Success and Its Price

The Institutionalization and Political Relevance of Industrial Ecology

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Keywords

environmental policy
ecological modernization
higher education
industrial ecology
institutionalization
sociology of knowledge

Summary

As industrial ecology (IE) solidifies conceptually and methodologically, and as it gains visibility and legitimacy in academia, industry, and government, it is important that the IE community periodically evaluate the status of its emerging institutional arrangements. At the same time, industrial ecologists should assess the political relations developing between the field and the larger world. We analyze four institutional criteria: professional legitimacy, viable clientele, entrepreneurial acumen, and occupational opportunities, as well as a more controversial fifth measure—political relevance. Drawing a comparison with the field of ecology, we argue that efforts to foster IE institutionally can, ironically, conflict with the objective of seeing IE become "the science and engineering of sustainability." The article concludes by reflecting on the importance of this kind of critical appraisal and on why many observers of the field remain hopeful.

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Volume 10, Number 1–2

Introduction

A decade ago, the early emergence of industrial ecology (IE) was celebrated in some quarters as an event of epochal significance. Proponents contended that a comprehensive systems approach to production predicated upon rigorous environmental performance standards would relegate many familiar process technologies to the dustbin. According to some commentators, we were witnessing the dawn of an exuberant new industrial revolution, and the seemingly intractable dilemmas of the modern industrial era would soon become mere historical curiosities (Allen 1993; Ausubel 1992; Frosch 1995). For all of its purported novelty, however, IE was not an entirely unique endeavor. During the 1990s, parallel revolutions appeared to be occurring in several allied areas of intellectual pursuit, most notably conservation biology and ecological economics (Müller 2003; Robertson and Hull 2001).

Over the last few years, several knowledgeable observers have sought to systematically gauge the status of IE and to forecast its future prospects (see, e.g., O'Rourke et al. 1996). Not surprisingly, such matters have also been frequent subjects of more casual discussion at academic meetings and other professional venues. These evaluations, for the most part, maintain that IE is gradually maturing as a definable and reputable sphere of inquiry and offer a cautiously optimistic prognosis for the future. The primary focus of the first gathering of the international society in Leiden in 2001 was necessarily devoted to demarcating the basic parameters of the field and creating formal systems of governance. Subsequent meetings in Ann Arbor (2003) and Stockholm (2005) provided forums for consolidating these achievements and projecting a more confident and ambitious agenda for the future. These events were marked by heady debate and forthright discussions, not only about how IE should delimit its internal boundaries, but also about how it should represent itself to—and engage with—the rest of the world.

As industrial ecologists reflect upon the proceedings of this past summer's third international conference, it is appropriate for the community to continue to consider IE's ability to meet its ambitious aims and to ponder possible future avenues of development. In recent years, considerable attention has been paid to identifying the engineering challenges the field faces (Thomas et al. 2003; Thomas and Graedel 2003). Industrial ecologists clearly need to be vigilant about intellectual and methodological soundness, and we see this capacity for self-inspection as an indisputable asset. In this article we attempt to complement this work—and to supplement earlier critiques (e.g., Bey 2001)—by critically examining the institutional and political challenges IE faces. After all, history is replete with once promising new scientific and engineering endeavors that, despite devotees' rigorous attention to methodological scrupulousness, eventually lost momentum.[1]

It is also necessary to be mindful of a corollary hazard: the allure of securing prominence at the cost of political passivity and innocuousness. IE's ability to avoid, on one hand, the intellectual graveyard and, on the other hand, historical marginality or irrelevance is by no means assured. In fact, a backward glance over the past century suggests that one would need a rather high risk tolerance to wager much on the success of this nascent enterprise. The stocktaking that we attempt here is intended to promote IE's vitality during what surely will be a complicated and hazardous transitional phase.

The second section describes four criteria for gauging IE's accomplishments to date, and in the third section we offer our assessment of efforts to meet these challenges. In the fourth section we turn our attention to a frequently neglected and discomfiting fifth criterion of success—namely, political relevance. The conclusion offers our assessment of the road ahead and reflects on the optimism that many observers of IE seem to express.

Avoiding the Boneyard

The institutionalization of science and engineering, and of specific technical and scientific disciplines, has been a long-standing area of social scientific inquiry (Bernal 1939; Kuhn 1970). In recent years, historical reviews have appeared discussing the mechanisms through which a number of academic fields have achieved prominence, including geology (Schofer 2003), ornithology (Forbes and Jermier 2002), and psychology (Rice

2000). A consistent finding of this work is that although the specific content that a prospective mode of intellectual thought engenders is obviously of vital significance, simple novelty is hardly a sufficient criterion to guarantee a productive future. We contend that the level of institutionalization is predicated upon four further conditions.

First, it would be folly to underestimate the importance of internal and external *professional legitimacy*. Institutional recognition—in the form of professorial appointments, dedicated funding lines, scholarly societies, degree-granting programs, academic journals, and book-publishing contracts—is essential for visibility and credibility. These not only are useful markers for the outside world, but help to forge collegial coherence and common identity among previously disparate, loosely connected individuals. To protect and nurture initial tokens of respectability, it often is necessary to divert some energy from philosophical framing and theory building toward more mundane tasks: policing emerging boundaries, managing administrative dilemmas, and securing financial resources.

Second, for a new form of knowledge production to achieve institutional standing, it must cultivate a *viable clientele*. Physics has achieved prominence during the past century in large part because its nuclear and ballistics expertise guaranteed a durable relationship with military planners and other politically influential patrons (Kevles 1995).[2] Similarly, economics owes its stature to an ability to provide entrepreneurs and political actors with tools to track, interpret, and extrapolate changes in trade and industrial organization; and geology has provided knowledge that helped satisfy a technological society's appetite for natural resources such as coal, oil, and precious minerals.

The uptake of new ideas is often not immediate, and slow assimilation can have serious consequences, for until a field becomes attached to a societal need and establishes suitable clients, it is likely to remain in an adolescent state. Ecology,[3] about which we will have more to say later, is a prominent example of this phenomenon. After the field was formally founded in the later nineteenth century, early ecologists toiled in virtual obscurity until a clear political rationale developed during the 1960s for elevating this form of knowledge into active service (see, in particular, Bocking 1997; Worster 1994). Such obscurity can, of course, mean severe difficulties both for individual theorists and practitioners and for the pace of their development of theory and knowledge. A prolonged period of adolescence also can have grave institutional consequences because it can give established disciplines the opportunity to selectively poach innovative elements that do not directly challenge accepted tenets or violate established boundaries. This particular process seems to have been at work in the demise of economic biology, which, after a rapid rise during the early part of the twentieth century, found itself dismantled by zoology, entomology, and mycology (Kraft 2004).

Third, a budding intellectual field, if it is to thrive, must be equipped with *entrepreneurial acumen*. It is not sufficient to offer the world a timely set of ideas and tools. It is also necessary to have a cadre of proponents that is able to play an effective promotional role. These individuals act as liaisons with key members of supradisciplinary organizations (e.g., scientific societies, national and transnational funding bodies, university presidents) and other influential figures with the discretionary power and the financial means to enhance the field's institutional profile and to cover the costs of its infrastructure.[4]

Finally, successful intellectual fields must be able to offer students prospective *occupational opportunities*. The campus "open house," an annual event in many colleges and universities, demonstrates that even first-year students recognize that academic specializations vary considerably in their ability to proffer gainful employment. Like shoppers scrutinizing potential purchases, students at these events try to calculate the comparative payoff that will come from studying, say, accounting versus civil engineering. Even at this tender age, students sense a political-economic reality that is one of the most striking features of the ostensibly egalitarian academy: specializations that can offer the promise of useful employment will be in ascendancy and lavished with ample institutional resources, whereas those with more uncertain and less lucrative occupational prospects will be relegated to marginality.

The passage of time frequently blurs our understanding of the motivational forces that

brought forth and nurtured modes of inquiry that we now take for granted. Because of the glacial pace of institutional change and the relatively short duration of the average career, it is often difficult to grasp some of these evolutionary processes (see Reuben 1996). But most of the departmental names that adorn academic buildings today did not exist a century ago—they are the victors of an arduous process of competitive selection.[5] It is important to remember that college and university administrators once rebuked anyone rumored to be teaching industrial engineering, deeming such knowledge wholly inappropriate in a formal educational setting and suitable only for students of inferior abilities (Cohen 1999; Pfammatter 2000). It was not until corporate employers began to demand students with technical skills that what we now see as an antediluvian mode of thinking fell away.

Assessing Industrial Ecology's Institutional Strength

How is IE faring in terms of these four criteria? Over the last several years, the nascent field has made commendable strides toward achieving *professional legitimacy*. The most obvious examples are the creation of an international association, the publication of a prominent academic journal, the establishment of a handful of professorial appointments, and the development of a growing nucleus of capable graduate students. Indications exist that IE's primary tools—life-cycle assessment, substance-flow analysis, and materials-flow accounting—are gaining visibility in the daily discourse of policymakers, regulators, and nongovernmental organizations (although some critics have expressed reservations about the way these tools are being applied [Castell et al. 2004; Udo de Haes 1997]).[6] Furthermore, well-established disciplines and professional practice are actively taking these approaches on board to supplement their existing methodologies.[7]

IE's ability to capitalize on this increasing legitimacy to secure a *viable clientele* remains tenuous, however. Although there has been some notable assimilation of IE's tools, there is little evidence that the field's long-term vision and agenda are being widely adopted in a substantive fashion in either industry or government (Ehrenfeld 2001; Ehrenfeld 2002). A number of authors, including Rejeski (1997), Gille (2000), and Kautto and Melanen (2004), have reported on different political contexts and concluded that the policy impact of IE has been minimal. And although IE principles have been incorporated into various proprietary frameworks, such as those of Amory Lovins' *Factor Four* and The Natural Step (about which, it is instructive to observe, many industrial ecologists remain skeptical), these initiatives, too, have rarely had an influence on government policy (Schlosberg and Dryzek 2002). To a large degree this situation—most pointedly, perhaps, in the United States—is a function of the contemporary political climate, and it certainly should give industrial ecologists pause. During the past decade, numerous Western governments have begun to view command-and-control approaches in environmental management as inadequate, ineffective, or even counterproductive and have started to reorganize their regulatory frameworks around voluntary compliance programs and market-based strategies. Although by many accounts this trend is consistent with the aims of IE, it is at best uncertain that it will translate into solid sponsorship for the new field.[8] At the same time, the U.S. federal government's current retreat from its decades-long commitment to environmental protection is a perverse development that hardly provides auspicious circumstances for IE to take root and blossom (see, e.g., Cohen 2004).

By virtually any measure, the placement of Frosch and Gallopoulos' 1989 article in *Scientific American*, a mass-circulation professional publication, demonstrated considerable *entrepreneurial acumen*, and commentators are correct in recognizing its catalytic role (Frosch and Gallopoulos 1989).[9] The regular coverage that IE has received in prestigious outlets such as *Science* and the institutional support it has gained from the AT&T Foundation and the Gordon Research Conference sponsors over the years have been indispensable in fostering intellectual identity and credibility. Any complete list of individuals who have ably played the role of promoter would include Braden Allenby, Roland Clift, John Ehrenfeld, and Thomas Graedel.

Finally, industrial ecologists have not yet begun to systematically generate adequate

occupational opportunities for their students. Although the quarterly installments of the ISIE newsletter and the association's website provide a trickle of employment announcements, these tend to be for research-oriented positions with academic institutions rather than industrial or governmental placements. To date, there is no indication that major firms are actively recruiting industrial ecologists with newly minted credentials or that traditional occupational classifications are being redefined to encompass individuals with training in the field. Indeed, there have been expressions of mounting apprehension that novice industrial ecologists will find that their specialized, interdisciplinary skills are of little value when they seek employment—and some evidence that this concern is justified (Grimes 2003, 2004).[10]

A corollary issue, and one that we quite frankly do not fully grasp, is the chasm that exists between academic industrial ecologists and a core group of proprietary consultancies that espouse IE-oriented approaches (see also Ehrenfeld 2001). We are thinking primarily here of individuals such as Michael Braungart, Amory and Hunter Lovins, Paul Hawken, William McDonough, Karl-Henrik Robért, and Ernst von Weizsäcker (Hawken et al. 1999; McDonough and Braungart 2002). Although there is, at least to our minds, little question that the current ambivalence is unhealthy on any number of levels, it is especially unproductive in terms of building employment networks and fostering professional opportunities. Whatever the reasons for the current situation, reconciliation in the interest of future collaboration would likely be mutually beneficial.

In sum, then, IE clearly is having some success establishing an academic foothold (see, e.g., Ehrenfeld 2001, 2002). The greatest progress is evident at specialized technological universities in Norway, Sweden, and The Netherlands.[11] Progress in North America has been slower, although the program at Yale University's School of Forestry and Environmental Studies is a notable exception that bodes well for diffusion to other institutions. A major source of IE's achievements thus far is the promotional skill of a relatively small group of enthusiastic leaders. A foremost challenge will be to cultivate a new generation of organizational entrepreneurs that is prepared to shoulder some of these essential duties. It is harder, though, for us to be upbeat about IE's ability to identify a client base, to demonstrate societal indispensability, and to make inroads into the wider professional community. In the coming years it will be necessary to devote an increasing share of attention to these issues, while at the same time maintaining the pace of academic advancement.

Political Relevance

A final criterion of an emerging field's viability is subtler, but no less important: genuine *political relevance*. Here the issue is not institutional survival, per se, but global efficacy—making a significant, positive contribution to meeting humanity's greatest needs. The challenge of political relevance lurks, in various guises, within a new field's efforts to satisfy the first four criteria. Degree programs, scholarly societies, and other features of professional recognition, so essential for the establishment of legitimacy, too often stifle the creativity and vitality that gave birth to the organized endeavor in the first place. Efforts to secure a reliable clientele too often lead to a loss of focus and an inability to respond to pressing social concerns, especially by subtly allowing economically powerful interests to commandeer the new field's intellectual trajectory. Effective advocates, who almost invariably wield considerable influence over the substance and shape of the enterprise they are promoting, too often nudge it toward narrowness, timidity, and political and economic inoffensiveness. And efforts to foster career opportunities for graduates frequently exacerbate all of these adverse tendencies. In each of these contexts, we would contend, there is an inherent temptation to define political relevance as political innocuousness.

The evolution of ecological science highlights the importance of political relevance in achieving and maintaining intellectual vigor. Because ecology shares a systems orientation and a focus on environmental issues, while at the same time serving as an important conceptual model for IE, it provides an especially useful point of comparison.

As noted briefly above, ecology had a long prehistory that preceded its maturation into a publicly recognizable and visible discipline (Bocking 1997; Bramwell 1989; Golley 1993; Hagen 1992; Worster 1994). A major reason for the field's eventual success is that it developed an ability to articulate its concerns with a political voice rather than strictly in the language of a community of scientific experts familiar with abstruse methodologies and formulas. For most of the past 40 years key elements of ecology have been closely entwined with environmentalism and, hence, the field has had a ready set of clients interested in claiming ecological knowledge as their own. This was not, however, an inevitable marriage. It is highly likely that scientific ecology would have remained politically marginal if not for key figures such as Rachel Carson, Barry Commoner, Paul Ehrlich, and Garrett Hardin. Part of the prominence of these scholars as credible scientific authorities and knowledge entrepreneurs in promoting a distinctly ecological worldview during the 1960s and beyond stems from their perceptive understanding of, and identification with, the political zeitgeist of the mid-twentieth century. It was largely through the efforts of these champions that ecology came to be seen as a noble calling. To answer that calling was to make an overtly political statement, one that embraced an unambiguous personal orientation toward the prevailing system of social relations, the organization of industrial production, and the balance of political power (see, especially, Bocking 1997).

One reason for the current lethargy—and we would contend declining public relevance—of ecology is its lack of enduring receptivity to this fusion. Since the early 1980s, the discipline has relaxed its commitment to social change and developed a more quiescent temperament. Most ecologists concentrate their attention on pristine places with few visible marks of human incursion. To conduct reputable studies—studies that garner collegial kudos and recognition—it is often necessary to travel thousands of miles to distant research sites: Arctic islands, Pacific archipelagos, and Amazonian rainforests. Although there are notable exceptions, the discipline has become increasingly preoccupied with computational esoterica and largely removed itself from direct, explicit engagement in political affairs.[12] Because of the demands of their funded research projects, highly regarded ecologists have little time to attend to issues outside of their immediate and ever-shrinking disciplinary boundaries—and even sporadic participation far too frequently elicits professional rebukes.[13]

To the extent that ecology remains an overtly political undertaking, it appears to do so primarily through a subset of ecologists concentrated within the ambit of conservation biology, a field that concentrates on land preservation and other strategies to slow the pace of species extinction (Soule 1985). Here, outside the mainstream of ecology, it is recognized that "[a]cknowledging values within scientific practice is . . . crucial for reintegrating ethical considerations into the production of knowledge and giving voice to concerns that cannot be reduced to concepts of efficiency or exchange" (Galusky 2000). The ethical and political commitments of conservation biology have allowed this emergent field to become deeply entwined with environmental activism in a way that more orthodox ecology no longer seems capable of doing.[14]

Mainstream ecology's movement toward the political and economic status quo can be attributed to the often perverse allures of institutionalization, which have taken a toll on so many disciplines across the academic spectrum (see Ravetz 1995). On one hand, most national research councils have shown a clear tendency to structure their programs around politically benign issues and inveterate methodologies. On the other hand, in an equally corrosive process, thousands of formerly independent academic research programs have become addicted to corporate funding and the research agendas that come with this territory (Bok 2003; Slaughter and Leslie 1999). Because ample funding is the mother's milk of professional prestige, the tacit orientations of government agencies and corporate sponsors subtly—and not so subtly—steer investigations away from politically charged areas of inquiry.[15] Researchers cannot produce uncomfortable results if they do not have funds to conduct credible studies. A system of institutional arrangements in which expert minds are occupied with methodological minutia and disciplinary skirmishes strongly favors the existing

system of social relations and reduces political volatility (Dickson 1988; Fischer 1990).

Conclusion

IE is on the brink of a new phase in its intellectual and institutional maturation. The progress achieved to date deserves acclaim and lays to rest the criticism of pessimists who were earlier skeptical of the inchoate field's promise (e.g., Commoner 1997). But the customary advice dispensed by investment counselors describes the circumstances in which industrial ecology finds itself today: past performance is no guarantee of future returns. If anything, the challenges confronting IE will become more pressing in the coming years as the stakes become increasingly consequential. Industrial ecologists have secured a degree of professional stature and have begun to generate expectations. From the outset, though, most individuals involved in the field ostensibly have sought to do more than participate in erudite academic discussions and garner a few professorships. If we are to take the public rhetoric of prominent industrial ecologists at face value, the aim has been nothing less than to revolutionize contemporary systems of production and consumption. This goal remains remote, and the obstacles are as daunting today as they were when Frosch and Gallopoulos published their seminal article more than a decade and a half ago.

In our experience, much of the allure that IE holds for nonengineers and nonscientists stems from the prospect, or hope, that the energy being poured into addressing the enormous technical challenges of sustainability provides an important opportunity to surmount immense social and political resistance. Some solace can be found in knowing that scientific innovation and the redesign of production and consumption technologies can reduce the daunting scale of this task. But at the end of the day, honest appraisal suggests that treating the human dimensions of technological systems as secondary considerations—or as relevant only *after* technical considerations have been addressed—can only imperil the long-term viability of IE's proposed reforms. IE's engineers and natural scientists—as well as its social scientists—need to resist the temptation to advance the discipline in ways that reify artificial distinctions between the sociopolitical and the technoscientific spheres. All industrial ecologists need to recognize, accommodate, and actively exploit the inherent symbiosis between these two realms. And we must confront the field's tendency to disguise political-economic conservatism as objectivity. Otherwise, we will squander resources and good intentions that our grandchildren are all too likely to wish had been better invested.

Acknowledgments

We are grateful for the assistance of Steve Breyman, Faye Duchin, Carl McDaniel, Jerry Ravetz, Edward Woodhouse, and Robert Jacksy, as well as the collegial advice of the journal's editor and three anonymous referees. This project has been supported in part by the U.S. Environmental Protection Agency's Science to Achieve Results graduate fellowship program (Grant U-91593401-3). It has not been subjected to EPA review and therefore does not necessarily reflect the views of the Agency, and no official endorsement should be inferred.

Notes

1. A prominent example is the study of biological taxonomy. One of the major constraints in biodiversity research today is the lack of adequate species inventories, due to the decline of this specialized area of botanical and zoological research (see, e.g., Valdecasas and Camacho 2003).
2. The recent Indian Ocean tsunamis in December 2004 offer an especially poignant example of the misshapen priorities that can occur at the confluence between science and the military. Synolakis (2005) notes that defense-related investment in fluid dynamics, because of its relevance in the development of naval technologies, has siphoned money and personnel away from the geophysical study of tsunamis.
3. Terminology is somewhat awkward here. Conventional or mainstream ecology is sometimes called "biological ecology" in the industrial ecology literature to make it easy to distinguish from industrial ecology. Some nonindustrial ecologists object to this label, though, because they see their field as crucially going beyond biology to incorporate abiotic elements. We use "ecology" in lieu of "biological ecology" in this article for this reason.
4. The role of Vannevar Bush in promoting the field of physics during the years following World War II

and the role of Howard Wesley Johnson in steering the Massachusetts Institute of Technology during the 1960s and 1970s illustrate the importance of prominent institutional supporters (see Johnson 1999; Kevles 1995).

5. Even monuments of seeming disciplinary endurance do not always enjoy certain and unproblematic futures, and a process of evolutionary churning is regularly at work. For example, during the last few years chemistry departments at several major British universities (including King's College London) have been closed and their expertise absorbed by other academic units (Freemantle 2004).
6. For example, the U.S. Environmental Protection Agency's Product Stewardship Program emphasizes LCA and related approaches (<www.epa.gov/epr/about/index.html>, accessed 6 January, 2005).
7. A prominent instance of this process is environmental toxicology's embrace of LCA (<www.setac.org/lca.html>, accessed 6 January, 2005).
8. O'Rourke and colleagues (1996) criticize industrial ecologists' failure to recognize the limitations of market-based approaches to environmental improvement and contend that this commitment holds the potential to undermine the ultimate effectiveness of IE. See also the critical analysis of the efficacy of voluntary programs by Harrison (1998).
9. In his authoritative analysis of the prehistory of IE, Erkman (1997) asserts that the Frosh and Gallopoulos article in *Scientific American* "can be seen as the source of the current development of industrial ecology."
10. In contrast, one anonymous reviewer who vetted this article indicated that graduates of his/her IE-oriented European program "are in great demand and start at salaries about 30 percent above those for conventional Ph.D.'s."
11. The list of academic institutions with a firm commitment to industrial ecology includes the Norwegian University of Science and Technology, Chalmers University (Sweden), the Royal Institute of Technology (Sweden), and a Dutch consortium composed of Erasmus University, Leiden University, and the Delft University of Technology.
12. Notable exceptions to this characterization include Theo Colborn, Richard Dawkins, Jared Diamond, and E. O. Wilson, although they—like Carson and Commoner before them—are not, strictly speaking, ecological scientists.
13. A prominent example of this sort of censure involves the widely reported case of Berkeley microbial ecologist Ignacio Chapela, who was denied tenure by the University of California in 2003. Chapela publicly opposed a university-based research program sponsored by the biotechnology industry and published a controversial paper about the infiltration of genes from genetically modified corn into native Mexican maize. A protracted legal battle ensued and the university ultimately overturned its earlier decision in the spring of 2005 (see, e.g., Dalton 2005; Mann 2002).
14. The Wildlands Project (<www.wildlandsproject.org/vision/index.html>, accessed 21 January, 2005) illustrates the ready fusion of conservation biology and environmental politics, as does the Conservation Biology graduate program at Antioch College New England (<http://csdept.antiochne.edu/csmdept.html>, accessed 21 January 2005).
15. Under the Bush administration, whose ideological and institutional ties have been widely noted (e.g., Baltimore 2004; Lawler and Kaiser 2004), government steering of research has become almost as blatant as corporate steering, to the extent that hundreds of scientists including Nobel laureates, National Medal of Science recipients, and others have been moved to publicly protest (<www.ucsusa.org/global_environment/rsi/page.cfm?pageID=1449>, accessed 5 January 2005).

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