Environmental Information Systems as Appropriate Technology

Kim Fortun

Environmental information systems—involving databases, computer modeling, remote sensing, GIS applications, and a host of other technologies—are now being developed around the world to address a range of issues, from climate change to loss of biodiversity, to economic underdevelopment.[1] The implications for the natural environment, human welfare, and democratic governance are significant. Environmental information systems structure what people see in the environment, and how they collaborate to deal with environmental problems. They shape scientific inquiry, legal argument, and how citizens participate in governance. They are technologies designed to produce new truths, new social relationships, new forms of political decision-making and, ultimately, a renewed environment.

I will discuss one particular environmental information system, an interactive Website supported by a relational database that contains profiles of more than 6,800 chemicals. Maintained by the Environmental Defense Fund, and called "Scorecard," the Website integrates local pollution information for the United States with information on health risks, and with information on relevant environmental regulations. It allows users to produce customized reports, and encourages communication with the U.S. Environmental Protection Agency, or with a polluting company. A Canadian version of Scorecard went online in April 2001, and a Japanese version is in the planning stage.[2] Scorecard could become a technology that is transferred to countries around the world.

My main argument is that Scorecard is an example of an *appropriate* environmental information system—designed in a way attuned to the material, political, and technological realities with which it works, and to the social actors who will be its users. The argument builds on the concept of appropriate (or "intermediate") technology popularized in the 1970s, with roots in Gandhian critiques of mass production articulated during the Indian independence movement.[3] Advocates argued that, in order to be "appropriate," technology should be designed to fit into its local setting, synchronized with available material resources, expertise, and labor time. I observed many such technologies in India while conducting field research in the early 1990s, and learned to appreciate how they could combine function with social, technical, and environmental sustainability. I also learned that "local settings" were inevitably punctured by flows of ideas, people, and goods from elsewhere; with

1 For examples of work on these topics in STS, see G. C. Bowker, "Biodiversity Datadiversity," *Social Studies of Science* 30:5 (2000): 643–684; P. Edwards, "Global Climate Science, Uncertainty and Politics: Data-laden Models, Model-Filtered Data," *Science as Culture* 8:4 (1999): 437-472; R. E. Sieber, *Computers in the Grassroots: Environmentalists, GIS and Public Policy* (Ph.D. Dissertation, Rutgers University, Department of Geography, 1997); D. Sarewitz, R. Pielke, Jr., and R. Byerly, Jr., eds., *Prediction: Science, Decision-Making and the Future of Nature* (Washington, DC: Island Press, 2000).

2 The Canadian version of Scorecard, once at www.scorecard.org/pollutionwatch, has been taken off the Web. I do not yet know the reasons. Bill Pease, the designer of Scorecard, mentioned the Japanese version in an interview with Erich Schienke in October 2001.

3 See E. F. Schumacher, *Small Is Beautiful: Economics as if People Mattered* (New York: Harper & Row, 1973). For a recent analysis that highlights the need for technology to match both users and needs in both complexity and scale, see B. Hazeltine and C. Bull, *Appropriate Technology: Tools, Choices and Implications* (New York: Academic Press, 1999).

both good and bad effects. I thus became interested in a concept of appropriate technology that would fit with the realities of globalization, and remain open to the wide array of technologies that could become local resources. Instead of assuming that appropriate technology had to be small-scale and completely controlled by the local community, I wanted to explore what "appropriate" technology meant in the high-tech, globally interconnected world of the twenty-first century.[4] My argument here extends this exploration, drawing out how information technology can attune to the realities of pollution at the local level.

My analysis draws on my own earlier work on how environmentalism has been practiced on the ground, in different settings, in the aftermath of the 1984 Bhopal disaster. In this work, I drew out the gaping information deficits that people must contend with when dealing with environmental problems, particularly as they impact human health, and the difficulties that arise when it is not possible to establish simple causal relationships between exposure and disease. I also examined how grassroots environmental groups function, and the political challenge of trying to influence corporate conduct.[5]

My analysis also draws on earlier research on the social implications of information technology. This research warns of the ill effects likely to emerge from widespread use and commercialization of information technology. It warns that information technology is likely to intensify and complicate the separation between haves and have-nots, and that the types of access people have to information will be a primary determinant of their social position, and of the opportunities available to them to change both their own positions and society more broadly.[6] It also warns of the emergence of a new "enclosure movement" that aims to make information technology, as well as information itself, increasingly proprietary.[7] Research on the social implications of information technology also has drawn out positive examples and indicators, often highlighting how information technology can enhance democracy. Examples of the way information technology can be appropriated for unexpected uses are important,[8] as are examples of the way information design can encourage creativity, and make it possible to visualize complex phenomena.[9]

I begin the essay with a description of what I think of as the "informating" of environmentalism—a trend that involves increasing use of information technologies to address environmental problems. In the next sections, I describe the Scorecard site in detail, and then explain why I think that Scorecard is an example of appropriate technology design. In the final section, I briefly comment on how appropriate technology design enables design to serve what Richard Buchanan calls "first principles."

4 The U.S. Office of Technology Assessment, for example, defined "appropriate technology" as "small scale, energy efficient, environmentally sound, labor-intensive, and controlled by the community" (cited in Hazeltine and Bull 1999, 3).

5 See Kim Fortun, *Advocacy After Bhopal: Environmentalism, Disaster, New Global Orders* (Chicago: University of Chicago Press, 2001).

6 See M. Castells *The Rise of the Network Society* (Malden, MA: Blackwell, 2000); and R. Kolko, L. Nakamur, and G. Rodman, eds., *Race in Cyberspace* (New York: Routledge, 2000).

7 See J. Boyle, *Shamans, Software, and Spleens: Law and the Construction of the Information Society* (Cambridge, MA: Harvard University Press, 1997) and "A Politics of Intellectual Property: Environmentalism for the Net?" www.law.duke.edu/boylesite/intprop.htm (1999, accessed July 2000).

8 See S. Lansing, *Priests and Programmers: Technologies of Power in the Engineered Landscape of Bali* (Princeton: Princeton University Press, 1991); P. Manuel, *Cassette Culture: Music and Technology in North India* (Chicago: University of Chicago Press, 1993); A. Melucci, *Challenging Codes: Collective Action in the Information Age* (New York: Cambridge, 1996); and R. Eglash, J. Croissant, G. Di Chiro, and R. Fouche, *Appropriating Technology: Vernacular Science and Social Power* (Minneapolis: University of Minnesota Press, 2004).

9 See R. Jacobson, *Information Design* (Cambridge, MA: MIT Press, 1999) and E. Tufte, *Envisioning Information* (Cheshire, CT: Graphics Press, 1990).

Informating Environmentalism

"Informational strategies" for dealing with environmental risk became law in the United States in 1986 through passage of the "Community Right-to-Know Act," Title III of the Superfund Amendments and Reauthorization Act (SARA). Widely regarded as the primary U.S. legislative response to the 1984 Bhopal disaster, the act mandated a range of initiatives to support emergency planning and public access to information.[10] A key component was the Toxic Release Inventory (TRI), the first federal database Congress required released to the public in a computer-readable format.[11] The goal was to allow the EPA as well as citizens to track and evaluate routine emissions from industrial facilities.

Some researchers argue that the TRI can be correlated with improved company performance on pollution.[12] Other researchers question the "market efficiency model" in general, as well as the substance of the reported emissions—arguing that the TRI is based on "engineering estimates" that are easily manipulated to create "phantom reductions." Many at the EPA nonetheless consider the TRI one of its most successful programs. And it is clear that the TRI has been a driving force in the emergence of corporate environmentalism, and in the emergence of new, information-oriented programs within environmental organizations of all sizes.[13]

Initiatives similar to those mobilized in the United States by right-to-know legislation now are being developed around the world, as recommended in Agenda 21, the guidelines for sustainable development agreed to at the Earth Summit held in Johannesburg in August 2002. Informational strategies have become a major focus at the World Bank and within UN programs, leading to environmental information initiatives in many developing countries, including Mexico and Indonesia.[14] In Europe, the right to know is the focus of the Aarhus Convention—a UN/European Economic Commission Convention on Access to Information, Public Participation in Decision-Making, and Access to Justice in Environmental Matters. Originally signed in Aarhus, Denmark in the summer of 1998, the convention establishes legally binding instruments guiding the creation of national Pollutant Release and Transfer Registers (PRTRs) in the UN/EEC region, as recommended by Chapter 19 of Agenda 21. PRTRs are databases containing information about pollution from industrial facilities, similar to the TRI in the U.S.[15] Environmental organizations such as the WorldWatch Institute considered PRTRs to be a key goal of the Earth Summit held in Johannesburg in August 2002. WorldWatch reports that there has been serious opposition to PRTRs by manufacturers since the Earth Summit 1992, and that only twenty countries have set up PRTRs as a result. WorldWatch considers PRTRs a priority because they "pinpoint the most affected communities, and the most polluting industries, thereby identifying targets for action."[16]

10 S. Hadden, "Citizen Participation in Environmental Policy Making" in S. Jasanoff, ed., *Learning from Disaster: Risk Management After Bhopal* (Philadelphia: University of Pennsylvania Press, 1994).

11 J. Young, "Using Computers for the Environment" in L. Brown, ed., *State of the World 1994* (New York: W.W. Norton & Company, 1994).

12 J. T. Hamilton, "Pollution as News: Media and Stock Market Reactions to the Toxics Release Inventory Data," *Journal of Environmental Economics and Management* 28 (1995): 98–113.

13 See J. Fillo and C. Keyworth, "Sara Title III—A New Era of Corporate Responsibility and Accountability," *Journal of Hazardous Materials*. 31:3 (1992): 219–231; and D. Grant, "Allowing Citizen Participation in Environmental Regulation: An Empirical Analysis of the Effects of Right-to-Sue and Right-to-Know on Industry's Toxic Emissions," *Social Science Quarterly* 78:4 (1997): 859–873.

14 S. Afsah, B. Laplante, and D. Wheeler "Controlling Industrial Pollution: A New Paradigm" (World Bank, Policy Research Department, Working Paper 167, May 1996); and T. Tietenberg and D. Wheeler, "Empowering the Community: Information Strategies for Pollution Control," paper presented at the Frontiers for Environmental Economics Conference (Airlie House, Virginia: October 23–25, 1998).

15 E. Petkova with P. Veit, "Environmental Accountability Beyond the Nation-State: The Implications of the Aarhus Convention" in *Environmental Governance Notes* (Washington, DC: World Resources Institute, April 2000).

16 A. P. McGinn, "From Rio to Johannesburg: Reducing the Use of Toxic Chemicals Advances Health and Sustainable Development" in *World Summit Policy Briefs* (WorldWatch Institute: June 25, 2002, e-mail edition), 3.

Right-to-know initiatives are raising difficult questions: What information must be provided to fulfill the right to know about the environment? *How* must information be provided? Must information be accessible through the Internet? Has access been realized if information is not organized for efficient use, and not correlated with other information that reveals its significance? Is the right to know, in effect, the right-to-computer models and to interactive, Web-based maps using Geographical Information System (GIS) software?

What is information provision supposed to accomplish? Is data delivery the goal, or something more complex? Should the primary goal be access to information, or should priority be given to facilitating production of dynamic, multi-authored datasets? How can information be leveraged into effective action? Should environmental information systems be envisioned as key components of efforts to build deliberative democratic processes attuned to a high-tech, globalizing world?

These questions raise difficult practical, conceptual, and ethical issues. They are, nonetheless, regularly discussed and debated—at conferences sponsored by government agencies, at community meetings, and on e-mail "listservs" that interconnect diverse stakeholders. They also are addressed through creative information technology designs.

The Scorecard Website

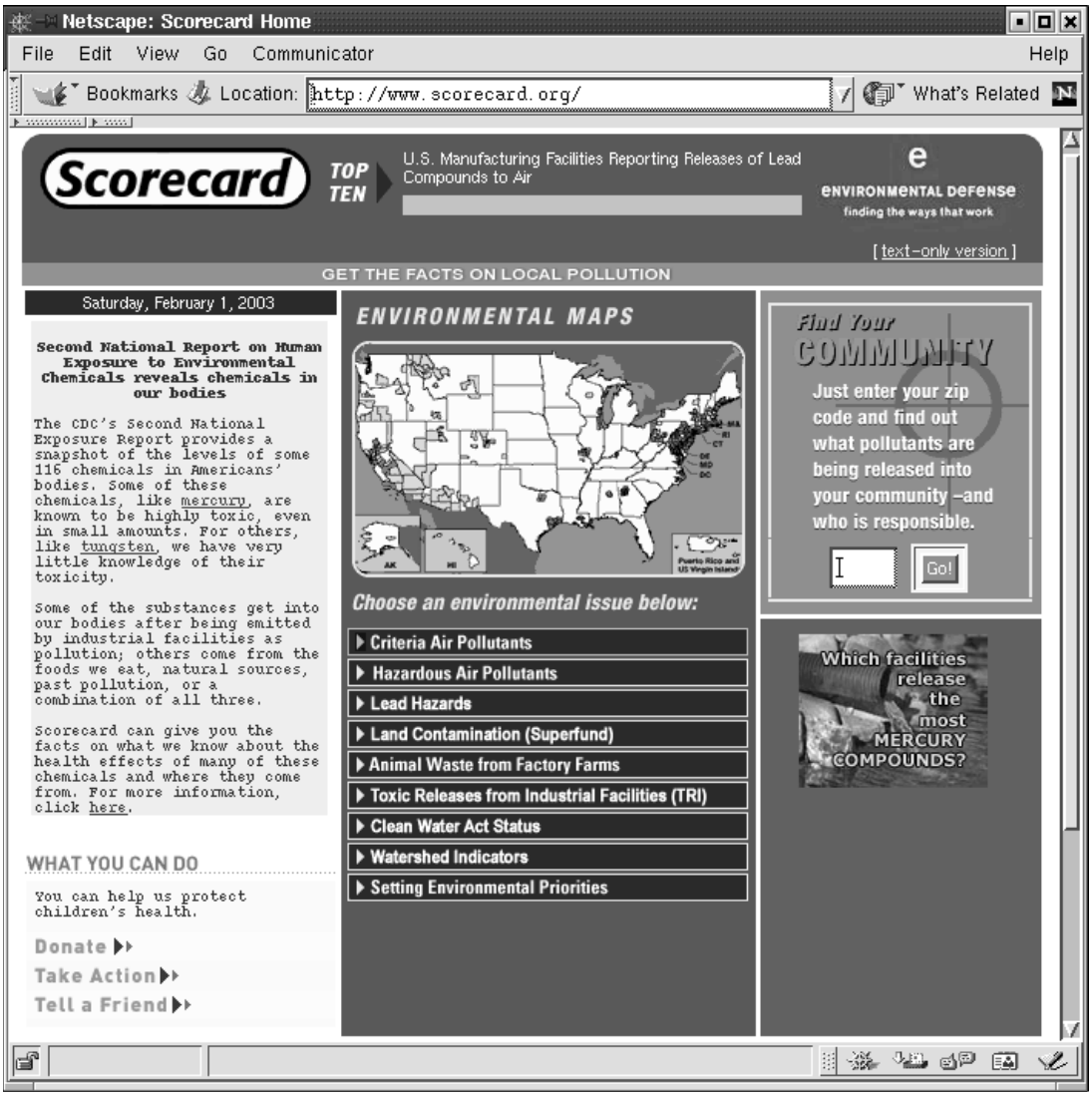
The Scorecard Website is one response to the recognition that people have a right to know about environmental problems. When the site was launched in April 1998, *Chemical Week* described it as the "Internet Bomb," because of the potential impact on the reputations of chemical companies.[17] *Oracle* Magazine featured Scorecard as an example of a well-executed and sophisticated Web application using a simple "script-based" approach.[18] Greenpeace refers to Scorecard as the "gold standard" of environmental information systems, and decided to follow EDF's lead in using the open-source arsDigital Community Systems (ACS) software for the new "Greenpeace Planet" Website, launched in June 2002. Greenpeace applauds Scorecard because it "bridges the gap between setting up passive information and creating a collaborative environment for action." [19].

The goal of Scorecard is to provide the information base for sustained effort to reduce pollution risks. Putting pressure on polluting facilities through disclosure of their emissions is a key strategy. EDF also wants it to be commonplace for people to use local environmental information when making decisions about what city or neighborhood to live in, or about what products to buy. A critical side effect will be greater recognition of the uneven distribution of pollution risk among social groups. Fred Krupps, president of EDF,

17 P. R. Fairley and A. Foster, "Scorecard Hits Home: Web Site Confirms Internet's Reach," *Chemical Week* (June 3, 1998).

18 K. Wiseth, "Next Generation Web: The Evolution of Thin," *Oracle Magazine* (November 1998). www.oracle.com/oramag/oracle/98-Nov/index.html?68cov.html (accessed June 25, 2002).

19 See "The Story Behind Greenpeace Planet" (June 24, 2002). www.greenpeace.org/features/details?features%5fid=14977 (accessed July 1, 2002).



wrote in an introductory letter posted on the Website that EDF's goal was "to make the local environment as easy to check on as the local weather."[20]

EDF, one of the "big ten" environmental organizations, with an annual budget of approximately $40 million and more than 300,000 members, is best known for its science-based lobbying to protect the environment.[21] It was launched in 1967, and played a lead role in winning a U.S. ban on the pesticide DDT. This was not a grassroots effort. In EDF's own account, it was an example of "how a handful of individuals can use science and law to bring about national reform." Today, EDF prides itself for having "more Ph.D. scientists and economists on staff than at any other such [environmental] organization," and for building teams of specialists that can investigate and devise solutions for environmental problems.[22]

Scorecard both extends this approach, and has taken EDF in new directions. Like other EDF projects, Scorecard is presented as

20 F. Krupp, "A Letter from EDF's Executive Director" (April 1999). www.scorecard.org/about/about-why.tcl (accessed July 5, 2002).

21 See Michael Stein's interview with Bill Pease, April 11, 2001 entitled "Environmental Defense: From Brochureware to Actionware" on the Benton Foundation Website. www.benton.org (accessed July 1, 2001).

22 See the EDF Website, www.environmentaldefense.org/aboutus.cfm?subnav=aboutus (accessed January 13, 2003).

authoritatively scientific. Unlike previous EDF projects, Scorecard has a local-level focus, though it also works on other scales. Scorecard is also EDF's first venture into cutting edge Web-based servers.

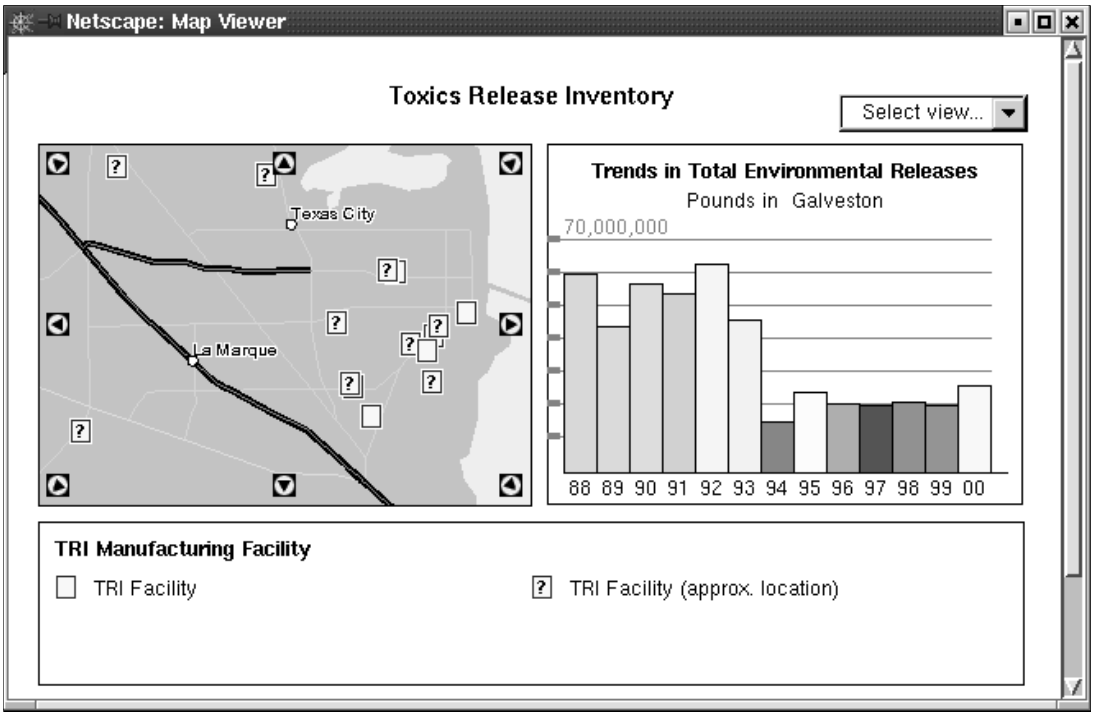
Scorecard runs on a Sun server running Solaris, Sun's proprietary version of UNIX, and is built on an Oracle 8i relational database manager and AOLserver. Original code was developed by arsDigita, and is now maintained by Get Active Software, a company run by Bill Pease and others on the original design team for Scorecard at EDF. The ACS codebase supports user administration and tracking, discussion forums, and other core functions. While the OpenACS component and AOLserver are open source, the Oracle and Solaris components are proprietary. Oracle (the second largest software company in the world after Microsoft) donated their relational database manager (an industry standard) to EDF.[23]

Scorecard's combination of (donated) proprietary and open-source software is important, as is the relationship between the nonprofit EDF and Get Active Software, a commercial firm with customers mostly in the nonprofit sector. It is because of such arrangements that Scorecard is technically, socially, and informationally sustainable. The database application created for Scorecard, for example, is able to generate Web pages dynamically, and this is critical given the complexity of the system. More than a billion pages potentially can be produced in Scorecard. If these were static files, the task of compiling them would be overwhelming, and the information on each page would quickly become stale. To deliver an up-to-date, customized page to a user, Scorecard accesses in excess of seven gigabytes of data, distilled down from more than 100 gigabytes of contributing databases.

The distillation of data by Scorecard is one of its most important functions. Scorecard pulls from more than 400 government and scientific databases containing information on chemical toxicity and toxic emissions. Information from these databases is in different units of analysis, and structured for a variety of uses. This data must be extensively massaged to be compatible with Scorecard's data model.

Scorecard also provides interpretations of environmental information. In addition to providing extraordinary integration of datasets, the site also provides rankings of health risks from pollution. The ranking system was developed by EDF and peer reviewed by *Environmental Science and Technology*. Viewers are not simply told how many pounds of toxics were released in a given year by a given facility. They also are told about probable risk—body system by body system—based on a hazard ranking system that relates all chemicals to the risk of benzene, a known carcinogen—to indicate "cancer potential"—or to toluene, a developmental toxin—to indicate "non-cancer risk." This ranking system provides users with relatively stable reference points for thinking about an otherwise confusing array of health risks. It is a purposeful simplification.

23 Stein, "Environmental Defense: From Brochureware to Actionware."



Pollution maps, the centerpieces of the Scorecard site, also provide users with familiar reference points.[24] Based on U.S. Postal Service Zip codes, these maps display the manufacturing facilities in a particular area that report their emissions to the EPA as part of the Toxic Release Inventory. The surfaces of the maps are interactive. A user selects the scale and type of information he or she wants with a click of the mouse. Pop-up charts display data associated with specific geospatial areas. The maps also allow users to compare and rank pollution situations across the United States.

Scorecard carefully notes that the maps do not cover all pollution sources, and—even for those it does cover—only accounts for the approximately 650 chemicals that are reported under the TRI. The information that is provided, however, is sufficient to provide a glimpse into pollution and health hazard realities—while also reminding users that important information gaps and uncertainties remain.

Scorecard allows users to zoom in to the local, and out to the national, clicking through graphs that provide snapshots of pollution dispersion, and through to chemical profiles that characterize pollution hazards. The experience of Scorecard can be dizzying. But Scorecard takes on some of the most recalcitrant problems within environmental politics—the need to deal with too little, as well as too much, information; the need to deal with contested scientific findings and intractable uncertainty about long-term effects; the need to think locally, as well as comparatively and globally.

24 Maps showing pollution distributions are made with ArcView (another industry standard, for Geographic Information Systems), which was donated by Environmental Systems Research Institute through their Conservation Support Program. The maps pre-produced for Scorecard with ArcView are displayed on the Website through a java-based Practical Map Server developed by EDF GIS consultant Karl Goldstein.

Appropriate Design for Contemporary Environmentalism

The design of the Scorecard site has not gone uncriticized. Some people have pointed out that Scorecard does not provide users with raw data, or with the software with which they can make their own maps—leaving them dependent on EDF's "cartographic gaze." Nor does Scorecard allow users to add their own data. Data collected through house-to-house health surveys, or through local air monitoring, cannot be integrated. The questionable quality of TRI also has been pointed out. Because TRI data is self-reported by polluting companies, and never audited, errors as well as misrepresentations are not unlikely.

The most basic criticism of Scorecard is that it is far from straightforward to use. One has to drill down through many layers to get what one wants. This takes a lot of navigational skill and patience. According to this criticism, the site provides too much information, and thus threatens to overwhelm and paralyze the user. The path to fax a polluting company or the EPA is a meandering one. Users of the Scorecard site are encouraged to wander through different kinds of information, visualizing comparisons, and noting connections between things. Users are not told final truths. Instead, users are interconnected—with different types of information, with the regulatory process, with people in both similar and different locales, with ways of visualizing and spatializing phenomena that usually are represented in abstract, impersonal terms.

The high level of information literacy required by Scorecard can be cause for criticism. It also can be argued that the way Scorecard requires and supports high levels of information literacy makes it an appropriate technology for contemporary environmentalism. Though Scorecard can be difficult to use, it nonetheless accomplishes many things. It consolidates and cross-links an extraordinary amount of environmental data. It leverages different kinds of expertise. It is adaptable to many different uses. It puts pressure on corporations to decrease legal as well as illegal toxic emissions. It makes creative, civic use of advanced technological capabilities. It cultivates advanced scientific literacy, and tolerance for both complexity and uncertainty. All of these things are important in the environmental field today.

Before Scorecard, the task of gathering data on pollution in a particular area, or related to a particular health risk was overwhelming. Bill Pease, the designer of Scorecard, learned about this in his first few months at EDF in 1995. As EDF's senior environmental health scientist, he was swamped with requests from grassroots groups needing help obtaining and interpreting information about toxics in their community. Pease needed a way to save people the time required to go from government office to government office, to the public library, and to the polluting facility in search of information that often wasn't easily available without argument or delay. He also needed to provide grassroots groups with tools for interpreting

the data they collected. His solution was to build an internal database, and to hire a team of environmental scientists and database consultants. Their plan, until they consulted with MIT computer scientist Phillip Greenspun, was to build a standalone program that could be downloaded, or distributed on CD-ROM. Greenspun convinced him to go the way of the Web.

In the mid-1990s, Phillip Greenspun was concerned about the collapse of noncommercial activity on the Internet, in particular because supporting software and systems didn't scale well. One of his antidotes was to spend some of his time working with EDF developing collaboration software for their specific needs, and then offering it for free to other potential users. His goal was to "make sure that Web publishers [could] adopt the modern collaboration religion without selling their souls to the banner ad devils."[25] He also believed that information could be power, if it could be interpreted and manipulated to be relevant at the local level. Greenspun came to this belief in part through his experience with the passage of Proposition 65 in California in 1986. Unlike the federal TRI, which simply required industry to report what they emitted, Proposition 65 required industry to report both what they emitted *and* whether the substances emitted were carcinogens or reproductive toxicants. The result was that California cut emission of chemicals covered by Proposition 65 to one-quarter of previous usage, while the TRI only led industry to cut emissions by half. What Greenspun learned from this is that "disclosure plus interpretation is more powerful that disclosure alone."[26]

Providing grassroots groups with the means to both aggregate and interpret pollution data was a significant social and technical challenge. While masses of data on pollution existed, alongside masses of data on the hazards of particular chemicals, the work of correlating these data was (and still is) at a preliminary stage, even at the EPA and at public health organizations like the Center for Disease Control. Pease, Greenspun, and their design team wanted something better. Using the Internet, they could pull together 750 megabytes of data on toxic releases and on the health effects of various chemicals, in customized formats. The result provided unprecedented consolidation and cross-linkage of environmental data. This could not have been accomplished without leveraging many kinds of expertise.

Scorecard also has the potential to be a resource for people with different kinds and levels of expertise. Scorecard itself is a very complex information resource, but it was designed to be linked to a wide range of interfaces. Bill Pease talks of the possibility of building a simplified rating system that would show users a green or red light, without any words or numbers at all, using distributive plotting. He also speaks of linking Scorecard to investors and consumers. Investors would have easy access to corporate environmental records while they made daily investment decisions. Consumers could consult a PDA while they shopped to access the

25 P. Greenspun, "Better Living Through Chemistry" in *Phillip and Alex's Guide to Web Publishing* (Morgan Kaufman Publishers, 1999), 3 (online version).

26 Ibid., 4.

environmental records of Tupperware, and other consumer plastics manufacturers.[27]

Scorecard works through disclosure. The intent is to regulate conduct that affects the environment through the circulation of information rather than expressly through law. Instead of dictating what polluting industries do, it publicizes what they do. The effect is impressive, even if "command" environmental regulations remain important. Bill Pease, for example, refers to the quiet changes that corporations make to get off of "top ten" pollution lists.[28] Phillip Greenspun points to Dupont's "The Goal Is Zero" advertising campaign as an index of Scorecard's success. Such campaigns are important because they address what now are *legal* emissions. All emissions reported through the TRI, and through many other reporting structures, are legal emissions. Scorecard thus provides a way to work with corporations beyond the reach of the law, encouraging corporate greening and "voluntary compliance."

The disclosure strategy built into Scorecard can help drive changes in industrial production processes that result in less pollution. Disclosure also breeds more disclosure. Consider, for example, EDF's successful campaign to get the Chemical Manufacturers' Association (CMA) to test high-production chemicals for toxicity. In an interview, Bill Pease explained how industry had been resisting this kind of testing for decades, and how the EPA was unable to get an agreement to do the testing on a reasonable timeline. Completion of the testing was expected to take until 2110! Using Scorecard, EDF "launched a campaign to get industry to commit to faster testing—threatening companies with public disclosure that they were using chemicals that they could not prove were safe. Industry caved in, and an extensive, expedited testing program (all toxicity data within three years) was designed and agreed to by EPA, CMA, and EDF" in 1999.[29] By circulating information about environmental problems, Scorecard drives awareness of the importance of such information. It helps change a culture in which corporate pollution information is considered proprietary.

Scorecard is also helping to undermine the tendency of information technology itself to be proprietary. Because it is designed with a combination of open-source and donated, proprietary software, Scorecard is economically sustainable within the nonprofit sector. The result is a high-end, non-commercial space on the Internet. Such spaces are crucial for dealing with environmental issues today. They support broad participation in deliberations about environmental issues, and help to expand the expertise that can be called upon to make environmental decisions. Public space on the Internet also enables comparative perspective and collective action. Scorecard, for example, tells users whether pollution in their community is worse than pollution in other communities. Such information can be used to enroll elected officials, or to argue against the siting of a new industrial facility that would be a new source of pollution. Public

27 Schienke 2001, 11.

28 Stein, "Environmental Defense: From Brochureware to Actionware," 4.

29 Ibid.

space on the Internet also facilitates collaboration among people who are geographically dispersed. This is particularly important in the environmental field because of transnational environmental issues and the need for international environmental campaigns, and also because of the way power often operates at the local level. A community working to reduce pollution at an Exxon plant in their community has little leverage when working alone, especially when jobs are at stake. Joining a network of groups working to clean up Exxon makes a big difference. Expertise can be shared. What has worked in one community can be pursued in another. Mainstream media coverage becomes more likely. Exxon soon encounters a big enough public relations problem that local environmental groups begin to be heard.

The comparative perspective enabled by Scorecard is politically significant. It can help shift power among citizens, corporations, and governments. The comparative perspective enabled by Scorecard is also culturally significant. Too often, decision-making is held up by a lack of definitive proof that something is wrong. The complexity of environmental issues shuts down action. Scorecard is designed to help users skirt this problem. Comparative perspective on pollution in different communities, for example, provides a basis for remedial action even when it is difficult to demonstrate a direct correlation between pollution and adverse health effects. There is a reason to take initiative even in the absence of definitive proof. This significantly challenges conventional ways of doing and thinking about things. The scientistic culture that has made it so difficult to deal with environmental problems is undermined, and a culture that deals well with complexity begins to take shape. Scorecard supports this cultural shift through its facilitation of a particular kind of scientific literacy. Users are provided with many kinds of scientific information, with information about missing information, and with tools for drawing different kinds of information together to make judgments and decisions. The complexity of environmental problems is acknowledged by design.

Appropriate Design as Design for Society

I have argued that Scorecard is an example of appropriate technology design for contemporary environmentalism because the design of Scorecard is attuned to the particular needs that arise from the tangle of issues, organizations, scientific challenges, and political forces that constitute the environmental field today. The design of Scorecard also takes advantage of new technologies in a way that responds both to environmental concerns and to broader concerns about the ways technological change is shaping society and politics. This synchronization is impressive on many fronts. It shows what can happen through design when social and technical expertise is effectively integrated. And it shows how design can become a means to address complex social problems.

The potential role of design in solving social problems has been elaborated on by design scholar Richard Buchanan. Reporting on the way design has been conceived in relation to the new constitution of South Africa, he stresses how design is "an essential instrument for implementing and embodying the principles of the Constitution in the everyday lives of all men, women, and children. Design is not merely an adornment of cultural life, but one of the practical disciplines of responsible action for bringing the high values of a country or a culture into concrete reality, allowing us to transform abstract ideas into specific, manageable form."[30] Buchanan emphasizes how design should aim to accomplish first principles—regarding human rights and dignity, for example—as well as practical ends. He does not discount the need for technical problem solving and cost-reasonableness. He does insist that the purpose of design is more complex.

Scorecard is built around a conception of the user as a citizen, and around a conception of democracy that requires ongoing participation by citizens, even in matters that are extremely complex, both scientifically and politically. Scorecard is effective because it is designed to respond to *particular* challenges faced by citizens and democracies in a historical period marked by massive pollution, scientific uncertainty about the health effects of pollution, and domination of political decision making by corporations. These characteristics of the contemporary period cannot be disentangled. It is their combination, or what toxicologists call "cumulative effect," that is so powerful. Scorecard addresses this cumulative effect by design. Scorecard is *appropriate* for the context in which it works, and thus is able to serve high ideals in concrete, practical ways.[31]

30 See R. Buchanan, "Human Dignity and Human Rights: Thoughts on the Principles of Human-Centered Design," *Design Issues* 17:3 (Summer 2001): 35–39.

31 Thanks to Erich Schienke, Alex Sokoloff, Ned Woodhouse, Jason Patton, and Dean Nieusma for help with both conceptual and technical aspects of this paper.