An open access e-Journal for sustainable solutions

Sustainability: Science, Practice, & Policy

Volume 3 • Issue 2
Fall 2007

ISSN: 1548-7733

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EDITORIAL

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Governance for sustainability

Sustainable development is rapidly moving from the periphery to the mainstream of politics, business, and science. Over the past several years, a strong consensus has started to emerge that some major global problems can only be overcome through large-scale concerted action. Recent additions to the debate include the reports by the International Panel on Climate Change, the Stern Report on the economics of climate change, Al Gore's "An Inconvenient Truth," and, perhaps less known, the Potsdam Memorandum. The latter pronouncement, recently presented by a broad group of Nobel laureates and entitled "The Great Transformation" pleads for fundamental changes in our economies and societies, asking,

> Is there a "third way" between environmental destabilization and persisting underdevelopment? Yes, there is, but this way has to bring about, rapidly and ubiquitously, a thorough re-invention of our industrial metabolism—the Great Transformation. This is an awesome challenge, yet we have one comparative advantage over all previous generations: an incredibly advanced system of knowledge production that can be harnessed, in principle, to co-generate that transformation together with courageous political leaders, enlightened business executives and civil society at large (Potsdam Institute for Climate Impact Research, 2007).

Since 2001, an experiment has been ongoing in the Netherlands to answer this call for a novel governance paradigm dealing with long-term social change. The emerging theoretical and practical results of "transition management" offer interesting insights for transforming science and policy for sustainable development. Transition management is being codeveloped in theory and practice by a wide network of scholars, policy makers, businesses, and nongovernmental organizations (NGOs). Since its introduction in the Fourth National Environmental Policy Plan (NEPP) six years ago, this experimental governance approach has been implemented in the areas of sustainable energy supply, mobility, agriculture, health care, and water management (VROM, 2001). Transition management is a coordinated effort to influence the speed and direction of large-scale social change based on the concepts of social transitions and sustainable development (Rotmans et al. 2001; Loorbach, 2007). Due to its extensive experience with environmental planning and coordinated innovation policy, the research and policy communities in the Netherlands have developed capacity for close cooperation and produced successful environmental policies. However, in spite of Dutch achievements over the past few decades, several problems persist for which existing policy or market instruments have proved ultimately inadequate. Neither top-down government policies nor bottom-up market forces can alone support directed long-term sector-wide changes; they can only occur through combinations of government policies, market forces, and bottom-up initiatives from civil society.

The unsustainability of contemporary society lies in persistent problems that are deeply rooted within our social structures, involve multitudes of actors, evolve on various scales, and require a very long-term perspective to understand and, presumably, to manage effectively (Rotmans, 2005). Society is regularly confronted with the symptoms of these persistent problems, such as energy crises, air and water pollution, environmental degradation, congestion, and ill health. Various sciences traditionally try to understand or address these problems through disciplinary analyses and the formulation of specialized solutions, but it appears that with each iteration the extant dilemmas become more complex and harder to manage.

Let us consider the mobility issue wherein measures to increase road capacity or to decrease emissions target traffic jams and automotive air pollution. Although such approaches generate incremental short-term improvements, they foster predictable mobility increases that ultimately intensify both congestion and pollution. From this perspective, sustainable development implies breaking with traditional routines and modes of thinking to overcome the inertia that limits innovation. In other words, new expressions of the same policy approaches—whether grounded in government regulations or market incentives—are unable to correct the range of problems that earlier interventions have created.

To deal effectively with persistent social problems, transitions—long-term continuous processes that fundamentally change a social subsystem—are necessary. Such transitions are recurring patterns of sociotechnical change in culture, structure, and practices. History has witnessed numerous transitions in economy, agriculture, mobility, and energy, but also in areas such as education, health care, and social structure (Rotmans et al. 2001; Geels, 2004). In these domains, relatively long temporal stretches of stability have alternated with relatively short periods of rapid social change. Transition management is based on an evolving understanding of these patterns and mechanisms. Various scientific disciplines have contributions to make here including ecology, biology, complexity science, and physics as well as the more socially and technologically oriented disciplines such as sociology, psychology, demography, science and technology studies, and history. Internationally, transition management is also recognized as an inspiring integrative concept, as it is slowly entering the debate in complexity science, governance, ecosystems management, and innovation research. Although different disciplines describe transition processes using their own terminologies, discourses, methodologies, and scales, a number of striking commonalities exist. Common points of agreement are:

- Transitions are the result of alternating processes of slow and rapid change leading from one relatively stable state to another.
- Transitions are the result of coevolutionary processes occurring at different levels of scale.
- Transitions are highly unpredictable and uncertain in terms of their speed and direction.
- Transitions are driven by changes in the external environment of a system as well as internal innovation.

The ambition of transition management is to generate processes that foster continuous social improvement while balancing economic vitality with resource use, social welfare, and cultural and social diversity. Such management of transitions can by definition not be a top-down, imperious approach. Due to inevitable complexity and uncertainty, the most influence we can expect over transitions is to shape their speed and direction. By articulating and debating desired future social states and development paths, transition management emphasizes the unavoidable need for normative processes and governance strategies. Sustainable development should not be seen as a blueprint or a fixed goal, but rather as a guiding notion that enables both science and society to search for long-term collective goals and ambitions, to experiment in the short term, and to regularly assess progress.

Several principles, grounded in transition thinking, provide the theoretical basis for transition management. The starting point is that society is analyzed in terms of complex systems with typical behavior and mechanisms (for example coevolution, emergence, and adaptation). The basic tenets are the need to:

- Simultaneously consider different domains (multidomain), different levels of scale (multilevel), and different system states (multiphase).
- Adopt a long-term perspective (generally 25 years or more) as a framework for short-term actions.
- Employ a multi-actor approach.
- Utilize both backcasting and forecasting to reconcile uncertainties and to plan for surprises.
- Focus on social learning through learning-by-doing and doing-by-learning.
- Encourage transitions through the creation of (sociotechnical) niches.

Transition management is concerned with the functioning of the variation, selection, and reproduction process at the societal level: creating variety informed by visions of and experiments for sustainability, as well as shaping new pathways and gradually adapting existing institutional frameworks and regimes (Kemp & Loorbach, 2006). In this sense, it is an example of what is called ”reflexive governance” (Voss et al. 2006). During the past several years, experiments with this approach in both the Netherlands and Belgium have been ongoing in areas such as energy supply, housing, waste and water management, and regional development (SenterNovem, 2005). These initiatives have led to the development of a governance framework to structure implementation of the approach to and the formulation of a number of “systemic instruments.” The framework distinguishes between different types of governance activities: strategic (informal processes of problem structuring and envisioning), tactical (networking, coalition building, negotiating, and developing new regulations, institutions, and structures), operational (experimenting, developing new businesses, involving consumers and citizens), and evaluation-oriented (monitoring and adjusting ambitions and agendas).

These different activities occur simultaneously through transition processes and influence one other, but each has its own dynamic, type of actors, and impact in different phases (Loorbach, 2007).

The systemic instruments based on this framework seek to influence ongoing transitions by bringing together innovators in policy, business, science, and NGOs to redefine and reframe urgent social problems and their potential solutions. An example of such a strategic transition management instrument is the "transition arena" that encourages a group of innovative frontrunners from different organizational backgrounds to formulate an alternative vision of the future and to develop strategies outside of the existing (policy) regime on how to reach such a future. The transition approach produces a common language and mode of communication to aid strategy development and to move toward concrete action. This facilitates the creation of a community with shared goals and ambitions at a collective, system level, while allowing for disagreement and competition on a more concrete and everyday level.

The concepts of transition and transition management are an inspiring basis for debate and action among scholars and different scientific disciplines. They also offer a fruitful context for cooperation and debate among scientists, policy makers, and business managers. As an analytical concept, transition management stimulates interdisciplinary analysis and offers a framework within which to discuss similarities, contradictions, and the relative value of various disciplines in contributing to different problems. In the Netherlands, a broad transition-research network exists and includes economists, historians, political scientists, technology and innovation experts, and consumption researchers with each specialist group focusing on particular aspects of transitions at different levels (see KSI Research Network, 2005). The possibilities for transition management to contribute to substantial methodological advances appear to parallel its opportunities to enrich social and policy practices. As a governance approach, transition and transition management facilitate cooperation and coproduction between science and policy, as well as the development and use of new scientific methods. New coalitions, strategies, and experiments involving pioneering scientists, "courageous political leaders, enlightened business executives and civil society at large" have been launched in the wake of transition management (Potsdam Institute for Climate Impact Research, 2007). This, in essence, is the definition of transition management as governance for sustainability: a collective process of learning-by-doing and doing-by-learning based on a shared way of thinking. The approach is not to achieve fixed goals, but to gradually work towards common ambitions through innovation, integration, and transition. And the beauty is that everyone can contribute in his or her own way and in doing so the search itself becomes the process of governance for sustainable development.

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About the Author

Derk Loorbach is a senior researcher and consultant at the Dutch Research Institute for Transitions (DRIFT) at Erasmus University Rotterdam where he received his PhD in June 2007. DRIFT is an interdisciplinary institute that combines research with close cooperation with policy and business to further sustainable development in practice. A central theme in Loorbach's research is the development of the transition-management approach as a new governance model based on complex systems thinking, governance theories, and sociology. This work

is aimed at facilitating and guiding processes of social change in the direction of sustainability through transition arenas and experiments. Loorbach is currently involved in various transition arenas, innovation programs, and visioning practices as a researcher, consultant, and participant. His research is an example of "sustainability science" combining fundamental and action research to contribute to sustainable development in practice. He can be contacted at the Dutch Research Institute for Transitions, Erasmus University Rotterdam, Room M5-30, PO Box 616, 3000 DR Rotterdam, The Netherlands (email: loorbach@fsw.eur.nl).

ARTICLE

Sustainable development: how to manage something that is subjective and never can be achieved?

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This article examines the notion of sustainable development that has emerged as a new normative orientation of Western society. We argue that sustainable development is an inherently subjective concept and for this reason requires deliberative forms of governance and assessment. We outline the contours of sustainability science as a new form of science, complementing traditional science. Such science is to be used in service to reflexive modes of governance, for which we outline the general principles and offer a practical illustration, the transition-management model. The example shows that it is possible to work toward sustainable development as an elusive goal through provisional knowledge about our needs and systems to satisfy these needs. Heterogeneous local understandings and appreciations are not suppressed but drawn into the transition process in various ways such as participatory integrated assessment and social deliberation. The social interest in sustainable development is exploited without falling into the modernistic trap of rational decision making that disregards local cultures.

KEYWORDS*:* sustainable development, public policy, social conditions, decisions, rights of future generations

Introduction

The essence of sustainable development is to provide for the fundamental needs of humankind in an equitable way without doing violence to the natural systems of life on earth. This idea was framed as "sustainable development" in the early 1980s and came from a scientific look at the relationship between nature and society. Sustainable development is also a stated aspiration of governments and societies. The notion represents a concern for the future in terms of well being and opportunities for development. Sustainable development is a kind of motherhood concept "encompassing three of the great goals of humanity, namely entitlement to health, wealth and justice in a single concept" (O'Riordan, 1996).

This article examines how problems of normativity, ambiguity, and uncertainty may be dealt with through sustainability science and reflexive modes of governance such as transition management. We will see that these problems cannot be handled in a once-and-for-all manner. One has to live with them and work with them. For this task sustainability science is useful, but it is certainly not a panacea. Sustainability science needs to be a part of reflexive modes of governance. In the Dutch transition management approach, which was to use sustainability science, this was only partially done. The article does not offer conclusive evidence of the value of sustainability science. What it does is to point to the advantages of sustainability science for dealing with sustainable development issues.

Sustainable Development as a New Orientation for Politics and Society

The idea of sustainable development or sustainability represents an attempt to link environment with development. This was effectively done through the report *Our Common Future* by the World Commission on Environment and Development (the Brundtland Report), which stated that critical global environmental problems resulted from both the South's enormous poverty and the North's unsustainable consumption and production. It called for a strategy that united development and the environment, described by the now-common term "sustainable development," defined as "development that meets the needs of current generations without compromising the ability of future generation to meet their own needs'' (WCED, 1987).

The Brundtland report argued that the vast and complex issue of environmental deterioration should be integrated with the equally vast and complex issue of human development and poverty, clearly suggesting that both challenges needed to be resolved simultaneously and in a mutually reinforcing way (Robinson, 2004).

The report was radical in stating that ecological sustainability cannot be achieved if the problem of poverty is not successfully addressed globally, but was reformist in its emphasis on growth. Sustainable development came to be formulated as a *different kind* of growth, one that is not harmful to the environment, bringing worldwide wealth and health. In this meaning, sustainable development is about conservation rather than preservation.[1] Sustainable development is progrowth and this is why people favoring value change and lifestyle change prefer the term "sustainability." However, preservation elements remain in the precautionary principle.[2]

Operationalizing Sustainability

Following publication of the Brundtland Report, numerous attempts were made to operationalize sustainable development. The most popular and common attempt is the triangular concept with the three pillars "economy," "environment," and "society," which in recent years has in some contexts come to be referred to as the P3 concept of "people, planet, profits."[3]

"Economy" refers to jobs and wealth; "environment" to environmental qualities, biodiversity, and nature's resources; and "society" to health, social cohesion, and opportunities for self-development attributable to education and freedom.

The pillar-focused approaches have gained great popularity, particularly in business circles, but they have often suffered from insufficient attention to overlaps and interdependencies and a tendency to facilitate continued separation of societal, economic, and ecological analyses (Kemp et al. 2005). Alternative depictions stressing interconnections and consideration of institutional aspects—as in the PRISM model of Spangenberg et al. (2002), Farrell et al. (2005) and the SCENE model of Grosskurth & Rotmans (2005)—offer useful ways forward.

Concerns with the poor and the weak that should be part of the sustainability debate do not feature prominently in the pillar approaches. These are, however, captured by the four principles of Newman & Kenworthy (1993):

- The elimination of poverty, especially in the Third World, is necessary not just on human grounds but as an environmental issue.
- The First World must reduce its consumption of resources and production of wastes.
- Global cooperation on environmental issues is no longer a soft option.
- Change towards sustainability can occur only with community-based approaches that take local cultures seriously.

An interesting aspect of the above definition is the attention given to local cultures and community-based decision making, a strategy that renders sustainable development less technocratic. In the beginning, ecocentered approaches dominated the sustainability discussion, but they have been increasingly criticized for being elitist and insufficiently democratic. Roe (1998) offers a penetrating criticism that condemns "resource management" approaches to sustainable development as "a new class version of managerialism that functionally serves to globalize and perpetuate the techno-managerial elite's control over everyday life" and in so doing is antisocial. This is a strong statement, but indeed sustainable development is not an autocratic project whose content can be objectively determined. What sustainable development means is essentially a political decision (Hajer, 1995).

Democracy and civility have come to be increasingly subsumed under sustainable development. Such an approach is consistent with the seven principles advanced by Robert Gibson (2001) which also include integration, human-ecological system integrity, sufficiency and opportunity, equity, efficiency, and throughput reduction and precaution (Box 1).

The requirements of sustainable development are multiple and interconnected. The main dimensions can be said to consist of maintaining the integrity of biophysical systems; offering better services for more people; and providing freedom from hunger, nuisance, and deprivation. To these one may add choice, opportunity, and access to decision making—aspects of equity within and across generations (Kemp et al. 2005).

[1] Conservation should not be understood as being antidevelopment. As Gunderson & Holling (2002) observe, "conserving the elements and functions of our socioecological systems (even particular eco-systems or even species) cannot be the overall goal of sustainable development. Otherwise our objectives would be a-historic and would ignore the nature of evolutionary change and related variability. Rather, a conservation goal must be resilience– that is the ability to maintain and conserve the ability to adapt to changing conditions and to be able to respond flexibly to surprises, thus turning them into opportunities" (quoted in Farrell et al. 2005).

[2] In the following discussion the concepts of sustainable development and sustainability are used as synonyms, but readers should bear in mind that sustainability is more about preservation and less about progress.

[3] At the United Nations summit in Johannesburg in 2005, the P3 concept of "people, planet, profits" was changed into "people, planet, and prosperity."

Box 1 Principles of Sustainability

Human-ecological systems integrity: Build human-ecological relations to maintain the integrity of biophysical systems in order to maintain the irreplaceable life support functions upon which human well-being depends.

Sufficiency and opportunity: Ensure that everyone has enough for a decent life and that everyone has opportunities to seek improvements in ways that do not compromise future generations' possibilities for sufficiency and opportunity.

Equity: Ensure that sufficiency and effective choices for all are pursued in ways that reduce dangerous gaps in sufficiency and opportunity (and health, security, social recognition, political influence, etc.) between the rich and the poor.

Efficiency and throughput reduction: Provide a larger base for ensuring sustainable livelihoods for all through reducing threats to the long term integrity of socio-economic systems by avoiding waste and reducing overall material and energy use per unit of benefit.

Democracy and civility: Build our capacity to apply sustainability principles through a better informed and better integrated package of administrative, market, customary and personal decision-making practices.

Precaution: Respect uncertainty, avoid even poorly understood risks of serious or irreversible damage to the foundations for sustainability, design for surprise and manage for adaptation.

Immediate and long-term integration: Apply all principles of sustainability at once, seeking mutually supportive benefits.

Adapted from Gibson (2001).

Interpretative Flexibility

The previous sections elaborated on selective views regarding sustainable development, although the number of definitions is estimated to run into the hundreds. The plethora of definitions has been deplored for creating confusion, but it also has advantages. As Robinson (2004) writes, "any attempt to define the concept precisely, even if it were possible, would have the effect of excluding those whose views were not expressed in that definition." Open definitions help communities and groups of actors to identify sustainability programs and actions that befit their concerns. Without such flexibility, no action may come from such connections; rather only actions that meet official sustainability aspects, such as global warming, would be deemed appropriate. Variation in the sustainability concept allows for a multitude of actors, possibly the whole of society, to be involved, encouraging locally adapted solutions. National governments and multinational corporations are better placed to deal with global environmental problems, working conditions, and global poverty than local agencies which are presumably more suited to deal with local poverty and resources. We are not opposed to official sustainability concerns and targets, laid down in sustainability strategies at the national or local level, but an overly narrow range of goals can act as a straightjacket. Sustainable development is not about making progress in terms of three or four parameters, but about achieving a positive process of social change that avoids generating internal contradictions that might undermine further advances (Meadowcroft, 1999a).

Sustainable development is a contested concept even when the fundamentals are clear: maintaining the integrity of biophysical systems and reducing poverty and risks. From a governance perspective, such disagreement is an essential part of sustainable development, but one that makes operationalization difficult:

- Different ideas exist regarding sustainable development for actors in various sectors (e.g., energy, transportion, agriculture, food systems, waste management).
- Existing solutions tend to be sustainable within these sectors rather than across the whole of society.
- New developments bring new risks that cannot be anticipated.
- Sustainable development is a long-term, open-ended project that precedes and supersedes limited term, democratically elected governments.
- Sustainable development involves making choices, and perhaps trade-off decisions, on highly contested issues (which is to say that in some cases the notion of a "trade-off" might prove to be no more than a euphemism for fundamental irresolvable dilemmas) (Farrell et al. 2005).

Sustainable development derives from social consensus on what we consider to be unsustainable and what constitutes progress, perspectives that will differ across nations and localities. The substantial content of sustainable development cannot be scientifically determined as "objective knowledge," but will always incorporate normative valuations that only become ascertained in the process of social interaction (Voss & Kemp, 2006). This situation calls for a different type of science, one able to deal with ambiguity, complexity, and uncertainty (Brand & Karvonen, 2007).

Sustainability Science

Sustainability based on social consensus of what is unsustainable requires a special form of science. A new research paradigm is needed that reflects sustainable development's complexity and multidimensional character. The new paradigm must encompass different magnitudes of scales (of time, space, and function), multiple balances (dynamics), multiple actors (interests), and multiple failures (systemic faults) (Martens, 2006).

This new type of science should be able to deal with complexity, uncertainty, and legitimate multiple viewpoints. Such a challenge calls for mutual learning, integrated assessment, and conflict resolution. In terms of science, it demands what Gibbons et al. (1994) refer to as mode-2 science that is interdisciplinary and transdisciplinary and promotes a context in which knowledge is coproduced and provisional. This form of practice differs from normal academic science which is monodisciplinary and based on peer review by the scientists themselves. Mode-1 science will remain important, but it is unable to deal with issues of values and multiple viewpoints. In mode-2 science, the scientists interact with practitioners, policymakers, and citizens to produce knowledge for action (Table 1). No single set of knowledge or viewpoint is privileged (Wiek et al. 2005).

Table 1 Properties of mode-1 and mode-2 science

Mode-1 science	Mode-2 science
Academic	Academic and social
Monodisciplinary	Trans- and interdisciplinary
Technocratic	Participative
Certain	Uncertain
Predictive	Exploratory

Adapted from Martens (2006).

A new field of sustainability science is emerging that seeks to understand the fundamental character of interactions between nature and society—at different scales—with special attention to the complex evolution of the nature-society system in response to multiple and interacting stresses (Kates et al. 2001). Sustainability science is not clearly defined, but central elements have begun to gain clarification (Martens, 2006):

- Inter- and intradisciplinary research.
- Coproduction of knowledge.
- A systems perspective with attention to the coevolution of complex systems and their environments.
- Learning-by-doing (and learning-by-using) as an important basis of acquiring experience, besides learning-by-learning (learning through detached analysis).
- Attention to system innovation and transitions.

Because sustainable development is an issue of complex systems and integration, systems science has a special role to play. Systems thinking is a way of understanding reality that emphasizes the relationships among a system's parts rather than the parts themselves (Hjorth & Bagheri, 2006). Systems thinking helps actors to see various systems aspects, to cross boundaries of science, and to create new conceptual frames that highlight interactions. It offers a powerful perspective, a specialized language, and a set of tools to address the most stubborn problems in everyday life and work (Hjorth & Bagheri, 2006). Models of complex adaptive systems are especially useful for conceptualizing change and developing steering strategies, as sustainability policy should combine the capacity to adapt to change with a capacity to *shape change* (Rammel et al. 2004). Soft systems methodology (Checkland & Scholes, 1990) offers a useful way to structure problems and to carry out integrated assessments. Dynamic issues of system change, such as path dependence, bifurcation, emergence, self-organization, and co-evolution may be analyzed with the help of complexity theory and agent-based models or evolutionary models (Gunderson & Holling, 2002; Windrum & Birchenhall, 2005).

Sustainability science is an integrative science, a science that sets out to break down the barriers that divide the traditional sciences (Martens, 2006). It involves not just the integration of disciplines, but also different individual viewpoints and knowledges in processes of deliberation and assessment. Debate regarding sustainability projects should be inclusive and participatory. The development of mutual trust and understanding of the reasons for participation provides great potential for successful interactions between "expertise" and "democratic processes" (Cough et al. 2003). However, given the weakness of certain actors, care is needed to defuse pressures from the most active and vocal, thus offering the less articulate and less empowered an opportunity for reflection and decision making regarding sustainability action. Participatory strategies must balance the right of citizen choice with technical competence to ensure informed decisions. Effectively implementing such an approach will ensure that processes of change, shaped by sustainability principles chosen by the participants, will remain responsive to different and evolving needs (Wijayaratna, 2000).

One might say that sustainability is about locally suited options that are globally sustainable, but it is also about contextual awareness and behavior. Conflicts are likely to occur between localism and globalism, characterized by different mindsets and different logics for action, as noted by Rosenau (2003). The tensions are difficult to reconcile, as the controversy over globalization shows.

Knowledge Implications for Policy

A look at the policy consequences of this new sustainability vision reveals the following. It is important for decision makers—both in politics and in the business community—that specific policy objectives, along with their associated time limits, be clearly determined. Figure 1 shows several possibilities. One of the options available to policymakers—and this is not so far from the current situation—is to aim for short-term goals and for simple or cheap means of achieving them. In contrast, a more proactive, innovative approach would pursue longer-term goals, taking into account developments at different levels of scale and in different sectors. Unquestionably, sustainable development demands the latter strategy.

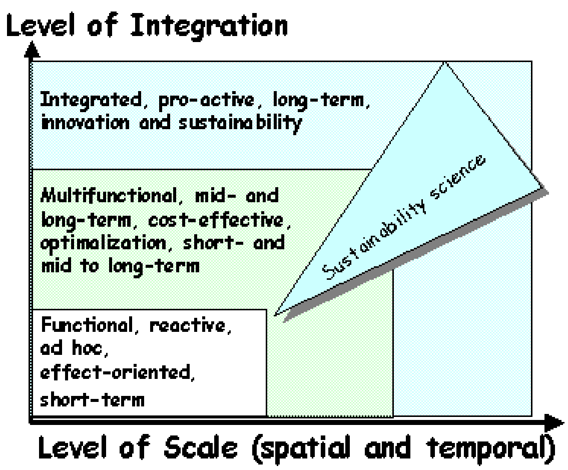

Figure 1 The role of sustainability science in the policy process (Martens, 2006).

To facilitate decision making, sustainability scientists must assist in rendering concrete both problems and solutions on all relevant temporal and spatial scales. This means that sustainability at the systemic level must be assessed, bringing to bear the following procedural elements: *analysis* of deeper-lying structures of the system, *projection into the future*, and *assessment* of sustainable and unsustainable trends. *Evaluation* of the effects of sustainable policy and the *design* of possible solutions through sustainable strategies are also necessary.

This sounds like a tall order. Fortunately, integrated approaches to sustainability issues in such areas as environment and development are not entirely new. The search for integrated theories that combine different disciplinary strengths is one way of creating a better decision-making basis regarding sustainability issues.

There is already evidence that an emergent form of sustainability science can help to deal constructively with the ambiguity, complexity, and uncertainty central to sustainable development. This challenge is taken up through an explicit concern with the wants and needs expressed by society and their system-wide effects across various scales. It does not aim at precision, but at exploration.

The Role of Visions

Should sustainability policy be based on visions? In general, sustainability researchers assign a positive role to visions. Visions challenge the dominant perspective of past and present and can inform action for innovative change, for instance the creation of a hydrogen economy. Visions may also help to make explicit what is involved in wide-ranging change, which can be useful for thinking and assessment and, of course, for action. Smith et al. (2005) identify five functions of visions.

1. *Mapping a possibility space*: Visions can help to identify the realm of plausible alternatives for conceiving sociotechnical functions and for the means of providing for them.
2. *A heuristic*: Visions can guide problem-solving activities.
3. *A stable frame for target-setting and monitoring progress*: Visions can stabilize technical and other innovative activity by offering a common reference point for actors collaborating on their realization.
4. *A metaphor for building actor-networks*: Visions can specify relevant actors (including and excluding) and can act as symbols that bind together communities of interest and practice.
5. A *narrative for focusing capital and other resources*: Visions can become emblems employed in the marshalling of resources from outside an incipient regime's core membership.

Visions can help to guide thinking and inform processes of action for achieving certain outcomes—material outcomes—but even more crucially learning outcomes that can inform further action. Through visions, new paths of development may be explored. While these are, of course, positive aspects of visions, they also have negative aspects. First, visions can advance the objectives of special interest groups that may not be consistent with the needs of wider groups, communities, and nations. Second, change may be ambiguous or even harmful. Serious repercussions and social costs may outweigh any benefits. These observations suggest that visions should be continuously assessed and refined and they should reflect the wider community interests and not just those of select groups.

Visions are important, perhaps even necessary, for system change. But any fundamental change also produces undesirable side effects and new risks. From a sustainability point of view, it is important to be mindful of these adverse implications and to contain them as early as possible in the overall process. Nuclear energy stands out as a prime example, but this point also holds for renewable forms of energy. For instance, the large-scale production of energy crops may destroy valuable ecosystems and the social fabric of local communities.

Because of this potential for unintended consequences, it is better to *explore multiple visions* and not just one. Visions create better worlds *together* rather than apart. Sustainable development requires *diversity* in technology, institutions, and ways of thinking. Diversity should be tolerated, even stimulated, as it offers a resource base for adaptation and reorganization (e.g., Lister & Kay, 2000; Rammel & van den Bergh, 2003). Diversity in product offerings is also needed for meeting heterogeneous preferences and to cater to local circumstances (Kemp et al. 2005).

The above three needs—integrated assessment that takes into account multiple viewpoints and concerns, interpretative flexibility, and learning and guidance—mean that decision making and policy for sustainable development should be reflexive, that the actors themselves should become aware of basic assumptions and mechanisms that help them to deal in novel ways with newly perceived problems.[4] Sustainable development requires increased capacity for reflection and an adaptive framework for making instrument choices.

Sustainable Development Requires Reflexivity

Many modernist policies have led to undesirable outcomes. Examples abound. Rational town planning has created inhospitable places for humans to live and interact. Scientific forestry practices have resulted in reduced timber production because of increased vulnerability to disease and weather (Scott, 1998). To avoid regrettable and disappointing results, sustainable development policy should have an inbuilt capacity for assessment and adaptation. What is needed are *reflexive* modes of steering and governance geared toward continued learning in the course of modulating ongoing developments rather than the maximization of control to achieve certain outcomes (Voss & Kemp, 2006). For this kind of learning to occur we need *reflexivity* on the part of the actors (about system effects and their own needs) and mechanisms of feedback on promising solutions, instruments, and forms of governance.

Practical instances of reflexive governance can be found in approaches such as constructive technology assessment (Rip et al. 1995; Schot & Rip, 1997), foresight exercises (Grin & Grunwald, 2000), transdisciplinary research (Wiek et al. 2005), and participatory decision making and cooperative policy making (Meadowcroft, 1999b). Similar evidence can be found in more comprehensive approaches for steering policy decision making such as transition management and adaptive management. Reflexive techniques facilitate several kinds of learning processes and help to modify our decision rules and mental models of the real world as we go along (Hjorth & Bagheri, 2006).

Sustainable development requires learning that feeds into decision making. Learning is needed on many fronts. We need learning about how to make products more ecofriendly, but also about new socio-technical systems for the delivery of goods and services. Learning is also needed regarding new business models based on sustainability and about how existing systems of governance can be made more reflexive. We furthermore need to learn about our "real" needs (instead of assumed needs) and various ways for meeting those needs in more sustainable ways.[5]

One approach that encourages reflexive governance is transition management (described in Rotmans et al. 2001; Kemp & Loorbach, 2006; Kemp et al. 2006; Loorbach, 2007), which consists of the following elements:

- The development of sustainability visions and the setting of transition goals.
- The use of transition agendas.
- The establishment, organization, and development of transition arenas (for innovative actors) besides the normal policy arena.
- The use of transition experiments and programs for system innovation.

[4] Interestingly, the notion of sustainable development is an example of reflexivity in which environmental protection was linked to poverty and development, creating a new normative viewpoint.

[5] According to Reisch (2001) understandings of welfare and "real" needs have become distorted (quoted in Shove, 2005). This is a controversial view, but human needs do evolve–endogenously and exogenously in transition processes.

- The monitoring and evaluation of the transition process.
- The creation and maintenance of public support.
- The practice of portfolio management.
- The use of learning goals for policy and reliance on circles of learning and adaptation.

Transition management offers a set of strategies for working toward sociotechnical "regime changes"—alternative systems of production and consumption that can help to reduce environmental impacts while yielding attractive services for users. Emergent alternatives should ideally combine individual and social benefits. This objective cannot be achieved on a short time basis and instead requires innovation at many points and levels, including governance. Policy actions are evaluated against two types of criteria: 1) the immediate contribution to policy goals (for example in terms of kilotons of carbon-dioxide (CO_2) reduction and reduced vulnerability through climate change adaptation measures); and 2) the contribution of the policies to the overall transition process. This two-pronged means of evaluation suggests that under transition-management policies have both a *content goal* and a *process goal*. Learning and institutional change are important policy aims and policy goals are used as means for change. The evaluation and adaptation of policies, strategies, and institutional arrangements in "development rounds" brings flexibility to the process without losing a long-term focus (Rotmans et al. 2001).

Transition management is not an instrumental activity. It accepts that actual policies are the outcome of political negotiations and processes involving the coevolution of governance and sociotechnical change that in turn inform further steps.[6] Transition management can create a new context for such processes, one in which sustainable solutions and structures can emerge due to participatory processes that develop, monitor, and evaluate new visions, institutions and coalitions, and experiments (Loorbach, 2007).

Transition Management in the Netherlands

Transition management is currently being used in the Netherlands as a model for sustainable development. Various ministries are adopting this approach following an initial period of learning and exploration. The Ministry of Economic Affairs (responsible for industry, innovation, and energy), for instance, has accepted transition management. Officials in the Ministry have been very active since 2001 in developing transition policies for a national sustainable energy supply system by 2050 and have opted for a co-management approach (Meadowcroft, 1999b).[7] In 2001, the Ministry started consulting various stakeholders (e.g., companies, researchers, nongovernmental organizations) to assess whether they saw possibilities for a transition and, if so, what these chances might be. Based on these conversations and an intensive scenario study (*Lange Termijn Verkenning Energie* (Long-Term Vision Energy) released in 2001), "robust elements" were selected for dealing with uncertainty. One element identified was the gas grid which could be used to distribute hydrogen and biomass-based gas. This process led to the identification of biomass and new gas (involving specific solutions such as micro-cogeneration and hydrogen) as interesting options.

In 2002, the Ministry started Project Implementation Transition (PIT) to investigate whether an array of sub-projects would generate sufficient support, enthusiasm, and commitment from the relevant stakeholders to create a climate in which they would be willing and able to work together. The project was initially financed with 35 million Euros (US$47 million) and supported by an eight-person staff. The main conclusions from this phase were that the transition approach appealed to a majority of stakeholders and they would be willing to invest time and money if the process were more concrete, more explicit visions for the future could be developed, and the government would support the transition both financially and procedurally.

Based on these findings, a green light was given for implementation of Phase 2 in 2003. The objectives of this stage were to develop a long-term vision on energy in general; to get all relevant actors in each of the subprojects to commit to the process; to map possible paths, barriers, and necessary preconditions for the transition; to set up plans for knowledge development, sharing, and communication; to chart international developments; and to develop transition experiments. In the case of biomass, the following vision emerged (Figure 2).

This particular figure, developed by actors of the biomass platform, is illustrative of the transition-management approach. There is a vision in which biomass plays an important role in the primary energy supply systems, with medium- and long-term goals and certain transition paths. The goals are indicative ambitions for the actors concerned. The paths evolve with time, benefiting from all kinds of learning processes, both technical and social. Similar

[6] The term "coevolution" refers to evolutionary processes that are part of more than one selection environment (van den Bergh & Stagl, 2003).

[7] For further details, refer to http://www.energietransitie.nl.

visions are being developed for other energy supply options with different visions coexisting alongside each other.

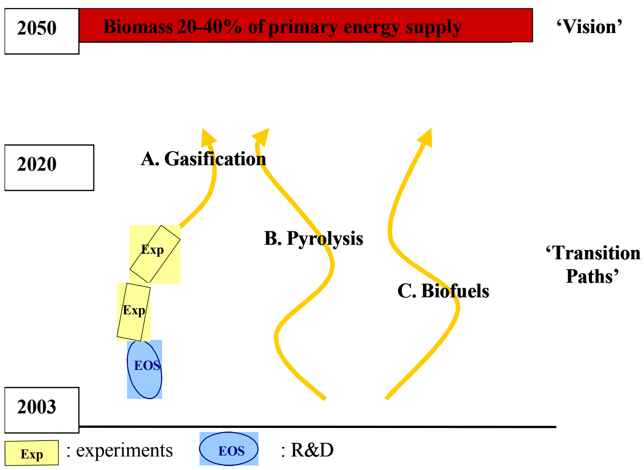

Figure 2 The Dutch vision for biomass

At the heart of the Dutch transition approach are so-called transition platforms consisting of people from business, academia, government, and civil society. In the energy transition, six platforms have been created: green resources, new gas, chain efficiency, sustainable mobility, sustainable electricity, and built environment. The platforms have played a pivotal role in the selection of main routes, the identification of possible transition paths, the identification of transition experiments, and the development of a broader transition community. The platforms' proposals for transition paths were brought together in a transition-action plan presented to the Dutch government and public in May, 2006.[8] The plan contained 26 paths (which later developed into 28 paths) for further exploration (not implementation). The transition-action plan furthermore argued for the doubling of energy-innovation expenditures [from 1 to 2 billion Euros a year (US$1.4 to 2.7 billion), to be allocated from general revenue] and made a plea for "consistency and continuity of policy based on a long-term vision about sustainable energy."

The policies in the transition-action plan made little use of sustainability science. The paths were identified by a selected group comprised mainly of business people and energy experts. The public was not involved in the process. Up until now, demand-side issues, wider considerations of societal embedding, and system-wide effects have been neglected. The transition experiments are very technological by nature; they are hardly aimed at fostering institutional or cultural changes. Efforts thus far have consisted of rather low-risk projects primarily related to CO_2 reduction (and not, for instance, to security). Participants in the process have neglected strategic issues related to integrated system analysis. An old scenario study for the energy system was used. Participatory scenario development [as advocated for transition management by Sondeijker et al. (2006)] was not part of the process. Sustainability assessment did not play an important role in the formulation of the various paths. Only biofuels were selected for inclusion in a large study that was commissioned to determine criteria for "sustainable biofuels."

Further analysis is required to determine why sustainability science was not used more extensively, though the relatively closed composition of the platforms seems to have been important in this regard. The platforms explored the future and engaged in problem structuring, but that was all. They neither developed long-term scenarios nor engaged in participatory integrated assessment of the paths that were selected. Perhaps the government has a specific role in sponsoring these activities.

This experience suggests that the deployment of sustainability science requires strong political commitment. Otherwise, neither the traditional scientific community nor businesses will use sustainability science processes. This observation cautions against great optimism. With increasing attention to issues of societal embedding and culture in the energy transition this situation may change, but it probably will remain problematic.

Conclusion

This article has discussed sustainable development and the twin notion of sustainability. From an anthropocentric point of view, sustainable development is about human betterment or progress. It reflects social consensus about what is unsustainable and what constitutes improvement, and therefore cannot be translated into a blueprint or a defined end state outlining specific criteria and calling for unambiguous decisions (Voss & Kemp, 2006).

Sustainable development is often seen as being about protection of amenities (including cultural diversity), but, as this article argues, it is equally about continued advancement and creation: a better and more just world. Both the protection of amenities and the creation of new and better services for more people require innovation in governance institutions and in sociotechnical systems (regime changes). Attempts to achieve these objectives should be carried out in a prudent, reflexive manner to avoid new problems and to make sure that actions taken lead to progress.

[8] The transition-action plan was developed by the taskforce on energy transition. The chairpersons of the platforms were members of the taskforce.

Sustainability science, based on integrated assessment, may help to identify directions in which change is needed. But the sustainability of new trajectories is not guaranteed. We need more reflexive modes of governance to ensure that the trajectories are indeed sustainable. Here the approach of transition management may prove useful. Transition management aspires to be inclusive and calls for setting medium- and long-term goals, for aligning short- and long-term policies, and for conducting strategic experimentation to supplement the use of traditional policies (e.g., regulation, taxes). It aims to achieve systemic change through small steps in strategically chosen directions. The "management" that is involved works through self-organization and uses visions and feedback cycles to convey the lessons of new experiences and endogenous institutionalization. It tries to avoid the modernist trap of rational decision making without, at the same time, being antidevelopment. Transition management helps to work towards a sustainability transition even when no one knows what a sustainable society would actually look like and the very idea of achieving sustainability may be illusory (O'Riordan, 1996). It is not a way to manage cultural change, but rather an approach for fostering innovation, especially system innovation. In the Netherlands the method is used, but only in a partial way. Greater involvement of society in the transition- management process is needed and more attention should be given to issues of societal embedding.

Sustainability science can guide decision making, providing provisional knowledge about social problems, the desirability of new systems of provision, and the long-term effects of interventions—issues for which customary science has no definitive answer. We do not think that sustainable development can be operationalized using mode-1 science. To try to do so would go against the grain of sustainable development as a deeply normative process that requires attention to long-term effects across various scales (e.g., geographic, functional systems, time). Sustainability may be understood as a specific kind of problem framing that emphasizes the interconnectedness of different issues and scales, as well as the long-term and indirect effects of actions that need to be accounted for as part of decision making (Voss & Kemp, 2006).

The overall conclusion with regard to this article's central problem is that sustainable development cannot be managed like a company, but it is nonetheless possible to work toward successful management via reflexive forms of governance that use sustainability science. We realize that this conclusion needs solid evidence beyond what this article is able to provide.

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Sustainability: Science, Practice, & Policy
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ARTICLE

Teenage consumption of cleanliness: how to make it sustainable?

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One third of all water and energy in Denmark, and in many other developed countries, is consumed directly in households. A significant part of this usage is related to cleanliness practices that are steadily changing toward more frequent showers and clothes washing. These trends will inevitably lead to still greater water and energy consumption. This article analyzes a set of in-depth interviews with teenagers and their parents to shed light on the cultural and social processes that shape cleanliness practices in the transition from child to adult. The conceptual perspective of this work is primarily predicated upon consumer theory that encompass modern and late modern consumption, conspicuous and ordinary consumption, and risk handling and hedonism in everyday life. Analysis shows that cleanliness practices are handed down from parents to children and also are subject to strong peer-group influence. Furthermore, the practices may involve considerations about risk handling in everyday life related to health issues. However, broader notions of sustainability are seldom reflected. The conclusion relates these insights to several policy questions.

KEYWORDS*:* energy consumption, water use, cleaning behavior, hygiene, adolescents, social values, public policy, risk factors

Introduction

High and continuously rising energy consumption jeopardizes the global climate; furthermore, drinking water is scarce in a growing number of localities. The household components of water and energy consumption are of a recognizable size. For instance, in Denmark households directly constitute one third of total energy and water consumption and practices of cleanliness are an important part of this resource- utilization pattern (Bechmann, 1996; Danish Energy Authority, 2003). Laundering accounts for an average of 10% of the electricity consumption in Danish households (Gram-Hanssen et al. 2004) and showering represents an estimated 20% of total household heat consumption and 30% of total water consumption (Gram-Hanssen, 2003). There are thus sound quantitative arguments to focus on practices of cleanliness from an environmental perspective. Throughout the years, public authorities and utility companies have regularly embarked upon campaigns to inform people about how to conserve water and energy, for instance, by filling the washing machine before starting it and by taking shorter showers. However, research convincingly indicates that despite these programs, the frequency of showering and laundering has risen during the last couple of decades (Shove, 2003). The aim of this article is to develop an understanding of the cultural and social dynamics behind these cleanliness practices.

As I am not the first person to be interested in the cultural aspects of cleanliness practices, the following discussion provides a brief review of relevant research—a body of work that can be divided into two separate, but overlapping, parts. First, there is the cultural approach put forward by anthropologists and ethnologists with Kaufman's (1998) work on couples and their laundry serving as a prominent example. Kaufman uses household handling of laundry as a way to explain relations and dynamics between men and women when forming a couple and he points to the strong role that women occupy as guardians of the laundry. A Norwegian study by Klepp (2006) takes a cultural-historical approach in understanding laundering and explaining why today's women launder. Neves' (2004) research in Brazil explores the cultural norms of how to launder and states that the pride connected with this task is not easily changed by the introduction of new washing products or artifacts.

The second approach includes a stronger emphasis on how technologies and culture codevelop in forming new practices. With a focus on how new technologies and infrastructures entered homes during the last century, Cowan (1983) describes the irony that while these appliances were once thought of as lightening women's work, in the end they created "more work for mother" (Cowan, 1983). Whereas Cowan takes a feminist approach to the rising standard of household expectations, Elizabeth Shove (2003) uses an environmental lens to examine the same issue. Shove describes how, together with the introduction of new appliances in households, the norms of what is clean, convenient, or comfortable change, and the continuously rising level of these standards are the real challenges for sustainable development. Other researchers have also stressed that the structural aspects of practices related to cleanliness are more relevant than focusing on individual behavior, as is done in many policy areas (e.g., campaigns to save water). With the focus on showering, scholars have shown how new technologies, new images of the body, and new understandings of the rush of everyday life all support contemporary showering practices (Southerton et al. 2004).

This article follows the outline of these cultural and sociotechnical understandings of cleanliness with a specific focus on teenagers. There are at least two different reasons for concentrating especially on teenagers and their cleanliness practices. The first motivation stems from quantitative analysis suggesting that teenagers account for a significantly larger share of household electricity and water consumption than do adults (Petersen & Gram-Hanssen, 2005).[1] The somewhat separable qualitative rationale is that by directing attention toward teenagers we are able to study how practices evolve over time and thus develop insight regarding the factors responsible for these changes. The teenagers who were interviewed for this study were at the transition between childhood and adulthood and their descriptions of how and why they change cleanliness practices can be useful in helping to reveal how norms of cleanliness are culturally and socially sustained and transferred.

The subsequent discussion first introduces the theories used in the analysis of the interviews, followed by a presentation of the study's empirical methodology. The analysis and results section interprets the interviews under different headlines, each with its own question, such as: To what extent and how are the norms of cleanliness passed on from parents to children? To what extent and how does the peer group of teenagers take part in transferring the norms? And what types of reflective approaches to laundering and showering can be found in established practices? Finally, the conclusion takes stock of the various insights generated in the foregoing analysis and briefly relates these findings to policy efforts to make teenage consumption of cleanliness more sustainable.

Theoretical Framework

As described above, previous studies of cleanliness have primarily been based on cultural or sociotechnical perspectives. This article focuses on consumer theory, which can include both cultural and sociotechnical approaches and provide insight regarding how the norms of consumer practices are being transferred to the next generation. A short introduction of the relevant theories follows.

One of the main questions within consumer theory has been whether modern or late modern understandings give the most adequate descriptions of consumer practices (see, e.g., Featherstone, 1991; Gronow & Warde, 2001). This discussion relates to whether habits and consumer choices should be interpreted as social class markers handed down from parents to children in modern society as described by Bourdieu (1984) or as the way individuals construct their biographies as group identities fade away in late modernity (Giddens, 1991; Beck, 1992). Among teenagers the question of modern versus late modern understandings may be even more relevant as we face a group of consumers at a life stage when they are torn between the norms of their parents and the construction of their own identities in close relation to peer groups.

However, following the discussion of modern and late modern theories, scholars have argued that these approaches are too strongly oriented toward conspicuous and extraordinary forms of consumption (and their social symbols) while the vast majority of consumption is actually mundane and based on routine (Gronow & Warde, 2001). Especially with respect to the subject of cleanliness, it could be argued that daily habits of showering and changing clothes are far removed from the realm of visibility and status that consumption theory tends to consider and work on routines is likely to be more appropriate. Most of the research on cleanliness that has been conducted from a sociotechnical standpoint has been within the purview of this approach (e.g., Shove, 2003).

Following the late modern theories of especially the German sociologist Ulrich Beck, other questions that might be relevant for cleanliness habits are reflexivity and risk handling in everyday life. Bente Halkier (2001a; 2001b) has worked on how contemporary consumers manage risks related to food within the context of their shopping practices and has described the ambivalence that characterizes these activities. This ambiguity is manifest in how to handle, on one hand, consumer information relating to

[1] These estimates of household energy and water consumption are based on statistical analysis of register data from 50,000 households. Household usage is strongly correlated with the type of housing and the number of household members; however, the age of the residents is not unimportant. In a model designed to include basic consumption for each type of housing and additional consumption per household member, the presence of a teenager is estimated to entail 10% higher levels of energy and water consumption than an adult.

healthy and unhealthy food as well as on the incorporation of environmental considerations into shopping praxis (i.e., buy seasonal, organic and local food) and, on the other hand, the families' desires for tasty food. A similar strategy might be relevant with respect to studies of cleanliness. In the 20th century health has been viewed as dependent upon a high level of personal hygiene, while in late modernity the connection between cleanliness and health may be less distinct due to concerns about both real and potential allergic reactions to cleaning products and the relationship between resource consumption and concern for the environment.

The last theoretical perspective that merits discussion here is the less frequently invoked work of Colin Campbell (1987) on hedonism and consumption. Campbell sought to develop a deeper understanding of the importance of dreams and images in the consumption process and he distinguishes between traditional hedonism (which is directed toward the satisfaction of needs) and modern hedonism (which is about pleasure). While traditional hedonism depends on physical consumption, modern hedonism can be related to dreams and fantasies as well as to products. When modern hedonism often leads to more physical consumption in spite of this predisposition, it is because pleasure, as opposed to needs, is in principle insatiable. One can dream of having or doing new things; however, actually having them does not necessarily give any satisfaction and new consumption dreams will inevitably arise and thus leading to an infinite spiral.

Methods

This study comprised qualitative interviews with nine teenagers (six boys and three girls) between 13 and 15 years of age together with their parents. Respondents were drawn from households with different socio-economic characteristics and varying levels of energy and water consumption. The selection process for the interviews included a survey instrument that was distributed to pupils of relevant age in two schools situated in two neighborhoods that varied in housing type and socio-economic background. A competition was organized and a reward was offered to the class that returned the largest number of questionnaires, motivating the pupils to ask their parents about household energy and water consumption and to return the requested information. The surveys also collected data on the income and education levels of household members. Respondents were additionally asked to indicate if they would agree to be interviewed. The questionnaire's main objective was to select interviewees with wide variation in the selected parameters. The interviews lasted one to two hours, were conducted using a semi-structured format, recorded, and transcribed for subsequent analysis. Specific questions centered on the use and size of the house, showering habits, patterns of clothes washing, and attitudes toward consumption and environment.[2]

The strength of qualitative interviews is that it is possible to derive in-depth information about social practices and the meanings that respondents attach to them. Respondents are furthermore able to compose responses in their own language and to express what they think and feel about the subject in question. The interviews can be variously interpreted in terms of the level at which the interviewees talk, the way they communicate, and the manner in which they convey interpretations of abstract concepts (Coffey & Atkinson, 1996; Kvale, 1996). The weakness of qualitative interviews as a research methodology stems from the fact that a limited number of persons can reasonably be interviewed if the intent is to generate in-depth analysis. This downside also means that the teenagers interviewed for this study are by no means representative of all teenagers in Denmark. The variation in the selection procedure is only to ensure the assembly of as many different views as possible. Nonetheless, a relatively small number of well-executed interviews can be more valuable than a large quantitative database or an extensive number of more superficially conducted interviews because of the richness of the details and descriptions.

Analysis and Results

In the following paragraphs, the general norms and practices of cleanliness are presented and the variations described as they appeared in the interviews. The responses of the participants are subsequently interpreted from more theoretical angles in order to focus on the ways in which norms are passed from parents to children, the role of peer groups in influencing behavior, the importance of reflections on risk and environment, and the significance of pleasure in understanding how cleanliness practices become established.

Norms and Variations on the Habits of Cleanliness

The interviews disclosed norms that, on one hand, tended to be very general in the sense that they were not topics for overt discussion and all of the respondents seemed to subscribe to the same set of practices. On the other hand, there was considerable variation in respondents' habits of showering and

[2] The same interviews also had a section on the use of information and communication technologies. This part of the study is reported in Gram-Hanssen (2005).

clothes laundering. The broader norms are strongly connected with questions of sweat and odor. Regardless of how often the teenagers and their parents showered, the strongest rationale for their customary routines derived from a desire to avoid smelling of sweat. Furthermore, the norm for changing clothes—one that suggests that it is necessary on a daily basis to put on a new pair of underwear, fresh socks, and a clean tee shirt—is based on concerns about the odor of perspiration. Another general feature that came out of the interviews is that none of the teenagers is familiar with the practice of washing oneself at a sink with a flannel washcloth. While the parents know about this cleanliness procedure (but do not use it anymore), this habit seems to belong to the grandparents' generation.

Identifying general norms for cleanliness in the interviewed families was relatively straightforward, while finding differences was similarly unproblematic. Some families, and especially the mothers, were very focused on cleanliness and showered at least once a day and changed their clothes completely every day. All clothes and towels were washed after each use and bed linen was typically laundered once a week. These households washed five full loads of clothes per person each week. This amount of activity meant that the washing machine ran more than twice every day, and typically the mother spent quite a lot of time on the laundry. However, as one of these mothers remarked, "we *have to* wash all the laundry." The habit of washing all articles of clothing after a single use was not up for discussion, even though some might view the allocation of such a considerable amount of effort as a problem.

Another family represented the opposite end of the cleanliness scale, or at least the mother's view of cleanliness could be interpreted in such terms. In this family, the mother only showered two or three times a week because she believed greater frequency was unhealthy for her skin. Her teenage son showered every other day, though the husband, as the mother expressed it, was "extremely cleanly," showering every morning. A year ago the son also started to shower daily, but his mother advised him that if he had to shower that often, he would have to take shorter showers as long daily showers were a waste of water. In this family, trousers, shirts, and other clothing were worn several times before being washed, and towels and bed linen were used for up to three weeks before being washed.

From the interviews it was learned that in general parents controlled the shower and bathing habits of their children up to school age, and in these early childhood years one bath/shower a day was often the norm. This period was followed by a stage when the child was expected to take care of his/her own cleanliness and under such circumstances it was not unusual for a child to shower once or twice a week. Parents would, however, comment on this situation and instruct the child to shower more often. After this period followed a subsequent phase when most teenagers were themselves very concerned about showering frequently and these practices were typically carried out independently of parental opinion.

The interviews also revealed that sports activities entailed a higher order of personal cleanliness. Many of the teenagers that were active in sports showered twice a day several days a week and a number of them left all of their sports clothes to be washed after each use (including the towel). Furthermore, laziness seems to have the paradoxical effect of generating laundry. Several parents described that their teenagers sometimes deposited clothing in the laundry simply because it was easier than folding the item and returning it to storage in a dresser drawer or closet. If clothes had left the wardrobe, the only way back was through the washing machine, even when the clothes had not been worn or had come out along with another article or because the teenager was considering whether to wear them.

This introduction to the cleanliness habits of teenagers and their families has been principally descriptive and nothing has yet been said about the reasons for why they act as they do. The following discussion takes a more theoretical approach and outlines how and why the teenagers' cleanliness practices have developed into their current form.

Habitus as a Way of Understanding How Habits Are Passed Down

How and to what extent are habits of cleanliness passed down from parents to children? This question can be approached both in terms of the relationship that exists between the interviewed parents and their teenage children and in the way the parents related to their own childhood and cleanliness practices. A particularly useful way to understand how parents influence their children is through Bourdieu's (1984) notion of habitus.

Habitus provides a way of ascertaining how children throughout their childhood are influenced by their parents' way of acting and thinking. This process of generational transmission occurs not necessarily because children are told how to act or think, but often transpires much more indirectly as they learn what is appropriate to do in all the various fields in which humans act. The concept of habitus thus includes how human beings assimilate the structures of the field they are in; in this way habitus becomes a practical sense, an acquired system of preferences of how the world should be perceived and divided. Because habitus is built into the body, so to speak, during childhood, the relation between agents and the social world comes to be based on preconscious and preverbal agreement. One does not necessarily know why he or she behaves and thinks in a particular way; it is just done because it seems normal and natural. However, people raised in other social environments may have learned other ways of behaving. According to Bourdieu, the constitution of habitus is closely related to the social space of childhood and hence to the cultural and economic capital of one's parents. Habitus thus becomes a way of expressing and sustaining social status in society.

The question then becomes to what extent the interviewed families and their cleanliness practices can be analyzed within this sort of framework. This research project included families in which the mothers were very concerned about cleanliness. When their children described their habits of cleanliness, they seemed to reflect very little on what they did and how they did it. At the same time, these children had strong verbal reactions to habits that were less focused on cleanliness than their own. In combination, these findings suggest that, on one hand, the teenagers reflected very little on their habits. On the other hand, they seemed to focus a great deal of attention on whether what they did was appropriate. However, in the family where the mother devoted less attention to cleanliness than most of the others, the teenage boy had reflected on his habits and other ways of acting. The reason for this situation may reside in the apparent fact that this young man encountered a conflict between his mother's norms and those of his friends. One way of solving this tension was for him to change clothes so that he never wore the same clothes two days in a row. However, he did not put the clothes in the laundry, but rather folded them and wore them again some days later. When the teenagers in some of the other respondent households were asked why they maintained specific practices, their answer was that they had decided this for themselves. However, the parents stated that if the cleanliness practices of their teenage children were not consistent with their own norms, they would interfere.

The parents themselves seemed to evince greater awareness that some of their cleanliness practices dated back to childhood and that they just could not overturn these modes of behavior. A single father, living with his son, was the strongest example of this predisposition. Several times during the interview he explained that he grew up in a rural area in a poor part of Denmark and that his family was among the community's poorest. The family had few possessions, so he learned to save. This habitus still followed him and one of the ways in which it showed was related to cleanliness in his bathroom. He described how there was no holder for the showerhead that was mounted on the wall. He further explained that this was a very effective way to impress upon both his son and a residential boarder to take short showers.

Bourdieu's (1984) notion of habitus is strongly connected with social class in society. Our habitus depends on the cultural and economic capital of our parents and thus becomes a way of expressing and sustaining social status. The higher social classes behave in a different way than the lower classes. If one has not learned this behavior during childhood, it is difficult as an adult to move up in social rank even when one possesses a high level of education or earns a great deal of money. The question then becomes whether this understanding of habitus as part of a class society is relevant for cleanliness. Historically, there is no doubt that this has been the case. Jonas Frykman has studied the hygiene practices of both Swedish bourgeoisie and peasants at the beginning of the last century, and even though he does not use the notion of habitus, it is clear that there were stark differences in the cleanliness habits of people belonging to the two social classes (Frykman & Löfgren, 1979). During the interviews that were part of the current study, however, there were few indications that differences in the levels of cleanliness were related to social class. The single father discussed above had a very poor childhood and this experience was a part of his habitus. He was now employed as a factory worker and could be regarded as occupying a position in the "middle range" with regard to cleanliness. Though, as described, he was very keen on saving water, this sensibility did not affect the frequency of his laundering and showering. Furthermore, none of the respondents in this study used expressions to indicate that cleanliness might be a way of distancing him/herself from lower social classes. Cleanliness may be a way of showing that one is within the range of normality, but no longer is a way of demonstrating social superiority. And, this should not be surprising, as nearly all people in Denmark today have bathrooms and most households have washing machines. Consequently cleanliness no longer provides a way for the higher social classes to distinguish themselves as was the case when bathrooms were rare and clothes were washed manually.

Lifestyle and Peer Groups as Explanations

It is reasonably clear that teenagers are influenced by their parents in their cleaning habits. However, adolescent cleanliness practices are perhaps even more powerfully shaped by the routines of their friends and schoolmates as well as the opinions conveyed by wider social networks. The logic of Bourdieu's notion of habitus might thus be transferred from the relation of the status group of the parents to the teenagers' own peer groups, and here the distinction might relate more to the interpretation of maturity versus immaturity rather than to social class (Martens et al. 2004). A number of late and postmodern thinkers, such as Giddens (1991), Beck (1992), and Bauman (1997) also pose questions regarding the role of social class in consumption. In different ways, these authors describe the disappearance of social class and, as a result, the identities that were established through membership in a particular social group. Such observations suggest that the late modern individual is forced to create his or her own identity and consumption becomes a lifestyle choice. It is a matter of who we are, who we wish to be, and how we want to be interpreted by others. Under these circumstances, anxiety becomes part of consumption decisions as one comes to fear the social consequences of making the wrong choices (Warde, 1994). Several authors comment on the fact that teenagers are at a life stage when the process of self-construction and self-expression is especially important and they describe how the youngsters need permanent confirmation of their identities by their peers (see, e.g., Campbell, 1995; Van Gorp & Mortelmans, 2003). The issue then becomes how cleanliness forms part of the social interaction between teenagers in their peer group as well as whether cleanliness is a matter of lifestyle and distinction or primarily of following a norm and staying within normality.

Most of the teenage respondents related stories of how there was strong pressure toward cleanliness among their classmates and friends. One of the girls described how she was once told in school that she smelled badly and "then I decided to go home." Since then she had been very careful not to smell and she took a shower at least every morning. She reported that it is "better [to be] late for school in the morning by five minutes than not having had my shower." Another young woman in the study related that a girlfriend of hers only showered once a week and how one of the other girls told the girlfriend that she was "stupid" because of this infrequency. Ever since this incident, the two girls have not been friends.

The male respondents did not relate any similar personal accounts where cleanliness was an explicit issue. However, most of them said that they would notice if any of their classmates did not change his or her clothes or shower often enough. One of the boys reported, "I think it gives a bad impression . . . is a bit yucky, if someone doesn't bother about himself to take a shower and get clean." The same interviewee thought that he had an obligation to inform his friends if they smelled bad, both to help them and to rid oneself of the smell. Another of the boys had the same opinion, but both of them explained that all of their peers were so careful not to smell that it was not a problem.

In these interviews, the female respondents tended to be more aware of and sensitive to peer-group opinion on cleanliness, or at least seemed more outspoken toward one another on cleanliness matters. One young woman also said that boys "need to be dirtier than girls." However, the interviews also showed that the boys did indeed care a great deal about cleanliness.

There appears to be quite strong pressure with respect to cleanliness among these teenagers, but the question for current purposes is whether one is able to express something through cleanliness or if the current standard is just a common norm one has to maintain. One of the girls related how she started to shower daily after having heard her friends talking about their morning showers. She observed that her parents and older sister showered every day and now also all of her friends did as well. As she explained, "then I realized that the time had come." One of the boys also connected the question of daily showering with becoming an adult. He explained that he thought all his friends showered every day, and he just said, "When you grow older, you do it every day!" From such statements it seems plausible that among young teenagers, cleanliness was also a way of showing maturity to friends.

Another question concerning lifestyle is whether one can demonstrate belonging to a special group of teenagers with a specific level of cleanliness or if cleanliness is part of the signal from some subgroups. Historically, this might have been the case among, say, the hippies of the 1960s and the 1970s or among punks and squatters of the 1980s. The empirical material from this study was, however, too limited to investigate similar contemporary subgroups. The only indication along these lines was that one of the female respondents explained that all "normal" youngsters change clothes often. However, she also said, "There are some who do not, but that is because they are mixed up in something. If they smoke hashish, for instance, they may not change their clothes, if they have been up all night." Whether this was a case of a conscious consumption choice or, as this respondent indicated, was just a matter of not having the energy to behave in a socially accepted way, was difficult to judge on the basis of the data on hand.

Hedonism or Risk Handling In Habits of Cleanliness

Late modern and postmodern theories have highlighted aspects of consumption other than identity and group belonging, and social practices such as daydreaming and the pleasures of consumption have been foci for consideration (Campbell 1987;

Featherstone 1991). The interviews for this study, however, suggest that household-water use is not driven by any expressions of hedonism. One of the girls who normally showered every day explained that if she knew that she was not going to see anyone over the weekend and would be at home relaxing on the sofa and watching television, she would not bother to shower. For her the pleasure seemed more connected with not showering. Some of the teenagers had access to bathtubs at home or at their grandparents' houses and reported that they sometimes took baths. This practice, however, seemed to be related to returning from periods at camp where they had become very dirty. But neither pleasure nor hedonism seemed to be a strong reason for cleanliness in relation to bathing. One of the girls thought that it was a bit boring just to be lying there and she actually dreamed of having a television in the bathroom. Other research, as well as advertisements for bathroom equipment, however, indicates that hedonism definitely is a part of showering and bathing habits (Jensen, 2001; Gram-Hanssen, 2003). It would appear that the hedonistic aspect of showering is something that these very young teenagers have yet to learn.

A last aspect of late modern theories of interest for current purposes relates to questions of reflectivity, environmental concern, and risk handling inherent in ordinary consumption. Are matters regarding individual health, like dry skin and allergic reactions to cleaning products, as well as concerns about energy and water consumption, important with respect to cleanliness practices? Among the teenage respondents in this study, environmental concern seemed to be very rare, at least in relation to energy and water consumption. Some had learned about this subject in school, but as one of the girls said, "you just forget all about it when you leave school." Among the parents, there were indications that some of them thought about the environment in relation to energy and water consumption. However, in none of the families was this concern so apparent that it influenced the level of cleanliness. One of the families expressed considerable concern about the environment, and this sensibility actually influenced a great deal of its consumer behavior. Family members bought mostly organic food and they had chosen not to have a car and to use bicycles instead. However, this household's consumption of both water and electricity was very high and it was obvious from listening to them describe their daily practices that environmental concern did not influence their usage practices. The reason for this paradox—to the extent that it could be deciphered from the interview—was that buying organic food and living without a car were both visible and conscious acts and therefore easier to regulate through conviction than daily habits that one just did without any conscious forethought. Furthermore, the mother also explained that as a family they actually regarded themselves as doing quite a lot for the environment and she was afraid that initiating discussions about changing daily household habits might cause considerable conflict with their teenage children.

In general, the interviews reflected that environmental concern or unease about the cost of energy and water could provide reason for parents to ask their teenagers to take shorter showers, but not to shower with less frequency. Respondents were apt to mention economy and the environment in the same sentence without actually reflecting on the relationship between the two. Such a conceptual connection indicates that they, on one hand, did not like "wasting" energy and water both for environmental and economic reasons; on the other hand, it was obvious that neither economy nor the environment had any real influence on cleanliness habits. Even for relatively poor people in Denmark, the cost of energy and water is not a crucial financial variable. In the current study, one of the families was comprised of a single, unemployed mother with two children who explained about her economic considerations related to buying computers and mobile telephones for her sons. However, she did not relate these same circumstances to the question of cleanliness and she was among the respondents who did the most laundering and showering.

Personal health was a slightly different matter than environmental concern. One of the mothers explained that her skin was unable to stand being washed every day so she only showered two or three times a week. Also, the showering habits of one of the girls were defined by her perception of risk. She had read on the Internet that it was unhealthy to shower every day, especially to shampoo her hair, so she only showered every second day. Furthermore, several of the parents, when asked directly about health problems attributable to too much cleanliness, said that they themselves normally did not use soap on most of the body and that they had taught their children the same practice. Clearly, when comparing risk handling in relation to environment and in relation to personal health, personal health had the strongest influence on cleanliness habits.

Conclusion

The point of departure for this article was that cleaning habits in everyday life are a relevant, but often ignored, part of an unsustainable practice. In the public discourse the issue of whether cleaning processes could be made more efficient is raised, but the level of cleanliness, as well as the move toward more cleanliness with frequent showering and still more clothes washing, is not normally questioned. One reason for focusing on teenagers was that they are at a transitional life stage that makes it easier to examine the mechanisms of habit construction. Analysis of in-depth interviews has shown how cultural understandings and practices are transferred from parents to children and has furthermore demonstrated strong social norms among young people relating to cleanliness practices. The preceding analysis has relied heavily on discussions of modern or late modern consumption, even though practices of cleanliness obviously must be considered within the context of routine or ordinary consumption. However, since this article has focused on a period when habits are in flux, it is important to draw on theories that can explain such changes. Bourdieu's notion of habitus would seem quite useful in this regard even though the class-based aspect of his work does not apply to the activities considered here.

In general, these types of insights can help us to understand how difficult it is to change cleanliness practices; however, the interviews also point toward openings with respect to altering extant practices. Perceptions of health risks related to excessive showering or the time use associated with growing household laundry may be the most effective arguments for changing individual practices. Furthermore, it is worth noting that contemporary teenagers are taught personal hygiene and cleanliness as part of the school curriculum, but here the link between too much cleanliness and unhealthy and unsustainable practices is not addressed.

Acknowledgement

The Danish Research Council for Social Sciences financed this study. I would like to thank the teenagers and their parents who agreed to discuss their daily habits as well as the institution of San Cataldo, which runs a former monastery in Italy, for providing the tranquility necessary to work on a previous version of this article. An earlier draft was presented at the workshop "Kitchens and Bathrooms: Changing Technologies, Practices, and Social Organisation: Implications for Sustainability," 27–28 January 2005 at the University of Manchester. This paper is also disseminated in electronic form by the Danish Building Research Institute.

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Sustainability: Science, Practice, & Policy
http://ejournal.nbii.org

ARTICLE

Payments, penalties, payouts, and environmental ethics: a system dynamics examination

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A generic system dynamics model was developed as an explicit thinking tool to investigate systems of payments for environmental services (PES) and possible feedback effects regarding environmental ethics. Healthy ecosystems may justify charges for environmental services, but damaged ecosystems will require payouts funded by other mechanisms, perhaps by penalties on ecodamage. Any payouts made may influence environmental ethics, but the direction of such influence is dependent on the level of payout, the influence that payouts have on the switchover to ecofriendly uses, and the changing attitudes of payout recipients. Payouts can cause a switchover to ecofriendly activities. If that switchover also reinforces a favorable environmental ethic it can lower the overall payout level needed to maintain ecofriendly resource-use activities.

KEYWORDS*:* environmental ethics, management tools, models, cost-benefit analysis, ecosystem management, resource utilization

Introduction

The concept of payments for environmental services (PES) has become popular among those interested in environmental conservation and those concerned with international development. The concept is that people could pay for ecosystem services normally viewed as free. Payments could fund payouts to encourage ecofriendly use of the environment. Some examples of these environmental services are the provision of clean water from well-managed watersheds, the availability of natural scenic areas, the protection of “biodiversity” for future generations, as well as the expectation of future climate stability (Scherr et al. 2004; WWF, 2006).

Human abuse of our natural environment has made the long-term realization of these benefits less likely. The PES concept recognizes that people who abuse the environment, and thus decrease benefits others receive, are sometimes merely trying to make a living. They may have difficulty changing their resource-use patterns without help. If environmentally degrading activities are to be lessened, this argument goes, and some compensation should be offered to assist resource users in making their activities sustainable. The underlying logic of these schemes assumes financial costs should be paid by those who receive environmental benefits. Such recipients might be individuals, communities, or society as a whole.

Do such schemes work? The cash-in value of tropical forests, for example, may be too high to be offset by any reasonable level of payments for benefits (Rice et al. 1997). On the other hand, Janzen (1999) makes a good case for the many biodiversity values that tropical forests hold and provides specific examples as to how these values might be incorporated into contracts that benefit both forest owners/users and outside beneficiaries of environmental services provided by those forests.

Landell-Mills & Porras (2002) provide a number of examples of these payment schemes. Conservation groups see such arrangements as a means of providing funding for protection of critical biodiversity areas. International development specialists view these programs as supplementing income for poor farmers and forest dwellers (Pagiola et al. 2005). Payment schemes may also encourage better management of carbon dioxide in our atmosphere–a major cause of global warming. Wunder (2005; 2006; 2007) has provided a comprehensive review of the concept.

The notion of payment for ecosystem services assumes that an ecosystem, if well managed and cared for, will provide certain services–for example, watershed protection. As various land uses degrade the ecosystem, services also become degraded. If people pay for the service provided–for instance high-quality water–this money can be transferred to individuals who own or use the ecosystem, providing an incentive for resource use that protects and restores the ecosystem.

An alternate view is that ecosystems, and the services they provide, belong to humankind, and resource users are morally obligated to use resources in a sustainable way. While appealing, this view may only be realistic in wealthy societies. The sad fact is that most resource users in the world have little incentive or means to alter their behavior without encouragement, including financial assistance.

On the other hand, many societies have strong traditional ties to their environments and a well-designed system might help awaken a favorable environmental ethic. Any reasonable policy should provide incentives to support environmentally sustainable activities, but at the same time avoid perverse incentives that could undermine existing environmentally friendly attitudes and activities (for example, see Pagiola et al. 2004). Under what circumstances might payouts for environmental services degrade the concept of land (or resource) stewardship, or enhance it?

Where economic pressures create incentives for intensive, unsustainable resource use, payouts for environmental services can provide a counterbalance to destructive economic pressures–a way of explicitly providing cash value for a benefit that is normally taken for granted. The typical example is of farmers who need to harvest their land more intensively to cover costs and provide a modest livelihood. This intensification not only leads to degradation of ecosystem services (e.g., watershed protection or biodiversity), but can also undermine the usefulness and profitability of the resources for future generations.

Clearly, the intended role of payouts is not merely to reimburse land owners for the environmental services that they provide, but to counterbalance wider economic pressures that compel the adoption of ecologically damaging land uses. That is, payouts for environmental services increase the profitability of sustainable resource uses so that they can compete successfully against damaging use options (Pagiola et al. 2003).

Existing PES schemes involve considerable money: US$2.5 billion per year according to Scherr et al. (2004). This figure might be disputed because it includes values that some consider resource use rather than environmental services. Thus, at some point we may need to differentiate between "services" and "uses." Extraction of timber from a forest is a use of the forest, not an ecosystem service like aquifer recharge, water-quality improvement, or carbon sequestration. However, the distinction between resource uses and environmental services is not always clear. Scherr et al. (2004) assume that non-timber forest products (e.g., rattan) are ecosystem services while timber production is a resource use. Most authors treat all "products" as results of resource use (e.g., Wunder, 2005). Ultimately, the PES concept tends to place a monetary value on all products and services, including items generally not considered to have monetary value.

This article examines PES systems from a big picture, generic perspective, as opposed to more detailed case studies that some feel are more helpful (Tomich et al., 2004). I examine the following questions: Conceptually, how does the PES system work? What is the relationship between penalties for abusing a resource and payments for good resource management? Might a system of payments deplete or reinforce a favorable environmnental ethic based on the concept of stewardship?

A Model–A Thinking Tool

The model described here represents one of many possible conceptualizations as to how PES systems could function. It is presented as a tool to assist thinking about these issues, especially in relation to environmental ethics. The model is deliberately generic, but incorporates the essentials of an environmental resource-payment system. System dynamics modeling, an approach for analysis of complex issues, emphasizes examination of system structure. The approach typically incorporates a stock/flow, differential equation, modeling paradigm and highlights feedbacks within a system. Detailed treatments of this approach are available (e.g., Ford, 1999; Sterman, 2000). This model was implemented with Vensim software.[1]

Factors Causing Changes in Resource-Use Patterns

In a simplified view, we can assume that any resource, such as timber, can be used in either an ecofriendly or a damaging way. The profitability of each approach determines the extent to which each is implemented within a given environment. PES systems help tilt market forces toward ecofriendly uses, but such payments may influence nonmarket forces, such as environmental ethics, which also affect ecosystem integrity.

Within the model, all resource use falls into one of two stocks:[2] *ecofriendly activities* or *damaging activities*.[3] The more profitable alternative will

[1] Details on Venisim are at http://www.vensim.com. The full model is available from the author.

[2] Stocks represent components in the model that are believed to change slowly. These factors are also called levels or state variables. Stocks are the integration of flows over time. Using a commonly accepted system dynamics format, a stock is represented in the figures by an outlined box with a capitalized name.

[3] Model components that appear in the simplified model diagrams in Figures 1 through 3 are italicized when first mentioned in the text.

gradually become more widely adopted. The *adjusted profitability of ecofriendly activities* is increased by the *payout per unit*. The *adjusted profitability of damaging activities* is lowered by any *penalty payments per unit* of damaging activities.[4] The switchover from one activity to the other is influenced by some threshold of profitability difference between the two activities (e.g., a potential 10% increase in profitability). This threshold incorporates change-over costs incurred by resource users. The likelihood of switching increases as the profitability differential expands beyond this threshold, although a small amount of switchover is possible even if the profitability difference is below the threshold.[5] Changes in the activity type do not happen instantly and may take a long time (e.g., planting and growing trees) (Figure 1).

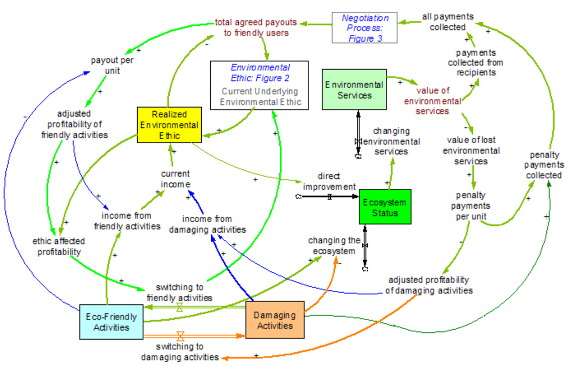

Figure 1 A schematic overview of the model. For simplicity, a number of model components are not displayed.

Also, as discussed below, the switchover from one resource use to the other is influenced by the level of environmentalism, or environmental ethic, within the community of resource users. A favorable environmental ethic has more influence when current resource users' incomes are sufficient, since this makes profitability less pressing. In the model, current income influences *realized environmental ethics*, which increases the *ethic-affected profitability* of ecofriendly activities. Thus ethic-affected profitability specifically incorporates nonmonetary effects of a favorable environmental ethic (Figures 1 and 2).

[4] Most arrows in the diagrams are labeled with a plus or minus sign. A plus sign indicates that a change in the originating component creates a change in the same direction in the second component, other things being equal. A minus sign indicates that the change in the second component is in the opposite direction.

[5] The full effect of current influences occurs when these impacts make the potential increase equal 10%. However, the lookup function allows some effect even when the profitability difference is smaller but positive. This might be considered, for example, as action by early adopters. This approach avoids an unrealistic sudden change in adoption.

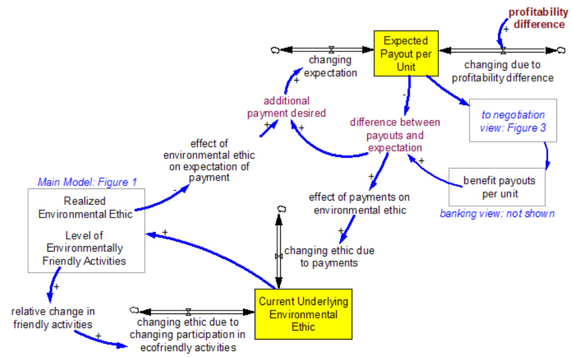

Figure 2 Hypothesized relationships determining the expected payout for providing environmental services and its relation to a favorable environmental ethic.

Optionally, a system of payments and penalties can be applied to improve profitability of ecofriendly activities. Funds for payouts to ecofriendly users are obtained from recipients of environmental services and/or from penalties on damaging activities.

The Environment and the Provision of Ecosystem Services

In the model, *ecosystem status* is represented as a single stock. One flow to and from the stock, called *changing the ecosystem*, represents the influence of changing resource uses on ecosystem status (Figure 1).[6] Changes to the ecosystem take time beyond that required to change resource use. A second flow, direct improvement, represents direct enhancements to ecosystem status that might shorten ecosystem recovery. Nevertheless, as modeled here, the maximum attainable ecosystem status is fixed and its attainment is determined by the relative amount of each resource-use type, with each resource use having a specific per-unit ecosystem value (Figure 1).

The amount of *environmental services* available is a stock that takes time to change and, in some cases, can be depleted. Environmental services are influenced by the way in which ecosystem status affects the flow-changing ecosystem services. Herein the relationship is defined so that each well-managed resource unit provides one unit of environmental services. In most cases, use of environmental services is nonconsumptive, and will not dissipate those services (e.g., scenic vistas), but such dissipation is possible, as in the case of overpumping water from an aquifer. The value of ecosystem services is the amount provided times an annual value per unit of benefit.

[6] Flows represent the changes that occur to stocks over time and they always have a value representing the change in the affected stock per unit time. Flows in the figures are represented by a pipe and valve structure. Not all flows are shown.

The Role of Payments and Penalties

Payments collected from recipients of environmental services are one means of funding payouts to resource users to increase the financial attractiveness of ecofriendly resource activities. In theory, payouts are based primarily on environmental services provided, but in a severely degraded ecosystem such services may be minimal. Other funds can be obtained with penalty payments per unit of damaging activity (e.g., special taxes) charged to recover some portion of the value of lost environmental services (Figure 1).

For practical reasons, penalty payments may be impossible, or may be capped at some fairly small fraction of damaging use profitability (e.g., 10%), that may represent only a small part of lost environmental services. Resource users may be unable to pay, and may not be responsible for past damage to the environment. Note, however, that environmental services recipients may also be unable to pay for those services (e.g., poor people living in flood prone areas may not have funds to pay resource users for watershed protection). It is possible, even likely, that payments and penalties will be insufficient to significantly raise the relative profitability of ecofriendly activities above the profitability of damaging activities.

Importantly, the model uses the value of environmental services provided, or lost, as the means of funding payouts or charging penalties. Money collected is paid out, following a negotiation process, to ecofriendly resource users. Since the *total agreed payouts to friendly users* is divided among the current number of ecofriendly resource units, the payout per unit will vary (Figure 1).

Resource users develop an expectation of a payout large enough to affect their resource-use decisions. The *expected payout per unit* of ecofriendly resource activity is partially based on the current profitability difference between ecofriendly and ecodamaging activities. Once made, payouts for environmental services come to be expected. The anticipated payout per unit is thus also based on recent benefit payouts per unit. For example, if payments exceed what was projected, the expected amount will increase, other things being equal. Increased expectations of payment are lowered by relative increases in favorable environmental ethic (Figure 2).

The determination of the total agreed payouts to ecofriendly users involves the expected payout per unit and the total of all payments collected from fees for environmental services or penalties. An additional influence is the actual remaining need for ecosystem improvement.[7] If this need is low, then (optionally in the model) the amount of payouts will be lessened (Figure 3).

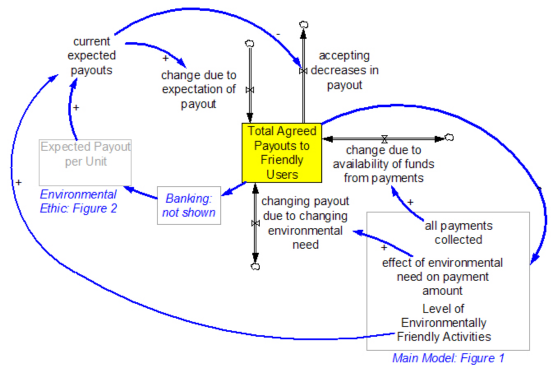

Figure 3 Factors determining the total agreed payouts to resource units employing environmentally friendly approaches.

Environmental Ethics

In many cultures there is an underlying belief that living in harmony with the natural world has a value of its own. In the late 1940s, North American forester and conservationist Aldo Leopold was already lamenting the loss of the land ethic and requests by land owners for cash payments to improve land use (Leopold, 1949).

The model attempts to address both the idea of an environmental ethic and the possibility that payouts might degrade or enhance it (Figure 2). The model assumes that an environmental ethic is strengthened when users actively switch to ecofriendly activities even if that switchover is influenced by payouts for environmental services. This logic follows the idea that proenvironmental actions help build an environmental awareness (Leigh, 2005). As people work on conservation activities, including those for which they are paid, or at which they make a living, they become more environmentally aware.

An increasing environmental ethic can also increase the likelihood that resource users will switch to environmentally friendly activities. In the model, an increasing realized environmental ethic causes an upward adjustment in the apparent profitability of environmentally friendly uses, making such activities more attractive (Figure 1). The act of switching to ecofriendly uses, in turn, enhances the current underlying environmental ethic (Figure 2). However, if payments are excessive, compared to typical profitability, there is a degradation of environmental ethic, based on the idea that payments become viewed merely as a source of income, rather than a reward for environmental stewardship. Similarly, penalty payments, if applied, are accepted as reasonable un-

[7] This model component is omitted from Figure 1.

less they are higher than a modest percentage of damaging use profitability. Within the model, environmental ethic is considered as a community quality reflecting many individual views.

The current underlying environmental ethic is tempered by reality in the form of financial need. Thus, realized environmental ethic may be less than the current underlying environmental ethic. Realized environmental ethic will increase as income increases, until it matches the underlying ethic. Such increases in current income can be derived from either damaging or ecofriendly activities (Figure 1). In the model, financial need is represented by relative income: current income compared to an arbitrary amount expected to be obtained from the resource.

Results

Basic Approach

The model uses a fixed number of resource units, starting with 50 under ecofriendly use and 50 under damaging use. Initially, both resource uses have a profitability of $100 per unit per year. In most runs random pink noise is added to the profitability of damaging use (Sterman, 2000). This addition has standard error of plus or minus 5% of the base profitability unless otherwise noted.

In a typical test scenario, damaging use annual profitability is increased by $15 over a two-year period (2030–2032) followed by a five-year phase-in (2040–2045) of a system of payouts for ecofriendly uses (Table 1). Details of different runs are described below.

No Payments or Penalties

When profitability of the two resource-use types is identical, then, without random fluctuations in profitability, there is no change in the relative proportion of the uses. If the underlying profitability of damaging use fluctuates, a range of outcomes is possible (Figures 4 and 5). There is a slight tendency toward more ecofriendly use caused by the hypothesized feedback effect of switching to ecofriendly use and the build-up of a favorable environmental ethic. All model runs include this feedback unless otherwise stated. Changes in ecosystem status and ecosystem services closely follow changes in the level of ecofriendly activities, but these ecosystem changes are delayed and occur more gradually than the changes in activities.

Table 1 Baseline values of basic components of the model. Values used are based on typical situations as reported in the literature.

Model Component	Base Value	Units	Typical Change Applied	Comments
Level of environmentally friendly activities	50	Units		Units are under either of two uses. Total is 100 units.
Level of environmentally damaging activities	50	Units		
Value of environmental services provided	20	$/(Year*unit)		Based on a benefit worth $20 for every fully functional ecosystem unit.
Profitability of eco-friendly activities	100	$/(Year*unit)		
Profitability of damaging activities	100	$/(Year*unit)	+15	Added over the 2-year period 2030–2032. Some runs include random normal fluctuations–see text.
Fraction of ecosystem services charged to recipients	0	Dimensionless	Raised to 1.0	Added over the 5-year period 2040–2045.
Penalty rate on damaging uses	0	Dimensionless	Raised to 8.0% of damaging use profitability	Added over the 5-year period 2040–2045.

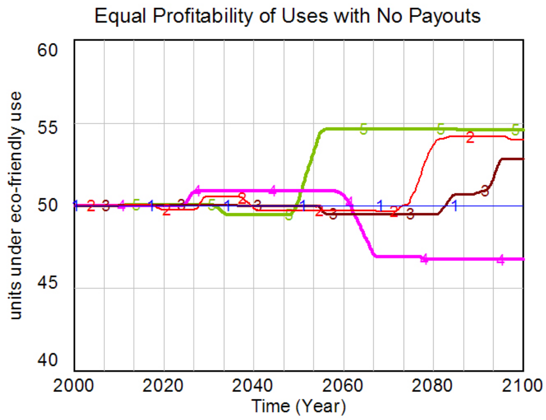

Figure 4 Changes to level of environmentally friendly activities when profitability of the two activity types is equal and there are no payouts or penalties. Line 1: no random component. Lines 2-5: examples with random variation in profitability of damaging use.

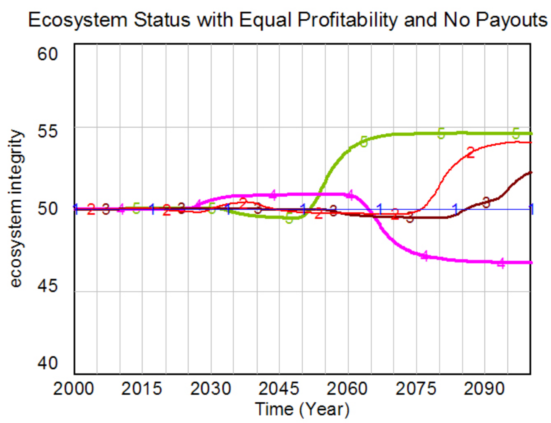

Figure 5 Changes to ecosystem status with equal profitability of the two use types. Model runs same as in previous figure.

Increasing profitability of ecodamaging use, as expected, causes a switch to such use, and in the process decreases ecosystem benefits (Figure 6). In this example, no payouts for ecofriendly use are expected, none are provided, and profitability determines the use to which the resource is put. A 15% rise in profitability is sufficient to convert all the resource to damaging use within 30 years. Adding a random variation to profitability of damaging use does not substantially change the outcome, which rapidly leads to depletion of the environment and the services it provides. Environmental ethic is also diminished by the complete switchover to environmentally damaging uses.

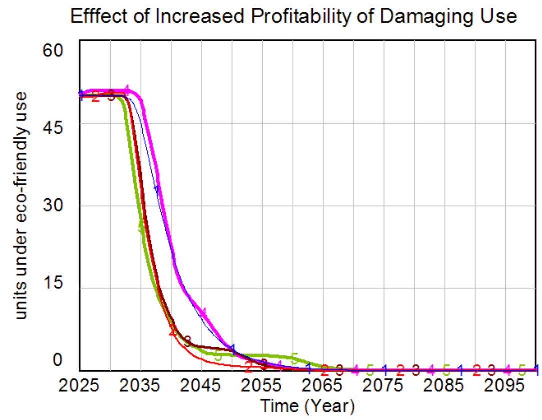

Figure 6 Level of ecofriendly use if damaging use profitability is raised by 15%. Line 1: no fluctuations. Lines 2-5 with random normal variations in damaging use profitability.

A System of Payments

A system of payments takes the following form. As above, profitability of damaging use is raised by 15% between 2030 and 2032. As the resource declines, a system of payments is phased in over five years, starting in 2040. This system bills recipients at 100% of the value of received environmental services, and uses this money as a basis for paying ecofriendly resource users. Initially, the payout expected by the resource users is the difference between the profitably of the two use types, but it is influenced by several factors including environmental ethics.

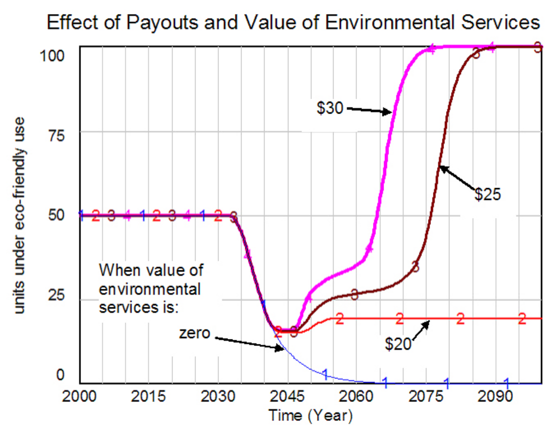

Figure 7 A system of payouts for environmental services can help recover the ecosystem, but only if the value of environmental services is sufficiently large.

The value of the services provided is critical. In the baseline example, this value, while preventing collapse of the system, is not sufficient to create a recovery. By assuming higher values for ecosystem services we can create a complete recovery (Figure 7). Nevertheless, the recovery is delayed partly because funds from ecosystem services are limited at first due to the degraded nature of the resource.

Collapse can also be prevented if a payment system is implemented sooner (Figure 8), but recovery will not occur unless payments are sufficient. The payout expected by resource users also plays an important role because high expectations can lower the beneficial effects of payouts both via a direct effect on environmental ethics and via the active feedback effect that switching to ecofriendly uses has on environmental ethic. Fluctuations in profitability tend to help ecosystem recovery. Each time profitability of ecofriendly uses increases sufficiently to cause switchover, there is a slight increase in environmental ethic, which, after some delay, helps further increase apparent profitability (Figure 9).

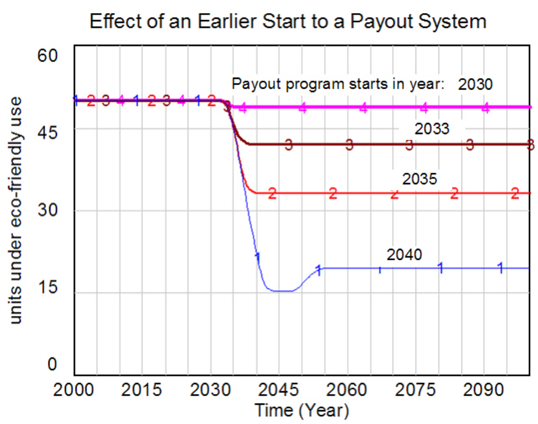

Figure 8 An earlier start to a payout system can help prevent ecosystem deterioration. All runs are based on a value of ecosystem services of $20 per fully functional resource unit.

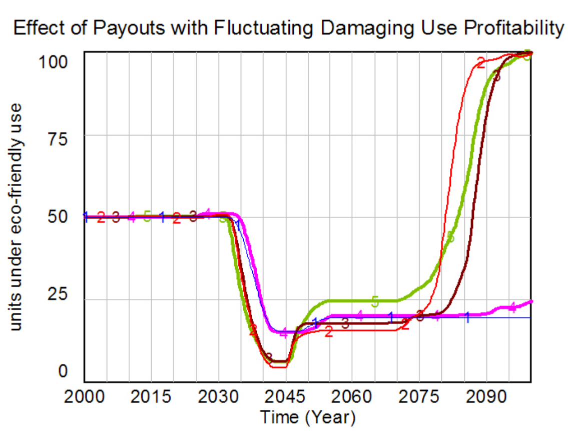

Figure 9 Fluctuations in profitability may assist ecosystem recovery. Here line 1 is the same as the $20 line (line 2 in Figure 7). The other lines have only a random component added to damaging use profitability.

The collection and distribution of funds depends on the value of services provided, the need for ecosystem improvement, and the expectation of payout by the resource users. Payments can exceed payouts, creating a positive cash flow for the system (Figure 10). This is because incoming funds are only one factor determining expected payouts (Figure 2).

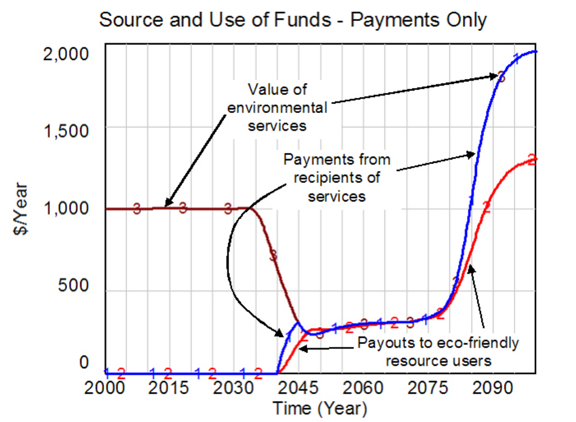

Figure 10 Sources and use of funds in a payments-only program. This run incorporates the same random influence as line 2 in Figure 9.

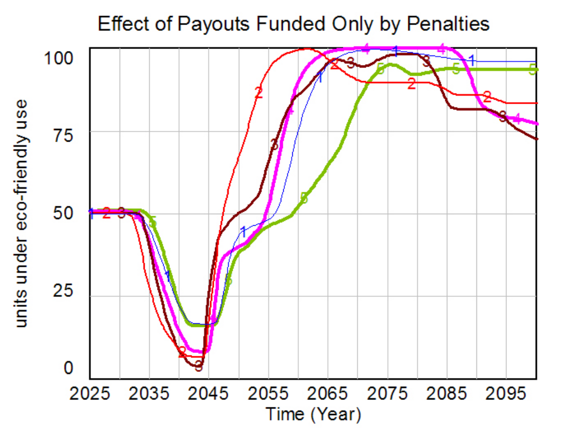

Figure 11 Payouts funded by penalties alone lose funding and run a deficit as the ecosystem recovers. All except line 1 incorporate random fluctuations in damaging-use profitability.

Using Penalties

Penalty payments applied to ecodamaging uses lower profitability, making that use less attractive, and can also help fund payouts to ecofriendly users. A system of penalties alone can lead to ecosystem recovery (Figure 11). However, penalties are dependent on ecodamaging use, which disappear as a switchover to ecofriendly uses occurs. As incoming funds diminish, expected payout also drops, but does not disappear. Payouts drop below expectation, lowering environmental ethic, and making the long-term maintenance of the ecosystem less likely. A system of payouts based on penalty payments alone will be unlikely to maintain an ecosystem recovery, especially if damaging use profitability varies significantly (Figure 12). Such a system, when resulting in recovery, will likely require deficit spending or outside funding.

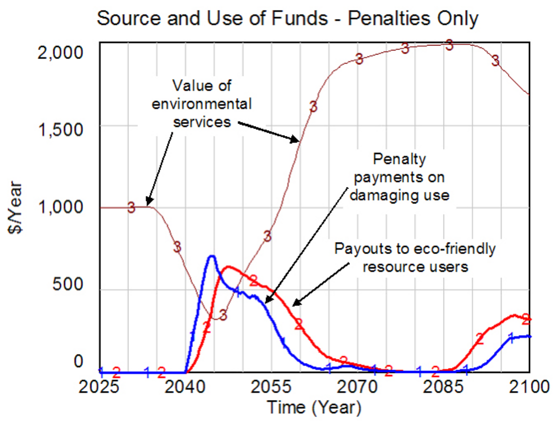

Figure 12 A system using only penalties to fund payouts.

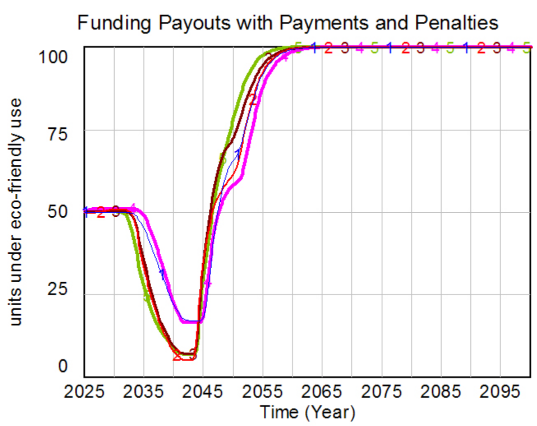

Figure 13 A system of penalties and payments allows a more rapid recovery of the system and provides for a stable future status by providing both startup and long-term funding.

Payments Plus Penalties: The Best Option?

Payouts for implementation of ecofriendly resource uses can be funded by a system of payments received from recipients of environmental services. But if those services are low, as in a degraded ecosystem, then few funds are available. Penalties can fund payouts when ecosystem services are still small or nonexistent. Penalties also lower profitability of ecodamaging activities making those activities less attractive. PES systems provide long-term funding to maintain higher profitability of ecofriendly resource uses. For these reasons, a combination of payments and penalties might be the best solution for funding payouts leading to a permanent recovery of an ecosystem and the services it provides (Figure 13). The difference between payouts and total funds collected reflects the difference between payouts expected by resource users and the value of environmental services provided. If this difference is large, then there may be no need to charge recipients of environmental services for the full value of received services (Figure 14).

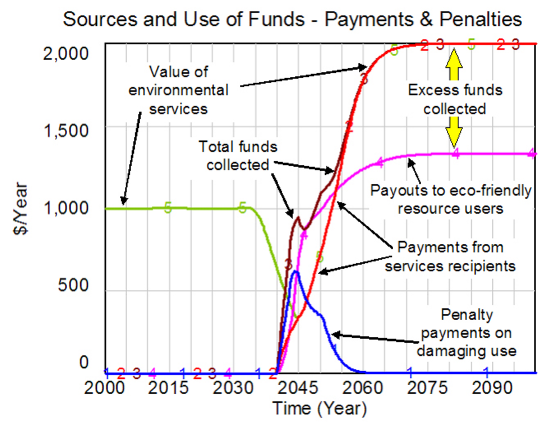

Figure 14 Source and use of funds in a system of payments and penalties.

The Role of Environmental Ethics

I have hypothesized that a favorable environmental ethic can increase apparent profitability of ecofriendly uses thereby lowering the level of monetary profitability needed to implement such uses. Importantly, the act of switching to ecofriendly use helps to further build environmental ethic. Even when only random changes in profitability make ecofriendly use temporarily more profitable, resource users switching to that use thus stimulate the build-up of environmental ethic. This positive feedback between environmental ethic and ecofriendly use makes an ecosystem recovery more likely (Figure 15). In many cases, this effect promotes ecofriendly use even when its profitability (blue line 1 in Figure 15) falls below damaging-use profitability (red line 2, Figure 15). Nevertheless, the role of environmental ethics is important primarily when profitability differences between the two uses are small.

Any relationship between a favorable environmental ethic and a switchover to ecofriendly uses would be difficult to assess. Different hypothesized relationships indicate possible effects on a recovering system where a system of payouts has been implemented (Figure 16). These relationships determine how much a changing environmental ethic might increase the ethic-effected profitability of ecofriendly use. Maximum values for lines presented in Figure 16 are 24%, 18%, 9%, and zero (top to bottom). This effect only becomes important when realized environmental ethic is large compared to long-term environmental ethic (between time 2060 and 2062 in the figures).

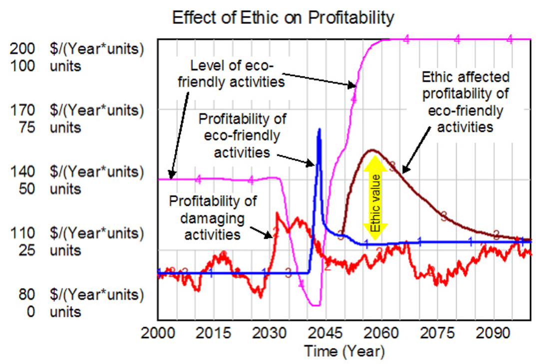

Figure 15 Illustration of the effect of environmental ethic on the profitability of ecofriendly activities. The yellow arrow represents the apparent change in profitability caused by environmental ethic.

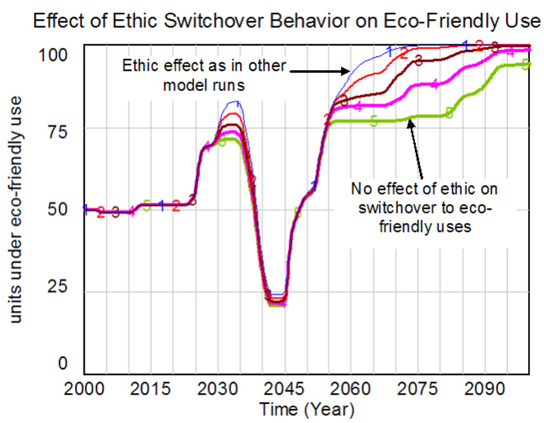

Figure 16 Illustration of the effect of different relationships between environmental ethic and the switchover to eco-friendly resource use. Top line (1): relationship as in other model runs. Lines 2-4: with progressively less influence of environmental ethic. Bottom line (5): with no effect of environmental ethic on switchover. In all runs the same random component added to damaging use profitability.

In the model, a rising environmental ethic also lowers expected payout below what would be anticipated with no effect of environmental ethic (Figure 17).[8] If, for some reason, environmental ethic later drops, raising expectations, the current payment level will be insufficient, causing a reversion to ecodamaging use. Rising environmental ethic also increases direct enhancement activities, although results of such activities are limited by the current potential of the ecosystem, based on resource-use types.

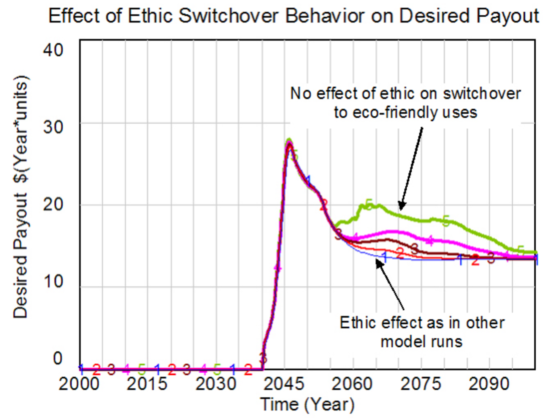

Figure 17 A favorable environmental ethic can lower desired payout. Model runs as in the previous figure.

Managers may be interested in policies that minimize the level of payouts needed for full ecosystem recovery, particularly in cases where charging for the ecosystem services in question (e.g., clean water) might be politically sensitive (Tognetti, 2005). Although penalties can provide additional funding, permitting lowered charges for environmental services, penalties eventually disappear as the ecosystem recovers.

It is hypothesized that a favorable environmental ethic is effective in making the switchover to eco-friendly uses occur at a lower monetary threshold. As modeled, the switchover then further reinforces environmental ethic. We can also see this effect in an additional simple example whereby environmental ethic is directly stepped up by 20% for five years. This would be similar to the effect of an environmental "awareness program." Such a change in ethic in the model is sufficient to cause a long-term switchover to ecofriendly uses, but this change can only occur when profitability of the two resource-use types is similar, a circumstance that payouts for environmental services could create.

Discussion

The concept of a PES system is a challenging subject for investigation with system dynamics modeling. The model presented here attempts to mimic a real PES system. It may differ from the actual world, particularly in that funding for payouts in the model is directly linked to environmental services actually provided and in that sense parallels Wunder's (2007)

[8] For the complete model and model equations see the author's website at http://pws.prserv.net/RGDudley/dudspbs.html.

definition of PES systems. The amount that each resource unit receives, or pays, will depend on the total amount of ecosystem services provided or lost, and also on the number of units within which each type of activity is carried out. In the real world such links may be less well defined. In fact, real-world payouts often consist of a flat fee paid for each resource unit (e.g., per hectare of land) on which ecofriendly uses are being applied. The fee may be comparable to a long-term gross estimate of actual environmental services provided, but often, even under the best systems, payouts are not directly linked to specific, measured environmental services (e.g., see Pagiola, 2007). Monitoring and sanctions for noncompliance with goals may also be insufficient (Ibarra & Hirakuri, 2007).

In the model, as more of the ecosystem comes under ecofriendly uses, ecosystem status, ecosystem benefits, and associated payments all approach a maximum. Consequently, payouts can decline somewhat, lowering the profitability per ecofriendly unit. This implies an incentive for self-enforcement of ecofriendly standards, because each new unit categorized as ecofriendly can decrease the per unit payout.

The model differs from many PES discussions by incorporating penalty payments applied to damaging uses as a possible source of funding for payouts for ecofriendly uses. Under this funding approach, increasing profitability of damaging use will also increase profitability of ecologically desirable activities. Penalties help environmentally friendly uses remain competitive, but time lags make such payments less helpful than we might expect. Also, penalty charges are rare in the real world, where taxes are based on economic value rather than on damage to the environment.

Use of penalties is only rarely mentioned in the PES literature (e.g., Gutman, 2003), perhaps because it deals primarily with situations where resource users are less financially secure than recipients of environmental services. However, a counterexample would be the situation where holiday villas of the wealthy built in a formerly forested watershed cause flooding of poor downstream farming and urban communities. In such a case, it seems reasonable that taxes on villa construction could supplement income from upland farm and forest activities, thus discouraging further villa construction. Penalties are most likely available when resources have been degraded, and may be most useful in restoring degraded ecosystems. Situations involving both payments and penalties would support the catchment-care principle of Hatfield-Dodds (2006).

Under circumstances when profitability varies substantially, temporary crashes can occur because the payment system, as modeled, is slow to respond compared to the changeover to damaging use. In the model, payments are based largely on the changing value of environmental services. Because ecosystem services are slow to recover, their value can lag behind changes in the resource-use pattern. Payments for services are also delayed, in some cases sufficiently to allow damaging uses to rise, pushing down benefits and payouts.

For model testing a basic price differential of 15%, plus normal random variation, was considered a realistic value for a PES model. In the real world, price differentials can be much larger, but as Wunder (2005) points out PES systems are less viable when profitability differentials are big, due in large part to the typically limited value of environmental services.

While the model may appear overly complex to some observers, the model boundary is actually fairly restricted. In fact, some of the excluded components may be of interest in similar models. In the real world, the adoption of one particular resource use may accelerate further such adoption. For example, if some farmers switch from tree crops to growing chilies then other farmers may do the same as local marketing capacity for chilies improves. The model presented here does not include that sort of influence. It is also possible that the value of ecosystem services will change with their availability. Demand for biodiversity products might increase as the products became more widely known, but excessive availability may cause a drop in value of these products. The model has an (optional) feedback that decreases payments as the environment recovers, but includes no specific adjustment in value per service provided as amount of services change.

The model also does not address any influence of resource users' knowledge that they are generating useful services. Formal or informal community recognition of the environmental services provided may positively influence environmental ethics, but when environmental services are very high they may be taken for granted. In a completely degraded ecosystem the value of ecosystem services may be forgotten, but it is possible that the costs of replacing lost environmental services influence a community's awareness of that lost value. Community awareness of environmental services will enhance support for better ecosystem management. These types of relationships might be included in site-specific models.

The model illustrates how environmental ethics might interact with payments, but only fairly tricky field inquiries can determine how real people will respond to payments. In the model, an increasingly favorable environmental ethic increases the likelihood of switching to ecofriendly uses, primarily by lowering the monetary threshold needed to switch to those uses. This observation supports the idea that issues other than profitability may influence resource users. In a rural part of the United States, only 23.5% of farmers who received PES compensation wanted to maximize profits. Other goals included soil and water conservation, maintaining a rural lifestyle, and ensuring that the farm would be passed on to family members (Lant et al. 2001). In the real world, as in the model, payouts allow resource users to shift their goals away from purely economic considerations. If both ecosystem status and the community's environmental ethic are high, then there will be less need for PES disbursements and these payments could be reduced.

We desire policies that protect and restore ecosystem status regardless of higher profitability of damaging uses. Under some circumstances, this goal may be attained through a PES system alone. Penalties on damaging uses can help fund payouts and lower damaging use profitability. If either of these options is sufficiently high, then ecofriendly uses can dominate. A system of payments plus penalties may work best, especially if the ecosystem is already degraded. In all cases, reaching the goal is more probable if policies also maintain or enhance environmental ethic. Typically, the limited value of environmental services means that PES systems are only likely to be useful in situations where the profitability difference between the two uses is relatively small.

Some interesting issues remain unanswered. If ecosystem services are normally viewed as free, then what is the long-term, larger-scale effect of paying for them? Do payouts for ecosystem services create incentives for others to request, or demand, payments for similar ecosystem protection? Who is it that actually owns the "ecosystem" in question–private resource owners/users or the public at large? What resource-use obligations do resource owners/users have? Is the implication that, without payment, they can do whatever they want? How can society distinguish among reward, payment, reimbursement, incentive, bribery, and extortion? Do these distinctions matter if the end result–protection of the ecosystem and its services–is attained?

Recent comments by McCauley (2006b) and subsequent debate (Costanza, 2006; Marvier et al. 2006; McCauley, 2006a; Reid et al. 2006) have highlighted the need for better means of integrating concepts such as environmental ethics into PES systems. If both payment and a favorable environmental ethic are useful in better managing natural resources, then both, and the interplay between them, should be explicitly stated in exploratory models of such systems. Likewise, issues such as the expectation of payment and its subsequent effect on desired payments can be explicitly defined in the models to allow discussion and investigation of these issues. Importantly, the structure of a system dynamics model attempts to assess causality. That is, model outcomes should not only be reasonable, they should be reasonable for the right reasons.

Exploratory system dynamics models like the one presented here are sometimes criticized on the grounds that they contain many poorly known relationships among model components. For example, the exact influence of a favorable environmental ethic on resource-use patterns is difficult to know. However, omitting such important components merely because we do not have (or cannot get) accurate information is clearly faulty. In these cases, approximate information is better than none. Nevertheless, due to the highly interlinked nature of system dynamics models the incorporation of some uncertain model elements can lead to high variability in model outcomes. Thus caution, or better information, is needed when attempting to use such models to derive policies.

In fact, the usefulness, rather than absolute accuracy, of a model is the real measure of its value (e.g., see Barlas, 1996), although ultimately satisfying both criteria would be ideal. Exploratory models are certainly useful as research-planning tools to help identify where new information is needed. Causal models could also be important in developing the type of conservation-evaluation programs suggested by Ferraro & Pattanayak (2006). This modeling approach can harmonize the work of many disciplines attempting to craft a sustainable future (Fiksel, 2006; Hjorth & Bagheri, 2006).

Acknowledgement

The author would like to thank Carol Colfer, Enrique Ibarra, and Sven Wunder, as well as several anonymous reviewers, for their helpful suggestions on various versions of this article and the model on which it is based.

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EDITOR'S NOTE

Policy debate: editorial introduction

This issue of *Sustainability: Science, Practice, & Policy* launches a new section called "Policy Debate" as a forum for discussions pertaining to sustainability policy making. My sincere hope is that it becomes a useful and dynamic space for the journal's international community of contributors and readers.

The first policy debate kicks off with an article by Alan Hecht & William Sanders on efforts to transform the U.S. Environmental Protection Agency into a "national environmental architect" and to fuse its multifarious legal mandates, voluntary initiatives, and educational programs into an integrated urban sustainability framework. The authors are ranking EPA officials who have played key organizational roles trying to move the agency beyond pollution control and remediation and to proactively engage in sustainability planning. This task, as anyone who has had close contact with EPA can attest, is not easy and success is by no means assured. Nonetheless, after a long period of public silence on the part of the federal government regarding such matters, Hecht & Sanders offer a set of ideas with the potential to catalyze constructive debate.

This new section of *SSPP* seeks to facilitate exactly this sort of consideration. Three distinguished sustainability scholar-practioners have been asked to reflect on this vision for EPA. First, Martin Bierbaum offers a skeptical perspective on the ability of sustainability champions to effect meaningful change within the agency given its long-standing commitment to media-focused pollution management. Institutional reorientation, he insists, requires commitment and endurance, as well as willingness to engage in protracted bureaucratic struggle. Bierbaum contends that it is one thing to develop lists of programmatic initiatives that have a sustainability veneer, but quite another matter to effect systemic and durable organizational change.

Second, David Pellow is similarly critical of Hecht & Sanders and is furthermore adamant that sustainability will be elusive for EPA unless the agency overcomes its predisposition for voluntarism. He argues that progress to enhance the livability of urban districts will only be achieved through the application of strenuous regulations. Pellow also encourages EPA to assume a leadership position in questioning prevalent notions of economic development and typical ways of distributing the gains of growth.

Finally, Arnold Tukker offers a few observations on Hecht & Sanders' sustainability blueprint from a European perspective. He is heartened to see such interest within EPA, but is perplexed over how any conception of urban sustainability could fail to consider the deeply problematic role of the automobile. Drawing on recent work in the Netherlands on transition management, he also highlights the cultural barriers to change, as well as the infrastructural and political obstacles that transformative progress must necessarily overcome.

This policy debate gives the last word to Hecht & Sanders who acknowledge the challenges that EPA faces but, at the same time, insist that the task is not futile. They describe several initiatives by the agency to work with local communities to anticipate climate-change risks and to meld regulatory and nonregulatory programs. They also reflect on the inevitable instability that is created by political shifts and the continual need to rebalance priorities in light of these circumstances.

I anticipate that the discussion will not end here. I encourage you to carry it forward by submitting your own reactions via the journal's "e-Letter Box" and details on how to respond in this way are available at http://ejournal.nbii.org. I heartily look forward to hearing from you and also welcome suggestions for future policy debates.

Maurie J. Cohen
Editor

POLICY DEBATE

How EPA research, policies, and programs can advance urban sustainability

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How can a regulatory agency with historic roots in controlling pollution implement sustainability? How does an agency organized by individual media offices for air, water, toxics, and waste develop an integrated systems approach to environmental protection? Aligning and integrating programs is crucial for sustained environmental protection, especially in urban areas. The role of the U.S. Environmental Protection Agency (EPA) extends beyond setting national standards for air and water, protecting against chemical discharges, and restoring contaminated lands. The agency has the potential to become a national environmental architect by promoting research and innovation targeted at urban sustainability. To develop tools for creating a truly sustainable urban environmental infrastructure, EPA must develop approaches for adapting to potential climate change impacts on urban systems. In short, EPA needs an urban environmental strategy.

KEYWORDS: environmental protection, EPA, management tools, urban environments, climate change, public policy, sustainable development

Introduction

The Heinz Center's (2002) first report on *The State of the Nation's Ecosystem* has a chapter on urban and suburban areas, which observes that "thinking of America's cities and suburbs as an ecosystem does not come automatically to many people."[1] Yet the unconventional urban ecosystem, where Americans spend most of their time, is affected by policies and programs of the U.S. Environmental Protection Agency (EPA). In 2000, 80% of the United States population lived in urban areas within 200 miles of either an ocean coast or the Great Lakes. Between 1973 and 1992, the urbanized land in 16 metropolitan areas examined in a U.S. Geological Survey study increased by an average of 173 square miles (Auch et al. 2004).[2] Achieving sustainability in an urban ecosystem requires that dozens of stakeholders—including residents, community groups, businesses, realtors, developers, city planners and managers, and federal agencies—interact in a coordinated manner. This is clearly not easy, yet linkages among green building design, green engineering, low-impact development, and smart growth are taking root in many communities.

EPA is an important player in urban environmental sustainability, setting national standards for air and water, protecting against chemical discharges, and working to restore contaminated lands. As our discussion will show, EPA has the potential to become a national environmental architect, helping stakeholders to develop urban sustainability practices, especially practices related to the potential impact of climate change on urban water systems.

Following a general discussion of urban ecosystems, this article explores how a regulatory agency historically rooted in pollution control can interpret and implement sustainability in an urban environment. It then addresses how such an agency, organized by individual media offices (air, water, toxics, and waste), can develop an integrated systems approach to environmental protection. The article concludes with suggestions on how EPA can develop an urban sustainability strategy.

The Built Environment: An Urban Ecosystem

In the past, little or no concern was given to how urban development might seriously impair the natural infrastructure and its concomitant ecosystem ser-

[1] The Heinz Center plans to publish a fully revised version of this report in late 2007.
[2] The cities included in the study were Atlanta, Boston, Chicago, Denver, Houston, Las Vegas, Memphis, Minneapolis-St. Paul, Orlando, Phoenix, Pittsburgh, Raleigh-Durham, Reno-Sparks, Sacramento, Seattle-Tacoma and Tampa-St. Petersburg.

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vices, such as the ability to absorb pollutants and render them harmless, to cleanse air and water, and to prevent storm and flood damage. Today, we are more aware that urban development can affect energy use, indoor and outdoor air quality, ecosystem quality and services, and natural habitat protection. The construction of roads, roofs, and other impervious surfaces leads to degraded water quality by altering stream flow and watershed hydrology, reducing groundwater recharge, and increasing runoff volume, stream sedimentation, and water acidity: a one-acre parking lot produces almost 16 times as much stormwater runoff as an undeveloped meadow of the same size. The EPA's *Draft Report on the Environment* identifies impervious surfaces and the extent of urban and suburban developed land as key indicators of the health of the water and terrestrial ecosystems.[3] Many tools are now available to support low-impact development that can significantly reduce water runoff and contamination. The EPA is using its Washington, DC headquarters as a testing ground for these new approaches (USEPA, 2006a).

We have also come to realize that building design is crucial in the urban ecosystem, for buildings account for 68% of electricity consumption, 40% of total energy use, and 38% of greenhouse-gas emissions (EIA, 2003). Recent studies project that by 2030 there will be 106.8 billion square feet of new development, about 46% more built space than existed in 2000—a remarkable amount of construction to occur within a generation; moreover, in 2030 about half of the buildings in which Americans live, work, and shop will have been built since 2000. By 2030 about 97.3 billion square feet of existing buildings will be replaced; new and rebuilt development will amount to 204.1 billion square feet, equal to almost 90% of the built space that existed in 2000. All of this adds up to about US$30 trillion in total new development (including infrastructure) that will occur between 2000 and 2030 (Nelson, 2004; 2006).

Anticipating these urban challenges, business leaders, developers and architects, nongovernmental organizations, cities, and federal agencies are combining forces to help shape a new generation of urban development and building design and retrofitting. In efforts to reduce energy consumption and greenhouse-gas emissions, former President Bill Clinton is helping to create a US$5 billion green building fund to retrofit existing buildings in a program that is bringing together cities, banks, and four energy-service providers. In new construction, the U.S. Green Building Council (USGBC), the foremost coalition joining leaders from all building-industry sectors, is working to promote buildings that are profitable, environmentally responsible, and healthy places to live and work (see USGBC, 2007). The USGBC's hallmark program, the Leadership in Energy and Environmental Design (LEED®) Green Building Rating System, is the nationally accepted benchmark for the design, construction, and operation of high-performance buildings.

In an urban ecosystem, achieving sustainability requires an integrated approach to environmental management and the establishment of linkages among community, ecology, and economy. The link between economic development and environmental protection is especially important. Metropolitan areas are now the major drivers of the country's economy. From 2000 to 2006, 90.5% of United States economic growth took place in metropolitan areas, while in 2006 payrolls included 116 million workers and GDP totaled US$11.4 trillion, an overwhelming 86.7% of the nation's total (Global Insight, 2007).

Increased urban development has focused attention at all levels of government on quality of life, urban sprawl, and growing demand for transportation and energy. Population growth has historically led to greater and more concentrated use of energy, water, and materials, and concomitant growth in waste, increasing air, water, and land pollution, with associated harm to ecosystems and human health. Economic growth has generally required increasing quantities of energy, materials, and water from expanded agriculture and industry, leading to more waste, toxic substances, and air and water pollution. Land and ecosystems change as materials are extracted, goods produced, infrastructure built, and wastes disposed.

The effect of air quality on respiratory diseases demonstrates the links between human health and environmental quality in the urban environment. As Howard Frumkin and his colleagues have shown, a healthy urban environment can also benefit a broad range of physical and mental health issues. They write, "Smart Growth is like a medicine that treats a multitude of diseases—protecting respiratory health, improving cardiovascular health, preventing cancer, avoiding traumatic injuries and fatalities, controlling depression and anxiety and improving well-being" (Frumkin et al. 2004).

These data and examples illustrate the important economic and health impacts of urban environments and underscore that EPA—working with cities and states, developers, realtors, investors, and retailers—can significantly enhance economic growth while promoting more sustainable environmental approaches. The growing national focus on green design and low-impact development, on reducing

[3] *EPA's 2007 Report on the Environment: Highlights of National Trends.* Peer Review and Public Comment Draft is available at http://www.epa.gov/indicators/docs/roe-hd-draft-08-2007.pdf.

stormwater runoff and greenhouse-gas emissions, and on improving air quality and human health is creating a new government-business framework seeking to more effectively balance economic growth and environmental protection. The threat of severe climate-change effects, including altered frequency and intensity of precipitation and increased energy demands, makes sustainable urban planning a financial and social necessity.

EPA Programs and Sustainable Urban Development

When President Nixon created EPA in 1970, he recognized the interconnectedness of the environment and the inherent cross-media nature of environmental protection. His plan to establish EPA noted that, for pollution-control purposes, "the environment must be perceived as a single, interrelated system" (EPA, 2007d). Since then, EPA has struggled to deal with the environment as an integrated system. At the agency's 15th anniversary, former Administrator Russell Train expressed his concern with EPA's "compartmentalized nature" and its resulting ineffectiveness in dealing with pollutants, which "tend to move readily among air, water, and land" (EPA Journal, 2007b). In the same year, Administrator Lee Thomas stressed the need for cross-media reviews so that "we don't just transfer pollutants from one medium to another" (EPA Journal, 2007a). The urban ecosystem clearly requires integration across media, and EPA is pursuing this objective. Although the built environment is a major area affecting human health and ecosystem protection, no single federal statute governs it. Indeed, states and local jurisdictions have major responsibilities regarding the built environment.

Integrating and aligning programs is a key to achieving sustained environmental protection. A recent report by a panel of the National Academy of Public Administration (NAPA) identifies current challenges facing EPA, headed by the complex environmental problems involving both point and nonpoint sources of pollution. The report authors found especially relevant to the urban environment the realization of "a major gap in the ability of current EPA programs to mobilize the multiple programs, federal agencies, state and local government, and other parties that must play important roles in achieving national goals to improve ambient environmental conditions" (Howes et al. 2007).

The NAPA report emphasizes integrating across problems, promoting collaborative problem solving and leadership. To highlight the challenge to EPA, the NAPA authors examined the Chesapeake Bay Program and found that reaching its pollution-prevention goals would require joint efforts among numerous government and private entities, including:

- Six states, the District of Columbia, and 3,169 local governments
- 23 federal agencies
- 678 watershed associations
- A large number of "riverkeepers"
- 2 interstate river basin commissions
- 30 regional councils (multi-county councils of local governments)
- 32 state-created tributary strategy teams
- 87,000 farm owners
- 5–6 million homeowners
- Hundreds of lawn-care companies
- An uncounted number of land developers, home-builders, and construction companies
- Agribusinesses and other companies that pollute the Bay
- A huge number of civic and nonprofit organizations (Howes et al. 2007).

The challenge of facilitating the interaction among key stakeholders is recognized in many of EPA's urban ecosystem programs. A sampling of agency initiatives that at least in part concern urban sustainability is highlighted in Table 1 and discussed in the following paragraphs.

Green Building

The greening of building construction is being promoted both within the federal government and in private industry. In January 2006, more than 150 federal facility managers and decision makers met for the first White House summit on federal sustainable buildings. The federal agencies signed an agreement to promote high performance and sustainability in building design (Interagency Sustainability Working Group, 2007). Executive Order (EO) 13423, issued in January 2007, establishes new and updated goals, practices, and reporting requirements for environmental, energy, and transportation performance and accountability (Bush, 2007). In the area of sustainable design and high-performance buildings, the new EO mandates five guiding principles for all new construction and major renovations: integrating design, optimizing energy performance, protecting and conserving water, enhancing indoor environmental quality, and reducing materials' environmental impacts. The EO also has set an aggressive goal for applying these practices to existing federal capital assets over the next decade. To address the need for a comprehensive guide for procuring green building products and construction services within government, EPA has partnered with the Federal Environmental Ex-

Table 1 EPA programs concerning the built environment.

EPA Program (Office)	Program Objective
Buildings: Facilities Management and Green Design (OA, OPPTS, OPEI, ORD)	Help identify green building criteria and standards.
Land: Smart Growth (OPEI)	Help design low-impact and green communities through sharing best practices and promoting ten development principles.
Land: SMARTe (ORD)	Provide web-based decision-support tool to help developers evaluate future reuse options for a site or area.
Land: Brownfield Revitalization (OSWER)	Revitalize contaminated sites to be economically productive.
Land: Environmentally Responsible Redevelopment and Reuse (ER3) (OECA)	Use enforcement and incentives to promote sustainable development of contaminated sites.
Water: Sustainable Water Infrastructure (OW)	Better manage utilities, including full-cost pricing, efficient water use, and watershed approaches.
Water: WaterSense (OW)	Help conserve water for future generations by providing information on products and programs that save water without sacrificing performance.
Water: National Pollution Discharge Elimination System (NPDES) (OW)	Control water pollution by green infrastructure and regulate point sources that discharge pollutants into United States waters.
Energy Use: ENERGY STAR (OAR)	Evaluate and test energy efficiency of products in more than 50 categories and provide information on green building design and energy efficiency.
Air: Air Toxics Strategy and Modeling (OAR) (ORD)	Identify and monitor urban air toxics from stationary, mobile, and indoor sources.
Air: Community-Based Air Quality Programs (OAR)	Support air-toxics projects in about 30 communities across the nation, helping inform and empower citizens to make local decisions concerning the health of their communities.
Indoor Air: Indoor Environment Management Research (ORD**)**	Improve understanding of relationships among emission sources; heating, ventilating, and air-conditioning (HVAC) systems; air-cleaning devices; and indoor air quality.
Climate: Climate Impact Assessment Research (ORD)	Integrate remote and ground-based data and dozens of models to assess potential impacts of climate change.

The acronyms in this table represent EPA offices: OA, Office of the Administrator; OPEI, Office of Policy, Economics, and Innovation; OSWER, Office of Solid Waste and Emergency Response; OW, Office of Water; OAR, Office of Air and Radiation; OECA, Office of Enforcement and Compliance Assistance; OPPT, Office of Prevention, Pesticides, and Toxics, and ORD, Office of Research and Development.

ecutive and the Whole Building Design Guide (WBDG) to develop the Federal Green Construction Guide for Specifiers (see Whole Building Design Guide, 2007). This voluntary guidance document recognizes approaches beyond minimum compliance with regulations and assists federal agencies in meeting pollution prevention and other green mandates already in place. The EPA received authority under the earlier EO 13101 to guide agencies in meeting these requirements (Clinton, 1998).

Smart Growth

At its core, smart growth involves development decisions on the broad universe of issues affecting everyday lives—people's homes, health, schools, taxes, daily commute, surrounding natural environment, community economic growth, and opportunities regarding their dreams and goals. Through grants, technical assistance, incentives, and recognition programs, EPA assists local communities in futures planning. Development strategies that protect critical habitat, reduce automobile emissions, clean up and revitalize brownfields, and reduce runoff of polluted water link smart growth and the environment. Today, smart growth programs are increasingly focused on reducing carbon footprint and energy use. The EPA's Smart Growth Awards recognize innovative cities and communities across the country.

SMARTe

Sustainable Management Approaches and Revitalization Tools (SMARTe) is one of many EPA open-source web-based decision-support systems for developing and evaluating scenarios for reusing contaminated land. SMARTe contains guidance and analytical tools for all aspects of the revitalization process, including environmental, economic, and social concerns. The SMARTe website provides information on newly available tools, technologies, and land-revitalization approaches (see SMARTe.org, 2007).

Brownfield Revitalization

EPA's Smart Growth Program works closely with the agency's brownfields program. The United States has more than 450,000 brownfields—properties characterized by the actual or potential presence of hazardous substances, pollutants, or contaminants that may complicate expansion, redevelopment, or reuse. Since its inception in 1995, EPA's brownfields program has empowered states, communities, and other economic redevelopment stakeholders to work together to prevent, assess, safely clean up, and sustainably reuse brownfields. Across the country, cleaning up and reinvesting in contaminated properties increases local tax bases, facilitates job growth, uses existing infrastructure, reduces pressures to develop open land, and improves and protects the environment.

Environmentally Responsible Redevelopment and Reuse (ER3)

EPA is using its enforcement and incentive programs to promote sustainable cleanup and redevelopment of contaminated sites. The ER3 program identifies and provides enforcement and incentives to developers and property owners to encourage sustainable development. It also develops partnerships with federal, state, public, and private entities to establish a network of expertise on sustainable development issues and promotes sustainable redevelopment of contaminated properties through education and outreach.

Sustainable Water Infrastructure

With water becoming scarce, the aging water infrastructure throughout the United States is a cause for much concern. The EPA's extensive gap analysis of water infrastructure lays out critical needs in drinking-water treatment, distribution, and storage and in wastewater collection, treatment, and reuse. In 2002, EPA estimated in its *Clean Water and Drinking Water Gap Analysis Report* that if investment in water and wastewater infrastructure does not increase to address anticipated needs, the funding gap over 2000–2019 could grow to US$122 billion for clean water capital costs and US$102 billion for drinking water capital costs (USEPA, 2002). The municipal water sector accounts for 40% of national water usage. Much of the country's water infrastructure was built in the 30 years following World War II and needs major repairs and upgrades. Urban sustainability clearly depends on reliable and well-maintained water and wastewater treatment, storage, and conveyance systems. The EPA's Sustainable Infrastructure Initiative for Water and Wastewater is guiding efforts to change how the nation views, values, manages, and invests in its water infrastructure. The EPA is working with the water industry to identify best practices that have helped many water utilities address a variety of management challenges and to extend these practices to a greater number of utilities.

WaterSense

This EPA tool promotes sustainable water use by identifying effective and efficient products that deliver needed services. Public education and product labeling can change behavior. Developing any environmental label requires working with industry stakeholders to ensure full openness, reliability, and mutual support. WaterSense evolved from a series of stakeholder meetings across the country to get input on designing a national, voluntary, market-based program for promoting water-efficient products. Research has shown that such technologies and practices help homeowners save natural resources and reduce water consumption and costs. The average family of four uses 400 gallons of water every day. The arid West has among the highest per capita residential water usage because of landscape irrigation. The EPA's WaterSense label identifies water-efficient products that are found to be 20% more efficient in their water use than other products.

National Pollution Discharge Elimination System

Water pollution degrades surface waters, making them unsafe for drinking, fishing, swimming, and other activities. As authorized by the Clean Water Act, the National Pollutant Discharge Elimination System (NPDES) permit program controls water pollution by regulating point sources that discharge pollutants into United States waters. Since its introduction in 1972, this program has significantly improved the nation's water quality. Moving toward sustainability, the NPDES program promotes green infrastructure as a cost-effective and environmentally friendly approach to reduce stormwater and other excess flows entering sewer systems. Green infrastructure is a way to protect surface waters and drinking-water supplies, reduce drinking-water and stormwater treatment costs, mitigate urban heat-island impacts, and provide more sustainable water-resource management. Green infrastructure approaches, such as low-impact development, use on-site, natural systems, including forested areas, rain gardens, and green roofs, to cleanse water and reduce excess volume by filtering and treatment with plants, soils, and microbes. Green infrastructure can reduce our reliance on pipes, channels, and engineered treatment systems that are costly to build, operate, and maintain. In April 2007, EPA and four national groups signed an agreement to promote green infrastructure to reduce stormwater runoff and sewer overflows (USEPA et al. 2007).

ENERGY STAR

Launched in 1992, this voluntary labeling program identifies and promotes energy-efficient products that reduce greenhouse-gas emissions. Beginning with computers and monitors, EPA later expanded product labeling to other office equipment and to residential heating and cooling equipment. In 1996, the agency joined with the U.S. Department of Energy in certifying products in additional categories. The ENERGY STAR label is now widely recognized as identifying major appliances, office equipment, lighting, home electronics, and other products that match or exceed the performance of competing models while using less energy and saving money. The EPA has further extended the ENERGY STAR label to cover new homes and commercial and industrial buildings (see ENERGY STAR, 2007). Through its partnerships with more than 8,000 private- and public-sector organizations, ENERGY STAR delivers the technical information and tools that purchasers need to choose energy-efficient solutions and best management practices. The program has delivered energy and cost savings across the country, saving businesses, organizations, and consumers about US$12 billion in 2005 alone. Over the past decade, ENERGY STAR has driven the expansion of such innovations as LED traffic lights, fluorescent lighting, standby-energy use, and power-management systems for office equipment.

Urban Air Toxics Strategy

Under the Clean Air Act, Congress instructed EPA to develop a strategy for air toxics in urban areas with broad risk-reduction goals encompassing all stationary sources of air pollution and with specific actions to address the many smaller local sources of air pollution. The Urban Air Toxics Strategy is the agency's integrated framework for addressing air toxics in those areas by examining stationary, mobile, and indoor source emissions (see USEPA, 2007b). Air toxics can pose special threats in urban areas because of the large number of people and the multiple sources of toxic air pollutants, such as cars, trucks, large factories, gasoline stations, and dry cleaning plants. Some of these sources may not individually emit large amounts of toxic pollutants, but in combination they pose significant health threats, particularly for the elderly, children, and other sensitive populations. The Urban Air Toxics Strategy focuses on the impact of toxic emissions on minority and low-income communities that are often close to industrial and commercial urbanized areas. The EPA air-transport models are critical decision tools in helping to evaluate air-dispersion patterns. These models form the core of a set of decision-support tools to help assess air quality as it relates to urban development patterns.

Community-Based Air Quality Programs (CBAQP)

Many of the more than 30 CBAQP projects underway are focused on integrated urban planning that links issues of development, transportation, and air quality. One of the largest projects is Sustainable Environment for Quality of Life (SEQL), an integrated environmental initiative encompassing 15 counties in the Charlotte/Gastonia/Rock Hill region of North and South Carolina (SEQL, 2007). SEQL involves business and industry groups, economic development, and environmental stakeholder groups working with elected officials and local government staff toward sustainable solutions to regional growth. Projecting and assessing this region's future growth patterns in an integrated manner is a key element of the SEQL program. A set of decision-support tools called ReVA (Regional Vulnerability Assessment) has been developed to help decision makers quantitatively assess ecosystem and environmental impacts of different development options.[4] Other community-based air-quality projects underway in New Haven, Cleveland, and St. Louis also are also integrating urban planning, transport, and air quality into sustainable urban policies (USEPA, 2007c).

Indoor Environment Management Research

Indoor air quality is not a new topic for EPA but it has a renewed sense of importance in light of urban population increases, aging, and the potential for billions of dollars of new construction. The issue regarding indoor environment now is not only urban air quality, but energy efficiency and worker productivity as well. The EPA's National Risk Management Research Laboratory is conducting fundamental and applied research on programs to enhance energy efficiency and control indoor air pollution. The research program has focused on developing standard methods and models for specific classes of potential indoor pollution sources (such as paints, cleaners, and adhesives), for large-chamber emission testing, and for technology verification (such as for air cleaners and office furniture). ASTM International, the global standards-developing organization, has adopted several testing and measurement procedures formulated by this EPA program.

[4] EPA researchers, who have long focused on urban planning, in 2000 compiled a summary of available models to help decision makers (USEPA, 2000).

Global Change Research

Because urban infrastructure requires long-term investment, wise decision making must consider the potential impacts of climate change on water resources. The EPA's broad-based climate-assessment program is included here to emphasize the importance of developing and using assessment models in making sustainable decisions. With billions invested in water infrastructure in the United States, potential changes in the intensity and frequency of rainfall, snow, and other storm events can significantly affect the quantity and quality of water available and the infrastructure required to collect and treat urban wastewater and stormwater. Implications for combined sewer- overflow systems are discussed later in this article.

A Model for Connecting the Dots: Green Building Workgroup (GBWG)

Although the programs listed in Table 1 were independently developed, each seeks to advance sustainability in urban development and building design. The EPA has supported these efforts by committing to green its own facilities, establishing the Sustainable Facilities Practices Branch, and adhering in its construction projects to the green building standards. Recognizing the need to coordinate across these numerous programs, EPA staff created the Green Building Working Group (GBWG) to guide programs, partnerships, communications, and operations that influence building and development. The GBWG is a model of how to connect the dots and thus focus and leverage ongoing programs to advance green building goals (USEPA, 2005).[5]

In developing its overall strategy, the GBWG recognizes that for EPA to meet its mission responsibilities and promote economic development and sustainable practices, it has to foster the widest possible adoption of environmentally preferable building and development techniques. There is no shortage of green designs and technologies, but the challenge is to move from a small percentage of the market to the mainstream. The GBWG also recognizes that, because EPA's building and development programs are largely voluntary, any GBWG strategy must partner with a variety of building sectors, governments, and green building organizations to promote sustainability in the marketplace by providing information, recognition, and other incentives (USEPA, 2006c).[6]

Thinking strategically about sustainability and the built environment, EPA's GBWG adopted a strategy with two goals: facilitating leadership and fostering innovation. In adopting this approach, EPA is primarily looking to the marketplace rather than regulation to advance sustainability. The approach to transformation is important at this stage in that green building and other sustainability programs, although growing dramatically, remain a small segment of the market and their success could yet be derailed by economic, social, political, and/or other factors.

Recent estimates of potential growth are impressive. In 2006, the National Association of Homebuilders reported that inquiries into green practices had increased by more than 250% from the previous year. Commercial green building and development projects will increase 30% over the next five years, according to estimates by the National Association of Industrial and Office Properties. The organization also explains that most large corporations that issued sustainability reports in 2005 stated that they want to build and occupy real estate that reflects their values, including green building practices. A recent survey by McGraw-Hill Construction projected the near-term market growth in green construction for several building sectors: education, 65%; government, 62%; institutional, 54%; office, 58%; health care, 46%; residential, 32%; hospitality, 22%; and retail, 20%. Owners and developers of commercial and institutional properties in North America are advancing green development through state-of-the-art tools, design techniques, advanced green products, and creative use of financial and regulatory incentives (Ortega-Wells, 2006).

The GBWG illustrates EPA efforts to overcome traditional barriers and integrate the agency's diverse programs. Rather than creating a separate sustainability program, the GBWG aims to integrate the principles of sustainability into existing programs. It is thus an effective and instructive model for making sustainability operational.

Toward an EPA Urban Sustainability Strategy

Achieving sustainability in the built environment is not something EPA or any other agency can achieve by regulations alone. What we know today about the impacts of urban development and building design on environmental quality and human health has to be translated into practical policies involving dozens of stakeholders. Building on a common interest among diverse stakeholders, EPA can be a leader

[5] The EPA-sponsored Construction Industry Compliance Center provides guidance for EPA building and development regulatory programs (see CICA, 2007).

[6] In 2006, EPA signed a Memorandum of Understanding with the American Institute of Architects (AIA) Committee on the Environment to advance sustainable development by partnering on key smart growth and green building activities (see USEPA, 2006b).

in promoting partnerships and fostering innovation toward urban sustainability.

The clearest immediate need is to have a broad "urban sustainability strategy" with unambiguous goals and metrics. Given the extent of urban development and building redevelopment, EPA has an opportunity to significantly influence future development and be-come a nationally recognized "environmental architect." We use this phrase to emphasize the importance of designing and planning in an integrated manner and to convey a different sense of EPA. The challenge is to think of such development in an integrated manner, rather than simply as a collection of related programs like those shown in Table 1.

Defining urban sustainability goals and metrics is important. The value of the 2002 Heinz Center report is its focus on indicators of change and assessing the quality of available data. This report identified 15 indicators that provide critical links to environmental parameters, but explained that many of the indicators have incomplete and inadequate long-term data records. Developing urban sustainability indicators across EPA programs can serve many purposes:

- Assist urban decision makers in understanding the practical meaning of achieving sustainability.
- Provide guidance for decision makers in designing and implementing policies to advance sustainability.
- Enable decision makers to see the interconnections among issues so they can make decisions based on comprehensive understanding.
- Promote cross-media policies and strategies within EPA.
- Serve as a framework for constructive dialogue and collaboration among business, government, and nongovernmental institutions.
- Provide on-going access to the data and information that support decision making for sustainability.

The GBWG, re-enforced by recommendations of NAPA and other outside panels, demonstrates the importance of EPA in encouraging sustainable decisions by facilitating dialogue among diverse stakeholders and promoting collaborative problem solving. As a national environmental architect, EPA is in a unique position to make several major contributions:

- Bring together different industry sectors and subsectors to collaborate on setting goals, measuring results, coordinating, and overcoming barriers to green development.
- Facilitate the coordination of federal, state, tribal, and local government policies; refine codes, specifications, and standards; and otherwise aid implementation of sustainable practices.
- Work with voluntary-based standards organizations to continue the development and advancement of voluntary consensus standards related to green design.

Sustainability Research: Helping Decision Makers Make Better Decisions

EPA can also be effective in promoting innovation and research that demonstrates synergies in the urban ecosystem. Building on a solid base of air-pollution modeling and urban system design, as well as engineering and technology development, EPA can greatly improve the quality of decision making, today and in the future.

The term "sustainability research" has become popular in academic circles. From EPA's perspective, sustainability science is developing the underlying knowledge that allows sustainable decision making. For natural resource managers, this means understanding how to provide maximum services today and in the future. For urban planners, this means understanding how to build cost-effective and efficient systems that protect both human health and the environment. For industrial decision makers, this means understanding how to enhance economic growth while minimizing the environmental footprint of production activities.

Sustainability science aims to anticipate problems and promote innovation. In one pilot project, EPA is working with community planners to develop a master plan for the sustainable revitalization of Stella, Missouri, which was chosen as a pilot for the Ozark Mountains area. At a May 2007 town-hall meeting, local citizens enthusiastically approved the final plan, which captures demographic and land-use changes and presents criteria for sustainable development. A local newspaper editorial proudly noted, "Stella, Missouri, was given the opportunity to be a model for all the small communities in the USA." With the plan moving toward implementation, EPA is helping to establish a baseline of environmental variables to evaluate planning results over the next decade. The Stella example demonstrates how EPA—using its full science capabilities and planning tools such as SMARTe—is helping local communities address important sustainability issues. Using EPA models like Integrated Climate Land Use Scenarios (ICLUS), EPA is working with communities to assess current trends and evaluate impacts of future-growth scenarios.

Climate change may seriously affect future land-use practices, particularly in urban environments. For this reason, Table 1 includes the Global Change Research Program as an EPA program affecting urban sustainability. Under this program, the ICLUS project is developing scenarios for land use, housing density, and impervious surface cover for the coterminous United States for each decade through 2100. These scenarios will be based on the Intergovernmental Panel on Climate Change (IPCC) Special Report on Emissions Scenarios (SRES) social, economic, and demographic storylines. These scenarios assess the effects of changes in climate and land use across the United States and identify areas where climate/land-use interactions may exacerbate impacts or create adaptation opportunities. Demonstrating efforts to integrate across programs, these scenarios will use the USGBC's research to help determine the national-scale benefits of different levels of smart growth. The Better Assessment Science Integrating Point and Nonpoint Sources (BASINS) model that EPA will release in late 2007 will include ICLUS scenarios, allowing users to consider the impact of changes in both land use and climate on water quality (USEPA, 2007a).

Looking ahead, EPA can be effective in helping a variety of decision makers (such as investors, realtors, and local governments) meet regulatory requirements and promote economic development. One area of significant investment is in water and wastewater treatment facilities. One major potential consequence of climate change relates to the impacts of storm events on wastewater-collection systems or combined sewer systems (CSSs), which are designed to collect municipal wastewater and stormwater runoff in a common transmission system (sewer). Under dry conditions, the CSSs transport municipal wastewater and during storm events they also transport stormwater. These systems are prevalent in older cities, particularly in the Midwest, the Great Lakes, and the Eastern United States. CSSs can overflow if they lack adequate capacity to transport the combined volume of municipal wastewater and stormwater during extreme or frequent storm events, resulting in combined sewer overflow (CSO) events. Municipalities that are served by sanitary sewer systems can also be affected by storm events due to infiltration and inflow of stormwater, depending on the age and integrity of the sanitary sewer system. The additional flow in the sewer systems can exceed the capacity of the collection system, resulting in release of untreated wastewater through sanitary sewer overflow (SSO) events. CSOs and SSOs can lead to uncontrolled releases of high concentrations of pathogens, inorganic and organic contaminants, sediments, and solids into the environment. As a component of the NPDES permitting process (see Table 1), communities must define mitigation measures to reduce CSO incidents.

What makes all of this so interesting is that current standards allow for four CSO incidents per year, a number that IPCC scenarios suggest will be exceeded given the likely future increase in intense rainfall events. At issue today is how to strategically invest billions of new dollars into developing more robust and sustainable urban water and wastewater systems. The answer is clearly related to developing an integrated urban sustainability approach that includes climate-change scenarios. The EPA is currently assessing how such climate change can impact future urban water and wastewater systems (USEPA, 2006a). Future planning should clearly link smart growth and low impact development with CSS designs.

Conclusion

It is not often that one can predict the future. But given the worldwide trend toward urban development and the projected extent of commercial redevelopment, any course of action other than sustainable urban development and green building design will have serious environmental consequences. The marketplace may drive a good deal of this kind of development. Sustainable urban systems are going to be increasingly linked to commercial and residential development, and the public is going to increasingly ask how such development supports a company's sustainability or social responsibility goals. The public will someday confront developers and retailers, who now advocate green policies in their supply chains and products, if their large urban footprint is increasingly damaging the urban ecosystem. By contrast, a new era of public and commercial investment can set high standards for building design and low-impact development. Urban shopping centers, residential complexes, and government buildings of the future can enhance water quality, protect downstream ecosystems, promote clean air, recycle products, educate the public, and sell products.

While history has shown that EPA's air, water, and land programs have each made significant contributions in their own areas, the environmental benefits from these initiatives can be multiplied by greater coordination and by a clear focus on sustainable outcomes. History also shows that, driven by current problems, EPA has moved incrementally in policies and research to integrate sustainability more broadly. The EPA is functioning as a "virtual agency for sustainability." We see this in the common objectives of many programs related to the urban environment. What is missing is an integrated approach. We postulate that EPA can more effectively achieve its core mission of protecting human health and the environment through a stronger commitment to policies, practices, and research that support sustainable development. In the case of the built environment, defining a set of common sustainability objectives and measures can create a strategic research and policy roadmap and maximize resources across programs. With a strong research focus and a clear policy roadmap, the agency can accomplish much more to advance environmental sustainability.

Authors' Note

The views expressed in this article are those of the authors and do not necessarily reflect official EPA policies.

Acknowledgement

We thank Heriberto Cabezas, Edward Fallon, Annette Gatchett, Verle Hansen, John Howard, Audrey Levine, Dale Madearis, Ken Sandler, and Ann Vega for their helpful comments.

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William Sanders was appointed Director of the National Center for Environmental Research (NCER) in October 2007 within EPA's Office of Research and Development (ORD). NCER's mission is to support high-quality research by the nation's leading scientists to improve the scientific basis for decisions on national environmental issues and to help EPA in achieving its goals. Prior to this assignment, Dr. Sanders served as Deputy Assistant Administrator in the Office of Prevention, Pesticides, and Toxic Substances. Between March 2004 and October 2007, he was the Acting Director of the Office of Children's Health Protection and Environmental Education in the Office of the EPA Administrator. Prior to assuming this post, Dr. Sanders was the Director of the Office of Pollution Prevention and Toxics, the Director of the Environmental Sciences Division at EPA Region 5, and as Deputy Director of the Water Division at EPA Region 5.

POLICY DEBATE

Response to How EPA research, policies, and programs can advance urban sustainability by Alan D. Hecht & William H. Sanders III

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Alan Hecht & William Sanders raise a profound question: Can an environmental regulatory agency with historic roots in controlling pollution implement sustainability? The probable answer is only with great difficulty, if at all. The basis for the authors' optimism remains a mystery, at least to this reader. While they are to be commended for asking the question, Hecht & Sanders disregard the formidable challenges involved and thereby reduce the chances for agency success.

The authors suggest that the potential exists for the U.S. Environmental Protection Agency (EPA) to serve as a "national environmental architect" by promoting research and innovation on urban sustainability issues. What do the authors mean by "national environmental architect" and what does "sustainability" mean in this context? Does it translate narrowly into the design of green buildings, or does it connote a transformation of our understanding of environmental protection and of the EPA mission?

If it is indeed the former, the rosy outlook of Hecht & Sanders can be more easily accepted. If the authors intend the latter interpretation, they have not dug deeply enough, failing to address inevitable resistance to change and how it might be overcome. What will be the role of leadership in articulating a new vision? How important will middle-management budget and resource-allocation decisions be? How will the agency celebrate its small wins to ensure building the necessary momentum? Will existing bureaucratic power relationships yield to reasonable changes? How does an agency find the time and resources to think, plan, and act for the long haul, while meeting daily pressures in the face of increased resource constraints?

Simply providing a list of EPA programs with brief descriptions, followed by an assertion that an already established Green Building Working Group (GBWG) will be successful in executing a strategy that consists primarily of programmatic integration will not do the trick. If organizational change is the goal, such transformation is not for the faint hearted. It requires strategy and political will. Moving from a media-based regulatory approach to a systems-based sustainability approach will not arrive as if by magic, absent requisite pain and effort.

Hecht & Sanders are correct in stating that "achieving sustainability in the built environment is not something EPA or any other agency can achieve by regulations alone." They then add that "the clearest immediate need is having a broad 'urban sustainability strategy' with clear goals and metrics." The concept of "urban" is never quite defined. However, that aside, the authors add that in light of the extent of urban development and building redevelopment, EPA may serve as a "nationally recognized environmental architect." But how will this occur?

They recommend the importance of goals and metrics, and they are useful. Touting their value leads one to ask to what extent they have been employed historically in an agency driven by its regulatory regime. How important can we expect them to be in the future?

Moreover, goals and metrics are only a couple of the pieces of this complicated puzzle. Culture change requires strong and resourceful leadership with vision, extensive staff training and education, guidance documents, tools development, process improvements, and a talent for marketing showcase projects to counter business as usual. What of government tools that transcend EPA confines, such as tax policy and infrastructure investments? What kind of coordination and integration external to EPA might we expect?

It also takes time. Transformation is a multiyear process and, indeed, more than likely to be a multi-administration effort that will not play out in unilinear fashion. Fits and starts are inevitable with each new administration, pushes and pulls marred by power struggles between political appointees and more permanent staff. Will the organization have the stamina for this?

While posing a profound question, Hecht & Sanders are scant on complexity and the multiple challenges that will be confronted. An improved approach would begin with reporting on the lessons learned to date by GBWG and identifying what is needed to move beyond its current limitations.

A substantial body of work already exists with respect to disruptive technologies and discontinuous change, but these accounts typically center on the private sector. What insights might be gleaned from that context if those lessons learned were judiciously applied to the public arena where drivers for change tend to be less robust and with continuity often even more difficult to achieve?

Once the social learning aspects are adequately explored internally, along with the challenges and ways to overcome them, the authors might usefully move to society-wide questions of power relationships and confrontational struggle. Only then will the effort necessary to become a truly "national environmental architect" be fully appreciated. Or maybe Hecht & Sanders' sights are much more modest and limited to simply adding yet another program alongside EPA's already extensive repertoire. Would this more modest gain still be satisfying as a social improvement?

About the Author

Martin Bierbaum holds a PhD in Planning and Public Policy, a juris doctorate, and a Master's Degree in City and Regional Planning from Rutgers University. He held a range of policy positions in New Jersey state government between 1987 and 2004 including Assistant Director of the Office of State Planning, Director of Environmental Planning and Quality Management Coordinator at the Department of Environmental Protection, Special Assistant to the Commissioner for State Plan Implementation at the Department of Community Affairs, and Deputy Policy Director of the Governor's Policy Office. In 2004, Dr. Bierbaum was named Executive Director of the Municipal Land Use Center at The College of New Jersey. The Center receives federal and state funding to provide technical assistance, grants, and training to local governments to promote smart growth and sustainable development. Dr. Bierbaum was awarded the 2006 Distinguished Leadership in Planning Award from the New Jersey Chapter of the American Planning Association.

Sustainability: Science, Practice, & Policy
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POLICY DEBATE

Response to How EPA research, policies, and programs can advance urban sustainability by Alan D. Hecht & William H. Sanders III

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At long last, officials of the U.S. Environmental Protection Agency (EPA) offer a coherent statement on urban sustainability. Many policy makers, environmentalists, and denizens of urban communities across the nation will surely welcome this development. The guiding questions in the article are well crafted and are of critical importance. For example, as Alan Hecht & William Sanders contend, it would be wonderful if EPA could move the nation toward ecological sustainability, rather than simply pushing a command and control approach to regulation. I personally believe EPA should do both sustainability work *and* regulation. Unfortunately, the plan suggests that the latter is largely off the table. Regulation is not on the agenda because EPA operates under a framework that endorses rather than confronts the current political and economic system. Another guiding question that emerges from the plan concerns whether EPA can articulate and develop integrated practices that move beyond the agency's traditionally fragmented efforts at addressing pollution based on particular environmental media (i.e., air, land, and water). This also is laudable, but unfortunately is moot if the first problem is not addressed.

One reason why Hecht & Sanders' plan is not likely to achieve a shift toward sustainability is because it embraces sustained growth rather than adopting a creative approach to the very idea of economic growth. What I call the *economic growth imperative* is deeply rooted in capitalist cultures; it is a nearly religious mandate with an abiding expectation that markets must continue to expand because this process will naturally benefit all social strata. Whether it is Adam Smith, Milton Friedman, or Thomas Friedman, most luminaries who have had the ear of governments and media outlets over the generations have proselytized this market model. Again, why not think in a truly innovative way and get us past the growth imperative? Here I would invoke a bumper sticker displayed by a neighbor of mine that reads, "Change is inevitable, growth is optional." Instead of uncritically accepting the axiom that growth is inexorable and inherently good, why not consider "steady state" economic models aimed at maintaining markets in ways that provide for people's needs without increasing the volume of commercial activity above what is ecologically sustainable? And if we insist on growth, then how about growing something else? Why not consider qualitative growth paradigms that would strive for an increase in the number of healthy communities or healthy sustainable business practices and in income/wealth/social equality? A redistribution of existing resources (e.g., public dollars, land) might be a good place to begin. In a nation that spends more than 50% of its federal discretionary budget on military operations, yet has 450,000 brownfields, failing public school systems, 47 million people without health insurance, and the greatest class disparities in 80 years, a plan that enhances economic growth while essentially praying for ecological salvation will almost certainly increase strains on ecosystems and widen social inequalities (see Appleby, 2006; Gould, 2007; Ip, 2007).

The authors seem to miss the social and cultural factors that contribute to both ecological harm *and* sustainability. It is not clear whether the plan's green building-design initiatives recognize that the buildings need to be constructed and maintained in an equitable fashion—for example via contracts that are fair and open to women and people of color, by union contractors, in consultation with surrounding communities, and with an understanding as to how they affect the surrounding ecology and contribute to the community. In other words, what is it about green buildings (or any initiative in the plan) that could take us above and beyond a "techno-fix" approach to environmental solutions?

It is also striking that Hecht & Sanders give the impression that EPA no longer practices regulation. It appears that the agency has decided to adopt an "all carrot and no stick" stance on environmental protection. Building on the troubling trajectory of the Reagan, Bush I, and Clinton years of deregulation and voluntary initiatives, EPA of today marches on, blindly confident that laissez-faire diplomacy will yield results. I defy anyone to show me how this would improve the nation's ecological systems. The plan reveals how EPA's WaterSense program relies on good faith, on voluntary methods for protecting and sustaining water quality. I live in a part of the country that is experiencing its worst drought in 500 years, yet the response has been little more than occasional timid public pleas for residents to voluntarily conserve water. It does not work. The ENERGY STAR program follows the same logic. This initiative began with a focus on computers and other electronics and has since expanded. The electronics industry is the world's largest and fastest growing manufacturing sector and is responsible for polluting watersheds, air, and land and threatens worker and residential health on an international scale. Voluntary initiatives have done little to temper the tide of this sector's globalized scorched earth practices (see Pellow 1999a; 1999b). What has worked are the sustained local, national, and global campaigns by nongovernmental organizations (NGOs) to pressure the industry into phasing out or reducing particularly toxic chemicals and adopting extended producer-responsibility protocols. And NGOs have had to act because governments like the United States' have refused to do so.

In short, Hecht & Sanders' perspective is virtually indistinguishable from the garden-variety environmental sustainability plan of any Fortune 500 corporation. Given that government has a primary obligation to regulate, control, and guide corporate behavior vis-à-vis the environment, this paradigm is disappointing indeed. Partnerships with corporations are fine as long as they do not substitute for regulation.

What is so problematic about these so-called voluntary approaches to regulation is that they assume that power is distributed evenly among stakeholders. More to the point, few people choose to live and labor under environmentally hazardous conditions. Many tribal communities and neighborhoods where people of color and working-class populations live face extraordinary pollution exposures associated with oil refineries, highways, and chemical-plant clusters. While some community leaders may welcome such public-health and ecosystem-threatening projects in the name of economic development, few residents do, and they are rarely fully informed as to the risks they will incur. So for EPA to adopt a voluntary approach to remediating environmental injustices that have been forced upon many populations is simply unacceptable.

While it goes without saying that EPA is just a single agency with a limited mandate and authority, the real problem here is the framework under which officials operate. That institutional context begins and ends with a commitment to sustaining market forces, not ecosystems and the communities that depend on them. The framework is explicit in ensuring that profit making will never be challenged in the interest of ecosystems or human rights. The organizational structure is also explicit in its deafening silence on the question of reversing the social and political inequalities that are, in my estimation, the root of the ecological crisis. And on that note, Hecht & Sanders display little sense of crisis or urgency. So there is no point in quibbling about technical details or how one might strengthen or reform a particular policy initiative, because the agency's overall mission and foundation steer clear of addressing the root problems in the first place. If EPA is unwilling to transform itself and raise these critical questions, I urge policy makers, environmentalists, and urban residents across the nation to stand up and take up that task, for all our sakes.

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About the Author

David Pellow is an activist-scholar who has published widely on environmental justice issues in communities of color in the United States and globally. He received his MA and PhD in Sociology from Northwestern University. His books include *The Treadmill of Production: Injustice and Unsustainability in the Global Economy* (with Kenneth Gould and Allan Schnaiberg, Paradigm Press, 2008), *Resisting Global Toxics: Transnational Movements for Environmental Justice* (MIT Press, 2007), and *Garbage Wars: The Struggle for Environmental Justice in Chicago* (MIT Press, 2002). Dr. Pellow is Professor of Ethnic Studies at the University of California, San Diego where he teaches courses on social movements; environmental justice; globalization; and immigration, race, and ethnicity. He is also the Director of California Cultures in Comparative Perspective, an international research initiative based at UCSD. Dr. Pellow has served on the boards of directors of several community-based organizations dedicated to improving the living and working environments for people of color, immigrants, and low-income persons.

POLICY DEBATE

Response to How EPA research, policies, and programs can advance urban sustainability by Alan D. Hecht & William H. Sanders III

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Alan Hecht & William Sanders provide an interesting contribution and certainly offer an impressive vision of the future of the U.S. Environmental Protection Agency (EPA). Their article illustrates a range of compelling initiatives and explains how these programs relate to urban sustainable development, a topic of utmost importance due to the fact that it is directly related to housing and mobility, the main activities driving environmental impacts (see, for example, Tukker & Jansen, 2006). The article concludes that many elements are in place for EPA to become a "virtual agency for sustainability" with respect to sustainable urban development, but that "an integrated approach" is missing.

So far, so good. It is indeed laudable that ranking EPA personnel have developed such thoughtful visions, see that environmental problems need to be tackled systemically, and want the agency to engage with such challenges. Yet, it is all too clear that admirable intentions—even among officials who occupy senior positions—are not nearly enough.

The work in the Netherlands of Elzen et al. (2004), Geels (2005), and others convincingly shows that achieving systemic change is tremendously hard. This truth holds whether we are considering a value-chain perspective (production and consumption systems) or a spatial perspective (urban or regional systems). The interrelations in system elements usually hinder improvement: one part cannot be modified without changing the rest. And mainstream approaches at the level of social practices are typically "molded" to macrolevel structures and developments beyond the reach of individual actors.

Let me provide a concrete example. As a cosmopolitan European, I am stunned every time I visit the United States and witness the extent to which primary transportation is organized around the automobile and the airplane. At home, I live quite contently in The Hague without even owning a car. My apartment is virtually atop one of the city's main railway stations, with trains to virtually any destination in the country every 15 to 30 minutes. In fact, using a car, enduring the frustrations of continual traffic, and having to find parking would be far more inconvenient than anything that I encounter as a regular user of public transportation. However, in most parts of the United States, even in the largest metropolitan areas, life without a personal automobile means a home-bound existence. Large detached houses, sprawling suburbs, and operationally bankrupt public transit systems perpetuate an autocentric life (though cities such as New York, Boston, and San Francisco provide instructive alternatives). Indeed, the small minority of Americans that forsakes automobile ownership carries a heavy stigma.

A few years ago, I had occasion to cross the border between Windsor (Ontario) and Detroit. The customs agents were astonished that a well-dressed man, claiming to be a scientist en route to a conference in nearby Ann Arbor, wanted to walk with a luggage cart into the United States. It jarred their mental picture, and they cross-examined me with disdain for over half an hour before finally letting me proceed.[1] "He's clean!" the customs agents told the boarder officer, a sure expression of my suspected criminal status—or worse.

These personal anecdotes of how systemic interrelations and social expectations determine individual transport choices are emblematic of more general circumstances—and it is astonishing that an urban sustainability strategy for the United States would fail to consider innovative alternatives to car travel. Systems theory makes very clear that once a dominant configuration is in place, its underlying parties will oppose change and vigorously protect their vested interests. And, usually, they will succeed. Change advocates typically have to start from scratch and do not have the institutional networks, the critical mass, and the access to resources that the main players have stockpiled. People who run the circuits in power

[1] I had the opposite experience in Japan. After a conference in Tokyo, I was due to travel to Thailand and arrived at the airport wearing old denim jeans and carrying a battered backpack. I could have hardly looked more suspicious. The Japanese customs officer smiled at me and gently asked if he could search my backpack. After a few minutes of rummaging around, he found my conference books, but nothing questionable. He smiled again, helped me to pack my belongings, and apologized for the inconvenience.

centers—be it Washington or Brussels—will have no difficulty confirming how assiduously lobby groups work to maintain the status quo. The automobile and petroleum industries are unparalleled examples of this phenomenon. Insurgents are usually only successful at the margins. In the environmental field, this implies implementing an end-of-pipe measure here, banning a totally unacceptable substance there, but nothing that stimulates truly radical change.

The present question is whether EPA can become a systemic change agent given the staunch opposition that the agency obviously faces. From a European perspective, I see little reason for optimism. Despite Hecht & Sanders' earnestness, the United States is not exactly well regarded for its contributions to the global sustainability agenda, particularly over the past several years. When unsustainable production and consumption was discussed at the 1992 Earth Summit, President George H. W. Bush famously announced that "the American way of life [was] not up for negotiation."[2] The current President Bush went out of his way to make sure that the Kyoto Protocol never received even passing consideration. The administration's primary policy objective has been to ensure access to critical resources, rather than to reduce dependency or to mitigate the country's large ecological footprint.[3]

Over the past several years, I have had the privilege of speaking with various EPA officials during trips to the United States. My impression with each subsequent trip was that the agency was becoming more restricted and its room to maneuver more delimited. I have great respect for Hecht & Sanders, but remain avowedly unconvinced that the present American political leadership is prepared to endorse a powerful, systemic, and unambiguous approach to resolving the country's (and the world's) sustainability problems.

So, sure, it would be wonderful if EPA could reinvent itself to become a "virtual agency for sustainability" and truly start programs designed to promote systemic improvements. However, the realization of this vision depends on EPA being granted political space that is currently not available.

[2] This frequently recounted comment is related in Vaitheeswaran (2004).

[3] As widely discussed in recent media reports, former Federal Reserve chair Alan Greenspan conveys this perspective in his new memoir, observing that the Iraq war has been largely about ensuring continued American access to oil.

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Dr. Arnold Tukker received his PhD in 1998 from Tilburg University and has worked for the Netherlands Ministry of Housing, Spatial Planning, and the Environment. He is currently the manager of Sustainable Innovation Programs at TNO, the Dutch research and public policy consultancy. He has published widely in the fields of life cycle analysis, industrial ecology, and sustainable innovation and has edited or authored several books including *Frames in the Toxicity Controversy: Risk Assessment and Policy Analysis Related to the Dutch Chlorine Debate and the Swedish PVC Debate* (with Judith Klostermann; Springer, 1999); *Partnership and Leadership: Building Alliances for a Sustainable Future* (with Theo de Bruijn; Springer, 2002); and *New Business for Old Europe: Product-Service Development, Competitiveness, and Sustainability* (with Ursula Tischner; Greenleaf, 2006). He is currently the director of SCORE! (Sustainable Consumption Research Exchange), a European Union-funded project to develop a research and policy network on sustainable consumption.

POLICY DEBATE

Rejoinder: How EPA research, policies, and programs can advance urban sustainability

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We thank the three reviewers for their thoughtful reflections on our article and would like to take this opportunity to respond to some of their comments.

Underestimating the Challenge

Martin Bierbaum highlights the formidable challenges we are addressing and asks if our vision is focused rather narrowly, as on green building, or more broadly, as on transforming "our understanding of environmental protection and the EPA mission." The answer is the latter. We see today's environmental problems as needing a systems approach. Organized along media lines, EPA faces the challenge of how to overcome its stovepipe mentality. From its historical roots, the agency has come a long way, as demonstrated in a recent article that one of us co-authored (Grossarth & Hecht, 2007). Our current *SSPP* contribution is intended to stimulate discussion and to provoke fresh thinking about the future of environmental protection, at least with respect to the urban environment. Our aim is to help move EPA to the next level.

Our article takes its lead from the current EPA Administrator Stephen Johnson, who has declared, "[a]ddressing the multi-dimensional environmental challenges of the 21st century requires a more holistic mindset, one that looks beyond today and toward achieving truly sustainable solutions for tomorrow." Because EPA's legislative foundation is based on separate laws dealing with specific media–land, air, water, and toxics–integrating across programs has become a big challenge. It is no secret that our article was composed when many Americans are preparing for a presidential election and debating national issues. We have sought to challenge ourselves as EPA managers to examine urban sustainability in an integrated fashion, as a means to stimulate innovative polices and to better coordinate EPA's many regulatory and nonregulatory programs.

As Bierbaum points out, we did not discuss the finer details of how such a transformation can happen. Our goal was instead to outline the need for a more integrated urban sustainability approach and to give examples showing where such integration is underway. By promoting an urban sustainability strategy and highlighting the work of the Green Building Working Group, we are challenging ourselves and EPA to address the integration of agency programs. We are optimistic because nearly all the programs identified in the article feature significant sustainability elements. Missing is the glue of management and the political will to hold them together. We hope that our contribution will raise public awareness and encourage a more integrated public policy response.

The EPA as an Environmental Architect

We are gratified that David Pellow judged that we "offered a coherent statement on urban sustainability," but our meaning may have been less than clear when we called EPA "the national environmental architect." Bierbaum, too, asks what we meant by this wording. We used this phrase to reflect EPA's role as an environmental leader and steward. Because EPA uses rules, regulations, voluntary programs, and public outreach to guide environmentally responsible and sustainable decision making, we indeed regard the agency as an "environmental architect."

Our idea is more clearly defined in EPA's new *Sustainability Research Strategy* (USEPA, 2007a). The *Strategy,* a roadmap for current and future administrations, articulates a clear vision:

> From the perspective of [EPA's] Office of Research and Development, the science of sustainability is developing the underlying knowledge base that allows decision-makers to make sustainable choices. For natural resource managers, this means how to manage our natural resources to provide maximum services today and in the future. For urban planners, this means how to build cost-effective and efficient urban systems that protect both human health and the environment. For decision-makers in industry, this means how to enhance economic growth while minimizing industry's footprint on the environment.

Our article provided an important example of EPA as an environmental architect in its role helping municipalities deal with climate-change implications for urban water systems (USEPA, 2006). A draft EPA study released for public comments in early 2007 demonstrates that rebuilding combined sewer systems in the Great Lakes region may not satisfy water-quality standards if their design fails to consider climate change. But the study also shows that the risks are manageable: city planners and water-resource managers can anticipate the effects of climate change and adapt their new designs to incorporate these effects. The draft EPA assessment thus provides timely information that can lead to more sustainable outcomes. Its results have already been shared with many mayors from Great Lakes cities and can offer concrete benefits to the 182 communities in the region that have combined sewer systems.

The insights provided by this EPA assessment will also be useful to other communities across the country that have combined sewer systems–some 770 jurisdictions with about 40 million people. These systems annually release 1,260 billion gallons of untreated sewage and storm water. An estimated US$45 billion or more in investment will be needed to redesign and rebuild these aging systems to attain water-quality standards. The EPA assessment will play a significant role in developing new systems that effectively protect water quality, aquatic ecosystems, and human health.

The EPA programs identified in our article feature many regulatory and voluntary activities that have demonstrated impacts on public behavior and the market place. A good example is the expansion of EPA's ENERGY STAR program to rate buildings and commercial plants (see ENERGY STAR, 2007). We believe that by linking these programs, EPA could have an even greater impact on public policy. Hence our focus on an urban sustainability strategy.

We are seeing the benefits of a more integrated approach to environmental issues in EPA's *Cooperative Science and Technology for Sustainability* (CNS) grants program.[1] Since 2004, this program has been enabling grantees to work together in exploring new approaches to environmental protection that are collaborative, systems-oriented, preventive, and forward-looking. CNS is a testing ground for scientifically based tools and approaches that can advance a sustainable future at a regional scale.

EPA created the CNS program to show how the agency can work across media lines. Several CNS projects have focused on urban sustainability, ranging from urban planning in Puerto Rico to designing watershed systems in Maryland counties. The CNS grants, and the processes that they generate, foster collaborative problem solving around key sustainability-related issues. In these projects, stakeholders with different economic and social interests work together to support efforts integrated across different media. We would argue that these activities are quite different from what Pellow calls a "garden-variety environmental sustainability plan of any Fortune 500 corporation."

Regulatory and Non-Regulatory Approaches

It is not clear to us why Pellow perceives that we assume growth is inevitable and inherently good, for we are not promoting an "economic growth imperative." We agree with his admonition to consider "qualitative growth paradigms that would strive for an increase in the number of healthy communities or healthy sustainable business practices and in income/wealth/social equality." However we certainly do not agree that "for EPA to adopt a voluntary approach to remediating environmental injustices that may have been forced upon many populations is simply unacceptable," or accept his assertion that "[u]nfortunately…regulation is not on the agenda because EPA operates under a framework that endorses rather than confronts the current political and economic system."

Over its history, EPA has applied four broad approaches to fostering environmental protection: (1) *Endorsing* encompasses polices that reward or encourage sustainable behaviors, such as EPA's ENERGY STAR and Design for the Environment programs; (2) *Facilitating* involves providing information, funding, or incentives to advance sustainable behavior, through such agency programs as Performance Track, as well as by providing consumer in-

[1] Previous and current CNS projects are described at USEPA, 2007b.

formation, monitoring energy and water use, and promoting its new stewardship initiative; (3) *Partnering* includes voluntary programs, such as EPA's Climate Protection Partnerships and a host of others, providing for collaborative problem solving; and (4) *Mandating* relates to enforcing legislation and executive orders (Grossarth & Hecht, 2007). Over time, and depending on its leadership and the nature of specific problems, the mix of these approaches changes. EPA must assess how it can best employ each approach in different settings to protect human health and the environment.

Looking Ahead

Urban sustainability is one element of a broader business and government sustainability agenda. Our article asks what role EPA will play in the future. While continuing to fulfill its vital regulation and compliance responsibilities, we believe EPA will need to assess how a regulatory agency created to address only pollution control must now face a new set of problems resulting from economic and population growth and increasing urbanization. This will be no easy task, but a necessary one for a healthy, prosperous, and sustainable environment. Our focus on promulgating a strategic plan is to promote public dialogue on these issues and to help shape EPA's efforts in addressing problems clearly defined by the American context and lifestyle.

Arnold Tukker notes the broad cultural differences between the United States and Europe in engaging with urban development problems. Our perspective values the four management approaches identified above, as well as collaborative work with local stakeholders, business, and government to achieve a different vision of the future. The timing is right for such a debate. We are looking ahead. Management expert Peter Drucker has said that "the best way to predict the future is to create it." Such is our intent.

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COMMUNITY ESSAY

SPIN-Farming: advancing urban agriculture from pipe dream to populist movement

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Author's Personal Statement:

I began advocating for urban agriculture in Philadelphia in 1998. What appealed to me is what draws many people to the cause: its social and environmental benefits are obvious and easy to understand. But it quickly became apparent that, compelling though they are, these benefits were not enough to motivate policy makers in a position to help urban agriculture succeed on any kind of scale. Instead, the economic benefits that many proponents had long acknowledged in theory, but few were able to demonstrate, had to be proven. SPIN-Farming is a very powerful tool for validating the economic viability of urban agriculture. However, while I had initially focused on solving some urban problems, it became clear that SPIN could also help to revive the farming profession, and this is where my professional background came into play. My working life has been spent helping entrepreneurs position, package, and promote their ideas and build them into successful businesses. In helping to develop SPIN, I applied that experience to farming. The big opportunities I see for SPIN-Farming are that it provides a farming concept that can be learned and practiced across all economic classes and geographical boundaries, and that it will foster engaged, rather than escapist, agriculture, whereby farmers return to cities and towns and rebuild local food systems that are human in scale and joyful in spirit.

Though social idealists in the United States and elsewhere have advanced the philosophical and moral imperatives of urban agriculture for decades, this has not been enough to motivate government and urban agencies to accord it the status and support of other industries. These circumstances have relegated urban farming to an add-on to not-for-profit "feel good" projects and kept much of its potential untapped. Recently, however, a different case for urban agriculture is gaining ground, one based on more practical concerns (for an overview refer to Mougeot, 2005).

Foremost among these concerns is that vast tracts of farmland continue to be lost to development. As suburban encroachment erodes the rural way of life, agriculture is having to adapt. For the first time in history, a majority of the American population is living in urban or peri-urban areas. As the United States Department of Agriculture (2000) notes,

> Urban agriculture is an alternative to what has been labeled conventional agriculture. However, it should not be considered solely an alternative means of producing food; it also is a viable adaptive function and response to urbanization. Urban agriculture is not so much an alternative to existing agricultural systems as it is an established branching of modern sustainable agricultural systems.

Second, more and more people want a direct connection to the food they eat. The reasons have become personal, not altruistic. Diet-related diseases, food-safety concerns, pollution created by transporting food great distances, water shortages, record heat waves, and extreme weather events are impinging directly on people's lives. And even when events do not have direct impacts, media coverage brings the damage very close to home and fosters a widespread awareness that today's most pressing problems are directly linked to the health of our food system. Increasingly, urban and suburban consumers want—and are willing to pay premium pricing for the opportunity—to know the face behind their food.

Third, growing numbers of policy makers are acknowledging the value of quality-of-life issues in attracting residents back to cities. Sustainability has gone beyond a buzzword and is now spurring specific plans for significant change in how cities function. Producing food for residents within municipal borders is a cornerstone of these plans. Some cities are considering, or have actually implemented, initiatives that require meeting a quota of their food needs through local food producers. This has very positive implications for commercial urban farming. The emerging consensus on climate change is also providing impetus to rebuild local and regional farming systems, and for supporting smaller, sustainable farms that are less energy intensive. People knowledgeable about cities, together with people knowledgeable about agriculture, are now beginning to recognize that commercial urban farming needs to play a role in the contemporary food production system.

While individuals in a position to help establish urban agriculture on a meaningful scale are at last finding the will and justification to do so, there is also, now, a way. It is called SPIN-Farming and it is the first method (1) to marshal the entrepreneurial benefits of urban farming; (2) to turn the challenges posed by urbanization to the farmer's advantage; (3) to make farming compatible with high-density population; and (4) to remove the two biggest barriers to entry for first generation farmers–land and startup capital. Urban agriculture therefore enables many more people to enter the farming profession.

SPIN stands for *S*mall *P*lot *IN*tensive.[1] The system was developed and is practiced by a Canadian farmer named Wally Satzewich who farms 25 plots located in residential backyards throughout Saskatoon, Saskatchewan. Satzewich's farming career began traditionally. He and his wife, Gail Vandersteen, initially started farming on an acre-sized plot outside of Saskatoon twenty years ago. Thinking that expanding acreage was critical to their success, they bought some farmland adjacent to the South Saskatchewan River forty miles north of Saskatoon where they eventually grew vegetables on about twenty acres of irrigated land.

After six years farming their rural site, the couple noticed that they were growing high-value crops like spinach, salad mix, carrots, and radishes in their backyard plot in town and low-value crops like potatoes, peas, and beans on their acreage in the country. This recognition led Satzewich to realize other advantages to subacre (less than an acre) farming in town.

In town, his irrigation system was the water faucet–he did not have to rely on fluctuating river levels. He and his wife comprised the work crew for his subacre plots; they did not have to depend on outside labor. The financials showed that, though the overhead costs of a subacre operation are a fraction of those for a large-scale conventional farm, their bottom lines were similar. It was at this point that Satzewich realized that a subacre farmer could earn significant income with a lot less stress and a lot less overhead and with much more certainty of success from year to year. Satzewich sold his farm in the country and his experiment in subacre city-based farming became the basis for the SPIN-Farming system.

What makes SPIN different from other "small scale" farming schemes is that it outlines a process for growing commercially on subacre land bases. Farmers need own little, if any, land. SPIN can be practiced on only 1,000 square feet, or it can be located on a half-acre of municipally-owned land, or it can be multi-sited on several residential backyards.

What also sets SPIN-Farming apart is that it requires minimal infrastructure and is therefore low capital intensive. Its major investments include commercial refrigeration capacity, a post-harvesting station, and a shed. Irrigation relies on the municipal water supply and the system consists of inexpensive garden hoses that can be purchased at most hardware or garden supply stores. The only mechanized equipment is a rototiller. Because of its subacre scale, labor requirements for a SPIN farm are minimal and can be readily obtained within a network of family, friends, or the local community.

In addition to its subacre and low capital-intensive orientation, what differentiates SPIN from other farming systems is that it ties crop production to specific revenue targets. Its revenue targeting formula is based on balancing production between high and low value crops, segmenting a farm into different levels of production intensity, and formulating market-driven planting plans. It also outlines specific workflow practices so that the farming operation can be managed like any other type of small business. So while other systems focus on growing techniques, SPIN outlines how to approach farming as a small business.

SPIN is also environmentally friendly. It is based on all-organic practices and its reliance on biological cooperation keeps operating overhead low. Most farm inputs are generated onsite and there is very little waste. In contrast to traditional large-scale agriculture's aim to produce predictable and uniform results from soils and plants, subacre farming unleashes a natural set of variables and is based on continual trial and error. SPIN farmers can be out constantly tending their plots and can be always vigilant to soil health and pest imbalance. Some of the main biological principles are: healthy soil produces healthy plants; natural resources such as water and biomass are meant to be conserved and recycled; and stable ecosystems are diverse. By respecting natural forces, SPIN demonstrates that the more sustainable a farm's agricultural practices, the more economically viable is its business.

The following points comprise the key concepts of the SPIN-Farming system:

- **Subacre land base**–SPIN transfers commercial farming techniques to subacre land bases. Farmers do not need to own much or any land to

[1] Further details about SPIN-Farming are available at http://www.spinfarming.com. See also, Ramsay (2007).

start their operations, and operations can be single or multi-sited.

- **Structured work flow practices**–SPIN outlines a deliberate and disciplined day-by-day work routine so that the wide variety of farm tasks can be easily managed without any one task becoming overwhelming.
- **High-road/Low-road**–SPIN distinguishes between different harvesting techniques. The high-road utilizes commercial refrigeration equipment; low-road harvesting does not.
- **High-value crops**–SPIN devotes most of its land base to the production of high-value crops, defined as those that generate at least US$100 per crop per bed.
- **Relay cropping**–SPIN calls for the sequential growing of crops in a single bed.
    - **Intensive relays**–Three to four crops per bed per season are grown.
    - **Birelays**–Two crops per bed per season are grown.
    - **Single relay**–One crop per bed per season is grown.
- **1-2-3 bed layout**–This term refers to the three different areas of a SPIN farm devoted to the different levels of production intensity.
- **75/25 land allocation**–This principle dictates how much land is assigned to the different levels of production on a SPIN farm. The aim is to balance production between high-value and low-value crops to produce a steady revenue stream and to target revenue based on farm size.
- **Farm layout**–SPIN provides guidelines for segmenting a land base into a series of beds separated by access alleys, which are small two-foot strips, just wide enough for a rototiller. An acre accommodates approximately 400 standard size beds, including the necessary paths and access alleys. SPIN can also be incorporated into more traditional approaches to land allocation.
- **Standard size beds**–SPIN utilizes beds that are two feet wide by 25 feet long.
- **Revenue targeting formula**–By growing high-value crops worth US$100 per harvest per bed, and by practicing intensive relay cropping that produces at least three crops per bed per season, SPIN targets US$300 in gross sales per bed per season. With 400 beds per acre, the maximum revenue potential is 400 beds x US$300 per bed per season = US$120,000 gross sales per acre. When farming is approached in terms of beds instead of acres, the result is a very precise idea of how much growing space can be utilized, and how that space can be managed to generate predictable and steady income.
- **Organic-based**–SPIN relies on all-organic farming practices. There are minimal off-farm inputs and very little waste.
- **Crop diversity**–A SPIN product line contains a much wider diversity of crops than most contemporary farming, with some SPIN farms producing over 100 different varieties and 50 different types of crops per season. However, SPIN also provides models that specialize in a particular crop.
- **Season extension is optional**–SPIN does not rely on season extension to expand production; however season extension can be used to push SPIN yields and income significantly higher.
- **Direct marketing**–SPIN bases crop selection on what local markets want. Being close to markets allows for constant product feedback and ensures a loyal and dependable customer base. "Grow what you sell, do not sell what you grow," is the SPIN farmer's mantra.
- **Mix-and-match multiple unit pricing**–SPIN's marketing approach is to pre-bag produce items and sell them at certain price tiers–for example, US$3.00/unit or any two for US$5.00.
- **Commercial refrigeration capacity**–SPIN calls for commercial refrigeration capacity because cooling crops immediately after they are harvested retains their quality which supports premium pricing. Refrigeration also provides control over the harvest schedule and allows for a manageable workflow.
- **Minimal mechanization and infrastructure**–SPIN's most important and costly equipment is a rototiller and a walk-in cooler or upright produce cooler. All other SPIN implements and infrastructure can be sourced at local garden supply or hardware stores.
- **"Home-based" work crew**–Supplemental labor requirements for a SPIN farm are minimal and can be readily obtained within a network of family, friends, and/or the local community.
- **Use of existing water sources**–SPIN relies on local water service or wells for all of its irrigation needs.
- **Low capital intensive**–SPIN farms have minimal infrastructure and minimal overhead to keep start-up and operating expenses manageable. The bottom line is little or no debt.

The intricacies of the SPIN system go far beyond what is outlined above, but this itemized list gives an idea of how SPIN can produce significant revenue from subacre land bases. Compared to a large-scale operation, a subacre farm can produce the same, or even greater, income, with much less stress and overhead and much more certainty of success from year to year.

Who is starting to practice this new spin on growing food? Some have been educated in other professions, or have had other careers. Some have home or community-gardening experience, while others have never had dirt under their fingernails. Some come from traditional farm families, but most do not.

SPIN farmers are refugees from unsatisfying jobs. Or they are seeking to balance their mentally demanding computer-oriented work with some purposeful exercise. Some people pursue farming full-time, others part-time. Some adherents have more money than they know what to do with, while others have less than they need. What unites them all is an ability to view and practice farming in a new way.

People who take up SPIN farming have a sense of idealism/romanticism, embracing independence and a pioneering spirit that is tempered by a pragmatic capacity for consistent effort. They recognize that cities are impulsive, boisterous, spontaneous, and competitive, while agriculture is plodding, tranquil, deliberate, and deferential. And they are capable of envisioning a world where for one to be right, the other does not have to be wrong.

Whether SPIN farmers establish their farmsteads in the middle of urban jungles or sprawling suburbia, they are all uniting behind SPIN to advance engaged, rather than escapist, agriculture. They are returning to the cities and towns that have segregated food production beyond their borders and are re-introducing the practice of intelligent, dedicated craft- and soil-based farming. They are making food production visible and palatable and galvanizing their neighbors around an activity that delivers both economic and environmental benefits. And they are bringing the well-documented redemptive power of agriculture to their communities in a commercially viable manner.

Examples of SPIN-Farming in practice include:

- A woman at the University of Minnesota who has created a subacre campus farm, sends emails about produce availability to people on her customer list each week, and harvests and delivers exactly what is needed to fulfill orders.
- A food co-op in Oklahoma City that is organizing a cooperative of local SPIN-Farmers so that it has a steady and reliable supply.
- A writer in Norfolk, Virginia, who has converted her backyard to subacre production to supplement her income.
- A woman in Kewanee, Illinois, who specializes in salad mix and sells via an email list.
- A man in Napa Valley who is redeveloping a mobile home trailer park and is incorporating SPIN-style farm plots into the individual residences.
- A woman who is redeveloping eight acres on a housing project in Milton, Florida, which sustained extensive hurricane damage, incorporates subacre SPIN-style farms to help residents generate income to offset the cost of their homes.
- A semiretired man in Zanesville, Ohio, who is farming a quarter-acre backyard and selling at the Muskingum County farmer's market.
- An urban farming organization in Buffalo, New York, that is using SPIN to convert 2.25 acres of vacant lots to a sustainable farming operation that will sell commercially as well as provide free distribution to low-income neighborhood residents.
- An immigrant senior center in Edmonton, Alberta, that is using SPIN to create an urban farming training program for immigrant seniors.

SPIN-Farming has more possible applications for individuals as well as developers, planners, and nongovernmental organizations. By recasting farming as a small business in a city or town, SPIN is providing people with a tool for redefining farming for the 21st century–subacre, low capital intensive, environmentally friendly, close to markets, entrepreneurially driven. This trend is helping to undo the image of urban farming as an activity of last resort for the downtrodden and the disadvantaged. It is redirecting aspiring farmers away from traditional agricultural products that lose money and toward products that meet the needs of urban and suburban customers. And it is helping to accelerate the progression of urban agriculture from an elitist pipe dream to a populist movement that cuts across geography, generations, incomes, and ideologies to provide common ground, quite literally, beneath everyone's feet.

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Sustainability: Science, Practice, & Policy
http://ejournal.nbii.org

COMMUNITY ESSAY

Thresholds of sustainability: policy challenges of regime shifts in coastal areas

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Author's Personal Statement:

With a bang or with a whimper? A number of studies address this key question related to the ways in which ecosystems degrade. Our angle is slightly different. In this essay, we discuss what challenges the possibility of abrupt change poses to environmental policy. As a reference, we use the concept of an ecological threshold which describes how systems can change dramatically from one state to another. Environmental experts have recognized the usefulness of the concept. Both conceptual understanding and empirical evidence from different ecosystems suggest negative and irreversible consequences of trespassing ecological thresholds. However, large gaps remain regarding how to use the concept to prevent negative or enhance positive changes. This observation motivated our review of key features of the threshold concept in order to discuss its use in policy. We draw especially on studies describing European coastal areas. We conclude that, particularly because thresholds cannot be identified and legally defined once and for all, a continuous learning process is critical. We also stress that societies will have to develop diagnostics that support such learning processes.

Introduction

Despite all human efforts so far, the Millennium Ecosystem Assessment (2005) concluded that the viability of ecosystems is rapidly decreasing over almost all of the earth. What does this mean? Will the earth gradually lose its ability to support human life as we know it, as T. S. Eliot would have it, not with a bang, but a whimper? Or do we approach a point at which the earth's systems undergo a sudden irreversible change, the grand AH-WHOOM that Kurt Vonnegut described in *Cat's Cradle*?

If we believe in Eliotian change, we have time to act gradually–one problem can be addressed at a time and we can reverse the negative trends in the way, for example, that ozone-depleting chlorofluorocarbons are being phased out. If the situation is approaching the Vonnegutian AH-WHOOM, which is the concern of many climate-change experts, then humankind is in a much more precarious situation. We are facing a need to fundamentally change our management of the earth and its resources to reduce the risk of irreparable damage before we have evidence that a threshold had been irreversibly crossed.

Whether change is gradual or sudden, there is a need to take action. The continuing degradation of ecosystems, in conjunction with a lack of innovative solutions, has been attributed to inadequate resources for environmental policies and insufficient information to guide decision makers about how to best use the available resources. Convincing proof about potential monetary and other costs of environmental damages, or savings gained from preventing harm, has been identified as critical.

In addition to the economic consequences of adverse changes, the nature of the changes needs to be understood. If ecological thresholds, once passed, are difficult or impossible to reverse, the search for prevention is much more urgent than if we are faced with smooth, gradual changes. In this light, ecological thresholds may gain particular political significance. By ecological thresholds, we refer to the level of stressors at which there is a relatively abrupt change in ecosystem quality, property, or phenomenon (Groffman et al. 2006).

This essay reviews how the concept of ecological thresholds can support policy development. Our aim is not to provide an in-depth analysis of certain cases, but to discuss a broad range of issues that should be addressed in a policy context. In a sense, we explore under what conditions the notion of thresholds can be used to mobilize social transitions. We draw especially on studies describing European coastal areas, but our ultimate aim is to identify some general characteristics regarding the conditions that might enable the use of thresholds in policy development.[1]

The Many Facets of Thresholds

Due to various anthropogenic pressures, ecosystems may switch abruptly to new states, as demonstrated in a number of different ecosystems (Scheffer et al. 2001; Walker & Meyers, 2004). Ecological thresholds explain some of these dramatic changes. Although ecologists have explicitly studied ecological thresholds for three decades, the concept's foundations are much older (Hugget, 2005). One can, for example, argue that already Malthus (1826) envisioned an ecological threshold where crises develop as exponential population growth passes a linear increase in food production.

Because the goal of management is often to maintain the status quo or to facilitate smooth change, it is obvious that ecological thresholds are of considerable importance. Field observations, well-planned experiments, and improved conceptual models are needed to gain a sufficient understanding for purposes of practical and effective management (Muradian, 2001; Scheffer & Carpenter, 2003; Groffman et al. 2006).

Despite their intuitive appeal, it is difficult to define a threshold exactly. The common definition refers to the level of a stressor that triggers an abrupt change in ecosystem quality, property, or phenomenon. It implies that relatively small changes in environmental drivers can produce large responses in ecosystems (Groffman et al. 2006). In toxicology, thresholds refer to something slightly different. A central task for both human and environmental toxicology is to estimate the threshold concentration beyond which a toxic effect is likely to occur (e.g., Kroes et al. 2005). Environmental stressors, such as ionizing radiation and small-sized particles ($PM_{2.5}$), are often believed to have a linear dose-effect relationship with no threshold, while a specific threshold value has been identified and used for regulatory purposes for many organic contaminants and heavy metals. Recently, the concept of hormesis has also re-emerged in toxicological discussions (Calabrese et al. 2006). Hormesis refers to low doses that can have the opposite effect of high doses, such that chemicals that have harmful biological effects in relatively large amounts can have beneficial effects in small quantities. Accordingly, the hormesis level can also be regarded as a threshold below which beneficial effects emerge.

There are many related concepts. For example, the critical load (a quantitative estimate of an exposure to one or more pollutants below which no harmful effects may occur) is widely used (e.g., Skeffington, 2006) and corresponds closely to the definition of a threshold outlined above. The concept of novel ecosystems has recently been developed to deal with what may be the result of transitions after thresholds are passed (Hobbs et al. 2006). Bottlenecks, switches, tipping points, and breakpoints are other terms used in connection with changing ecosystems.

The following sections use thresholds in a broad sense to describe nonlinear changes that can be attributed to increasing (or decreasing) pressures. As is shown, the systems can respond in many ways.

The System Responses

Ecological thresholds do not just refer to sudden jumps in a time series. They imply nonlinear dynamics, with possibilities for alternative stable states, regime shifts, hysteresis, and points of no return. In practice, it is difficult to assess whether a certain dramatic change is caused by essentially nonlinear dynamics or by stochastic events. The consequences of passing an ecological threshold can, furthermore, be of different types. A change in the mean value of a variable is only one consequence. In other cases, the variances of individual system components may increase, or mass flows and functional relationships between system components may change. The ecosystem-health approach seeks to identify several variables that, taken together, would indicate a systemic shift from a healthy to a compromised system (Rapport, 2006).

Most of the reported structural changes in marine systems have been inferred from apparent step changes in the mean values of time series of observations. While a change in the mean value of a single component can be a simple and intuitive indicator of structural change, proper statistical testing of the existence of such a breakpoint is a nontrivial task that requires quantitative tools for separating random fluctuation from nonlinear change (Andersen et al. 2006; Matías et al. 2006).

It is important to note that a linear change in one set of variables does not necessarily mean that the whole system will behave linearly. For example, it seems that even though marine physical time series describing the North Pacific are characterized by linear behavior, the changes of marine biological time series are nonlinear (Hsieh et al. 2005). Whenever a system exhibits marked nonlinear behavior in va-

[1] The research on which this discussion is based was conducted in the context of the "Thresholds of Sustainability" project that was part of the European Union's Sixth Framework Programme. For further details refer to http://www.thresholds-eu.org.

riables of direct interest to humans, managers will have to pay attention to the possibility of sudden change. This situation calls into question the use of static interpretations of, say, maximum sustainable yield in fisheries.

Alternative stable states have been identified as one cause for relatively sudden large ecosystem shifts (Scheffer & Carpenter, 2003; Schröder et al. 2005). In these instances, the state of the system itself gradually approaches a threshold and then flips to a new state that is characterized by changes in the nature and extent of feedbacks in the system.

The concept of ecosystem health argues in a related way that sudden degradation of the state of a system occurs not as a consequence of a gradual change in a single pressure, but of the cumulative effect of a number of stressors leading to an ecosystem-distress syndrome (Rapport et al. 1985; Hildén & Rapport, 1993).

Even when trespassing a threshold suddenly changes system feedbacks, the resulting changes can be slow. Hysteresis refers to instances where there may be significant time lags between a pressure change and a corresponding change in an ecosystem. Hysteresis was originally used to describe physical systems that do not instantly follow the forces applied to them, but instead react slowly, or do not, with the passage of time, return completely to their original state. In some cases, the original environmental state can be reached after the change, but the return path is drastically different from the development that caused the altered state.

When a threshold has been passed, it may be impossible to recover the system's original state. For example, certain species can survive in a degraded environment for some time, especially if temporary conditions, such as the weather, are favorable. Eventually these species will, however, go extinct. This inevitability of extinction is what ecologists call extinction debt (e.g., Hanski & Ovaskainen, 2002). Extinction is perhaps the most fundamental ecological threshold and is usually seen as irreversible, a point of no return, even though it is in theory possible to reintroduce a locally extirpated species with the help of gene banks, zoos, or the introduction of individuals from elsewhere (see Caro, 2007). However, the loss of a species may drastically alter the ecosystem itself. Even if the species is reintroduced, it may not be able to establish viable populations because the ecosystem dynamics have changed.

Thresholds Are Not Fixed Points

Thresholds can be characterized as points or zones on an axis measuring the pressure on an ecosystem. Representing thresholds as fixed points that are constant over different places and times is, however, misleading because natural systems vary. Therefore, it will not be possible to determine an ecosystem breakpoint with the exactness of, for example, a toxicity test in which all variables except the stressor are kept constant.

Systems often shift gradually from one state to another rather than changing suddenly at a specific point (Huggett, 2005). An analogy can be found in the first and second order transition of physical systems. In a first order transition the actual threshold level, such as the boiling point of water, is exactly defined. In second order transitions only the definitive loss of characteristics, such as the loss of magnetism in iron as a consequence of heating, is well defined, whereas the process is distinguished by an accelerating change towards the loss.

Perception of the threshold depends on the timescale. Timescales relevant for everyday life or policy making may be much too short for certain regime shifts, such as some impacts of climate change that may transpire over hundreds or thousands of years. However, on geological or evolutionary timescales these changes are quite rapid. Other modifications, such as lakes that shift from clear to turbid, standing water that becomes overgrown by floating plants, or coral reefs that lose color, can occur within timescales that are easily grasped by citizens, policy makers, and journalists because they correspond to human scales (Adam, 1998; Lyytimäki, 2007). At the other end of the spectrum are changes that occur so fast that humans do not typically think of them as thresholds. For example, the succession of bacterial species in decaying organic material is likely to pass unnoticed. Due to this variability, studies describing ecological thresholds must be done at different temporal, spatial, and structural scales (Groffman et al. 2006).

Ecological Thresholds in Coastal Areas

Some examples of regime shifts in coastal waters are well documented, but many more have probably occurred, or are likely to occur, if pressures increase (Walker & Myers, 2004). Examples include regime shifts from early pioneer stage vegetation to late successional stage vegetation caused by enhanced nitrogen loss, sulfide toxicity and nutrient accumulation, and massive coral bleaching; the latter can occur for various reasons including exceeding an ocean temperature threshold (Adema et al. 2002; Bellwood et al. 2004; Graham et al. 2006).

Some of the mechanisms underlying regime shifts are reasonably well known. For instance, the loss of plant communities on the sea floor can be attributed to increasing nutrient concentrations that stimulate the growth of phytoplankton and epiphytic algae, and their expansion in turn shades seagrasses and macroalgae (Krause-Jensen et al. 2007b). Duarte et al. (2007) describe a threshold of light attenuation of 0.27 m^{-1}, setting a depth for seagrass in the Mediterranean.

Similarly, an analysis of a large dataset from Danish coastal waters demonstrates that the cover of macroalgal communities in deeper water decreases markedly along a eutrophication gradient (Krause-Jensen et al. 2007a). The analysis indicates that algal abundance initially responded slowly to increasing eutrophication, but showed a more marked response at nitrogen concentrations around 35-40 µM, indicating a second order transition.

Research has demonstrated that thresholds are not universal constants that can be linked to stressors, but depend strongly on context. For example, *Phaeocystis* colonies form recurrent high-biomass harmful algal blooms in the Eastern Channel and Southern Bight of the North Sea. These blooms develop in spring between the early spring and summer diatom blooms. The long-term diatom biomass and the spring dominance of *Phaeocystis* colonies over diatoms were determined by the combined effect of the North Atlantic Oscillation and freshwater and continental nitrate carried by the Scheldt (Breton et al. 2006). In this case, a nonlinear but monotonic relationship was found between *Phaeocystis* colony bloom magnitude and winter nitrate (NO_3) enrichment, though not for winter phosphate (PO_4) enrichment. This observation points to the key role of NO_3 in determining the height of *Phaeocystis* blooms. By contrast, in the Baltic Sea a vicious circle of eutrophication is largely driven by phosphorus loading (Vahtera et al. 2007). Springtime algal blooms fuel summertime phosphorus release from sediments, favoring in turn blue-green algae (Tamminen & Andersen, 2007). In this system, nitrogen fixation by cyanobacteria can be highly significant with up to 500 kilotons or more of nitrogen fixed. The contribution can thus exceed the total estimated mean riverine input (MARE, 2001).

In coastal and transitional waters one encounters systems that can shift between states and for which the health of any one state may be debated. The Ringkøbing Fjord on the west coast of Denmark clearly displays transitions that indicate thresholds (Håkanson & Bryhn, 2007). This lagoon's water salinity is driven by sluice management. From 1995 to 1997, a dramatic change took place because of a small change in water salinity due to the implementation of a new sluice practice. The ecosystem changed from a nutrient-driven turbid green water to a grazing-controlled clear water. This regime shift has major implications for ecosystem management (Petersen et al. 2005). The fjord is now closer to many environmental objectives, even though the improvements were not caused by a reduction of anthropogenic pressures, such as nutrient discharges. However, the southern part of the lagoon is designated as a Ramsar site under the Convention of the Wetlands and as a Special Bird Protection Area under the European Union Birds Directive. Several of the birds forage on the water vegetation, which has decreased dramatically. Return to the previous turbid green state would be an obligation from the perspective of bird protection, but would not be admissible under the European Union Water Framework Directive. This contradiction between nature conservation and environmental protection may eventually be solved by the gradual increase in macrophyte coverage.

Ecological Thresholds and Sociotechnical Transitions

Regulatory authorities, the public, and other actors tend to ignore information on thresholds due to economic interests, institutional barriers, or deeply rooted personal beliefs if a threshold of adverse change has not previously been reached (Hukkinen, 1999; Harremoës et al. 2001). This initial resistance against the very idea of thresholds must be overcome if the concept is to be of any use.

The notion of nonlinear change is not a recent idea. Most mythological tales and beliefs describe nonlinear dramatic changes in the state of the earth and heavens. Examples include the biblical flood, the Ragnarök of the Norse sagas, and the Ramayana in Asia. Nevertheless, human minds tend to revert to linear reasoning, intuitively trusting developments to be foreseeable and continuous. One way of overcoming the conflict between information on thresholds and the way everyday life is conducted is to demonstrate ecological thresholds through analogies and parallels. For example, displays of the consequences of algal blooms in water bodies distant from a target audience can increase awareness, but are clearly not sufficient to trigger action.

Despite numerous examples of the dramatic emergence of adverse conditions in coastal waters, the ability of the human mind and institutions to defy and ignore facts perceived as unwanted can efficiently inhibit, or at least delay, mobilization of preventive or corrective actions. For example, in the Gulf of Finland and the Archipelago Sea, local degradation of coastal waters was documented for many years, but only when the blooms of cyanobacteria became widespread, readily observable, and recurring was forceful action taken, not only by government but also by private firms. A special foundation was set up to channel voluntary donations aimed at reducing emissions from Russia by improving wastewater treatment plants (see John Nurminen Foundation, 2007).

It is becoming increasingly common to translate ecological information into monetary terms to increase the policy relevance of ecological insights. The success of the Stern Report (2006) on the likely financial impacts of climate change appears to confirm the effectiveness of this approach. However, although nearly all human economic activities ultimately depend on ecosystem services, the economic calculus can be a double-edged sword. In Belgium, a survey of beach users indicated that they were each willing to pay only €16.39 (US$23.19) per year for a program that guarantees a low level of foam caused by *Phaeocystis* blooms and only €8.40 (US$11.88) per year for an intervention that entails a middle level of foam (Longo et al. 2007). Thus, even if hypothetically a million beach users would benefit from additional wastewater treatment, the sums would be small in comparison with the costs. For example, the neighboring Netherlands invested the equivalent of €4.5 billion ($6.4 billion) between 1970 and 1994 in wastewater treatment (Kemp, 2001).

External costs and benefits generated by alternative land and water use in threshold situations can differ widely. It is essential to consider not only the direct losses associated with a change, but also time lags, uncertainty, and points of no return. Valuations of specific water-based environmental issues include the impacts of eutrophication, food-web disruptions, and hypoxia. Some valuations have also estimated the value of specific goods and services, such as recreation and carbon sequestration (Taylor et al. 2006). However, the sums are in many cases rather uncertain and are not always likely to provide a rigorous cost-benefit argument for the avoidance of thresholds. The maintenance of ecosystems in a healthy state is also a political and moral issue. Therefore, awareness and economic considerations need to be supported by legislation, rules, and norms.

Although rational arguments can be presented for management systems that avoid thresholds, it is not evident that societies and policies are capable of handling thresholds in any systematic way. In fact, shifts in rules, legislation, or norms often follow only after an undesirable ecosystem change. In some cases, ecological changes can induce profound sociotechnical transitions, fundamental nonlinear shifts from one dynamic equilibrium to another (Loorbach & Rotmans, 2006).

Sociotechical transitions are no less complicated than nonlinear ecosystem changes. They arise as a set of connected changes that reinforce one another but take place in several different areas and at various scales, such as macrolevel cultural changes, mesolevel institutional changes, and microlevel changes in beliefs and attitudes. For example, extensive media coverage in Finland of intensive algal occurrences during the summer of 1997 increased pressure to improve the monitoring and communication about algal blooms, both in the country's inland waters and in the Baltic Sea. As a result, in 1998 a nationwide monitoring program was launched that has provided the media with easy-to-use information (Lyytimäki, 2007). In this case, the intensive algal blooms were the trigger that, together with gradually increased public awareness about eutrophication, changed the social process (Peuhkuri, 2002).

The interplay between ecological thresholds and social system transitions can be described using the concept of panarchy, a term created as an antithesis to the word hierarchy (Gunderson & Holling, 2001). Panarchy views coupled human-natural systems as a cross-scale set of adaptive cycles that reflect the dynamic nature of human and natural structures across time and space. Sudden shifts in ecosystem states can induce changes in human understanding of the way the systems need to be managed. These modifications, in turn, may alter the institutions that carry out management and, as a result, prompt new changes in ecosystems. In these cases, the concept of thresholds is useful in policy, but only *post festum*–as a way to interpret an otherwise confusing situation and to understand and justify changes.

One way of understanding both ecological thresholds and sociotechnical transitions is to see them as periods when the intensity of changes is different from regimes previously and after (Adam, 1998). This concentration of changes can create possibilities to induce large-scale transformations. However, both sociotechnical transitions and ecological thresholds are characterized by many factors beyond human control (Meadowcroft, 2005; Shove & Walker, 2007). Even if the system is rapidly changing and transient, it is often very difficult to guide it along a particular trajectory. As Gallopin et al. (2001) argue, nonlinearity, plurality of perspectives, emergence of properties, self-organization, multiplicity of scales, and irreducible uncertainty are fundamental properties of complex socio-ecological systems.

Thresholds in Policy Implementation

Dealing with thresholds without convulsive change requires information on ecological thresholds in sustainability policy. It is a challenging task. First, although thresholds can be assumed to exist in many ecological systems, they are not universal in the sense that one could use them as a fixed reference in legislation. Second, even when there is compelling evidence of threshold behavior, it remains difficult to specify the level in advance. Prescient and reasonably precise diagnostics of an approaching threshold are needed in order to take precautionary action in time. Intervention that came too early could result in a waste of scarce resources. Third, it is difficult to communicate the need for mitigative action early and convincingly without being accused of "crying wolf."

What, then, are the key requirements for the thresholds concept to be useful in policy implementation and management of coastal waters? At an operational level, the following conditions can be identified.

1. Responsible authorities, the public, and other actors (including researchers engaged in the study of the systems) must acknowledge that the state of the system can change rapidly and that it can be costly or impossible to act after the apparent signs of degradation have been observed.
2. Estimates of the economic consequences of passing a threshold, as well as of managing the system to remain within the bounds of recognized thresholds, should be available.
3. A set of diagnostics must exist that can provide early warnings of impending losses in the healthfulness of the system before a threshold of dramatic change is reached, and spur an interest in monitoring actual system changes.
4. Organizations and institutions must be in place with the capacity and mandate to take action, but also to debate and (re)interpret research findings to maintain a learning process.

Despite the uncertainties, ecological thresholds, or assumed thresholds, are at present often translated into clear-cut and absolute limit values. Such procedures are an attempt to make threshold-like concepts amenable to systematic management and correspond to the first condition above. Environmental policy and law has introduced exact limit values for nutrient concentrations and various chemical substances, as well as for pressures such as toxic emissions. Although the threshold has not been used explicitly as a legal concept in European Union legislation on marine and coastal waters, many of its environmental standards and programs are implicitly based on assumed, but ultimately unknown, thresholds.

Quantitative estimates provide regulators and other authorities with rules to decide on whether certain actions or conditions can be allowed. Although these limit values are based on the best available scientific knowledge of potential ecological and health thresholds, significant uncertainties are often associated with the estimates. The challenge is that what appears a purely ecological or biological question can have significant economic and social consequences. The social cost can be rather high for such precautions as introducing large safety factors in the limit values to ensure special protection for sensitive areas or parts of a population (Hildén, 2006). In such instances, confidence should be reasonably high with respect to the appropriateness of such a legally binding limit value as compared with other management methods. The evidence that limit values are always appropriate is far from convincing (Assmuth & Jalonen, 2005).

Diagnostics are needed because thresholds are not constant and some ecosystems are more resilient than others. Standards, on the other hand, are generally fixed across a wide range of ecosystems. Furthermore, knowledge about thresholds is unavoidably incomplete. Responding to a risk of exceeding a threshold by strict precautionary actions is usually not politically popular, but management difficulties also arise if irreversible damages occur due to the neglect of incomplete or uncertain information. The legitimacy of a thresholds-based policy is thus dependent on the existence of reliable and commonly accepted diagnostics. It is highly unlikely that any single diagnostic would be adequate for this purpose. Instead, an ecosystem health-based approach that uses several sources of data to discern adverse change is more appropriate (Rapport, 2006).

Diagnostics on approaching thresholds are, of course, useless unless an institutional actor is empowered to take action. This situation places demands on the organizations that are created to manage ecosystems. For example, in the European Union the Water Framework Directive and the future Marine Strategy Directive play key roles. Such legislation has to address two fundamental questions related to thresholds. First, how can "good environmental status" be specified? Second, what action should be taken to avoid slipping from good to moderate status or to return from moderate or worse to good?

Answers to these questions must be part of management strategies, which must assess measures in terms of economic feasibility and political acceptability. Assessment and evaluation frameworks are being developed to take into account specific results and tools that make the systems manageable. They include:

- Methods for devising quality indicators and identifying thresholds and points of no return (e.g., Austoni et al. 2006).
- Methodologies supporting socio-economic assessment of externalities in the presence of threshold effects (Taylor et al. 2006).

- Examples of drivers and sources of pressures that may be associated with threshold effects (e.g., Vasas et al. 2007).
- Examples of avoidance and mitigation measures aimed at influencing drivers to reduce pressures to levels that minimize the risk of exceeding thresholds (e.g., Duarte et al. 2007).

Single measures are, however, not likely to solve the problems related to thresholds. Measures must be integrated into packages, taking into account that they interact in several ways: in some cases they are substitutable and in other instances a more pluralistic strategy is needed. If positive synergies between measures are in place, the final effectiveness of a combination of measures could even be higher than the sum of the individual measures. In all situations, there is a need to build in mechanisms to ensure learning opportunities. It is not possible to assess in advance the effectiveness of all measures and their combinations. Therefore, thresholds management must be part of ongoing feedback processes that make it possible to revisit fundamental assumptions about the relationships that constitute socio-ecological systems.

Concluding Remarks

The concept of ecological thresholds is essential in alerting users of natural resources to the risk of irreversible changes and in demonstrating the challenges in changing adverse conditions to acceptable ones. The concept is not, however, without problems. The difficulties in identifying thresholds, the lack of suitable indicators, and the deficiencies of externality valuation in thresholds situations are some factors that complicate the concept's use in a policy context. Ecological thresholds related to a certain system can have large variations because of the interactions between external and internal changes and pressures. There is a need to understand the diversity of systems and the variability in them (Håkanson et al. 2007).

Although several examples serve as warning signals, the assumption that ecosystem responses to pressures are often nonlinear has not yet been extensively reflected in policy making. One reason is that the evidence has not yet been validated on a sufficiently large scale (Lindenmayer & Luck, 2005; Groffman et al. 2006). Research on ecological thresholds has so far concentrated mainly on the characteristics of possible thresholds. Further case studies and conceptual research are clearly needed to critically examine the existence and attributes of such limits, as well as to formulate advance diagnostics to identify them.

Research on ecological thresholds will improve policy making only if we are able to identify and implement better methods of interaction between scientists and decision makers. It is not only a question of efficient consultation, but also entails selecting understandable indicators, visualizing the data, conveying insights to intended target groups at the appropriate time, and evaluating the effects of communication. The question is also one of conducting research that can produce answers relevant for policy making in the first place and that can convince decision makers early in the maturation of a particular problem. One-way communication from scientists to decision makers is often insufficient to achieve this objective (Clark & Dickson, 2003). Interaction among different stakeholders is needed to find policy-relevant research questions, to guarantee the timeliness of communication, and to ensure that the key messages are understood and acted upon in an appropriate way.

The role of the media can be critical in learning to live and deal with thresholds. Public attention is an increasingly important factor influencing thresholds information in policy making. Without substantial media consideration new (or even old) issues are unlikely to gain the political traction to mobilize the resources required to implement possible solutions (Hannigan, 1995). However, not all issues highlighted in the media are warranted. Intensive media attention can be devoted to true warnings or false alarms and there is no definitive way to separate them (Mazur, 2004). Research focused on identifying ecological thresholds can help at times to distinguish between legitimate concerns and more illusory ones, but it is naïve to expect that this information will be treated in an undistorted way in the media.

There is currently a mismatch between the way that scientists formulate problems and the way they are construed by policy makers (e.g., Turnhout et al. 2007). While the scientific community tends to address specific questions, policy is driven by broad issues and more general concerns. To avoid this incongruity, it seems necessary to involve all key stakeholders from an early stage in the policy-development process. Furthermore, all relevant data should be available and communicated in a clear and accessible form, including information that highlights the uncertainties associated with the scientific evidence. The role of scientists when assisting policy development should be to provide the best evidence available to inform the development of the policy, to help to monitor the effects of current policies, and to provide solutions to unexpected events and policy failures.

Several attempts have been made to develop a common language between the natural and social sciences to incorporate ecological indices into policy processes and to add humans into the "equation" (Hughes et al. 2005; Groffman et al. 2006; Turnhout et al. 2007). The translation of research into usable policy information and the rendition of policy into specific research questions remain, however, challenging tasks.

To summarize, evidence is accumulating that threshold behavior chacterizes many systems, but this does not mean that thresholds are found in every system or in every situation. Even when they exist, it remains difficult to identify them and to predict when the critical limits are likely to be reached. But based on our current knowledge of ecological thresholds, the poet T. S. Eliot was not completely right. While many systems may change with a whimper, others can undoubtedly change with a bang or with a grand AH-WHOOM. Humankind should learn to cope with this possibility.

Acknowledgement

The European Union, under contract number 003933, supported this study. The authors are grateful for information and insights provided by Professor David Rapport and several members of the Thresholds of Sustainability project, and for the comments by anonymous referees and the editors of *Sustainability: Science, Practice, & Policy*.

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BOOK REVIEW PERSPECTIVES

Jan-Peter Voß, Dierk Bauknecht, & René Kemp (Eds.), *Reflexive Governance for Sustainable Development*

Edward Elgar, 2006, 480pp, ISBN: 9781845425821

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The environmental challenges of the 21st century are novel and ever varying. It is easy to hope for technological change to meet them, and technology is providing powerful tools to do so, and will undoubtedly provide many more. But without implementation technology is useless, and this requires effective governance. For some, it may be axiomatic to fall back on top-down, modernist governmental methods, such as mandates, to move toward sustainability, but, as the editors and contributors of *Reflexive Governance for Sustainable Development* argue, this will not meet today's complex challenges. Strategies of reflexivity are crucial and are predicated upon constantly reacting to change, minimizing unintended side effects, and responding to the initiatives of multiple stakeholders. In 16 chapters by experts from across Europe, *Reflexive Governance for Sustainable Development* explores strategies, policies, and programs that may help move us through an era of uncertainty.

This book can be loosely divided into two sections, the first largely discussing theory, the latter dealing with practice, although, of course, the two overlap. The theoretical part can be slow going, abstract, and replete with jargon. This is the devilish riddle of governance theories; they are needed to get anything done, but when removed from empirical application come across as slippery and esoteric. Fortunately, the latter part of the book puts meat on the spectral skeleton of the former, discussing such issues as sanitation, biodiverse agriculture, and biorefineries.

The early chapters discuss the increasing obsolescence of modernist notions that a small group of experts can identify a problem, figure out the best solution, and regulate it out of existence. Such a theory of governance was always suspect, and regarding sustainability is even more so. Rather, the authors argue, "[U]ncertainty and ambivalence are features of the operation of sustainability" (p. 424). Centralized, regulation-oriented governance gains inertia as it moves toward a target, ignoring the many unexpected consequences and altered circumstances in its wake. With numerous interest groups and stakeholders taking part in the discussion, and given the small scale and localized nature of crucial technology, sustainability will require radically different thinking from the customary. Sustainability blends two astoundingly complex and unpredictable metasystems: human governance and the environment. As such it requires a new governance paradigm.

Yet, the book, while attacking modernist certainty, avoids rehashing a vulgar deconstructionism in which meaning breaks down in an endless process of self-subversion. As Ulrich Beck explains, "[T]he post-modern idea proves inadequate. It explains, indeed, why the old ways of perceiving modernity are no longer valid; but it does not even pose the question as to what concepts we need in order to describe, to analyse and to make ourselves masters of the new realities" (p. 35). This observation, however, risks repeating the modernist fallacy of mastery. In doing so it points to the precarious position of theories of reflexive governance: they must acknowledge how much we do not know while at the same time leading to action.

Voß, Bauknecht, & Kemp cover some of the strategies that are only beginning to be employed. Key among these novel interventions is the ability to reflect upon an action's consequences, not just initially but continually, and hence to change governance strategies to react to unfolding events and accumulated experience. As the authors explain, reflexive governance is "geared towards continued learning in the course of modulating ongoing developments, rather than towards complete learning and maximisation of control" (p. 7). In other words, reflexivity is always provisional, employing such techniques as iterative learning, feedback loops, and meta-analysis as methods of continuous learning. A related principle is to draw in a large number of stakeholders to ensure as much as possible that a vast number of interests and opinions work—directly or indirectly—toward a set of goals loosely organized under the rubric of sustainability. Granted this may be like herding cats, but there are ways to encourage cats to move together, and even to employ the grace, speed, and independence of individual cats.

Transition management, scenarios, risk management, and niche-based approaches are key strategies discussed in the book. Such interventions aim to provide some guidance and predictability in an increasingly volatile global situation. Reflexive governance must thus be implemented on a number of scales at once, from global to local, with the ongoing lessons shared as much as possible.

It merits noting, however, that reflexive governance is not as novel as the foregoing discussion might imply. Various versions of it have been occurring, albeit in partial and provisional ways, for quite some time. So John Grin points to arguments that "the most successful cases of planning have been those in which government has subtly shaped the market, not only through regulative interventions, but also through creating the societal conditions under which the market might operate" (p. 73). Adrian Smith makes a fruitful comparison between the alternative technology movement of the 1970s and current reflexive approaches, showing the former as grassroots, individualistic, and even rebellious, while the latter is a far more policy-minded movement toward similar goals. Reflexive governance, though it might seem pedestrian and bureaucratic, spreads and implements seeds sown by earlier, more revolutionary movements. Indeed, a number of chapters show how activities such as wind power and sustainable sewage, begun with a small-scale, individualistic orientation, have since diffused via very different policy-oriented processes.

The book could have done more to examine long-term precedents. It would have been interesting to include further discussion of what ways such historical developments as early capitalism, the American experience with representative government and checks and balances, and Keynesian economic principles, to name a few, could be construed as forms of reflexive governance and in what ways they failed to meet the necessary criteria. The volume does, nevertheless, supply some strong contemporary examples of reflexive governance. Many chapters explore specific forms with wide implications for the whole approach. For instance, a study of adaptive management in Hungary's Tisza River Basin shows the unpredictable consequences to which policy makers must be prepared to adapt. The chapter's authors point out that modernist assumptions about human ability to control nature have been undermined by "a series of surprising, catastrophic collapses of regional fisheries, agriculture and forestry in the twentieth century" (p. 134). Indeed, the Tisza River Basin's system of dikes has failed repeatedly, while increasing floods have "created a race to raise and reinforce the dikes higher than the next major flood, but the history of dike failures shows how re-engineering the defense system could never catch up" (p. 138). While managers have concluded that protective infrastructure by itself is not enough to manage the basin, the opposite solution, a return to an idyllic past in which nature manages itself, is also unworkable. The basin remains an experiment in management with adverse consequences for every mistake, a microcosm of what is occurring at the global level, though with its own intricate idiosyncrasies.

Reflexive governance, then, remains a work in progress. In their conclusion, Voß, Bauknecht, & Kemp discuss a profound problem, namely that the break up of linear decision making may lead to paralysis. Referring to this dilemma as the "efficacy paradox," the authors suggest that the interplay between questioning and making decisions is never-ending, that getting the balance right is critical, but that there are no hard rules for finding this balance. The process is a slippery one, and practitioners searching for definitive guidelines will find this book frustrating. The authors even admit that "this book is a first outline of a new theoretical perspective that may look rather 'impressionistic'. It may even fail to impress" (p. 436). Yet getting reflexive governance right will be critical. It is, in part, a movement into the unknown, filled with trepidation but also with hope, bolstered by an awareness of our own limitations, a humility that we must learn to use as an asset.

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