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Shimmering Data and Ecological Collaboration: Paying Attention to Intruding Ecological Situations

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The alarming effects of global warming and the challenges associated with the Anthropocene have emerged as two of the defining problems (re)organising and (re)orienting contemporary knowledge projects across the arts and sciences. That is, scientists, artists and theorists are increasingly working to find ways to transform their practices and methods in order to account for the problems of scale and complexity that characterise the challenges of the Anthropocene and anthropogenic global warming. In so doing, artists and scientists, as pointed out by McKenzie Wark, are responding to the specific challenges of the Anthropocene and global warming by working to "create the space within which very different kinds of knowledge and practice might meet" ("Molecular Red").

This essay, therefore, will examine two different knowledge projects built to address and respond to the challenges of the Anthropocene and anthropogenic global warming. I will begin at the scale of the globe and planet by discussing the achievement of climate and Earth system scientists to produce computer models that reliably simulate global climate changes. Climate models produce relevant and reliable knowledge about global climate changes, but in the words of science scholar Paul Edwards, their data "shimmers," and thus cannot be interpreted as indisputable facts of nature that are free of interpretation and mediation (xviii). This shimmering or fuzzy quality of climate data has consequences for forms of eco-political practice. From there, the second part of this essay will examine another scale-building, relation-building and meaning-making apparatus that differently empowers situated humans and nonhumans. Specifically, I will examine the art/science practices of Natalie Jeremijenko that enrol ecological knowledge technologies, like air quality sensors, to build ecological structures of participation that draw people, technologies and nonhumans together into situated encounters that activate open source, user-generated ecological interpretations and entanglements.

Both of these knowledge practices demonstrate a move in the arts and sciences to build models and apparatuses that communicate a sense that the human is merely one kind of material/semiotic actor among many different kinds of material/semiotic actors, thus alerting knowledge producers of the translations between the biological and the technical, natural and cultural, material and discursive. Whereas climate models work at the scale of the globe and Jeremijenko's ecological modelling practices activate more localised situations, they both work to render sensible aspects of complex ecological situations in ways that challenge traditional science/politics, subjective/objective distinctions. In effect, the knowledge practices I will discuss here contribute to a shift in the way artists and scientists perceive, feel and connect to ecological phenomena in the Anthropocene.

The Challenge of the Anthropocene and Global Warming

Designating a newly proposed epoch of Earth history that follows the Holocene, the Anthropocene was put forward in 2000 by geologists, evolutionary biologists and Earth system scientists to account for their findings that since about the Industrial Revolution, the human species has become a geo-physical force [1] – a geo-physical force producing novel and unexpected Earth system arrangements such as dramatic atmospheric warming, depleted oceans and accelerating rates of species extinctions. [2] More specifically, the extent of erosion and sediment transport associated with anthropogenic processes like agriculture and urbanisation, and the associated anthropogenic environmental conditions such as global warming, ocean acidification and the spread of oceanic "dead zones," along with habitat loss and changes to the chemical composition of the atmosphere, imply the emergence of a geologically novel and environmentally distinct phase of Earth history shaped by human agency and history (Subcommission on Quaternary Stratigraphy).

Not surprisingly, the proposal that a "Human Age" be recognised as an official epoch of geological time has been met with much interest and concern across the sciences, arts, and humanities – and no doubt, the name accounts for much of the term's notoriety. [3] On the one hand, proponents of the Anthropocene proposal, such as those at the Silicon Valley think-tank the Breakthrough Institute, argue that our geo-physical agency can and should be embraced to foster a "good Anthropocene" imaginary marked by planetary stewardship and geo-engineering. [4] While on the other hand, critics of the Anthropocene proposal, such as Eileen Crist and Mark Lynas, argue that naming an epoch of Earth history after "the human anthropos" speaks to our narcissistic desire to see ourselves as "the God species" (Lynas *The God Species*; Crist "On the Poverty"). In opposition to the "good Anthropocene" imaginary, Crist and Lynas want to highlight the point that naming a geological time-scale after "the human" universalises and essentialises the human species as an undifferentiated figure. In so doing, critical attention fails to focus on the historical differences and inequalities (particularly in terms of greenhouse gas production and consumption) that precipitated the ecological crises of the Anthropocene in the first place [5].

A third response to the Anthropocene proposal, also concerned by the "good Anthropocene" rhetoric, highlights the point that the Anthropocene proposal works to direct attention to the myriad of ways that human agency and history are unavoidably bound up with and woven into nonhuman histories and more-than-human agencies. Rather than being the culmination of the history of "Man," theorists like Nigel Clark, Bruno Latour, Donna Haraway, McKenzie Wark, and Timothy Morton show how the Anthropocene epoch is a period where human histories are interrupted by "nonhuman entities that are incomparably more vast and powerful than we are, and [the realization] that our reality is caught in them" (Morton, *Hyperobjects* 130). No longer the background of human projects of world-building, the stories of the Anthropocene speak of an Earth that has intruded onto the scene, interrupting any universalising and human exceptionalist enclosure of "the human anthropos." (for more, see Stengers, "Matters of Cosmopolitics" 176) So even though in name "the Anthropocene" is problematic from numerous gendered, cultural, and geo-political perspectives as it risks universalising and de-historising "the human anthropos," the ecological conditions underlying the Anthropocene render sensible an Earth that, in the words of Isabelle Stengers, is no longer that which rationality conquers, sustainably manages or stewards, nor a unique and wondrous Mother Earth to be revered and pacified, but is "gifted with the daunting powers to dislodge 'us' from our commanding position" ("Matters of Cosmopolitics" 177).

What this anthropo(de)centric line of reasoning emphasises is that in addition to the countless biophysical challenges and social inequalities that characterise the Anthropocene, practices of knowledge and thinking across the arts and sciences are challenged to break from the epistemological and ontological assumptions programmed into subject/object and nature/culture distinctions. Many knowledge practices situated in the humanities and sciences, and built in the

context of the modern, English-speaking University, tend to be deeply rooted in the presupposition that human knowers are the active subjects standing over and against the passive objects and mechanistic processes of nature they want to represent – distance affording them a power to manipulate and intervene in what is seen and known. [6] Yet, as a recent collection of essays on the Anthropocene proposes, "the scale and pace of the shifts occurring on Earth [in the Anthropocene] are beyond human experience and expose the anachronisms of 'Holocene thinking'" predicated on subject/object, nature/culture, and active/passive distinctions (Hamilton et al. *The Anthropocene and the Global Environmental Crisis*). In fact, one reason the Anthropocene and anthropogenic global warming are such significant problems is because their size, scope and scale opens significant gaps between cognition and action, thinking and being, perception and reality – gaps that challenge political epistemologies attempting to treat the ecological crises as a problem to be "handled by the human means at our disposal" (Chakrabarty 3). For Bruno Latour, "the idea of a science that emerges from the dispassionate study of external phenomena is now [in the Anthropocene] much more difficult to sustain" ("Diplomacy in the Face of Gaia" 44), because, as Wark notes, "some neutral, pre-given planetary nature is no longer available as a fiction of the real" ("Climate Science as Sensory Infrastructure").

Therefore, rather than (only) critiquing the way things like science and technology threaten nature, and rather than perpetuating the redemptive myth that human entrepreneurial ingenuity will save a threatened Earth, perhaps what is needed are new methods and approaches to respond to the micro and hyper ecological entanglements of the Anthropocene – entanglements that are not completely amenable to human access and control, manipulation and instrumentality. As noted by Davis and Turpin in the introduction to their book on art in the Anthropocene, "finding new approaches to posing problems is the work of both making art and making theory in the Anthropocene" (7). As such, the challenges of the Anthropocene pose questions about how to ground knowledge claims and compose collective assemblages of enunciation that do not break down along subject/object and nature/culture distinctions.

In the remaining sections of this article, I want to work through two kinds of knowledge projects that respond to these challenges of the Anthropocene. The examples I want to highlight not only represent new information about a world of nature existing outside "the human" but also articulate new modes of thinking and feeling, and evoke new regimes of sensibility for an Anthropocene epoch. As such, my focus will be on knowledge production practices spanning the arts, sciences and humanities that lead to alternate worldly stories, entanglements and becomings. As an example of this, I will reference the work of Natalie Jeremijenko, but first I will use the work of science studies scholar Paul Edwards as a relay to situate some of the parameters conditioning ecological knowledge in the Anthropocene.

Collaborative Ecological Modelling and Knowledge Infrastructures

Paul Edwards' 2013 book, *A Vast Machine: Computer Models, Climate Data and the Politics of Global Warming*, is a history of the production of what he calls a global climate knowledge infrastructure that has reliably rendered anthropogenic global warming as a matter of scientific, political and popular concern. This global climate knowledge infrastructure, as noted by Edwards, "delivers not only specifics about the past and likely future of Earth's climate, but also the very idea of a planetary climate as something that can be observed and understood, affected by human wastes, debated in political processes" (8). That is, the novel achievement of this historically specific knowledge apparatus is its ability to render sensible the changing aspects of the climate at a global and planetary scale, while at the same time becoming a key apparatus translating the global climate into public attention and political discourse.

For Edwards,the success of this climate knowledge infrastructure is that through negotiations and collaboration, actors from diverse scientific and political institutions have been able to knot and link particular scientific networks, epistemic communities and technological systems into a sturdy tapestry of humans and nonhumans, knowledge and materials, science and politics, that reliably

attest to an ongoing state of affairs that is global. As noted by Edwards, the climate simulation models that animate this knowledge infrastructure are the product of a vast "sociotechnical system that collects data, models physical processes, tests theories, and ultimately generates a widely shared understanding of climate and climate change" (8). Edwards goes on to suggest that the global climate knowledge infrastructure is "made up of many interlocking technical systems representing many links and layers of systems and structure [that connect] a vast array of knowledge producers [that] bring their disparate methods and products to bear on a common project" (xvi-xvii).

Being the product of collaborative, cross-disciplinary practices of interpretation and mediation, calibration and re-calibration, climate models do not provide unmediated, direct access to the climate as a thing-in-itself. One achievement of Edwards' book is to show that there is no such thing as a "pure climate simulation" if what is meant by "pure" are simulation models free of mediation, interpretation and politics (xiii). Bruno Latour has written extensively on this practice of climate change knowledge production. "The reason," Latour argues, "it is so important to stress this slow, tapestry-weaving process of calibration, modelling and reinterpretation is because it shows that even for the climate scientists there is no way to measure up *directly* with the Earth" ("Waiting for Gaia" 6). Climate models, therefore, are highly mediated compositions fabricated from specific kinds of data sets, collected according to specific methods, by specific scientists, in specific institutions. "The climate knowledge infrastructure," Edwards notes, "is constantly opening itself up, re-examining every datum and data set, [and] adding to its metadata. Over time, countless iterations of that process have brought us shimmering data, an ever-expanding collection of global data images that will keep on growing, but never resolve into a single definitive record" (xviii).

This does not mean that climate models are merely social constructions that tell us nothing objective about the world. Rather, the global perspective opened by such models is the product of an immense effort of composition and construction linking heterogeneous, time-scale varying and dynamically interconnecting global environmental and socio-technical systems. There is no unifying, authoritative view on the "globe" authorising clear political prescriptions because no amount of data collection and data input will be enough to get the global climate simulations "total" or "right." Climate simulation models will always be haunted by the noise of uncertainty. For Latour:

> [If] climate scientists have been able to obtain a "global" view, it is because they managed to build more and more powerful models able to recalibrate data points elicited from more and more stations or documents – satellites, tree rings, logbooks of navigators dead long ago, ice cores, and so on. Interestingly enough, this is exactly what leads the climate-deniers to their denials: they find this knowledge too indirect, too mediated, too far from immediate access…. They are incensed to see that no data point in itself has any sense, that those data all need to be recalculated and reformatted. ("Waiting for Gaia" 6)

There are many ways of reading Edwards' informative book. For example, it can be read as a document contributing to current debates about climate denialism, and situated in relation to discussions about the extent people choose to believe in climate science or not. Yet in a more speculative mode, I cannot help but think of a future where Edwards' book would be read as a historical document attesting to a specific constellation of climate knowledge that will be, for future readers, quite different. That is, the book can be read as a document attesting to a specific arrangement of global climate knowledge prior to being enclosed into matters of fact, and articulated as problems that speak primarily to top-down policy makers, bureaucratic eco-stewardship initiatives, or in terms that conform to socio-economic parameters of reason and progress (with recourse to geo-engineering being the logical and inevitable next step). Isabelle Stengers, in particular, has documented how this future history is already being written into the narratives orienting much climate research [7].

Taking up this issue, Natalie Jeremijenko points out that in response to administrative, electoral and policy demands requiring clear and definitive predictions on the future of global climate change, state and inter-governmental agencies are increasingly mandating heavily regulated compliance protocols dictating what data is to be collected, how it is to be collected, and by whom. In effect, this encloses and reduces ecological rendering and visualisation practices. As Jeremijenko points out, many state-run environmental institutions, like the U.S. Environmental Protection Agency, too often attempt to mechanically eliminate the shimmering and fuzzy contingencies in climate knowledge (Jeremijenko & Bratton 16-17). For Jeremijenko, it is important:

> to understand that environmental data is mainly collected in response to regulatory compliance issues. This means that data is being collected by hired engineering firms or staff, not by people who have a professional reputation invested in what that data means or why it is being collected [as do academic climate scientists, for example]. (Jeremijenko & Bratton 17)

My point is not to challenge the production of reliable knowledge able to resist multiple challenges and objections, but that the plurality of divergent matters of concern connected to the climate knowledge infrastructures documented by Edwards are at risk of being captured and enclosed by a polemical power of Truth that separates what "really" objectively matters to ecological questions, and what ultimately can be eliminated as inconsequential, subjective and irrational (for more, see Stengers, "Matters of Cosmopolitics" 176-178). It is not that plans to intentionally engineer the Earth's atmosphere as a means to offset the negative impacts of global warming are imminent, but geo-engineering is quickly becoming a realistic ecological response to climate change. Stengers, a trained chemist and science scholar, notes:

> [S]ince the nineteenth century, the sciences have become "fast" sciences, with researchers regarding whatever concerns that do not directly contribute to "the advancement of knowledge" as a sinful waste of time.… The apotheosis of this paradigm is geo-engineering, the mobilization of technology against the Earth, a mobilization that both preserves and presupposes a human exceptionalist and anthropocentric imaginary. ("Deleuze and Guattari's Last Enigmatic Message" 153)

Rather than relying on ready-made solutions predicated on the "human control over nature" and/or the "human protection of nature," what may be needed is the deterritorialisation of these refrains, a deterritorialisation that activates different kinds of relation and connection-making practices. The question then becomes about the cultivation of structures of participation that gather humans and nonhumans together around a situation that demands thought, care, and what Haraway calls response-abilities, but is irreducible to hard distinctions between experts and non-experts, science and politics, subjects and objects, human and nonhuman [8]. The point, therefore, is "making present, vivid and mattering, the imbroglio, perplexity and messiness of a worldly world, a world where we, our ideas and power relations, are not alone, were never alone, will never be alone" (Stengers, "Wondering about Materialism" 371). In order to do so, I will end this paper by turning to the art/science practices of Natalie Jeremijenko.

Structuring Ecological Participation

Jeremijenko foregrounds fuzziness, noise and instability as a means to gather wider non-expert communities and nonhuman actants into situated meaning-making and relation-making practices that are irreducible to nature/culture, subject/object, expert/non-expert, and virtual/actual distinctions. Trained in neuroscience, engineering and biochemistry, and coupled with her work as an artist and environmental health activist, Jeremijenko describes herself as a "thingker" ("The Q and A"). Combining "things" with "thinking," her focus as a "thingker" is to think with and through things. To this extent, Jeremijenko challenges the traditional humanist distinction separating thinking and things, subjects and objects, that positions thought and knowledge as

disconnected mediums that reflect and represent natural objects "out-there." Thingking, therefore, can be seen as a collaborative and de-centering practice that works to dislodge knowledge producers from an elevated, commanding position, and thus giving to situations and nonhuman actants a power or agency to challenge well-defined categories and structures of participation (Stengers "Wondering about Materialism" 373).

Jeremijenko's strength is to craft structures of participation that do not dictate or prescribe modes of thinking and action, and they do not merely de-stabilise human perspectives as an end-in-itself. Rather, by working to activate ways for people to figure out how to respond to situated ecological processes and nonhuman actors, her projects are constructive, relational and compositional. In an interview, Jeremijenko argues:

> [A] radical way to redesign socioecological systems is to understand that we are designing within complex [human/nonhuman] systems, and we have very specific opportunities that we can use and exploit that require participation, not fascist bullying, and engaging the imagination. I know it works to engage people's imagination. (Pompilio)

The point (as shown by Edwards) is to evoke the fact that the information visualisation technologies working to model and simulate ecological situations, like the changing climate, "throw up a lot of data and suggest that the sense is self-evident! It's not!" (Jeremijenko & Bratton 50).

Jeremijenko has worked on numerous projects spanning the arts and sciences, but I am only going to focus on the project called "OneTree(s): An Information Environment – Replicating Paradox Trees and Simulating A-trees." [9] The OneTree(s) project is an exhibition and public art installation composed of 1000 genetically identical cloned trees that were planted throughout the San Francisco Bay area in 2004 (planting sites include Golden Gate Park, 220 private residences, public schools, and a range of others). The point of the project was and remains to evoke the different environmental conditions or micro-ecologies that are impacting the growth of genetically identical trees. Because the trees are genetically identical, the growth of the trees over subsequent years will render sensible the situated ecological differences that the trees are subjected to. In effect, the cloned trees bear witness to the environmental stressors operating in particular socio-environmental neighbourhoods. Jeremijenko suggests that "the biological sameness of the trees will render both the environmental and social differences to which they are exposed. The trees will become evidence, witness, and mediator of these differences" ("Sites and Ecosystems"). To this end, the genetically identical trees act as ecological diplomats bearing witness to the diverse socio-environmental topographies populating the San Francisco Bay area, allowing residents to witness and ask questions about the environmental health of particular neighbourhoods. By evoking the impact that widely different socio-ecological contexts have on environmental health, and how genetically identical trees respond differently to the same socio-ecological contexts, Jeremijenko presents abstract and global environmental problems in immediately observable and situated ways. The wager is the following:

> [If] we have trees with precipitation sensors and soil moisture sensors and particulate matter sensors making explicit some of the environmental variables to which they are exposed, we would therefore somehow be able to make better sense of those trees. (Jeremijenko & Bratton 12)

Stengers' thought is helpful in getting at what is going on here. Jeremijenko's structures of participation, including OneTree(s), "do not dictate, but [rather] 'call', and the call always requires the elucidation of the concrete meaning of the situation for the person exploring it" (Stengers, *Thinking With Whitehead* 249). OneTree(s) is an apparatus designed to give the trees "the power to cause us to think, feel and wonder, the power to have us wondering how practically to relate to [them], how to pose relevant questions about [them]" (Stengers "Wondering about Materialism"

374). Like all of Jeremijenko's projects, OneTree(s) is about responding to and transfiguring concrete situations that the trees evoke or activate. It is about responding, relating and connecting to situations, configurations and agencies that the trees bring to bear on the experience of situated human participants. The goal is to have the different life courses of the genetically identical trees provoke thought, discussion, criticism, debate, and questioning.

Doubling the cloned biological trees discussed above is a collection of online virtual e-trees created using some of the same computer algorithms and programming software used by climate change scientists to model climate change. People can download from the OneTree(s) website open-source software to "grow" a virtual "graft" of the cloned biological tree planted around San Francisco. Therefore, not only is the OneTree(s) project composed of 1000 cloned trees planted in San Francisco, but also contains an indefinite number of virtual e-trees "grown" in online virtual environments around the globe. A key aspect to the e-trees is the injection of "real-world" contingency into the virtual models. By doing so, Jeremijenko aims to compose knowledge production practices built around human/nonhuman interaction that provides a more situated and collaborative way of conceiving and interpreting ecological information. To inject contingency into the virtual growth of the e-trees, Jeremijenko provided participants with carbon dioxide sensors that can be attached to the serial port of personal computers to measure real time carbon dioxide concentrations. These situated carbon dioxide readings are then fed into the algorithms modelling the growth of the virtual trees (Jeremijenko "Artificial Trees & Artificial Life").

Discussing the OneTree(s) project with media theorist Benjamin Bratton, Jeremijenko argues:

> [W]ith the collision in the public imagination of the environmental climate destabilisation and environmental concerns more generally, there is suddenly a utopian idea that we can use these new [environmental] technologies and sensors and visualization techniques to address pervasive environmental issues with pervasive computation. (Jeremijenko & Bratton 10)

She is quick to point out the valuable and important work these models do in helping provide an understanding of global warming, but argues that producing a "nice diagram is not all that is required in making sense of something" (Jeremijenko & Bratton 12). She adds that her "intuition is that there is a better sense to be made, one that is more robust, one that can be challenged. Not just better sensors but better sense-making" (Jeremijenko & Bratton 49). The problem here is not the climate models and the work they can do, but the theory of knowledge and structure of participation contextualising how these models are too often interpreted and read. In agreement with both Paul Edwards' argument and many practicing climate scientists, virtual modelling and information visualisation projects should not be read as part of a progressive narrative where expert subjects (i.e. scientists) acquire more and more of the right data from nature allowing models to eventually become full, self-evident representations of the thing being modelled.

In the words of Bratton, Jeremijenko aims to:

> [T]ake a step back and look again at the promise suggested by ubiquitous computing in relation to the climate crisis and other environmental concerns, [and] the assumption that these [issues] can be solved by blanketing the world with sensors, and that we would somehow address environmental issues at the largest scale directly and effectively. (Jeremijenko & Bratton 34)

Jeremijenko's work with OneTree(s) explicitly aims to overcome this felt distance between situated individuals and global ecological issues by creating ecological structures of participation that craft connections and relations between humans and nonhumans in ways that activate practice, questions, thinking and wondering. Her ecological structures of participation lure into being situated connections, entanglements and configurations that are not imposed by "expert"

knowledge communities. The following passage is key to understand what Jeremijenko is after: "[W]hat I see and in many senses try to instantiate in particular examples is the capacity to change the structure of participation: who is producing the data, who is interpreting that data, and who can do something with that data" (Jeremijenko & Bratton 21).

To this extent, Jeremijenko's use of carbon sensors, virtual information modelling programs and other kinds of ecological technology is to create alternative data collection practices that activate a "diverse [ecological] citizenry" (Jeremijenko & Bratton 21). The goal, therefore, is to have nonhuman actants, like carbon dioxide and the different growth patterns of cloned trees, come alive with information in new ways, giving these ecological actants very situated voices that require the demanding work of interpretation and relation-building. Jeremijenko is "trying to imagine the possibility of extrapolating new forms of political institutionalization on the basis of computational technologies that we both discover and invent, including computers that look like trees" (Jeremijenko & Bratton 16). Jeremijenko creates structures of participation that invite participants to build relations between, for example, "this" tree in "that" park impacted by "those" specific pollutants.

To this extent, I believe a good way of evaluating and approaching Jeremijenko's work is not whether it will "fix" our ecological problems, but by asking, with Haraway (commenting on the work of Katie King), "how well it learns and models how to be affected or moved, how well it opens up unexpected elements of one's own embodiments in lively and re-sensitizing worlds" ("SF: Science Fiction, Speculative Fabulation"). Going beyond structures of participation aiming to "fix" nature or "save" nature, Jeremijenko's strength, as pointed out by Bratton, is to ask:

> [H]ow it is that we may sense the world, or how *the sensibility of the world might be distributed* … and activated to become part of the way the commons understands and narrates itself. It is not only an image, like a propaganda poster, it is a tool for a politics that doesn't yet exist. (Jeremijenko & Bratton 37)

By way of a conclusion, I want to return to the question of the production of knowledge practices to think, feel and imagine forms of ecological co-existence in the Anthropocene. These kinds of knowledge, thinking, relation and sense making practices I have discussed add reality to situated matters of concern, they are worlding practices that deflect anthropocentric narratives that work to subtract and eliminate what complicates the heroic tales situating a universal "we" of all humanity. These knowledge practices world "us", humans and nonhuman situated in the Anthropocene, as a multi-species achievement, luring thinking and sense-making practices into a place not of self-certainty or cynical detachment, but of wonder, creativity and sincerity. Jeremijenko's work provides "us" thinkers, knowledge producers and story-tellers situated in the Anthropocene with grappling hooks to think-with situated ecological questions. In the end, these knowledge practices are a pragmatic challenge that entails not fairy tales about an idealised past nature, but rather, to paraphrase Stengers ("Matters of Cosmopolitics: On the Provocations of Gaïa"), an ongoing care and concern for the fragility of the assemblage, and for the maintenance of what is always a more-than-human interdependence.

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Endnotes

1. Dating the start of the Anthropocene to the beginning of the Industrial Revolution and the invention of the steam engine has been one of the key debates animating the Anthropocene proposal. For an informative overview of this debate about periodising the Anthropocene, see Hamilton, Gemenne, and Bonneuil, *The Anthropocene and the Global Environmental Crisis* 1-14.

2. For more on the Anthropocene, see Clark 19-37; Crutzen 23; Crutzen & Schwägerl; Crutzen & Stoermer 17-18; Zalasiewicz et al. 2228-2231; Zalasiewicz & Williams 4-8; Yusoff 779-795.

3. The popular science journal *Nature* recently published a feature article titled "Anthropocene: The Human Age," see Monastersky.

4. For a compelling introduction to the Breakthrough Institute and their notion of the "good Anthropocene," see their *An EcoModernist Manifesto* 1-32; or Ellis "The Anthropocene: A Man-Made World." For a critical reaction to the "good Anthropocene," see Hamilton "The New Environmentalism Will Lead Us to Disaster."

5. For more critical perspectives on the Anthropocene, see also Hamilton "The Technofix Is In"; Malm & Hornborg 62-69; Rigby 1-12.

6. For a key text focusing on the intersection of vision, distance and power, see Haraway 575-599.

7. See Stengers, "Matters of Cosmopolitics: On the Provocations of Gaïa"; and Machin, *Negotiating Climate Change*.

8. For more on response-abilities see Haraway *When Species Meet*, or Despret 51-76.

9. For more on Jeremijenko's diverse work, see work on her "Environmental Health Clinic," as well as the "Feral Robotic Dogs" and "Goosespeak" projects.

Works Cited

Breakthrough Institute. "An Ecomodernist Manifesto." *The Breakthrough*. <thebreakthrough.org/index.php/voices/michael-shellenberger-and-ted-nordhaus/an>

Chakrabarty, Dipesh. "Climate and Capital: On Conjoined Histories." *Critical Inquiry* 41.1 (2014): 1–23.

Clark, Nigel. "Geo-Politics and the Disaster of the Anthropocene." *The Sociological Review* 62.1 (2014): 19–37.

Crist, Eileen. "On the Poverty of Our Nomenclature." *Environmental Humanities* 3 (2013): 129–147.

Crutzen, Paul. "Geology of Mankind." *Nature* 415 (2002): 23.

Crutzen, Paul, and Christian Schwägerl. "Living in the Anthropocene: Towards a New Global Ethos." *Environment 360* (2011). <e360.yale.edu/feature/living_in_the_anthropocene_toward_a_new_global_et hos/2363/>

Crutzen, Paul, and Eugene. F. Stoermer. "The 'Anthropocene.'" *Global Change Newsletter* 41 (2000): 17–18.

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

Despret, Vinciane. "Responding Bodies and Partial Affinities in Human-Animal Worlds." *Theory, Culture & Society* 30.7/8 (2013): 51–76.

Edwards, Paul. *A Vast Machine: Computer Models, Climate Data, and the Politics of Global Warming* . Cambridge, Massachusetts: The MIT Press, 2013.

Ellis, Erle. "The Anthropocene: A Man-Made World." *The Economist* 26 May 2011. <www.economist.com/node/18741749>

Hamilton, Clive. "The New Environmentalism Will Lead Us to Disaster." *Scientific American* 19 Sept. 2014. <www.scientificamerican.com/article/the-new-environmentalism-will-lead-us-to-disaster/>

---. "The Technofix Is In: A Critique of 'An Ecomodernist Manifesto.'" *Earth Island Journal* 21 Apr. 2015. <www.earthisland.org/journal/index.php/elist/eListRead/the_technofix_is_in/>

Hamilton, Clive, Christophe Bonneuil, and François Gemenne. "Thinking the Anthropocene." *The Anthropocene and the Global Environmental Crisis: Rethinking Modernity in a New Epoch*. Eds. Clive Hamilton, François Gemenne, and Christophe Bonneuil. New York: Routledge, 2015. 1–14.

Hamilton, Clive, François Gemenne, and Christophe Bonneuil, eds. *The Anthropocene and the Global Environmental Crisis: Rethinking Modernity in a New Epoch*. New York: Routledge, 2015.

Haraway, Donna. "SF: Science Fiction, Speculative Fabulation, String Figures, So Far." *Ada: A Journal of Gender New Media & Technology* 3 (2013).

---. "Situated Knowledges: The Science Question in Feminism as a Site of Discourse on the Privilege of Partial Perspective." *Feminist Studies* 14.3 (1988): 575–599.

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

Jeremijenko, Natalie. "Artificial Trees & Artificial Life." *OneTrees: An Information Environment*. <www.nyu.edu/projects/xdesign/onetrees/atrees/index.html>

---. "Environmental Health Clinic Introduction." The Environmental Health Clinic, New York University. <www.environmentalhealthclinic.net/environmental-health-clinic>

---. "Feral Robotic Dogs: Mission Statement." <www.nyu.edu/projects/xdesign/feralrobots/projectindex.html>

---. "Feral Robotic Dogs (project Website)." <www.nyu.edu/projects/xdesign/feralrobots/>

---. "Goosespeak': Human Goose Interface." <www.nyu.edu/projects/xdesign/ooz/>

---. "Sites and Ecosystems." OneTrees: An Information Environment. <www.nyu.edu/projects/xdesign/onetrees/ecosystems/index.html>

---. "The Q&A: Natalie Jeremijenko, Thingker." *The Economist* 20 Sept. 2010.

<www.economist.com/node/21010968/print>

Jeremijenko, Natalie, and Benjamin Bratton. "Suspicious Images, Latent Interfaces." *The Architectural League of New York: Situated Technologies Pamphlets 3* (2008): 6– 53.

Latour, Bruno. "Diplomacy in the Face of Gaia: Bruno Latour in Conversation with Heather Davis."

Art in the Anthropocene: Encounters Among Aesthetics, Politics, Environments and Epistemologies. Ed. Heather Davis and Etienne Turpin. London: Open Humanities Press, 2015. 43–56.

---. "Waiting for Gaia. Composing the Common World through Arts and Politics." *Bruno Latour*. (2011).
<www.bruno-latour.fr/sites/default/files/124-GAIA-LONDON-SPEAP_0.pdf>

Lynas, Mark. *The God Species: How the Planet Can Survive the Age of Humans*. London: Fourth Estate Books, 2011.

Machin, Amanda. *Negotiating Climate Change: Radical Democracy and the Illusion of Consensus*. New York: Zed Books, 2013.

Malm, Andreas, and Alf Hornborg. "The Geology of Mankind? A Critique of the

Anthropocene Narrative." *The Anthropocene Review* 1 (2014): 62–69.

Monastersky, Richard. "Anthropocene: The Human Age." *Nature* 519. (2015). 144-147.
<www.nature.com/news/anthropocene-the-human-age-1.17085>

Morton, Timothy. *Hyperobjects: Philosophy and Ecology After the End of the World*. Minneapolis: University of Minnesota Press, 2013.

Pompilio, Natalie. "Robot Dogs and Other Weird Creatures Bring Nature to the City: How to Create a World Where People Fly, Salamanders Text, and Trash Is Useful." *YES! Magazine. Powerful Ideas, Practical Actions* Winter 2013.
<www.yesmagazine.org/issues/what-would-nature-do/shocking-the-big-city-with-a-little-green-grass>

Rigby, Kate. "Writing in the Anthropocene: Idle Chatter or Ecoprophetic Witness?" *Australian Humanities Review* 47.1 (2009): 1–12.

Stengers, Isabelle. "Deleuze and Guattari's Last Enigmatic Message." *Angelaki* 10.2 (2005): 151–167.

---. "Matters of Cosmopolitics: On the Provocations of Gaïa: Isabelle Stengers in Conversation with Heather Davis and Etienne Turpin." *Architecture in the Anthropocene: Encounters Among Design, Deep Time, Science and Philosophy*. Ed. Etienne Turpin. University of Michigan Library, Ann Arbor: Open Humanities Press, 2013. 171–182.

---. *Thinking With Whitehead: A Free and Wild Creation of Concepts.* Trans. Michael Chase. Cambridge, MA: Harvard University Press, 2011.

---. "Wondering about Materialism." *The Speculative Turn: Continental Materialism and Realism*. Eds. Levy Bryant, Nick Srnicek and Graham Harman. Melbourne: Re.Press, 2011. 368–380.

Subcommission on Quaternary Stratigraphy / International Commission on Stratigraphy, 2015. Working Group on the "Anthropocene." *What Is the "Anthropocene"? Current Definition and Status*.

<quaternary.stratigraphy.org/workinggroups/anthropocene/>

Wark, McKenzie. "Climate Science as Sensory Infrastructure." *The White Review* Aug. 2014. <www.thewhitereview.org/features/climate-science-as-sensory-infrastructure/>

---. "Molecular Red: Theory for the Anthropocene (On Alexander Bogdanov and Kim Stanley Robinson)." *e-flux* Mar. 2015. <www.e-flux.com/journal/molecular-red-theory-for-the-anthropocene-on-alexander-bogdanov-and-kim-stanley-robinson/>

Yusoff, Kathryn. "Geologic Life: Prehistory, Climate, Futures in the Anthropocene." *Environment and Planning D: Society and Space* 31 (2013): 779–795.

Zalasiewicz Jan, Mark Williams, Will Steffen and Paul Crutzen. "The New World of the Anthropocene." *Environmental Science and Technology* 44.7 (2010): 2228–2231.

Zalasiewicz, Jan, and Mark Williams. "Are We Now Living in the Anthropocene?" *Geological Society of America (GSA) Today* 18.2 (2008): 4–8.