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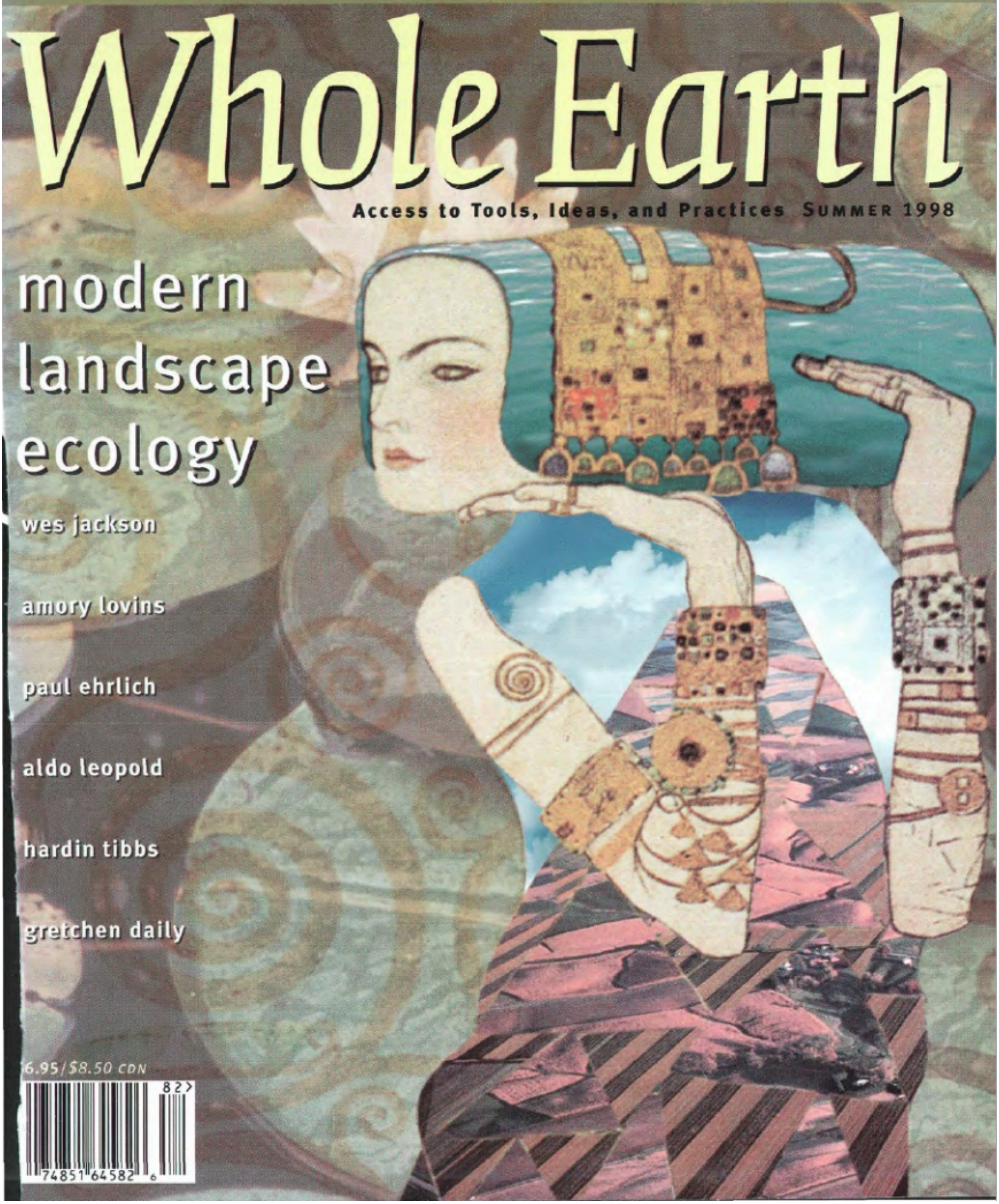

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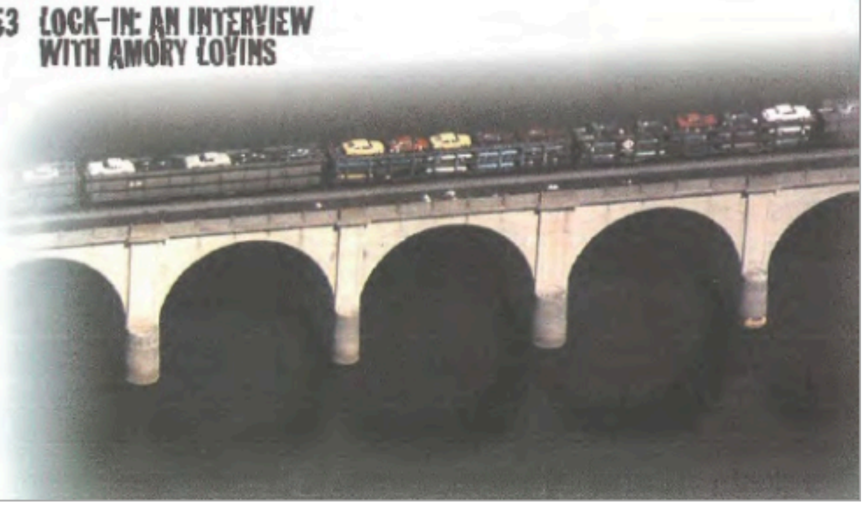


Humane Ecostructure

Can Industry Become Gaia's Friend?

Hardin Tibbs

Quick, define "industrial ecology." Does it mean "linking manufacturing facilities together like an ecosystem to reduce or eliminate waste"? Well, yes and no. This definition is accurate up to a point, but there is more to industrial ecology than this.

Industrial ecology is the need to place the whole global-industrial system in the context of planetary physiology. Its ultimate aim is to create a planetary order of technology for the long haul—a planet-wide deployment of technology suited to the special characteristics of Earth. Put another way, this means the emergence of a technological infrastructure that can harmonize with the Earth's unique biogeochemical processes and cycles. One of the main reasons for thinking on such a large scale is that industry itself has now reached planetary scale—its throughputs and waste flows are so large that they are disturbing the large-scale planetary life-support systems on which we all depend.

Industrial ecology focuses not only on the structure of industry, but also on the systems and structures of planetary physiology. The appropriate long-term structure of industry cannot be determined until we have a good understanding of the way the planet works, at both large and small scales, both in time and space. Since the whole concept of looking at the physiology of the Earth itself is relatively new, industrial ecology has important contributions to make in this area, focusing study on the insights needed for the design of industry.

The British scientist James Lovelock coined the term Gaia (the name of the ancient Greek goddess of the Earth) to express the idea of the entire planet as a single living superorganism, complete with its own physiology, as complex as any regular organism. Lovelock pioneered the study of planetary physiology, or geophysiology as he calls it. As we begin to uncover the intricately interlocked workings of geophysiology, the implications for industry become clear. We contain within our bodies biochemical processes that not only serve our own life, but also enable the biogeochemical processes of Gaia. In a very literal sense, we are a functional part of the planet. Industry needs to be structured the same way—to serve human needs as well as planetary needs. Industry must become a cooperative part of the planet, of the life of Gaia.

Geophysiology and Industry

Needless to say, industry is far from that today. So how do we make a bridge between geophysiology and the design of industry? The keys to geophysiology are to understand the cycles of matter, the way feedback loops regulate the cycles, the key stocks and flows in the system, and the way living and non-living elements in the entire system interact. We can study how industry works on the large scale

Industrial Ecology is a field of knowledge and endeavor that aims at ensuring that human ecostructure can meet the needs of all peoples and exist in harmony indefinitely with the natural biogeochemical systems of this planet.

by mapping it in much the same way. The study of industrial metabolism, pioneered by scientist Robert Ayres, is a natural complement to geophysiology—indeed, given the scale on which we are doing things, it is rapidly making a significant impact on it. Industrial metabolism involves looking at the way elements flow from the environment into and through industry, and back out into the environment. The elements or molecules of most interest are those that flow in the greatest volume, and those that are the most toxic—either to organisms or to Gaia—carbon, sulfur, nitrogen, heavy metals such as cadmium and mercury, CFCs, etc.

Once we have understood better how Gaia works, and once we have a good grasp of today's industrial metabolism, we will be in a position to devise a new form of industry. At that point, we may find we have to redefine the concept of industry itself. This is why the idea of industrial ecosystems, and eco-industrial parks like the one at Kalundborg in Denmark, although vital, are not enough on their own. The heart of the industrial ecosystem at Kalundborg is a large—1500 megawatt—coal-burning electricity generating station called Asnaes. While it is true that many valuable savings in the use of materials and water have been achieved by linking Asnaes to other industrial facilities in the surrounding area, it seems unlikely that burning coal for energy production can be acceptable for very much longer.

In the larger context of materials, open combustion of hydrocarbon fuels, at least on the huge scale that we do it today, is not sustainable. Already the carbon released by human activity, 7.5 billion metric tons a year, or about a sixth of the natural annual exchange with the atmosphere from terrestrial plants and animals, is perturbing the global carbon cycle, with possibly serious effects on climate. In the long run we will have to choose industrial materials and processes that not only interlock with each other, but also with geophysiology. In principle, we could engineer the whole of industry so that there were no flows at all into the environment (this has been referred to as a Type III industrial ecosystem). In practice, not only will there inevitably be leaks, but some processes are intrinsically open—for instance agriculture and the production of biomass feedstocks, and many end-uses of materials.

When an industrial ecosystem is created to reduce materials use and waste, what happens if or when one of its component processes becomes obsolete? Does the whole industrial ecosystem then become unviable? Or can structures of interlock be designed which allow for change—such as cleaner future technology—without creating increased dependence on such things as coal-fired power plants? Put differently, can interlock be achieved without unwanted lock-in?

Interlock, Not Lock-In

The answer is likely to depend on working through a sequence of steps. One approach would be first to identify a set of materials which have long-term geophysiological compatibility. A fairly small set of acceptable materials could probably be used to supply eighty percent or more of all production needs. The next step would be to devise clusters of production processes which use some or all these materials, and which can be interlocked ecosystem-style. Once this was done, the resulting industrial clusters or industrial ecosystems might stand a reasonable chance of being stable over time. Gunter Pauli of the Zero Emissions Research Initiative (ZERI) at the United Nations University in Japan, has shown that focused industrial clusters of this sort, based on biomass inputs and zero waste, can make very good business, social, and environmental sense.

Volumes

If closed loops of materials flows are established, the next question is whether the volume of materials flowing in the loops can be allowed to grow or not. Linear throughput growth (in which materials flow through the economy as if through a straight pipe) places a double burden on the environment—once during the production of virgin materials, and again when wastes are ultimately dumped—and about ninety-five percent of all the materials we use end up as waste before the finished product is even purchased. But if all materials flow in a loop, does the volume in the loop matter? At first sight, it would appear not, but on closer examination, it is an issue.

First, as global population and relative affluence increase, the demand for materials is growing exponentially. In the United States alone, total materials use has ballooned from 140 million metric tons a year in 1900 to 2.8 billion metric tons a year in 1990, up from about 1.6 tons a person to 10.6 tons a person. If all materials flowed in a closed loop, more and more virgin materials would need to be poured into the loop to meet this growing demand. Suppose this growth was offset by dramatic dematerialization of the useful products created, to the point where the volume of materials in the loop could at least be kept stable. Would this be enough? The answer depends on the level of leaks from the loop, and the characteristics of the energy used to keep materials moving round the loop. Even in a loop, materials need to be transported and processed repeatedly to keep them useful, and this requires energy. If energy production still has a high environmental cost—for example because it still results in high carbon dioxide emissions—then the volume of materials in the loop would have to be reduced over time to lower the energy consumption. Once again, simply folding linear flows into webs and loops is not enough.

More Than Tools

Another misleading, partial definition is to think in terms of industrial ecology as simply a combination of best practice environmental management tools, such as life cycle analysis (LCA) and design for environment (DFE). This fails to grasp the larger intent of industrial ecology. It is not just another tool, nor is it even another environmental management system (EMS). Industrial ecology is—or at least aspires to be—the emerging field of knowledge that inter-relates the various environmental tools and management systems that have been devised so far. It generates an overall context and gives the whole set of tools and systems a coherent objective—aligning industry with geophysiology.

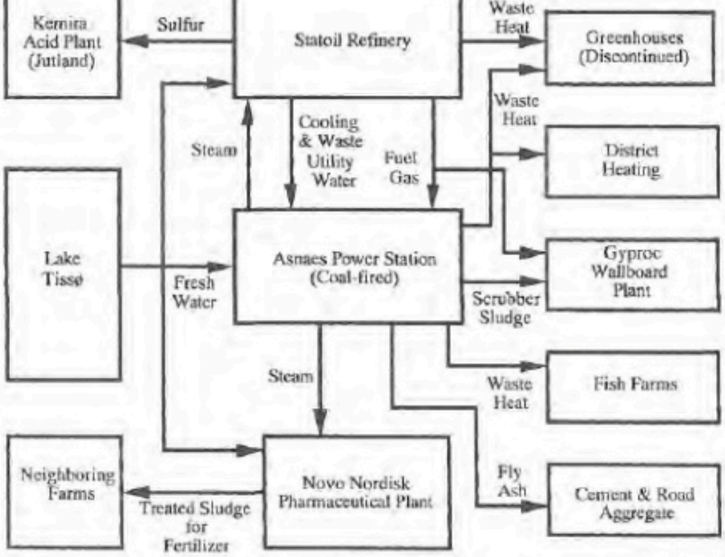
The trouble with the word "industry" is the image it typically evokes of gloomy gray buildings with saw-tooth roofs and tall stacks belching grimy smoke. We need a different conception of industry. In ecology, the term "ecostructure" refers to the pattern of physical structures created in ecosystems by the organisms that comprise them (and to the physical structures ecosystems occupy). Simple examples would be spider webs in a meadow, termite nests arrayed in a savanna, and beavers' dams in a watershed. Humans create ecostructure, too—lots of it, ranging from landscape patterns of buildings, roads, and bridges, to vast dams, water and sewerage systems, and energy supply grids, not to mention all the productive infrastructure of industry. Just as a dam built by beavers both serves the purposes of the beaver and plays a role in the hydrology of the landscape, so all the structures and systems we create should have a benign dual role too. This means applying the logic of industrial ecology to the design of human ecostructure in general, and learning to think of it as a single system, an interlinked design endeavor.

Industrial Ecology: The New Phase

In the broadest sense, industry and human ecostructure equate with our total use of technology around the world to serve society and individuals. If we factor into this the need to work within geophysiology on both the large and small scales, the need to do this equitably, and the ability to keep doing it over time, a more comprehensive definition of industrial ecology emerges. It might read something like this: "Industrial Ecology is a field of knowledge and endeavor that aims at ensuring that human ecostructure can meet the needs of all peoples and exist in harmony indefinitely with the natural biogeochemical systems of this planet."

It is important to stress that this refers not only to the physical components of the system. In systems terminology, structure implies more than physical features, it includes the pattern of relationships in the system, the way the set of stocks, flows, loops, and delays are connected together. The relationships between beavers, their dams, and the landscape are to a large extent programmed in their genes. Similarly, we need to embed appropriate conceptual structures for human ecostructure design into organizational planning and strategy, and government policy.

As it happens, the ecosystems metaphor is already becoming influential in corporate strategic



The industrial ecosystem at Kalundberg, Denmark. —Journal of Industrial Ecology (see review, p. 64). This view is incomplete; it does not include the influence of coal-burning on the atmosphere.

planning. Strategists are increasingly talking about "business ecosystems," about "value webs" rather than value chains, and about "co-opetition," a balance between competition and cooperation as is found in nature. This amounts to a realization that business is more successful when it adopts a "live and let live" orientation rather than when it attempts to destroy all competition, and that the "survival of the fittest" is best understood in terms of the "survival of those that fit best." This shift of outlook is an ideal grounding for the next step, which is to relate business strategy and survival not only to adaptive fit with other businesses, but also to adaptive fit with the natural environment. If strategic ideas and industrial ecology flow together—a convergence whose time may be just about to arrive—it could well open the way for industry, and indeed all human ecostructure, to become truly sustainable. ⊕

Hardin Tibbs's original paper on industrial ecology appeared in WER No. 77. (It can also be downloaded from the web at www.sustainable.doe.gov/articles/indecol.htm). Hardin is an associate of the Global Business Network (GBN) in Emeryville, CA, and is also Managing Director of Ecostructure, an international consulting firm based in Canberra, Australia, specializing in strategy for sustainability. He can be contacted at htibbs@ecostructure.com.au.