Three Environmental Discourses in Human-Computer Interaction

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CHI 2009, April 4 – 9, 2009, Boston, MA, USA
ACM 978-1-60558-246-7/09/04.

Abstract
A review of the past decade of human-computer interaction relating to environmental issues identifies three discourses whose commitments and assumptions have consequences for the design of new interfaces and interactive systems: sustainable interaction design, re-visioning consumption and citizen sensing. It suggests two promising directions for future research: participatory design and infrastructure.

Keywords
Sustainability, environmentalism, nature, design, discourse analysis

ACM Classification Keywords
H5.m. Information interfaces and presentation, K4.m Computers and Society

Introduction
> *To protect the nature that is all around us, we must think long and hard about the nature we carry around inside our heads. [10]*

In response to predicted dangers to humanity such as climate change, pollution, and resource depletion, the field of human-computer interaction has seen a recent "burgeoning" [32] of projects focused on environmental issues, particularly in terms of sustainability. These

varied works – such as prototype systems, workshops and special interest groups, conference publications, special journal issues, and magazine articles – address a dizzying array of technologies and contexts. Their goals are equally varied, including intervention in purchasing/disposal cycles; decreasing resource consumption in use; enabling more effective pollution detection; and frameworks for understanding environmentally positive technology practices and the values they embody (see [28] for a brief overview).

How we frame problems as "environmental" and then evaluate potential solutions has specific, concrete consequences for the products we design and the policies we promote as designers, engineers, and educators. The repetition of "environmental" and "sustainable" as descriptions of various programs and projects may obscure significant differences in theoretical orientation, research methodology, and practical objectives. In particular, an unacknowledged "ubiquitous ambiguity" [25] in our definitions of "the environment" and "environmental information" deserves attention as a destabilizing source of misunderstandings between proponents of different discourses.

While thoughtful literature reviews (especially in [4] and [43]) inform this overview, there is a dearth of systematic, detailed overviews of "environmental HCI." This paper attempts to remedy that lack. Its purpose is not to highlight one "best" approach to environmental questions and answers. Rather, it compares three environmental discourses within HCI to delineate some categories within this flourishing field of research and suggest promising areas for future work.

Discourses of the environment in HCI

But what exactly is the "environment" that we are protecting? For the purposes of environmental information systems, one conventional definition of "the environment" has been "the soil, the water, and the species in the world around us" [16]. It appears to exclude all human-built artifacts, such as buildings, roads, or computers – and perhaps even humans themselves.

In his classic *Uncommon Ground* [10], historical geographer William Cronon details how environmentalism as an intellectual and political movement has derived considerable rhetorical power from an assertion of "natural" purity opposed to human society and its technological products. Yet as a site of human beliefs and activities, "nature" and "the environment" can encompass multiple and even contradictory meanings [26]. Definitions of "the environment" and "nature," and even their assumed worth, vary dramatically over time [15] and space – even over the distance of a few miles [26]. Engaging with the history of "nature" as a material experience and intellectual concept considerably complicates the notion that there is an objective, unambiguous object called the "environment" that external human actions affect. As Cronon writes,

> *"Nature" is not so nearly so natural as it seems. Instead, it is a profoundly human construction. This is not to say that the nonhuman world is somehow unreal…But the way we describe and understand that world is so entangled with our own values and assumptions that the two can never be fully separated.* [10]

Sources		Numbers
Peer-reviewed publications	Journal articles	52
	Conference papers	
	NSF grant abstracts	5
Project documentation	Project websites	19
	Magazine articles	2
Event proceedings	Calls for proposals	6
	Position papers	36

Table 1 Discourse analysis inventory

Given the complexity of even a seemingly simple concept such as "the environment," can we talk about a specifically "environmental" form of HCI? If environmental HCI exists, it is a singular field or many? This literature review seeks to answer that question through a discourse analysis of the past decade of research in environmentally motivated HCI.

Why the past decade? Certainly, environmental information systems – systems that collect and manage information about physical phenomena – have been a consistently popular subject for research over the past forty years within computer science and environmental informatics [18]. Research on motivations for environmentally positive behaviors has also been popular within applied and environmental psychology (ie, [24] and [40]). But as some observers have noticed, a recent flurry of papers and events has perhaps created its own "hype" [32], keeping us from critically analyzing sets of inherited assumptions (but see [42] for one such analysis) about the potential scope and role of the field.

A discourse is "a shared way of apprehending the world," produced rhetorically through "assumptions, judgments, and contentions that provide the basic terms for analysis, debates, agreements, and disagreements." [15] Discourses influence more than debates. In framing thought, they have concrete consequences for action.

A "discourse analysis" is the systematic surfacing and naming of those frameworks through close reading of documents [1]. It is an appealing lens for studying environmental agendas in HCI because HCI as a field is itself constituted by discourse: publications, panels, grant applications, workshops, special interest groups (SIGs) and even prototype documentation. It is also an appealing tool for organization because it prioritizes not just what is said, but also the types of assumptions and gaps in attention that can suggest novel directions for research.

This review analyzes a collection of 120 documents on the subject of human-computer interaction related to "nature," "the environment," or "sustainability." These documents were mainly assembled through searches of the United States' National Science Foundation (NSF) grant database and the IEEE and ACM publication archives. As well as research papers intended for academic audiences, the collection includes documentation of design processes and research agendas designed for a broader audience: prototypes, visual documentation, and project websites. It begins with a 1998 study of appliance "eco-feedback" [30], and ends in June 2008 with a study of "getting to

green" [9]. Of course, this collection has limitations. Most importantly, using the NSF database biases results towards the United States. However, international participation in conferences and journals should diversify the perspectives of authors.

The resulting corpus of documents (summarized in Table 1) resulted in the identification of three separate discourses: sustainable interaction design, re-visioning consumption, and citizen sensing.

Sustainable interaction design

Sustainable interaction design (SID) draws on green industrial design philosophy [39] to call for changes in manufacturing, use, and disposal practices. SID advocates the agency and central role of designers in mitigating those "material effects" (but see [33]) of computationally intensive lifestyles and working towards less damaging "viable futures" [4].

In pursuit of those futures, projects often involve persuasive technological interventions (such as in [35] and [23]) to motivate behavior change in individual end-users [17][19] as well as designers [32]. SID projects typically do not address individuals constrained by material circumstances such as poverty, by deeply held beliefs about the role of technology, or by powerful political institutions (see [4] for a discussion). The designers and users of technology are imagined as *consumers* with leisure and power to choose within a free market of possessions, services, and ideals. Often, SID projects draw on theories of behavioral psychology to predict that consumers who are given new information will change their behavior. Groups of people are often envisaged as social networks — freely elected associations linked on Facebook or other social network websites [29]. From this perspective, one role of designers is to influence technology consumers with information that motivates better decision-making. Successful projects influence people individually to change their behavior, creating widespread change incrementally.

Notions of free choice are embodied in three main design directions:

- Systems that provide information relevant to the sustainability of products and services [11][21].
- Visualizations of resource consumption ([20] has a thorough summary of this genre).
- Persuasive applications, such as games [2][29].

These design choices emerge logically from the assumptions described above. Visualizations of energy use can be aesthetically appealing ways to induce behavior change with situationally appropriate information. Games provide a built-in incentive – winning – to motivate immediate behavior changes and perhaps longterm behavior modification.

Often, the goal of SID projects is to give consumers information about what they buy and use at the moment of consumption. We can also see how the choice of interfaces reflects an emphasis on *private* consumption: personal possessions [34], appliance accessories [17], body-worn communication devices [21] and office lobby displays [17].

Notions of choice and human agency are also exemplified through the *footprint* as a recurring metaphor for humans' relationship with the environment. The footprint, it has been argued (quoted in [6]),

> *is a good metaphor for our individual impact on the social or natural environment. It's personal, tactile, organic, and immediately comprehensible.*

Whether referring to a "carbon footprint" (or measure of carbon dioxide output) [11] or simply to the general "ecological footprint" of resource consumption [29], the footprint symbolizes a view of humans as powerful actors, and the Earth as a passive receiver of their imprints.

Sustainability[1] is a powerful and influential new orientation towards the environment within HCI. Blevis' definitional manifesto [4] received a CHI Best Paper Award in 2007, and is (perhaps consequently) currently the most cited paper retrieved by searches for "sustainable design" and "environmental decision making" in ACM's Portal. Projects self-identified as "sustainable interaction design" or substantially following the rhetoric of Blevis' original paper comprised 95 of the 120 items reviewed.

Re-visioning consumption

The focus of projects within re-visioning consumption is how people enact beliefs about humans, technology, and the environment. One NSF grant award abstract sums up this approach [37]:

> *to highlight the aspects of everyday IT design which are predicated on industrialized orientations such as mass production and consumption of consumer goods.*

Researchers working to "re-vision" new approaches information technology often try to specify "what exactly" they mean by environmental responsibility [43]. One common approach is studies of "marginal" [37] groups and behaviors that represent viable alternatives to resource-intensive technology behaviors.

Re-visioning consumption examines how humans perceive their relationships to the material aspects of the world – both the human-built environment and the "natural" features of water, dirt, air, plants, and animals. Often focusing on values [31], re-visioning consumption tends to de-prioritize recommendations for immediate, active solutions to perceived environmental problems in favor of engagement with the imagined landscapes of human beliefs and aspirations. Constituting 14 of the 120 items reviewed, it is distinctly a minority approach to environmental HCI.

Re-visioning consumption attends to "orientations" to consumption not only as personal decisions but also as responses to shared experiences. Instead of defining users by how they consume technology, re-visioning consumption studies tend to define users through their membership in groups in spatially defined communities [30][38] or households [43] with coherent sets of beliefs about the non-human world. Research participants are identified as people with a specific orientation or "value commitment" [31] to a conception of "nature" [3] [30] or "green values" [31]. These belief systems emerge in dialogue [3] over time with local landscapes (see [43] and [3] for exploration of two very different landscapes and groups) and relationships with other people.

Re-visionist work often contributes not design interventions but plausible visions of how technology

[1] Ie, the International Symposium on Electronics and the Environment has changed its name to the International Symposium on Sustainable Systems and Technology.

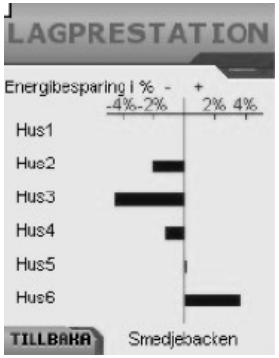

Figure 1 Typical artifacts produced in different discourses. (from top): Sustainable interaction design: Screenshot of PowerAgent [2]; Re-visioning consumption: "nature probes" used to prompt conversation [3]; Citizen sensing: Visualization from website of Urban Pollution Monitoring Project [38].

practices embody feelings toward nature such as connection [34] or belonging [3] The canonical product of this approach is not the prototype but the probe [3][33] or critical art installation [5] – an ambiguous, flexible, yet richly inspirational experience "meant to inspire and provoke questions rather than just answer them" [5].

Citizen sensing

Environmental information systems collect and manage digital data about ecosystems and natural resources [16]. They represent an important 20th century ecological philosophy of enlightened natural resource management and protection [15] by professional scientists and policy-makers. Since the 1960s, the development and evaluation of these systems have comprised a well-established field, with its own journals, conferences, and institutes [18]. As complex sociotechnical systems, they have received attention as boundary objects within computer-supported collaborative work (ie, [41]). Since the emergence of environmental information systems, innovations in capturing and representing massive amounts of environmental data (notably in wireless sensor networks such as [27]) have allowed scientists to sense and monitor conditions affecting non-humans with ever less labor and in ever more detail.

The *citizen sensing* research framework moves sensor-based environmental information systems from wilderness areas to cities. It attempts to replace the authority of accredited scientists with that of engaged citizens [36] acting as "agents of change."[2] As a means to this end, citizen sensing often attempts to visualize spatial variances in local levels of air pollution, noise pollution, or water pollution (ie, [8][38]). Those representations can then be used to create "a new political space" [7] for group action or to guide more individual action. The underlying assumption is that "higher quality data tend to generate more significant action and better understanding" [8].

Citizen sensing projects often represent their outcomes as techno-political tools rather than prototype products. Participatory Urbanism's website promises "an architecture of participation and democracy," while Bratton and Jeremijenko call for "ecosystemic interfaces" [7]. Of course, the use of visualizations in political action is not new. In the 1960s, the Club of Rome sounded a call for urgent environmental action with creating data visualizations derived from digital environmental models [15]. But unlike these earlier agendas, citizen sensing emphasizes community-based, "participatory" (see [8] for an in-depth discussion of one such agenda) nature of data collection and visualization.

Like SID, citizen sensing relies on notions of individual agency. But unlike SID, for whom people as *consumers* leave damaging footprints upon the earth, citizen sensing imagines people as *civic actors* who need highly localized, reliable information to protect themselves from pollution. One striking metaphor used to promote citizen sensing to the general public is that of *exposure*[3]. Exposure has a double meaning. Most literally, it denotes a personal

[2] Participatory Urbanism. Retrieved from http://www.urban-atmospheres.net/ParticipatoryUrbanism/ on September 16, 2008.

[3] See for example PEIR: Personal Environmental Impact Report. Retrieved from http://peir.cens.ucla.edu/ on September 13, 2008.

encounter with harmful pollution. Yet it also highlights how data visualization *exposes* otherwise invisible environmental conditions, transforming data into tools for activism. Unsurprisingly, the main design outcomes of citizen sensing (besides sensor platforms) are computer-generated pollution maps (Fig 1) aimed at making local pollution data legible to a wide audience.

New directions

Having identified and analyzed the assumptions, goals, and technological outcomes of these different orientations to environmentalism in HCI, I outline two relatively under-explored areas that suggest promising directions for future work.

Participatory design

Histories of environmental movements argue [10][15][26] that there can be no universal agreement on the identity and extent not just of "environmental problems" but even the concept of "nature" itself. Even seemingly objective phenomena come to be *seen as* important or meaningful through human processes of contestation and negotiation, sometimes through temporary "strategic essentialism" (as discussed in [14]) that can produce a temporary accord. Consequently, designers, engineers, and research participants cannot assume that discussions rest on common ground. Even within HCI, subtle differences in projects' originating assumptions and metaphors may produce very different material outcomes. Designing effective, appropriate, accepted interventions in everyday perceptions, behaviors, and decisions may mean foregrounding people's perceptions of their relationships to the living world as a primary research question rather than as a taken-for-granted design rationale.

Participatory design is a valuable but under explored (with the notable exceptions of [12] and [13]) methodology for surfacing and productively grappling with disparate notions of environmental issues (PD). By giving potential users power within the design process, PD can help empower potential users to surface, reflect upon and creatively respond to their own unmet needs [13] in a complex, respectful dialogue with the makers of new technologies. It can also help designers attend to the political and ethical responsibility inherent in persuading others to change their behavior [12].

Moving beyond human-centered computing

The discourses of environmental HCI have tended to be human-centered. They study the behaviors, desires, and beliefs of individual humans (sometimes in groups), and design largely for privately owned, human-defined artifacts such as homes, office buildings, cars, and mobile devices. Yet the possibilities for materially sustainable lifestyles are bound up in politically sensitive, less "tractable" negotiations with corporate and governmental infrastructures and institutions [42]. As a discipline, HCI can and should grapple with the institutional politics of transit, finance, building construction, and state regulation.

Yet such a turn towards the political and the infrastructural may require different theoretical orientations and pragmatic alliances. Moving beyond human-scale spaces and human-centered computing experiences does not mean abandoning an ethical concern for human well-being or the appropriateness and usability of technical systems. Environmental information systems have long stimulated long-term interdisciplinary partnerships between scientists; perhaps a new brand of environmental HCI will

stimulate long-term partnerships between designers, policy makers, community activists, and non-profits.

Conclusion

The multiplicity of "environmental" viewpoints in HCI suggests that we should not treat "environmental HCI" or "sustainable interaction design" as a singular agenda. There are instead multiple orientations to the environment, to the place of humans and non-humans, and to the role of designers in current HCI research.

Though their methodological choices and favored outcomes differ, these discourses are not necessarily antagonistic. Proponents of the different discourses co-organize scholarly forums and co-author papers. In the end, they share common ground: that humans cause and are in turn harmed by planetary-wide problems of pollution and resource depletion; and that designers, businesspeople engineers, and scientists have a responsibility to both humans and the rest of the planet.

Acknowledgements

I am grateful for the continuing advice of Nancy Van House, Kimiko Ryokai, Paul Groth, and Elizabeth Churchill, as well as helpful and timely suggestions from Phoebe Sengers and Paul Dourish. I have also benefited from posts to the publicly accessible Sustainable CHI group.[4] This research was supported by a National Science Foundation Graduate Research Fellowship.

[4] Located at http://groups.google.com/group/sustainable-chi/.

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