for environmental education is the necessity of setting absolute limits to material throughput. Fortunately, numerous policies, technologies, and conceptual and social approaches to achieving the goal of optimal sustainable scale exist. Environmental education can and should play a vital role in spreading understanding of the central importance of this concept to both ecological sustainability and social justice.

In summary, the basic lessons to integrate into environmental education programs are: set absolute limits, share, focus on prevention, use science, focus on well-being (rather than material consumption), frugality first then efficiency, practice stewardship, set policies at appropriate levels, cherish humility, and act cautiously.

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