Industrial ecology: Moving beyond technological innovation to culture change[1] (#1)[2]

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Abstract

Besides providing concepts for much improved production systems, industrial ecology can also guide a transition to sustainability by changing key cultural beliefs and norms. More efficient production cannot alone alter unsustainable patterns of consumption. Sustainable consumption requires a shift in cultural values and beliefs. Extending the ecological metaphor that shapes the field to incorporate complexity can interrupt and shift what are now normal, but unsustainable, practices.

The general theme of this conference is transitions toward sustainability. We have heard how industrial ecology can be used to create new technologies and new institutions that are more consistent with what most people call sustainability or sustainable. This kind of innovation is very important to a transition, but, in my opinion, is insufficient. Anticipating what I will discuss, almost all the work reported here and in the greening world, in general, is aiming at reducing unsustainability, that is, the loss of resiliency and functions of the global cultural and natural worlds. In reality, these two large domains, often described as two distinct worlds, are but a single, organic, holistic complex system, with no inside or outside, like the Klein bottle in the slide. (#2). In a few moments, I will define sustainability as a property of this combined complex world, and argue that it will take a deep-seated cultural transformation to bring forth sustainability. Unless the structure on which culture rests is dramatically changed, we are doomed to continue along the present path leading, many say toward a collapse of the world system. Malthus may have been wrong in terms of the only world he could imagine, but his notions still apply to a now very full Earth.

Most efforts to stem the tide of unsustainability have come in some form of eco-efficiency. Industrial ecology offers general principles for substantial improvements over historical industrial development patterns. Life-cycle analysis (#3) and now life-cycle management find opportunities for material and energy savings and for risk reduction going backward into the supply chain and forward through the use and recovery stages. Industrial symbiosis (#4) extends the single product life-cycle focus to a cluster of facilities exchanging materials and energy. Improvements in efficiency of the order of factor four or so seem reasonable, but not as much as factor 20 or more, as some suggest is necessary to avoid a disaster. The resultant remedies are

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[1] This lecture draws on Ehrenfeld, J. 2008. Sustainability by Design: A Subversive Strategy for Transforming Our Consumer Culture. New Haven, CT: Yale University Press.

2 The numbers with the hashmark refer to the slides that were used with the presentation.

designed to reduce the intensity of human interactions with the environment to a level that will maintain its resiliency. These themes of industrial ecology address only the symptoms of unsustainability.

Although climate change has taken center stage, sustainability has a human as well as an environmental dimension. Industrial ecology with its historical focus on technology has, perhaps, less to offer to the human dimension, but still can contribute by adding new systems-based concepts to the melange of beliefs that underlie our social processes and individual actions. To reveal these useful ideas within industrial ecology, I have, first, to identify the elements of the current culture that are creating unsustainability.

The origin and refractoriness of unsustainability can be attributed to many causes but two stand out to me as foundations: 1) the scientific mindset of modern cultures and 2) the hegemony of technological and technocratic solutions to virtually all individual and collective problems. Since the time of Descartes and even earlier, we have viewed the world as existing out there, separate from the mind which stores and manipulates images of that external world. The basic existential model of modernity is a contemplative human subject (#5) gazing on and thinking about an external, objective world. Our visions, images, reflections, and thoughts about this world form the foundation for what is frequently denoted as "objective reality": objective in the sense of "objects" or things fixed in time and space, and objective in the sense of pure or true representations of those things, unfiltered through the subject's misperceptions.

At the most general level, this view attempts to understand reality by separating the immediate perceived world into pieces, each of which can be described by fixed rules of behavior, whether the object at hand is part of the inanimate world or is a living organism. Our current practices are still surprisingly close to those of René Descartes, who proposed them in 1637. Descartes was "…seeking the true method for arriving at the knowledge of everything of which my mind would be capable." Two of his four methodological axioms are, "The second, to divide each of the difficulties I would examine into as many parts as possible and as was required in order better to resolve them. The third, to conduct my thoughts in an orderly fashion, by starting with those objects that are simplest and easiest to know, in order to ascend little by little, as by degrees, to the knowledge of the most composite things, and by supposing an order even among those things that do not naturally precede one another."[3]

The consequences of adopting this way of discovering how the world works are profound. Out of Descartes' musings come many of the belief and norms that drive action in modern cultures. According to this model, the world is a mechanical system, composed of many interacting, but separable parts. Further, we can know how the whole system works if we know how each of the pieces works. (#6) The various parts are handed out for study to the myriad of disciplines that populate the academia. Each discipline or sub-discipline can learn only about a minute part of the world and, then, cannot communicate its knowledge to others who do not speak in the same tongue. Even in our own small field we have several distinct sub-disciplines,

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[3] Descartes, R. 1998/1637. Discourse on Method and Meditations on First Philosophy. Fourth Edition. Translated by D. Cress. Indianapolis: Hackett Publishing Company. p 10-11.

for example, life cycle analysis, material flow accounting, environmentally extended input-output analysis, or industrial symbiosis

The scientific method that follows from the Cartesian duality places the observer apart from and outside of the system being examined. Further with roots going back to ancient history, the reality revealed by the method is timeless and acontextual; it exists outside of our mental processes and the place from which we observe. We eventually, without being conscious of our stance, see ourselves as disconnected from the natural world and unaware of its critical role as a life support system. The Cartesian method alone, apart from any other basis for placing humans apart from other species, creates anthropocentrism, putting us at the center of everything, much as pre-Galilean astronomers placed the Earth at the center of the cosmos. When focused on human beings, Cartesian reductionism transmutes into individualism. Each human being becomes an atom embedded in a culture, but acting independently. Reductionism in its several forms is the first root of unsustainability. (#7)

The context-free reality of material objects in the world spills over to "objects" of human construction (#8), such as beauty, love, flourishing, or health—which concepts are among the most important ends of human strivings and shape the meaning of sustainability. As I will note below, the apparent materiality of these important normative qualities appears to us as something we can measure, acquire, and have. This process of reification or materialization is the second root. (#9)

The absolute, unquestionable sense of this form of reality produces authoritarianism and domination, (#10) both of which contribute to unsustainability in human terms. Humberto Maturana, a Chilean biologist, has argued that our reductionist, Cartesian view of reality is the most central and critical issue facing humanity. He argues that in the system of objective reality, "a claim of knowledge is a demand for obedience."[4] It is most ironic that the Enlightenment belief that reason would free humankind from the tyranny of dogma has created its own form of domination. The idea of objective reality and its associated "truths" is the third root of unsustainability. (#11)

Another indirect consequence of Cartesian thinking is the dominant economistic view of humans as a bundle of insatiable needs, operating a maximization calculus on a "computer" in the mind. (#8) Economists gloss over the source of these needs and invoke a mysterious criterion--preference or utility. The reductionist scientific method is inadequate and imperfect when we try to understand ourselves, and fails to describe much observed human behavior unless severely qualified. For example, Herbert Simon's notion of bounded rationality arguably explains why actors behave in ways that are not deemed "rational" by observers.

Mainstream economists and other scientists have been criticized as suffering from the fallacy of misplaced concreteness[5]. This fallacy, named by Alfred North Whitehead almost one hundred

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[4] Maturana, H. R. (1988). "Reality: The Search for Objectivity, or the Quest for a Compelling Argument." Irish Journal Of Psychology **9**(1): 29.

[5] Whitehead, A. N. 1925. Science and the Modern World. New York: Macmillan.

years ago, involves the presumption that an abstraction derived from worldly observations is the same as its reality, thus, leading thinkers and dsigners to make errors concerning the real world. The centrality of the fundamental abstraction of economics, Homo economicus, coupled with the hegemony of economics in the world of normative policy making, has produced a culture driven by consumption.[6] This model of human behavior is the fourth root of unsustainability. (#13)

The poverty of this model of human Being has not gone unnoticed.[7] The eminent psychoanalyst Erich Fromm wrote more than 30 years ago in his prescient book, To Have or To Be, that, "The first crucial step toward [a healthy economy] is that production shall be directed for the sake of 'sane consumption.'"[8] Fromm comes to this notion from his psychologist and therapist roots by observing the possibility of two modes of human existence—Being and having—and claims that the "having" paradigm now dominating modern cultures has turned pathological. Fromm says that, "having and being are two fundamental modes of experience, the respective strengths of which determine the differences between the characters of individuals and the various types of social structures."[9] (#14) Only a shift to an alternate mode, "Being," can save both the human species and the natural world in which we live. At the extreme, the relationship of humans to each other and to the surrounding world collapses into an equality, "*I am = what I have and what I consume*." (Emphasis in the original)[10]

Having is consistent with the rational, computer-in-the-mind model of what it is to be human. This mode is all about the need for objects that produce satisfaction but without any idea of what constitutes satisfaction. Values are reduced to a monetary or another quantitative scale. Other human beings become merely other objects to be assessed and selected for their utility. One's self-worth is tied to what one owns. The dominance of "having" over "Being"is the fifth root of unsustainability (#15)

The sixth and last root is our overwhelming reliance on technology, construed as the tools we use to satisfy our everyday needs. Francis Bacon, who lived about the same time as Descartes, saw the possibility of putting the remarkable body of newly discovered knowledge to work in the service of God—perfecting the human species in the face of the rigors of the harsh world. Bacon saw knowledge, obtained through scientific thinking, as power, especially when transformed into new kinds of technological artifacts. Put to work, this knowledge would drive history in a progressive direction, a teleological future that would be ever and ever better than the present.

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[6] Daly, H. E. and J. B. Cobb. 1994. For the Common Good: Redirecting the Economy toward Community, the Environment, and a Sustainable Future. Boston: Beacon Press.

[7] I use upper case, Being, to distinguish the existential sense of what it is to be human from beings as things that we perceive in general.

[8] Fromm, E. 1976. To Have or To Be? Edited by R. N. Anshen, *World Perspectives*. New York: Harper & Row. p. 176.

[9] ibid. p. 16.

[10] ibid. p. 26.

Our still-existing optimistic stance about technological innovation springs from those seeds planted some 350 years ago. We also see evidence of our confidence in science in the predominance of technocratic processes that underlie the rules and regulations that shape cultural behavior. Policies are based on the technical knowledge of experts trained in formal disciplines, that is, fields focused on discrete areas of human behavior, each built upon its own set of "scientific principles." Industrial ecology plays a role in this domain. LCA is a principal tool for product design and life-cycle management. LCA has contributed to the policy arena through extended product responsibility. MFA informs materials policies. Industrial symbiosis helps explain the development of interchanges among firms and contributes to the planning of industrial eco-parks.

Part of the dominance of technological "solutions" goes back to the notion that our species stands outside of nature. We are tinkerers reaching into our bag of technological tricks to solve all the problems within that external world. (#16) Every problem that shows up "in the world" is just another normal problem to be understood through science and fixed through technology. Over the centuries since Descartes, Bacon, Newton, and others founded the Enlightenment with these ways of thinking, the technological way of acting has created a mindset that the world is little more than a huge toolbox where all things out there are only potential instruments for getting our jobs done. The intrinsic value that things have in just existing has largely vanished The environment is there only to provide services. This assertion is partly true. The environment does have extraordinary value when expressed in normal economic terms.[11] But its value to sustainability is priceless. We are at home in the world in much more than any instrumental or economic sense. In his broad critique of technology, the German philosopher Martin Heidegger spoke of this instrumental view of the world as "enframing" and termed everything out there as merely "standing reserve."[12](#13). The 6th root cause is our technological mindset.

The persistence of unsustainability

There is little question that science and technology have greatly improved the lot of the human species since Descartes' and Bacon's time, but not without the accumulation of undesired, unintended consequences. This conference is focused on a positive theme—transitions toward sustainability--but also reflects our deep-seated concerns that the present disharmonious world cannot continue to support life on the Planet as it has for ages. The continuing unfolding of humanity foreseen by Bacon and others that created the notion of The Enlightenment is threatened by the very way of life they foresaw. Another irony of modernity.

The good news that technology carries frequently is accompanied by bad news as well. Technological solutions often treat the symptoms of a problem. The two main general business strategies aimed at unsustainability--eco-efficiency and corporate social responsibility (CSR), are fundamentally remedial—fixing problems that have arisen out of the ordinary activities of our

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[11] Daily, G., ed., Nature's Services: Societal dependence on natural ecosystems. Washington, DC: Island Press. 1997.

[12] Heidegger, M. 1977. The Question Concerning Technology and Other Essays. New York: Harper & Row.

modern, technologically based culture. The original problem frequently fails to disappear or reoccurs after time passes because the root causes are still in place. Systems dynamics has developed archetypes that describe this and other common behavioral patterns. The most basic act is to treat the symptom. (#18-1), but the problem tends to recur. (#18-2)

New problems related to the choice of solution can also appear. (#18-3)These so-called "side-effects" can grow, eventually even surpassing the original problem. Driving cars to work or elsewhere is the normal response to the need for mobility in a modern urban setting, but at the same time dumps carbon dioxide and other pollutants into the atmosphere. We can and do try to reduce such undesired results by building hybrids or raising CAFE (corporate average fleet economy) standards, but the underlying causes, for example, sparse density patterns and single-use zoning ordinances in the US, remains untouched. Side-effects is a misnomer because such outcomes are as much a response to the solutions being applied as are the intended results. Unintended consequences is a more accurate way of talking about these outcomes. Unsustainability is one of these unintended consequences, but on a grand scale. (#19)

Industrial ecology with its systems framework can visualize the interactions of technology and the environment in a larger context than more focused disciplinary models and, as a result, can lead to remedies more effective than those arising from these more narrowly based models. Such efforts can reduce the immediate burden on the Earth and perhaps stop or reverse the pathological consequences, but are not real solutions. Eventually, growth in consumption, exacerbated by the rapidly growing economies of China, India, and elsewhere, will overtake gains made by eco-efficient technologies. Further, eco-efficient technology cannot begin to remedy the loss of habitat and other natural resources now occurring at an accelerated pace. Technology cannot replace the natural processes that drive ecosystems, counter to the claims of geo-engineering.

To break out of these patterns resulting from the failure to get out of the loop (#20-1), the root causes, resting in the lower loop must be exposed and addressed. (#20-2) With each apparently successful technological innovation, attention is drawn further and further away from the root causes of the symptoms that raised concerns initially. The systems dynamics archetype for this pattern is called "shifting-the-burden," (#20-3) meaning that those seeking to solve the problem move farther and farther away from discovering the path to the real causes and to fundamental remedies. This archetype can even become pathological in which case it is called addiction when the "solution" produces new problems that transcend the old. (#20-4) Alcoholism is an epitome of this behavioral pattern. Alcohol consumption at first seems to make the unwanted symptoms, stress, for example, disappear, but, then, begins to destroy the body, itself, and creates a new and more difficult problem to address.

Consumption, broadly construed, has become addictive in the same sense. (#21) We keep acquiring objects to find satisfaction without being aware of what we are authentically seeking in life. Treating immaterial qualities like companionship and love as things, we attempt to acquire them as if they were objects. Social networking technologies may exacerbate this process. The fundamental human quality of friendship is largely lost in the banal "friending" of Facebook. When Burger King offered a coupon for a free hamburger to anyone who would defriend, that is,

delete, 10 people from their list, over 200,000 people responded. Now we have real data to calculate what a friend is worth--one-tenth of a hamburger.

Moving from the upper to the lower loop, that is, to dissolve, rather than solve the intertwined problems of unsustainability is a huge challenge. As in any form of addiction, it is not possible to make this move simply by willing it and doing better. An intervention that forces the user to confront the sources of the addiction is critical. As unsustainability is a system-wide issue, the intervention must raise the collective consciousness. The consciousness-raising event is often a crisis that cannot be ignored or explained away. With unsustainability in general and climate change in particular, the development of the problem is subtle and gradual, and is not easily perceived nor accepted. Some even argue that there is no crisis at all. Until those holding power in government or business announce that unsustainability is a "clear and present danger," we will probably continue only to chip away around the edges.

Moving toward a new consciousness

Living in harmony with nature and other human beings will not come to be until our current cultural drivers are replaced by a different set of beliefs and values. Einstein recognized the impossibility of bootstrapping ourselves out of intractable problems when he said we cannot solve our problems by using the same way of thinking (and acting) that got us there. Cultures are fundamentally conservative. Social activities are driven by structure deeply buried in the collective "consciousness," which structure is reinforced by the very activities it produces. Imprecations to change can be effective, but usually only in the face of a palpable threat or an untapped powerful vision.

But change is possible, albeit slowly. Changing the modern set of beliefs and norms can be driven, first, by adopting a new vision of what we mean by sustainability beyond the standard formulaic definition of sustainable development. In a moment, I will offer such a definition. Then we must find new sources for beliefs and norms beyond those created by the modern worldview. The first such model I offer is based on complexity with its holistic framework, replacing the reductionist, mechanistic model of the world. Second, as an alternative to the economistic view of human Being as striving for happiness through a materialistic drive, I draw from the existential philosophy of Heidegger and others, which offers us a possibility to think of our "selves" fundamentally differently from the Cartesian ways.

Much attention in the press, corporate statements, and political speech is directed at the subject of sustainability, but unaccompanied by any explicit vision of its goal other than to do less harm while producing more. The most widely cited definition of sustainable development, popularized in the so-called Brundtland Report, begins with, "Sustainable development is a form of development . . . " The formulation has no hint of a world fundamentally different from today. It rests on a modification, not transformation, of today's basic market-oriented, technological, problem-solving mode of individual and collective action. No transitions are needed. Radical technological innovation perhaps, but not something I would deem culturally discontinuous. Transitions refer to moves from one regime to something new and distinct. (#22) There is nothing in this concept of sustainable development that might invoke a new image of sustainability. Is it merely the absence of unsustainability? Without some positive vision of the

future, remedial strategies—the essence of sustainable development—are bound to fall short in the long run.

Let me, then, work my way towards defining sustainability. I start with an admission that I am skeptical or downright critical of almost all claims made about green this or that or sustainable this or that. It's not that I believe that most claims are a form of greenwashing. Many are, but I do believe that most organizations making such claims intend to improve the state of the world. The problem all have, whether serious or manipulative, is that they do not know what sustainability really is, and, thus, don't know how to talk or act about it. All action follows languaging, so if the words send a confusing message, the results will go astray.

I use the unfamiliar word, languaging, intentionally. Human actions are coordinated through the use of language. Requests and promises create the future. Assertions establish the facts that actors use to assess choices for getting there. The transparency of action, that is, the ability of the actors to arrive at a commonly held result depends on their interpretations of the words used. When the words are part of the deeply embedded "standard" vocabulary, actions generally go smoothly, But when the words have not yet been added to the stockpile, the outcomes are less reliable. Sustainability is clearly one of these not yet universally understood words. So, it is important to keep pushing for a definition that puts everyone on the same page.

The basic meaning of the word, sustainability, is the likelihood that a system will produce normatively desirable outcomes continually over time. Sustainability by itself tells you nothing about what is to be produced. It's a meta-property of a system. To have meaning for the actors concerned, that is, the stakeholders, some specific set of outputs must be designated. With this preface, it is meaningless to talk about sustainability without specifying what is to be sustained. This failing is what gets most people in trouble, and contributes to accusations of green washing. Sustainability sort of floats in the air.

I have defined sustainability as the possibility that human and other life will flourish on the planet forever. (#23) Let me repeat. Sustainability is the possibility that human and other life will flourish on the planet forever. It's only a possibility because the present system clearly fails to do this. Possibility has no material existence in the world of the present. It is, however, perhaps the most powerful word in our language because it enables humans to visualize and strive for a future that is neither available in the present nor may have existed in the past. It means bringing forth from nothingness something we desire to become present.

Because we are talking about the whole Earth system, we should pick output qualities that sweep in a broad set of normative features. For me, flourishing does just that in a single word. (#24) Flourishing is the key to a vision of a sustainable future, not the reified, meaningless, but hegemonic, economic notion of welfare. Flourishing does not collapse into a thing or numerical measure of well-being to be managed. Flourishing is an emergent property of a complex system, like beauty is. Neither can be reduced to some technical dimension or measure. Beauty has emerged from da Vinci's Mona Lisa for centuries. It is a feature of the Great Masters that their works continue to produce beauty, even as cultural tastes change. They exhibit sustainability.

For human beings, flourishing includes the ability to continue along our species' biological

evolutionary path, and to enjoy culturally produced qualities like freedom, dignity, and others. When used in the vernacular of the moment, most people refer to sustainbility as meaning activities aimed at preventing the collapse of the ecosystem. There are many other issues of equal importance. What about equality and justice for all? What about security? It's an error to expect to find sustainability in a system that is failing to produce such qualities. The existing system must be ransformed before we can think about sustainability. Here and from now on, when I use the term, sustainability, I implicitly refer to flourishing as the property we seek.

Sources of inspiration

With this vision to pull us ahead in time, where do we go for the new beliefs and practices that will produce the transition we are gathered here to talk about? Models serve as sources of inspiration for new ideas. Industrial ecology owes its existence to just such a model, that of a natural ecosystem. Drawing analogies to ecosystems, we seek understanding of the material and energy metabolism of industrial systems. Much of our work has centered on closing material loops, another feature found in nature. Using these ideas, industrial ecology has helped reduce the impact of economic activities on the Planet. But reducing unsustainability does not create sustainability. (#25) These two notions are not simply the two sides of a single coin. They belong to distinct categories.

First, let us examine complexity (#26) and see how far it can take us along the road to a new consciousness. Complex systems are assemblages of interrelated parts that cannot be described by the kinds of analytic rules that reductionistic thinking produces. Patterns of behavior inhere in the relationships of the parts, not in the parts, per se. The philosophical and methodological implications of complexity turn Cartesian reductionism on its head. The whole in complex systems is truly greater than the sum of the parts. Interesting properties emerge from these systems.

Consciousness and even life itself are such emergent properties. Flourishing is also. The whole system needs to be working for it to emerge. In contrast, unsustainability can be caused by separate dysfunctional parts of the systems. Our technological mind set tells us to apply Band-Aids here and there and everything will be all right.

Natural ecosystems, with or without the presence of humans, are complex in this sense.[13] Further they are complex adaptive systems and maintain their viability by adjusting to changes coming from inside or out. Complex living systems operate in regions of stability. (#27) Powered by energy coming into the system, the state rests somewhere within the valley but away from the bottom equilibrium point. Changes in the system move the state around and may even move it to a cusp (part b) from which it may return or may flip into a whole new region of behaviors. (part c). Without developing the technical aspects of the complexity model, it is possible to point to several critical characteristics that can replace parallel notions in the reductionistic world-view.

To understand living systems like a forest and, by extrapolation, human societies, which are

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[13] For further reading see Gunderson, L. H. and C. S. Holling, eds. 2002. Panarchy: Understanding Transformations in Human and Natural Systems. Washington, DC: Island Press.

also a type of ecosystem, one must abandon the reductionistic way of thinking. These complex systems make sense only when viewed as a holistic, organic, interdependent set of entities, inexplicable as a mere collection of parts. It is a community, not simply a collection of individuals. Properties, like flourishing, are created from the workings of the whole system, but their emergence cannot be predicted. It is not that the time-dependent behavior is subject to probabilistic uncertainty, the future states of complex systems cannot be predicted at all. They are indeterminate, that is, analytic laws cannot be developed that describe patterns of behavior. This should not be taken as a negation of governance systems. We do manage our natural resources, but increasingly rely on local, learned knowledge rather than some induced theory. In spite of such learning, our forms of societal governance still rely on technocratic theories as espoused by experts.

Before concluding this talk, let me add a few sentences about the second key model that, , with complexity, can introduce new beliefs and practices consistent with sustainability. We need not only to think differently about how the outside world works, we also need a new model about how our own inside world works, that is, what it is to be a human being. For this, I have turned to a model that centers on care, not need, as the central feature of human existence. (#28) We are the only species that ever questions, that is, cares about what it means to exist. Our language arose in the course of taking care, that is, acting within three practical categories: ourselves, other humans, and everything else. Our caring is manifest through the actions we take in these three categories. Fromm juxtaposed having against Being. Having springs from the way need plays out in shaping our culture. Being and caring go together, but neither are very much present. Taking care also means acting responsibly.

Being is, like flourishing, an emergent property, in this case, of the whole worldly context that surrounds an individual actor, and comes forth only when all three domains of self, others, and the world are being taken care of. Taking care of refers to a network of relationships, not to the possession of things. We must be always conscious that all actors with interests in what a system produces (stakeholders in the usual sense) are part of the system, not external to it. It is when, as outsiders, actors attempt to manage a system as if it were a machine, that troubles start to appear.

This model is important to industrial ecology if we continue to be serious about incorporating the idea of sustainable consumption as a normal part of our activities. Leaving aside my dislike of using sustainable as an adjective, sustainable consumption efforts have been largely coupled to eco-efficiency. Where firms seek to produce more value with less environmental impact (sustainable production), consumers seek to acquire more value with less impact (sustainable consumption). The secret is to get the two sides to meet in the marketplace. The standard, rational model of human behavior constrains our efforts, for example, to thinking about information and incentives that shift purchasing toward less burdensome goods and services. Certainly this is meritorious, but like similar efficiencies coming from the production side, it is inadequate to produce the transition to sustainability. The addictive character of consumption remains in place. Starting with the caring model, we can search for radically different ways to alter consumer behavior. The result of taking care is authentic satisfaction and the realization of Being. The result of satisfying needs in the normal economic sense is simply the need for more.

Now with some guideposts to begin the process of transformation, what's the next step? I believe we are at a bifurcation point (#29), typical of the state I showed in the complexity slide. We can We can slip into a new even more dangerous regime, or we can move to one that pulls us towards flourishing. We cannot continue with business-as-usual, even with higher efficiencies everywhere.

But having stated this as choice, I also note the paradox, that we have to do both. Transformation although mentally an instantaneous process, takes a much longer time in cultural terms. We have to keep the ship afloat until we get to the new regime.

Perhaps it is easier to think of transformation in a framework. (#30) The framework is only an analytic convenience. Only if both domains are be addressed will it be possible for flourishing to emerge. Further, although the focus here in Lisbon is on technological pathways and on climate change, I believe the human dimension is the more critical of the two domains. Without a change in our beliefs and norms that change the cultural mindset to accommodate a lifestyle change based on lower carbon emissions, the political process is highly unlikely to lead the way.

We can now begin to design our way to sustainability. It has to be done in an adaptive and open manner. We must learn as we go and be prepared to change our strategies as we go. Something very difficult for politicians who always must claim some form of omniscience. The key, I believe, is to start at the bottom by using artifacts and processes that carry new beliefs and norms embedded in their design. Individuals, as they use introduce these into everyday practice will slowly produce the transformation in the society as a whole. (#31)

Let me finish with a few suggestions about how industrial ecology can become more directed toward sustainability as I have defined it. Industrial ecology can and should contribute to attaining sustainability in several ways.

1) The field should continue to provide guidance and designs toward reducing unsustainability. Its systems, interdisciplinary framework can suggest more powerful remedies than can a single traditional discipline. We can use the tools of industrial ecology to identify priorites and key leverage points. But we must always keep in mind that reducing unsustainability is not the same as creating sustainability. (#32-1)

2) The field should continue to invite workers from other fields and create fora for extended collaboration. Interdisciplinarity reaches fruition only after an extended conversation that enables all players to learn each other's jargon and their basic, underlying assumptions. Industrial ecology has already made a significant start in this direction and should establish and maintain institutional structures to support further developments. Significant inroads into the subject of consumption requires inputs from the social sciences, still under-represented in the field. (#32-2)

3) Complexity should be explicitly added to the standard set of concepts that constitute industrial ecology. The work of James Kay could serve as a foundation, as Kay had started to interweave complexity, sustainability, and industrial ecology before his untimely death. Understanding of complexity is rapidly growing in our community, but has not yet taken on the same level of importance as the traditional ecological metaphor. (#32-3)

4) Adaptive management, as for example, developed by Buzz Holling and his colleagues,

should be made an explicit subject in the industrial ecology curriculum with as much emphasis as LCA, MFA, IS and other of the original subjects. (#32-4)

5) Researchers in the field should plan, execute, and monitor small-scale social experiments. Such trials can determine the effectiveness of transitional strategies based on changing culture, with little risk. Similarly, adaptive management strategies can be studied in such experiments. Such systems of governance ("management" of complex systems is a bit of an oxymoron) rely on continuous learning from small steps and on local knowledge rather than exclusively on expert judgment. Computer simulation, as we have heard here, can contribute to visualization and understanding of the processes involved, but always falls short of matching the reality of the complex world. (#32-5)

As I end this plenary talk, I am also ending the role of Executive Director I have played since the Society was formed. I have been fortunate to work with so many of you who have contributed to the intellectual and the institutional growth of the field. Speaking of transitions, we have moved from a centralized structure to one directed by the elected leadership of the ISIE with support from two offices. I expect to continue, for at least a little while, to stay active collaborating on research and teaching. So as I step down from the podium and from my office, I say good-bye only till we meet next time. (#33)