Digital Environmental Metabolisms:

An Ecocritical Project of the Digital Environmental Humanities

by

Amanda Starling Gould

Department of Literature
Duke University

Date:_____

Approved:

_____
Katherine Hayles, Supervisor

_____
Mark Hansen

_____
David Bell

_____
Michael Hardt

Dissertation submitted in partial fulfillment of
the requirements for the degree of Doctor
of Philosophy in the Department of
Literature in the Graduate School
of Duke University

2017

ABSTRACT

Digital Environmental Metabolisms:

An Ecocritical Project of the Digital Environmental Humanities

by

Amanda Starling Gould

Department of Literature
Duke University

Date:_____
Approved:

_____
Katherine Hayles, Supervisor

_____
Mark Hansen

_____
David Bell

_____
Michael Hardt

An abstract of a dissertation submitted in partial
fulfillment of the requirements for the degree
of Doctor of Philosophy in the Department of
Literature in the Graduate School of
Duke University

2017

Copyright by
Amanda Starling Gould
2017

Abstract

By combining literary, ecocritical, and media techniques with a mindfulness of the environment, "Digital Environmental Metabolisms: An Ecocritical Project of the Digital Environmental Humanities" contributes to the urgent task of re-orienting media theory toward environmental concerns. It is informed by the premise that, in our present Anthropocenic age defined by humans acting as a geophysical force, human bodies, cultural technologies, and the earth are intersecting material practices. I argue this intersectionality is neither cyborgian nor posthuman, as some media scholars insist, but is something far more natural: it is a metabolic relationship wherein each system is inherently implicated in the perpetuation of the others. Through a series of chapters that dispense with standard maps of cyberspace and the social network replacing them with a digital geography of wires, workers, warehouses, and waste, this project shifts the media theoretical focus from one grounded in computation to one fully rooted in the earth. Unlike others, like those mentioned here within, who are contributing to what may be called an emerging environmental media studies, I offer several practical and theoretical interventions, including Permaculture and Ecocritical Digital Humanities, that are capable of moving us toward more sustainable digital practice and a more robust Anthropocene Humanities.

Dedication

"The plain fact is that the planet…desperately need[s] more peacemakers, healers, restorers, storytellers, and lovers of every shape and form. It needs people who live well in their places. It needs people of moral courage willing to join the fight to make the world habitable and humane."

David Orr

Dedicated to those who work to heal the earth.

Contents

List of Figures

Acknowledgements

This project would not have been possible without the steady guidance of my advisor Kate Hayles, the tireless support of my closest mentors Mark B. N. Hansen, David Bell, Mark Olson, and Cathy Davidson, and the enthusiastic encouragements of colleagues and faculty in the Duke Literature Department, the Duke University Libraries, the Duke Franklin Humanities Institute, and the Duke PhD Lab in Digital Knowledge. I owe each of them a great debt of gratitude and it has been an unforgettable pleasure to work with them all. It takes a village to complete a project of such heft and I am grateful to family, friends, mentors, and colleagues, at Duke and beyond, who have lent a hand along the way.

Chapter One: Digital Environmental Metabolism

Introduction

"Make Kin Not Babies!"
Donna Haraway

Welcome to the Anthropocene![1] That we are living in worlds profoundly altered by human influence is no longer a speculative issue. The facts and figures of anthropogenic environmental change daily rehearsed in news outlets and on social media illustrate, among other things, climate changes, sea level rises, severe weather events, polluted living conditions, growing mountains of toxic waste, and extinction-level losses of biodiversity. Environmental change is registering now too in international treatises, religious encyclicals, global activist action, and national legislation. The implications of environmental change and its storied manifestations are, borrowing the words of Ian Baucom and Matthew Omelsky in the introduction to their recent edited collection,

[1] "Welcome to the Anthropocene," invites an *Economist* article from 2011 that bids us to consider our ways of living and knowing in the modern geological/environmental moment characterized by Anthropogenic alteration: "Humans have changed the way the world works. Now they have to change the way they think about it, too." *Economist.com*, May 26, 2011, "Welcome to the Anthropocene." Though promoted as an Epoch three years before (by Zalasiewicz et al. in 2008), publicized as a geological marker years before (by Paul Crutzen in 2002), coined several times prior to that (Eugene Stoermer 1980s) and (Soviet scientists 1960s), novelized as an idea in the science fiction genre for decades (see, among many, for instance R.L. Sherlock's *Man as a Geological Agent* published in 1922), and conceived as an idea centuries ago (Antonio Stoppani 1873 and George Perkins Marsh 1864), the Anthropocene is really only now (the 2010s) taking a more primary place within common conversation and political, artistic, and academic discourse. No matter what we prefer to call it, we do all seem to more or less agree that things have changed and those changes change knowledge, practice, and theory in the humanities.

Climate Change and the Practices of Knowledge, "deeply connected to what it means to be human on earth in the twenty-first century."[2]

Make Kin Not Babies! So chants Donna Haraway in her recent project *Staying with the Trouble* (2016). "Making kin and making kind," she says, "stretch the imagination and can change the story."[3] In the so-called age of the Anthropocene when the planet's wealthiest and most educated humans have, through their daily acts of modern living, accelerated climate change more than 170 times its natural pace, we must begin recognizing our nonhuman kin and the roles we play together as messy multispecies metabolic partners. We must begin to tell new stories that illustrate our Anthropocenic togetherness. In our blind adoption of techno-reproduction as the apex of human progress, we have sentenced ourselves to lives lived with those technologies and the implication of their geophysical wastes.

Haraway claims she is not a posthuman but a compost-human. If what it means to be human has shifted due to our twenty-first century digital lifestyles, then indeed we all are. We are compound, composing, de-composing creatures working in concert with

---

[2] Baucom and Omelski, 1.

[3] Haraway, 2015, 161. She continues: "I think that the stretch and recomposition of kin are allowed by the fact that all earthlings are kin in the deepest sense, and it is past time to practice better care of kinds—as assemblages (not species one at a time). Kin is an assembling sort of word. All critters share a common "flesh," laterally, semiotically, and genealogically. Ancestors turn out to be very interesting strangers; kin are unfamiliar (outside what we thought was family or gens), uncanny, haunting, active." Haraway, 2015, 162.

all the many component parts of our technocapitalist habits and habitats. We "require each other in unexpected collaborations and combinations, in hot compost piles," [4] and it is in our overlapping kinships that we both *are* human and *can learn to be* humans prepared for living in uncertain Anthropocene futures. To survive our condition, we must learn to be proper compost-ists. Our theories and our practices, beginning here with those digital, must be based upon frameworks that take to heart that humans and nonhumans are oddkin (Haraway) meshed together in inseparable bonds of cooperation. Our digital theories can no longer assume the digital world is something we enter upon opening a webpage. We are in it now. Always. Geologically. Reciprocally. Our digital scholarship, in order to be more sustainable and materially effective, must recognize our oddkin digital metabolic partners.

The Technosphere

Welcome to the Technosphere! Despite claims that technology will save us (from ourselves), our digital technosphere is in fact partly, if not largely, to blame for our current Anthropocene habitat. Digital systems and networked technologies now embody an increasingly agentive ecological sphere—what Environmental Engineer Peter Haff calls the *technosphere*—of their own. The technosphere, in Haff's configuration, is the physical layer of technological accumulation that now blankets the

[4] Haraway, 2016, 4.

earth. As an earth scientist, his task had traditionally been to isolate elements in their purity in order to better understand them. Not so long ago, he realized that there are no longer any geophysically-pure elements; everything is now touched by human, and most particularly human technological, intervention.

The digital sphere includes now billions of devices, big and small, millions if not billions of servers sitting in millions of data centers around the world. It includes too a massive infrastructure of wires and undersea cables. There are no satellites despite the airy metaphors. The technosphere also includes enormous piles of e-waste, un-paid or underpaid workers in mines, and an unruly amount of toxic pollution, wasted clean water, and ecological destruction. On top of that, this technosphere has a hungry appetite for energy. The cloud alone uses more energy than most countries. Our emails, spam messages, and Google searches all have carbon footprints as well. Most people are pretty surprised by this. And understandably so. We are told to 'think before we print' but never told to think before we send an email.

Despite claims that the web is clean and green, the majority of the energy it uses still comes from coal and dirty fossil fuels. The carbon footprint of the digital sphere now rivals, and is set to soon surpass, the carbon footprint of the aviation industry. It has been estimated that every two seconds, Google emits the same amount of carbon that would be emitted if a car was driven, nonstop, for nearly two days. The same

amount of energy powering two seconds of Google could power a 13-watt CF lightbulb, continuously, for nearly nine years.

The ecological footprint of the device, even before we turn it on, is staggering (see more in chapter two here). Its transportation footprint is equally so. Edward Humes in his 2016 book *Door to Door* calculates that the transportation footprint of a single mobile phone is equivalent to a round trip voyage to the moon. It is reported that there are now more active cellular phones *in use* than there are human bodies on the planet and that by 2020, our vast network of networking devices is estimated to reach 26 billion units.[5] It is these physical things, and *not* immaterial magic bytes, that constitute the digital universe. This is the technosphere. The technosphere began when the earth became irreparably impure and technology became metabolically entangled with the human and the precarious environmental balance of our earthly habitat.

Greening Media Studies

Myriad digital media studies[6] detail how the digital systems that network the earth are actively altering human biologies and societies, but this project is something different: it shifts the digital media focus from one grounded in computation to one fully

[5] Gartner, n.p.. Note: these numbers are estimates and they tend to differ slightly according to source.
[6] See bibliography for a representative sampling.

rooted in the earth.[7] Despite the obvious materialities of digital technology, classical humanist discourse, with only a representative handful of clear exceptions, more or less neglects this in favor of focusing on the affective nature of the digital universe on the human sphere.

Among those media, literary, and digital theorists who do take up the materiality of the digital, there is a relative absence of a sustained consideration of its total trajectory as tracked fully through from its earthly beginnings (minerals) to its earthy returns (wastes). This project responds by introducing a metabolic relational ontology that orients the digital network and digital media as constitutive parts of today's bio- and geo-material metabolisms. By considering minerals, miners, manufacturing, and e-waste, it brings to light the tangible—but rhetorically invisible—marks that our networked digital technologies are registering on the earth, the biosphere, and the human body. What becomes clear is that the daily use of our seemingly weightless wirelessly-connected digital devices becomes ethically-charged with heavy issues of labor, pollution, human health, and environmental sustainability. The digital networks that maintain our cities, our wireless web searches, and our online social networks here regain their thickly-wired substrates.

Digital Environmental Metabolisms follows trajectories set by contemporary interdisciplinary media scholars who extend their media study to include the rooted

---

[7] The term "digital universe" is borrowed from George Dyson (2012).

material histories, environmental footprint, and geopolitical effects of technological materiality. These digital media materialists (my term not theirs) take up the geopolitical force of media geology (Jussi Parikka, Sean Cubbitt), the accumulation of electronic waste (Elisabeth Grossman, Jennifer Gabrys), the manual labor of digital production and breakdown (Trebor Scholtz, Jenna Burrell) and even the historico-social implications of the undersea cables that make our digital network possible (Nicole Starosielski). These studies acknowledge that digital media studies have much to gain from expanding their purview to include the grounds, whether they be geological (the minerals) or anthropological (the miners), of digital media. Though media theory's efforts at distilling the social and affective nature of the digital network are integral to understanding twenty-first century culture, we must recognize those social affects as dependent on a long line of stocks and flows that come before and after.

The technosphere, which is now estimated to weigh 30 trillion tons,[8] makes technology a geological question. As such, our view of the digital network should be at the level of this full (eco)system. It should be dirtied with stories of dusts, soils, soots, pollution, noise, and corruption. It is only when we recognize how the boundaries between the digital, the human, and the environment are so muddied that we begin, as

[8] Newitz, n.p..

Haraway says, "to become capable, with each other in all of our bumptious kinds, of response."[9] Our task, following Haraway,

> is to make kin in lines of inventive connection as a practice of learning to live and die well with each other in a thick present. Our task is to make trouble, to stir up potent response to devastating events, as well as to settle troubled waters and rebuild quiet places.[10]

This project's purpose is to add a dirty dimension to our contemporary studies of digital media and culture so that we might cultivate a more sustainable digital media studies in response. It hopes to *stir up* trouble by positing a digital-human-environmental metabolism that troubles traditional notions of anthro-geo-techno relationships and, as Haraway challenges, makes kin out of oddkin so that we complicate matters of responsibility, connection, and contemporary digital consumption.

We have come to think through, with, and alongside our technologies (Hayles) but we must now learn how to live with and within our technologies and the environments they have created. This requires a reorientation of our digitally-related practices and theoretical frameworks.

---

[9] Haraway, 2016, 1.
[10] Ibid.

Digital Metabolism

The concept of a digital metabolism is inspired by resource and waste management engineers Peter Baccini and Paul Brunner's project to map a metabolism of the *anthroposphere* by analysing its stocks and flows,[11] and by sociologist Hannah Landecker's development of metabolism as a distinct theoretical design—suffused with knowledge of the environment and of information—for understanding life and the world.[12] The argument here is not that the digital is biological, just as urban (Baccini and Brunner) and industrial (Landecker) environments are not strictly biological, but that the digital technosphere demonstrates a digitally-instantiated systemic metabolism of its own that necessarily connects it to the systems in which it overlaps—namely the bio- and geophysical spheres.

Today's context-aware smart devices and networks exemplify a new breed of technology that "is no longer a machine with fixed architecture carrying out a fixed function."[13] It is instead a system, Brian Arthur says, "a network of functionalities—a metabolism of things-executing-things—that can sense its environment and reconfigure

---

[11] Baccini and Brunner define anthroposphere as 'the network of urban, terrestrial, and aquatic ecosystems that constitute the Earth's biosphere' Baccini, Peter and Paul H. Brunner, 1.
[12] She continues saying that metabolism is "both a conceptual domain and a set of experimental practices, this new metabolism is a regulatory zone, not a factory system; it is understood to be constituted by a dynamic web of cellular signals, built by and responding to environmental information…." Hannah Landecker, "Post-Industrial Metabolism: Fat Knowledge," 496.
[13] Arthur, 206.

its actions to execute appropriately."[14] Indeed in Arthur's full configuration, modern technology itself *becomes* a metabolism:

> a technology in operation…ceases to be a mere object at work. It becomes a metabolism. This is not a familiar way to look at any technology. But what I mean is that the technology becomes a complex of interactive processes—a complex of captured phenomena—supporting each other, using each other, 'conversing' with each other, 'calling' each other…. It is ongoing and continuously interactive.[15]

Digital metabolism is not a metaphor but an operational—and observable—definition of the digital's functionings and interconnections with the earth's human, biotic, and geological ecologies. As follows, one of the primary goals of the framework is to ground the digital within its oft ignored physical and ecological contexts. What digital metabolism makes thinkable is a world in which digital and environmental systems are collaborative coauthors in the material and affective processes of modern life.

Metabolisms

The role and definition of metabolism is to change, to transform. Metabolism concerns itself with the dynamic processing of material stocks and circulating flows within a sustainable (operating) system.

---

[14] Ibid.
[15] Arthur, 52-53.

Biological metabolism takes two primary forms: *catabolism* destructs matter to transform it into energy and *anabolism* uses energy to construct matter. All biological systems have a metabolism and all metabolic systems are functionally similar. Matter is taken in and transformed into energy by a catabolic process so that anabolism can transform this energy into matter. This is a life-sustaining process as these systems are in constant motion responding to the environment in order to ensure system preservation.

The notion of *non*biological metabolism begins, it is said, with Karl Marx and Friedrich Engels (1867) who positioned metabolism (*Stoffwechsel*) as a social framework. Marx speaks of the "metabolism between man and nature" in reference to the labor process: "Labour is, first of all, a process between man and nature, a process by which man, through his own actions, mediates, regulates, and controls the metabolism between himself and nature."[16] According to Marina Fischer-Kowalski, Marx and Engel's social metabolism was inspired by biologist Jacob Moleschott (1852) who described metabolism as "an exchange of matter between an organism and its environment, rather than as a cellular biochemical conversion, as modern textbooks do."[17] Metabolism in its Marxist configuration is then a material-energetic accounting of the correspondence between humans and nonhumans. It is a description of the process of material

[16] Swyngedouw, quoting Marx, 25.
[17] Fischer-Kowalski, 1998, 64.

transformations required to maintain a working, sustainable society. For Marx and Engels, according to Erik Swyngedouw,

> With this view of metabolism as ecological-historical process, and combined with Darwin's equally historical-metabolic views of the biological world, and Lyell's theories of the world's geological reconstruction, historical-geographical materialism could mobilize the concept of metabolism, neither as just an organic analogy to the social order (see Padovan 2000) nor as a mere metaphor to be transposed onto society, but as the very foundation of and lasting condition for the social.[18]

In social metabolism, energy (labor power for instance) transforms matter (like raw materials) into new types of matter (like tables, sweaters, and high-tech cellular phones) to be circulated, used, and sold. Energy is then required again at the end of this product's lifecycle when it is broken down and/or recycled into yet another form of matter. Just as in biological metabolism, matter here is transformed by way of energetically-powered breakdown and re-building, and it is this constant dynamic process that maintains the urban social system.

Peter Baccini and Paul Brunner go beyond the simple city system to speak about the metabolism of the full anthroposphere. For them, the anthroposphere, as "mankind's sphere of life" is "a complex technical system of energy, material, and information flows" and as such, it is metabolic. The metabolism of the anthroposphere "includes the

[18] Swyngedouw, 23.

uptake, transport, and storage of all substances, the total chemical transformation within the sphere, and the quantity and quality of all refuse."[19] They continue:

> The structure of the metabolism of the anthroposphere is given by a series of activity-induced *material systems*. These systems consist of linked processes and goods through which material is flowing. If such a material system is extended by energy flows, it is called a *metabolic system*.[20]

In Ludwig von Bertalanffy's general system theory[21] we find a framework for thinking systems that helps us conceptualize how this might be true. He says "the fundamental characteristics life, metabolism, growth, development, self-regulation, response to stimuli, spontaneous activity, etc., ultimately may be considered consequences of the fact that the organism is an open system."[22] For Bertalanffy, all dynamic open systems—and he defines an open system as "a system in exchange of matter with its environment, presenting import and export, building-up and breaking-down of its material components"—share system characteristics above and before they are delineated into unique kinds.[23]

> …there exist models, principles, and laws that apply to generalized systems or their subclasses, irrespective of their particular kind, the nature of the component elements, and the relations or 'forces' between them. It seems legitimate to ask for a theory, not of systems of a more or less special kind, but of universal principles applying to systems in general. In this way we postulate a new discipline called *General System Theory*. Its subject matter is the formulation and

---

[19] Baccini and Brunner, 1.
[20] Ibid, 85.
[21] General System Theory was later changed to General *Systems* Theory. I here use the original.
[22] Bertalanffy, 1968, 149.
[23] Ibid, 141. Bertalanffy defines a system as "complexes of elements standing in interaction" Bertalanffy, 1968, 33.

derivation of those principles which are valid for 'systems' in general.[24]

Bertalanffy's work helps us understand why living organisms have a biological metabolism, and why the digital universe may be said to have a similar but differently substantiated metabolism as well.

> It can be shown that the *primary* regulations in organic systems, i.e., those which are most fundamental and primitive in embryonic development as well as in evolution, are of the nature of dynamic interaction. They are based upon the fact that the living organism is an open system…This state of affairs is a consequence of a general principle of organization which may be called progressive mechanization. At first, systems—biological, neurological, psychological or social [*and here we'll editorialize to add technological*]—are governed by dynamic interaction of their components; later on, fixed arrangements and conditions of constraint are established which render the system and its parts more efficient.[25]

If, as Bertalanffy says, living organisms have a metabolism because they are open systems and, if the digital universe too is a dynamic open system—and there are many from various fields who argue convincingly that it is (see for instance: Dyson's *digital universe*; Deleuze, Guattari, and DeLanda's *mechanosphere*, and Haff's *technosphere*)[26]—

---

[24] Ibid, 32.

[25] Ibid, 1968, 44, 134. Bracket insertion is the author's.

[26] Quoting Haff in full: "The technosphere, the interlinked set of communication, transportation, bureaucratic and other systems that act to metabolize fossil fuels and other energy resources, is considered to be an emerging global paradigm, with similarities to the lithosphere, atmosphere, hydrosphere and biosphere. The technosphere is of global extent, exhibits large-scale appropriation of mass and energy resources, shows a tendency to co-opt for its own use information produced by the environment, and is autonomous. Unlike the older paradigms, the technosphere has not yet evolved the ability to recycle its own waste stream. Unless or until it does so, its status as a paradigm remains provisional. Humans are 'parts' of the technosphere—subcomponents essential for system function. Viewed from the inside by its human parts, the technosphere is perceived as a derived and controlled construct. Viewed from outside as a geological phenomenon, the technosphere appears as a quasi-autonomous system whose dynamics constrains the behaviour of its human parts. A geological perspective on technology suggests why strategies to limit environmental damage that consider only the needs of people are likely to fail without parallel

that the digital has its own metabolism should not surprise us. Bertalanffy's model makes it an inherent possibility for all open systems.

Working within information infrastructures such as genetic information or social regulation, biological and social metabolisms transform matter using energy. Though the digital's metabolism is necessarily different from either biological or social metabolisms, it demonstrates a strikingly similar disposition. Industrial metabolism has much to lend an ecocritical digital theory as it tracks the lifecycle of products and urban processes from beginning to end. This is something media theory has not yet done.

Digital Metabolism: Information, Energy, Transformation, Matter

The digital's internal metabolism uses energy to transform and circulate information. When input such as voice, text, or video enters a digital system, it is converted into data that is broken into data packets to be sent through material networks of wires and routers to the designated location where they'll reassemble back into the original information input. When sending an email, for instance, the multimedia content that is your message is transformed into digital data and metadata that is broken into packets and transferred through routers until it reaches its desired destination and

---

consideration of the requirements of technology, especially its need for an abundant supply of energy." Haff, 2013, 1.

reconstitutes itself into your originally composed message.[27] Along the way, that message gets written, stored, and pushed through up to half a dozen servers, equally as many if not more Internet Exchange Centers, and countless wires and routers.[28] This breakdown and reformation process is almost as elegant as catabolism and anabolism. We might say that a digital catabolism transforms information to bits (binary digits) and a digital anabolism transforms those bits back into human-legible information. This isn't magic, this is fossil-fuel-powered transformation and movement.

The metabolic transformations taking place in the digital system not only define the system, but as media theorist Shane Denson points out in his study of our modern "post-natural" condition, they are one if its inherent properties. [29] It isn't just that

---

[27] When you open your Internet browser and navigate to your email client, your computer sends a request to your Internet service provider (ISP) which then sends a request to the domain name server (DNS) that hosts your client. The request sent will route through different servers—as a sensor-signal system—until it eventually (but seemingly instantly) finds the server that houses your email. That server will then 'respond' to you by sending data files in the form of packets of information. The website information is neither sent directly nor in its complete entirety. Information is broken into pieces—packets—that are sent, routed through sensors and signals, until all of the parts arrive and are reconstituted on your individual browser, identifiable by your computer's unique IP address. These packets may or may not take the same path but each will take the past of least resistance until your email inbox appears. You review your received and saved email messages (all which are written and stored on a data server located in a data center) and you send another. When you send an email or make a voice or video call using your online email interface, the same thing happens: your voice, video, and/or text are broken into packets and shot out across the web's connected routers until they arrive and reconstitute themselves at their requested destination.

[28] Kirschenbaum writes that "a simple email message may leave a copy of itself on half a dozen different servers and routers on the way to its destination, with the potential for further proliferation via mirrors and automated backup systems at each site." Email and computer records, according to computer privacy expert Michael Calonyiddes, actually "are far more permanent than any piece of paper." Kirschenbaum.

[29] "…we can restate Khurana's point thus: Luhmann guarantees the possibility of medial transitionality by establishing what Gilbert Simondon defines as a "transductive" relation between substrate and media—i.e. an irreducible relation in which the related terms do not precede or exist outside the relation—as opposed to a more traditional distinction of apparatuses and (separable) content, where change is primarily a matter of content-level variation, or else requires intrinsic (teleological) or extrinsic (e.g. human) causal agencies to

dynamic systems are open to transformation, but following the metabolic requirement, they *must* undergo persistent transformation in order to sustain themselves. Though individual components can be turned off, retired, or put to sleep, the system writ large—e.g. the digital universe—keeps running. A healthy system must both transform and learn to manage its transformations in a manner that demonstrates a sustainable relative stability. Persistent change is required for continuous persistence.[30]

As with any metabolic system, the digital's metabolism is reliant upon material stocks and energetic inputs. These are arguably its most important parts, as without such support structures, it would have neither a material substrate (a location for the transformation) nor a fuel source (to catalyze the transition). These parts that are often ignored are the focus of this project. Thinking about digital technologies this way opens us to seeing their ecological and environmental positions. And these are what most concern us.

At its core, digital metabolism is a concept of co-living, of overlapping and co-constituting systems. Metabolic thinking gives us a rather radically ecosystemic way of looking at our bodies and our ecological connections, and when applied to the digital, it

---

affect apparatuses. The advantage, then, of Luhmann's conception is that *eigendynamische* transitions are enabled by the transductive inseparability of substrate and form that, as a dynamic process, subjects both to transformation through emergent connections—much in the manner of the equally transductive relations of Latour's 'mediations'." Denson, 316.

[30] Or as Erin Manning says, we must sway in order to stand still. See Manning, 2013.

reminds us of the mineral beginnings and the wasteful ends of the digital technosphere. It is a method for re-imagining how the human, the environment, and technology are inherently linked as kin.

Metabolism as Ecological

In *The Phenomenon of Life*, Hans Jonas says "Metabolism and its constant dynamic inter-conversions simultaneously bind organisms to the environment and free them from it…[Metabolism is an] exchange of matter with the surroundings."[31] This pervasive exchange of matter with the environment, he says, "is not a peripheral activity engaged in by a persistent core: it is the total mode of continuity (self-continuation) of the subject of life itself."[32] Metabolism for Jonas is inherently ecological as it demonstrates the mutual co-constitution of the organism and the environment.

For both Jonas's and Landecker's philosophical metabolisms, metabolism is not a passing-through process but a transformative changing-of: "things enter the body, are digested, and in shaping metabolism, become part of the body-in-time, not by building bones and tissues, but by leaving an imprint on a dynamic bodily process …things outside of the body are transformed *into* the biology *of* the body…."[33] Open systems are fundamentally in and of the environment and they shape each other through a mutual

---

[31] Jonas, 75-76.
[32] Ibid, 76.
[33] Landecker, 2011, 177-178.

symbiogenesis. The digital network is such a system; it is a hyper-connected entity that persists by way of metabolic transformation and exchange with its environmental cohort systems. Without these intrasystemic transformations and intersystemic exchanges, the digital universe—as well as potentially its cohort systems—would perish.

My aim in offering a digital environmental metabolism is to point to the ecological nature of the digital universe's interspheric relations. Following Denson who echoes the Marxian metabolic sentiment, we can say that metabolism as a process highlights how the human and nonhuman spheres are "interactively stabilized."[34] Indeed this *interactive stabilization* defines the goal of any metabolic system and it is becoming increasingly important that we pay proper attention to the increasingly intertwined, process-based *mechanospheric* (or *technospheric*) relationships.

Thinking metabolically not only allows us to rethink our relation to the digital but also, as Denson points out, allows us to think about a "more symmetrical relation between human and nonhuman agency as 'constitutively intertwined.'"[35] A rhetorical or theoretical perspective that is either too anthropocentric or too technocentric often misses this. Thinking metabolically gives us an ethological distance that allows us to

---

[34] Denson, 260. "Media in Denson's understanding….operate less as agents *within* any given system, than as environmental forces conditioning the development of an autonomous material domain and informing the disparate becomings that compose such development." Mark Hansen in Denson, 11.
"If Denson is right that the metabolic operationality of media displaces the anthropocentrism of the human bodily synthesis of space and time, then what he proffers as the anthropotechnical interface holds forth the promise to access this metabolic materiality, this domain of distributed embodiment, without imposing on it the specific form of *human* embodiment." Denson, 14, Hansen introduction.
[35] Ibid.

deprivilege both technology and the human and in so doing reveal their co-implication. The digital is not an independent system. Nor could it ever actually be. It is metabolic, interdependent, and contingent on an environment that is equally transformed in the exchange.

But this is not what we've been trained to see.

An Ecocritical Reading of Digital Theory

"The insidious destruction of the biosphere by pollution and the incapacity of the system to reconstruct a social economy adapted to new technologies …ought to lead to the mobilization of minds, sensibilities, and wills. But the acceleration of a history that might lead us to ruin is masked by the sensationalist (in fact banalizing and infantilizing) imagery the media concoct…"
Guattari[36]

In *Greening the Media*, Richard Maxwell and Toby Miller rightly note that "a deep ecological materiality has eluded the humanistic knowledge of media technology."[37] They point out that the majority of contemporary media studies thinking falls into one of two camps, either humanistic or mechanistic: the humanist focuses primarily on affective results of technologies while the mechanistic theorist looks at digital media's codes and algorithms. Neither tend properly to the environmental effects of our digital technologies, and I argue, by situating the digital as an affective (humanist) or

[36] Guattari, 2008, 119.
[37] Maxwell and Miller, 11.

algorithmic (machinic) artifact, both actually perform de-materializing abstractions that perpetuate the neglect of concrete environmental thinking in the field. Since our digital network of connected things and connective infrastructure is now profoundly entangled with Anthropocenic environmental concerns, media studies has a role to play in creating new narratives to capture these emerging relations. Despite the environmental metaphors at work in media theory, from 'media ecologies' to 'atmospheric media,' there is little to no mention of the earth's geophysical ecosystem. Media ecologies in the history of media theory represent media *as* ecosystems working within cultural and technical systems. Media is conceptualized as an environment, but it is rarely seen as *of* or consequential to the actual environment.

A standard genealogy of Western thinking on new media technologies nearly always includes, if not directly leads to Marshall McLuhan. In *Understanding Media*, McLuhan explains that electronic technology has "abolish[ed] the spatial dimension," and in so doing, has contracted the globe into village size: "with instant electric technology, the globe itself can never again be more than a village…"[38] With our technologies, McLuhan says, "we everywhere resume person-to-person relations as if on the smallest village scale….the organic everywhere supplants the mechanic."[39] For

[38] McLuhan, 341, 454.
[39] Ibid, 341.

McLuhan, we might suppose here that technologies are no longer mechanic but purely connective.

Rhetorically speaking, electronic technology connects us by folding, and nearly obsoleting, distant times and spaces. McLuhan believed, reminding us of Marx's dictum that capitalism results in an annihilation of space by time, that our electronic technologies extended our nervous systems[40] across all space and time:

> After more than a century of electric technology, we have extended our central nervous system itself in a global embrace, abolishing both space and time as far as our planet is concerned. Rapidly, we approach the final phase of the extensions of man—the technological simulation of consciousness, when the creative process of knowing will be collectively and corporately extended to the whole of human society, much as we have already extended our sense and our nerves by the various media.[41]

This 'global village,' was taken up in the late 90s and early 2000s to become a popular synonym for the World Wide Web. The very purpose of our Internet connections is to connect us, in 'real-time,' to others either directly via communications applications, or indirectly by way of accessing content they've left for us. With our always-on, always-connected devices, the ease and instantaneity of connection is what we experience when we go online. What McLuhan's 'global village' overlooked were the physical connections that intertwine the technology user with manufacturers, miners, e-waste pickers, pollution, and ecological upset across the globe.

---

[40] See too *Honest Signals* by Alex "Sandy" Pentland (MIT Press, 2008)
[41] McLuhan, 5.

In a similar move, XEROX scientist Mark Weiser, further 'abolished' the space and place of the digital when he published in *Scientific American* (1991) that "the most profound technologies are those that disappear."[42] For Weiser, digital computing's goal was to be ubiquitous computing (ubicomp)—to be ever-present but never seen. Though Weiser's work is undoubtedly significant, his characterization and popularization of the language of invisible ubiquity has done us a disservice. Weiser's ubicomp articles are, according to media scholar Lori Emerson, "surely responsible for introducing the term invisible into the lexicon of interface design, defining invisibility as a device's ability to be simultaneously everywhere…"[43] She continues,

> …it's not only that these ubicomp-related devices make it possible for users to engage with them "inadvertently, unknowingly, or even unwillingly" but also that the discourse of invisibility, which he called the "discourse of seamlessness" "deprives the user of meaningful participation in the decisions that affect his or her experience.[44]

Weiser's language has been modernized by companies like Apple who tout their devices as "truly magical and revolutionary."[45] Apple's "practically magic" campaigns peddle the iDevice as a window—an invisible platform—that allows a user to dis-appear the device and focus on the digital content it makes possible. They perfectly ignore, and in an important way obscure, the beginnings and the ends, the inputs and outputs—the

---

[42] Weiser.
[43] Emerson, 5.
[44] Ibid, 6.
[45] The Apple video introduction of the iPad can be viewed on YouTube.

thick universe of wires, disks, machines, cords, tubes, hard drives, server stacks, data centers, energies, miners, e-waste pickers and manual laborers—that constitute the digital's full system and work very hard to orchestrate its always-on 'invisibility.' Add to that rhetoric the practice of offering new free phones to cell phone contract users each year and we've created an imaginary by which our devices' physical parts—especially the dirty ones—are irrelevant, and without monetary value. MIT's Sherry Turkle goes so far as to say our devices are like phantom limbs, they are felt but not physically present:

> Technology is the architect of our intimacies, but this means that as we text, Twitter, e-mail, and spend time on Facebook, technology is not just doing things for us, but to us, changing the way we view ourselves and our relationships. We text each other at family dinners, while we jog, while we drive, as we push our children on swings in the park…*The technology has become like a phantom limb, it is so much a part of us*.[46]

Concretizing this digital-natural divide are notions like 'cyberspace,' 'virtual reality,' 'the cloud,' and the 'matrix' that have tracked through popular fictional manifestations of the digital network (as portrayed for instance in *Neuromancer*, *Blade Runner*, and the *Matrix*). These figurations perpetuate the spectacular notion of the digital as an immaterial multidimensional nonspace that is entirely divorced from the "meat space" of the "real world." The digital network has been in fiction, and in theory, distanced as an "other" and "otherworldly" space.[47] Writing in 1998, science writer

---

[46] Turkle, emphasis mine.

[47] Hayles, for instance, has explained "cyberspace" as an "other" or "othered" space.

Margaret Wertheim glamorized the metaphysical nature of the digital, nearly evoking an *Alice in Wonderland*esque fantasy world:

> Through the medium of the computer a loophole has been found in the material metaphysics that has dominated Western culture for the past three centuries…In a quite literal sense, cyberspace is outside the physical complex of mater-space-time that since the late seventeenth century has increasingly been held as not just the basis of reality, but as the totality of the real.[…]. Cyberspace subverts three hundred years of Western epistemic history, repudiating the tyranny of materialism and once again suggesting the possibility of a genuinely dualistic vision of reality….the psyche will be "freed" from the bondage of the body and downloaded into digital immortality in cyberspace.[48]

Wertheim was far from alone in positioning the digital network as such. Other science writers, including for example the executive editor of *Wired Magazine*, Kevin Kelly, (who we would have hoped understood the *wired* nature of the web) also considered the digital Internet as an immaterial playground where the mind and *soul* were released from their bodily boundaries. In 1995, Kelly wrote "I have experienced soul-data through silicon."[49] Though this sounds like a line from a William Gibson novel, this language was regularly used to describe the *uncanny* sensations one felt when 'going online.'

The distance between 'real-life' and cyberspace life can be seen too in writings like John Perry Barlow's 1996 *A Declaration of the Independence of Cyberspace*. Addressing "Governments of the Industrial World" Barlow writes, "I come from Cyberspace, the

---

[48] Wertheim, 47, 54.
[49] Ibid, 48.

new home of Mind. On behalf of the future, I ask you of the past to leave us alone. You are not welcome among us. You have no sovereignty where we gather."[50] The Internet in this Declaration is figured as a bodiless ungovernable mindspace with neither boundaries nor borders. In this space, we have not humans but "denizens" or "netizens" or "cybernauts" of the web who want not to be bothered with 'real life' geographies.[51] Owing to the effective ease and sheer proliferation of these terms, today we carry this language with us, and carry it over into our media theory and daily digital device relations. These theoretical provocations and media advertising theatrics work to obfuscate the far less palatable images of the messy material realities behind them. They have created an environmentally-removed digital imaginary that, in its unexamined nature, has contributed to digital metabolic dis-ease.

Though not claiming digital invisibility, when digital theorists equate the digital to computation, they are performing the same dematerializing gesture. Early theoretical formations informing present digital network thinking, such as those like Claude Shannon's information theory wherein information is bodiless and dimensionless, have lent false credence to the idea that the digital is synonymous with computation. This argument brings us back to the immaterial argument by way of a different path. David

---

[50] Barlow, n.p..
[51] Referenced for instance by Jesse Stommel at HybridPedagogy.com, in *Virtual Dimensions*, and in countless other popular pieces.

Berry's 2014 *Critical Theory and the Digital* is just one representative example of the result of this information theory influence. Berry's work wants to find an "adequate means to provide a critical response to its [the digital's] multifaced surfaces" by looking only at its *computationality*.[52] His approach is to level the digital network into pure bits, as for him it is "computationality [that] presents us with a research object."[53] The digital network becomes computation.

This computational flattening is seen too in the popular edge-node mathematical graph in the oft-cited network theory of Alex Galloway and Eugene Thacker.[54] Their *The Exploit*, co-opts the graph diagram, boxing the Edge and the Node into structurally and functionally separate spheres. This strict compartmentalizing of parts (edges and nodes) separates the network from its associated milieux and establishes a view of the network as a closed, mappable diagram where edges and nodes float in (non)space unconnected to any real ground. By situating the human and the environment as domains entirely outside the network, this gesture effectively perpetuates one of the typical misconceptions of our "disconnected relationship" with digital network systems.[55] Notions of "the cloud" do the same thing. The accepted concept that data rather incomprehensibly "lives in the cloud," is perpetuating a digital mysticism that leads to a false and fractured understanding of our larger digitally-inf(l)ected earth systems. It is

---

[52] Berry, 11.
[53] Ibid, 95.
[54] Galloway and Thacker, 32.
[55] Mark Hansen takes up a similar critique in *Feed Forward.*

also leading to a potentially dangerous environmental blindness. Though the cloud is really just a server somewhere in a vast ocean of servers housed in a large, always-on data center, the concept of cloudy wirelessness cancels out the very possibility of this type of grounded, energy-hungry infrastructure. In practice the digital's data center carbon footprint was recently revealed to be as large as the aviation industry with an estimate that by 2020, this footprint will increase by as much as 60 percent.[56]

Media theory's focus on the affective, immaterial, and computational has naturalized particular definitions, relationalities, and functionalities of digital technology and digital culture. Digital technology is algorithmic, invisible, a mass of edges and nodes. It is technologic, sociologic, anthropologic…anything but geologic.

Each of these motifs, though fictional, enables the stories we tell when we talk about the digital. Our concept of the digital as immaterial is not based in fact but is instead the result of a deliberately-devised and well-executed program of alchemical thinking. The digital is not magically metaphysical but we've been guided to believe so. Sold to us as the ubiquitous, location-less global village, the digital network, when viewed as a metabolic system, actually emerges as a geologic, geographic phenomena with a large physical footprint. The irony is staggering: we marvel at miniature, nearly invisible microchips yet we overlook the massive mines from which they came and the mountainous piles of waste to which they will return.

---

[56] Schildgen, n.p..

When this kind of knowledge about the digital is used to exclude, or is used at the exclusion of, material knowledge, immaterial tropes reign, further distancing the human from his detrimental technological contribution to earth systems. These motifs do a sort of violence, a certain injustice, as they sever us from the relationships and cause-effect chains that link humans to the environment and to the environmental implications of our digital technology use. These are the stories this project works against.

The algorithmic, immaterial motifs very cleanly foreclose the messy waste, the environmental degradation, and the vast apparatus of manual labor so that we need not acknowledge them. By bracketing out the traces of the digital's biophysical, geological, and material physicalities, we are able to guilelessly proceed with our privileging of the culture of the digital user and the tech-savvy consumer. This can be a useful configuration, but equally pressing is the human-harming environmental destruction caused by our growing infrastructural technosphere.

If it is true that we relate to an artifact through our (mis)conceptions of it, with these tropes, we are perpetuating distant and irresponsible relationships between the digital and its human and environmental spheres. Our mental concepts preclude the metallic ones; they get embedded in our notions of the technological device and the digital network at the necessary exclusion of the material. Thinking metabolically

undoes these stories of invisibility by making the digital's environmentality an inseparable aspect of its digital mediation. The digital is as mineral as it is magical. Living without critical examination of the materiality and metabolic consequences of our everyday consumption is ignoring the oddkin with whom we are making our future habitats.

Conclusion

In his "A Material History of Bits" computer scientist Jean-François Blanchette details the theoretical damage an oversight of the material dimensions of networked digital systems such as the Internet can do. Following others such as Katherine Hayles who focus on the mechanisms instantiated in the digital's materialities, Blanchette writes

> …the characteristics of [the computing] infrastructure matter a great deal, since it determines the base materials conditions under which applications, services, and devices will perform. Furthermore, a focus on materiality highlights that computation is a *mechanical process* based on the limited resources of processing power, storage, and connectivity.[57]

"However immaterial it might appear" Blanchette writes, "[digital] computing [is] a material process through and through....'[58] It is critical that we appreciate this when thinking about digital systems or we risk ignoring what Blanchette rightly points out are their 'essential dynamics':

---

[57] Blanchette, 2.
[58] Ibid, 1-2.

> One can envision the difficulties that would arise in attempting to account for architecture without a working concept of the tensile strength of steel, of the durability of concrete, of the density of wood. Indeed, that these materials differ in their physical characteristic registers on the entire ecology of the field…and no meaningful analysis can ignore these differences…Without a basic understanding of the material constraints under which computing systems operate, essential dynamics that animate the built environment of the virtual will remain invisible and unaccounted for.[59]

Ours is a messy multispecies existence (Tsing). And in order to understand the forces at work in the world, we must understand their connections and what happens when they collide in various situations and under different contexts, conditions, and in different stories. Environmental thinking requires us to divorce ourselves from the dualistic human-nature and nature-culture separations that pervade traditional western humanities and still track through contemporary media theory.

Though once projected to be the medium that would prevent pollution, curb environmental destruction, and eliminate the need for physical consumption, the digital universe is so far nothing of the sort.[60] From mining to manufacturing to maintenance to waste, water, energy, and pollution are part and parcel of each stage of the process that creates our 'carbon-footprint-less' technologies.[61] Metabolic thinking prevents uncritical notions of the digital as unground, magical, and bodiless.

---

[59] Ibid, 25-26.

[60] Examples of each of these can be found in Maxwell and Miller, Gabrys, and Parikka 2011.

[61] A ready example can be seen by comparing a digital book to a print book. It is estimated that the environmental impact of one eReader is equivalent to that of 100 print books. The production of one printed book requires 2/3 lb of materials, 2 gallons water, and 2kw hours of production time whereas the production

When we apply the metabolic lens to the digital sphere, we move away from thoughts of the digital as immaterial or magical, simply affective or algorithmic, and we begin to see things differently. Thinking metabolically means that when we look at our phones, those that most of us own, we see these lines of flight backward (to the mines) and forward (to their waste).

It means too that we see how we are ecosystemically-connected, through our devices and digital use, to labor, pollution, minerals, and environmental upset in all corners of the globe. The side-effects of digital technologies that should concern us are not so much those that alter our dinner table etiquette as Sherry Turkle is prone to warn—but those that are irreversibly altering our bodies and our planetary habitats. If we want to talk about the effects the digital has on the human, we must talk about the material and the energetic natures of the digital.

---

of one eReader requires 33 lbs of materials, 79 gallons of water, and 100kw hours of fossil fuels. The eReader also requires electric consumption for reading. Energy statistics report that "reading online for ½ hour equates to 90 minutes of watching television." Though true that an eReader can contain—if its storage capacity permits—often over its material and energy equivalent of 100 print books, it is said that with its built-in obsolescence, an eReader's lifetime is on average about two years. Then it becomes toxic waste. We will see in later chapters that digital waste is becoming a significant analog problem not only in its mounting accumulation but also in its decaying afterlife: biological and ecological toxins are estimated to be 70 times greater in the eReader. "When side-by-side comparisons are made, the environmental costs of production for one e-reader (including raw materials, transport, energy and disposal) far outweigh those of one book printed on recycled paper." Accepting that our e-devices are undeniably greener than their print equivalent is a highly perpetuated false assumption.

Exempting the digital from its physical and geophysical implication establishes a presumption that the digital universe produces no waste, has no ground, consumes no energy, and functions entirely outside the bio- and geospheres. If the digital is dimensionless and intangible, it has no material footprint and neither participates in nor contributes to the heavy world of stuff. The misguided notion that our digital networks are composed of 'immaterial' 'clouds' of digital data that one 'goes to' when one 'gets online' or 'jacks in' to the *Ether*net is revealed to be at best untenable and, at worse, blindingly destructive. It denies the digital network's raw-materiality and its inter- and intra-actional forces, and is thus wholly detrimental to a proper understanding of the digital itself and of the digital's implication in the physical world. A metabolic framework corrects this to remind us of the material (embodied), contextual (embedded), and territorial (grounded) nature of the digital universe. Though innovation, progress, and magic get embedded into our technologies, what should also be embedded are material histories, manual labor, and environmental relations.

By presenting the idea of a digital environmental metabolism as an alternate way to understand the relationship between humans, technology, and the environment, this chapter draws attention to the rhetorical discourses that have prevented a robust environmental media studies and proposed an ecocritical reading through the metabolic lens. It argues the digital network operates as does a metabolic system, by way of a

constant flow of inputs, transformation, and outputs. More importantly, it argues that because of this metabolic input-output requirement, the digital system is inherently implicated in the biophysical and geophysical systems with which it overlaps and intertwines. Rejecting the premise of the digital as an immaterial force, I instead insist that contemporary digitality is profoundly environmental, and the issues this relationality raises are human(e) concerns we cannot ignore.

Going forward, chapter two asks how an environmental humanities perspective, one that takes seriously the physical environmental aspects of digital media's infrastructure, can contribute to the reconfiguration of media theory's most prominent frameworks by drawing attention to the discourses that prevent a robust environmental media studies. It argues we must re-story digital materiality to help narrate unseen relationships and articulate alternate Anthropocene futures. It re-figures the environmental metaphors already present in media theory (e.g. the cloud, atmospheric media, media ecology) to embed them concretely within their earthly material contexts.

In her preface to *Ecology and the Environment*, Mary Evelyn Tucker says science and policy are proving, despite bringing with them the "dire facts" of our situation, so far insufficient motivators for changing environmental anthropogenic behaviors. Scientists, environmentalists, and policy makers, she says, are beginning to see the need, and are even calling for, a greater engagement from/with humanists who can bring

"broad, new thinking to make a transition to a sustainable future possible."[62] Sverker Sorlin is one such scientist. In a recent essay in *Bioscience* (2012), titled "Environmental Humanities: Why Should Biologists Interested in the Environment Take the Humanities Seriously?," Sorlin wrote "our belief that science alone could deliver us from quagmire is long dead…If humanity is the chief cause of the ominous change [as signaled by the term 'Anthropocene'], it must surely be inevitable that research and policy will be focused on human societies and their basic functions."[63] We need human(e) stories to help us manage the human and environmental impacts of digital technologies in the Anthropocene.

Chapter three brings the digital's physical realities to bear on cultural critique by looking at how environmentally-focused digital artworks can challenge our digital-material (hi)stories and provoke new figurations of the complex relationship between humans and the environment. It takes to heart Walter Benn Michaels's claim that art can indeed make a difference:

> On the one hand, it is perfectly true that if what you want is changes in policy, you are not likely to get them from art. On the other hand, if what you want is a vision of the structures that produce both the policies we have got and the desire for alternatives, art is almost the only place you can find it.[64]

The final chapter proposes permaculture—a profoundly interconnected set of ethical design principles that I borrow from natural farming—and Ecocritical Digital

---

[62] Tucker, 3-4.
[63] Sorlin, 788.
[64] Michaels, n.p..

Humanities as models for sustainable scholarly practice. It asks how we might begin to practice knowledge differently using permaculture as a guide. "Continued life on earth" Anna Tsing says, "depends on getting our knowledge into as good a shape as possible."[65] In *The Three Ecologies*, Felix Guattari writes "the contemporary world—tied up in its ecological, demographic, and urban impasses—is incapable of absorbing, in a way that is compatible with the interests of humanity, the extraordinary techno-scientific mutations which shake it…it has become imperative to recast the axes of values, the fundamental finalities of human relations and productive activity…"[66] The permacultural proposition in my final chapter seeks to do just that. It provides a seed that will recast the "axes of values" and lead to the cultivation of more generous, caring, resilient, permanent-permutable knowledge systems.

In an interview in *Art in the Anthropocene*, Haraway says "we inhabit a planet that is undergoing systemic transformations…Rich worlds crucial to human flourishing can and do disappear…Understanding that in the tissues of our flesh seems to me really urgent."[67] I read her 'in the tissues of our flesh' here doubly: 1) we must understand the metabolic entanglements inherently and 2) our relationship to that metabolism is not one of distinct differentiation but one of fleshy entwinement. In our present

---

[65] Tsing, 2005, 81.
[66] Ibid, 91.
[67] Davis and Turpin, 256.

Anthropocenic age defined by humans acting as a geophysical force, human bodies, cultural technologies, and the earth are intersecting material practices. I argue this intersectionality is neither cyborgian nor posthuman, as some media scholars may insist, but is something far more natural: it is a metabolic relationship wherein each system is inherently implicated in the perpetuation of the others.

The story I tell is one of inherent interdependence and inseparability between the human, the environment, and technology. As Environmental Law Professor Jedediah Purdy writes in his *After Nature*, "the Anthropocene finds its most radical expression in our acknowledgement that the familiar divide between people and the natural world is no longer useful or accurate."[68] Ours is a world where our digital devices are kin and our Anthropocenic techno-dealings are metabolic. The relationship binding the human, the earth, and technology is neither post-natural nor post-human. It is radically ecosystemic.

[68] Purdy, 2015, 2.

Chapter Two: Restor(y)ing the Ground with Digital Environmental Media Studies

Introduction

Figure 1: Screenshot from September 5, 2015 White House Instagram post.

On September 5, 2015, former U.S. President Obama took a photograph of himself while standing in front of a melting Alaskan glacier. In a deliberate attempt to use social media to call attention to climate change, he posted his 'selfie' on the White House Instagram account with the hashtag #ActOnClimate. Though the post generated a robust exchange of comments, an almost radical incongruity was overlooked: the very devices and networked connections required to use the mobile-only Instagram platform are among the most noxious of modern contributors to climate change. President Obama

is using visual social rhetoric to create a story about glaciers and climate change, which I commend, but he's missing the narrative about the digital's own implication in the Anthropocene. This leads to the problem at the heart of this chapter: How can a metabolic media theory re-story digital materiality to help narrate unseen relationships and articulate alternate Anthropocene futures?

The first chapter drew attention to the discourses that prevent a robust environmental media studies. With repeated use from a wide range of sources, the de-materializing rhetorical motifs we've constructed become commonplace and are normalized into our beliefs about the networked digital system. Digital technology has been sold as the 'green' alternative to material-intensive analog machines, but it most certainly is not: the digital sphere now has a carbon footprint that rivals, and may soon overtake, the aviation industry; our wirelessness requires heavily wired infrastructure; and even our Google searches and spam emails have a carbon footprint.

A metabolic media framework, as described in chapter one, considers the beginnings (e.g. minerals and metals) and the ends (e.g. wastes, toxins, and pollutants) of digital media as critical sites for contemporary study that link the human, the environment, and digital technology into a dynamic metabolic system. The remaining chapters, beginning here with chapter two, seek to narrate these links using what I call a digital environmental media studies (DEMS) framework that performs digital metabology as strategy to begin repairing our technology-related Anthropocene

damages. DEMS merges material digital metabolic ontology with environmental humanities to shift the digital media focus from one grounded in computation to one fully rooted in the earth. In so doing, it makes inroads in the project to restore, and re-story, digital materiality so as to bring attention to the consequential digital physicalities that are most often deliberately, and dangerously, ignored.

The DEMS project is inspired by environmental humanities (EnHu) work, like that done by scholars like Anna Tsing, Donna Haraway, Lawrence Buell, Deborah Bird Rose, Thom van Doreen, Valerie Plumwood, and others. Their research radicalizes and breaks down the boundaries traditional humanities has constructed between the humanities on one end and the natural sciences on the other. Unlike, but not removed from ecocriticism, EnHu seeks to produce and propel new narrative configurations so as to reconfigure our current notions, terms, and specious motifs by refocusing the stories we tell.

Combining environmental humanities with digital media studies raises new questions about the role of media studies, digital practice, digital art, and environmental humanities; it helps us better understand contemporary environmental problems caused by our digital technologies, and gives us a new lens for thinking about (what we know about) the human-tech-earth relation.

In DEMS, standard media theory terms are put to new use in order to reconstruct the rhetorically-ruptured relationships between the earth, the human, and technology:

ubiquitous computing presumes a corresponding ubiquity of physical, resource-needing, energy-using compounds; digital memory refers not to zip drives but to bioaccumulation and geophysical marks; the figure of the cyborg is re-figured; and our notions of contemporary media become grounded in minerals, manual labor, and e-waste. If our terms become screens through which we see the world, the immaterial implications of many of our prominent media terms (e.g. the cloud, wirelessness, ubiquitous computing, cognitive labor) may actually create damaging worldviews that deny the digital's relation to the environment and, in so doing, excuse producers and users from any active material responsibilities. Deeply embedded in our current digital stories is a willful material ignorance and an ethical moral pass; and this *matters*. It matters, Donna Haraway says, "which stories tell stories, which concepts think concepts, mathematically, visually, and narratively it matters which figures figure figures, which systems systematize systems."[69]

We see this type of narrative re-programming regularly manifest in popular culture, politics, and academia. In politics, it is called 'spin': when the Affordable Care Act (ACA) insurance initiative in the United States became 'Obamacare', conservatives had a term to rally against. When in early 2017 the Republican administration claimed it would do away with 'Obamacare', more than a few conservatives who were getting insurance from the ACA were still vilifying 'Obamacare' and calling for its repeal. When

[69] Haraway, 2015, 160.

they realized their insurance from the ACA was indeed the despised 'Obamacare' they fought to destroy, they were given quite a terminological shock. Re-storying other narratives like those around smoking (smoking as cool vs smoking as deadly), around women's choice (pro-choice vs pro-life), around gay marriage (equal rights vs 'protection of marriage'), and the Iraq war (as "Operation Iraqi Freedom"), have also proven to make an impact on mass opinion and daily habits. In the environmental sphere, we have similar popular and political re-terming phenomena: when "global warming"[70] was put into question by climate change deniers who point out that we still have cold weather, the environmental movement switched, with some success, to the terms "climate change" or "environmental change"; when SUVs, first seen as outdoor adventure vehicles, were re-written as earth-killing gas-guzzlers, sales of SUVs decreased; when oil drilling is framed as "energy exploration" or coal is touted as "clean coal" or excessive consumption is coupled with an eco-friendly mission, Americans relieve themselves of any environmental guilt that might accompany less savory terms.

DEMS sees new terms and narratives as potential sites for more environmentally-enlightened intervention and engagement, and it asks how an expanded understanding of digital materialities and metabolic relations might lead to a

[70] Note: in scientific parlance, these terms refer to distinctly different phenomena. In popular culture and media conversation however, they have largely been seen as analogs with one or the other being chosen often primarily for its political rhetorical force.

more environmentally-aware media studies, and ultimately to digital narratives that inspire more sustainable behaviors.

A digital environmental media studies, as I here define it, is research that, when placed alongside work by Jenna Burrell, Jussi Parikka, Jennifer Gabrys, Nicole Starosielski, and Sean Cubitt, helps re-body the digital as literally, and not just figuratively, human and environmental. A digital environmental media studies speaks to the challenge, put forth by Diana Coole and Samantha Frost in their introduction to *New Materialisms*, for us to "reorient ourselves profoundly in relation to the world, to one another, and to ourselves" in response to recent developments such as climate change, technogenetic engineering, and the "saturation of our intimate and physical lives by digital, wireless, and virtual technologies."[71] This reorientation is necessary, they say, because a commitment to today's more radical forms of materiality—those that follow our unprecedented twenty-first century forms of production, reproduction, and consumption—is required to properly account for the ways we live and coexist with non-living things. Indeed DEMS is informed by the premise that, in our present Anthropocenic age defined by humans acting as a geophysical force, human bodies, cultural technologies, and the earth are intersecting material practices.

If media studies is, as Mark Hansen and W.J.T. Mitchell define it in *Critical Terms for Media Studies*, "a mode of understanding, a perspective from which to engage our

---

[71] Coole and Frost, 2010, 6.

world,"[72] then changing our narratives can help generate new knowledge and methodological structures that reconnect our weightless, wireless digital devices to their physicality and their interpermeable relations. DEMS's relational, metabolic ontology helps us re-story and re-world through its focus on the inherent interconnections between the digital, the environmental, and the human. To steal a line from Raymond Williams: we need different stories because we need different relations.[73]

In this chapter, this renarrativizing act is applied to common digital media terms—elemental media, atmospheric media, cyborg bodies, and digital labor—to demonstrate how we might better 'ground' them in their environmental material contexts. In more ways than one, media theory already gives us the terminology we need to begin thinking more environmentally, and this chapter demonstrates how we might exploit our inclination to metaphorically use environmental terms (e.g. 'environmental media' in theoretical terms refers to the invisible ubiquity of contemporary media and not to the physical environment as such) to do vital relational work. DEMS intervenes not by throwing out media terms but by disengaging their abstract meanings and repositioning them into a more concrete, whole-ecosystem context. I steal the justification of the terminological project here in this chapter from Giorgio Agamben who, in the opening lines of his essay "What is an Apparatus?" writes

---

[72] Hansen and Mitchell, 2010, xxii.
[73] Williams, 1980, 85.

"terminological questions are important in philosophy…terminology is the poetic moment of thought."[74]

The hope in grounding our terminology, then, is that new stories will inspire new ways of thinking and doing and will, as Haraway says, story new stories. As I tell my students, each time we name or define something—and in class I give them the impossible task of defining 'nature'—our definition both opens and closes possibilities, it opens and closes new stories.

For philosopher Rosi Braidotti "the lack of concepts and terminology to deal with the ecological environment and nonhuman others is a serious deficit in view of the mutation we are experiencing toward the [Anthropocene] predicament."[75] By adding an environmental layer to our contemporary media theory, I hope to provoke new patterns, processes, practices, and 'poetic moments of thought' in digital theory and rhetoric. Starting with the digital's 'beginnings,' this chapter first takes a look at the 'real' stuff of media—the mineral realities of our 'elemental media'—and then it turns to wires, warehouses, and waste.

---

[74] Agamben, 1.
[75] Braidotti, 2016, 20.

Elemental Media

Digital Mineralities/Mineral-ties

In *The Marvelous Clouds*, John Durham Peters argues that media are elemental in the sense that they have become of elementary importance—they have become as necessary as earth, water, fire, and air, those four considered by the ancients to be life-sustaining. We are in a time, he says, "when it is impossible to say whether the nitrogen cycle or the Internet is more crucial to the planet's maintenance."[76]

Peters's terminology here offers an opportunity for re-storing. Unpacking "elemental media" with an eye toward mineral materiality, we come to see that contrary to the manufactured narratives of the digital universe as an *Ether*net made of only ethereal bits, bytes, and sleek modern devices, the digital quite literally begins with(in) the earth: more metals, minerals, and chemicals pass through our digital devices than through many basic high school science labs.

Today, there are more than 60 elements and somewhere around 200 chemical compounds contained in a pocket-sized smartphone, and the National Resource Defense Council (NRDC) reports that between 500-1000 chemicals are used in computer circuitry production.[77] Tantalum (coltan) is in your capacitor, silicon is found in your semiconductor chip and integrated circuits, copper is fused to your circuit board,

---

[76] Peters, 2015, 2.
[77] Rathi, 2013.

lithium helps power your battery, gold lines semiconductor wire connectors, mercury and lead might be in your LCD screen, platinum coats the hard drive, and silver and tin create the glue that holds it all together. Our devices and infrastructure also contain more than a dozen different types of petrochemical plastics.

Despite marketing schemes selling our digital devices as magical (see for instance the original iPad advertisement in Figure 2), oil, wires, water, and heavy metals are the true stuff of our magically weightless, wireless web.

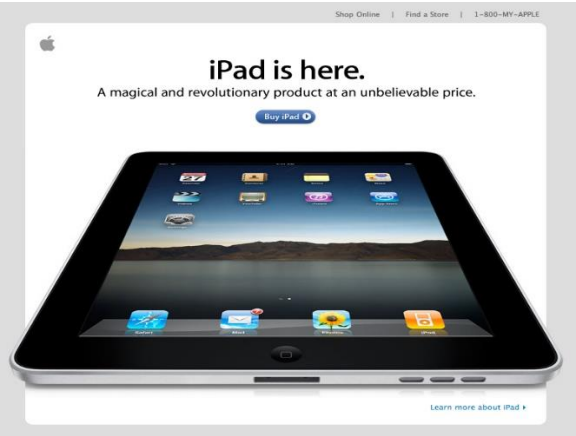

Figure 2: The "magical and revolutionary" iPad, screenshot of the original iPad advertisement sent via email to Apple customers, April 3, 2010.

Though according to a recent statement by IBM, big data is "the next natural resource," our digital system is dependent first on physical, elemental natural

resources.[78] Big data as a sociocultural issue or *natural resource* relies first on real earth-moving mining.

Digital Ecological Rucksack

Counter to the motif that conceives the digital as a resource-light, eco-friendly medium, its environmental footprint, from water and energy use to ecological destruction and carbon emissions, is undeniably significant.

'Ecological rucksack'[79] is a term that refers to the amount of earth that must be moved to find the minerals that become component parts and fuel for our digital infrastructure. An example calculation of a digital rucksack can be seen here from the Great Recovery Project group in the UK: "For all the mobile phones in the world today [2014], the metal in them would have required 450 million tonnes of rock to be dug up, smashed and processed. This is equivalent to 12 x the weight of all the cars on UK roads."[80] The digital's ecological rucksack, when expanded to include water and energy use, as well as air pollution and toxic waste, provides a helpful context for thinking about the full impact of the technosphere on the earth. The ecological rucksack of digital mineral mining alone, which is just the first step of the manufacturing process, includes

---

[78] Richards, 2013.
[79] "The concept of the "ecological rucksack" measures how many kilos of material must be mined (or grown) to produce one kilo of end-product. According to a report by NOAH, the Danish Friends of the Earth, every 1 kg of gold in your hand carries an invisible history of 540,000 kg of material in its ecological rucksack. A few other notable metals in the report: polyethylene's rucksack is a mere 2.4 kg of "abiotic" material per kg of end material, copper's is 356 kg/kg, stainless steel's is 23 kg/kg, and virgin aluminum's is 66 kg/kg, while recycled aluminum is just 1.2 kg/kg." Worldchanging, n.p..
[80] RSA, 2015, 9.

substantial levels of soil erosion, air pollution, groundwater contamination, bioecological upset, toxic waste, and consumption of a remarkable amount of water and energy.

Overall, the NRDC reports that mining accounts for about 10 percent of global energy use and The Global Water Intelligence group reports that the global mining industry is the second largest industrial user of water.[81] Parts of the mining industry have recorded a 70 percent increase in energy required for mining over the last 30 years, and that number is growing by about 6 percent per year.[82] Regrettably, the majority of the mining industry's energy is not clean (it comes from coal and fossil fuels), while the majority of the water is (it is the same freshwater that countries, states, and towns across the world are finding increasingly depleted).[83] As global freshwater reserves drop to drought conditions, it becomes ever more readily evident that the digital's metabolic needs are contingent on human and ecological metabolisms. As the US Drought Monitor reports, California and several other Western states are presently experiencing "extreme" or "exceptional" drought conditions.[84] In the summer of 2015, *USA Today* reported that "California's historic drought appears to be matched by severe dry spells on three other continents…wreaking havoc on millions of peoples' lives and

---

[81] Casson, 2011.
[82] "Why be energy efficient?," 2015.
[83] Recently there are trends pointing to a growing greening of the sector's energy use and though these changes are seemingly due more to cost benefits than environmental ones, the cleaning of the sector will certainly be a welcome change in our digital-environmental metabolism.
[84] See an interactive drought map here http://www.cnn.com/interactive/2015/05/us/map-drought/.

livelihoods."[85] When *The Guardian* recently published an article with the headline "The tech industry is threatening to drink California dry," it wasn't so far from the truth.[86] Media in its minerality is undeniably elemental. Minerals make digital media an ecological matter of concern, and the environment a digital issue that must be carefully considered.

Atmospheric Media

In his recent *Feed Forward*, Mark Hansen writes that twenty-first century media is atmospheric, or 'environmental,' in so far as it is everywhere—and with an estimated 26 billion networked devices set to be connected by 2020, this is hard to dispute—and it occurs in an always-on condition outside of our awareness. Hansen describes it this way: "the technical mediation of sensation in ubicomp [ubiquitous computing] environments is atmospheric, impersonal, collectively accessible, and microtemporal in its sensory address."[87] Environment and atmosphere, in this context, refer not to environment-as-nature or atmosphere-as-gaseous-earth-layer per se, but to the domain

---

[85] Rice, 2015.

[86] Shemkus, 2015. What is more, it is reported that production uses between 50 and 80 percent of an electronic product's total energy requirement, and yet most of our sustainability language focuses only on the energy used to power a laptop or cellular battery (clearly a narrow focus since it only costs about $0.41 per year to power a cell phone). A 2012 NRDC study explains that embedded energy rates for digital electronic devices are much higher than for other energy-expensive appliances like refrigerators and washing machines largely due to shorter lifetimes: digital lifetimes are 1-5 years whereas appliances and automobiles can live for decades. According to Carol Baroudi, it takes about the same amount of energy to produce a few microchips as it does to produce an entire car. To put this into context, due to the rapid accumulation of 'green' and 'smart' technologies, according to Gartner, by 2020 we should have 25 billion digitally networked things—each with its own 'ecological rucksack'—contributing to the technosphere's environmental toil.

[87] Hansen, 2012, 73.

of experience and "environmental sensory processes" that new media enact in automated machine-to-machine interaction. When we think, however, in terms of the digital's material footprint and the environmental nature of the digital's pollutants, the rhetorical construct of ubiquitous digital technologies as 'atmospheric' rings true on a level far more literal than Hansen's intent.

According to the National Wildlife Federation,

> The hard rock mining industry is the single largest source of toxic waste and one of the most destructive industries in the country….The mines that produce our gold, silver, copper, and uranium are notorious for polluting adjacent streams, lakes, and groundwater with toxic by-products. The Environmental Protection Agency estimates that 40 percent of the watersheds in the western United States are contaminated by pollution from hard rock mines.[88][89]

As materials—most already highly processed through post-mining energy-, water-, and waste-intensive refining processes—move from the mines to the

---

[88] "Hard Rock," n.p..

[89] Rare earth minerals are particularly toxic—they are radioactive. Rare earth elements are the "magic fairy dust" that make our digital world possible. There are 17 rare earth minerals and 9-12 of those are in the typical smartphone. Rare earth minerals can be terrifically difficult to mine due to their co-occurrence with radioactive elements like thorium and uranium, and their mining and processing can release radioactive toxins and produce radioactive waste (Grossman, 2016, 68). At present, China has a monopoly on rare earth mineral mining, controlling somewhere between 87-97 percent of global production. China's monopoly is not because it is the sole reserve of rare earth materials, as Austrialia, Canada and the United States also have domestic rare earths, but because, according to Michael Klare in his The Race for What's Left, China is more disposed to extract them. China is in fact one of the few places willing to mine these, and to do so 'affordably' presumably by using dubious and unsafe methods. More from Klare: "…natural concentrations of rare earths are uncommon, and so normally they must be extracted from composite ores containing many other minerals — including, in many cases, radioactive materials — through a costly and hazardous process. The procedure usually involves using acids of various kinds to leach rare earths from the surrounding stone, producing toxic wastes that can poison farms and water supplies unless they are carefully disposed of. By overlooking the environmental risks and lowering its production costs, China was able to undercut the other REE supplies, eventually leading nearly all of its competitors to suspend their operations." Klare, 157-158.

manufacturers, they produce even more toxic chemical pollution that seeps into our soils, airs, waters, and grocery store shelves. In *High Tech Trash*, Elizabeth Grossman reports that these chemicals are most prevalent in Americans and these chemicals have actually been found in foods in major grocery store chains.[90] Mining chemicals such as mercury, arsenic, lead, cadmium, and sulfuric acid have been found in run-off and groundwater reserves used by communities in locations near mines. These are dangerous neighbors: arsenic has shown to be cancerous and deadly, as has sulfuric acid; overexposure to cadmium can cause kidney disease, lung disease, and weakening of the bones; mercury and lead are equal opportunity offenders as they can affect any bodily organ and can damage reproductive systems.[91] These metals can also accumulate in the bodies of animals and aquatic wildlife, and in the roots and shoots of plants.[92] Here pollutants from media production are atmospheric media.

On the gravest scale, the atmospheric aspects of media have destroyed entire urban habitats. Mining towns, such as Picher, Oklahoma have been deemed toxically uninhabitable Superfund sites by the Environmental Protection Agency and subsequently abandoned.[93] According to Grossman, "pooled beneath the communities of Santa Clara, Cupertino, and Mountain View, California—to name but a few—are

---

[90] Grossman, 2006, 1-2.
[91] Martin and Griswold, 2009, 1-4.
[92] Ibid, 5.
[93] Shepherd, n.p..

thousands of gallons of poisonous volatile organic compounds left by the manufacture of semiconductors."[94]

Toxic remediation of these pollution disasters is a hazardous, costly, and sometimes simply impossible task. When it comes to digital environmental media thinking, *remediation* resumes the meaning it had prior to Richard Grusin and Jay David Bolter's new media intervention: though they were certainly correct that re-mediation is a defining feature of the digital age, they skipped the fact that while digital media may re-mediate previous technologies, the bigger concern is that processes of digital media making may require serious *environmental remediation* in the truest sense of the term.

These unattended materialities are the matters of fact that concern us here; to treatments of data mining and IBM's excitement around big data, DEMS adds mineral mining and the dirty atmospheric media issues of pollution, digital manual labor, digital carbon footprints, and ecological destruction.

The Cyborg

The popular figure of the cyborg is another site for productive redefinition; this is another term we can easily reconfigure to facilitate more ecological thinking. A common concern of digital media theory is the physical and/or affective notion of our future-present lives as technonatural cyborgs. In this brand of thinking, popularized by films such as the *Matrix*, *Blade Runner*, *Mad Max*, and *Avatar*, the future human is one

---

[94] Grossman, 2006, 3.

with a mind and/or body augmented by a wide range of visible and implanted digital technologies. This motif of the cyborg is no doubt inspired by the largely accepted notion that due to the proliferation of digital technologies, tomorrow's human will be a redesigned post-human, techno-biological product of digital enhancement.

There is a flashy diagram circulating on the web, largely popularized by Ray Kurzweil's TEDxSiliconAlley talk on the singularity ostentatiously titled "How To Create A Mind," that shows a Darwinesque evolution of human bodies that moves from ape to homo sapiens to a burst of computational data in a cloud.[95] A similar, and probably not unfamiliar, diagram can be found here, in Figure 3, where the human evolves from ape to human to robot:

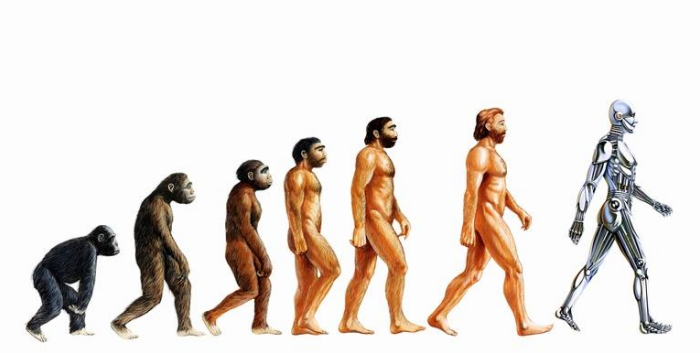

Figure 3: Modern Evolution.[96]

[95] See animation: Ray Kurzweil at TEDxSiliconAlley, Video link here begins the clip where we want to begin—from about minute 17:38 to about minute 18. http://youtu.be/RIkxVci-R4k?t=17m38s.
[96] Image Source: http://ichef.bbci.co.uk/images/ic/1200x675/p0338yd1.jpg.

In Kurzweil's version, the human is more or less subsumed into a computer screen and then shot into an orbiting satellite (which is a curious error since wireless infrastructure and data centers are located on and under the earth and oceans). The argument is that the future body is a cyborg configuration that isn't really a body at all but a container for an uploaded brain.[97]

We can see this too appearing in digital theory where the human body is now imagined as *coded* or *cellularized*, and is seen to be "integrated with digital circuits…the digital nervous system incorporates itself progressively in the organic nervous system, in the circuit of human communication, and re-codifies it..."[98] When thinking metabolically about the physical body's relationship to the digital network and the earth, this human-digital integration figures differently: in DEMS thinking, our nervous systems are becoming digital though biophysical and ecological interaction with the material stuff of the digital network.

What is missing from this provocative techno-evolutionary stance is the recognition that long before our bodies turn into pure computation, they'll be biologically and biophysically altered by the bioaccumulation of technology-related toxins and environmental habitat destruction. We metabolize the atmospheric media, in the form of pollutants, that enter our bodies daily. One example is chilling: tissue

---

[97] Kurzweil has diagrams that he says supports this prediction.
[98] Berardi, 2012, 142-143.

samples have shown that breast-feeding human mothers are polluted with the synthetic chemicals used to make our technologies fire resistant. This more imminent evolution is what we should be streaming; the cyborg concept prepares us for thinking about human-machine coupling, we just need to think about it differently.

The proliferation of such iconic images supports a number of our ungrounded environmental media terms and environmentally-unaware theoretical practices. The visual rhetoric here performs lasting ideological work. When images like these dominate the field of view, alternative visions are ignored, rejected, or (like waste) mindlessly discarded. This cannot continue if we are to hope for a more sustainable media practice.

One way forward toward illustrating a re-narrated digital body is to re-story the bodies who do our digital labor.

Re-narrating Digital Labor

Though digital media and cultural scholars have written rather extensively on the 'cognitive' and 'immaterial' labors associated with the digital universe (see for instance the *Digital Labor* collection edited by Trebor Scholz and the work done by Jonathan Beller, Tiziana Terranova, and Maurizio Lazzarato, to name a few), the critical mapping of the particular physical labors associated with our digital age is far less prolific. As Christian Fuchs outlines:

> In its first phase, the digital labor debate has focused on understanding the value-creation mechanisms of corporate social media such as Facebook, YouTube, and Twitter…The general task has been how to best understand and conceptualize that users under real-time, far-reaching conditions of commercial

> surveillance create a data commodity that is sold to advertising clients and that users essentially create value that manifests itself in social media corporations' profits.[99]

As influential scholars Michael Hardt and Antonio Negri write in their *Empire*, "the passage toward an informational economy necessarily involves a change in the quality and nature of labor."[100] Though they primarily focus on immaterial and cognitive labor, which has seen shifts in our Age of Information, what digital metabolic thinking makes clear is that manual labor too has been altered.

The stories not often told, and sometimes deliberately hidden, are of the manual digital labor done in digital mineral mines and manufacturing facilities. These laborers—most often men but so too women and sometimes even children—are, in certain locations and circumstances, subjected to deplorable, toxic working conditions. Transferring our humanistic gaze from digital users to digital manual laborers reveals the marginalized bodies that are hidden by our fetishistic fascination with the digital's magical, cloud-based immateriality. These bodies are subjected daily to the ills of the digital's ecological rucksack.

In *Geology of Media*, Parikka approaches digital labor through dust. During production and manufacturing stages, great measures are taken to ensure there is no dust in our digital machines as dust could render them unworkable. At the same time,

---

[99] Fuchs, 2015, 53.
[100] Hardt and Negri, 289.

though, as Parikka points out, dust from the processes involved in mining the minerals required for those computers to work is actually harming the workers who inhale it.

Dust shows us one example of how digital materiality mingles with the body and the environment in ways uncaptured by current media theory frameworks. Dust gives us a new way of thinking about how the digital truly in-corporates into the human nervous system. Dust not only reveals the human bodies and labor practices associated with digital capitalism, but also shows that the materiality of the clean, sleek iDevice is actually a very dirty materiality—one made possible only by the physical labor of sometimes dangerously dirty work: "The materiality of minerals and metals, from silicon to coltan, is entangled with the materiality of the lungs. In other words, this is the materiality of hardwork [sic] that connects to the labor sustaining the hardware."[101] Mineral mining is, as Parikka says, "media work in and through bodies,"[102] and without proper protections, the laborers are working in seriously noxious conditions, all in the service of producing the materials and the devices used to make our so-called 'green' technologies possible (and invisible).[103]

---

[101] Parikka, 2015b, 92.

[102] Ibid, 93.

[103] Miners and factory laborers are exposed to chemical environments that include mercury, lead, radioactive radiation, cadmium, barium, and hexavalent chromium. The mining industry relies on chemicals as aides to mineral and metal extraction. These can cause, among other symptoms, damage to the heart, liver, spleen, kidneys, and central and peripheral nervous systems. They can cause brain swelling and muscle weakness as well as birth defects and death. Silver and silicon dust can result in breathing problems in laborers as well as lung, throat, and stomach irritation. Gold mining, for example, uses, among other noxious chemicals, cyanide and mercury. In fact, in the United States, gold mining is a major producer of mercury pollution.

Miners and factory laborers are exposed to chemical environments that include not just mercury but also lead, radioactive radiation, cadmium, barium, and hexavalent chromium. These can cause, among other symptoms, damage to the heart, liver, spleen, kidneys, and central and peripheral nervous systems. They can cause brain swelling and muscle weakness as well as birth defects and death. Silver and silicon dust can result in breathing problems in laborers as well as lung, throat, and stomach irritation.

What follows very closely from the radically detrimental human health conditions of some of our digital mines are the sometimes equally violent social and political situations that drive the digital mining and manufacturing industries.

Greenpeace, the International Labour Organization, the United Nations, the Basel Action Network, and other NGOs have recently launched reports detailing a harsh material reality for those doing the manual labor of the digital network. Where this is beginning to register in the humanities and in media theory is through work by, for instance, Grossman, Cubitt, Parikka, Sy Taffel, and the collected authors in the important *Challenging the Chip* project. In their research, stories of slave labor, war, drug trades, toxic chemical and metal exposure, and cruel capitalism are threaded through digital media as constitutive digital social realities. If we are to talk about how the digital alters the social, we cannot ignore how these social structures lie alongside those more affective issues, like attention, distraction, social etiquette, data privacy, online ethics,

computation/algorithmics, and social media labor, for instance, that media scholars tend to give primacy.

Of our critical digital materials, South and Central Africa are major producers of gold, chromium, nickel, cobalt, and platinum-group elements. They are also major extractors of columbite-tantalite from which tantalum or *coltan* (a shortened form of columbite-tantalite) is refined. Popularized largely in the early 2010s by journalistic reports, social media, and activist movements, coltan, considered a 'conflict mineral,' was made known to be involved with war-ravaged ethical/social/human catastrophes in areas of Central Africa. Central Africa supplies about a fourth of the world market and much of the minerals sold are extracted under forced or coerced labor conditions."[104] Coltan is used in nearly all smart phones and consumer digital electronics.

Certainly not all mines are improperly or violently deployed, but minerals and metals from conflict mines are finding their way into our digital technologies. And, according ibtimes.com American companies are looking askance:

> Nearly 80 percent of American companies are failing to adequately check their supply chain for "conflict minerals," which are sourced from war-torn regions in Central Africa, according to a new report by Amnesty International and Global Witness. A survey of 100 U.S. firms published in the report, titled "Digging for Transparency," reveals that only 21 percent of companies are adhering to U.S. laws prohibiting the use of conflict minerals.[105]

---

[104] See ICIJ.org for more: http://www.icij.org/projects/coltan/five-things-you-need-know-about-coltan.
[105] Pandey, 2015.

The major technology companies are now trying to distance themselves from these conflict elements, but it is proving difficult. Minerals from the Democratic Republic of the Congo (DRC), for instance, are prohibited for use by US companies but are almost impossible to trace. It has been reported that countries near the DRC, like Rwanda and Burundi, are selling minerals that they have no local stores of themselves, and the DRC is intentionally using such intermediaries—as many as ten or more—to move its 'conflict' minerals. In so doing, it is injecting these minerals into the conflict-free stream. What is more, many of these minerals are shipped to smelters in places such as China and Kazakhstan where there is little tracking and oversight. According to Fahmi Panimbang, "global value chains in the electronics industry are more geographically extensive and dynamic than in any other manufacturing sector."[106] Illegal coltan mining and manual labor practices have not only destroyed bodies but also full ecological systems. In the DRC,

> Illegal mining camps in national parks have also lead to miners hunting endangered species such as Grauer's Mountain Gorilla (Taylor & Goldsmith, 2002: 421) and elephants (UN 2001) as food. Miners hunt these animals due to a lack of alternative food sources; given the choice between bushmeat from endangered species and starvation it is hard to blame the miners for feeding themselves. Problems of starvation are linked to land use change surrounding agricultural land converted into artisanal coltan mines…[107]

---

[106] Panimbang, 13.
[107] Taffel, 2012, 13.

In 2014 and again recently in 2015, Intel said it would go 'conflict free' by 2016 but with inadequate auditing methods and deliberate obstruction by the DRC, many in the activist-academic community are openly dubious (see researcher Denisa Kera for instance). Apple joined the Conflict-Free Sourcing Initiative in 2009, but still in late 2015 its annual report said that it was not yet conflict free: "Of the 233 smelters and refiners that furnished these minerals used in Apple products last year, 24 were from the Democratic Republic of Congo or adjoining countries."[108] In 2012, the Enough Campaign ranked digital electronics companies—many of them signatories to the Conflict-Free Sourcing Initiative—based on their efforts toward reducing conflict minerals. Toward the top were Intel and HP; toward the bottom were Samsung, Sharp, and Nintendo.[109] Even the newest of phones and digital devices today might contain coltan, gold, tantalum, or tin from the war-torn areas of the DRC. Older devices are even more likely to contain them. Our 'immaterial' digital devices have deep and complex material histories that must be narrated if we are to have more meaningful understandings of the digital's materiality. It is worth quoting Ted Smith and Chad Raphael at length:

> One of the sharpest ironies of the Information Age is that it is easier for electronics to trace people than for people to trace the materials and labor that make their electronics. A fragmented global supply chain conceals who makes what, how they make it, and with what materials. Electronics companies have a strong incentive to conceal this supply chain from their employees, customers, and even from top management: it is filled with hazards for workers and their

---

[108] Chmielewski, 2015.

[109] See the full ranking and report: http://www.raisehopeforcongo.org/content/conflict-minerals-company-rankings-0.

> communities that tarnish the image of a clean industry of the future. Even the major brand owners—Apple, Dell, and the like—do not know all of the materials and chemicals that end up in these companies' own products.[110]

What is more, international labor groups have found that "working hours routinely flout laws, regulations, and outsourcing company guidelines, and there is a routine falsification of records to comply with codes of conduct."[111]

In 2010, after 14 workers at digital component manufacturer Foxconn committed suicide and 4 others were injured from suicide attempts, the working conditions of the digital laborers became global news. Among the offenses found were "low wages; long hours (over ten hours per day with few breaks); frequent shift changes; monotonous work; physical harm caused by chemicals such as benzene or solder paste; lack of protective gear and equipment…"[112] Others that came to light were the use of unpaid interns doing work unrelated to their studies, packed prison-like dormitories, harsh punishments and prohibitions, and even beatings and harassment from security guards.[113] More than 400 thousand people work for Foxconn. Also named Hon Hai Precision, Foxconn was named the 5th largest corporate employer in 2012 and assembles, or has assembled, products for Samsung, Sony, Nintendo, Microsoft, Apple, Dell, and Amazon.[114] More than half of our mobile devices are assembled in China.

---

[110] Smith and Raphael, 2015, 78.
[111] Hesmondhalgh 34.
[112] Maxwell, 2016, 53.
[113] Ibid.
[114] Ibid.

When Foxconn's conditions garnered public attention in 2010, the reach of its labor injustices led to further revelations about other electronics manufactures. Foxconn is just one of many of these types of contracted digital material manufacturers across the world. Similar abuses have been found in other India, South America, and other East Asian digital electronics factories. What is more, the current structure of the digital industry does little to disincentivize labor injustices.

> In an industry where practically all production is outsourced to supplies and the company whose name appears on the final product is mainly involved in design, marketing, and branding, the name and location of the supplier factories is almost never publicly revealed, making independent auditing and journalistic investigation extremely difficult.[115]

The game Phone Story, released in 2011 by Molleindustria, was created in part to publicize these digital mining and manufacturing abuses.[116] Designed as a basic four-level game for Apple's iPhone—originally loaded to, but then very quickly banned from, the Apple App Store—Phone Story takes the game player (the phone user) through coltan mines, Foxconn factories, e-waste heaps in Pakistan, and corporate Western offices where the planned obsolescence of these devices is deliberately designed. According to the game developers, "Phone Story is a game for smartphone devices that

---

[115] Hesmondhalgh, 34.

[116] Game Credits: A game by Molleindustria; Original concept and website content: Michael Pineschi; Voice: Jesse Stiles; Music: "Derecha" by Minusbaby 8BP110; Thanks: Soyo Lee, Olivia, Tenley, YesLab; Supported by: AND festival, Gwangju Design Biennale. The game can be downloaded onto Android devices and played online. A full video walkthrough can be found: https://www.youtube.com/watch?v=sSMSFLAsNzc.

attempts to provoke a critical reflection on its own technological platform."[117] The mining level shows a line of young-looking barely-clothed crouching miners (children?) being guarded by gun-carrying men in military gear. The player's objective is to help the miners mine quickly enough, by forcing them to work, in order to 'save' the miners from being killed by the gunmen. In the background, a voice tones

> Once upon a time, there were minerals resting in the bowels of the earth. One of these minerals, called coltan, is found in most electronic devices. The majority of coltan's world supply is located in Congo, a country torn by a brutal civil war. The increasing demand of coltan produced a wave of violence and massacres in Congo. Military groups enslaved prisoners of war, often children, to mine the precious material.[118]

In the Foxconn manufacturing level, tiny cartoon humans jump from the rooftop of a non-descript four-story factory. The game player, while listening to the level's monologue on the conditions under which the manual compilers of our cell phones work, tries to catch the falling human by moving a tiny 'suicide prevention net'—a bouncy net held on either side by a little running person—back and forth. The voice in this level is as gruesome as the previous level:

> Like most electronic gadgets, this phone [the one the game player is using to play] was assembled in China, inside a factory as big as a city. The people working there are constantly subjected to abuse and discrimination. They work in inhumane conditions and are forced into illegal overtime. Over the span of a few months, more than twenty workers committed suicide out of extreme desperation.[119]

---

[117] *Phone Story*, 2011.
[118] Ibid.
[119] Ibid.

Figure 4: Screenshot from Phone Story.

The game hopes to remind users that "When you buy a gadget, you aren't only buying the sleek image the companies advertising team worked so hard to create, you are also buying the whole line of production used to create it."[120] By being released first only on the iPhone operating system, the game deliberately implicated its users in the dirty production practices that come as a result of their own digital consumption. This is the type of intervention—and we'll look at many more in the upcoming chapters—that can re-narrate the digital story and elucidate the porous connections in the human-computer-earth relationship. Digital labor has never been strictly immaterial.

What mapping digital mineralities and manufacture makes evident is that when we equate digital mining with data mining and digital production with programming, we are overlooking important material facts, and as follows, important matters of

[120] Ibid.

concern.[121] Our ignorance of the 'real' digital miners and makers perpetuates the myth of immateriality thus excusing us from the responsibilities of our consumption. It is said that these technologies, with their endless communicative connective capabilities, link places far and wide together into a McLuhanesque transgeographic 'global village,' but the material truth of the digital reveals that our digital technologies connect us even more literally to places and people across the world by way of the minerals, metals, pollutants, waste, and labors that compose them. The geography of the digital becomes the geography of the earth; the sheer size—and neverending growth—of the technosphere connects us to each other and to the earth as it never has before.

Our phones, as well as our laptops, tablets, and smart-enabled devices, are part of a vast human- and natural resource-intensive system (digital metabolism). Each device begins in the mines, proceeds to a manufacturing plant, and returns to the earth as waste after its deliberately short lifetime. Cumulatively across the globe in 2014, 1.2 billion *new* cell phones were purchased and this was up 28.4 percent from 2013.[122] Keep in mind that many of us have half a dozen or more (sometimes far more) other digital devices in our homes. Globally 4.5 billion people used cell phones and more than 300 million bought new PCs in 2014. In the US alone, there are more than 400 million rechargeable electronic devices (U.S. DOE 2013)."[123] If we continue at this rate, we'll be

---

[121] See Bruno Latour on matters of fact and/as matters of concern.
[122] "Gartner," n.p..
[123] Behdad et al., 2010.

activating new phones at a phenomenal pace. Yet we prefer new phones to considerations of the contingency and consequentiality they embody. "We must not forget" Maxwell and Miller write in *Media and the Ecological Crisis*, "that our high-tech subject matter comes into being at tremendous cost to the Earth's ecosystems and the biophysical health of its organisms...delinking our high-tech systems from their real ecosystem contexts in this way reinforces a dangerous ecological-amnesia."[124] DEMS attempts to re-story the digital narrative by highlighting the absences, the ungrounded abstractions, and the metabolic consequences of our digital actions.

These are the types of stories we must tell alongside our 'cognitive' digital labor narratives. We are all eco-digital cyborgs now. The digital's ecological rucksack illustrates how mineral mining, human bodies, and environmental destruction are metabolically concomitant. If we premise media work as work performed only by interface designers, software engineers, and tech-savvy Internet users, we can easily overlook the physical (hi)stories that accompany our digital lifestyles. The Internet, our digital devices, and the global social network, however, are made first by real bodies doing real physical work.

[124] Maxwell and Miller, 2015, 90-93.

Locative Media

Media Located: Wires, Warehouses, and Infrastructure

Moving from mining and manufacturing to the infrastructure that maintains our wirelessness, we see that global connectivity is physical, and physically-placed.

In twenty-first century media studies, locative media is a budding artistic and communicative form. Enabled by GPS and mobile devices, locative media refers to content that is location-based, most particularly to content that has been geo-located to particular coordinates that can be accessed at that location by a user with a smart phone or tablet. Augmented reality art is an example as are location-based games, spatial and audio annotation, and experiential mapping. Locative media emerged as a named type, I argue, because the digital network as such is seen as placeless and thus place-based digital media is considered novel due to its association with place. This section turns the term *locative media* on its head to suggest digital media has always been located, and its massive monuments of locativity—its wires, warehouses, and infrastructure—are what make the myth of wireless placelessness possible.

According to CTIA-The Wireless Association, wireless penetration in the US is already at over 104 percent. Cisco predicts that by 2020, 80 percent of the world's adult population will be connected[125] and there will be more than 250 things connecting *each*

[125] These connections will be primarily mobile with an estimated 7.6 billion broadband subscriptions by 2020. *Clicking Clean*, 5. And CTIA, originally known as the Cellular Telephone Industries Association but now by the moniker above: http://www.ctia.org/your-wireless-life/how-wireless-works/wireless-quick-facts.

second for a total of more than 50 billion things composing what is called the Internet of Things—from "mobile devices, parking meters, thermostats, cardiac monitors, tires, roads, cars, supermarket shelves, and yes, even cattle" connected to the digital network.[126] Thinking about the media infrastructure that makes this possible gives us a way into thinking environmentally about our digital cloud.[127]

Peters has recently written about infrastructures saying "because of their vast technical complexity and costs, infrastructures are often cloaked from public scrutiny, their enormous risks and unintended consequences shielded from debate."[128] This is the situation we find ourselves in today. The wires and warehouses that connect us are hidden by a rhetorical scaffolding of wirelessness and cloud computing.[129] By falling into the fetishistic motifs we outlined in chapter one, we perpetuation the illusion.

An early article on locative media by Anne Galloway and Matt Ward claimed "pervasive computing and locative media are emerging as technologies and processes

---

Note: these are estimates and nuanced estimates at that. For a detailed breakdown of estimated IoT units by 2020, see http://spectrum.ieee.org/tech-talk/telecom/internet/popular-internet-of-things-forecast-of-50-billion-devices-by-2020-is-outdated or http://www.rcrwireless.com/20160628/opinion/reality-check-50b-iot-devices-connected-2020-beyond-hype-reality-tag10.

[126] Tillman, n.p..

[127] "Today's infrastructures invite an environmental view of media, and we are fortunate that the intellectual history of the concept offers ample justification and materials for that project." Peters, 49.

[128] Peters, 31.

[129] Much of media and cultural studies (see for instance Sherry Turkle, David Berry, Nicholas Negroponte, and many others) today perpetuates the rhetoric by effectively bracketing out the physical architectures at the root of the network.

that promise to reconfigure our understandings and experiences of space and culture."[130] The article argues that, when it comes to locative media, "nothing is considered more important than context."[131] Ironically, what was missing from the article was any mention of the physical contexts and locations of the digital network itself. As a general collective pubic, we somehow skipped over the materialities of the digital to marvel at its immaterial 'locative contexts'. Instead, we need to look at our habits as a result of a long line of material and productive infrastructure. We need to tell the stories of the roots of the circuitry in our smart phones and below our feet and understand them not just as the very stuff of the network, but also as the link that physically connects the technosphere-geosphere-anthrosphere metabolic system.

> While the notion of wireless networks implies that there are fewer wires, it could easily be argued that actually there are more wires. Rather than wireless cities or wireless networks, it might be more accurate to speak of the rewiring of cities through the highly reconfigurable paths of chipsets. Billions of chipsets means trillions of wires or conductors on a microscopic scale.[132]

Nicole Starosielski's recent study, *The Undersea Network*, offers a corrective by pointing our attention to the undersea cables that transmit our global 'wireless' signals. Starosielski looks at undersea cables as the "deepest strata of the Internet."[133] Though they are hidden far below sea level, these cables form a strong part of the actual

---

[130] Galloway and Ward.
[131] Ibid.
[132] Mackenzie, 2010, 64-65.
[133] "…undersea cables are rarely investigated as media infrastructure. This might be in part because they are one of the deepest strata of the Internet — laid on the bottom of the seafloor, they appear relatively distant from the user interface and embodied encounters with media content." Parks and Starosielski, 55.

circulatory system of our World Wide Web. This is important infrastructural work for the project of mapping a material metabolic digital network. Without most of us realizing it, our digital consumption connects us daily to oceanic depths: Submarine fiber-optic cables are responsible for transporting almost all (99%) of global digital communication. Any intercontinental (and in some cases, even intracontinental) text message, email, website, video, or phone call passes through the ocean before arriving at its destination.[134] As of 2014, there were 285 communications cables undersea; these oceanic tubes are the ties that bind us.

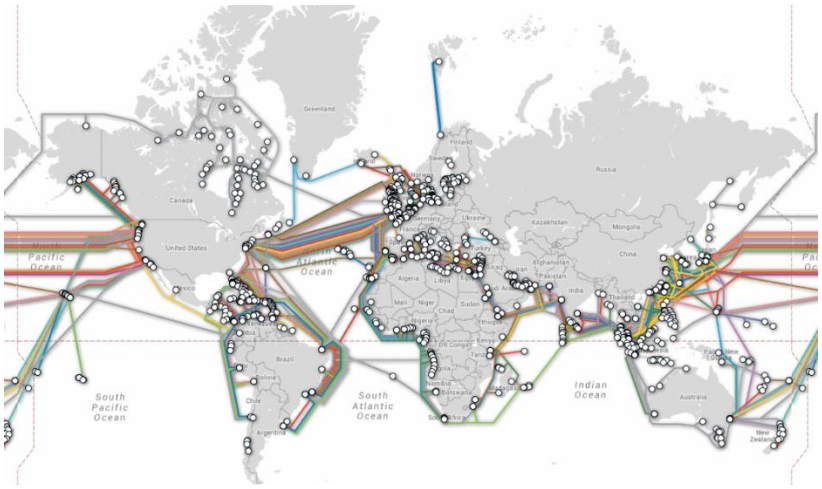

Figure 5: A screenshot of the interactive Submarine Cable Map, which tracks active and planned submarine cable systems and their landing stations according to the Global Bandwidth Research Service. Credit: Courtesy of SubmarineCableMap.com.

Starosielski's goal is to illustrate that these infrastructures are solidly entrenched in politics, economics, geography, energy, local and global cultures, and the everyday

[134] Starosielski, 1-2.

lives of many who make and maintain them and/or who live near them. They are territorial and territoried. They are subject to human policies, histories, and geopolitical power debates, and they are the cause of much human subjugation. "Analyzing undersea cables as media infrastructure," she says, "draws our attention to the ways that seemingly nebulous digital circulations are anchored in material coordinates."[135] This is locative (located) media; this is oceanic media. These are as much a part of our digital world as are wireless hubs and GPS-based content.

Warehouses: There is No Cloud

"I had learned what the Internet looked like," Andrew Blum says in his *Tubes: A Journey to the Center of the Internet*, "generally speaking: a self-storage warehouse."[136] He begins his book with the story of the day his Internet 'breaks.' A brief investigation by his service provider shows it was neither a networking error nor an electricity or signal issue but instead his outage was caused by a squirrel who accidently acted as a sort of denial-of-service[137] bot by chewing through his physical Internet cables. This episode inspires him to set out on a journey to find the real 'tubes' of the Internet. The Internet—the backbone of our networked digital infrastructure—is, as Blum finds, a sprawling urban snake of wires and a rural workhorse. If our notions of the Internet or the cloud

---

[135] Parks and Starosielski, 67.
[136] Blum, 154.
[137] "In computing, a denial-of-service (DoS) attack is an attempt to make a machine or network resource unavailable to its intended users, such as to temporarily or indefinitely interrupt or suspend services of a host connected to the Internet." http://dbpedia.org.

contain any hint of immateriality, we are mistaken. Blum goes as far to say the Internet is 'handmade.' He writes "new links don't just happen according to some automated algorithm, they need to be created, negotiated by two network engineers, then activated along a distinct physical path."[138]

The cloud, though it may be deliberately hidden, is actually the term we use for storage space—most likely owned by a large data or Internet company—on servers housed in rather large warehouse-like data centers. Cisco estimates that before 2018, global cloud traffic will reach 5.3 zettabytes with 69 percent of all Internet traffic processed in the cloud.[139]

To accommodate this traffic, we use energy-hungry data storage and exchange centers. A lot of them. According to the International Data Corporation, there will be about 8.6 million data centers worldwide by 2017. Those data centers will take up about 1.94 billion square feet of digital geographic real estate.[140] That's about 35,000 football fields for those of us counting. In addition to these, there are hundreds of Internet Exchange points in more than 150 countries. The largest data center to date, to be opened in 2016 by Baidu, a Chinese social media/social networking firm, has 120,000 square meters of space, a capacity to store 4,000 petabytes of data, and 700,000 central processing units. According to sources, "the storage capacity of the Baidu cloud center

---

[138] Blum, 118.

[139] "a single zettabyte is equal to one billion terabytes or, in more concrete terms, 250 billion standard DVDs or 36 million years of HD video" *Cisco.com*, 2013.

[140] See more at *IDC.com*, http://www.idc.com/getdoc.jsp?containerId=prUS25237514.

would therefore enable it to house the data equivalent of 268,000 Libraries of Congress."[141] The largest US data center to date (2016) is the NSA's Utah data center which has more than 1 million square feet of data-holding space.

Without wires, data centers, and exchange points, we'd have no Internet movement. And yet these are not part of our digital consciousness. Peters suggests that these physical monuments have left the popular periphery because it is the nature of infrastructure to do so: "Infrastructure in most cases is demure. Withdrawal is its modus operandi, something that seems a more general property of media, which sacrifice their own visibility in the act of making something else appear."[142] In fact, he says, "the bigger the infrastructure, the more likely it is to drift out of awareness and the bigger the potential catastrophe."[143] But we must undo this illusion. Our studies of infrastructure must, as Adam Rothstein says, "do what infrastructure itself has failed [because it was hidden geographically and rhetorically] to do, creating situated knowledges that teach us what is underneath our society, rather than simply metering information as commodity through more optic tubes."[144]

---

[141] Mosco, 34.
[142] Peters, 34.
[143] Ibid, 32.
[144] Rothstein, n.p..

Powering the Cloud

The geophysical footprint of each of these data and exchange centers is dwarfed by their energetic footprint. Each of these contain hundreds if not thousands of computer servers that run around the clock, powered by electricity, cooled by water, and backed up by gas-powered generators or lead-acid batteries. "Forget the images of blinking lights on computer servers," Tung-Hui Hu says in his *Prehistory of the Cloud*, "What data center managers pay attention to is not the spectacle, but the temperature."[145] The SC1 center in Silicon Valley, for example, "has a half-million-gallon chilled water tank to cool off the machines if the regular air-conditioning system fails. The tank looks like a small office building, easily six or seven stories tall. But when the servers are running at capacity, they produce enough heat to evaporate all of that water in just 30 minutes."[146] In a state like California where there are more than 800 data centers and "extreme" drought conditions, the water consumption of the digital network is a growing ecological concern.

The global energy used to keep servers cool and data running through the wires is, by some accounts, more than India uses in a year.[147] Greenpeace estimates the cloud, if it were a country, would rank at about 6th in energy usage.[148] Though we think email to

---

[145] Hu, 73.
[146] Henn, n.p..
[147] Maxwell et al, 2015, 4 (ebook numbering).
[148] Henn, n.p.. "Researchers at Greenpeace estimate that if the cloud were a country it would be one of the biggest consumers of electricity on the planet. "It would rank around sixth in the world," says Gary Cook at

be ephemeral and digital streaming to be 'greener' than purchasing physical media, we are mistaken. Data sending, streaming, searching, storing, and sharing all require energy. It is estimated that a single Google search emits between 0.2-7 grams of CO2. Email has a carbon footprint as well: Gabrys describes it in full in her 2014 "Powering the Digital" essay:

> an average spam emails generates 'emissions equivalent to 0.3 grams of carbon dioxide (CO2) per message.' Multiplied by 62 trillion spam emails sent in 2008, and this cumulative amount of emissions from spam is equivalent to 'driving around the Earth 1.6 million times.' Whereas each individual search, page use, or email sent might have a comparatively small resource or greenhouse gas footprint, the amounts of data sent, received, stored, and otherwise processed contributes to overall energy use and emissions of considerable quantities…Attempting to demonstrate the increasing demand for energy needed to power and connect up digital technologies, these carbon footprints make evident the resource requirements of seemingly fleeting and immaterial activities such as Internet searching and social media browsing.[149]

Greenpeace. "That is right after Russia and right before Germany." Other estimates are smaller, but the figures are still staggering. The New York Times estimated that cloud computing consumed 30 billion watts of power a year in 2012. That is as much power as produced by 30 nuclear power plants. And the cloud is growing fast. So to control electric costs, big cloud computing companies are traveling to the ends of the earth. Joel Kjellgren works for Facebook in Lulea, Sweden, as the data center manager. Lulea is just south of the Arctic Circle, and in January, the outside temperature might be minus 20-25." Henn, n.p..

[149] Gabrys goes as far to discuss the energy consumption of electronics as a type of electronic waste: "Estimates of energy used to power electronics are significant in one sense because they are an indication of the material immaterialities of electronics and their networks, which operate seemingly free of resources. In another sense the energy required to power electronics results in distinct forms of pollution that are different from the stacks of abandoned digital devices often associated with electronic waste. The material fallout from electronic energy registers in different ways, both in the resources used to power these device and in the embedded energy used to manufacture them: through carbon footprints, coal dust, greenhouse gas emissions, and extensive land use taken up with data centers (and power plants)." She notes the energy used during the full process and notes that much of the energy — especially that used at data centers is coal-powered (50-80 percent today is still coal powered). Gabrys in Maxwell et all, 2015.

As with mining and manufacturing, much of that energy is wasted[150], much of it is still 'dirty' (e.g. coal-powered)[151], and much of the water[152] use comes from freshwater stores. In fact, energy consumed to power our digital network is one of the fastest growing contributors to atmospheric climate change.[153] As a metabolic partner with the earth and the biosphere, the high-energy nature of our cloud becomes a major player in reshaping earth's geographies; metric tons of soil must be moved to fuel our devices and the air we share is polluted in its wake. Wirelessness is not an invisible—nor yet a very 'green'—condition as we've been promised. As it turns out, streaming a video online has a far greater ecological footprint than does watching a DVD.

The media infrastructure—our true locative media—is hidden in plain sight but we've been duped into overlooking it in sort of in(at)tentional blindness. Our attention

---

[150] "It has also been estimated that data centers can waste 90 percent of the power that they pull off the grid, and their carbon footprint will likely surpass that of air travel by 2020. The definition [end p82] of 'wasting' power has been debated in this context — a recent New York Times investigation found that, on average, data centers were using only 6 percent to 12 percent of the electricity powering their servers to perform computations. The rest was essentially used to keep servers idling and ready in case of a surge in activity that could slow or crash their operations." Parks and Starosielski, 82-83.

[151] *Clicking Clean 2015* provides a full breakdown and energy 'scorecard' of major data, colocation, and exchange center companies' energy consumption. Though some of the more popular brands—Apple, Google, and Facebook, for instance, are making vocal moves toward green power, many companies are not and other companies' claims are more performative than reality. Many, if not still the majority, are in fact still energized by electricity companies still primarily powered by 'dirty' fossil fuels such as coal (including major centers powered by North Carolina's Duke Energy and Virginia's Dominion Resources). Once again, we see the cloud being deeply tied to the Earth's airs and resource provisions. That large NSA data center we mentioned above is estimated to require 65 megawatts of electricity per year and 1.7 million gallons of water per day.

[152] "Water use in data centres has "flown under the radar for the longest time" but it's something companies are starting to get to grips with, says Jack Pouchet, a board member with The Green Grid, a non-profit that promotes resource efficiency in information technology. Water-cooled data centres use an estimated 13.25m litres (3.5m gallons) per MW each year, according to Pouchet. The data centres used by major players can range in scale from 5MW to 30MW." Shemkus, n.p..

[153] Maxwell et al, 4/15 (ebook numbering).

has been shifted elsewhere, largely by popular cultural and political stories but also by twenty-first century media theory and social media rhetoric. We focus on the powers of coding, computation, and connection while overlooking their attending issues of e-waste, toxic manufacturing, and depletion of rare-earth minerals. Lisa Parks says "we are socialized to know so little about the infrastructures that surround us even though many of us use mobile phones each day."[154] Media studies can, and I argue should, do its part to bring these infrastuctures and their attending environmental (locative) impacts to light.

Digital Memory

When we talk about digital memory now, we talk about zip drives and cloud storage. These are important but impermanent memories, subject to decay, loss, and physical destruction. Aligned with the metabolic project, I propose we might instead think of digital memory as the permanent marks left on the earth by our digital networked system. Through bioaccumulation, our soils, bodies, and biosphere are registering permanent traces of the digital's ecological rucksack. Through waste

[154] Parks, 2009.

accumulations, our digital activity is becoming fossilized as future memories of our past and present action.[155]

"We are embedded in our trash," John Knechtel writes in his book called *Trash*, "there is no easy way to leap beyond it and build a utopia without garbage…its production is rooted in survival, represented in every culture, and magnified by economic success."[156]

If Cisco is correct that by 2020 we'll have 50 billion connected things, we'll also then have 50 billion things that will, if the life rates of those things remain as paltry as they are today, be very quickly 50 billion things for the waste heap—to be replaced by 50 billion more things ad nauseam until resources expire. As far as our technology consumption is concerned, we are effectively living in Italo Calvino's Leonia.[157]

The "opulent" city of Leonia renews itself each morning—it "refashions itself every day: every morning the people wake between fresh sheets, wash with just-unwrapped cakes of soap, wear brand-new clothing…"—only to find that its renewal is indeed its destruction.[158] The street cleaners arrive each morning to remove the previous

---

[155] Davis and Turpin write, "while the manufacture of plastics [and we can say other components as well] destroys the archives of life on earth, its waste will constitute the archives of the twentieth century and beyond." 347.
[156] Knectel, 9.
[157] Story and quotes from Calvino, *Invisible Cities*, 114-116.
[158] Ibid.

day's waste and "nobody wonders where, each day, they carry their load of refuse." [159] The trash meanwhile, is creating mountainous piles outside the city and, following Leonia's desire for newness, as new, more decay-resistant materials are created, the piles become ever larger with ever longer lifespans. "A fortress of indestructible leftovers surrounds Leonia, dominating it on every side, like a chain of mountains." [160] The result, Calvino's narrator Marco Polo tells us is that "the more Leonia expels goods, the more it accumulates them; the scales of its past are soldered into a cuirass that cannot be removed. As the city is renewed each day, it preserves all of itself in its only definitive form: yesterday's sweepings piles up on the sweepings of the day before yesterday and all of its days and years and decades. Leonia's rubbish little by little would invade the world…"[161]

If the moment we buy an electronic device is the same moment it becomes obsolete, we are living in an endless cycle of consumption. We are purchasing electronic waste that we'll use for an embarrassingly short amount of time before dumping it and moving on to the next. "Smartphones, laptops, tablets, and e-readers all at one time held the promise of a more environmentally healthy world not dependent on paper and deforestation. The result of our ubiquitous digital lives is… quite the opposite: not

---

[159] Ibid.
[160] Ibid.
[161] Ibid.

ecological health but an environmental wasteland, where media never die."[162] We've developed a strange sort of 'green' awareness whereby we sign our emails "think before you print" but we've not yet cultivated the same sort of stewardship of our devices.

A recent United Nations University (UNU) report claims the amount of global e-waste reached 41.8 million tons in 2014.[163] That's the equivalent of about 22 million standard-sized sedans. Most, if not all of that, is wasted. The United Nations Environment Program (UNEP) reports "between 60-90 percent of electronic waste is ending up in mountains of rubbish throughout the developing world, or is traded through criminal e-waste smuggling networks worth billions of dollars."[164]

In the US, Americans currently average a per-person e-waste dumping of more than 65 pounds per year. Waste devices and their wasted resources are, as one might guess, expected to rapidly rise hitting a predicted 65.4 million tons of e-waste in 2018.[165] Not all of this is digital waste—this includes non-digitized household appliances—but the digital proportion is growing, and our appliances are growing more digital. The UNU report estimates that our wasted devices contained

---

[162] Parikka, 2015b, back cover.
[163] From *The Global E-Waste Monitor 2014*: http://unu.edu/news/news/ewaste-2014-unu-report.html.
[164] They continue: "Because e-waste is considered a 'hazardous substances,' the UN says this trade is in violation of the Basel Convention." See more here: http://www.chinafile.com/reporting-opinion/environment/chinas-role-illegal-trade-toxic-e-waste-rising-sharply.
[165] The authors of this report prefer building comparisons saying that 65.4 million tons is the equivalent of 200 Empire State Buildings or 11 Great Pyramids of Giza. http://www.step-initiative.org/tl_files/step/_documents/MIT-NCER%20US%20Used%20Electronics%20Flows%20Report%20-%20December%202013.pdf.

> 16,500 kilotons of iron, 1,900 kilotons of copper, and 300 ton of gold as well as significant amounts of silver, aluminum, palladium, and other potentially reusable resources…This e-waste represented some US$52 billion of potentially reusable resources, yet little of it was collected for recovery, or even treated/disposed of in an environmentally sound manner. Less than one-sixth is thought to have been properly recycled or made available for reuse.[166]

It goes without saying that all parts of the digital network are subject to becoming waste, from laptops, smart meters, and device packaging to wires, environmental sensors, and undersea cables.[167] Parikka calls this zombie media: "media do not die," he says "media persist as electronic waste, toxic residue, and its own sort of fossil layer of disused gadgets and electronics."[168] They become memorialized in our bodies, soils, and earth and are finding new digital afterlives as toxic waste, oceanic debris, and even new geological formations:

> The social itself is part of a new geology, as the beaches have been remade into plastiglomerate, their sands mingled with the pulverized microplastics of our petroleum age…Geologists have now begun to study "technofossils" and the sedimented debris layers…that now constitute part of the geological and planetary record.[169]

---

[166] Ibid.

[167] "When cables cease to be commercially viable, they remain in the ocean and create various ripple effects through organizations invested in marine space. After cables are disconnected and decommissioned, they often disappear from view. Early cables were left on the seafloor after they broke or became obsolete, their locations often removed from cable maps and nautical charts. Today cables can also be deinstalled and retrieved or rerouted; this is done more often to keep the cables from conflicting with potential alternative uses of the seafloor than to avoid any document environmental impact. In fact, pulling the cable up from the ocean can disrupt the seabed and aquatic creatures that have fastened themselves to the cable, especially if it has been there for decades. Although companies are not always required to pull up undersea cables, they are not allowed to abandon ownership or responsibility." Starosielski, 221-222.

[168] Parikka, 2015, 144.

[169] Thill, 3-4.

Electronic waste, from toxic materials to plastic casing, is being written into oceanic history—according to Ellen MacArthur, there will be more plastic waste, some of that coming from e-waste, than fish in the ocean by 2050[170]—and it is interacting with the earth to create new rock types called plastiglomerate.

Plastiglomerate, found so the coasts of Hawaii, is a new, and some say markedly Anthropocenic, stone that organically combines natural soils with plastic debris. This new rock, demonstrates the digital's metabolic memory in a rather profound, somewhat uncanny, way.

Figure 6: Kelly Jazvac, *Plastiglomerate*, 2013. Image courtesy the artist.

[170] Wearden, n.p..

Tossed 'away' and forgotten by their owners, our devices and their plastic casings become actively geologic. They also become quite toxic.

Whether trashed or dutifully recycled in well-managed centers, in their de-manufacture and destruction, the devices become toxic. Though properly packaged within our devices so as to not cause direct harm to the user, when the devices are broken down, burned, or buried at the end of their perceived or performative lifetime, the toxic components we encountered in the mining and manufacturing stages become actively harmful again. When improperly broken down, toxins, pollutants, and carcinogens directly re-enter the biophysical and environmental metabolic streams.

E-waste is another of our 'global village' connectors and another area for concern when it comes to digital labor practices, child endangerment, human health, and environmental justice. Though not given proper treatment here, there are many recent studies, see for instance Grossman, the documentary *Exporting Harm*, the UN's Global E-Waste Monitor and Greenpeace's many e-waste reports, that illustrate these global health and labor problems associated with these e-waste heaps. They discuss too how climate change disproportionately affects the marginalized laborers and communities that our motifs already work to hide.

Digital media theory's omission of e-waste is perhaps the most indicting of the mystique-building techniques of our 'magical' 'invisible' digital motifs. In sharp contrast

to its promised invisibility, the moment a device becomes waste, it becomes a concretely environmental and distinctly digital issue. Despite the marketing rhetoric and our disconnected relationship to trash, e-waste is a serious global digital-cultural problem. Digital de-construction is nauseating business, literally and figuratively.

Media theorists should be studying, sharing, and creating these stories of e-waste if they are to claim a comprehensive media study. Digital disposal can be seen, Parikka says,

> as an ever more central technique concerning our media culture, and it reveals a much more complex relation to materials, nature, and the economy than just pure discarding. Its momentary disappearance from sight just extends to a longer geopolitical and geographical network of waste management. This is an extension of our normal media studies concerns.[171]

There is much to be gained by taking our media study from beginning (mineral) to end (e-waste). We need to take seriously the idea that the digital network, and all of its parts, is, despite our biasing motifs, one of the most physical aspects of contemporary media study. When we do, we see that the health and future of environmental systems (and the humans that rely on them) require that we shift the focus of digital media and digital cultural studies from user-centric computation and affectation to the full metabolic intermingling of planetary digital ecologies. How will we produce a more ecologically and temporally sustainable foundation for media theory if we do not?

---

[171] Parikka, 2013.

Conclusion: Digital Sustainability

Though currently in media thinking and digital project work the concept of 'sustainability' refers to the longevity of a digital work—which is often limited due to, among other things, link rot, platform evolution, and lack of required maintenance—in DEMS, sustainability refers to performing digital practice and knowledge work with a mindfulness of the digital's environmental-metabolic relation with the world.

When we create robust relational narratives that more adequately reflect the full force of the digital's geophysical contingencies, we make positive steps toward a more sustainable digital media studies. This chapter has suggested that generating new narratives by re-defining our terms is one way forward. In shifting the way we think and relate to the technosphere and the geosphere, digital environmental media studies is an example of how we might intervene in contemporary crises (like climate change, for instance), not by throwing out our terms, but by disengaging their abstract meaning to invoke more concrete and environmentally-aware patterns, practices, and processes of thinking for contemporary digital media studies. Though I commend former President Obama for his Instagram glacier selfie, I believe *this* is how we might more sustainably #ActOnClimate. In an age when even our hashtags tell stories, we must be careful about the narratives we promote.

This is a first step media studies can take toward cultivating a more responsible theoretical position. The Anthropocene context has given us an opportunity to develop

environmentally-aware core concepts, breed new perspectives, and breathe life into disregarded relations and connections. It is an opportunity we can, and must, oblige by re-storying our digital narratives.

Chapter Three: An Ecosystem of Excess

Introduction

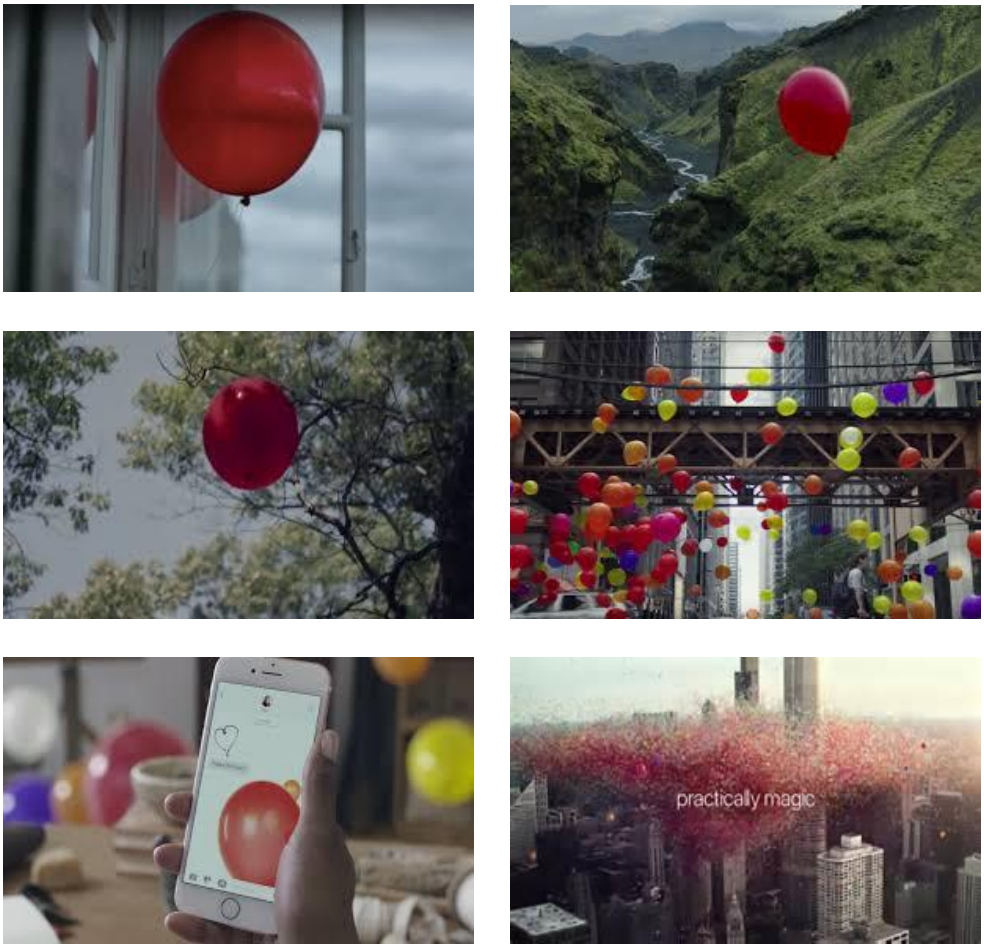

Figure 7: Stills from Apple's iPhone 7 Red Balloon ad, 2016.

Taking its cue from the 1956 classic film *The Red Balloon*, Apple's 2016 iPhone 7 ad turns a text message into a sentient red balloon. The 1s and 0s that must travel through a non bucolic highway of wires are instead manifested as a friendly bit of

inflated plastic. The balloon floats from open window to open window through human-less landscapes of mountains, fields, and streams. It dances its way through branches while "there isn't a mountain too high" tones in the background. It is unstoppable. Unpoppable. As it approaches its destination, it meets its friends, multicolored balloons who are also lightly, spritely moving on their own flight paths toward their final destinations. Our red balloon, after traveling mountain and morass, lands at its destination, back in its original form, as a digital balloon part of an excitedly-received happy birthday text message. The digital embodies its plasticity but does so in a way that still makes the digital immaterial. And practically magic.

Compare that to Pinar Yoldas's *An Ecosystem of Excess* (2013). In *Ecosystem*, artist Pinar Yoldas teases out the consequences of our technospheric Anthropocenic lifestyles by creating a living ecosystem out of a hypothetical technospheric primordial soup. Taking as a premise that today's waste heaps are tomorrow's breeding grounds, the question Yoldas explores in *Ecosystem* is one of evolution: if our current consumer excesses—the expanding digital network-of-things among them—are leading to man-made environments characterized by waste, pollution, loss of biodiversity, and extreme weather events, how might organisms of the future evolve to adapt? In *Ecosystem*, Yoldas combines artistic innovation with scientific and socio-economic data to investigate what, or who, may come from our wasteful consumption. Hers is an eco-

rhetorical strategy that transforms the refuse of human excess into material for speculative design.

Yoldas's *Ecosystem* includes insects, fish, birds, and reptiles that are endowed with what she terms "petrogestive" organs that sense and metabolize the waste plastics that now populate our air, soil, and water.[172] Responding to the fact that hundreds of thousands of marine turtles die each year from ingesting ocean waste plastics, most particularly plastic balloons, Yoldas created the Plastic Balloon Turtle. This new breed of technospheric sea turtle has, after eating ocean plastics over many years, evolved to have a shell made of plastic balloons that can inflate, Yoldas says, when climate change forces unpredictable sea level rises.

[172] There are many different types of plastic, including military grade and 'enhanced' plastics, composing our digital backbone and ultimately its waste. Chemically-treated synthetic plastics have replaced more 'natural' materials such as wood, stone, leather, glass, and metal, and are used in nearly every aspect of our digital network from fiber optic cables and device casings to server towers and transport packaging. Most of our e-related plastics are covered in highly-toxic brominated flame retardants that, when wasted, have been known to cause damage in animals and humans and to bioaccumulate, (steadily leach into) ecosystems.

Figure 8: Pinar Yoldas, Balloon Turtle, An Ecosystem of Excess, 2013.

Where other artists like Chris Jordan, for instance, with his images of plastic-filled albatross corpses, choose to depict the repulsive, deadly side of our e-waste excess, Yoldas provocatively highlights life. She avoids the popular Anthropocene-as-apocalypse narrative and works instead within the ecosystemic paradigm of inter-relationality, transformation, and evolution. The creatures living in the "plastisphere" of *An Ecosystem of Excess*, Yoldas says, "are life forms that can turn the toxic surplus of our capitalistic desire into eggs, vibrations, and joy."[173]

---

[173] *An Ecosystem of Excess* http://www.pinaryoldas.info/WORK/Ecosystem-of-Excess-2014. For plastisphere, see "Life in the 'Plastisphere': Microbial Communities on Plastic Marine Debris," *Environmental Science & Technology*, Zetler, Mincer, Amaral-Zettler.

What *An Ecosystem of Excess* brings to light is our implication in the pollution-ridded, waste-strewn landscapes that are altering wildlife biologies and habitats. It untangles, and in an important sense erases, the distance between our digital consumption and its environmental consequences. *Ecosystem* invites us to think on the level of the system at the scale of the planetary, urging us to see how our present behaviors will accumulate into the living archives of the future.

When read alongside the text message balloon, Yoldas's Balloon Turtle provokes a different tangible figuration of the digital-as-plastic to challenge or change our digital-material (hi)stories and subsequently our relationship—or at least our understanding of our relationship—with technology and the earth. It performs a critical act of opening that blurs the boundaries between the human, the digital, and the earth. Its narrative complicates the lovely red balloon commercial and urge us to see how our present behaviors will accumulate into the living archives of the future.

This concern about the digital's environmental effects is showing up in a range of provocative new art works. This chapter looks at how environmentally-focused digital artworks like Yoldas's can provoke tangible figurations to challenge or change our digital-material (hi)stories and subsequently our relationship—or at least our understanding of our relationship—with technology and the earth. The works profiled here perform a critical act of opening that blurs the boundaries between the human, the digital, and the earth.

Digital Environmental Art

As discussed in chapters one and two, notions of *cloud-based* data storage, *invisibly-ubiquitous* computing, and *cyberspace* Internet disembodiment have clouded the deep and heavy physical realities of our digital infrastructure. The situation of our networked digital systems as intangible, virtual phenomena promotes a series of misleading distancings: it removes the digital device from its mineral contexts; it hides the co-evolving, co-constituting nature of the digital's material and operational instantiation; and it excuses the digital from its geophysical implication. In chapter two, we used narrative strategies to re-story those notions, concretizing and literalizing the ecological metaphors already at play in digital media theory. In this chapter, we turn to art as another mode of re-stor(y)ing the cloud.

Environmental philosopher Val Plumwood says "the inability to see humans as ecological and embedded" destructively permeates contemporary culture. This type of thinking, she says, has distorted human life and scholarship and has become a liability to survival.[174] She says we "need skills and structures at all levels of our lives that can make us aware and responsible for our ecological impacts."[175] Yoldas's work is such a skill; it is a tool that undoes the illusions of anthropocentric disembeddedness by illustrating how our consumption can directly affect today's and tomorrow's lifeworlds.

---

[174] Plumwood, 5.
[175] Ibid, 240.

Yoldas is, as Haraway might say, *thinking with* the Anthropocene and its environmental conditions; she is taking seriously the fact that our present objects have interminable afterlives and that our excessive techno-consumerist wastes are the immortal marks we mortals are leaving on the earth.

A major project of the environmental humanities is to dislodge traditional anthropocentric notions of human-nature separability and disengage the abstractions that permeate our thinking about the relationships between the human, technology, and the earth. Plumwood says this is urgent work if we are to properly care for the earth and the creatures, including humans, it sustains. Digital environmental media studies, as I so develop it, merges environmental humanities with media studies to displace anthropocentric immaterial conceptions of digital media and the digital network to draw out the physical ties that bind human bodies, digital technologies, and the environment as intersecting material practices. New media artworks like Yoldas's, and those profiled below, aid in this project by telling untold digital stories and by staging complex, thoughtful human-digital-environmental interactions.

Artists employing Glitch, Augmented Reality, QR codes, and GPS locativity in their arts, for example, have been working at the intersections of digitality and material (or new materialist) practice in such a way that explores various tangible aspects of platforms, algorithms, and digital code. Yoldas and other artists, such as Revital Cohen and Tuur van Balen, Martin Howse, libi rose striegl, Joana Moll, and Tamiko Thiel, are

redefining the digital material project by combining digital media with eco-aware sustainable environmental art to express something akin to digital metabolic narratives—narratives that expose how the anthro- digital- and geo- spheres are inherently connected and intertwined with the ecosystemic sustainability of the others. For them, the eco-digital abstractions that typify digital and environmental rhetoric provide a dynamic crux for material investigation.

In *A Cosmopolitics of Energy*, Jennifer Gabrys presents eco-energy arts as a budding category of environmental *art*ivism that, by performing various ruptures, makes visible our immoderate energy use. For Felix Guattari, artistic ruptures can narrate stories and subsets of stories not often or not yet heard. Guattari says the contemporary world "is incapable of absorbing, in a way compatible with the interests of humanity, the extraordinary techno-scientific mutations which shake it."[176] It is art, he says, that has the ability to unhinge preconceived notions of the 'perceived world' and reshape the experience of the viewer.

In *Cosmopolitics*, Gabrys points to projects that visualize energy as a physical, nonrenewable resource in order to challenge viewers to confront the significance of their consumption.[177] These projects, she explains, "take up these materialities as explicit sites in which to actively materialize energy in order to develop deliberative encounters that

---

[176] Guattari, 1995, 91.
[177] Gabrys, 2014b, 2098.

may lead to reduced consumption."[178] They work with a configuration of materiality as tangibility, she says, that allows "new everyday practices [to] emerge through the process of encountering the material and visual evidence of consumption."[179]

These artists' hybrid practices of digital environmentality speak to the metabolic aspects of the technosphere, reminding us that the beginnings and ends of our devices—the minerals, metals, pollution, carbon footprints, waste, energy use, bio-diversity loss, and human labor—link our digital media to the environmental surround. They translate digital environmental problems into visual and/or experiential discourse that is more accessible than data-based facts alone and provide sophisticated artistic narratives for visualizing metabolic ecosystemic entanglements.[180] They offer new language and creative-aesthetic mental models for reconceiving interconnectedness in the digital metabolic technosphere, and for facilitating more environmentally-aware material engagements with our devices and the infrastructure that powers them.[181]

Contemporary theorists such as Katherine Hayles and Mark Hansen have paved trajectories that establish medium-specific analysis and new media art critique as critical

---

[178] Ibid.

[179] Ibid.

[180] Yoldas makes her agenda clear: at the end of a talk at Transmediale 2014, on a panel designed with *An Ecosystem of Excess* as its topic, she leaves us with a slide that reads "reduce.reuse.recycle (horseshit) refuse.refuse.refuse." If we understood the direct and indirect consequences of our technospheric actions might we begin to refuse? Yoldas's work asks us to at least consider it by imagining a future based on our daily Anthropocenic excesses.

[181] Technosphere, as defined in chapter one here, refers to the inseparable overlap between the anthroposphere, biosphere, geosphere, atmosphere, and now the digital technological systems (the network-of-things) inhabiting, and shaping, the earth. For more, see Peter Haff, 2014, 2015.

practices exemplifying the role media theory can play in understanding our Anthropocenic, technospheric condition. New media art not only facilitates a creative connection to the many technologies that now populate our daily habits and habitats but also, as all art movements do, expresses and shapes cultural imaginations. Medium-specific analysis attends to the particularities inherent in each technical medium recognizing that, as Hayles says, "the *nature* of the medium in which [texts] are instantiated *matters*."[182] As environmental texts instantiated in uncanny bodies, the artworks that follow merge digitality with earthly minerality to reflect on contemporary digitally-related environmental issues.

Mineral Visions

H/AlCuTaAu (2014), by artists Revital Cohen and Tuur van Balen and *E-Waste* (2014) by Katherine Behar distill materiality into minerality, constructing artistic geologic sculptures from the digital's mineral and metallic components.[183] Using our digital infrastructure itself as a mining site for materials, the artists displace the digital's value as one based in networked communication to one grounded in its mineral composition.

---

[182] Hayles, 2004, 67, emphasis mine.
[183] *H/AlCuTaAu*, See: http://www.cohenvanbalen.com/work/h-alcutaau.

Cohen and van Balen deconstruct digital devices in order to extract their natural minerals for use as material for reconstructing geologic ores. Instead of repairing the devices, they 'repair' the mineral ores that were destroyed to create them. As such, *H/AlCuTaAu* becomes a commentary on, and a physical engagement with, the geologic nature of the digital, and the environmental damages our digital appetites have wreaked. Similar in spirit to striegl's phone labels, these works condense the digital into its geologic state calling out the complex intermingling of the digital with the geological.

In her *E-Waste* (2014) series, Behar creates what she calls mutant fossils made by concretizing found electronic digital waste—its plastics, metals, minerals, and often fixable moving parts—into stone sculptures. Recalling *H/AlCuTaAu* above, *E-Waste* takes obsolete electronic components as raw material for artistic creations that meditate upon, in Behar's words, "consumer technology's environmental impact, digital labor's perverse acceleration, and big data's corporeality."[184] USB cords and SD cards are encased in stone alongside working fans, speakers, and blinking lights that are "doomed to continue working long after the humans they were designed to serve have gone extinct."[185] Behar accelerates the temporal and causative distance between our digital devices and their inevitability as immortal (and toxic) e-waste by illustrating how today's consumer

[184] *E-Waste*. See http://www.katherinebehar.com/art/e-waste-installation/index.html.
[185] Ibid.

decisions will be, and already are, tomorrow's fossils. The digital is literally entangled in the geologic with each becoming active with, and being activated by, the other.

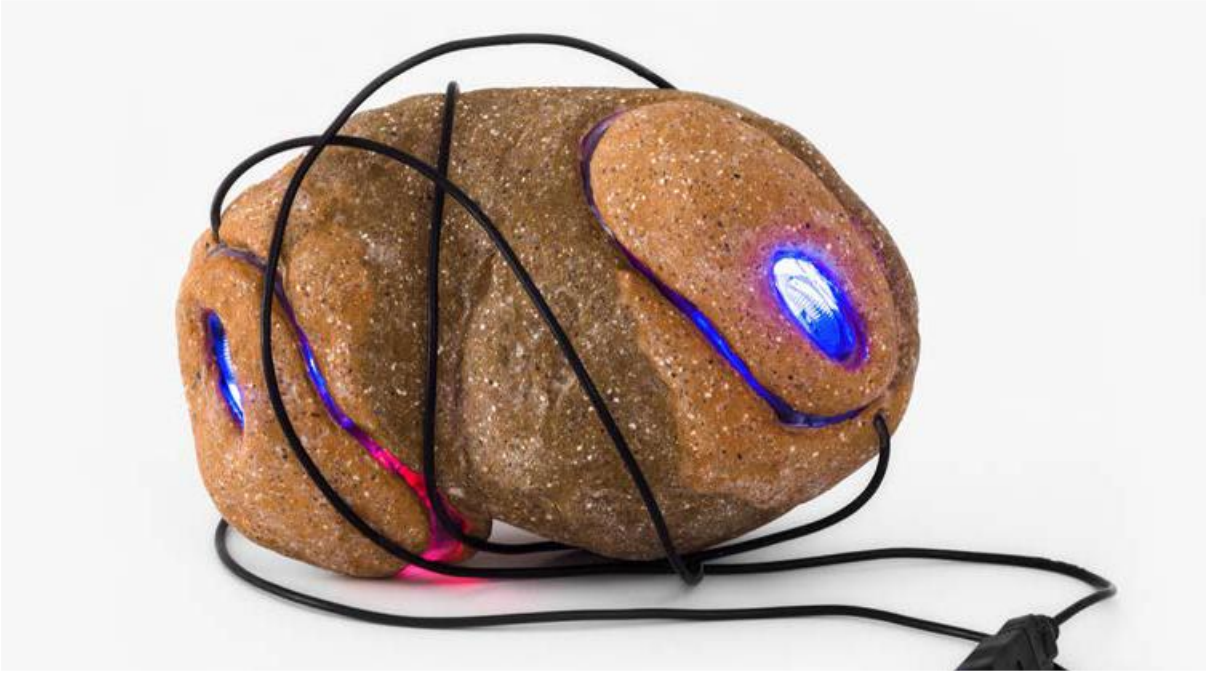

Figure 9: Katherine Behar, E-Waste (UCM-OR2X), 2014, USB corded mouses, Magic-Sculpt, Paverpol, Styrofoam, stone filler, pigment, cords. Variable dimensions. Photo by Jason Mandella. Image courtesy of the artist.

By putting these works alongside each other, one can see how each ruptures and frames differently to create a different access point to the story of digital materiality and metabolism. These works, akin to *Ecosystem*, offer metabolic narratives which enact a more profound demonstration of the global issue of digital mineral consumption and electronic waste. By focusing on geo-bio entanglements, these work**s** move our thinking

from the immaterial networked digital web to the web of minerals, metals, and manufacturing required to maintain it.

Mother Earth, Mother Board

Whereas *H/AlCuTaAu* and *E-Waste* primarily focus on visualizing digital mineralities, artists Martin Howse, Jonathan Kemp, and Ryan Jordan extend this program, asking what it might mean if the earth itself could evolve a computer. Their *The Crystal World* (2012) and *Earthcodes* (2012) projects speculatively reflect on the natural substances and metabolic (operating) systems of the earth. Combining aspects seen above in Yoldas's, Behar's, and Cohen and van Balen's works, these projects take from the digital to give back to the earth—after of course, the minerals have been taken from the earth to power the digital—by excavating minerals, exposing geological materials, and asking how these might be recuperated to perform a digital-environmental (metabolic) critique.

The Crystal World workshops, conducted in 2012, explored "various bi-directional decrystallizations of the digital, returning to the earth redundant electronics, the poisonous support for a synthesized dystopic world, the pure mineral."[186] *The Crystal World* investigations cut across two intersecting lines of experimentation: Howse, Kemp,

---

[186] *The Crystal World* v.02. See: http://crystalworld.org.uk/wiki/doku.php?id=the_crystal_world:space:publicity#cw_lab_exhibition_index.

and Jordan wanted first to extract minerals from defunct technologies and second to create working technologies from deep-earth mineral concoctions.[187] The premise of both is to reveal computation's minerality by way of showing that computation *is* mineral, and that minerals are the materials of computation.

> Inside every digital computer are wires, circuit boards, integrated circuits and other components. They are made from iron, copper, phosphorous, boron, tantalum and other rare earth elements. The central processing unit of a computer keeps time using a quartz crystal. The products of deep geological time are suddenly unearthed and set to pulsating millions of times a second... Computers are crystal engines. They are mineral fetishes that we use to manipulate powerful unseen forces that we believe we have mastered, like crystal healers working with a patient's energy grid. But they are so invisibly familiar to us as our smartphones and laptops and their use in logistics and media is so pervasive that it takes an effort for us to perceive their operation or their implications...[188]

Earthcodes is a subsequent series of projects by Howse that moves forward (or downward) from *The Crystal World*, to demonstrate the digital's implication in the geological sphere. In *Earthcodes's Earthboot*, Howse 'plugs' his computer directly into the earth so that he might, as he says, "sidestep dirty mining actions, and the expensive refining and doping of raw minerals; thus avoiding environmentally wasteful

---

[187] "Mimicking the often dangerous processes undertaken in the extraction of rare and precious metals by the dispossessed, The Crystal World proposes to expand these world interventions through experimentation in the formation of novel crystal geologies aimed to etch unexpected psycho(geo)physical distortions and contingencies into our contemporary crystalline cycles." Ibid.
[188] Myers, n.p..

production techniques for the construction of data bearing devices such as hard drives or USB memory sticks…"[189] He continues:

> The laptop, or PC, literally boots up directly from the specially designed, earthboot USB device pushed into the earth, running code which is totally dependent on small fluctuations in electric current within the local terrain….Quite often the earthboot operating system is not always fully functional as expected. Crashing is the price to pay for booting straight from the earth….[190]

Earthcodes's Sketches for an Earth Computer further demonstrates the physicality of the digital-geological coupling by actually burying a computer system in the Earth, thus re-embedding it back into its original mineral context. In *Sketches for an Earth Computer* various configurations of raw minerals were implanted within the earth. (One may be led to wonder here what would happen if Cohen and van Balen and Behar buried their mineral sculptures!) Howse anticipates that over time these materials, when interacted on by both natural and synthetic flows of minerals, rainwater, and underground electric currents, would evolve into a functioning computer. It would be, he says, an "earth computer; a machine without wires, without components and without abstractions, operating in the earth and proposing a negative ecology, a true earth animism."[191] As such, this Earth computer, he says "enters a feedback loop with the environment itself as geophysical, biological and electro-chemical elements can both encode and be modified

---

[189] Howse, n.p..
[190] Ibid.
[191] *The Crystal World* v.02, "Post Description," http://crystalworld.org.uk/wiki/doku.php?id=the_crystal_world:space:postdescription.

by the computational structures."[192] Howse's work demonstrates quite literally the material entanglement of the digital with the bio- and geo-logical spheres. His work renders the boundaries between digital, biological, and geophysical indistinct by closing the digital-earth distance.

Another Ecosystem of Excess

In *Fifty Sisters* (2012), artist and computing researcher Jon McCormack is, in a way, performing another ecosystem of excess insofar as he is also imagining forms of life that might result from our current Anthropocenic situation. Where Yoldas builds creatures in *An Ecosystem of Excess*, McCormack builds digital plants that reflect on our destructive over-reliance on fossil fuels. These are digital GMOs designed to get us thinking about how our (dirty) energy use is tied to the planet.

In *Fifty Sisters*, oil—a mineral resource derived from plants—is computationally returned to plant form by way of digital mediation.[193] Using digital technology, necessarily powered by electricity from the burning of fossil fuels such as oil, the project translates the corporate logos of the so-called Seven Sisters oil cartel into digital plants. The message is not just that organic raw materials are implicated in the digital's

[192] Debatty, n.p..
[193] McCormack, 74.

metabolic evolution but that so too are corporations and digital technologies enmeshed in the natural environment's metabolism.

McCormack's process works by way of generative evolution. He inputs a graphic logo into a digital program he designed to mimic evolutionary and biological processes. This program outputs pseudo-genetic digital DNA code, which is then read by a 3D renderer. The renderer then *cultivates* the logo seeds into code-based geometrical 3D offspring with photorealistic plant bodies. Following the digital metabology, these resulting plants are not 'immaterial' as one may be tempted to argue, but are digitally-constituted results of a generative digital breeding in a computational environment. These plants metabolize oil logos.

Figure 10: Fifty Sisters, exhibition image Ars Electronica, 2012. Image courtesy the artist.

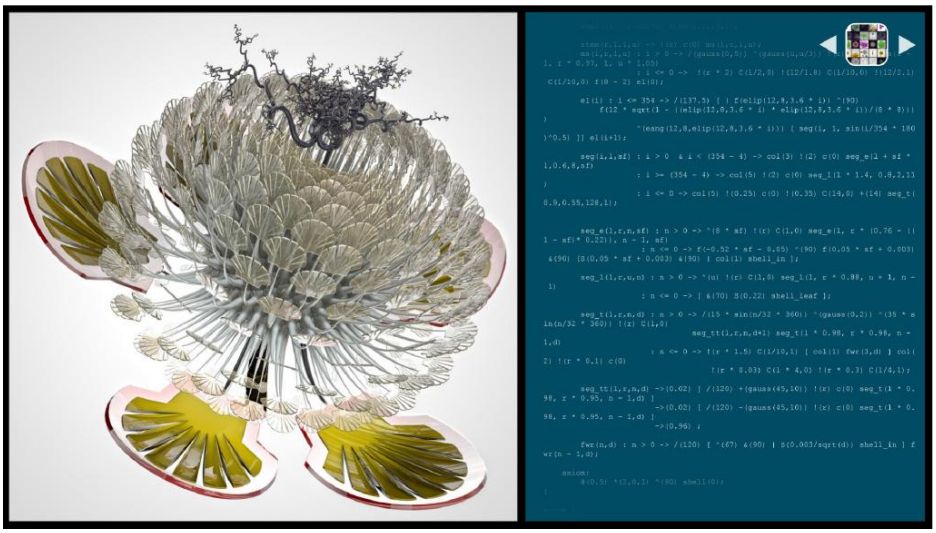

Figure 11: Fifty Sisters, exhibition image Ars Electronica, 2012. Image courtesy the artist.

As is evident in the exhibition images included here, the oil logo is sometimes prominently visible and other times entirely abstracted. The manifested differences are

the result of an emergent co-authorship between the logo seeds, the programmed plant morphology protocols, the 3D renderer, the computational software, and the energies required to power the process. Each element contributes properties and complexities, and each leaves traces on the final plant product.

In her introduction to the *Ecosystem of Excess* Transmediale panel mentioned above, Daniela Silvestrin references BP Oil CEO Tony Hayward who said of the 2010 Gulf of Mexico oil spill that it was "small in comparison to the huge ocean". She quotes his line: "We should not worry, as nature would absorb the industrial accident."[194] McCormack's plants demonstrate this 'absorption' in the same way that Yoldas's creatures absorb our electronic and plastic wastes. Seen in this way they complement each other. Not only could McCormack's plants be sculpted as future habitats in *An Ecosystem of Excess* but, when placed alongside Yoldas's plastic-digesting creatures they demonstrate another ecosystem since plastics are derived, as we know, from petrochemicals. As Elizabeth Grossman says, "Looking at the entire environmental footprint and life-cycle of plastics production means considering the environmental health impacts of oil and gas extraction and refining these liquid fuels into the monomers that form the building blocks of the polymers that make up plastics."[195]

---

[194] Transmediale 2014, *An Ecosystem of Excess*, panel, with Pinar Yoldas, Heather Davis, Jennifer Gabrys, Bernd Scherer, Daniela Silvestrin, At Haus der Kulturen der Welt, Berlin 1.2.2014.
[195] Grossman in Maxwell et al, 69.

Being attentive to works like McCormack's and Yoldas's reminds us of our dependence on fossil fuels and interconnected flows of energy and geologic material. An attentiveness and broader understanding of digital materiality and metabolic relationality opens us to the environmental, atmospheric, geologic scope of what is at stake with Anthropocenic-technospheric digital metabolism.

By transplanting oil logos, quasi-representations of petrochemical extraction, into the digital environment and then into printed artefact, *Fifty Sisters* participates in the digital metabology by visualizing, and in a sense reterritorializing, the digital within its natural ecological contexts. It artistically (re)embeds the material into the digital—and then the digital back to the material—to highlight the dynamic geological and biological metabolic entanglements that characterize the *nature* of the digital.

Local Colour (2011), by artist and academic Mitchell Whitelaw plays with deeper dimensions of constructive relationality to interrogate the physical materialities of the digital and highlight 'transmateriality' which for him seems to represent both his process and the natural properties of the digital. Transmateriality, he says "emphasizes the continuity between computation and material environment"[196] thus erasing the boundaries between digital and 'natural.'

[196] Whitelaw, 2013b, n.p..

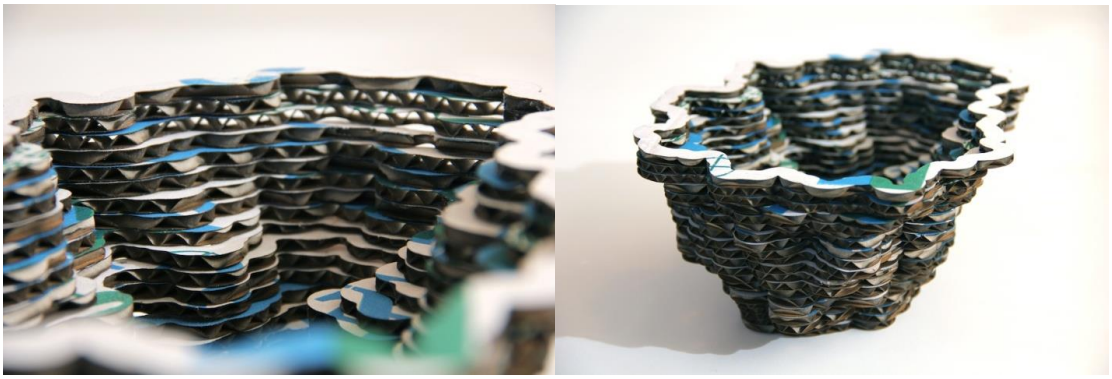

Figure 12: *Local Colour*, exhibition images *ISEA*, 2011. Images courtesy the artist.

In *Local Colour*, a laser cutter, programmed using generative software, cuts terrace-like layers into reclaimed cardboard boxes to produce a bowl-shaped, digitally-incorporated physical structure. The bowls are designed through an interactive, iterative technique whereby the cardboard material, the fabrication software, and the algorithmic process coordinate to 'grow' the designs. He says:

> At times, material specificity 'reaches back' into the digital process. This tangles the simple causality that fabrication often implies, where matter is a passive thing to be formed. In this project the material feeds back to cause the digital form even as the digital form ultimately shapes the material. For example the dimensions of the bowls are constrained by the source boxes (as well as the laser cutter). The number of slices—and so the height of the bowl—is also constrained by the material available; again this reaches back to inform the algorithm generating the cutting instructions.[197]

The digital here enacts a co-dependent metabolic loop with the physical material of the cardboard substrate; the digital algorithm responds to the box, and the box

[197] Whitelaw, 2011, n.p..

responds to the digitally-logical fabricator. Together, they engender an original sculptural form. It is perhaps no coincidence that the bowls resemble the quarries from which the minerals required to produce the digital are extracted.[198]

Figure 13: Edward Burtynsky, Highland Valley #8, Teck Cominco, open pit copper mine, Logan Lake, British Columbia, Canada, 2008.

Local Colour's metabolic transmateriality loops full circle, not just rhetorically, as is primarily the case with *Fifty Sisters*, but also materially as the work's physical parts and its meaning-making gestures cycle from Earth to digital to bowl to Earth again.

For Whitelaw, digital fabrication uncovers the already material nature of all things digital. Fabrication, he says, "applies the functional logic of the digital to its

---

[198] Edward Burtynsky, Highland Valley #8, Teck Cominco, open pit copper mine, Logan Lake, British Columbia, Canada, 2008. Image Source: https://www.theguardian.com/artanddesign/gallery/2016/sep/15/edward-burtynsky-corrupted-landscapes-aerial-photography-in-pictures?CMP=share_btn_fb. Note: Copper is the most prevalent mineral in our phones.

materials…",[199] initiating a cycle whereby digital "patterns traverse [physical] material [and] the embodied is dynamically re-embodied."[200] Not only do digital works "exist as a material pattern of voltages and magnetic flux inside [the] computer,"[201] but the digital is also always embedded in a material substrate. The digital is embodied, for instance, as light travelling through optic fibers, as a magnetic charge on a disk, and as data traces on a drive. As such, it is not 'immaterial' but exists as a material configuration, situated within larger material configurations of the physical ecologies of the anthroposphere. For Whitelaw, digital fabrication allows "the specificity of digital media [to] emerge at human scale [as] the material patterns of computation congeal into objects we can wear, touch, or inhabit."[202] The digital becomes tangible in an immediately perceptible way.

If transformation, as Parikka says, can be "a central way to understand the technological assemblages in which metals and minerals are mobilized,"[203] we can use works like Yoldas's, Cohen and van Balen's, McCormack's, and Whitelaw's as what environmental humanist Joni Adamson calls 'seeing instruments' that point our attention to inter-systemic metabolic processes formed between the digital and the earth when we think on anthropocentric (or deep time for Parikka) temporal scales.

---

[199] Whitelaw, 2013, 223.
[200] Whitelaw, 2011, n.p..
[201] Ibid.
[202] Whitelaw, 2013, 231.
[203] Parikka, 2015b, 48

These artworks reproduce and make poignant the co-constitutive, *technogenetic*[204] environment we encounter in daily life. As such, these artworks give us a contact point for unpacking the digital's participation within Anthropocenic metabolic processes.

In *Feed Forward*, Mark Hansen illustrates how our interactions with everyday digital media processes and networked digital systems is endlessly fed back to us in recursive circulation:

> In our interactions with twenty-first century, atmospheric media, we can no longer conceive of ourselves as separate and quasi-autonomous subjects, facing off against distinct media objects; rather, we are ourselves composed as subjects through the operation of a host of multi-scalar processes, some of which seem more 'embodied' (like neural processing), and others more 'enworlded' (like rhythmic synchronization with material events).... Conscious experience of twenty-first century media increasingly occurs as the result of a complex… process involving digital techniques of data gathering… that facilitate the 'feeding-forward' of multiple experiential sources into a potential future synthesis within [our] consciousness...[205]

We could say the same about the digital's interaction with the earth. In the twenty-first century we can no longer conceive of the digital as separate and quasi-autonomous from earth processes. In twenty-first century digital networked systems, the co-relation between the earth, human and non-human biologies, and the digital is not adjacent but contingent, and metabolically intermingled. We are geological bodies, Kathryn Yusoff tells us, and this extends to the digital—we are all now digital-mineral

---

[204] Technogenesis is defined is 'the idea that humans and technics have coevolved together' (Hayles, 2012, 10).
[205] Hansen, 2014, 5, 46.

bodies. This contingency in the feed-forward nature of the digital is investigated in the works below.

Digital Mineral Labels

Instead of deconstructing a device to remove its minerals, artist libi rose striegl performs a different extraction operation. After compiling elusive statistics on the approximate metal and mineral components of the iPhone 5, she designed and printed 2″ x 3.5″ peel-and-stick mineral 'nutrition' labels that affix perfectly to the back of the iPhone's body. The labels list 'component facts' for the iPhone detailing the specific quantities of metals, minerals, and plastics required to produce it. The label includes the device's energy use and vital warnings reminding the user that the contents of the phone are non-renewable and largely non-recyclable with several of them being known conflict minerals.

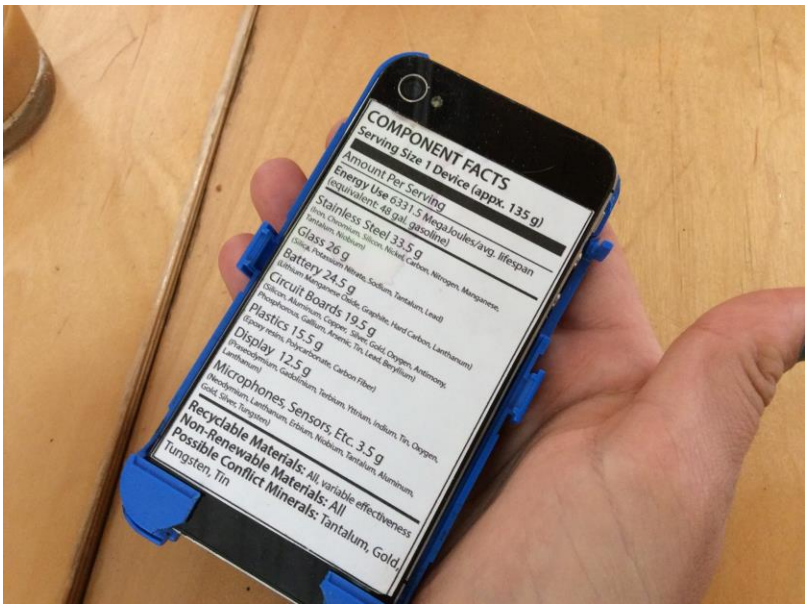

Figure 14: libi rose striegl, iPhone mineral label project, 2015, photo taken by Gould with artist's permission.

Striegl is here staging an uncanny relation, an eco-mindshift, as environmental artist Natalie Jeremijenko might say. The phone is as it always was but now we see its mineral history written on its (inter)face. With its mineral label, the phone becomes doubly networked: it is linked to the digital cloud and to the physical network of workers, wires, and waste that accompany every digital device. In an act of artistic intervention (or rebellion), striegl sticker-bombed the Apple store in Chicago (2015) placing the labels on several of the display phones. The buyers of those phones will be reminded, daily, of their implication in the digital-environmental metabolism. Striegl has also made the sticker open-source and available for download so that anyone might participate in the artivism of digital labelling.

What striegl's project manages to do is distil the iPhone's minerality into a legible, familiar shape. We understand nutrient labels to indicate the contents, and their calorie counts, of the manufactured product to which they are affixed. Recent studies on 'real' nutrition labels have shown that people do indeed change their purchasing behaviors, especially when they are buying food for children, when faced with nutrition facts at the point of purchase. When Starbucks added calorie count to their café menus, they saw a sustained decrease in calories purchased.[206] A 2011 study in New York City showed similar decreases when McDonalds, Au Bon Pain, and KFC added calorie counts to menus.[207] Equally important, researchers at Johns Hopkins University have found that posting calorie counts on restaurant menus actually influences restaurants to modify or drop certain items while also providing more healthful options.[208] In other words, they do tend to affect behavior.

If all digital devices were required to come with a content label listing not just what is inside but also embedded energy use, country of origin, carbon footprint, ecological rucksack (chapter two), pollutive-chemical content, and date of planned obsolescence (with facts about where it will go upon 'death'), it seems certain that corporations, if not also, one would hope, consumers, would take note and begin to

---

[206] Bollinger, 91–128.
[207] Dumanovsky T, Huang CY, Nonas CA, et al., n.p..
[208] Bleich, Sara N, et al., 1877-1884.

pursue more sustainable behaviors.[209] Apple tells us the iPhone is magical; striegl shows us otherwise.

Artist Joana Moll conceptualizes digital network minerality with a different, but arguably companion project: her ***Co2gle*** materializes wirelessness and digital behavior by way of visualizing the material-environmental marks it is making on the earth. The power of the iPhone and all digitally-connected devices lies in the data centers that store and share the data we exchange. Data centers are, as Google likes to say, where the Internet *lives*. There are roughly 3 million data centers in the US alone and the majority of those still use coal (i.e. the mineral form of carbon) and dirty petrol to fuel the energy-hungry servers that make the web and its cloud possible. It should be no wonder then that our online activity has a carbon footprint: Google searches, spam emails, and video streaming are not 'green' alternatives to their off-line analogs. Believe it or not, all of our online activity results in atmosphere-eating greenhouse gas emissions. *Co2gle* seeks to make this reality part of our everyday experience of the web.

[209] In countries where producers are required to abide by Extended Producer Responsibility (EPR) rules that mandate a company is responsible for the end of a product's life, producers begin designing more sustainable, more resilient, more recyclable products.

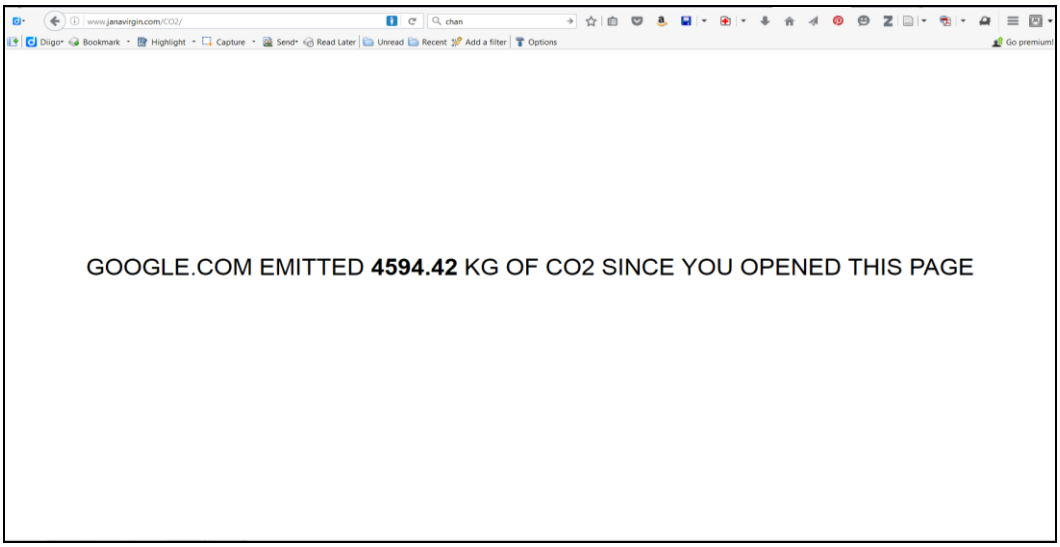

Figure 15: Screenshot from Joana Moll's Co2gle.com webpage, taken May 2016.

Deceptively simple in presentation, *Co2gle* nonetheless deliberately brings attention to the profound impact our web activities have on the Earth. *Co2gle* is a web-based installation that displays the amount of Co2 emitted each second by Google, the world's largest search engine.[210] By visualizing Google's carbon footprint on a web-only platform, Moll not only calculates Google's constantly increasing footprint, which tops more than 500kg of Co2, each second,[211] but also implicates the user in its never-ending growth. One must open a carbon-emitting webpage, often accessed searching through

[210] In 2013, traffic through and to Google in all of its forms, Google Mail and Drive included, represented nearly 40% of all Internet traffic. See more from *Forbes*: http://www.forbes.com/sites/timworstall/2013/08/17/fascinating-number-google-is-now-40-of-the-Internet/#5d3ae57a6ca2.

[211] Google Statistics here: http://www.Internetlivestats.com/one-second/#google-band.

Google, in order to view the work. What is critical about this piece is that it links our wireless web use to its environmental footprint.

A similar simple-but-striking example of this particular intervention is Tamiko Thiel's *Clouding Green* (2012). An artist working largely now with Augmented Reality technologies, Thiel creates artistic interventions that overlay digital environmental information onto physical locations. Thiel geolocates graphic designs which can be viewed when the particular locations are scanned using AR applications on a smart phone or tablet. The beauty of AR arts is that one can see the actual physical space annotated with digital interruptions. With *Clouding Green*, Thiel placed virtual sooty black and green clouds atop real digital data centers to indicate their poor performance on Greenpeace's Clean Energy Index. Those buildings with a lower score are accompanied by the darkest, largest clouds. If using the AR app when standing outside Google's, Apple's, and Twitter's headquarters, a viewer would see the clouds looming over the buildings. Thiel's intention is to call attention to the companies' non-green energy practices and to provoke curiosity, surprise, and hopefully thoughtful pause.

Figure 16: Tamiko Thiel, "Clouding Green—Apple HQ" Greenpeace Clean Energy Index 15.3%. AR installation by Tamiko Thiel, 2012. Image courtesy the artist. [212]

Thiel, like striegl and Moll, is rescripting our interactions with the cloud. It is through these types of restor(y)ing performances, Jeremijenko says, that we can begin to address critical environmental issues. If a work of art can be, as Guattari says, "an activity of unframing, of rupturing sense…which leads to a recreation and a reinvention of the subject itself," works like those here can be profound tools for digital environmental humanities thinking.[213] They focus on the medium-specific environmental mineralities of one of our most ubiquitous eco-offenders in order to dispel myths of the digital as immaterial and instead grounded it its earthly

[212] Thiel, Image Source: http://www.mission-base.com/tamiko/AR/clouding-green.html.
[213] Guattari, 1995, 131.

implications. These images bring the digital's materiality into the spaces we frequent, and by extension, into the bodies and ecosystems we inhabit. Boundaries are blurred, and environmental realities are brought to life.

This type of eco-metabolically-conscious intervention has recently taken a more public turn with many projects going *en plein air* to bring awareness to our everyday common spaces. These works include those such as artist Olafur Eliasson and geologist Minik Rosing's *Ice Watch*[214] which placed melting pieces of Arctic glaciers directly on the Place du Panthéon during COP21. Artist Andrea Polli's *Particle Falls*[215] is similarly palatial: it digitally projects visualizations of real-time air quality onto the side of public buildings in major US cities. Poet Simon Armitage and scientist Tony Ryan's *In Praise of Air*[216] actually enacts its environmental message as it is a poem painted on the side of a University of Sheffield building using an ink infused with an air-cleansing catalyst that actually 'eats' pollution. These art projects can bring our attention to what Latour and Maria Puig de la Bellacasa call "matters of concern" and "matters of care," respectively, by inviting viewers to engage meaningfully with the 'facts' about digital environmental impacts. They reflect our growing concern about how humans are influencing environmental issues and how those issues are influencing the health of today's and

---

[214] *Ice Watch*: http://icewatchparis.com/.
[215] *Particle Falls*: http://www.particlefallsclt.org/.
[216] *In Praise of Air*: https://www.sheffield.ac.uk/news/nr/worlds-first-air-cleansing-poem-1.373843.

tomorrow's humans. They also, some more deliberately than others, awaken us to awareness and urge us to take action.

One reason these works are so effective is because they build on two critical lessons taken from communications theory and behavioral economics: 1) they meet the viewers where they reside and 2) they create new shared stories, or 'common articulations' as Latour would say, that democratize and normalize environmental knowledge, making these environmental matters of fact/concern/care accessible and approachable. Experts in communication for environmental behavioral change have tested these conclusions and, as it always seems to be, we humans can be wonderfully predictable: we are more likely to change our behaviors if our neighbors do and we tend to be reflective on purchases when we are met with compellingly-presented facts at the point of consumption.[217] Greenpeace and other environmental groups have also tested these theories and the use of art and found them too to be effective campaign tactics.

It is in this way that art can communicate to those unfamiliar with the material and relational aspects of their digital consumption. The stories these works tell bind local and individual actions to global consequences contracting complex environmental

---

[217] A recent study in California showed that homeowners will adopt, and keep, energy-saving behaviors if they believe their neighbors are using less energy in their homes. Factsheets alone were not enough to change behavior in these trials but neighborhood comparisons delivered on monthly energy bills worked. Other studies have shown that using cloth grocery bags, installing solar panels, and driving electric cars can be 'contagious' leading neighbors do to the same.

issues to a more relevant and personal scale.[218] Art has the ability, and artist Eliasson says the *responsibility*, "to help people not only get to know and understand something with their minds but also to feel it emotionally and physically…[by] break[ing] rules and find[ing] unorthodox ways of approaching contemporary issues"[219] The works profiled here use digital technology in uncanny ways to reflect on its own materiality; they give formal expression to imaginative thought and in so doing they tell new stories about our digital participation.

Conclusion

By illustrating digital metabolism and speaking to the consequences of our actions, these works point to our ethical and ecological responsibilities. Digital petrol flowers, speculative bodies, and iPhone labels become productive objects to think with. They become, in the words of Rafico Ruiz, 'objects of amplification.' If art and literature can, as says Lawrence Buell, one of the early trailblazers in environmental ecocriticism, "script environmental-ethical concern,"[220] then they can help us develop a sensitivity to the complex interacting factors leading to, and demonstrated by, climate and ecosystemic change due in part to our ever-growing technosphere.

---

[218] Catanese, n.p..
[219] Eliasson, n.p..
[220] Buell, 25.

The works profiled here perform with and within various digital paradigms to collapse the gap separating digital from geologic. In so doing, in cooperation with the material metabolic framework, they provide new patterns for (re)thinking the digital's rhetorically-established distancings. A "What Might Happen If" question is at the heart of each: What might happen if future creatures emerged from our technospheric waste; if smart phones came with content mineral labels; if digital dust could speak; if people knew the carbon footprint of their Google searches; if the earth itself could create a computer? These are questions we need to be asking. What is at stake here is the health of our planet and our bodies. What is needed is a reformation of our digital-environmental imaginary. The works here suggest a path forward for achieving just that.

Chapter Four: Sustainable Digital Scholarship through Permaculture and Ecocritical Digital Humanities

Introduction

Chapter one traced the patterns that materialize when we begin thinking metabolically about vital digital-ecological interconnections. Chapter two applied environmental humanities methods to digital media studies in an attempt to draw attention to complex technosphere environmental issues. In chapter three, the digital metabolic lens was used to examine digital artworks that do the same. In those chapters, and this project as a whole, metabolic media thinking allows us to frame questions of digital technology so that they reflect the intertwined nature of digital, environmental, and anthropological systems. *Excessive* unseen *connections* and *unruly* continuous *categories*, to borrow Haraway's language,[221] emerge when the digital becomes a metabolic partner. Today, perhaps more than ever, we need models for thinking critically about our physical connections and ethical commitments as citizens involved in digitally-entangled global ecological systems. We need to seed digital media study—and the digitally-related humanities writ large—with the deep roots of *active* sustainability, environmental awareness, and eco action (or activism).

---

[221] As Haraway says, to understand life as it is today, "we have to get inside all of the excessive connections and unruly categories in order to make sense of it all." Haraway, 2004, 2.

In this chapter I propose methods for enacting deeper engagements with our entanglements as well as solutions for developing a more sustainable digital practice. I ask here how we might infuse digital practice with a necessary environmental sensitivity in the hopes that by developing new forms of digital humanities practice in partnership with the use of more sustainable digital language, we can ensure our 'immaterial' digital technologies do not continue to cause irreversible physical damage to the earth and, in return, to our bodies.

Activating Digital Environmental Metabolism

"The critical mind, if it is to be relevant again, must devote itself to the cultivation of a stubborn realism."

Latour

In her keynote for the Digital Humanities conference in 2014, Bethany Nowviskie challenged listeners to think about how their scholarship might change when confronted with the ecological challenges, the *stubborn realities* Latour speaks of above, of the Anthropocene: a planetary epoch that—to paraphrase atmospheric chemist Paul Crutzen—coincides with human-driven forces fundamentally changing the composition of the planet. Nowviskie, confronted with the coming extinction of numerous species and the loss of ecological habitats, wonders whether the digital humanities, in all of its broad forms, should change its global sense of scale to embrace larger temporalities, to

teach its practitioners to memorialize and live differently, and to pursue an active, engaged praxis that connects technology, the environment, and the "ethical conditions of our vital here-and-now."[222]

Media theory has at various times taken cybernetic, non/post-human, media-ecological, planetary, and material *turns*, but still lacks a hands-on praxis for putting systems theory into action. Though inclined to adopt environmental metaphors, only very recently has there been movement on a more material-environmental media theoretical front (sees chapters one and two). Our contemporary, new, and post-human media theories have largely ignored the fleshy, earthly contexts of our digital technologies. And yet, as our digital technosphere continues to expand and connect, it is imperative we devise a model of thinking (and doing) that does not leave a robust environmental program elusive from digital media theory.

This chapter proposes permaculture—a profoundly interconnected set of ethical design principles that we'll borrow from natural farming—and ecocritical digital humanities as ethical and active practical skill sets that might unhinge dominant forms of *doing* in digital humanities scholarship, especially those that either deliberately or unknowingly support ungrounded digital motifs, to provide a richer and more engaged framework for digital media and humanities practice. If we understand theory to be a

---

[222] Nowviskie, Keynote.

critical creative act, practice might be positioned as its active counterpart, performing and rehearsing its ideas through critical material couplings. Positioned as such, how might we use permaculture as a model to initiate more mindful scholarly and digital practices? How might adopting a permacultural ethos help develop a new, sustainable, material relationship with our digital practice? And if, as Karen Barad says, "knowing is a direct material engagement," how might this new engagement reflexively inform and alter our ways of knowing and living?

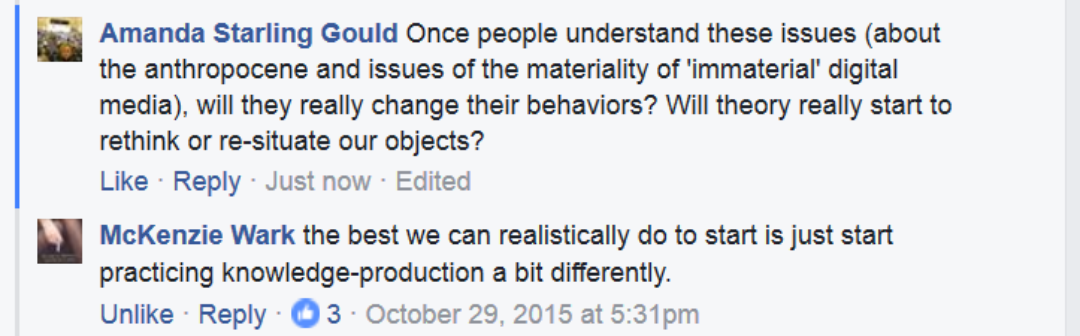

Figure 17: Screenshot of conversation between Gould and McKenzie Wark, Facebook, October 29, 2015.

We turn here to praxis by thinking with permaculture as a metabolic model for developing care-full relationships with our geo-digital technosphere. "The best we can do," McKenzie Wark says, to facilitate more environmentally-aware digital scholarship, "is to just start practicing knowledge-production a bit differently."[223] A metabolic-permaculture intervention into media theory gives us a spongier digital-material

[223] Wark, Personal communication via Facebook.

humanities, one that absorbs the full force of our interconnections, and leads us toward knowledge-production tailored to the concerns of our emerging Anthropocenic humanities.

What is Permaculture?

Permaculture is a set of design principles and ethical guidelines based on natural patterns that provide practical skills for more sustainable living. It was created by Bill Mollison and his graduate student David Holmgren in the 1970s based on traditional knowledge of natural farming, indigenous knowledge of ecosystemic patterns, the principles of modern science (like biology, ecology, geology, thermodynamics, economics), and deep ecological thinking. It was inspired by what Mollison and Holmgren identified as an urgent need for more sustainable approaches to environmental care, food systems, community relationships, and healthy living. Originally coined as a combination of 'permanent' and 'agriculture', Mollison and Holmgren have since decided 'permanent-culture' to be more fitting.

Permaculture combines three basic ethics, *earth care*, *people care*, *fair share*, with a set of twelve main design principles to provide an active program for developing productive-generous regenerative systems that benefit both the human and the environment. These three ethics guide the twelve design principles Holmgren and

Mollison designed which are meant to be "thinking tools, that when used together, allow us to creatively re-design our environment and our behavior in a world of less energy and resources."[224] The twelve are: Observe and Interact; Catch and Store Energy; Obtain a Yield; Apply Self-Regulation and Accept Feedback; Use and Value Renewable Resources; Produce No Waste; Design From Patterns to Details; Integrate Rather Than Segregate; Use and Value Diversity; Use Edges and Value the Marginal; Creatively Use and Respond to Change.

As the permaculture movement spreads, the ethics and design principles are being adopted as sustainable values for fields such as business, urban design, education, and eco-friendly living. In bringing permaculture into digital thinking, we do something similar by reinterpreting the performative aspects of the ethics and design principles. When applied to digital media theory, permaculture is the active counterpart of the metabolic framework.

In an exercise of appropriation, I here condense the ethos of the three ethics, the twelve principles, and the original teachings of Mollison and Holmgren into several overarching guiding tenets that might be taken from farm-to-*digital*-table: everything is connected and a paradigm shift in our practices—agricultural and otherwise—is required for more sustainable living; earth care *is* people care and attentive care is

---

[224] Telford, n.p..

paramount to sustainable relationships; care-full acting can lead to more sustainable, fruitful systems; and finding creative ways to obtain a yield is crucial for reliable, long-term self-sustaining systems.

Just as these tenets have been successfully brought into offices, institutions, homes, and communities, I argue they can have an equally powerful impact if brought into contemporary digital literary and media scholarship, and can become a guide for designing what science fiction author Kim Stanley Robinson—in whose *Fifty Degrees* permaculture features prominently—calls "permanent-permutable" permaculture-based models for sustainable digital practice. This is the driving experiment of this chapter: to bring permaculture into digital media praxis as a way to extend the metabolic project to re-root digital media fully into its earthly material contexts. As used here, permaculture becomes the active counterpart of narrative re-storying and provides both a model for sustainable practice and a pattern for putting digital environmental media studies to work in the world with the aim of producing an environmentally-conscious digital *yield*.

Through permaculture, we revive Michel Serres's "natural contract" which, he argues, in its adoption, "leads us to consider the world's point of view in its totality."[225] Serres says that if we are to repair our relationship with the earth in the face of global

[225] Serres, 46.

environmental change, we *must* "add to the exclusively social contract a natural contract of symbiosis and reciprocity in which our relationship to things would set aside mastery and possession in favor of admiring attention, reciprocity, contemplation and respect…"[226] We will not survive us if we do not. Permaculture is such a natural contract. It is a provocation to consider ourselves geological subjects (Yusoff) incorporated in inseparable multispecies planetary affiliations.[227]

When developing the interconnected permaculture principles, Mollison was inspired by the natural farming methods of Masanobu Fukuoka (1913-2008), a Japanese microbiologist, agriculture scientist, farmer and philosopher. Fukuoka maintained twelve acres of citrus and vegetables and grew 4,000-6,000 lbs. of grains each year without machines, pesticides, chemicals, or water overuse (and Mollison himself said this was "unbelievable")[228] by managing a natural, regenerative system of farming that mimicked natural patterns. Following the natural premise that everything is connected, Fukuoka designed his farm so that it would more or less run itself—waste was recycled, water was reused, crops were planted in mutually-beneficial relationships, citrus trees

---

[226] Ibid, 38. He continues: "the Earth speaks to us in terms of forces, bonds, and interactions, and that's enough to make a contract. Each of the partners in symbiosis thus owes, by rights, life to the other…" Serres, 39. And goes on to say that "any contract creates a collection of bonds, whose network canonizes relations; today nature is defined by a set of relations whose network unifies the whole Earth. The natural contract connects the second and the first networks into one." Serres, 46.

[227] "If we use the anthropocene as a provocation to begin to understand ourselves as geologic subjects, not only capable of geomorphic acts, but as beings who have something in common with the geologic forces that are mobilized and incorporated, it is possible to identify some of the collaborative junctures that govern and provoke these affiliations to enact corporeal and planetary (de) sedimentations." Yusoff, 2013, 781.

[228] Mollison, 1978, 18.

provided shade and water to ground plants, chickens fertilized and ate crop-killing insects, humans ate chickens, weather was a natural partner in the process, humans benefited from more efficient processes and large yields, and the earth was not damaged as is in other types of farming but was actually replenished by his methods. In permaculture there is a saying that "everything gardens". Everything gardens in so far as every thing and every act modifies its environment. As Fukuoka shows, when systems are designed so that the modifications are mutually beneficial, the system naturally thrives.

Permaculture as Sustainable Digital Practice

Deep Digital Ecological Thinking: Everything is Connected

> "To recognise our actions and ourselves as part of nature is a cultural transformation begun but not completed. The change from seeing human impacts on nature as improvements to seeing them as destructive may be a necessary step in [our] evolution, but the transformation comes when we no longer see ourselves as outside nature."[229]

Permaculture's commitment to deep ecological thinking neither is nor stems from a theoretical or metaphysical trope but comes from an understanding of nature's flows and a belief that following those will lead to more productive, sustainable systems. In the natural world, everything is connected to everything else and the relationships

---

[229] Holmgren, 2002, 265.

that bind them are, if allowed to flourish naturally, productively complex. Though our cultural-scientific Western bias has long been to reduce complexity and isolate elements in order to study them in their purity, such a 'purity' is no longer possible. This is exactly what led Peter Haff to posit the technosphere as a new category of geological phenomena. Traditional geology looks at the physical earth and the processes that alter it; it deliberately removes the human from the equation. This was becoming increasingly impossible, Haff says, and it thus became necessary to create a new frame of reference for geological study because a human-free 'pure' Earth no longer exists. The dualistic hyperseparation, of human and nonhuman and human and environment, to which Western humanities are prone, can no longer be entertained. Permaculture bases its designs on this very principle: nothing is segregated—including humans from nonhumans and their environment—and it is diverse polycultures that most successfully thrive. The permaculture flower is meant to visualize this interconnection:

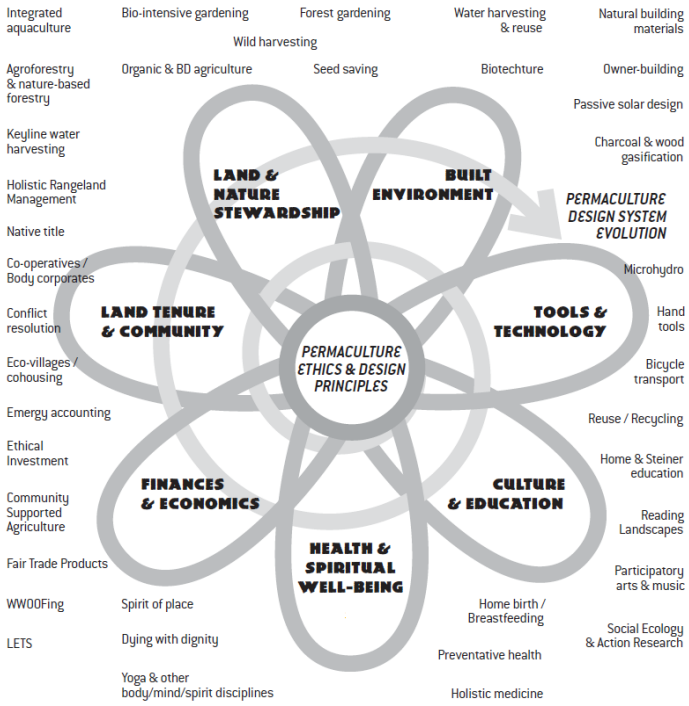

Figure 18: The Permaculture Flower. Adopted from *Introduction: Permaculture Principles & Pathways Beyond Sustainability*. Copyright 2002.

We see here (Figure 18) how the permaculture ethics and design principles are the core of the practice, connecting all elements of the human-technology-nature system and guiding our behaviors within it. Each petal represents one of the domains that must, according to Holmgren, be included in our permacultural designs. These are, as indicated by the spiral, integrated elements and a sustainable global socio-economic permaculture requires each petal domain be considered, beginning on the personal-local level and, eventually, spiraling outward toward the collective-global level.

What the permacultural flower does is expose relationships between humans and nonhumans (both living and non) and the environment (and even climate) as it opens, provokes, and permits new questions about humans, nature, policies, consumption, waste, and practices of living.

In permaculture, systems—whether they be farms or officespaces—are deliberately designed *as* relationships: every element, including the human, is linked to every other and each element performs several tasks within the system. The body, the earth, and all of the systems human and nonhuman each contains are conterminous and continuous. In permaculture's ecosystemic way of thinking, the frame of reference becomes as Braidotti says, "the world in all its open-ended, interrelational, multi-sexed, and trans-species flows of becoming."[230] From a more human positioning, permacultural thinking frames the environment as our habitat.

This is the type of material ecological thinking that permaculture can help us draw out of digital theory. In *When Species Meet*, Haraway talks about the "relentlessly fleshy entanglements" we have with what she calls the 'techno-organic' world. Katherine Hayles, though using different terminology, has too long held that our bodies and technologies are connected, are co-evolutionary, and in her *How We Think* she explores how we think through, with, and alongside digital media. For Haraway,

---

[230] Braidotti 2016, 35. Also in Braidotti 2006, 2013.

though, the relationships is one more of *living with*, it is more metabolic: Haraway uses the concept of 'companion species' to think through these relationships and to understand how we *live with* them. "Thinking with," Maria Puig says, "should always be a living with, aware that relations of significant otherness transform those who relate and the worlds they live in."[231] Haraway says her "real concerns" are "to explore the layered meanings of historically cohabiting companion species of many ontological kinds, organic and not."[232] Drawing out this more physical interconnection is the task of digital metabolism—the digital not only changes how we think but in, material terms, changes the very earth we live on. Just as Pinar Yoldas's *Ecosystem of Excess* showed us in chapter three, if everything gardens we cannot affect one system without destroying, or creating, another bred from that alteration. And if everything gardens, every action, and as Latour warns, even every act of the imagination (including terminology or notions of care-full response-ability) leaves long traces.

Permacultural thinking considers as present artifacts the long-range effects of our technologies; it shortens the space between our behaviors and their interminable afterlives. It is designing thinking, asking us to imagine the consequences of our current cultural designs and the possibilities of others. "Understanding our dependencies" Jed Purdy says, "is a key to understanding our obligations. This means considering not only

---

[231] Puig, 2012, 207.
[232] Haraway, 2004, 5.

what we rely on for our convenience, but what is required for the continued well being of the achievements, practices, and values that we love most."[233] The goal of responsible living isn't so much to "save the environment" but to save ourselves and our preferred ways of living. "In the lifeworld of connectivity," Deborah Bird Rose says, "the well-being of one is enmeshed in the well-being of others…To care for others is to care for one's self."[234] The anthropo-technosphere's metabolic nature ensures that what we do to the earth, we do to ourselves—the traces we leave, and all of our actions leave traces Latour rightly says, are fed (literally often through food) back into our (eco)systems altering not only our habitats but also our bodies—and certainly too the habitats and bodies of those who'll come after us. All of our traces leave traces and all of the things we care for—or are careless with—are tied into countless relationships and processes.

Making the Case for Care: Earth Care is People Care

In *Matters of Care in Technoscience*, Puig discusses care in the context of knowledge politics in Science and Technology Studies (STS). She asks how concern and care might inflect how STS observes and presents its technoscientic objects and ideas. She concludes that concern and care—or the lack thereof—can have world-making effects in so far as they, and she borrows Barad's terminology here, "are intimately

[233] Purdy, 2000, 191.
[234] Rose, 2011, 27.

entangled in the ongoing material remaking of the world."[235] Care she argues, refocuses our attention, adds an urgency to engage differently with the material life of things, and opens new modes for doing and intervening.[236] Placing care at the core of a technotheory is one of Puig's primary interventions into the field. Care for Puig is grounded in the practical everyday relatings that engage with the complex and "inescapable troubles of interdependent existences."[237] She looks at human-technology-environment care relations as permaculturists do: as intertwined material practices working within entangled ecological systems. Thinking with Maria Puig has been formative to my thinking about how relations, care, permaculture, and technoscience can intertwine. Her work provokes the question of how digital-care practices might transform the way we do digital theory.

Thom van Dooren configures care as an "exploration of contingencies," and as such it becomes the locus for a more embodied, practical ethics that allow us to perform our responsibility to action.[238] For him, when we situate our critical inquiries within a care-practice, our critique becomes "grounded in a new way in the specificity of real bodies and worlds in ongoing relationship." Understood as such, he says, "care is a vital

---

[235] Puig, 2011, 87.
[236] Ibid, 96.
[237] Puig, 2012, 199.
[238] van Dooren, online at *FutureLearn.com*: Environmental Humanities course (one must be enrolled in the online course to access the content).

concept for an engaged environmental humanities."[239] As members of the planetary cycle, we have an obligation to be aware of our material and energetic (read: metabolic) connections and their implications.

For his monograph *Flight Ways*, van Dooren spent time *living-with* several endangered birds on the edges extinction. Rose, who frequently collaborates with van Dooren, has conducted a range of her own hands-on environmental humanities field work with dingos, flying-foxes, and Hawaiian monk seals. Both demonstrate that through active interdisciplinarity and commitments to care, the environmental humanities can illustrate the overlooked and underappreciated connections that we must begin considering if we are to do sustainable environmental humanities scholarship. Haraway in her work on companion species says "care is a doing necessary for significant relating" [240] and you cannot have one, either care or a meaningful relationship, without the other. Without care, we continue to live with the same technospheric troubles that the 'immaterial' motifs endorse (chapter one). By caring for our digital technologies in so far as we recognize our care for them as directly affecting human and ecological health, we can begin living-with a more natural, sustainable earth-tech-human union. In the context of digital metabolic thinking, this way of care-full figuring links human responsibility and action with the digital, with the earth, and

---

[239] van Dooren, 2014b, 293.
[240] Puig, 2011, 98.

back again. The responsibilities of caring for our technologies and our earth are commitments to our own human permanence.

Following Puig, Haraway, and van Dooren, my argument here is not that we should focus on care so much as it is that we should focus on our digital media objects, our theoretical frameworks, and our digital practice *with* earth-people-digital care relationships in mind. Doing so may challenge and/or positively inflect our scholarship with more sustainable praxis. The point here, as it is for Puig, is to make care a way of relating, a way of closing the distances that rhetorically separate us. Puig reminds us to be sensitive to normative or overly feminized notions of care—think mother and child, for instance—and says that we should think of care instead as "an attempt to add something to the world, something that, we hope, will connect the gatherings we study and make a difference."[241] Puig writes that we must "insist on this interweaving in order to be able to think how care holds together the world as we know it and allows its perpetuation."[242] She continues:

> Acknowledging the necessity of care in every relation is to be aware of how all beings depend on each other. Moreover, if care is a form of relationship it also *creates* relationality…we are *in* relations of mutual care. Many nonhuman agencies are taking care of many human needs, as much as humans have their own tasks in the maintenance of the web of caring.[243]

---

[241] Ibid, 96.
[242] Puig, 2010, 13.
[243] Ibid, emphasis in original.

In permaculture, care is this type of interwoven connected gathering that performs in reciprocity: care for the earth returns its caring in the form of people-care through healthy ecosystems, abundant food, and resilient communities. This is the type of care we need in digital media and humanities praxis. Care here isn't meant to anthropomorphize digital, just as Haraway never meant to anthropomorphize the canine with her companion species figuration and Puig does not intend to anthropomorphize nonhumans. Instead, the challenge is to see the metabolic entanglement as the tie that binds us into mutually-reflexive relationships that require maintenance and upkeep if we are to maintain a permanent-permutable culture. Permaculture gives us an alternate sort of humanistic model that places the human always and incontrovertibly as a system of earth-human. As Haraway says, "nothing comes without its world."

Puig herself finds inspiration in permaculture appreciating how permacultural ethics are "born out of material constraints and situated relationalites" and how they are based on the notion that embeds us in a "web of complex relationships in which personal actions have consequences far more than ourselves and our kin."[244] What Puig

[244] Ibid, 9.

sees at stake in permaculture's inseparability of people care and earth care is that in this arrangement, "interdependency is not a principle but a vivid material constraint."[245]

> So the obligation 'to care' is more than an affective state, it has material consequences. As I said previously, in permaculture practices the condition of sustainable collective caring is the maintenance of resources, including those of one's self. In a conception of care as a collective good, care has to be shared, the 'surplus' of life and energy that it produces returned to the carers in order to avoid affective and material burn-out.[246]

This materiality is what the earth-human, and the digital-metabolic, configuration draw out—as humans metabolically entangled with the earth and all of its elements (digital, mineral, biological, chemical), all of our actions are physical acts performed in a material world in which everything is materially connected. We see this insistence appearing too in the rather heady metaphysical/philosophical works of those like Barad and Whitehead, but what permaculture's notions provide that these theories do not are simple, generous, actionable thinking and acting tools that are always grounded in the material-natural world. It is thus in permaculture that I see a relevant, approachable, applicable toolkit for cultivating more sustainable digital scholarship.

Previous chapters provide glimpses of how people—from miners to manufacturers to users—and the earth—from soils to airs to waters—are affected by digital use and the stories we tell. Indeed if we look back, chapter two's major project

---

[245] Ibid, 15.
[246] Ibid, 14.

was to suggest that what the digital is thought to be may affect the ways we care for it. If digital *use*, in addition to digital language became, at least partly, a care relationship, how would we treat our technologies? On a hands-on, practical level, how can care lead to action, and what care-full actions can we take? This is the question the remainder of this chapter seeks to answer. Permaculture helps us begin actively performing scholarship differently.

Permaculture Manual for the Digital: Appropriate Technology, Sustainability, Maintenance, and Repair

Appropriate technology

Permaculture advocates not an absolution of technology but a practice of 'appropriate technology' that takes as its first principle that we work *with*, and not against, the technosystem appropriately, and that we do so *with care*. It provides a practical vision for what it might look like if we wove care into our digital practice. We see a version of this in action in a way in the work being performed by the digital humanities Minimal Computing group. The group, composed of digital scholars, researchers, and makers, describes this project as a "critical movement, akin to environmentalism, asking for balance between gains and costs in related areas that

include social justice issues and de-manufacturing and reuse, not to mention re-thinking high-income assumptions about "e-waste" and what people do with it."[247]

Appropriate technology in the permacultural sense is sustainable, small where possible, easy to maintain, repairable, resilient, and used appropriately to suit its contexts. Digital permaculture as I'll develop here, integrates notions of appropriate technology with the primary permacultural principles of sustainable design and sustainable maintenance. Digital permaculture outlines a model for more sustainable digital practice and introduces a method for digitally cultivating a yield.

Sustainable Maintenance

In *After Nature*, Jed Purdy concludes with a chapter that is a question: What Kind of Democracy? "Democracy has not been doing well," Purdy says, and he argues this is due to a lack of self-restraint: foolish wars, economic crises, and environmental failures have resulted from governments' and citizens' unsustainable excesses and disengaged decision-making.[248] Purdy's chapter asks us to consider what type of democracy we want and what actions will be necessary to achieve it. In this chapter, we ask the same thing: What kind of environment do we want? How can we reverse the lack of self-restraint that has led to "unstainable [digital] excesses and disengaged [digital] decision-making?" And how can we stop waiting for someone else—someone with more power,

[247] Minimal Computing github site: http://go-dh.github.io/mincomp/.
[248] Purdy, 2016, 256.

more wealth, more time—to make change before we start making change in our own small corner of the planet? The environment has not been doing well, and, in many parts of the world, neither have humans. This is no coincidence.

Many of us now acknowledge that it is our negligent care and greedy pillaging that is largely to blame for the rift in the earth-people metabolic cycle. Consensus among climate and earth scientists has reached nearly 100% and surveys of climate change opinions conducted in countries around the world show that belief in anthropogenic climate change, even among our more conservative neighbors, has reached a tipping point whereby there is now a significant majority who agree with the scientists. Those same studies show, however, that of those who agree, the percentages are split pretty evenly between active participants (those who are acting, in any big or small way, to help the situation), those who think that any small act that they do will have no impact, and those who would like to act but simply aren't sure how to begin.

In permaculture, you start at home, cultivating slow and small daily solutions. You begin by observing the patterns of the environment(s) you inhabit and you work with the system you are given in order to cultivate it from the inside out. We can translate this ethos, and its language of empowerment into our daily digital practice, both scholarly and more generally, to ensure our own digital behaviors are sound. Until

businesses are ready to support more sustainable design and production, it is each of us who can, and I insist must, begin making changes.

Individual environmentally-friendly behaviors are "contagious," researchers at Yale and the University of Connecticut tell us. Solar power, conscientious electricity consumption, cloth grocery bags, and electric cars have all proven to be contagious: it takes only one person or one household to start a meaningful trend.[249] Many recent studies are showing too that it is individuals, communities, and grass-roots movements who are making meaningful changes that spread upward to government, corporations, and institutions.[250] Not only will we make our corners of the world more perma-cultural but recent trends have shown that corporations and governments are responding to consumer behaviors.

---

[249] See for instance http://www.vox.com/2016/5/4/11590396/solar-power-contagious-maps and http://www.vox.com/2016/8/29/12690798/electric-cars-contagious.

[250] See for instance http://www.huffingtonpost.com/sonia-maria-dias-/grassroots-movements-may_b_11994392.html and http://www.huffingtonpost.com/annie-leonard/shifting-power-to-protect_b_11974760.html. See too http://www.sustainablebrands.com/news_and_views/products_design/hannah_furlong/trending_consumers_want_fewer_phones_more_e-waste_recy:
"A new Greenpeace study suggests consumers have had enough. A survey of 6,000 people across the U.S., China, Mexico, Russia, Germany and South Korea revealed that over half of consumers want manufacturers to release fewer phone models and do more to help them recycle their old devices.….The Greenpeace survey showed that more than 80 percent of consumers wanted smartphones to be designed to last and be easy to fix…Nearly half of all respondents believe that mobile phone manufacturers should be the most responsible for making recycling accessible; the sentiment was particularly strong in Germany (61 percent) and China (53 percent)." Other case students have shown that consumers, especially Millennials, mothers, and Generation Y, are willing to pay more for conscientious products.

Personal responsibility, Holmgren says, though thought to be naïve, has been shown to be effective throughout history at fighting political and ecological battles. Personal responsibility allows us to make change regardless of the strength of our institutions (political and otherwise). What is more, personal responsibility, Holmgren says, "is the fastest way to rebuild needed negatives (and positive) feedback mechanisms….Because we [those of us in the richer nations] are not frequently faced with the consequences of our decisions and actions, normal negative feedback and self-regulation mechanisms which act to prevent or ameliorate inappropriate behaviour in traditional societies, fail to function in modern society."[251]

Likewise for Braidotti, the sustainable subject is one who "practices a humble kind of hope, rooted in the ordinary micro-practices of everyday life: simple strategies to hold, sustain and map out thresholds of sustainable transformation."[252] The sustainable subject is sustainable in her ordinary everydayness. "What 'sustainability' stands for, therefore," Braidotti says, "is a regrounding of the subject in a materially embedded sense of responsibility and ethical accountability for the environments she or he inhabits. What is at stake is the very possibility of the future, of duration or continuity."[253] Though it is easy to wait for others to make change—or make us change—we owe it to ourselves to be more personally responsible.

---

[251] Holmgren, 2002, 84.
[252] Braidotti, 2006, 278.
[253] Ibid, 137.

Care-full Digital Use

In permaculture, mindfulness of materials, waste, consumption, and use are core ethical design principles. When adapted to the digital practice, this mindfulness translates into decisions about purchasing, personal digital behavior, device maintenance and repair, and choices about a product's end-of-life destination. These decisions provide opportunities for steps each of us can perform to ensure our corner of the world is more care-fully tended.

Our digital consumption begins with our purchasing decisions. Care-full purchasing would be purchasing Energy Saver products, refurbished devices, and purchasing only from sustainably-run companies. Companies like Fairphone and Nascent, for instance, are developing ethically-sourced devices that are long-lasting and repairable. Apple, Dell, and HP repair and sell certified refurbished devices, and community fixing and trading fairs provide avenues for obtaining locally owned and repaired devices. Mindful purchasing not only lowers your ecofootprint, it also sends a message—we do vote with our dollars, no?—that consumers desire products and producers that care for the environment. It goes without saying that we should also only purchase what we need—do you really need a new phone this year to replace the one you purchased only 18 months ago?—and purchase for longevity and growth. If we

purchase well-made products that can be repaired, can be updated, and can be repurposed after their initially intended use, we are buying for longevity.

Once we have our devices, we must then properly maintain them. We've been sold the story that our devices are immaterial and we've responded by being complacent to their physical care. In permaculture, complacency alters the fluidity of the system. Simple habits, like insuring our devices so they can be inexpensively repaired when needed, transporting them properly so they are protected, handling them with care, and maintaining them as is recommended, can make a significant difference. The elderly (non-smart) phone I own has been with me for nearly nine years. I've done nothing more than smart buying and basic care-full handling to maintain its functioning.

As we discussed in chapter two, the language we've used and the consumption practices we've adopted surrounding our devices—being offered "free" phones each year, for instance—has reduced our devices to worth-less tools we can easily replace.

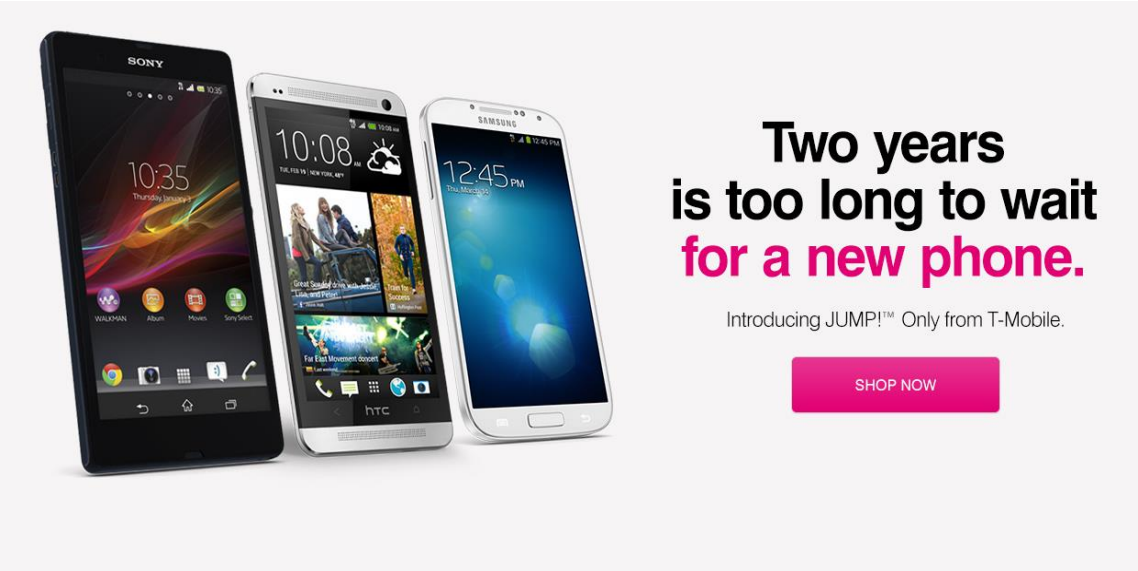

Figure 19: T-Mobile website marquee image, 2016.[254]

As an antidote to this casual-ty, seeing how our devices fit metabolically into the world should convince us that every device is deeply entrenched in a material and ecological history and every new device perpetuates a destructive cycle. We can resist excessive implication in that cycle. Together, small gestures of care can collectively disturb that cycle on a larger scale. If we reduced our device consumption by half—buying refurbished, buying conscientiously, and/or keeping a device for 4, 5, or even 9 years—we would reduce waste, pollution, mineral consumption, human labor, and digitally-related ecological upset by half. That would be monumental.

---

[254] Image Source: http://www.t-mobile.com/content/dam/tmo/en-g/jump/landingpage-marquee-jump-desktop.jpg, 2016.

Energy maintenance is another trick consumers can easily integrate into their work flows and daily habits. The NRDC reports that computer settings and charging behaviors can have a significant impact on our energy savings, and our cash savings.

> Until the government and manufacturers act, computer users can take action on their own to reduce the energy waste from their machines, including buying an ENERGY STAR® computer (the label signifies some of the more efficient models on the market) and purchasing a more efficient laptop in lieu of a desktop. While at your computer, close unused windows and browser tabs, avoid energy-wasting screen savers, power down the machine when not in use, and adjust the settings so it will automatically power down to sleep or off mode after 30 minutes or less of inactivity in case you forget to do it manually.[255]

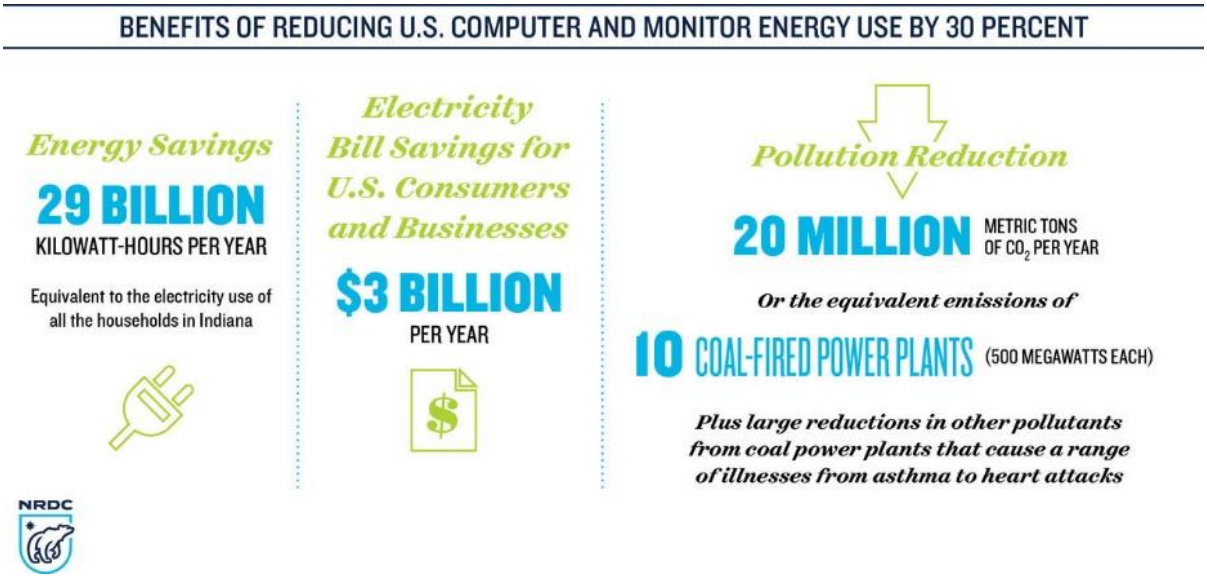

Figure 20: Energy-saving illustration from the NRDC.[256]

[255] Delforge, n.p..

[256] Illustration from the NRDC report "Slashing Energy Use in Computers and Monitors While Protecting Our Wallets, Health and Planet." 2016. Image Source: https://www.nrdc.org/experts/pierre-delforge/new-report-computer-energy-use-can-easily-be-cut-half.

A study recently conducted at UCLA finds that simply "conserving with new technology and changing behavior could reduce carbon discharge by 123 metric tons per year—or about 20% of the dispersion attributed to household use."[257] Another report, this one commissioned by the *New York Times*, found that we can power our devices optimally—by not overcharging our phones—in order to maximize battery longevity.[258]

When online, we can reduce our footprint by limiting unnecessary high-carbon online activities like streaming, by creating low-carbon websites with energy-maximizing design choices, by selectively backing up heavy data and avoiding over-redundancy in cloud use, by using carbon-neutral data hosts and search engines, and by supporting companies and websites that follow green practices. As of early 2017, tools exist already to assist the 'greening' of our web behavior: *Ecosia*, for instance is a carbon-neutral search engine; *Tabs for a Cause* is a philanthropic browser tabs extension; Greenpeace's Chrome-based *Click Clean Scorecard* rates websites' clean energy use; and there are more than a few certified "green" web hosts. Using green hosts is one of the most significant acts we can take today to offset our digital footprint. If we'll remember from chapters two and three, the energy footprint of our data centers rivals, and is set to soon surpass, that of the aviation industry. Supporting only those who use renewables is one step toward disturbing the entire system.

---

[257] Kelleher, n.p..
[258] Treacy, n.p..

In *Sustainable Media*, scholar Shane Brennan explains that unnecessary redundancy in cloud storage is another significant, and in some senses a paradoxical, energy waste. Cloud data is often backed up and stored in several data center locations and often too on several servers within a single center. This is seen as 'digital sustainability' in the data world but this digital sustainability comes at the cost of unsustainable energy use and carbon emissions, and at many centers, non-recyclable fresh water use. Brennan points out the irony of our backing up: data is backed up in multiple locations so as to ensure its perpetuation despite natural and infrastructural disasters like floods, storms, and power failures and yet in so doing, it contributes to climate change (through its ever-growing carbon footprint, its embedded material and energy rucksack, its dirty energy use, its backup fossil-fueled generators, and its always-on energy requirements) which brings on even more severe weather events and power outages. The system as is seems rigged against us.

Holmgren says permaculture "could be seen as ecological rationalism: it recognises the design rules and measures of value in energy descent, and it provides ethical and positive pathways for embracing those design rules."[259] He says we should come to see self-regulation, "rather than the expansion of technology for resource exploitation and growth" as representing evolutionary development and progress.[260]

---

[259] Holmgren, 2002, 79.
[260] Ibid, 73.

Performing care-full, accessible sustainable acts could help shift the digital metabolic rift toward one more suitable for a permanent-permutable future digital culture.

Repair

In permaculture, maintenance and repair are at the heart of care. As Puig says, following the creative-critical repair work of Steven Jackson, "foregrounding the importance of care, maintenance and repair to the very material sustaining of the world" is crucial to more perma-cultural digital practices.[261] She continues, "thinking from the significance of caring relations suggests that no output, no growth in the future and, one could say, no innovation or emergence of newness are possible without a commitment to the everyday maintenance and repair that supports the work of care (Jackson, 2014) and the continuity of life."[262] For Puig, caring *is*, in a very strong sense, the acts we undertake of maintenance and repair; it is "those doings needed to create, hold together and sustain life's essential heterogeneity."[263]

Jackson's "Rethinking Repair" asks "what happens when we take erosion, breakdown, and decay, rather than novelty, growth, and progress, as our starting points in thinking through the nature, use, and effects of information technology and new

[261] Puig, 2015, 708.
[262] Ibid.
[263] Puig, 2012, 198.

media."[264] Jackson begins by noticing the metabolic—my word, not his—aspects of the technosphere: erosion, breakdown, and decay illustrate technology's liveliness (not alive-ness) in our ecological system. What we make from the earth, inevitably returns to it. Considering our technologies as metabolic partners, as I've argued here, poses challenges to our understanding of the techno-human relationship. In our metabolic relation, technological repair becomes an act of care—one necessary for our perma-cultural futures.

Jackson sees breakdown, maintenance, and repair as "crucial but vastly understudied sites or moments within the worlds of new media and technology today."[265] What he calls "broken world thinking" provides a counterpoint to our much beloved narratives of progress; Jackson sees breakdown and repair *as* progress, challenging our assumption that innovation, design, and development come only from the new. Permaculture does the same: in permaculture design, one begins with the materials one is given. Permaculture design *is* repair; it is productive, positive disturbance.

For Anna Tsing, positive disturbance is a transformative encounter. She explains that though humanists unfamiliar with "thinking with disturbance" are prone to equate the term with damage, "disturbance, as used by ecologists, is not always bad—and not

---

[264] Jackson, 221.
[265] Ibid, 226.

always human."[266] As such, disturbance is ordinary, productive, necessary. Disturbance, she says, "opens the terrain for transformative encounters."[267] She continues:

> Landscapes are not backdrops for historical action: they are themselves active…disturbance [is] an opening for action. Disturbance realigns possibilities for transformative encounter.[268]

Repair for myself, and too for Jackson as I read him, is such a disturbance. Broken world thinking, he says, and I quote him here in full:

> …offers fresh potential to both longstanding and emergent approaches in media and technology studies today. First, and if nothing else, it can help us think beyond the remarkably restricted and unusually binary sets of actors that have dominated media and technology studies to date: senders and receivers, producers and consumers, designers and users. The world of technology is more complex and less orderly than that, full of dynamics, tensions, and powers that neat binary distinctions—and the systems of explanation built on them—struggle to explain. *Modes of thought that expand our cast of characters, including but certainly no limited to the breakers, fixers, and maintainers highlight here [in his article], are therefore necessary and promising addition to the field. Second, attention to maintenance and repair may help to redirect our gaze from moments of production to moments of sustainability and the myriad forms of activity by which the shape, standing, and meaning of objects in the world is produced and sustained—a feature especially valuable in a field too often occupied with the shock of the new*.[269]

I present here permaculture, as he presents breakdown and repair—as a "mode of thought that expand[s] our cast of characters" and "redirect[s] our gaze from moments of production to moments of sustainability."[270] It gives us, as do his narratives

---

[266] Tsing, 2015, 160.
[267] Ibid.
[268] Ibid, 152.
[269] Jackson, 233-234, emphasis mine.
[270] Ibid, 234.

of breakdown and repair, "deeper and richer stories of relationality to the technological artifacts and systems that surround us, positioning the world of things as an active component and partner in the ongoing project of building more humane, just, and sustainable collectives."[271] Permaculture is a mode for positive disturbance.

Repairing our devices isn't as daunting as it may seem. Organizations like iFixit, Instructables, and regular maker folks on YouTube are publishing open, accessible tutorials for those of us interested in attempting to care for our devices through repair. Empowering ourselves to repair, and then actually repairing our devices, implicates us in the permacultural notion of cyclical lifecycles.

Despite notions that digital fixing is only for those computer-savvy makers who are already technically-inclined, this isn't just a niche practice. In 2016, the *New York Times* partnered with pro-repair organization iFixit for an article titled "Choosing to Skip the Upgrade and Care for the Gadget You've Got."[272] Repair is positioned as the ethical, aware, money-saving thing to do.

In other circles repair is a mode of empowerment (EcoWatch), an opportunity to learn a new skill and marketable trade (Triangle Ecycling), an exercise in artistic resistance (striegl), a community building exercise (PlanetRepair), a legal right

---

[271] Ibid, 235.
[272] Chen, n.p..

(NBCNews), and an anti-capitalist gesture of freedom-from-apple's-unfixable-devices (iFixit and others).[273]

Before beginning this project, I had adopted a battered iPhone that had been tossed aside because its 'On' button had become stuck. It was otherwise functional but, as we know, one cannot turn a working device on without the on button. I was planning to use the phone to as a prop to demonstrate libi striegl's mineral label project (chapter three) but in the course of writing this chapter decided that I could use it—not instead but additionally (because the permaculture ethos says all elements should play multiple roles in a system)—as an example of how a fixer novice could empower herself to repair a bruised, but not obsolete, device. With the help of online tutorials, an eye-glasses repair kit, a manageable bit of fuss and frustration (I am new to this, after all), and a

---

[273] See more at "Why Fixing Your Phone Is One of the Most Empowering Things You Can Do": http://www.ecowatch.com/fix-smartphone-2003233934.html,and and PlanetRepair: https://planetrepair.wordpress.com/about/, Right to Repair: Movement: http://www.nbcnews.com/news/us-news/advocates-tinkerers-fight-their-right-repair-devices-n641931: "We are currently engaged in projects to correct the inefficient, wasteful, and resource intensive structures of our house in order to create a home that is built from natural, local and living materials, and powered by captured energies that pass naturally through our landscape. Similarly, we are linking our resources and energetic flows with those of our neighbors in order to build a resilient and connected human community. We envision a neighborhood that is a rich ecology, with each aspect filling a niche where it can thrive, while sustaining, supporting, and strengthening the whole. As such, we are developing new forms of economy where we can exchange and share the assets and resources that each of us already have in the neighborhood in order to make each of us stronger and derive prosperity from our collective abundance. We use the tools of placemaking and block repair to create spaces where our neighbors can reclaim the commons and remediate the collective disfunction [sic] that has been imposed on our cities by the colonization of the grid….We call ourselves Planet Repair, not because it is our ambition to reshape the planet according to any prescribed theoretical model, but because we believe that the repair of the planet has to happen by repairing one home, one block, and one neighborhood at a time. We strive to be a conduit for the germination of this kind of change in our neighborhood, and to cross pollination with the inspiration of other localized projects in order to rebuild a healthy thriving and interconnected planet."

small piece of regular paper folded just so, the phone 'on' button went from "broken" to care-fully repaired. Practically magic.

Organizations like, for instance, Triangle Ecycling and the FIX IT! Philly Fixer Guild are partnering recycle-and-repair processes to bring DIY empowerment and repair pedagogies into communities. Triangle Ecycling is a permaculturally-brilliant hybrid center for recycling and repair. Consumers bring their "end-of-life" devices to the center where they are repaired by high school students, often those from less-privileged neighborhoods and schools, who have come to Triangle Ecycling as student apprentices. Once the devices are repaired, and the students are educated, the products are put on the re-sale market for reasonable cost thus allowing those less-privileged neighborhoods access to devices they might otherwise be unable to afford. "Broken" devices are cared for, recirculated, and co-opted to teach career-building skills to those otherwise without access.[274] In states across the nation, Repair Cafés are popping up that function as community centers for collaborative fixing. The New Paltz Repair Café in New York's Hudson Valley has taken its touchstone from a Leonard Cohen's lyric: "There is a crack in everything. That is how the light gets in."[275]

---

[274] It is worth noting that scholars/professors like Jentery Sayers and Mark Sample are bringing this type of fix-it ethos into the university classroom.

[275] The Café's website is here: http://www.repaircafehv.org/new-paltz.

Repair here reduces waste, teaches new skills, brings together communities, contributes to re-use economies, and empowers unlikely novices to fend for themselves by fixing instead of buying. Digital repair becomes a renewable resource. Even those devices that cannot be repaired, can be valuable sources of replacement parts. The goal is to keep the materials in circulation, to keep them from becoming "pollutants" as so defined by Bill Mollison as "an output of any system component that is not being used productively by any other component of the system."[276] It is only once the device itself has been mined for its usefulness that it should then be reduced to 'waste' and properly recycled.

The Anthropocenic age is largely so far one that contributes to the digital metabolic rift: corporate design decisions and clever marketing drive eco-unfriendly consumer digital behavior; lax environmental regulations influenced largely by corporate power enable corporations and communities to produce irresponsible digital devices, infrastructures, and systems; and politics combine with a robust lack of digital-environmental awareness—fed by the immaterial motifs we are served—to perpetuate dirty, unsustainable behaviors. Though these are the weighty systemic conditions within which we are entangled, they are not, I argue, disabling or unmovable boundary conditions. Consumers, activists, local communities, and enlightened politicians—regular people in their everyday lives—are increasingly proving that we are not

[276] Holmgren, 2013, 15.

powerless against these larger structures. Tomorrow's Anthropocenic age, with the help of permacultural care ethics and practical principles, can be one that *repairs* the digital metabolic rift.

Recent scholarship has shown that individual people, through their purchasing behaviors, repair practices, and collaborative campaigns, have pushed corporations and governments to institute computer take-back systems (Dell), e-waste recycling programs (Apple), Extended Producer Responsibility (EPR) initiatives, more sustainable device design (Fairphone), the removal of conflict minerals from products (Intel), moves toward carbon-neutrality vis-à-vis energy use (Google), Fair Repair laws (in KS, MN, MA, NE, NY, WY), and cell phone Right-to-Know legislation (Berkeley).

These are positive, possible pulses of disturbance within the system we are given. Care, maintenance, and repair translate, as permaculture prescribes, our problems into solutions by looking at how we might use technology to create more sustainable digital systems. Ways of life, Wendell Berry says, change only in our daily living of them.[277] Just as negative consequences breed further negative consequences, positive disturbance at one level can breed positive disturbance at another. By embracing change, contingency, and fluidity, digital permaculture works with the system in order to rebalance the metabolic rift. Digital permaculture is the necessary seed we need to breed more sustainable daily behaviors and more ecocritical scholarly digital practice. "If more

[277] Berry, 2002, 126.

of us were to choose caring over not caring," Wendell Berry says, "the culture would change…The necessary examples would be more numerous and more available. The way would be clearer."[278]

Everything Gardens: Using Ecocritical DH to Obtain a Yield

Ecocritical Digital Engagement

Despite the urgency of Nowviskie's keynote, few scholars in the digital humanities have yet taken up her call for an ecologically-informed digital scholarship. And surprisingly so. Digital scholarship is uniquely positioned to address the ecological concerns of climate change. Ecocritical digital scholarship can intervene to produce what Nowviskie calls a "capacious" thinking capable of responding to Anthropocene-age challenges by operating simultaneously across scales, disciplines, and institutions.

Ecocritical *digital* work like that we'll discuss here has the advantage of being public, global, accessible work. As such, it can reach a wide audience to engage public, global issues such as environmental justice, climate change, eco-awareness, environmental health, and daily living in Anthropocene futures. It can translate human-environmental issues into digital interventions that can meaningfully *obtain a yield* through outreach, participation, education, and organization. It can help us actively

[278] Berry, 1995, 64.

remake our ideas about nature and the relationship between humans and the environment. As a digital permacultural practice, it works within the problem (technological disruption of environmental processes) to create a solution (using technology to address those disrupted environmental processes).

Ecocritical digital work comes in the form of digital archives, digital activism, digital data, and digitally-based research projects. It is self-reflexive while performing its work: it is aware of its ecological footprint and acknowledges its role in environmental anthropogenic/technogenic destruction. Ecocritical digital work pivots from traditional ecocritism by refocusing from reading representations of environment in text to more environmental active and activist projects that instead focus on the material effects of our digital tools/texts and documenting/sharing 'real' environmental issues. It is, as our digital artworks were in chapter three, a digital skill and structure for exploring and publicizing the (in)human(e) aspects of our increasingly severe environmental issues.

Though the field is small, there is a growing number of admirable Eco Critical digital projects coming out of universities and research labs around the world. The critical data-saving post-Obama North American #Datarefuge project has humanists rallying to archive critical climate and environmental data from United States government websites. Projects like 100 Views of Climate Change, Future Coast, and Climate Stories NC capture climate stories from people across the globe. Carl Sack's #NoDAPL Map plots indigenous cultural areas alongside governmental geographic

areas and oil pipeline sites. Researchers at the University of British Colombia and Yale, among others, have developed augmented reality projects that educate and compel users to initiate more sustainable behaviors. Other ecocritical digital projects digitize and archive historical environmental media, map the overlaps between poverty and pollution, provide public updates on air and water quality, illustrate the relationship between environmental and human health, and elicit public participation in local pro-environmental activities.[279]

Mark Sample's tweeting sharks project is an example of an open and accessible eco critical digital media that works to reconfigure, or re-narrate, the relationship between humans, technology, literature, sharks, and the earth. In this project, Sample hacks into OCEARCH's website to turn a pair of location-pinging sharks, Mary Lee and Katharine, into literary swimmers.[280]

OCEARCH's open-source Global Shark Tracker monitors, and share, the surfacing activity of great white and tiger sharks.[281] When any of their tagged sharks surface for longer than 90 seconds, their tags send location data to the OCEARCH's website and app. OCEARCH's researchers then share that information via social media

---

[279] See, for instance, U Penn's Da/um project, lexiconofsustainability.com, Digital Detroit, The Asthma Files, Environhealthsense.org, EnviroAtlas,

[280] Sample, n.p..

[281] Since 1962, the US National Marine Fisheries Service (NMFS) Cooperative Shark Tagging Program (CSTP) has tagged more than 300,000 sharks.

as well. This is similar to Australia's Surf Life Saving Western Australia project which has, since 2014, had more than 300 sharks tweeting their locations in alert as soon as they swim within half a mile of a beach.[282] These sharks have been co-opted by marine scientists into providing a social service act of tweeting their locations to potential ocean-goers.

What Mark Sample's project does is hijack this scientific project turning it into a more ecohumanist enterprise. Sample discovered an undocumented application programming interface (API) in OSEARCH's shark tracking database that allowed him to pull OSEARCH's location data on the two great white sharks Mary Lee and Katharine from its site so that he could feed it into his twitter bot @Shark_Girls. He then partnered Mary Lee and Katharine's location information with a coded Python program that randomly-generates sentences from Virginia Woolf's novel *Night and Day*, whose main characters are Katharine and Mary. The result is a twitter bot—an automated twitter account—that tweets an image of Mary Lee and Katharine's mapped location data along with a line from Woolf's novel. Reading through the twitter feed, we watch Mary Lee and Katharine appear in different oceanic locations, reporting one day to be near Florida, another to be near South Carolina, and another to be in the Pelagic Sargassum Habitat Restricted Area. As we track their travels, we 'hear' them speak lines of literature. Their tweets are like postcards we receive from vacationing friends.

[282] See http://surflifesavingwa.com.au// and Yu, n.p..

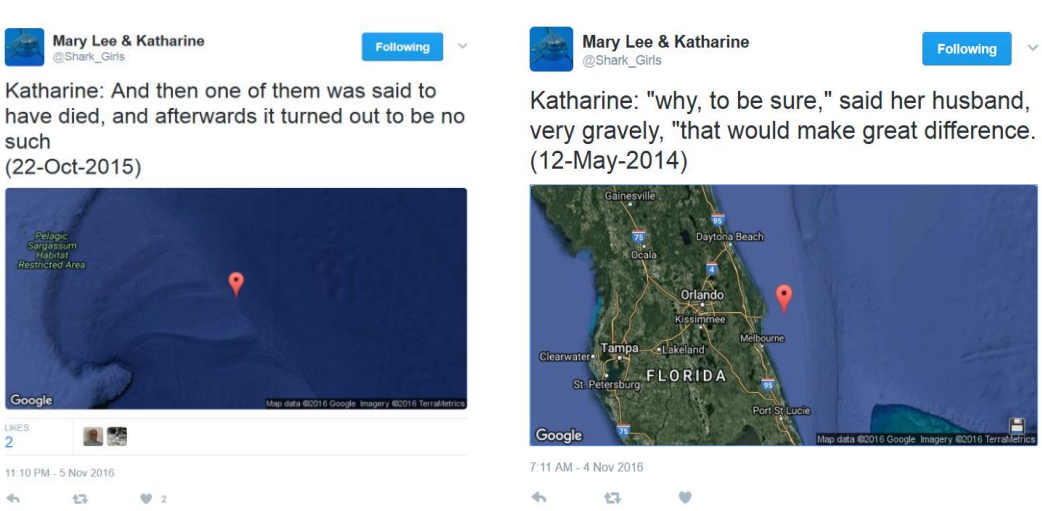

Figure 21: Screenshots from Mark Sample's @Shark_Girls

What Sample's project urges us to do is reconsider the relationship between oceanic wildlife (sharks), humans (those who are engaging the tweets) and our technospheric surround. If carefully considered, it brings to light our interconnections. It amplifies the live-ness of the sharks by allowing tweeting technohumans a glimpse at their pelagic daily lives. We see them move, driven by predators, prey, reproduction, death, and weather. We meet them here, on twitter, as kin, as creatures similar to ourselves.

When placed alongside images of sharks interacting with (and sometimes even biting) undersea Internet cables, we are introduced to a second layer of anthropogenic shark behavior: not only are we making them tweet, we are also disturbing their habitat with our transpacific hyperspeed telecommunications cables. Perhaps rightfully so, they

are disturbing us back with their bites. In 2014, Google began wrapping its transpacific fiber cables in Kevlar to protect from shark bites.[283] Who would have thought that our digital metabolic entanglement extended to the ocean floor?! The hope of a project like Sample's, from an ecocritical digital perspective, is that we'll recognize the sharks, both those who tweet and those who eat upon our Internet cables, as oddkin implicated in our digital system.

Haraway mentions a similar project, the Pigeon Blog, a project by UC Irvine's Beatriz da Costa in 2006 that used pigeons to monitor and report air pollution. Miniature pollution-stations were put into tiny backpacks that were worn by professional racing pigeons—with the collaboration of the pigeon's owners—who flew throughout Los Angeles recording and reporting pollution data. Their data was transmitted in real-time to the project's researchers and shared on the Pigeon Blog.[284]

Haraway talks about how these projects like Pigeon blog do actually change hearts, minds, (pre)conceptions, and behaviors. In the context of the Pigeon Blog, she says the youth who are involved in the project "move from seeing pigeons as 'rats with wings' to sociable birds with lives and deaths. [They] transmute from bird hecklers and sometimes physical abusers to astute observers and advocates of beings whom they had

[283] Chowdhry, n.p..
[284] Dr. Da Costa unfortunately passed in 2012 and the blog is no longer active.

not known how to see or respect."[285] The youth she says, "became response-able."[286] To those still dubious, she offers: "I know this account is a story, an invitation as much as an accomplishment, but the space for recuperation across despised cross-species categories of city dwellers deserves to be widened, not shut down….To re-member, to com-memorate, is actively to reprise, revive, retake, recuperate."[287]

The human-animal, human-nature divide—what Plumwood calls hyperseparation—holds us apart and "contributes to our inability to be *affected* by the incredible loss of this period of extinctions."[288] These projects, The Pigeon Blog and Sample's literary sharks close the distance between the human, technology, and the natural nonhuman world. They open, as van Dooren might say, new sensitivities to the living practices of nonhuman creatures.

In his work, van Dooren asks us to imagine life forms as forms-of-life that are entangled with other forms-of-life in inescapable webs of co-dependence. He asks us to "pay attention to species as evolving 'ways of life' that are shared, produced, and nurtured in the world through the work of successive generations of living beings."[289] These ecocritical digital projects provide us an avenue to do just this. "In being attentive

---

[285] Haraway, 2016, 24-25.
[286] Ibid, 25.
[287] Ibid.
[288] van Dooren, 2014, 18.
[289] Ibid, 22.

to the stories of penguins and others" which here for us are pigeons and sharks, "help to challenge the closure of human-centric narratives" van Dooren says. We open new stories and in turn, open new possibilities for care relations when we recognize nonhuman others as partners in the "ethical, collaborative, communicative and mutualistic" project that is Anthropocenic living.[290]

When we are unable or unwilling to recognize/acknowledge the stories and relationships that other creatures have, we distance, destroy, and ignore their ways of living—and ultimately, subsequently, our own. "Knowing more matters" van Dooren says, "not least because it can and does enable us to see differently, and so to be drawn into new kinds of relationships, new ethical obligations."[291]

Consider too environmentally-related citizen science work, most particularly that of Jennifer Gabrys, that co-opts neither sharks nor pigeons but instead human bodies, to promote data-based human-nature interactions. In Gabrys's Citizen Sense work humans become digital sensors and the living loci bridging the digital, the environmental, and the human.

---

[290] Ibid, 79, Plumwood, 175.
[291] van Dooren, 2014, 83.

Unlike an ecologically-minded Augmented Reality project which uses carbon-devouring large-screen AR technology to "immerse" a user in certain "natural" environments, Gabrys's citizen science immerses users in "real" natural habitats—their own and those that surround them—asking them to experience anew the relationships and lifecycles, the metabolic systems, if I may, in which they are always already implicated.

Citizen Sense's pollution sensing projects display pollution data and develop platforms to make that data more accessible. The projects "attempt to make more immediate and actionable the details of environmental pollution" through direct engagement, collaborative citizen-powered fieldwork, and thoughtfully composed human "data stories."[292] In a project like Dustbox (October 2016-April 2017), Citizen Sense lends, from the Deptford Lounge Library, air monitoring kits called 'Dustbox sensors' to south Londoners so that they might monitor and report local rates of particulate matter and pollution. Nearly 9,500 Londoners die each year due to exposure to NO_2 and particulate matter and Dustbox puts "the itinerant qualities of individual exposure to air pollution" to work as a site for citizen engagement and empowerment with and against this fact.[293] A similar project conducted by Citizen Sense in 2013-2015 in Pennsylvania worked with residents living near oil fracking facilities to develop air

[292] See Citizen Sense's website: http://citizensense.net/projects/pollution-sensing/.
[293] Ibid.

monitoring kits that would allow them to measure and report local conditions. For both projects, the Citizen Sense team created a user-friendly, human-friendly platform that translated their captured data into 'data stories' that organize, visualize, and otherwise transform abstract numbers into usable narratives and actionable responses. Earth health (care) and people health (care) are shown to be intimately interrelated.

As citizen scientists use their smart phones and/or small DIY electronics to *sense*, record, access, and engage environmental data, they gain access to a sixth sense—one digitally mediated by technological devices—that moves environmental data from an abstract, and often unseen, concept to a concrete experience of embodiment. The body of the citizen sensor becomes not one set in opposition to nature but one that is as Spinoza long ago recognized "radically open to its surrounds and can be composed, recomposed and decomposed by other bodies."[294] The citizen sensor's body is always caught up in the material systems and beings that compose their immediate environments and these projects make that connection visible. "[W]ith every breath you take" Thomashow says, "you participate in a dynamic exchange of global metabolism."[295] When that breath is filled with pollutants and particulate matter, our dynamic exchange becomes one of metabolic disease. I believe one of the fundamental roles of ecocritical digital work is to highlight exactly this and facilitate methods for citizen response.

---

[294] Moira Gatens in (*Imaginary Bodies: Ethics, Power, and Corporeality*, 1996, p110) paraphrasing Spinoza, qtd Alaimo, 28.
[295] Thomashow, 2002, 2.

The hope here, from an ecocritical angle, is that the average daily consumer will become aware of her behaviors, will subsequently reduce her contribution to pollution, and will also become an amplifier of the message that humans and nature and consumption and pollution are all deeply intertangled and are, in some senses (for the relatively well-off and careless consumer) one and the same.

Gabrys's work exemplifies embodied digital work in so far as it enables material interactions between person-machine-environment. Participants enact ways of knowing through doing with their bodies. Here, pollution data is (as it should be) human data, and is of human concern. She recruits human bodies to be active in data projects that affect human bodies

Her projects help us understand how human bodies and communities are bound and implicated in processes of extinction, re/production, disturbance, and how those feed back into human bodies and communities. In the Citizen Sense projects, and many others akin to them (see, for instance: the Center for Research in Environmental Epidemiology in Barcelona, Spain, where researchers are using wearables to track and map pollution[296] and the collaborative work of the CITISENSE consortium of 29 institutions from 14 countries) alongside consumer buyable or DIY makeable products like UC Berkeley's Clarity sensor, Dustduino, Air Quality Egg, Smart Citizen Kit, Tzoa,

[296] For more, see http://www.smithsonianmag.com/innovation/with-wearable-devices-that-monitor-air-quality-scientists-can-crowdsource-pollution-maps-180954556/#5zKIohrRUEkmuLlr.99.

Airbeam and Speck, translate earth data (which is also human data) into its embodied, embedded contexts.[297] Where Gabrys's work stands out is that it then further translates that data into seeds to obtain a yield.

> [D]ata are seen to enable modes of action that are meant to offer effective ways to respond to those problems. With more data, potentially more accurate data, and more extensively distributed data, environmental problems such as air pollution are intended to be more readily and effectively addressed. Data are intertwined with practices, responses to perceived problems, modes of materializing and evidencing problems, and anticipations of political engagement.[298]

By measuring environmental data of human concern, with the help of the humans who are affected by it, and then creating human-legible data stories, Citizen Sense makes visible the unseen, the ignored, and the overlooked. If, as Gabrys asks "environmental problems need to be visible in order to be actionable," these projects are revealing untold stories and facilitating participation—both bodily and narratively—between humans, pollution, and the environment.[299]

The ecocritical digital projects mentioned here allow us to 'read' air, birds, marine animals, and environmental health as environmental texts through digitally-mediated collaboration. These are perhaps precarious, imperfect readings but they are,

---

[297] See too https://www.wired.com/2014/11/clarity-wearable/, http://www.treehugger.com/clean-technology/environmental-sensors.html, http://jacobsschool.ucsd.edu/news/news_releases/release.sfe?id=1295, and visit Instructables to find instructions to make your own DIY sensor: http://www.instructables.com/id/Environmental-Pollution/. As of early 2017, the United States EPA website even has an 'Air Sensor Toolbox' for citizen scientists: https://www.epa.gov/air-sensor-toolbox.

[298] Gabrys, 2016, 159.

[299] Ibid, 138.

in a way, entry points, or "ecotones," if we might borrow a term from ecology and permaculture, that blur the boundaries between human and nonhuman and environment. If we respond by making moves to clean, restore, and protect those who—and that which—'speak' to us through data, these ecocritical digital projects are indeed planting seeds. They open, as Gabrys says "new ways of approaching digital technology as material, processual, and more-than-human arrangements of experience and participation" while all the while also opening new ways of approaching our environments as material, processual, and more-than-human arrangements of agencies.[300] In bringing an ecocritical humanities lens to environmental issues, these projects complicate the complex relationship between humans and animals and illustrate the fragility of the claim for human-nature separation and the damage done by what Plumwood calls hyperseparation.

Projects like *Soil Selfies* and *FutureCoast* combine the mediated digitality of Mark Sample's sharks with the human-involvement of Gabrys's Citizen Sense projects to create wholly new experiences. The goal of the 2015 *Soil Selfies* project, developed by Australian environmental educator Jeanie Clark, was to coerce people to develop a new, and more caring and familiar, relationship with the soils upon which they walk and from which their food feeds.[301] Participants were invited to take and post photos of

---

[300] Ibid, 21.

[301] See the Soil Selfies project here: http://soils.enviroed4all.com.au/soil-selfies/.

themselves with their soils and to thus take a moment to consider how intimately associated their lives are with the soils we live with. Soil provides food, plants (which clean the air), natural environmental protection like water barriers, human and nonhuman habitat, minerals, raw materials, water filtration, and even carbon storage. Soils are our friends and *Soil Selfies* celebrates this.

FutureCoast is a more robust project devised by *World Without Oil* designer Ken Eklund and a team at Columbia University. Funded by a National Science Foundation grant, *FutureCoast* is a storytelling project that asks participants to record voicemail messages from the future. Those voicemails are then organized, published, and promoted on the *FutureCoast* website. Recognizing that science has not yet been able to tell compelling behavior-altering stories of climate change and Anthropocene futures, *FutureCoast*'s simple intervention adds the missing human dimension. The human voice replaces scientific data and the contemporary medium of voicemail message brings the future into the present. Chilling quick messages left by friends, family members, and neighbors report of water shortage, underground markets for fish or fruit, carbon rationing, and extreme weather events[302]:

> "Hi it's me…the city has just turned off the water…if you've got water, bring home as much as you can…love you, bye."

---

[302] All from *FutureCoast*.

> "Hi Mom…I'm calling to see if you or grandpa happen to have any credits left on your Cal Card for the month…I was [robbed] and they got my Cal Card…and we're running low on food here."
>
> "Oh hey, Jordan, this is Dave…The house battery isn't charging like it used to. I even hooked it up to the bicycle recharger and it's just not holding a charge anymore….Do you think you can come by and take a look?"

Other messages, from automatic robotic messaging systems, foretell eminent institutional organizations[303]:

> "Good morning valued citizens, this is your monthly reminder from the Department of Resource Conservation and Rationing. Remember that your water usage is limited…Each family is allowed two gallons a day. Failure to comply will lead to disciplinary action and potential deportation." (Automated Human voice)
>
> "Hello, this is the Federal Department of Rations reminding you to renew your sixth-month order of rations…We thank you for your cooperation. Have an eco-friendly day." (Robot Voice)

These glimpses from the future remind us of our present. The voices compel us to rethink our relationship to water, oil, food, and our resource-sharing human and nonhuman kin. They ask us to think about what we'd would we do if we didn't have water to grow our last cucumber seeds or bathe before work. They introduce us to short tales of woe due to rationing, scarcity, surprise weather events, and property value loss due to climate change. The voicemail messages, with different voices and various

---

[303] Ibid.

qualities of transmission (like 'real' voicemail messages) put us on the phone with the future.

Eklund reports that participants in his globally-known *World Without Oil* project—which created a simulated no-oil world, complete with an infrastructure of news updates, mock protests, and live participant feedback to make the situation more 'real' and asked participants to live as if the world was experiencing an inescapable oil shortage—actually succeeded in transforming participants' lifestyles. After being immersed in the alternate realty of a world without oil, participants planted gardens, started cycling to work, and adopted other oil-saving practices. The hope, of course, is that *FutureCoast* participants and listeners will do the same. As an ecocritical project, it uses digital technology to reflect on a diminished present and future habitat in part propelled by our excessive overreliance on polluting material-intensive technologies.

All of these projects reconfigure our perceived contingencies. They re-narrate through digital tools and hands-on practice, reframing, providing 'proof', collaboration, ecodata, and digital stories. As a digital permaculture adjunct, ecocritical digital work recognizes our technospheric condition and disturbs it, positively, by reconfiguring the problem (wasteful carbon-heavy digital use) into its solution: using digital tools with carbon-awareness and to 'obtain a yield' through education, outreach, participation, and cultivation of new flows of behaviors with the system.

The point is not to advocate we rid ourselves of technology—after all, man is both ecological and technological as Claire Colebrook reminds us—but to add a layer of metabolic awareness to our technology use and theory and to use our technologies to obtain a sustainable yield.[304]

Conclusion

Previous chapters were about taking care with our terms and stories; this chapter is about designing methods that take care with our tools and practice. I advocate not for a refusal of digital technologies (which would erase the need for digital media studies, right?), but for a more environmentally sustainable digital media theory and practice. We have an opportunity to set an example from within our own digitally-inflected humanities fields of praxis, and we have a ready platform for using our knowledge to help foster lasting changes of practice and relational understanding.

Permaculture is proposed as a way into sustainable digital environmental humanities that helps us better understand the relational nature and relationalities/continuums between contemporary digitality, media studies, ourselves, global ecologies, our environment, and our future. It is to these calls for a new paradigm of ethics + practice + material-ecological awareness that this chapter responds.

---

[304] Colebrook, 195.

Epilogue

A lifetime won't be enough
to bring it back. A man
would have to live maybe
five hundred years
to make it good again
—or learn something of the cost
of not making it good.
But hard as it is, I accept
this fate. I even like it
a little—the idea of making
my lifetime one of the several
it will take to bring back
the possibilities of this place
that used to be here.

Wendell Berry[305]

Let's return here at the end to Tsing's disturbances. Disturbance tracks through this entire project: chapter one disturbs current theories; chapter two both traces how landscapes are disturbed by care-less digital tech use and offers re-storying as a way to cause a counternarrative disturbance; chapter three looks at how digital environmental art can disturb categories and cultural awarenesses; chapter four offers a digital-based land-inspired disturbance in the form of tactics and strategies that might help repair the metabolic rift (and thus the techno-geologic dis-ease we are currently experiencing). We

[305] From "The Bringer of Water" in Berry, 1970, 92-93. Note, this section of the longer piece was removed from the 2011 edition.

must reinvent not the planet (though geo-engineering is said to be one of our climate saviors) but our behaviors with and on it.

This project follows Yusoff and Gabrys who believe "creative practices may open up new scales of sensation, new forms of representation, both aesthetic and political, and expand publics for engaging with this critical issue [climate change]."[306] They continue

> However, the most radical potential of the arts and humanities is the ability to constitute alternative possibilities to neoliberal approaches to environments, which actively attempt to disable the imagination of alternatives…in this sense, arts and humanities do not necessarily 'mediate' science, but rather the intersection of these fields realigns these disciplines and the terms of their encounter, providing not just practical adaptation, but also cultural resilience in the production of alternatives.[307]

This project of reinvention will be a common project—one we share with all members of the planet.

"Disturbance brings us into heterogeneity"[308] Tsing says, and this is the way of the compost-human. As compost humans we recognize and champion our messy coming together[309] and tend to the metabolic overlaps between human and nonhuman systems. Vermicomposting—the kind with worms—requires that each element in the

---

[306] Yusoff and Gabrys, 519.
[307] Ibid.
[308] Tsing, 2015, 161.
[309] "In [our] messy coming together, with divergent and overlapping durations and possibilities, much is at stake…Paying attention to these complex temporalities…draws us into new kinds of connections, and so new responsibility, introducing us to an ethical claim that is made on us to hold open space in the world for other species." van Dooren, 2014, 23.

system retain its uniqueness while also working in symbiotic co-ordination. Without worms being worms and worm-attractive table scraps being worm-attractive table scraps, the digestive-metabolic system of the vermicompost bin self-destructs and there is no resulting fertile soil to spread in our gardens to feed new (metabolic) systems. Compost is about co-existence and collaboration. In compost as in life, "ways of life develop through coordination in disturbance….As ways of life come together, patch-based assemblages are formed. Assemblages…are scenes for considering livability—the possibility of common life on a human-disturbed earth."[310] The aim of this *Digital Environmental Metabolisms* project is to suggest that our digital scholarship be more compostable, more interdisciplinary, and more focused on the interrelational systems (metabolisms) that bind the digital, the human, and the environment.

In *Shock of the Anthropocene*, Christophe Bonneuil and Jean-Baptiste Fressoz write that "human societies will have to face up in the coming decades to changes of state in the earth system to which the genus *Homo*…has never experienced, and to which therefore it is neither biologically adapted nor culturally prepared. The Anthropocene thus opens a new situation for humanity, a new human condition."[311] The Anthropocene not only opens new situations for the humanities but demands we produce new stories and new practices in response. We must interrogate the narratives and terms that frame

---

[310] Tsing, 2015, 163.
[311] Bonneuil and Fressoz, 24.

our digital technologies as magical, and must instead insist on stories that are deeply mineral and inherently relational. The Anthropocene "beckons environmental justice thinking, asking what worlds are we intentionally and inadvertently creating, and what worlds are we foreclosing while living within an increasingly diminished present."[312]

The Anthropocene gives us an opportunity to play out our compost-humanness (and our compost humanities). Today we must understand the environment as a dense site for digital materiality and the digital as a site for ecocritical intervention. We, as digital scholars and digital users, can contribute to more sustainable behavior by carefully reconstructing our terms to be more expansive and more aware of the interpermeable planetary ecologies of which the digital is now a constitutive part.

I argue here that the technosphere—the digital + human + earth—is a metabolic system and one we've designed. As such, it can benefit from a redesign and really must begin doing so if we are to reduce the digital's environmental impact. I argue too that those of us who study digital media culture play a certain role in the system and we are uniquely placed to facilitate its sustainable, permacultural redesign. We need to understand our work as being rooted in the geologic and, inherently, in waste. Climate futures, Yusoff and Gabrys argue, "require approaches that are not only characterized by calculability and risk, but also mobilize imaginative acts that open new spaces and

---

[312] Davis and Turpin, 8.

practices for dealing with uncertain futures."[313] We have work to do, they say, especially in the cultural sphere of knowledge production, practices, and responses to climate change.

It is as 'Professor' Irwin Corey says: "If we don't change direction soon, we'll end up where we're going."[314] The hope of this project is that with care-full shifts in our language, our digital use, and our digital scholarship, we'll end up going in the direction of a permanent-permutable (as Kim Stanley Robinson says) permacultural future. That hope is that, as Tsing and Elizabeth Pollman say, "unexpected connections can make new things come into being." Indeed a more sustainable media theory depends on it. Futures of all sorts, Tsing and Pollman continue, "are forged in the contingencies of strange connections."[315] *Digital Environmental Metabolisms* is meant to be such a strange connection.

A lifetime won't be enough time, Wendell Berry says, to restore the earth, but using our lifetimes to help it mend is something we can all begin today.

---

[313] Yusoff & Gabrys, 518.
[314] Quoted p5 of Nadzam and Jamieson, 2015. Corey, who died in early 2017 at the age of 102, was a comedian, actor, and activist, referred to as the "Professor" and "The World's Greatest Authority" in Robert A. Heinlein's novel *Friday*.
[315] Tsing and Pollman, 2009.

References

Adamson, Joni. et al. *Keywords for Environmental Humanities*. New York: New York University Press, 2016.

Alaimo, Stacy. *Bodily Natures: Science, Environment, and the Material Self*, Indianapolis: Indiana University Press, 2010.

An Ecosystem of Excess, Transmediale 2014 panel, with Pinar Yoldas, Heather Davis, Jennifer Gabrys, Bernd Scherer, Daniela Silvestrin, At Haus der Kulturen der Welt, Berlin, 2014.

Arnold, Darrell, ed. *Traditions of Systems Theory: Major Figures and Contemporary Developments*. New York: Routledge, 2014.

Arthur, Brian. *The Nature of Technology: What It Is and How It Evolves*. New York: Free Press, 2009.

Ayres, Robert U. and Udo Ernst Simonis. Eds. *Industrial Metabolism: Restructuring for Sustainable Development*. New York: United Nations University Press, 1994.

Baccini, Peter and Paul Brunner. *Metabolism of the Anthroposphere: Analysis, Evaluation, Design*. Cambridge, Mass.: MIT Press, 2012.

Barlow, John Perry. "A Declaration of the Independence of Cyberspace." *Washington, D.C: American Humanist Association*, 1996. 18. Vol. 56, 1996.

Baroudi, C. "Electronics and Embedded Energy Blog," March 16, 2015, http://blog.arrowvaluerecovery.com/electronics-and-embedded-energy/#_ftn1.

Baucom and Omelski. "Knowledge in the Age of Climate Change." *South Atlantic Quarterly*, 116:1, 2017.

Beckmann, John. *The Virtual Dimension: Architecture, Representation, and Crash Culture*. Princeton: Princeton Architectural Press, 1998.

Behdad, S. et al. "PCRR E-waste Stream Analysis" SEI Reports, Illinois Sustainable Technology Center, SEI TR-001, 2010.

Bennett, Jane. *Vibrant Matter: A Political Ecology of Things*. Durham: Duke University Press, 2010.

Berardi, Franco. “Soul Work,” in C. Wiedemann and S. Zehle (eds) *Depletion Design: A Glossary of Network Ecologies*, Amsterdam: Institute of Network Cultures, 2012.

Berry, David. *Critical Theory and Contemporary Society: Critical Theory and the Digital*. Bloomsbury Publishing, 2014.

Berry, Wendell. “The Obligation of Care,” *Sierra*, 80, 5. Sept 1995, 62-66.

---. *The Art of the Common Place: The Agrarian Essays of Wendell Berry*, Berkeley: Counterpoint, 2002.

---. *Farming: A Handbook*. New York: Harcourt Brace Jovanovich, Inc., 1970.

Bertalanffy, Ludwig von. *General Systems Theory: Foundations, Development, Applications*. New York: George Braziller, Inc., 1968.

--- *Robots, Men and Minds*. New York: George Braziller, Inc., 1967.

Blade Runner. Dir. Ridley Scott. Prod. Ridley Scott and Hampton Francher. By Hampton Francher and David Webb Peoples. Warner Bros., 1982.

Blanchette, Jean-François. "A Material History of Bits." *Journal of the American Society for Information Science and Technology* 62.6: 1042-57, 2011.

Bleich, Sara N, et al. “Restaurants With Calories Displayed On Menus Had Lower Calorie Counts Compared To Restaurants Without Such Labels,” *Health Affairs*, November 2015, 34:11, 1877-1884, 2015.

Bollinger BB, Leslie P, Sorensen A. “Calorie posting in chain restaurants,” *American Economic Journal: Economic Policy*. 2011, 3 February, 91–128.

Braidotti, Rosi. *Transpositions: On Nomadic Ethics*. Cambridge, UK: Polity Press, 2006.

Braidotti, Rosi and Paul Gilroy, eds. *Conflicting Humanities*. New York: Bloomsbury Publishing, 2016.

“Bright Green: Your Stuff: If It Isn't Grown, It Must Be Mined” *Worldchanging.com*, http://www.worldchanging.com/archives/007708.html.

Buell, Lawrence. “Literature as Environmental(ist) Thought Experiment” in *Ecology and the Environment: Perspectives From the Humanities*, Swearer, D. and S. McGarry, eds., Cambridge, MA: Harvard University Press, 2009.

Burrell, Jenna. *Invisible Users: Youth in the Internet Cafes of Urban Ghana*. Acting with Technology. Cambridge, Mass.: MIT Press, 2012.

Butler, Samuel. *Erewhon: Or, over the Range*. Over the Range. Eds. Breuer, Hans-Peter and Daniel Francis Howard. Newark; London: University of Delaware Press; Associated University Presses, 1872, 1981.

Calvino, Italo. *Invisible Cities*. New York: Harcourt Brace Jovanovich, 1978.

Catanese, Christina. "Art in a Changing Climate," *Schuylkill Center*, April 28, 2016, http://www.schuylkillcenter.org/blog/art-in-a-changing-climate/.

Casson, C. "Don't Waste a Drop—Water in Mining," *Mining Magazine* October 2011, http://www.globalwaterintel.com/dont-waste-drop-water-mining/.

Chen, Brian. "Choosing to Skip the Upgrade and Care for the Gadget You've Got." *NYTimes.com*. April 20, 2016, https://www.nytimes.com/2016/04/21/technology/personaltech/choosing-to-skipthe-upgrade-and-care-for-the-gadget-youve-got.html?_r=0

Chmielewski, D. "Apple Reports Progress in Eliminating 'Conflict Minerals' From Its Devices," *Recode.net*, February 12, 2015, http://recode.net/2015/02/12/apple-reports-progress-in-eliminating-conflict-minerals-from-its-devices/.

Chowdhry, Amit. "How Google Stops Sharks From Eating Undersea Cables." *Forbes.com*, August 15, 2014.

Chrysoulakis, Nektarios et al. Eds. *Understanding Urban Metabolism: A Tool for Urban Planning*. New York, NY: Routledge, 2015.

Chun, Wendy Hui Kyong. *Control and Freedom: Power and Paranoia in the Age of Fiber Optics*. Cambridge Mass.: MIT Press, 2008.

Chun, Wendy Hui Kyong. *Programmed Visions: Software and Memory*. Cambridge, Mass.: MIT Press, 2011.

Colebrook, Claire. "Not Symbiosis, Not Now: Why Anthropogenic Change is Not Really Human." *The Oxford Literary Review*, 34.2 (2012): 185-209.

Coole, D. and Frost S. eds *New Materialisms: Ontology, Agency, and Politics*. Durham: Duke University Press, 2010.

Davis, Devra. *Disconnect: The Truth About Cell Phone Radiation, What the Industry Has Done to Hide It, and How to Protect Your Family*, New York: Dutton-Penguin, 2010.

Davis, Heather and Etienne Turpin, eds. *Art in the Anthropocene: Encounters Among Aesthetics, Politics, Environments and Epistemologies*, Open Humanities Press, 2015.

Debatty Régine. "Sketches for an Earth Computer," *We Make Money Not Art*, 23 July 2014, http://we-make-money-not-art.com/archives/2014/07/earth-computer.php#.VFwQh8mg-uN.

DeLanda, Manuel. *A Thousand Years of Nonlinear History*. Swerve Editions. New York: Zone Books, 1997.

---. *War in the Age of Intelligent Machines*. New York: Zone Books, 1991.

Deleuze, Gilles and Felix Guattari. *A Thousand Plateaus: Capitalism and Schizophrenia*. Minneapolis: University of Minnesota Press, 1987.

Delforge, Pierre. "New Report: Computer Energy Use Can Easily Be Cut in Half." *NRDC.com*, July 28, 2016, https://www.nrdc.org/experts/pierre-delforge/new-report-computer-energy-use-can-easily-be-cut-half.

Denson, Shane. *Postnaturalism: Frankenstein, Film, and the Anthropotechnical Interface*. Bielefeld: Transcript Verlag, 2014.

Deuze, Mark. *Media Life*. Cambridge: Polity Press, 2012.

Dumanovsky T, Huang CY, Nonas CA, et al. "Changes in energy content of lunchtime purchases from fast food restaurants after introduction of calorie labelling: Cross sectional customer surveys." *BMJ*, 2011.

Dunaway, Finis. *Seeing Green: The Use and Abuse of American Environmental Images*. Chicago: University of Chicago Press, 2015.

Dyson, George. *Darwin among the Machines: The Evolution of Global Intelligence*. Helix Books. Reading, MA: Addison-Wesley Pub. Co., 1997.

---. *Turing's Cathedral: The Origins of the Digital Universe*. New York: Pantheon Books, 2012.

Eliasson, Olafur. "Why Art Has the Power to Change the World," *Huffington Post*, January 24, 2016.

Emerson, Lori. *Reading Writing Interfaces: From the Digital to the Bookbound*. Electronic Mediations; 44. Minneapolis: University of Minnesota Press, 2014.

Feigelfeld, Paul. "From the Anthropocene to the Neo-Cybernetic Underground. A Conversation with Erich Hörl." Online www.60pages.com, 2013.

Ferrão, Paulo and John Fernandez. *Sustainable Urban Metabolism*. Cambridge: The MIT Press, 2013.

"Fifty Years of Moore's Law Made Possible by Semiconductor Equipment and Materials Suppliers Worldwide," April 14, 2015, http://www.semi.org/node/55676.

Fischer-Kowalski. "Society's Metabolism: The Intellectual History of Materials Flow Analysis. Part I, 1860-1970." *Journal of Industrial Ecology*. 2 (1), 1998.

---. "Analyzing sustainability transitions as a shift between socio-metabolic regimes." *Environmental Innovation and Societal Transitions*. Volume 1, Issue 1, June 2011, 152–159.

Fischer-Kowalski, M. and Hüttler, W. "Society's Metabolism: The Intellectual History of Materials Flow Analysis Part II, 1970-1998." *Journal of Industrial Ecology*, 2: 107–136, 1998.

Fischer-Kowalski, M., and J. K. Steinberger. "Social Metabolism and Hybrid Structures." *Journal of Industrial Ecology*, 15 (5). 642-644, 2011.

"Five things you need to know about coltan," *International Consortium of Investigative Journalists*, March 4, 2012, http://www.icij.org/projects/coltan/five-things-you-need-know-about-coltan.

Fuchs, Christian. "Dallas Smythe and Digital Labor" in R. Maxwell (ed) *Routledge Companion to Labor and Media*, New York: Routledge, 2015.

Fuller, Matthew. *Evil Media*. Cambridge: MIT Press, 2012.

---. *Media Ecologies: Materialist Energies in Art and Technoculture*. Leonardo. Cambridge: MIT Press, 2005.

Gabrys, Jennifer. *Digital Rubbish: A Natural History of Electronics*. Ann Arbor: University of Michigan Press, 2011.

Gabrys, Jennifer. *Program Earth: Environmental Sensing Technology and the Making of a Computational Planet*. Minneapolis: University of Minnesota Press, 2016.

---. 2014b. "A Cosmopolitics of Energy: Diverging Materialities and Hesitating Practices," *Environment and Planning* A 46(9) 2095—2109, 2014.

---. "Powering the Digital: From Energy Ecologies to Electronic Environmentalism," In *Media and the Ecological Crisis*, edited by Richard Maxwell, Jon Raundalen, Nina Lager Vestberg. New York and London: Routledge, 3-18, 2014.

---. "Re-thingifying the Internet of Things," in *Sustainable Media: Critical Approaches to Media and Environment*, Starosielski, N and J. Walker, eds., New York: Routledge, 2016.

Galloway, Alexander R. and Eugene Thacker. *The Exploit: A Theory of Networks*. Electronic Mediations; V. 21. Minneapolis: University of Minnesota Press, 2007.

Galloway, Anne and Matt Ward. "Locative Media as Socialising and Spatializing Practice: Learning From Archaeology." *Leonardo E-Journal Archive*, 14(3), 2006.

Garrett, T. J. Long-run evolution of the global economy: 1. Physical basis, Earth's Future, 2, 127—151, 2014.

"Gartner Says Smartphone Sales Surpassed One Billion Units in 2014," Egham, UK, March 3, 2015, http://www.gartner.com/newsroom/id/2996817.

Gatens, Moira. *Collective Imaginings: Spinoza, Past and Present*. New York: Routledge, 1999.

---. *Imaginary Bodies: Ethics, Power and Corporeality*. New York: Routledge, 1996.

Gibson, William. *Neuromancer*. New York: Ace Books, 2004.

Gillespie, Tarleton, Pablo J. Boczkowski, and Kirsten A. Foot. *Media Technologies: Essays on Communication, Materiality, and Society*. Cambridge: The MIT Press, 2014.

Glaser, Marion. Ed. *Human-Nature Interactions in the Anthropocene: Potentials of Social-Ecological Systems Analysis*. Routledge Studies in Environment, Culture, and Society; 1. New York: Routledge, 2012.

Goldsworthy, Andrew. "The Biological Effects of Weak Electromagnetic Fields," 2007, http://www.cellphonetaskforce.org/wp-content/uploads/2012/04/Biol-Effects-EMFs-2012-NZ2.pdf.

Gonzalez, A. et al. “What We Know and Don’t Know about Embodied Energy and Greenhouse Gases for Electronics, Appliances, and Light Bulbs,” Natural Resources Defense Council, 2012 ACEEE Summer Study on Energy Efficiency in Buildings, 2012.

Grossman, E. *High Tech Trash: Digital Devices, Hidden Toxics, and Human Health*, Washington, DC: Island Press, 2006.

Grossman, Elizabeth, “The Body Burden: Toxics, Stresses, ad Biophysical Health” in *The Routledge Companion to Labor and Media*, Maxwell, R, ed., New York: Routledge, 2016.

Guattari, Félix. *Chaosmosis: An Ethico-aesthetic Paradigm*. Bloomington: Indiana University Press, 1995.

---. *The Three Ecologies*. New York: Continuum, 2008.

Haff, Peter. "Humans and Technology in the Anthropocene: Six Rules." *The Anthropocene Review* 1.2: 126-36, 2014.

---. "Technology as a Geological Phenomenon: Implications for Human Well-Being." *Geological Society, London, Special Publications* 395.1: 301-09, 2014.

Hannah, Landecker. "Postindustrial Metabolism: Fat Knowledge." *Public Culture* 25.3 71: 495-522, 2013.

Hansen, Mark. *Embodying Technesis: Technology Beyond Writing*. Studies in Literature and Science. Ann Arbor: University of Michigan Press, 2000.

---. *New Philosophy for New Media*. Cambridge, Mass.: MIT Press, 2004.

---. *Bodies in Code: Interfaces with New Media*, New York: Routledge, 2006.

---. “System-Environment Hybrids,” in *Emergence and Embodiment: New Essays on Second-Order Systems Theory*. Eds., Hansen, Mark and Bruce Clarke. Durham: Duke University Press, 2009.

---. *Ubiquitous Sensation or the Autonomy of the Peripheral: Towards an Atmospheric, Impersonal and Microtemporal Media*, in U. Ekman (ed) in *Throughout: Art and Culture Emerging With Ubiquitous Computing*, Cambridge: MIT Press, 2012.

---. *Feed-Forward: On the Future of Twenty-First -Century Media*. Chicago: University of Chicago Press, 2014.

Hansen, Mark and Mitchell, WJT. *Critical Terms for Media Studies*, Chicago: University of Chicago Press, 2010.

Haraway, Donna. "Anthropocene, Capitalocene, Plantationocene, Chthulucene: Making Kin," *Environmental Humanities*, vol. 6, pp. 159-165, 2015.

---. *Manifestly Haraway*. Minneapolis: University of Minnesota Press, 2016.

---. *The Haraway Reader*. New York: Routledge, 2004.

---. *When Species Meet*. Minneapolis: University of Minnesota Press, 2008.

---. *The Companion Species Manifesto: Dogs, People, and Significant Otherness*. Chicago: Prickly Paradigm Press, 2003.

---. *Staying with the Trouble: Making Kin in the Chthulucene*. Durham, NC: Duke University Press, 2016.

"Hard Rock Mining Pollution," (n.d) *National Wildlife Federation*, http://www.nwf.org/What-We-Do/Energy-and-Climate/Drilling-and-Mining/Mining-Loopholes.aspx.

Hardt, Michael and Antonio Negri. *Empire*. Cambridge: Harvard University Press, 2000.

Hayles, N. Katherine. *How We Became Posthuman: Virtual Bodies in Cybernetics, Literature, and Informatics*. Chicago: University of Chicago Press, 1999.

---. *Writing Machines*. Mediawork. Cambridge, Mass.: MIT Press, 2002.

---. *My Mother Was a Computer: Digital Subjects and Literary Texts*. Chicago: University of Chicago Press, 2005.

---. "Unfinished Work: From Cyborg to Cognisphere," *Theory, Culture & Society*, December 2006 23: 159-166.

---. *Electronic Literature: New Horizons for the Literary*. University of Notre Dame Ward-Phillips Lectures in English Language and Literature. Notre Dame, Ind.: University of Notre Dame, 2008.

---. "RFID: Human Agency and Meaning in Information-Intensive Environments," *Theory, Culture & Society*, March/May 2009, 26: 47-72.

---. *How We Think: Digital Media and Contemporary Technogenesis*. Chicago: University of Chicago Press, 2012.

---. "Print Is Flat, Code Is Deep: The Importance of Media-Specific Analysis," *Poetics Today* 25:1 (Spring 2004), 67-90.

Henn, Steve. "Searching the Planet To Find Power For the Cloud." *NPR All Things Considered*, April 21, 2014.

Heynen, Nikolas C., Maria Kaika and E. Swyngedouw. Eds. *In the Nature of Cities: Urban Political Ecology and the Politics of Urban Metabolism*. Questioning Cities Series. London; New York: Routledge, 2006.

Hillis, William Daniel. *The Connection Machine*. Doctoral Dissertation, MIT. Online: http://dspace.mit.edu/bitstream/handle/1721.1/14719/18524280.pdf, 1985

Holmgren, David. Permaculture: principles and pathways beyond sustainability. Hepburn, Vic: Holmgren Design Services, 2002.

---. Essence of Permaculture. Hepburn, Vic: Holmgren Design Services, 2013.

Hörl, Erich. "Variations on Klee's Cosmographic Method." *Textures of the Anthropocene: Grain Vapor Ray*. Ed. Katrin Klingan, Ashkan Sepahvand, Christoph Rosol, Bernd M. Scherer. Berlin: Revolver Publishing, 2014.

Howse, Martin."The Earthcodes Project: substrate/shifting the site of execution." http://www.1010.co.uk/org/earthcode.html.

Humes, Edward. *Door to Door: The Magnificent, Maddening, Mysterious World of Transportation*. New York City: Harper Collins Publishers, 2016.

Internet Live Stats, *Real Time Statistics Project*: http://www.Internetlivestats.com/.

Jackson, Steven. "Rethinking Repair," in *Media Meets Technology: Essays on Communication, Materiality, and Society*. Eds. Pablo Boczkowski, Kirsten Foot, and Tarleton Gillespie. Cambridge: MIT Press, 2014.

Jamieson, Dale and Bonnie Nadzam. *Love in the Anthropocene*. New York: OR Books, 2015.

Jonas, Hans. *The Phenomenon of Life: Toward a Philosophical Biology*. New York Harper & Row, 1966.

Kelleher, Kathleen. “Changing Habits, Saving Power: The Study of Incentives.” *Newsroom.UCLA.edu*, July 22, 2016, http://newsroom.ucla.edu/stories/changing-habits-saving-power:-the-study-of-incentives.

Kemp, Jonathan. “The Crystal World: Executing a New Media Materialism,” Doctoral Dissertation, University of Westminster, 2013.

Kirschenbaum, Matthew G. *Mechanisms: New Media and the Forensic Imagination*. Cambridge, Mass.: MIT Press, 2008.

---. *Digital Forensics and Born-Digital Content in Cultural Heritage Collections*. Clir Publication; No. 149. Eds. Donahue, Rachel, Richard Ovenden and Gabriela Redwine. Washington, D.C.: Council on Library and Information Resources, 2010.

Klare, M. *The Race for What’s Left: The Global Scramble for the World’s Last Resources*, New York: Metropolitan Books, 2012.

Kroker, A. and Weinstein, M. *Data Trash: The Theory of Virtual Class*, New York: St. Martin's Griffin, 1994.

Landecker, Hannah. "Food as Exposure: Nutritional Epigenetics and the New Metabolism." *BioSocieties* 6.2: 167-94, 2011.

---. “Postindustrial Metabolism: Fat Knowledge.” *Public Culture,* Volume 25, Number 3 71: 495-522, 2013.

---. "The Metabolism of Philosophy, in Three Parts," 193-224 in *Dialectic and Paradox: Configurations of the Third in Modernity*, B. Malkmus and I. Cooper, eds., Bern: Peter Lang, 2013.

Lanier, Jaron. *Who Owns the Future?* London: Allen Lane, 2013.

Latour, Bruno. *Reassembling the Social: An Introduction to Actor-Network-Theory*. Oxford: Oxford University Press, 2005.

---. Network Theory|Networks, Societies, Spheres: Reflections of an Actor-network Theorist. *International Journal of Communication*, [S.l.], v. 5, p. 15, Apr. 2011.

---. *An Inquiry Into Modes of Existence*, Cambridge: Harvard University Press, 2013.

----. “Fifty Shades of Green,” *Environmental Humanities*, vol. 7, pp. 219-225, 2015.

Mackenzie, Adrian. *Transductions: Bodies and Machines at Speed*. New York: Continuum, 2002.

---. *Wirelessness: Radical Empiricism in Network Cultures*. Cambridge: MIT Press, 2010.

Manning, Erin. *Always More Than One: Individuation's Dance. Durham*: Duke University Press, 2013.

Manovich, Lev. *The Language of New Media*. Leonardo. Cambridge: MIT Press, 2001.

---. *Software Takes Command*. International Texts in Critical Media Aesthetics; Volume 5. New York, NY, USA: Bloomsbury Academic, 2013.

Martin S and Griswold, W. "Human Health Effects of Heavy Metals," *Center for Hazardous Substance Research, Environmental Science and Technology Briefs for Citizens*, Issue 15, 2009.

Mason, Mark. Ed. *Complexity Theory and the Philosophy of Education*. Malden, MA: Wiley-Blackwell, 2008.

The Matrix. Dir. Andy Wachowski and Larry Wachowski. Warner Bros. Pictures, 1999.

Maxwell, Richard, ed. *The Routledge Companion to Labor and Media*, New York: Routledge, 2016.

Maxwell, Richard and Toby Miller. *Greening the Media*. New York: Oxford University Press, 2012.

Maxwell, Richard. et al, eds *Media and the Ecological Crisis*, New York: Routledge, 2015.

May, Kyle. Ed. *Data Space*. Clog. Brooklyn, NY: Clog, 2012.

McCormack, Jon. "Representation and Mimesis in Generative Art: Creating Fifty Sisters," in xCoAx 2013: Proceedings of the first conference on Computation, Communication, Aesthetics and X, eds. Mario Verdicchio and Miguel Carvalhais (Bergamo, Italy, 27-28 June 2013): 74.

McLuhan, Marshall. *A McLuhan Sourcebook*. Assembled by William Kuhns. In Eric McLuhan and Frank Zingrone (eds) Essential McLuhan. Concord, ON: Anansi, 1995.

Mejias, Ulises Ali. *Off the Network: Disrupting the Digital World*. Electronic Mediations; V. 41. Minneapolis: University of Minnesota Press, 2013.

Michaels, Walter Benn. “Interview with Walter Benn Michaels on Photography and Politics.” *Nonsite.org*, June 12, 2011, http://nonsite.org/editorial/interview-with-walter-benn-michaels-on-photography-and-politics.

Mollison, Bill. *Introduction to Permaculture*. Sisters Creek, Tasmania, Australia: Tagari Publications, *2009*.

---. *Permaculture: A Designer’s Manual*. Tyalgum, Australia: Tagari Publications, 1988.

---. "The One-Straw Revolution by Masanobu Fukuoka - Book Review." *Nation Review*, 15–21 September 1978, 18.

Mosco, Vincent. *To the Cloud: Big Data in a Turbulent World*. New York: Routledge, 2015.

Munster, Anna. *An Aesthesia of Networks: Conjunctive Experience in Art and Technology*. Technologies of Lived Abstraction. Cambridge: MIT Press, 2013.

---. “Digital Embodiment/Digital Materiality,’ in *Depletion Design: A Glossary of Network Ecologies*, eds. Carolin Wiedemann and Soenke Zehle. Amsterdam: Institute of Network Cultures, 2013.

Myers, Rob. “The Crystal World: Algorithms, Inhuman Speed and Complexity,” *Furtherfield*, 18 October 2012.

Negrotti, Massimo. *The Reality of the Artificial: Nature, Technology, and Naturoids*. New York: Springer, 2012.

Newitz, Annalee. “The “Technosphere” Now Weighs 30 Trillion Tons.” *Arstechnica.com*, December 6, 2016, https://arstechnica.com/science/2016/12/the-technosphere-now-weighs-30-trillion-tons/.

Nowviski, Bethany. “On Capacity and Care.” Keynote presentation at the 2015 Office of Digital Humanities project director’s meeting at the National Endowment for the Humanities, 2015.

---. “Digital Humanities in the Anthropocene.” Keynote presentation at the Digital Humanities Conference, 2014.

Pandey, A. “Conflict Minerals Enter US Unchecked, Hidden By 'Blind Spots' In Supply Chains,” April 22, 2015, http://www.ibtimes.com/conflict-minerals-enter-us-unchecked-hidden-blind-spots-supply-chains-1891692.

Panimbang, Fahmi "Breaking the Chains: Workers' Struggles in Electronics Supply Chains" in *Labour Rights in High Tech Electronics: Case Studies of Workers' Struggles in Samsung Electronics and its Asian Suppliers*, Eds. Kathleen Kearney, Sanjiv Pandita, Fahmi Panimbang. Hong Kong: Asia Monitor Resource Centre, 2013.

Parikka, Jussi. *Digital Contagions: A Media Archaeology of Computer Viruses*. Digital Formations, 1526-3169; V. 44. New York: Peter Lang, 2007.

---. *Insect Media: An Archaeology of Animals and Technology*. Posthumanities; 11. Minneapolis: University of Minnesota Press, 2010.

---. *Medianatures: The Materiality of Information Technology and Electronic Waste*. Online http://www.livingbooksaboutlife.org/books/Medianatures, 2011.

---. "Dust and Exhaustion: The Labor of Media Materialism." *Ctheory*: 1, 2013.

---. "Green Media Times: Friedrich Kittler and Ecological Media History" in *Archiv für Mediengeschichte*, 69-78, 2013.

---. "Media Zoology and Waste Management: Animal Energies and Medianatures. *NECSUS* 2 (2): 527-544, 2013.

---. *Anthrobscene*, Minneapolis: University Of Minnesota Press, 2015.

---. *A Geology of Media*, Minneapolis: University Of Minnesota Press, 2015.

---. "So-called Nature: Friedrich Kittler and Ecological Media Materialism" in *Sustainable Media: Critical Approaches to Media and Environment*, Starosielski, N and J. Walker, eds. New York: Routledge, 2016.

Parks, Lisa and Nicole Starosielski, eds. *Signal Traffic: Critical Studies of Media Infrastructures*. Chicago: University of Illinois Press, 2015.

Peters, J.D. *The Marvelous Clouds: Toward a Philosophy of Elemental Media*. Chicago: University of Chicago Press, 2015.

Phone Story Molleindustria. Video game, phonestory.org, 2011.

Pickering, Andrew. *The Mangle of Practice: Time, Agency, and Science*. Chicago: University of Chicago Press, 1995.

Plumwood, Val. *Environmental Culture: The Ecological Crisis of Reason*. New York: Routledge, 2002.

Pötzsch, H. and Hayles, K. “FCJ-172 Posthumanism, Technogenesis, and Digital Technologies: A Conversation with N. Katherine Hayles” *The Fibreculture Journal*, Issue 23, 2014.

Prosser, I. et al. “Water in mining and industry,” in *Water: Science and Solutions for Australia*, Australia: CSIRO Publishing, 2011.

Puig de la Bellacasa, Maria. "Matters of Care in Technoscience: Assembling Neglected Things." *Social Studies of Science*, vol. 41, no. 1, 2011, pp. 85-106.

---. "Making Time for Soil: Technoscientific Futurity and the Pace of Care." *Social Studies of Science*, vol. 45, no. 5, 2015, pp. 691-716.

---. "'Nothing Comes without its World': Thinking with Care." *The Sociological Review*, vol. 60, no. 2, 2012, pp. 197-216.

---. "Ethical Doings in Naturecultures." *Ethics, Place & Environment*, vol. 13, no. 2, 2010, pp. 151-169.

Purdy, Jedediah. *After Nature: A Politics For the Anthropocene*. Cambridge, Mass: Harvard University Press, 2015.

---. *For Common Things: Irony, Trust, and Commitment in America Today*. New York: Vintage Books, 1999.

“Pure water, semiconductors and the recession.” *Global Water Intelligence (GWI)*. 10.10, 2009.

Rathi, A. “The metals in your smartphone may be irreplaceable,” December 5, 2013, http://arstechnica.com/science/2013/12/the-metals-in-your-smartphone-may-be-irreplaceable/.

Richards, H. “IBM’s “Ginni” Rometty Predicts Three Ways Technology Will Transform The Future Of Business,” *Intelligenthq.com*, September 3, 2013, http://www.intelligenthq.com/intelligence/ibms-ginni-rometty-predicts-three-ways-technology-will-transform-the-future-of-business/.

Rice, D. “On four continents, historic droughts wreak havoc,” *USA Today*, July 27, 2015, http://www.usatoday.com/story/news/world/2015/07/24/historic-droughts-wreak-havoc-usa-brazil-n-korea/30513289/.

Robinson, Kim Stanley. *Green Earth*. New York: Del Rey Books, 2015.

Rose, Deborah Bird. *Wild Dog Dreaming: Love and Extinction*. Charlottesville: University of Virginia Press, 2011.

Rothstein, Adam. "How to See Infrastructure: A Guide for Seven Billion Primates," *Rhizome.org*, July, 2, 2015, http://rhizome.org/editorial/2015/jul/2/how-see-infrastructure-guide-seven-billion-primate/.

The Royal Society for the Encouragement of Arts, Manufactures and Commerce (RSA), "Great Recovery Report," September 2014, http://www.greatrecovery.org.uk/resources/the-great-recovery-report/.

Sample, Mark. "Your Mistake was a Vital Connection: Oblique Strategies for the Digital Humanities." Keynote Address, Institute for Liberal Arts Digital Scholarship, 2015.

Sassower, Raphael, and Nimrod Bar-Am. "Systems Heuristics and Digital Culture," in *Traditions of Systems Theory: Major Figures and Contemporary Developments*. Ed Arnold, Darrell. New York: Routledge, 2014.

Schleeter, Ryan. "4 Reasons Art Is Essential to Activism," *Greenpeace.org*, November 16, 2015, http://www.greenpeace.org/usa/4-ways-art-is-essential-to-activism/.

Schildgen, Bob. "Hey Mr. Green, How Clean Is My Cloud Data Company?." *Sierraclub.org*, June 1, 2015, http://www.sierraclub.org/sierra/2015-3-may-june/green-life/hey-mr-green-how-clean-my-cloud-data-company.

Schmidt, Alfred. *The Concept of Nature in Marx*. Schmidt, Alfred, 1931-2012. Begriff Der Natur in Der Lehre Von Marx. English: London NLB, 1971.

Scholtz, Trebor. *Digital Labor: The Internet as Playground and Factory*, New York: Routledge, 2012.

Serres, Michel. *The Natural Contract*. Ann Arbor: University of Michigan Press, 1995.

Shemkus, Sarah. "The tech industry is threatening to drink California dry," July 20, 2015, http://www.theguardian.com/sustainable-business/2015/jul/20/water-california-drought-tech-gaints-data-centres.

Shepherd, Dan. "Last Residents of Picher, Oklahoma Won't Give Up the Ghost (Town)." *NBCNews.com*, Apr 28 2014, http://www.nbcnews.com/news/investigations/last-residents-picher-oklahoma-wont-give-ghost-town-n89611.

Singer, Katie. *An Electronic Silent Spring: Facing the Dangers and Creating Safe Limits*, Great Barrington, MA: Portal Books, 2014.

Smith, T and Raphael, C. "Health and Safety Policies for Electronics Workers," in In Maxwell, R (ed) *The Routledge Companion to Labor and Media*, New York: Routledge, 2015.

Sörlin, Sverker. "Environmental Humanities: Why Should Biologists Interested in the Environment Take the Humanities Seriously?." *BioScience*, Volume 62, Issue 9, 2012.

Starosielski, Nicole and Janet Walker, eds. *Sustainable Media: Critical Approaches to Media and Environment*, New York: Routledge, 2016.

Starosielski, Nicole. The Undersea Network. Durham: Duke University Press, 2015.

Swyngedouw, Eric. "Metabolic urbanization: The making of cyborg cities," in *In the Nature of Cities: Urban Political Ecology and the Politics of Urban Metabolism*. Eds. Heynen, Nikolas C., Maria Kaika and E. Swyngedouw. New York: Routledge, 2006.

Taffel, Sy. "Escaping Attention: Digital Media Hardware, Materiality and Ecological Cost" *Culture Machine* vol. 13, 2012.

Telford, Richard. "Permaculture Design Principles," permaculturedesignprinciples.com, found at https://permaculturepriciples.com/principles/.

Thill, Brian. *Waste*. New York: Bloomsbury Academic, 2015.

Thomashow, Mitchell. *Bringing the Biosphere Home*. Cambridge: MIT Press, 2002.

Tillman, Karen. "How Many Internet Connections are in the World? Right. Now." *Cisco.com*, 2013. http://blogs.cisco.com/news/cisco-connections-counter.

Treacy, Megan. "To Make Your Smartphone Last Longer, Avoid Overnight Charging?" *Treehugger.com*, August 23, 2016, http://www.treehugger.com/gadgets/make-your-smartphone-last-longer-avoid-overnight-charging.html.

Tsing, Anna. *The Mushroom at the End of the World: On the Possibility of Life in Capitalist Ruins*. Princeton, New Jersey: Princeton University Press, 2015.

---. *Friction: An Ethnography of Global Connection*. Princeton, New Jersey: Princeton University Press, 2005.

Tsing, Anna and Elizabeth Pollman. “Global Futures: The Game,” in *Histories of the Future*. Eds Susan Harding and Daniel Rosenberg. Durham: Duke University Press, 2009.

Tucker, Mary Evelyn. “Preface” in *Ecology and the Environment: Perspectives from the Humanities*. Eds. Donald K. Swearer et al. Cambridge: Harvard University Press, 2009.

Turkle, Sherry. “The Tethered Self: Technology Reinvents Intimacy and Solitude” *Continuing Higher Education Review*, Vol. 75, 2011.

“Types of Plastic: How Many Kinds of Plastics Are There?.” *Plastics Make it Possible*, American Chemistry Council, Inc,, January 18, 2012.

van Dooren, Thom. *Flight Ways: Life and Loss at the Edge of Extinction*. New York: Columbia University Press, 2014.

---. 2014b. "Care." *Environmental Humanities*, vol. 5, no. 1, 2014, pp. 291-294.

van Dooren, Thom, and Deborah Rose. "Introduction." *Australian Humanities Review*, no. 51, 2011.

van Dooren, Thom, and Deborah B. Rose. "Lively Ethography: Storying Animist Worlds." *Environmental Humanities*, vol. 8, no. 1, 2016, pp. 77-94.

van Dooren, Thom, Eben Kirksey, and Ursula Münster. "Multispecies Studies: Cultivating Arts of Attentiveness." *Environmental Humanities*, vol. 8, no. 1, 2016, pp. 1-23.

Wark, McKenzie. *Molecular Red: Theory for the Anthropocene*. London: Verso, 2015.

“Water Use in the Semiconductor Manufacturing Industry,” August 8, 2013, http://engineeredenvironment.tumblr.com/post/30464844411/water-use-in-the-semiconductor-manufacturing.

Watts, Duncan J. *Six Degrees: The Science of a Connected Age*. New York: Norton, 2003.

---. *Small Worlds: The Dynamics of Networks between Order and Randomness*. Princeton Studies in Complexity. Princeton, N.J.: Princeton University Press, 1999.

Wearden, Graeme. “More plastic than fish in the sea by 2050, says Ellen MacArthur” *TheGuardian.com*, 19 January 2016,

https://www.theguardian.com/business/2016/jan/19/more-plastic-than-fish-in-the-sea-by-2050-warns-ellen-macarthur.

Weiser, Mark. "The Computer for the 21st Century." *Scientific American*, 1991. 94-104. Vol. 265.

"Welcome to the Anthropocene." *Economist.com*, May 26th 2011, http://www.economist.com/node/18744401.

Wertheim, Margaret. "The Medieval Return of Cyberspace," in *The Virtual Dimension: Architecture, Representation, and Crash Culture*. Princeton: Princeton Architectural Press, 1998.

Wiedemann, Carolin and Soenke Zehle, ed. *Depletion Design: A Glossary of Network Ecologies* Institute of Network Cultures, 2013.

Williams, R. *Problems in Materialism and Culture*, Brooklyn: Verso Press, 1980.

Whitelaw, Mitchell. "Transmateriality: Presence Aesthetics and the Media Arts," in *Throughout: Art and Culture Emerging with Ubiquitous Computing*, ed, Ulrik Ekman, Cambridge, MA: MIT Press, 2013.

---. "Local Colour and Networked Specificity," Presented at ISEA 2011: 17th International Symposium on Electronic Art, Istanbul, Turkey, 14-21 September 2011.

---. 2013b. "Data-Mysticism, Algorithmic Ecologies & the Human-Executable—Interview with Mitchell Whitelaw." *Neural Magazine*, no. 40, 26 March 2013.

"Why be energy efficient?" Australian Government Department of Industry, Innovation and Science, http://eex.gov.au/industry-sectors/mining/, 2015.

Worstall, Tim. "Fascinating Number: Google Is Now 40% Of The Internet," *Forbes.com*, August 17, 2013.

---. "Over 60% Of All Website Visits Are Bot Traffic," *Forbes.com*, December 13, 2013.

"Your Computer's Lifetime Journey," Natural Resources Defense Council, *ArsTechnica*, November 30, 2011, http://www.nrdc.org/living/stuff/your-computers-lifetime-journey.asp.

Yu, Alan. “More Than 300 Sharks In Australia Are Now On Twitter.” *NPR.org*, January 1, 2014, http://www.npr.org/sections/alltechconsidered/2013/12/31/258670211/more-than-300-sharks-in-australia-are-now-on-twitter.

Yusoff, Kathryn. “Geologic Subjects: Nonhuman Origins, Geomorphic Aesthetics and the Art of Becoming Inhuman” *Cultural Geographies*, 2014.

---. “Geologic Life: Prehistory, Climate, Futures in the Anthropocene.” *Environment and Planning D: Society and Space*, Volume 31, Issue 5, 2013.

Yusoff, Kathryn and Jennifer Gabrys. “Climate Change and the Imagination.” *Wiley Interdisciplinary Reviews: Climate Change*, Volume 2, Issue 4, 2011.

Zettler, Erik, et al. “Life in the 'Plastisphere': Microbial Communities on Plastic Marine Debris," *Environmental Science & Technology*, 47 (13), pp 7137–7146, 2013.

Artworks

Arnall, Timo and Jorn Knutsen, Einar Sneve Martinussen, *Immaterials: Light painting Wi-Fi*, 2011.

Armitage, Simon and Tony Ryan. *In Praise of Air* https://www.sheffield.ac.uk/news/nr/worlds-first-air-cleansing-poem-1.373843

Behar, Katherine. *E-Waste* http://www.katherinebehar.com/art/e-waste-installation/index.html

Eliasson, Olafur and Minik Rosing. *Ice Watch*, 2015, http://icewatchparis.com/

Fournier, Abelardo. *Mineral Vision*, 2015, http://abelardogfournier.org/projects/mineral-vision

Howse, Martin and Jonathan Kemp, and Ryan Jordan. *The Crystal World*, 2012, http://crystalworld.org.uk/wiki/doku.php?id=the_crystal_world:space:publicity#cw_lab_exhibition_index.

Howse, Martin. *Earthboot*, 2012, http://www.1010.co.uk/org/earthcode.html.

Jordan, Chris. *Midway: Message from the Gyre*, 2009, http://www.chrisjordan.com/gallery/midway/#CF000313%2018x24

Lamm, Nickolay. *What If You Could See Wi-Fi?*, 2013, http://nickolaylamm.com/art-for-clients/what-if-you-could-see-wifi/.

Lamm, Nickolay. *What If You Could See Your Cellular Network?*, 2012, http://nickolaylamm.com/art-for-clients/what-if-could-see-your-cellular-network/.

McCormack, Jon. *Fifty Sisters*, 2012, http://jonmccormack.info/~jonmc/sa/artworks/fifty-sisters/.

Moll, Joana. *Co2gle*, 2015, http://www.janavirgin.com/CO2/CO2GLE_about.html.

Polli, Andrea. *Particle Falls*, 2014, http://www.particlefallsclt.org/.

striegl, libi rose. *iPhone Mineral Nutrition Label Project*, 2015, website forthcoming.

Cohen, Revital and Tuur van Balen. *H/AlCuTaAu*, 2014, http://www.cohenvanbalen.com/work/h-alcutaau.

Whitelaw, Mitchell. *Local Colour*, 2011, http://mtchl.net/local-colour/.

Yoldas, Pinar. *An Ecosystem of Excess*, 2013, http://www.pinaryoldas.info/WORK/Ecosystem-of-Excess-2014.

Biography

Amanda Starling Gould was born in Cape Girardeau, Missouri, in 1982. She attended Vanderbilt University where she received a B.A., *summa cum laude*, in French, (with departmental honors) and a minor in Italian in 2005. She received an M.A. in publishing and writing from Emerson College in Boston in 2010 receiving the Book Design Award, Boston Bookbuilders Scholarship for her final M.A. thesis book project *Innovative Narrative Design*. After teaching a year of Graduate Writing courses at Northeastern University, receiving a nomination for the Excellence in Teaching Award, in 2011, she was awarded a James B. Duke Fellowship to attend Duke University as a Ph.D. candidate in Literature. During her tenure at Duke, Gould was the recipient of the Franklin Humanities Institute Graduate Digital Scholarship Initiative Grant ($10,000), the Andrew W. Mellon funded Humanities Writ Large Environmental Arts and Humanities Emerging Network Grant ($10,000), and a Duke University Flipping the Classroom Faculty Fellowship grant ($1,000). Gould graduated from Duke University in May of 2017 with a Ph.D. in Literature and a certificate in Information Science & Studies.

Portions of this dissertation have previously appeared in print as "Remaking the Arts through Ecocritical Digital Humanities" in *Media Commons* Field Guide (2017), "Restor(y)ing the Ground: Digital Environmental Media Studies," in *Networking Knowledge*, (2016), "Grounding the Cloud, or Mapping a Digital Metabology Through Art," in *Dissect* Journal, (2015).