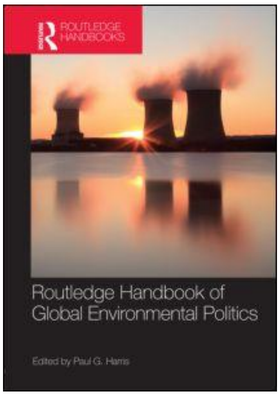

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Sustainability

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Part III

Ideas and themes in global environmental politics

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Sustainability

Foundational principles

Thomas Princen

Institutions, from the local to the global, are constructed, built out of raw materials such as beliefs, ideas, and values. Like the doors, windows, and walls of buildings, though, most of what we see is only the outward manifestations: the laws, regulations, treaties, procedures, and practices (see Chapters 8, 10, 12). Yet underlying these is a foundation: norms and principles (see Chapter 9). These too are constructed, and even easier to ignore; they are just there, down below, well hidden, the infrastructure that holds everything up because, we assume, it is well built, appropriate to the task of supporting the superstructure, the walls, floors, and roof. And, of course, we assume that altogether the infrastructure and superstructure will shelter the occupants well.

When the goal of the construction – the building or the institution – changes, sometimes it is enough to just change the superstructure: move a wall, tile the floor, add a window; revise a law, tighten enforcement, subsidize a program. Other times entirely new structures are in order, a new foundation, a new set of norms and principles. A premise of this chapter is that the constructed institutions for material and energy use in modern industrial societies are not up to the task of living within our means, of global society functioning within global ecological constraints.

Existing institutions for material provisioning, generally subsumed under the term "the economy," are supremely well built to extract resources rapidly and thoroughly, to convert them into products people will buy, and to dispose of the wastes in the least-cost, least-noticeable manner possible. But they are not constructed to operate within immutable constraints such as a single planetary climate system, a self-sustaining level of biological diversity, or humans' limited cognitive and social capacities. Rebuilding the infrastructure is in order. For that the builders and occupants alike must rethink how humans relate to nature, how the economy is structured, how industry is organized, how communities and individuals produce and consume and dispose. And that very rethinking is, arguably, at the root of a politics of the global environment where the goal is to reverse current biophysical trends and get on a socially and ecologically sustainable path.

In that rethinking, in that institutional design for global sustainability, new norms and principles are needed. Just as the house builder must survey the site and determine whether stone or brick or concrete is best suited as the foundation, a global environmental politics must ask whether prevailing norms and principles – growth, efficiency, specialization, mobility, speed, consumer sovereignty – are appropriate to the task of avoiding ecological overshoot and sustaining the biophysical prerequisites to life. This chapter, then, is an attempt to point in a different direction, describing, developing, and justifying a preliminary set of norms and principles for global sustainability. I first lay out the role of principles and define ecological consonance. I then develop first-order, second-order, and third-order propositions and principles grounded, respectively, in the biophysical, the human, and the political. I conclude by identifying key questions of institutional design and human propensity.

Ecological consonance

Principles have relevance to ecological sustainability when the locus of decision-making is at the intersection of the human and biophysical systems. Neither the purely human nor the purely biophysical is the primary realm: it is the decision-making *at the intersection* – the cutting of trees, the plowing of ground, the casting of fishnets, the pumping of water, the generating of power – that leads to either depletion or conservation. Decisions are "ecological" to the extent they (i) entail effective feedback loops, positive and, especially, negative from both the human and biophysical systems; (ii) have a long-term orientation (relevant to ecosystem functioning and geologic processes); (iii) preserve genetic and cultural information; and (iv) build in buffers to account for irreducible uncertainties (Dryzek 1987; Princen 2005: 23–47).

Decision-making is informed by worldviews mediated by institutions (norms and principles, rules, procedures and practices) and language (concepts, ideas, metaphors, myths). While worldviews vary widely among individuals and across societies, institutions are designed to achieve particular goals and thus they appropriate institutional features selectively. Early promoters of industrialization, for example, appropriated principles from a mechanistic worldview – speed, clock time, efficiency. Later, advocates of consumerism appropriated the economistic principles of consumer sovereignty and factor mobility from economics to construct consumer-led capitalism.

The challenge for sustainability advocates is to develop principles that meet two conditions: (1) they are consonant with ecosystem functioning; and (2) they can be appropriated from extant worldviews (i.e., they do not have to be created de novo). Put differently, if the ecological is a necessary condition for sustainable practice, it does *not* follow that all members of a society must convert to an ecological worldview. Rather, the ecological worldview, grounded in ecosystem functioning alongside human interaction with that functioning (practices that can be put under an agrarian worldview), is the *source* of first-order principles (Princen 2010a, 2010b: 147–77). Second- and third-order principles can come from elsewhere, however ecological. The most ready sources, those with the highest likelihood of adoption, are extant principles, not completely new ones. They must, nevertheless, be governed by the ecological to qualify as principles of sustainability. This grounding and governing I call *ecological consonance*. From this arises my first proposition:

> *Proposition 1*: Decision-making and design are more likely to lead to sustainable practice to the extent they are governed by ecological principles which are in turn governed by the constraints of ecosystem functioning, that is, to the extent decision-making criteria and design principles are *ecologically consonant*.

Because humans unavoidably organize themselves and do so at many scales, they employ principles: principles of social organization, whether implicit or explicit. Principles are rules of a system, with moral claims. They are "should" statements that guide a relevant set of actors toward an agreed goal in an issue area. They are not universal guidelines, but *particular guidelines* for those actors, that issue, and that goal. Principles can arise spontaneously (witness children playing: "You can't do that! It is not fair!") or, in cases of enduring social organization, they are deliberately constructed (e.g., the core of a country's constitution; the pillars of a world trade regime). If a principle does evolve into a universal statement, applicable to many sets of actors in varied contexts (e.g., freedom, growth, efficiency), then it is an ethic, a myth, or a taboo. Principles therefore work only in limited contexts, and new contexts demand new principles. From this arise two additional propositions:

> *Proposition 2*: A social system (e.g., the economy) has high integrity to the extent: (i) its principles match a system goal (e.g., labor specialization leads to wealth generation); and (ii) principles across goals and issues mesh (e.g., labor specialization promotes job creation).

> *Proposition 3*: For the large social goal of sustainability, principles are effective and systems have integrity to the extent they simultaneously match the goals of the social system and the biophysical system (see principles below).

The biophysical grounding: the source of first-order principles

Two broad biophysical phenomena define the conditions around which society can organize itself for long-term ecological and social sustainability – ecological capacity and natural flux. Each, singly and in combination, leads to a set of design principles, the first set static, the second dynamic. First-order principles are those tightly linked to the biophysical phenomena. That is, they (i) have *ecological content* (hierarchically structured complex biophysical systems that are adaptive and resilient at the same time they are subject to flipping into a degraded state, and that accounts for all species, *Homo sapiens* included); (ii) focus on the *intersection* of the biophysical and the social (mutual feedback of critical system-maintaining and system-adapting information, positive and negative); and (iii) are oriented to the *long term* (via cycles of life, nutrients, water).

Second- and third-order principles (see below) are oriented to other conditions, even industrialization and economic expansion, yet offer guidance to the sustainability goal to the extent they mesh with the first-order principles. All of these principles are stronger to the extent they embody features of *biophysical* and *human capacity*:

- absolute limits – e.g., a single water supply; critical nutrients; need for sleep; amount of directed attention.
- periodicity – e.g., reproductive periods, diurnal and seasonal fluctuation.
- bioassimilation – e.g., decomposition, nutrient uptake, energy flow.
- complexity – e.g., successional stages; predator–prey dynamics; self-organization; collective action; strategic behavior.

Ecological capacity

Although ecosystems are resilient and adaptive, they have limits. On the strictly physical side, the amount of water on the planet is fixed, and there are no substitutes (see Chapter 34). Minerals, once mined and dissipated or burned, are permanently removed from human use. The ultimate physical limit is the planet itself and its solar flux, the mostly constant flow of energy from the sun and mostly uncontrolled escape of energy into space. No amount of tinkering, no pricing scheme, no new technology will change these immutable and unavoidable constraints. On the biological side, organisms are limited to a narrow band of temperatures, pH levels, and pressures. An astronaut's view of the planet reveals just how thin is the skin of life – some 10 cm deep into the soil, less than a hundred meters high into the air, and only a few hundred meters deep into lakes and oceans. In that skin, organisms live and die, species emerge from novel environmental conditions and they go extinct. All these are immutable facts. Humans can act as if they do not exist, but not indefinitely.

A primary social principle corresponding to the constraints of *ecological capacity* is the *ecological cap*. Cap-and-trade programs for emissions reductions are well known and broadly accepted. Implementation, especially of carbon emissions, is still contentious, but the idea of setting an upper bound on pollution (the capping being the ecologically significant piece of cap-and-trade, not the trading) is widely acknowledged. Target loadings is a similar concept: biological pollutants (e.g., sewage, phosphorous, nitrogen compounds) can be introduced to an ecosystem only to a point, that of assimilative capacity. To the extent the target is set according to downstream assimilative capacity (e.g., in the case of acid rain, the buffering capacity of downwind alkaline soils and bodies of water; see Chapter 30) and not to status quo emissions (often the "politically acceptable" target level), the cap is ecologically grounded and thus a first-order principle for ecological sustainability.

Emissions, though, are only one realm where biophysical capacity limits must be matched by caps on human activity to ensure long-term resource use. Harvest rates tend upward for economic reasons – short-term returns on investment increase, for example, as forest rotations shorten and fishnets lengthen. A cap on harvest rate indicates that regenerative capacities of populations and, most important, of entire ecosystems – forests and fisheries, for example (see Chapters 38 and 36) – are limited, unlike the seemingly unlimited capacity of industrial systems such as monoculture tree plantations and fish pens. Water use is an obvious area for caps: to ensure long-term water security, the withdrawal rate cannot exceed the recharge rate.

If caps on emissions, harvest levels, and withdrawal rates make sense – ecological sense, that is – then under certain conditions, so would caps on entrants, consumption, throughput, technologies, and even GDP and trade. The primary condition would be a tight, demonstrable link to limited ecological capacity. What is more, the limiting case for caps is, at one end of the organizational spectrum, a ban or prohibition. That is, processes and substances that are fundamentally unecological, that generate non-assimilative waste (e.g., nuclear waste) (see "Cycling" below), that cause irreversibilities (e.g., habitat destruction that drives species extinct; see Chapter 37), have no place in an ecologically sustainable society (Princen 1996). At the other end of the spectrum, there are activities and substances that, having no inherent ecological content, require no capping. Freedom, artistic expression, democratic participation, human rights, parental love, sport are examples. Every activity in between requires some kind of limitation, some kind of check to function within the ecological capacities on which that activity depends. This brings us to the first principle of sustainability:

> *Principle 1*: When human activity is inherently constrained by biophysical conditions, *capping* those activities according to ecological functioning enables sustainable practice. Conversely, not to impose caps, even on distal processes such as technology or consumption, is to invite depletion and irreversible diminution of ecosystem services.

Caps imply maximums, ceilings against which producers of wealth tend to push their resource use, if not push the ceiling itself higher. Thus, two necessary complements to the principle of ecological capping are the principles of restraint and buffer, what emerge from complex systems and limited control perspectives.

Complex systems, write systems analysts James J. Kay and Eric Schneider, "do not maximize or minimize their functioning" (Kay and Schneider 1994: 35). To push a component of the system to its maximum, to spin a wheel at its fastest speed, to reduce forest tree species to only those that have commercial value, to pump water just as fast as the estimated recharge, is to make such systems "brittle," vulnerable to disturbance and likely to flip into a degraded state. Integrity, resilience, and adaptiveness come to a system (or follow an intervention) when each factor varies within a comfortable range, when a "red zone" at the extremes of the range exists (or is created through intervention). An animal's heart beats rapidly in a fight-or-flight response to a threat; its heart can also lumber along during sleep or hibernation. But if the animal functions at either extreme for long, if its adrenaline pumps constantly (a caribou pursued for hours by a pack of wolves) or it lies about day after day (a zoo specimen), the system deteriorates – or it requires more input, more energy, more nutrients, more protection, more technical fixes. In short, systems must allow for occasional activity at the extremes yet, at the same time, they need mechanisms that keep activity mostly within the safe range, the "green and yellow zones." Like governors on a flywheel that automatically engage when the wheel exceeds its safe speed, systems must have built-in mechanisms of restraint to keep in the safe range, to operate in the middle ground, below the ceilings and above the floors, to be, in a word, *sufficient*. A first-order principle under the biophysical condition of ecological capacity constraint is thus *restraint*.

The economy, that social system of material and energy flow, part of which is measured by GDP, investment, savings, consumption, capital and trade flows, has, at present, no governors, not with respect to irreversible change in natural resources and waste sinks anyway. Monetary supply is tempered by inflation and employment concerns, trade by imbalances. But there are no brakes on the system that keep it within rates of change commensurate with ecological change, that, as Herman Daly continuously reminds us, keeps the scale of the economy in tune with the scale of the biosphere of which the economy is a subset (Daly and Townsend 1993: 360–1). The industrial, growth- and efficiency-oriented, consumerist economy is all about maximizing (e.g., output, return on investment) and minimizing (e.g., prices and labor).

Social systems can have caps on expansion and prohibitions on non-assimilative substances, but given the human tendency to explore, to innovate, and to expand, changes in the system are likely to bump up against *absolute limits*. What is more, they can do so with inadequate or delayed feedback. Overshoot is a constant threat because individuals and collectivities do not know of their predicament until it is too late to reverse course. Hence, another first-order social organizing principle under the biophysical condition of ecological constraint is *buffer*. Social systems, themselves complex and often exhibiting expansionist tendencies driven by positive feedback loops and cause–effect time lags (think a modern industrial economy), must build in a cushion, a margin of error, a safety barrier, some "slack," to keep from going over the edge, from incurring irreversibilities. Often as not, a buffer takes the form of rules of thumb, not precise measures, what typify maximization strategies (Scot 1998; Gadgil and Guha 1992). Engineers build bridges and levees and automobiles to withstand expected stresses; then they multiply by 1.5 to give a 50 percent safety margin. Farmers clear land to plow but leave a hedgerow or patch of forest or stretch of marshland, enough to block the wind, retain moisture, and allow useful predators to pass.

> *Principle 2*: All material systems, including the human economy, are subsystems of larger systems. To sustain themselves, systems must remain within the adaptive capacities and scale of the larger system. When the human scale of activity tends to exceed ecological capacities, social limits must be built in to be sustainable. Maximization strategies thwart social limits while *sufficiency* strategies – *restraint* and *buffer* – enable them.

Natural flux

The flux of nature includes (1) the flows of energy, nutrients, and water, and (2) the fluctuations of these flows and all life processes. Like a river defined as an identifiable flow of water, its water level rises and falls, it course meanders across flat plains changing, it seems, on a whim, and its volume occasionally crashes violently over precipitous falls. What is more, a river is never finished, never complete, only cycling, only channeling its portion of the hydrologic cycle. Thus, two features of natural flux are cycling and recurrent change. The primary social analogs are flexibility (or adaptiveness) and congruent change.

Cycling

Life processes go in cycles; things go up and down, back and forth, around and around; they assimilate, decompose, and reassimilate. Organisms follow diurnal, lunar, and seasonal cycles and variations in temperature, humidity, nutrients, and water flows. They experience periods of intense activity and periods of rest. Nearly all advanced animals sleep and they have distinct times for feeding, reproducing, and wakeful rest. Machines are just the opposite. The best ones run constantly, all the time, 24/7/365, or at least whenever we want them to. The clock is the archetype, but the generator, the refrigerator, the radio, and the computer also typify the machine's constancy. Because organisms cannot function constantly (even if we wanted them to), because resiliency among organisms and within ecosystems requires "down time" in one form or another, it follows that this observed periodicity in the non-human world requires periodicity in the humanly constructed world. The requisite socially constructed down time I'll call *respite*, a first-order principle most evident in social systems that depend directly on resilient natural systems – e.g., farms and timber operations and water supply systems.

To illustrate, consider lobster fisheries in the western North Atlantic. One of the healthiest is that surrounding a small island called Monhegan. There the fishers have a six-month season, with the off-season corresponding to the lobsters' molting and reproducing. Marine biologists see more than coincidence in the health of the local fishery (and, through larval dispersion, nearby fisheries) and this annual respite from fishing pressure. Similar stories can be told almost anywhere there are successfully managed fisheries (Acheson 1988; Princen 2005: 223–89). Among agriculturalists, a fallow serves a similar purpose. Allowing the land to "rest" breaks disease cycles, allows nutrients to rebuild, and restores water balance (see Chapter 40). Among wildlife managers, refuges provide spatial respite from harvesting and hunting (Gadgil and Guha 1992; see Chapter 37).

> *Principle 3*: The more tightly human *respite* is connected to natural cycles, the more likely the social system will operate within ecological constraints and be self-sustaining. For sustainable resource use, from the local to the global, periodicity must be built in.

Cycling not only implies fluctuation and downtime but the *absence* of one-way flows (the one exception being, at the planetary scale, solar energy). Materials that do not decompose (e.g., persistent substances such as DDT and PCB, heavy metals, and radioactive waste; see Chapters 32 and 33) are one-way creations. They cannot be assimilated and thus cannot supply nutrients or energy to other organisms. Many of these substances bioaccumulate and interfere with endocrine and reproductive functions of higher animals, including humans. They are thus alien to ecosystem functioning and have no place in an ecologically sustainable society.

Hence, with the possibility of human-induced one-way substances the necessary social principles for capping these substances at zero are *prevention* and *prohibition*. Small, highly controlled experiments with constant monitoring are associated practices. The burden of proof would be on those who would risk creating such substances, however inadvertent; it would not be on those who bear the biological insult as is the case now in most industrial societies (the notable exception being pharmaceuticals).

> *Principle 4*: There is no ecological basis for anthropogenic non-assimilative substances and they therefore have no place in a sustainable society. As a necessary step for sustainable resource use, they must be *prohibited*, *eliminated*, and *prevented*.

If this proposition appears to be overly stringent, consider the position of the US–Canada body, the International Joint Commission, charged with, among other things, ensuring the water quality and ecological integrity of boundary waters such as the Great Lakes: There is no "acceptable assimilative capacity for persistent, bioaccumulative toxic substances.…The only appropriate water quality objective is zero." And this is not simply a biological or economic issue, nor even strictly a health issue, the IJC told its clients, the governments and publics of the two countries: "The production and release of these substances into the environment must…be considered contrary to the [Great Lakes Waters Quality] Agreement legally, unsupportable ecologically and dangerous to health generally. Above all, it is ethically and morally unacceptable" (International Joint Commission 1994).

Recurrent change

Ecosystems are in constant flux. They have bursts of energy, they mature, they stabilize, then they decline and rebuild. Populations rise and fall. Species adapt. Biomass fluctuates. And sometimes, with external shocks (due to shifts in climate or geologic formations, for instance), ecosystems "flip"; they slide into a permanent state of low biological activity. For all this dynamism, ecologists still talk about ecosystem "integrity" (high levels of bioproductivity or genetic diversity, for example) and "resilience" (the ability to withstand perturbations without flipping). Humans can perturb an ecosystem, intervening to extract food or fiber. They can cause ripples that eventually flatten out leaving the ecosystem intact. Or they can send tsunamis through the system, permanently degrading it.

From the perspective of human use, the question is how to intervene without degrading the system, how to maintain its essential ecological functioning, however variable, while still participating in that functioning. Human use of ecosystems, like ecosystem functioning itself, is about change. But not all change is the same. From the human use perspective (especially with the goal of long-term resource use), human-induced change must be *of a sort* and *at a rate* such that the ecosystem can change accordingly, that is, that it can *adapt*, and avoid flipping. In fact, ecologically sound human intervention is one that entails adaptation by *both* the biophysical system and the social system (see Proposition 3). The issue, thus, is less about control – humans controlling yield, biomass, species, habitat, or flow – and more about human adaptability – the ability of human systems to *adapt to* biophysical systems, and to do so as those very systems are adapting, all without incurring irreversible loss.

To illustrate, a timber company can adopt harvesting methods and hiring practices to extract only mature, slow-growing trees in a natural forest, taking specimens from all species and allowing the ancient trees to reseed and the young ones to fill the gaps. Or it can select the most commercially valuable trees, replant only those species, clear away competing plants and, as a result, risk a forest collapse with an invasion of bark beetles. A coastal town can institute water conservation measures and pump underground freshwater only in the rainy season when recharge keeps the saline front at bay. Or it can pump year-round and hope that the front doesn't move in and permanently salinize the freshwater aquifer.

Put differently, change in complex adaptive systems (ecosystems with high levels of integrity and resilience) is fundamentally different from change in highly engineered, highly simplified systems. When the world is seen as a complex adaptive system, one that has multiple interconnections and many equilibrium states, one that changes discontinuously, predictability and, hence, control, are highly limited, sometimes impossible (Costanza et al. 1993; Schneider and Root 1996; Perrings 1991). "There are points in any system's development where several possible directions of radical change are open," write systems analysts Kay and Schneider, "and it is not possible to predict, with certainty, which one will occur" (Kay and Schneider 1994: 34). And, then, when interactions accumulate, predictability is even more difficult. Advances in meteorology have led to vast amounts of data feeding into sophisticated computer models. Yet weather forecasts are still limited to about five days. The dynamics of land, water, air, and biological activity accumulate, creating chaotic behavior of such proportions that no amount of data or sophistication of modeling can capture it. "Computers cannot substitute for crystal balls," say Kay and Schneider, "except for very limited classes of problems that occur over short spatial and temporal dimensions" (Kay and Schneider 1994: 34). The second law of thermodynamics states that energy dissipates and systems tend to run down. But an open system with high-quality energy inputs (low entropy) resists this tendency; it self-organizes. Self-organizing systems, write Kay and Schneider,

> exist in a situation where they get *enough* energy, but *not too much*. If they do not get sufficient energy of high enough quality (beyond a minimum threshold level), organized structures cannot be supported and self-organization does not occur. If too much energy is supplied, chaos ensues in the system, as the energy overwhelms the dissipative ability of the organized structures and they fall apart. So self-organizing systems exist in a middle ground of *enough*, but not too much.
>
> (Kay and Schneider 1994: 34; emphasis added)

Change is inherent in complex adaptive systems. But to have integrity, to be self-sustaining, systems must find that *middle ground*, that in-between position of changing enough but not too much. *Sufficient change* is thus the social analog to recurrent biophysical change.

> *Principle 5*: Because (i) recurrent change is inherent to both biophysical and social systems, (ii) dramatic biophysical change can undermine social systems, and (iii) fundamental biophysical processes are given (e.g., forests accumulate biomass, organisms reproduce), sustainable practice requires that social systems adapt to biophysical change, not the other way around. *Primacy* in resource decision-making (regarding, for example, harvest, withdrawal, emission rates) accords to the biophysical in sustainable systems, not to the economic or political.

> *Principle 6*: Social adaptations to biophysical change must aim at middle-ground operations, not maximums or minimums. *Sufficient change* is inherently risk-averse and adaptive – i.e., *prudent*.

The human grounding: the source of second-order principles

The preceding propositions, deriving directly from demonstrable biophysical phenomena – capacity constraints, cycling, recurrent change – lead to a set of first-order social organizing principles: ecological capping, restraint and buffer, respite, prevention and prohibition, resource primacy, and sufficient change. Second-order principles are less tightly connected to the biophysical. They are nonetheless necessary for sustainability because they aim at human behavioral propensities, individual and collective, that otherwise thwart long-term resource use. In other words, they deal primarily with *human capacity*, again individual and collective, and thus parallel the first-order principles that primarily address biophysical capacity. An ideal set of second-order principles would deal with:

i. human group tendencies to:
   a. minimize variabilities in food, water, temperature, light;
   b. accrue surpluses;
   c. externalize resource costs while internalizing benefits;
   d. shift and expand territorial boundaries;
   e. aggress against others for resource access, surpluses, technology, and labor.
ii. inherent problems of collective action (e.g., free-riding, individual versus collective rationality, limited iteration, mixed motives, commitment, and communication).
iii. physiological limits (of, e.g., sleep, nutrition, sex).
iv. cognitive limits (e.g., directed attention, spatial and temporal orientation, ability to deal with only a handful of issues at a time).

Here, however, I focus on those principles affecting direct interactions between human action and biophysical functioning – i.e., ecological consonance. A comprehensive theory would encompass these and the well-known and well-studied (from evolutionary biology to psychology to political science) issues of territorial expansion, aggression, collective action, personal health, cognition, and the like.

Selectively permeable boundaries

All systems have boundaries, however arbitrarily they may be drawn. Farmers put fences around their land; fishing communities plot points in nearby waters. Some things flow freely across those boundaries – air, water, insects, plankton, fish, grain, seed, fertilizer, machines, money. Other things must be restricted to maintain the system – users, disease organisms, predators, pollutants, destructive technologies, and overwhelming financial capital. Inshore fisheries are not open to all-comers, nor to all technologies (e.g., giant trawls, dynamite), and many restrain capital flow via owner-operator and residency requirements. Such measures limit the otherwise very human tendencies to expand and to encroach. What's more, many such measures connect to reproductive, trophic, or predator–prey dynamics – e.g., catch limits, harvesting seasons. So the boundaries of resource systems are permeable, but *selectively* permeable. To the extent the selection criteria are ecologically grounded, *selective permeability* is a second-order principle for sustainability.

> *Principle* 7: Because the boundaries of resource systems are inherently permeable and because a free flow of materials and agents can overwhelm a system, selective entry and exit are necessary for system integrity and resilience. To increase the likelihood of sustainable practice, *selective permeability* requires ecologically grounded criteria.

Problem absorption

All environmental problems are, in some sense, both local and global. With ecological frontiers unavailable, a society's attempt to develop by constantly exploiting resources and moving on bumps up against others' attempts to do likewise. Similarly, attempts to solve one's waste problem by sending it away eventually engenders resistance from those downriver or downwind. Protecting the environment by reducing a pollutant or saving a species often means that the pollutant is transferred to another medium (e.g., from land to air to water) or another species becomes threatened (e.g., a charismatic mammal such as the dolphin is protected while so-called trash fish are ignored to the detriment of the functioning of the food web). When everything is connected and the planet is finite, seemingly local activities cannot depend on an infinite supply of "other places" or on an "away" to throw wastes. To truly solve an environmental problem, that is, to use resources sustainably, is to *absorb the problem*, not displace it.

When a town's aquifer no longer satisfies growing demand for water, it doesn't look for "new supplies," an untapped aquifer (in a "full world" there are none) or a nearby river. Rather, to function in a sustainable society, it looks for ways to develop within the regenerative capacity of its own aquifer. When a near-shore fishery declines, fishers don't move to the next harbor (it's fished, too). Rather, they find ways to reduce fishing pressure. When a timber company can't buy more timberland to feed its mills, it sets milling capacity at a level supportable by existing timberland. When a city's traffic is so heavy that gridlock is a daily occurrence, it doesn't build more parking garages but reduces the incentives for easy access to the city center (which may include *reducing* parking). Problem absorption becomes a necessary condition of sustainable practice and thus another second-order principle of sustainability.

> *Principle 8*: In an ecologically full world, a world full of human impacts, there is no "away" for solving environmental problems. For sustainability, resource users must *absorb environmental problems*, not displace them.

Decision proximity

Decisions about resource use – whether to harvest now and at what rate, for instance – are rarely single-node decisions. Only within a household, say, might decisions be made by those who both produce and consume (i.e., subsistence use). Otherwise, resource decisions result from a sequence of decisions, some resembling straight chains, others networks: a timber owner decides to cut a parcel of timberland followed by a mill owner who decides how to carve up the logs into planks and chips. A shipper then decides where to send the wood for further processing until a retailer decides to carry the product and a consumer decides to buy it. Finally, the consumer, or the consumer's municipality, decides how the discarded product is to be disposed of. Along the way, decisions about waste products – wood waste, heat, pollutants – are made by producers, consumers, and government officials. The more the consequences of those decisions, especially the negative consequences over time, are borne by the decision-makers themselves and relevant populations (downstream or future generations), the more likely they will be made on a sustainable basis (Princen 2002: 103–31). Those whose worldview has a strong agrarian component (e.g., people who procure directly many of their necessary resources and depend on that procurement for their livelihood) and therefore have local knowledge of resource conditions are most likely to perceive and experience the closeness of such decisions. This is *decision proximity*.

The proximity principle is ecologically consonant in part because it follows from an essential feature of well-functioning ecosystems, indeed of any high-integrity complex system, namely, feedback loops. Feedback loops, positive and negative, are more effective the tighter their connection to critical nodes within the system. Systems whose feedback is delayed, fuzzy, remote, or roundabout tend to get too much positive feedback before the negative kicks in, risking overshoot via continuous growth. Similarly, systems that have too-ready negative feedback may whither as the positive feedback, delayed through time or distant agents, say, is never enough to reach a minimal viable size.

An ecologically informed principle of proximity increases the chances of effective feedback by putting priority on those nested layers of social organization most in tune with the biophysical and social environments. For example, the beginning of a fishing season is often dictated by a national resource agency on a given calendar day, June 1, say. The target species may be offshore that day, ocean currents may have shifted, a storm may be brewing, or predators may have just moved in. Or a fishing family may have suffered a personal tragedy. By the proximity principle, the start decision would go to those who best know such conditions and most depend on the resource. In this example, it is those who work on the water and whose livelihood depends on knowing how the combination of currents, weather, and predator–prey relations affects the target species and whose success depends on everyone getting a fair chance regardless of personal circumstance. Of course, fisheries biologists and remote-sensing technicians will also have data. But the essential knowledge, that which combines direct experience and need, will be held by the fishers. What's more, they will know what non-fishers cannot know: whether boats are ready to go out, crews have arrived, loans secured. The conditions in the harbor constitute the relevant social system at that particular time, what also has its feedback loops. Knowing whether it makes sense to go out on a given day is therefore hardly a simple question; any arbitrariness in setting the start day effectively erases large amounts of relevant information – that is, it breaks essential feedback loops between the biophysical and social systems.

Notice that in this construction of knowledge and decision authority relevant to sustainable resource use, "making sense" is, from a systems perspective, shorthand for effective feedback loops between the biophysical and social systems. From a perceptual perspective, it is drawing on all relevant senses (sight, touch, smell, say), what those who steer a boat experience, and those who stare at a computer screen do not (Abram 1996). It is in the fisher's realm of *practice* that key actors "read" the environment and "the environment" reacts, prompting those actors to adjust behavior, to cope, to live *with* their environment, not simply manage that environment (Bavington 2002). It is here that incentives for short-term profit align with incentives for long-term productiveness. In short, this is where sustainable practice is most likely to be enacted.

Proximity is thus not a romantic ideal. It is a *scientific ideal*, a social scientific and biophysically scientific ideal, and it is an *experiential ideal*, an ideal born of practice and need. What is more, it is an economic ideal if, by "economic," we mean economical (i.e., frugal, prudent) use of a resource over the long term, the ecologically meaningful long term (Daly and Cobb 1989).

> *Principle 9*: Because *decisions proximate* to the resource draw on experiential knowledge to tighten feedback loops, feedback within and between social and biophysical systems, such decisions are more likely to be sustainable than those distal or distanced, whether in space or time or both.

The political grounding: the source of third-order principles

Third-order principles are distal to the ecological, proximate to the mechanistic and strategic. That is, they are tightly associated with the economistic, the industrial, the commercial, the political – in short, with all that makes for an endlessly expanding, fossil-fuel-based, consumer-oriented political economy. Consequently, third-order principles would appear to have little to contribute to a sustainable economy, and, in fact, would appear to be a sustainable economy's very nemesis. But the premise here is that a broad-scale societal transformation necessarily starts with what exists (De Young and Princen 2012: 325–40). Yet not with all that exists, not with every behavioral assumption, every value, every concept. Rather, the transformation selects from what exists, much as new species in effect select from genetic material that exists, or new technologies select from scientific knowledge (and technologies) that exist. And the criteria for the social selection are, once again, ecological, not industrial, not mechanical, not expansionist, not colonial, but ecological – biophysical, cyclical, fluctuating, relational.

So third-order principles, being distal to the biophysical, relate to the social organization for sustainability by analogy, by the abstract social constructions of markets and laws, of physics, chemistry, and biology. They are disconnected from long-term biophysical functioning yet necessary for other goals – e.g., material wealth generation, waste reduction, justice (see Chapter 24). They are, therefore, technical, economic (as in market behavior), legal, moral (see Chapter 25). They accept contemporary practices, however unsustainable, as an unavoidable part of the platform from which a sustainability trajectory can be launched. They are, in short, a necessary part of an adaptive strategy since all adaptations, physical and cultural, proceed from preexisting conditions. And they are a necessary part of a political strategy since all politics, local to the global, are about influence, about marshaling forms of power (ideas, knowledge, resources, manpower) to chart a course.

Priority use

In fisheries law, formal and common, subsistence fishers are typically accorded top priority followed by commercial and sport fishers. The practices may be identical – longlining, say, or setting crab pots – but the uses are widely recognized as different: those who fish to put food on the table, their own table and that of their families and immediate community, take precedence over those who fish to sell in a market and those who fish for recreation. Similar priorities of use exist in other forms of hunting – deer, birds, rodents – and gathering – wood, herbs, thatch – especially where some kind of common property, public or open or common, exists (Birkes et al. 1998). Extensions to private property regimes would follow logically to the extent such regimes have common or public components, or both, which is generally the case (Ostrom 1990). For instance, in the face of water privatization efforts around the world, water law is increasingly moving toward a presumption that water *sources* – headwaters, aquifers, lakes, and springs – must be held publicly even if downstream flows are extracted and traded privately (Palaniappan et al. 2004).

These fishing and water use examples suggest that the general case for a priority use principle in resource use situations is where competition is high and technologies and capital access vary. As an ethic, the priority use principle is commonsensical. As an organizational principle it makes common sense – and ecological sense – as well: subsistence use tends to have more brakes, more built-in mechanisms for restraint than commercial and sport uses. And, as with the proximity principle, users "sense" their environment differently depending on the mode of resource use – subsistence versus market versus recreation. So if the priority use principle makes sense ethically, organizationally, and ecologically, it is noteworthy that it does not make sense economically, or, more accurately, economistically. An economistically oriented policy-maker would measure the value (read economic value) of each competing use and prescribe a mix of uses that equates marginal values. In other words, following the economic principles of maximization and efficiency with market price the metric, subsistence would prevail, even exist, only if the dollar value of the fish consumed exceeded that sold in the market or the dollar value for sport fishing exceeded that of subsistence. The fact that such situations rarely, if ever, occur (wealthy sports individuals can always outbid subsistence fishers) suggests that market principles are orthogonal to the priority use principle. And, because the priority use principle is demonstrably ecological and market principles are not (see efficiency below), it suggests that market principles can, at best, only be subsidiary, not primary, in an ecologically sustainable order (see Principle 5).

> *Principle 10*: Because subsistence use meets basic needs directly, is tied to the resource, has built-in restraints, and tends to operate for the long term, it has *priority of use* in a sustainable economy. Commercial use meets needs indirectly, is mobile, tends toward expansion, and responds to short-term incentives. Subsistence use thus trumps commercial use of resources in a sustainable economy.

Efficiency

Resource efficiency occurs when the ratio of individual or societal benefit to resources expended (and wastes emitted) increases. Sustainable-use efficiency occurs when that ratio increases *and* resource use levels off or reduces so as to stay within regenerative and assimilative capacities. Put differently, under conditions of *excess throughput*, an efficiency gain can be presumed beneficial to the goal of sustainability if and only if it does not result in a net increase in consumption and deposition and there is no net loss in social welfare (see Chapter 16). Otherwise, a prudent approach to efficiency measures would be to assume that, in a growth-centric economy, efficiency gains will be taken to *increase* resource use and waste deposition: more efficient automobile engines will be more powerful and the cars will be driven faster and farther; more efficient light bulbs will result in more lighting.

A stringent efficiency, one aimed at reducing or leveling resource use, contributes to a reversal in a trend of ever-increasing use and the threat of overshoot. Coupled with caps and buffers, such an efficiency, a throughput-reducing or throughput-leveling efficiency, helps put a society on a sustainable path and is thus a third-order principle for sustainability.

> *Principle 11*: To contribute to sustainability, *efficiency gains* in resource use must be coupled with measures (e.g., ecological design principles 1–8) that hold resource use within ecological capaciies. The result is a net reduction or leveling of resource use or waste sink filling.

Propensity and primacy

Principles for sustainability will be effective to the extent they aim at human propensities, individual and collective, to exceed biophysical capacity. These propensities have likely been shared by our ancestors, including those who appear to have lived sustainably. And many are shared by other animals. One might, consequently, claim that propensities toward excess are perfectly "human," even "natural," and hence should not be tampered with: It is who we are. When they get us in real trouble, we'll adjust; we always have. There is a certain truth in this position, a truth worth examining in a project of designing systems for global sustainability. First, yes, as a species we've always had a growth imperative, a tendency to fill a habitat, create new niches, grow our population, consume at increasing rates, and move on. In such a pattern, we've extended our ecological reach around the world, from savannah to tundra, from desert to mountain, from river bed to ocean beach. We've always done this and always either adapted or crashed. Those groups who adapted did so in part by creating their own niche and in part by squeezing out others – predators and unwanted trees, for example. In that sense, they weren't unlike the starlings and kudzu that have spread globally.

For human communities, though, the adaptations were both ecological and cultural; success was not a matter of continuous expansion, of endless "moving on." Among those who came to the Nile River, for example, the successful ones were those who settled and developed an agriculture to match the annual flooding. And that agriculture was indeed cultural, a set of institutions for using and sharing water, and doing so not just for a few seasons, but for generation after generation, for some 5,000 years as it were. At the center of those institutions were *principles*, principles derived from biophysical conditions and social demands. As far as is known, the principles and corresponding rules evolved over centuries, possibly the entire 5,000 years. Whatever agricultural practices the early peoples brought with them, such practices most likely changed dramatically (from those, say, of the desert or savannah or marshland). What's more, the river changed as the flow changed, evaporation increased, the delta shifted, and so forth. It was in constant flux. The two, the human system and the riparian system, co-evolved, both, in a sense, in response to the other and all without degrading one another.

Second, the notion of "propensity" itself requires explanation. Humans have a broad range of propensities, from competition to cooperation, selfishness to altruism, exploitation to nurturing. To say people have a propensity – say, competitiveness – is not to say that that propensity is exclusive or dominant. Few would dispute that humans are competitive. But we are also cooperative. Pick the most competitive individual you've ever known, or the most ruthless corporation, and you can find a cooperative side. The individual assembles a team that cooperates to out-compete opponents. The corporation cooperates within its board and among its managers and staff, and it colludes with governments (a form of cooperation with a negative connotation, but cooperation nonetheless).

So along any continuum – cooperation–competition, selfishness–altruism, say – human behavior can be located simultaneously at different points. The issue from a social change perspective is this: What are the conditions under which humans lean one way and not the other with respect to a social goal? Under what conditions will humans be mostly cooperative or mostly competitive, mostly selfish or mostly altruistic in society's efforts to promote economic development or democracy or human rights? With respect to the goal of long-term resource use (i.e., sustainability), what propensities contribute to sufficient use, which do not, and what conditions encourage those that do? In a sense, the essence of the sustainability project is just this – identifying relevant propensities and specifying their enabling conditions. It is not persuading people to love nature, not bribing them to act correctly, not scaring them out of their denial and lethargy (Norgaard 2011).

The challenge before us today is one of dealing with our "natural" propensities, what we indeed have a long history of doing and, arguably, a mental capacity to handle. Only the scale is greater. Spatially, it is not one people and one river valley, as with the Egyptians, but all peoples and the entire globe. Temporally, it is not marginal change by trial and error over decades and centuries, but the imperative to rapidly arrest ecological decline in a matter of years and decades. But just as every Egyptian farmer and village developed its own practices within the larger Nile system, so each nation, each region, even each village and borough will develop its own practices and, when necessary, will do so rapidly. What they will need is a set of overarching principles, principles consonant with biophysical realities of the planet's ecosystems and with the social realities of diverse societies. Those principles, to repeat, must aim at human propensities to exceed ecological capacity, propensities that may have a long biological and cultural history, but for which countervailing cultural adaptations – norms and principles, myths and metaphors – also have a long history. In other words, there's nothing new in deliberately constructing new norms and principles, new myths and metaphors, all to meet the peculiarities of an ecological challenge. What may be new is the scale, spatial and temporal.

Conclusion

The core elements of institutions are norms and principles. They set the broad normative context – the "shoulds" – from which specifics – rules, procedures, practices, habits, rituals, laws, regulations, treaties – follow. Long-standing institutions may develop norms and principles over time through trial and error. Their rules and procedures emerge to meet needs while norms and principles are implicit yet governing. New institutions may start from scratch and, if the need is pressing, require not just new rules and procedures but new, and explicit, norms and principles. In fact, arguably all new institutions and all substantial changes in existing institutions require the explicit articulation of norms and principles from which specifics follow. It has certainly been the case for the creation of a world trade order (centering on the World Trade Organization), a Western security alliance (centering on the North Atlantic Treaty Organization), international peacemaking (centering on the United Nations), not to mention the founding of new constitutional democracies. In all cases, the test for an institution's norms and principles is their *congruence* with the nature of the need: commercial institutions require market transparency and enforceable contracts, military institutions require hierarchy and loyalty, diplomatic institutions require prevention and collective decision-making, democracies require shared powers and due process.

With the need for sustainability becoming ever more pressing, from the local to the global, old institutions must change and new institutions must be devised. While much of sustainability has features in common with existing institutions – the need for cooperation and the minimization of waste, for instance – what defines sustainability is its focus on the ecological, especially human *interaction* with the biophysical, and a long-term orientation. Norms and principles *for* sustainability must account for these special features. In fact, to construct and implement a strong notion of sustainability, a notion that is more than conventional conservation or pollution control, such norms and principles must be accorded *primacy* in the building of institutions for sustainability. The three propositions and eleven principles developed here thus constitute a provisional set of conditions under which sustainability might proceed. They can also serve as criteria to evaluate projects and policies purporting to be sustainable.

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