DIGITAL RUBBISH

a natural history of electronics

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Conclusion

DIGITAL RUBBISH THEORY

> In these reflections on the multiple, on the mix, on the speckled, variegated, tiger-striped, zebra-streaked aggregates, on the crowd, I have attempted to think a new object, multiple in space and mobile in time, unstable and fluctuating like a flame, relational.
>
> —MICHEL SERRES, Genesis

> If you make a motor turn in reverse, you do not break it: you build a refrigerator.
>
> —MICHEL SERRES, The Parasite

Zero Waste

Two waste fantasies occupy the imagination of Kevin Lynch at the beginning of his study *Wasting Away.* These are opposing fantasies, one involving a "waste cacotopia," a society that produces waste rampantly and profligately, destroying everything it touches. The other involves a waste-free society, where there is "no more garbage, no more sewage; clean air, an unencumbered earth." In this place, "Plants and animals will be bred to reduce their useless parts: stringless beans, boneless chickens, skinless beets."[1] There would be no parasites, no weeds, no stray animals, no trash, no dirt, no dust, and "no spills, no breakage, no smoke or smog." Silence would prevail, and "friction" would be "reduced to the minimum needed to keep us erect and keep things in their place." As part of this friction-free campaign, "the edges of the continents" would even be "smoothed to reduce the tidal losses."[2] This vision of a waste-free society seems as startling as the wasteful one. As Lynch writes, "One fantasy has bred another, and neither seems attractive."[3] Yet it is typically these two polarities that are presented in relation to waste, producing it

Computer keyboards—electronic waste documentation, China, 2005. (Photograph courtesy of Greenpeace / Natalie Behring-Chisholm.)

in abundance, while simultaneously imagining the utopic possibilities of a waste-free society. Perhaps, however, the strange prospect of each of these worlds presents cause for reconsidering the intractability of waste; and by focusing on waste, it may be possible to unearth overlooked relations within the politics and poetics of things.

Strategies for dealing with waste often proceed by imagining its elimination: a society of "zero waste." In resonance with the second of the two preceding waste fantasies, zero waste is a concept and movement that has emerged as a response to the profligate wastefulness of Western societies and, in particular, to the wastefulness of manufacturing processes.[4] While the objectives of zero waste—to minimize waste in the waste stream and to develop ways of redesigning industrial processes—are important for addressing waste, "zero" may be a misleading approach to waste. Waste management and sustainable development scenarios typically consist of proposals not just to eliminate but also to make newly productive and profitable the remainders from previous cycles of production and consumption.[5] In these scenarios, the assumption is often made that if markets emulate "nature," then it may be possible to arrive at perfectly streamlined material economies. In this way, economies may also become "natural."[6] But the sense of the "natural" at work here is twofold: it is supposed, on the one hand, that the "natural" condition of environmental systems is to be at "harmony" (i.e., nature produces no waste) and, on the other hand, that material economies will ideally emulate and advance such natural harmony through the eventual progress offered by new technologies and systems.

Things wear out, fail, and break; systems of value shift and render some things worthless; transience takes hold of even the most enduring artifacts, practices, and places.[7] Rather than encounter waste, failure, and transience as conditions in need of elimination, it may be possible to consider these conditions as constitutive elements of material processes.[8] As I have argued in the pages here, there are multiple ways in which electronics generate waste. Rather than imagine the simple elimination of this waste, I have traced these residues from the fossils of manufacture to the sites of technological imagining. By working through these remainders, I have attempted to demonstrate that waste is more than a heap of defunct objects; it is also a mixture of flickering and mutable relations. Through waste, it is possible to think a "new object." This natural history of electronics, then, proposes a different sense of the "natural," which does not purify this category as an (ever-receding) ideal to move toward but, instead, considers how new natures are always in the making, emerging in that fluctuating mix of machines, nonhumans, and people. Wastes, too, are a critical part of this natural history: they are not excrescences to be weeded out at some future date. If waste, as Hawkins suggests, is "inevitable,"[9] this is not because of some tacit agreement with rampant forces of production and consumption but because no society can entirely rid itself of waste. By acknowledging the inevitability of waste, it is possible to think of it not exclusively as a menace to be eradicated but as a formative part of our material lives.

Visions of a waste-free future potentially obscure the very conditions through which waste emerges. Once waste is understood as an integral aspect of processes of materialization, it is no longer possible to imagine its complete elimination or to position it simply as raw material to be fed into friction-free futures. Instead, the persistence of waste occurs in part through the unavoidable remainders that do not easily recycle into new systems of production or that are left behind as the pollution and residue from previous activities. Waste does not consist just of the fossils from past cycles of production and consumption; it is also the remainders generated from continually unanticipated futures. When proposals are made for a "solution" to the waste "problem," waste is often displaced back into the same productive mechanism that produced waste in the first place.[10] But as discussed in chapter 5, such a "discount on the future," as Van Loon and Sabelis characterize it,[11] does not account for the "costs of irreversibility,"[12] which will contribute to future complexities beyond our present methods of accounting. By appending "zero" to waste, we obstruct the possibility of considering how irreversibility and remainder emerge as integral aspects of waste.[13]

As long as our basic approach to waste depends on its eventual and continual eradication, it will be difficult to grasp the ways in which waste emerges and operates—as generative and dynamic and, as Hawkins suggests, as the "terrain of ethics."[14] Arguably, the development of apparent waste-eliminating strategies such as recycling not only obscures the inevitability of waste[15] but also defers the ethical aspects of how we attend to waste—whether we bury it, ship it to developing countries, or leave it to future generations to trawl through. It may be possible to move beyond a "dos and don'ts" approach to waste, as Van Loon and Sabelis write, and instead "to generate a radical reconceptualization of waste itself."[16] Rather than consider recycling as the instant reintegration of waste into the market, it may be possible to attend to the ways in which waste—as a mutable and relational object—offers "possibilities for the unexpected, the creative and the ethical."[17] The creative and ethical aspects of waste are often typically elided, particularly in campaigns for its elimination or reintegration, yet it is from these remainders and fragments that it is possible to realize the political and poetic registers of matter. Remainders direct us not toward the recovery of "wholeness" but toward new possibilities for working with the "scatter" of the world. Waste allows the possibility for "imagining a new materialism," as Hawkins suggests, resonating with the material imaginings put forward by Benjamin.[18] But the question of how this materialism emerges and registers still persists.

Garbage Imaginaries

In many cases, attempts to imagine a new materialism for electronics extend from improving the life-cycle impacts of these devices, minimizing their ecological footprint, improving working conditions for fab workers, and banning the exportation of wastes to developing countries for "recycling."[19] In addition to stricter environmental policies and regulations, design is often seen as a key way in which to improve the environmental impact of electronics. Numerous design projects address ways in which to eliminate, reincorporate, or otherwise track remainder, from point of manufacture on to consumption and disposal. These projects, often based on life-cycle analyses, suggest that waste may be minimized by altering design approaches. This is an ideal way in which to "regulate" waste, as Molotch suggests, because "design determines about 80–90 percent of an artifact's life-cycle economic and ecological costs, in an almost irreversible way."[20] Hazardous materials and landfilling can be avoided through the more careful design of electronics. In this way, Greenpeace's "Guide to Greener Electronics" suggests that electronics companies develop "a chemicals policy based on the Precautionary Principle" and phase out known hazardous materials that are used in machines, including brominated flame retardants and other "problematic substances."[21] A complex composite of plastics is also used in electronics, plastics that are difficult to reuse or recycle at end of life and that could be simplified for this purpose. If electronics companies were responsible both for what goes into machines and for their eventual take-back and recycling, then they might possibly begin to find it effective to make these devices less toxic at the outset.

Without a doubt, the reduction of hazardous materials and introduction of methods of recycling and disassembly are necessary developments within the world of electronics.[22] Within this area, there are so many projects underway that it is tempting to make a modest proposal and public appeal for someone to write a "handbook" about green machines—the sort of handbook that could be circulated to enable new ways of thinking about electronic design and production.[23] "Green technology" is not only seen as a major area of invention; it is also a complex and interesting terrain for new design projects. In an industry that is preoccupied with continual invention—where pronouncements are made about the "convergence" of technologies, about pervasive computing, about Web 2.0 and the death of the Internet and the end of Moore's Law—it seems appropriate to consider how that invention can extend into this other terrain.

Emerging proposals for "green electronics" or "green ICT" (information and communication technology) include schemes that address the material composition and manufacture of electronics, from computer keyboards made out of carrot and spinach extracts to mobile phones that "plant" sunflower seeds when they decompose.[24] Microchips that are oxidized through ultraviolet radiation, rather than energy-intensive furnaces, are now in prototype stage; PCs are available in die-cut cardboard, rather than a composite of plastics; and mobile phone prototypes "self-recycle" by popping apart when heated, for ease of disassembly and recycling.[25] An extensive number of electronic design projects also focus on ways of improving energy consumption within the operation of devices.[26]

Other projects document or propose interventions within the life cycles of electronic devices.[27] Some designers have gone so far as to suggest that design not only should alter at the manufacturing phase but should also extend into "everything that happens after that." In this sense, designer Ed van Hinte writes, goods should not be "impenetrable boxes" but, rather, should have "a career plan."[28] In this scenario, design extends to consumer use, commodity alterations, and eventual dismantling. Other projects draw attention to the expanded circuits and possibilities of things beyond the manufacture stage by using electronics to track trash, so that electronic devices may even become the means for possible infrastructures of reuse.[29] These tracing and tracking projects pay particular attention to the object—electronic or otherwise—as it cycles from manufacture to use and death.

Still other projects reconsider the relatively functional role of electronics in our lives and draw out the more imaginative and uncanny dimensions of these devices.[30] Repurposing obsolete electronics through reverse engineering and hacking has been one strategy not only for unpicking the assumed functionality of these devices but also for extending the practices of reuse and recycling beyond the simply material toward new technological deployments.[31] Concepts of "reuse," "appropriation," and "maintenance" are emerging as practices for investigating the possibilities of sustainable computing.[32] Electronic capabilities may, at the same time, enable other modes of encounter with environments, and much of the literature on "sustainable HCI" (human-computer interaction) has dealt with not just issues of green machines but also ways in which social networking, citizen science, and ecological monitoring and information may persuade and raise awareness about environmental issues.[33]

Together, these projects address everything from materials and manufacture to systems and new imaginaries for the use and abuse of electronics. It is a significant step toward a more "green" and creative approach to electronics. Yet the question that remains within such initiatives is whether attention to waste, as well as the extended political and economic effects of electronics, will provoke us to think about technologies differently. Designs for green electronics may be most successful when they consider not only the material effects but also the extended social, political, and imaginative terrain of electronics. This means that it may be possible to do more than just alter electronics to contain fewer contaminants, have an ease of disassembly, and be more readily reusable; we may also reconsider how electronics materialize and rematerialize across multiple spaces and practices. This natural history of electronics, then, raises questions about how to go beyond the gadget as it passes through its life cycle. Such a conception of electronic technologies potentially settles on one dimension of the life and death of these devices. However, a complex circuit of places and politics, materials and ecologies, and uses and manufacture makes possible and sediments into electronics and electronic wastes. As a thing and technology, electronics and electronic wastes are the sites of stories that exceed product life cycle and that ultimately connect up lives, labor, and imaginaries.[34]

The natural history of electronics developed here draws on these proposals and suggests that one way to develop "sustainable" electronics would be to address the multiple materialities, politics, ecologies, economies, and imaginings that give rise to electronics.[35] These technologies are not only a part of natural-cultural arrangements; they also provide insight into the ecologies we inhabit. In this sense, there are opportunities to engage with the creative and ethical aspects of electronics and electronic waste not just through improving electronics manufacture but also through linking up ecologies—political and otherwise. Supplying ICT for the developing world is just one way in which electronics can be deployed not so much for another round of consumption but, instead, to connect up communities who may not otherwise have access to electronic communications and to make these technologies less toxic in the process. Soenke Zehle suggests we revisit earlier proposals for an "environmentalism for the net."[36] Such an environmentalism might consist of "info-political initiatives" that encompass not just the digital commons but also the "broader agenda of economic and environmental justice."[37] In this way, applications are being developed through original uses of renewable energy—wireless that runs on wind power—that begin to take up a digitally relevant environmentalism that expands beyond but also encompasses less deleterious and resource-intensive manufacture and energy processes.[38]

Some of the most compelling projects to be found working in this area establish creative ways to make the environmental, social and environmental relations that emerge through electronics a site of reinvention and provocation. The "Zero Dollar Laptop" project, a collaboration by Furtherfield, Access Space, and St. Mungo's charity for the homeless, offers a series of recycling workshops that engage with obsolete electronics. The participants engaged with the project recycle outdated laptops, and install Free and Open Source Software on the machines to enable the use and creation of media files, and to provide access to the Internet. Obsolete hardware and software offer up a set of new resources, as this project demonstrates, if the terms of use shift to engage with alternative economies and exchanges. In a different approach, Graham Harwood and Matsuko Yokokoji have made the material and energy requirements of computers evident in their "Coal Fired Computers" project, which demonstrates how central coal power is to the manufacturing and firing of computer circuits, since coal still provides a considerable amount of power to our modern energy economies.[39]

The focus in this study has been to unpack the black box of electronics by charting stories that converge in the saturated soil of Silicon Valley, in the run of numbers that flicker across NASDAQ interfaces, in the global trawl of waste shipments, in the defunct machines gathering archival dust, and in the thick sludge of the landfill. In considering these places and stories, where the debris of electronics collects, I suggest there are other ways of thinking about material culture through these remainders.

Electronics constitute "materializing and transformative processes." Such processes, as Buchli writes, give rise to "new kinds of bodies, forms of 'nature' and political subjects."[40] The processes whereby materials congeal and fall apart are essential for understanding things as matter. The ways in which electronics stabilize and destabilize are bound up with technological trajectories and markets, methods of manufacture and consumption, and imaginaries and temporalities.

There is even potential in this space of imagining to consider the fantastic qualities of electronics and for a material imagination that surpasses the strictly instrumental and the progressive.[41] Remaining in cast-off objects is that same "wishful" element that Benjamin saw as most potent at the moment of their introduction. The fossils in his natural history were not without fascination; in fact, they depended on it. Without a doubt, there are many approaches to electronics that may begin to find the advantages of operating in these fields, beyond the appeal of novelty and functionality and toward a kind of garbage imaginary. So perhaps what we need are electronics that exploit and expand on the cracks, the failures, and the garbage, as a way to move toward the creative and ethical aspects of electronics and electronic waste, as a way to imagine new material relations.

This garbage imaginary is a fitting place to conclude this study into electronics and waste. The "cultural imaginary" of garbage, as Shanks, Platt, and Rathje write, "is at the heart of the composition and decomposition of modernity and modernism."[42] A garbage imaginary might emerge not just by seeing the matter of things, the fields through which they circulate, and their modes of transformation and animation; it might also emerge, as Lynch suggests, by "wasting well." If waste is inevitable, then it may be possible to begin to address how matter transforms and to draw out the moments and movements where energies, resources, values, temporalities, and spaces shift. In dirt, there is potential. Dirt rituals have existed for quite some time. To this extent, Lynch even considers the fascination of "collision derbies and the art of piano-smashing."[43] It may be possible that we need more and better ways of encountering the ways in which things run down and wear out. With a less exclusionary sense of waste, it might be possible to see that matter moves in "gradations" and, thereby, to devise "ceremonies of transformation."[44] By registering the ways in which materials transform—the processes of materialization through which things sediment—it is possible to take greater responsibility for our material lives.

But in these moments of transformation, the smashing ceremony that resonates the clearest is the one described by Benjamin in his "Theses on the Philosophy of History." He describes how, "on the first evening" of the "July revolution," the clock towers in Paris "were being fired on simultaneously and independently from several places."[45] In this moment, time no longer progressed along a chronology. With the clock towers shot out, the empty space of progressive time was stopped in its tracks. In the absence of progressive time, a shift in the *experience* of time could emerge. In the "now" of suspended progressive time, the "new" could materialize through other temporalities, not as a space of transition or even revolution, but as a space of material relation and imagination. This is a transformation that takes place not simply in succession but through a generative and waste-based imaginary that involves the politics as much as the poetics of materials. That imaginary, as described here, settles into a natural history of electronics.

International Computers Ltd. instructional material, ca. 1970, Science Museum of London. (Courtesy of Fujitsu.)

55. Ibid., 196.

56. On Benjamin's interest in undoing the insistence on progress, Peter Osborne writes, "The avant-garde is not that which is most historically advanced because it has the most history behind it (the angel), but that which, in the flash of the dialectical image, disrupts the continuity of 'progress,' and is thus able (like the child) to 'discover the new anew.' Benjamin's philosophy of history is a struggle to wrestle the idea of the 'new,' essential to any concept of the avant-garde, away from the ideology of 'progress'" ("Small-Scale Victories, Large-Scale Defeats: Walter Benjamin's Politics of Time," in *Walter Benjamin's Philosophy: Destruction and Experience,* ed. Andrew Benjamin and Peter Osborne [Manchester: Clinamen, 2000], 88).

Conclusion

Michel Serres, *Genesis,* trans. Genevieve James and James Nielson (Ann Arbor: University of Michigan Press, 1995), 91.

Serres, *Parasite,* 68.

1. Lynch, *Wasting Away,* 6.

2. Ibid., 6–8.

3. Ibid., 10.

4. For example, see Murray, *Zero Waste.*

5. "Waste management," as Loon and Sabelis write, not only entails "the commodification of excess productivity into renewable resources," it also "becomes a euphemism for the displacement and misplacement of the unwanted and unmanageable consequences of modernization" ("Recycling Time," 292).

6. Ibid., 296. Loon and Sabelis further write, there emerges "a new, higher moral union," where "the environment enters the capitalist system through commodification, while in return capitalism is further mythified as 'natural.'" There are numerous texts and projects that have been developed within the natural-capital nexus. For one example relevant to design, see William McDonough and Michael Braungart, *Cradle to Cradle: Remaking the Way We Make Things* (New York: North Point Press, 2002).

7. Moser similarly writes, "Waste is permanent and unavoidable, for there is no system—whether biological, technical, social, or historical—that does not produce remnants, remains, scraps, leftovers, that does not leave certain parts to decay, that does not secrete or reject. Anything in a system can become waste" ("Acculturation of Waste," 102).

8. Serres, *Parasite,* 12–13. I discuss the notions of "systems" and "harmony" at greater length in Jennifer Gabrys, "Sink: The Dirt of Systems," *Environment and Planning D: Society and Space* 27, no. 4 (2009): 666–81.

9. Hawkins, *Ethics of Waste,* 122.

10. For an example of this sort of return of waste to productive mechanisms, consider the proposal Judd H. Alexander makes in his book *In Defense of Garbage,* where he suggests that garbage is a good thing because it offers a way to fill up all the holes that result from mining and other forms of resource extraction. He calculates that in the United States, more than twenty-three times the amount of land is removed through resource extraction than is filled. Clearly, the solution is to fill all the holes with garbage. In Alexander's strange mathematics, the distinc-

tion between raw material, commodity, and waste collapses. Materials seem only to have wanted to leave the ground to return as trash. But the transformation that these materials undergo and the remainders and irreversible effects they generate comprise a critical distinction and an overlooked area of investigation. See Judd H. Alexander, *In Defense of Garbage* (Westport, CT: Greenwood, 1993).

11. Loon and Sabelis, "Recycling Time," 296. Addressing the mythic solution engineered by waste management, these authors write, "Progress is simply conceived of in terms of a differential discount on the future. This means that while progress is accounted for in the present, it entails a reduction of the complexity of futures that springs from the indeterminacy of the difference between the actual and the possible."

12. Ibid., 297. These authors make the statement, "Markets cannot resolve ecological issues because they are not geared toward providing infrastructures for dealing with negative utility (excess). The win-win economics of ecological marketing ('it is possible to capitalize on waste') will not pay off if the hidden costs are taken into account" (302).

13. The difficulty of even agreeing on what constitutes waste and what the severity of certain types of waste consists of has meant that hazardous waste may not be acknowledged as such and will be improperly handled. This is certainly true with electronics, where the apparent inertness of these devices conceals the hazards that lie within the machines. Electronic waste and other forms of waste often waver in such spaces of indeterminable status. As *The Guardian* reports, "One of the great challenges of our time is to collectively agree on what is waste and what are second-hand products—this question extends to end-of-life ships as much as to electronic goods" (Hilary Osborne, "Rich Nations Accused of Dumping E-Waste on Africa," *Guardian,* November 27, 2006).

14. Hawkins, *Ethics of Waste,* 122.

15. Ibid.

16. Loon and Sabelis, "Recycling Time," 295, 298.

17. Ibid., 303.

18. Hawkins, *Ethics of Waste,* 81.

19. See Electronic Product Environmental Assessment Tool, http://www.epeat.net; Silicon Valley Toxics Coalition, "Green Chemistry," http://www.svtc.org/site/PageServer?pagename=svtc_green_chemistry; Green Electronics Council with the National Center for Electronics Recycling and Resource Recycling, "Closing the Loop: Electronics Design to Enhance Reuse/Recycling Value," January 2009, http://www.greenelectronicscouncil.org/documents/0000/0007/Design_for_End_of_Life_Final_Report_090208.pdf; E-Stewards Initiative, http://www.e-stewards.org/; Solving the E-waste Problem (StEP), "Annual Report, 2009," http://www.step-initiative.org/pdf/annual-report/Annual_Report_2009.pdf; Sibylle D. Frey, David J. Harrison, and Eric H. Billett, "Ecological Footprint Analysis Applied to Mobile Phones," *Journal of Industrial Ecology* 10, nos. 1–2 (2006): 199–216; C. Kieren Mayers, Chris M. France, and Sarah J. Cowell, "Extended Producer Responsibility for Waste Electronics," *Journal of Industrial Ecology* 9, no. 3 (2005): 169–89.

20. Molotch, *Where Stuff Comes From,* 245–46.

21. Greenpeace, "Guide to Greener Electronics," December 2008, http://www.greenpeace.org/rankingguide. Together with improving electronic design through the use of fewer toxic materials, this report proposes extended producer responsibil-

ity, or EPR, as an important strategy in the take-back and recycling of electronics.

22. These initiatives have also emerged in response to the RoHS and WEEE directives in Europe, which have begun to inform the manufacture and disposal of electronics (as previously discussed in this study). For a review of this program, see United Nations University, "Review of Directive 2002/96 on Waste Electrical and Electronic Equipment (WEEE)" (Tokyo: UNU, 2008). See also "Dell's 2008 Corporate Responsibility Summary Report" (2009), http://www.dell.com/sustainability report, for an example of a current approach to electronics that focuses on product life cycle, hazardous substances, and product take-back. U.S. responses have often occurred at the level of state legislation, but for a more comprehensive, if voluntary, approach developed by the EPA, see "Responsible Recycling ('R2') Practices for Use in Accredited Certification Programs for Electronics Recyclers," October 30, 2008, http://www.epa.gov/waste/conserve/materials/ecycling/r2practices.htm; see also Basel Action Network, "Detailed Critique of Problems with R2 Standard," November 2008, http://e-stewards.org/wp-content/uploads/2010/02/Detailed_R2_Analysis.pdf.

23. When I first made the proposal for a "green machines" handbook in 2006, there were relatively few examples of green computing in circulation. As this study is completed, an increasing number of projects are developing in this area, including the recent Bill Tomlinson, *Greening through IT: Information Technology for Environmental Sustainability* (Cambridge, MA: MIT Press, 2010).

24. "Compostable Keyboard," as documented in Alastair Fuad-Luke, *The Eco-Design Handbook* (London: Thames and Hudson, 2005); Joseph Chiodo, "Active Disassembly," http://www.activedisassembly.com/index2.html.

25. On these few (among many) examples of reworking the material form of electronics, see "Cool Light Leads to Greener Chips," *BBC News*, June 30, 2006, http://news.bbc.co.uk/1/hi/technology/5128762.stm; "Cardboard PC Case by Lupo," October 21, 2005, http://www.ubergizmo.com/15/archives/2005/10/cardboard_pc_ca.html.

26. Alternative materials and reduced energy consumption are two areas of considerable attention within design projects. For example, see Core 77, "Greener Gadgets Design Competition," http://www.core77.com/competitions/GreenerGadgets. Given concerns over energy use and climate change, increasing attention is now being drawn to the amount of energy that electronic technologies require—not just to power the devices themselves, but also to power the extensive servers, networks, and interlocking systems that allow these devices to communicate. See Bobbie Johnson, "Google's Power-Hungry Data Centres," *Guardian*, May 3, 2009; Richard Wray, "Spam 'Uses as Much Power as 2.1M Homes,'" *Guardian*, April 15, 2009.

27. The project "How Stuff Is Made," conducted by design students and academics, documents the resources, manufacturing processes, and labor and environmental impact of contemporary goods (see http://www.howstuffismade.org). The United Nations Environment Programme has also recently produced a document that focuses on the social aspects to life-cycle analyses. See United Nations Environment Programme, "Guidelines for Social Life Cycle Assessment of Products," DTI/1164/PA (2009), http://www.unep.org./pdf/DTIE_PDFS/DTIx1164xPA_guidelines_sLCA.pdf.

28. Ed van Hinte, *Eternally Yours: Visions on Product Endurance* (Rotterdam: 010 Publishers, 1997), 27. Sterling similarly projects a relatively friction-free future for technologies. He imagines one speculative version of technology that will "eventually rot and go away by itself." This completely biodegradable and "auto-recycling" technology will, when it breaks down, give rise to new "complicated forests, grasslands and coral reefs." But this technology will not require "natural materials"; rather, it will sprout up in a "room-temperature industrial assembly without toxins." See Sterling, *Shaping Things,* 143.

29. For examples of "trash-tracking" projects, see Eric Paulos and Tom Jenkins, "Urban Probes: Encountering Our Emerging Urban Atmospheres," *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems,* April 2–7, 2005. (Portland, Oregon); Trash Track, http://senseable.mit.edu/trashtrack/; Valerie Thomas, "Radio-Frequency Identification: Environmental Applications" (white paper, Foresight in Governance Project, Woodrow Wilson International Center for Scholars, Washington, DC, 2008).

30. Examples of these projects include Natalie Jeremijenko and Proboscis's feral robotic dogs, http://www.nyu.edu/projects/xdesign/feralrobots/. In a related way, Dunne explores how electronics constitute "post-optimal objects," and he seeks to capture the "para-functionality" of electronics in order to consider how these objects may become critical devices and "provide new types of aesthetic experience." See Dunne, *Hertzian Tales,* 12–14.

31. See Jonah Brucker-Cohen, "Scrapyard Challenge Workshops," http://infamia1.infamia.com/coin-operated.com/; Benjamin Gaulon, "Recyclism," http://www.recyclism.com/.

32. See the call for CHI 2010, Jina Huh et al., "Workshop on Examining Appropriation, Re-use, and Maintenance for Sustainability," http://jinah.people.si.umich.edu//chi2010/reuse.html.

33. "Sustainable HCI" approaches range from the informational to the artistic and from the interventionist to the persuasive. See Carl DiSalvo, Kirsten Boehner, Nicholas A. Knouf, and Phoebe Sengers, "Nourishing the Ground for Sustainable HCI: Considerations from Ecologically Engaged Art," *Proceedings of the CHI Conference on Human Factors in Computing Systems,* April 4–9, 2009 (Boston), 385–94; Marcus Froth, Eric Paulos, Christine Satchell, and Paul Dourish, "Pervasive Computing and Environmental Sustainability: Two Conference Workshops," *IEEE CS* 8, no. 1 (January–March 2009): 78–81.

34. Frow, "A Pebble, a Camera, a Man Who Turns into a Telegraph Pole," 273–74.

35. Felix Guattari's discussion of "three ecologies," spanning from the individual to the sociocultural and environmental, is a relevant reference for addressing the multiple versions of ecologies that inform environmental issues. See Felix Guattari, *The Three Ecologies,* trans. Ian Pindar and Paul Sutton (London: Athlone, 2000).

36. Zehle's proposal is based on James Boyle's article "A Politics of Intellectual Property: Environmentalism for the Net?" 1997, http://www.law.duke.edu/boylesite/Intprop.htm. Where Boyle proposes environmentalism as an analogy for how to negotiate the digital commons of the Internet, Zehle suggests we take this environmentalism more literally into the realm of digital material effects. See Soenke Zehle, "Environmentalism for the Net 2.0," *Mute: Culture and Politics after the Net,* September 21, 2006, http://www.metamute.org/en/Environmentalism-

for-Net-2.0. Together with Geert Lovink, Soenke Zehle set up the Web site incommunicado.net as a space to discuss and critique the global arrangements of the "information society." As part of this project, regular discussions of electronic waste and technology workers have appeared. See Geert Lovink and Soenke Zehle, eds., *Incommunicado Reader* (Amsterdam: Institute of Network Cultures, 2005); Matthias Feilhauer and Soenke Zehle, eds., "Ethics of Waste in the Information Society," special issue, *International Review of Information Ethics (IRIE)* 11 (October 2009).

37. Zehle, "Environmentalism for the Net 2.0."

38. There are an increasing number of projects that are operating within this area of digitally relevant environmentalism, which consider ways to address issues of environmental justice and green machines. For examples, see Shuzo Katsumoto, "Information and Communications Technology and the Environment: An Asian Perspective," *Journal of Industrial Ecology* 6, no. 2 (2003): 4–6; Jonathan Fildes, "Wireless Power System Shown Off," *BBC News,* July 23, 2009; Jonathan Fildes, "The Winds of Change for Africa," *BBC News,* July 23, 2009.

39. See Furtherfield, "Zero Dollar Laptop," http://www.furtherfield.org/zero dollarlaptop/; Access Space, http://www.access-space.org; Graham Harwood and Yokokoji Yoha, "Coal Fired Computers," *Discovery Museum* (Newcastle, United Kingdom: AV Festival, March 12–14, 2010).

40. Buchli, *Material Culture Reader,* 15. Jane Bennett similarly draws out the possibilities for thinking through new natures and new subjects that emerge through materializations. See Jane Bennett, "The Force of Things: Steps toward an Ecology of Matter," *Political Theory* 32, no. 3 (June 2004): 347–72.

41. Taussig, *Mimesis and Alterity,* 99.

42. Shanks, Platt, and Rathje, "Perfume of Garbage," 64.

43. Lynch, *Wasting Away,* 32.

44. Ibid., 41.

45. Benjamin, "Theses on the Philosophy of History," in *Illuminations,* 261–62.

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