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Environmental Technology and the Absence of Maintenance

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Abstract: This article considers the general absence of the theme of maintenance in environmental ethics and philosophy. Despite an environmental orientation at least partially motivating much of the growing literature on repair and maintenance, there is a lack of work that brings environmental topics, sites, applications, or infrastructures under direct consideration. I interrogate why the notion of maintenance is missing from environmental ethics and philosophy, eventually arguing that the way technologies have been conceptualized in the environmental ethics and philosophy literature precludes the possibilities of maintenance in two ways. I suggest that maintenance is a promising and apt lens for thinking through human-environmental relationships, which are ongoing, co-constructive, and laborious.

Key words: Maintenance, environmental philosophy, environmental technologies, Anthropocene, intervention

Introduction

The growing literature on maintenance and repair is associated with, and at least in part motivated by, environmental concerns. Early, stage-setting work by Stephen Graham and Nigel Thrift rightly points out "a multiscaled environmental politics" (2007, 18) in the context of maintenance, specifically surrounding and determining possibilities for the recycling, repair, and reuse of technologies ranging from consumer commodities to large-scale infrastructures. Steven Jackson's now widely cited frame for theorizing technology and repair, "broken world thinking," responds to the fragility and instability of a world that is "almost-always-falling-apart," and where "old socio-natural bets are off" (2014, 221–22). Other authors have pointed to the advent of the Anthropocene as a critical moment for thinking

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about repair and planetary maintenance (McLaren 2018; Zwier 2024) and for examining the ongoing labor involved in maintaining infrastructure and reproducing other social and more-than-human-relations (Corwin and Gidwani 2021).

Given that environmental concerns, broadly speaking, motivate interest in maintenance and repair, there is surprisingly little work in the emerging subfield of maintenance and repair studies[1] that brings *environmental* topics, sites, or applications under direct consideration. In a literature that focuses so frequently on cases and material sites while attending to the functioning and malfunctioning of the built environment and environing world, it is striking that environmental cases are largely absent. Instead, the focus is human systems, infrastructures, and technologies, without much attention to the nonhuman world or to the ways that human systems, infrastructures, and technologies relate to and together comprise this world. An example illustrates this divergence: conservation, in environmental ethics, is a key theme, relating to the preservation of nonhuman species and biodiverse places. In the context of the maintenance literature, however, "conservation" refers to the conservation[2] of historic buildings, heritage sites, and other old artifactual things that require skill and expertise to repair and maintain (Jones and Yarrow 2013; Tait and While 2009). In maintenance and repair studies, conservation connects to place and human work over time in ways very distinct from conservation in an environmental ethical context.

Other work that focuses on ideas of repair is broadly environmentally concerned, especially through the lens of consumption as environmentally degrading. The design of systems and goods that eschew or foreclose maintenance is criticized for advancing a throwaway culture (Weber and Krebs 2021) that disempowers and deskills human agents, reproduces uneven and colonial power arrangements (Beckett and Keeling 2019) and poses environmental threats by squandering resources and creating vast amounts of waste (e.g., Crosby and Stein 2020; Henke and Sims 2020; Houston and Jackson 2016). While these themes relate to the environment as they highlight the environmental, social, and other consequences of non-repair-oriented attitudes, lifestyles, and practices, they again do not focus squarely on environments, either built or non-built, as sites of maintenance or repair, or on artifacts or technologies with clear environmental relation.

One important exception is Christopher R. Henke, whose work on infrastructure, the built environment, and repair takes an explicitly environmental and sometimes ecological focus. Henke highlights the built environment as a meeting of the human and nonhuman, "a complex ecology of culture, practice, and materiality" (2007, 137), and he attends to the ways that infrastructures shape how people

encounter and are involved in the world around them. While notions of repair and maintenance are sometimes lauded in the broader maintenance literature as signaling hope, resourcefulness, and care, Henke's work complicates this picture by attending to the power relations that infrastructures instantiate and reproduce. Additionally, infrastructures, by enabling humans to manage, intervene in, and exploit Earth's resources on a global scale, are increasingly suspect as human activities are recognized as unsustainable. Thus, for Henke and Sims (2020), given the mounting environmental crises, repair is too uncritical. They write: "If we are at a point in human history when maintaining our existing infrastructures might lead to our very extinction, we face a paradox centered on repair: Can we repair infrastructural repair itself?" (Henke and Sims 2020, 122). Their answer is yes, repairing repair, what they term "reflexive repair," enables a critical stance that requires ongoing attention to that which repair perpetuates and upholds and that which needs transformation rather than maintenance.

Henke's work is helpful here for establishing links between infrastructure, local and global environments, sustainability, and maintenance. He and Sims also bring in the notion of the Anthropocene, which, as I argue later, represents a key dimension of the technologies typically considered 'environmental.' But Henke's work notwithstanding, I return to my initial observation and raise it as a question—why is there almost no literature on maintenance and the environment? Are environmental topics not pertinent to maintenance? Is there something about environmental topics, technologies, and cases that fail to coincide with maintenance? This paper takes these questions as a point of departure. In parts 1 and 2, I interrogate why the notion of maintenance is missing from environmental ethics and philosophy and what this absence means. By studying the absence of maintenance, I bring the key commitments and orientations of these fields into sharper focus. I argue (2.1) that the way technologies have been conceptualized in the environmental ethics and philosophy literature precludes the possibilities of maintenance. This framing shows an uneasiness with human involvement in the world within environmental ethics and philosophy, an orientation that is at odds with maintenance and thinking through technologies over time. Through the analysis in sections 1 and 2, some of the affordances of maintenance become apparent, but in the paper's final section, (3), I argue that maintenance is a promising and necessary lens for thinking through human environmental relationships, which are ongoing and laborious.

1. The Missing Notion of Maintenance: Technological Aversion in Environmental Ethics

There are two reasons I suspect for the maintenance/environmental lacuna observed in the opening of this paper. The first I will discuss briefly, and the second will be the main inquiry in the paper's second section. Both connect to the relation of maintenance to the technological, although I make my inquiry through environmental ethics and philosophy.

The first reason for this absence relates to the respective orientations of maintenance and repair studies and environmental ethics and philosophy. Where maintenance and repair studies takes artifacts, technologies, and their continued use as its objects of focus, environmental ethics and philosophy have historically been oriented toward nature and the natural. Environmental philosopher Warwick Fox observed this emphasis in environmental ethics more than ten years ago, even as the field was broadening to contemplate the built environment:

> [E]nvironmental ethics, as a formal field of enquiry, has been overwhelmingly focused upon the spontaneously self-organising, 'natural' environment, as opposed to the humanly created, or intentionally organised, *built* environment. It seems, then, that *environmental* ethics has not yet truly earned the name that it presently goes under. (Fox 2012, 2, emphasis in original)

Indeed, many of the field's long-standing debates pit the natural against the artifactual (Elliot 1982; Lo 1999; Brennan 1984; Siipi 2008; Katz 2015), which has contributed to a generally technology averse stance in this field.[3] For many environmental ethicists, preserving nonhuman nature is best accomplished by excluding human presence, intervention, and design. Even environmental ethicists who do not take so hard a line generally eschew the artifactual and technological in favor of nonhuman nature and the natural.[4] Given such commitments to the 'spontaneously self-organizing, natural,' i.e., nonhuman environment, it is hard to see where or how maintenance would even occur as a theme. Maintenance, I suspect, is simply too closely associated with the realm of human making and contriving to be taken up by those concerned mostly with questions of the value and protection of nonhuman nature.

However, the idea of *management*, features much more commonly in environmental ethics and philosophy. This too is the subject of much disagreement, and considerable literature focuses on questions as to how nature and natural resources, ecosystems, and wilderness should or should not be managed. The adjacent fields

of conservation biology, ecology, and other environmental sciences deal explicitly with the science and strategies of managing nature and natural resources. How does management differ from maintenance? At least as far as these disciplinary divisions are concerned, this distinction seems to be an orientational issue that considers *resources*[5] to be the kinds of things that are managed and *technologies and artifacts* to be the kinds of things that are maintained. Management connotes a greater autonomy, or otherness, of the nonhuman component, implying a role for human stewardship or design, but only to a limited extent.[6] Maintenance, by contrast, suggests a greater capacity for and more exacting level of control. As environments and nature have been conceptualized more in terms of resources than of technology, literature dealing with them does so through the notion of management rather than maintenance. This, I suggest, partially explains why maintenance has not featured in environmental ethics and philosophy: the non-technological orientation of these fields has resulted in the prevalence of *management*, instead of maintenance, when human intervention and intentions are involved in the nonhuman world.[7] In the next section, I provide the second, and what I take to be the more important reason, for the maintenance/environmental lacuna.

2. Environmental Technologies—Lee and Preston

Despite the prevailing non-technological orientation in environmental ethics and philosophy, there are, nevertheless, technologies taken to be *environmental technologies,* which have gained increasing attention in these literatures in recent decades. Two authors, Keekok Lee and Christopher Preston, are central if we are to understand which technologies count as *environmental* and which do not. To be clear, my aim in this section is not to defend the categorization(s) that Lee or Preston advance or the distinctions and arguments involved therein; I intend only to describe what they, respectively, have proposed. My claim is that their categorizations have influenced the kinds of technology that have come to be understood as environmental, even though neither Lee nor Preston advanced this designation *per se*.

In her book, *The Natural and the Artefactual* (1999), philosopher Keekok Lee differentiated problematic environmental technologies into two kinds, based on their respective ways of relating to nature.[8] Lee observed that, by the end of the twentieth century, technologies that consumed or degraded the environment had received the most attention from environmental ethicists and others concerned about the environment. In Lee's terms, these *nature polluting technologies* included things like chemical compounds, such as DDT or CCFs, introduced to the

environment either intentionally or as byproducts; other water and air pollutants; and technologies that generally resulted in climate change or biodiversity loss. *Nature polluting technologies* are then, as the term suggests, things that pollute or otherwise harm nature through the "adverse impacts" (Lee 1999, 107) introduced by their use.

Lee was more concerned, however, about technologies of the second kind, what she termed *deep technologies*. According to Lee, *deep technologies* are so called for their ability to interfere with or replace nature: technologies with the (potential) ability to "transform the natural to become the artefactual" (1999, 107). Deep technologies, like nanotechnology and terraforming, involve a novel synthesis, by humans, of entities that had previously only ever been natural in origin. Novel artifacts, created by humans, could replace or supersede natural kinds, and, by changing the physical world, would also challenge the conceptual categories of the natural and the artifactual. According to Lee: "[deep technologies] pose seriously the radical possibility of technology transforming the natural to become more or less totally the artefactual" (1999, 115).

The distinction that Lee draws between these two types, and the assumptions underlying her categorization, has been contested (C.J. Preston 2008; Vogel 2015; B. Preston 2013). But her work, and this distinction specifically, has been decisive in shaping what environmental philosophy and ethics take to be environmental technologies. We can see this most clearly in Christopher Preston's work, which is directly informed by Lee and offers the most developed account of what I take to be environmental technologies in this literature.

However, neither Preston nor Lee use the term 'environmental technologies'; Preston instead introduces 'Anthropocene technologies,' which are technologies through which humans intentionally intervene in and alter fundamental (natural) biotic or abiotic Earth processes.[9] As with Lee's *deep technologies*, Anthropocene technologies involve change at a fundamental level: Preston uses metaphors like altering, taking control of the Earth's "metabolism" (2017), or rearranging the fundamental building blocks of life (2018) when describing Anthropocene technologies. Nanotechnology provides a prime example. Following Preston, nanotechnology "attempts an unprecedented rearrangement of the materials that nature provides [. . .] allow[ing] our species to insert itself into the very nature of matter in a way that humanity has not done before" (2018, 17). Whereas Lee was more concerned with the artifactual replacing the natural, Preston is more concerned with human tinkering with nature and attempts to redesign it.

There are three features I suggest we should pay attention to in order to understand the significance of Anthropocene technologies for representing what technologies we count as environmental. First is what Preston himself highlights: the depth, or fundamental nature of the intervention that Anthropocene technologies introduce. Like Lee observed, these kinds of technologies cannot be aptly characterized in terms of a superficial impact on the environment; rather they are involved in altering nature in a more elemental way. Second, for Preston, these interventions are novel or unprecedented. Third, they are intentional. Humans have altered key Earth processes, even on a planetary scale (e.g., nitrogen and carbon cycles) through historic and present-day activity, but what makes Anthropocene technologies different, on Preston's view, is that they are deliberate: they intervene by design. Anthropocene technologies "insert human designs into the planet's fundamental biogeochemical processes" (C. J. Preston 2017, S41).

The idea of climate engineering is another example of an Anthropocene technology. Climate engineering has come to be the technology most widely written about in environmental philosophy and adjacent fields,[10] and it is perhaps the technology most associated with the Anthropocene. As environmental researcher Duncan McLaren writes, climate engineering is "arguably the signature Anthropocene technology," (2018, 137). Typically defined as intentional, large-scale intervention into the climate system for the purposes of lessening the impacts of anthropogenic climate change, climate engineering can refer to a range of strategies that remove carbon dioxide or reduce the amount of solar radiation entering the Earth's atmosphere. The latter strategy is generally regarded as the more radical, due to its aim of intervening in one of the most significant processes for life on Earth: energy reaching and warming the atmosphere as sunlight. It is for this reason that climate engineering rises to the level of an Anthropocene technology: it signifies, according to Preston, an "intent to reorder a process that has been fundamental to Earth's history up to this point [. . .] Intentional solar radiation management would for the first time insert human design into this basic and highly formative planetary process" (2017, S38). In climate engineering we have the three features previously distinguished: novelty, intentionality, and deep intervention. To be clear, these are not meant to be sufficient or necessary conditions but instead are features, or characteristics, of the kinds of technologies that environmental ethicists and philosophers have focused on when they focus on technologies. These are the kinds of technologies that, I am claiming, have come to count as *environmental technologies* because of the influence of Preston and Lee. In the next section, I will further elaborate these features of environmental technologies and discuss

why the prevailing framing of these technologies has not opened up thinking on maintenance.

2.1—Foreclosure of Maintenance in Environmental Technology

In 1999, Keekok Lee urged environmental ethicists and philosophers to pay attention to a specific kind of technology. My claim is that they have largely done so in the intervening 25 years. Lee and, later, Christopher Preston have significantly influenced what kinds of technologies environmental ethicists and philosophers consider. These *environmental technologies* are, thus, framed around the features of novel, intentional, and deep interventions into a pre-existing 'nature.' They include technologies already identified by Lee and Preston: nanotechnology; climate engineering (especially in the form of solar radiation management); synthetic biology and gene drives; and 'de-extinction' techniques. The growing attention to these kinds of technologies in environmental ethics and philosophy makes sense, as such technologies, following Lee's and Preston's warnings, have the potential to alter the natural world in novel and fundamental ways and to shift human relationships to it radically. Preston, interested in this shift and what it means ethically, politically and socially, sees a "widespread restructuring of ethical relationships to the surrounding world currently under way" (2017, S38). That these technologies seem to offer unprecedented possibilities for human design of the nonhuman world has attracted attention in governance, innovation, and technology studies as well. Environmental policy specialist Jesse Reynolds suggests that 'Earth systems interventions,' defined as "intentional, large-scale interventions in Earth systems" (2021, 133) are "the technologies of the Anthropocene."[11] Or consider this passage from Michel Bourban and Johan Rochel highlighting the innovative angle of Anthropocene technologies:

> With ongoing technological innovations, we are in the process of replacing some of nature's most historically influential operations with synthetic ones of our design—how DNA is constructed, how ecosystems are composed, the amount of solar radiation reaching the Earth. From the atom to the atmosphere, new technologies have the potential to remake the natural world by replacing unplanned physical and biological operations by conscious, intended processes. Our planet is becoming increasingly malleable to us, something we design. (Bourban and Rochel 2021, 382)

Their points about the scale of human intervention into 'nature's operations' echo Preston's, and they highlight the additional dimension of human design and re-

making that Anthropocene interventions afford. Anthropocene technologies open possibilities for humans to intervene in and redesign parts of nature according to human intentions and aims.[12] Most environmental thinkers writing about Anthropocene technologies do so to urge careful consideration or to warn against this kind of intervention, often by raising questions about responsibility, novelty, and the potential consequences of intervention and intentions to design nature. While important, these aspects also foreclose other questions, a concern which I will attempt to bring into focus by considering what environmental technologies, conceived as Anthropocene technologies, exclude. I address two major exclusions in the following sections.

The first exclusion is of other technologies that might be considered environmental. Because of the focus given in recent years to Anthropocene technologies (i.e., large-scale, intentionally interventionist technologies that open up novel possibilities for remaking nature), technologies that pose positive or negative environmental impacts, or that reduce or mitigate the effects of human activities, have not received sustained attention from environmental ethicists and philosophers. This is especially true when compared with the focus given to topics like climate engineering, synthetic biology, genetic engineering, and de-extinction.[13] Construed more broadly, 'environmental technologies' could extend beyond Anthropocene technologies to encompass the range of technical artifacts and practices through which humans engage the nonhuman environment:[14] for example, technologies aimed at sustainability and mitigating environmental harms; technologies involved in energy transitions (e.g., wind turbines off-, near- and onshore; LEED certified buildings; practices of retrofit and other climate mitigation and adaptation strategies in the built environment; electric vehicles); and infrastructures and the engineering works that underwrite daily environmental interactions (roads and transportation; systems of drinking and wastewater; flows of resource and waste; electricity and communications, etc.). All of these technologies have material implications for the environment, not only in terms of a given impact, or footprint, but also in the ways that these technologies continually mediate human experiences of the worlds around them, shaping the kinds of environmental relations in which humans are constantly participating. By failing to attend to these technologies, and instead attending only to the large-scale, Anthropocene technologies, the ways in which our lives and societies are always already involved in environmental intervention and engagement escape our notice.[15] As ethicists and philosophers of the environment, we miss persistent opportunities to consider how technologies mediate our environments, to examine how they might contribute to

or undermine human and nonhuman flourishing, or to raise other normative or environmental ethical questions about their aims, underlying values, or how they can or should function. The focus on Anthropocene technologies risks eclipsing other ostensibly environmental technologies that do not achieve the scale or grandeur of the Anthropocene designation because they are not characterized by disruption and existential questions about human-nature relations, but are indeed projects of engagement with the nonhuman world.

Second, 'environmental technologies,' conceived of as the Anthropocene technologies described by Preston and Lee, also act in an exclusive way. As we have seen, these technologies are characterized as making possible unprecedented, large-scale, intentional interventions into nature, or environment. This conceptualization raises certain points of focus and questions and not others. Specifically, this conceptualization attends to precursory questions—questions that precede a potential intervention these technologies would set in motion. This framing forecloses possibilities of maintenance.

My argument in the previous section is that all environmental technologies, broadly construed, can be seen as already intervening in the environment. This conceptualization should broaden not only what we consider to be 'environmental technologies,' but also the notion of intervention, such that we can think of intervention as participation, co-constitution, or engagement with the nonhuman world. Moreover, through these technologies, participation, or co-creation, has long been underway. By contrast, the intervention at the heart of Anthropocene technologies, as Lee and Preston have implied, represents a specific, narrower kind of intervention characterized by large-scale, deep-reaching intervention that involves the possibility of intentional human (re-)design of nature. Such interventions are momentous, shown by the kind of questions and concerns they raise. Preston provides examples of this, often through metaphors of crossing a threshold, or entering into a novel moral situation: it is "by entering into the nanoscale" that humans can choose to "recalibrate the relationship between humanity and the physical stuff of the world" he writes, or, of the same technology, "to some, it seems like a step too far" (2018, 11). The kinds of questions Preston and others raise about Anthropocene technologies are precursors to their use: What would it mean to use this technology? What kind of people would we become? Are these technologies morally permissible? These are precursory questions, questions that make sense given the Anthropocene intervention framing where humans stand at the threshold of re-making nature. They ask about what could and, in some cases, should happen should the technology under consideration be introduced and the

threshold crossed. But they fixate on one point in time: the point of intervention. Given the momentousness of Anthropocene interventions, questions that pertain to later stages, to the maintenance and ongoing workings of a technology, seem to be of secondary importance if they are considered at all.

In one of the only existing papers specifically on maintenance and environmental technology, Pak-Hang Wong (2014) observes the same emphasis in the context of climate engineering. Critical of the weight given to precursory questions even at early stages, Wong argues that environmental ethicists have been preoccupied with such questions to the neglect of others. Specifically, he argues that focusing only on questions about the moral permissibility of climate engineering technologies and the distribution of benefits and harms motivating or discouraging their use has led to an oversight of post-implementation scenarios, of crucial importance in the case of any climate engineering technology.

Writing about another Anthropocene technology, Keje Boersma, Bernice Bovenkerk, and David Ludwig similarly criticize the prominence that of the moment of intervention has been given in discussions of gene drive technologies. They write:

> critical engagement with gene drives needs to address empirical, moral and ontological concerns together, and that this in turn requires a perspective that zooms out from a narrow focus on specific intervention context and relation. *Such a perspective reveals how a view of gene drives as specific interventions into nature obfuscates the interventionism already present in the bioengineer's lab prior to any field release*. (Boersma, Bovenkerk, and Ludwig 2023, 9, emphasis added)

Their work on gene drive development problematizes the notion of intervention, showing that the idea of an intervention as amounting to an action taken at a single point in time (e.g., in the release of the gene drive) obscures ongoing practices and existing environmental relations. Their problematization highlights an example of what I take to be a much larger, prevailing preoccupation in environmental ethics: a deep uneasiness with the ongoing nature of human involvement in the world. This attitude may indeed be appropriate with respect to Anthropocene technologies, technologies that portend entering into new relationships and responsibilities that demand reflection and deliberation before they are begun. However, this attitude fails to appreciate the ongoing and long-established relations and engagements—rather than only interventions—between humans and nonhuman elements taking place. The focus on moments of interventions entailed by Anthropocene

technologies means that the possibilities of thinking about maintenance, of duration, and the ongoingness of human-environmental relations are foreclosed.

What we miss, then, through this foreclosure, are questions (and arguments) about the sets of relationships and decisions that will follow, or that are already ongoing—questions that maintenance brings up, which would aid environmental philosophy in thinking through environmental technologies of all kinds. These are questions like: How would these technologies, and relations, be maintained over time? Who would be responsible for designing and carrying them out? What networks, labor, and expertise do they need to be sustained? Who would work on them? What would the practices and technologies themselves look like in a longer time duration? How might they change in use? What would function or malfunction look like, or result in? Could they be discontinued or phased out? What capacities for flourishing do they, or could they, support? What would it be for humans and nonhumans to live with these technologies, and how might they refashion or reshape relations with the nonhuman world over time?

I have claimed that environmental technologies have been conceived of too narrowly, as Anthropocene technologies, and that this focus has foreclosed thinking about technologies through which humans already are involved in the world. My suggestion is that environmental technologies should encompass all technologies with environmental impact, relevance, or that shape human engagement in and with the world. In the concluding sections, I propose maintenance as an approach for conceptualizing this broader class of environmental technologies and for thinking through ongoing human-environmental relations.

3. Why Maintenance?

In the previous sections, I introduced maintenance, asking why this theme has not featured in environmental ethics and philosophy, and I have attempted to provide an answer by interrogating the absence of maintenance in these literatures. I argue that a technology-averse stance has precluded ideas of maintenance from becoming central, and, further, that technologies that are conceptualized as 'environmental' are limited to only a specific class of technologies, which I use the shorthand of *Anthropocene* technologies to describe. This means that there is an array of technologies that have profound environmental impacts, that shape how humans relate with and make use of the nonhuman world, and that are decisively important for the present and future flourishing of humans and nonhumans, but these technologies are undertheorized in the fields of environmental ethics and philosophy. What's more, even regarding interventionist Anthropocene technolo-

gies, the existing literature mainly focuses on them as interventions into 'nature' and, thus, considers only the initial stage of their prospective use. I claimed that, by only posing ethical quandaries about intervention, this literature forecloses thinking about maintenance, or how such technologies would persist and need to be kept up over time. These factors explain why almost no work in environmental ethics and philosophy thinks through the processes and ongoingness of these technologies—what happens beyond a decision to use them or not, how their use may open up new questions and issues, and how they help, or undermine, or could make us think about what our long-term environmental goals and normative ideals are altogether. These omissions are instructive: they point to a reluctance to recognize the ongoing technological relations that humans have in the worlds around them, what I described above as a deep uneasiness with human involvement in the nonhuman world. In concluding this paper, I suggest that maintenance is an apt and needed approach not only for the large-scale environmental technologies of intervention, but also for the overlooked, undertheorized technologies that shape our experience of much of the world.

Already emerging from the previous discussion is a sense of what this narrower conception of environmental technologies misses. In the closing sections of the paper, I present two of what I take to be maintenance's key offerings for environmental ethics and philosophy. First, I argue that maintenance necessarily attends to the ongoingness of technologies though its focus on their processes, operations, and duration over time. Maintenance enjoins a thinking *through* of technologies. Such an effort, secondly, requires attending to how technologies are situated with regard to the social, built, and nonhuman factors that already comprise the environment. Maintenance, in other words, highlights the workings of our environments: that they are co-constructed and that labor goes into making them at various levels.

3.1 Technology Through Time

First, the idea of maintenance already pushes thinking in a certain direction, namely beyond the preliminary stages of ideation, design, and development (or, in the language of the previous sections, beyond intervention) and towards practices and processes of use. Maintenance goes "beyond design" (Steinert 2024, 217) in at least two senses: first, as maintenance scholar Mark Thomas Young argues, maintenance challenges prevailing views in engineering and technology design that are based in what he terms the design paradigm. The design paradigm focuses on the production of artifacts and technologies, created "through the development

and realization of designs" (Young 2020, 356). In the context of an environmental technology, we could translate this paradigm into overemphasis on the initial design, siting, and construction of, for example, an offshore wind turbine and less attention to its upkeep, operation, and eventual decommissioning. This, as Young observes, makes maintenance activities secondary and subservient to the original design and production of the artifact or technology. According to Young, especially for the premium placed on invention and innovation, the design paradigm misrepresents how much of engineering work is maintaining existing systems and technologies, and, crucially, it misunderstands the nature of maintenance. Young writes: "Against the common characterization of maintenance work as derivative, [. . .] studies of maintenance contend that such practices are not simply conservative—they are also deeply creative" (2020, 362). The second sense in which maintenance moves beyond design is closely related to the first. Maintenance is temporally beyond design: it requires thinking *through* time. Maintenance starts after something—an artifact, a technology, an infrastructure—already exists, and it attends to its existence over time. This matters not only for the designers and engineers engaged in processes of maintenance, but also for others involved in thinking about the values and ethical implications of existing or future designs. Writing in this context, philosopher of technology Steffen Steinert explains:

> The maintenance perspective invit[es] us to take the entire temporal spectrum of technology seriously. Technology is not finished after the design stage, and the designer's intention does not determine it. Instead [. . .] technology has multiple temporal dimensions that require ongoing consideration [. . .] we must also consider the ongoing processes that maintain or transform values over the entire life cycle of technology. (Steinert 2024, 217)

For environmental technologies, thinking of maintenance requires that we not only consider the threshold moments of intervention, but that we connect these moments to longer temporal durations, processes, and stages of technological development, use, and possible phasing out. That technologies persist over time means that they have time-relevant normative dimensions. Wong argues that "the requirement of maintenance," (2014, 188) which refers to the need to continuously monitor, service, and otherwise keep running any, in his case, climate engineering technology after its deployment, is crucial for the successful operation of the technology, and therefore should inform decisions in the first place about whether such technologies should ever be deployed. Wong emphasizes maintenance to push

"researchers to reconceptualize the ethics of geoengineering [. . .] not as a one-off event but as a temporally extended process" (2014, 190) with normative considerations arising along the way. The issue, for instance, of responsibility extending through time is one evident (Sand, Hofbauer, and Alleblas 2023) but nevertheless undertheorized dimension of the ongoingness of (environmental) technologies. Other issues will open up over time, and some limited work considers these. For instance, Christopher Preston (2013) helpfully sketches a timeline of ethical issues encountered at each stage of climate engineering, from prospect to termination. Evelyn Brister et al. (2024) argue that advanced cryogenic technologies, in the context of environmental conservation, are best understood as *technologies of logistics*, given their potential to link conservation projects, practices, and operations across time and space.

These, however, are exceptions. Environmental ethicists working on climate engineering or other environmental technologies have not yet paid much heed to Wong's call for the requirement of maintenance to inform ethical considerations. I second Wong's urging: thinking about the ongoingness of technologies through time that maintenance opens up provides additional avenues for thinking through the normative considerations of environmental technologies, broadly construed. Further, thinking through time and maintenance could find support from existing literature on sustainability, intergenerational justice, and Indigenous environmental perspectives where time and temporality are central.

3.2 Environmental Workings and Labor

Second, the lens of maintenance affords a way of looking at the environment as a site that is already comprised by ongoing human and nonhuman engagement. This differs markedly from the concept of nature implied by Anthropocene technologies discussed above. While perhaps not relevant for all areas of environmental ethics, maintenance provides an extremely helpful way of attending to the built environment, environmental technologies broadly construed (as I argued above), and other cases where the environment is understood to be comprised or constructed according to human intentions and design, in collaboration with nonhuman elements. There are two points of interest I will indicate here as very brief suggestions for future work.

The first follows from the work of Steven Vogel (2015) and emphasizes the ongoingness of human engagement in the nonhuman world by focusing on the ways in which human input and labor always already make and maintain our environments. For Vogel, environmental ethics and philosophy have neglected how

thoroughly constructed our environments are, through human labor and other social processes and practices. He argues that humans are alienated not from nature, as is commonly claimed, but rather from our own environmental labor, as we are unable to see human activities and practices as making the world we inhabit (Vogel 2015). The lens of maintenance fits extremely well into Vogel's post-natural environmentalism. Maintenance too asks that we pay more close attention to the ongoing workings of the environment and think more carefully about what our aims are and how they are carried out. To understand how something is or should be maintained means understanding what the system or technology is or does, its intended use and users, how its parts contribute to its functioning, what its impacts are, etc.[16] Considering environmental technologies with these questions in mind may very well alleviate the problem of environmental alienation that Vogel diagnoses by revealing human intentions and labor in the making of the world. But as maintenance scholars point out, maintenance does not have to imply a heavy-handed and instrumentalizing imprinting of human designs and plans on the world (Young 2020). Instead, maintenance is a creative, responsive, and ongoing activity, needed because plans are never sufficient: technologies, artifacts, and policies exist over time and are always subject to change, unexpected outcomes, deterioration and breakdown, and nonhuman dynamism and recalcitrance. In fact, environmental ethicists and philosophers have much to contribute about how elements like nature and natural forces, nonhuman others, agency, or wildness, could participate in, undermine, or complicate maintenance of environments and technologies.

Secondly, thinking through maintenance and thinking of the environment as a site of ongoing work also invites questions of labor in the workings of the environment: what is the work, is it valued, neglected, or invisible, and who, or what is doing it? Maintenance themes already have a long legacy in feminist scholarship, especially related to domestic, unpaid, and reproductive labor, and 'dirty work' (Cowan 1983; Federici 2012; Duffy 2007) some of which directly involves environmental topics. More recently, writing about maintenance and repair work in the Anthropocene, Julia Corwin and Vinay Gidwani elaborate the linkages between maintenance and care, which often have direct or indirect environmental relevance:

> If the work of repair and maintenance is invisible, it is not because everything is working perfectly but because someone, somewhere, is expending invisible and often undervalued labour [. . .] From utility repairers who fix electric and water mains, sewer workers who keep the drains running in cities, construction workers who patch the roads, gardeners and sweepers

> [. . .] the waste pickers and scrap dealers who salvage and recycle people's discards [. . .] It is frequently mundane work, yet a vital form of labour that takes care of human and non-human others around us. (Corwin and Gidwani 2021, 1–2)

What kind of work might be considered environmental, and to whom does this work fall? By paying attention to who is doing the undervalued and often dirty work of maintaining existing environments, from industrial agriculture and food production, to waste and recycling (McAllister, Magee, and Hale 2014; Amuzu 2018), to ecological stewardship and repair, maintenance can respond to calls by ecofeminists to recognize undervalued environmental labor (Plumwood 2008; Shiva and Mies 2014; Gaard 2017) by foregrounding invisibilized, unevenly distributed, and oppressive forms of (environmental) work.

Conclusion

This paper finds its general motivation in the idea that maintenance is a useful theme for environmental ethics and philosophy for thinking through environmental topics and technologies, and its growing literature offers important resources. I've used the idea of maintenance to explore the conceptual underpinnings of Anthropocene technologies and the interest that environmental fields have taken in them. My argument is not that environmental ethics and philosophy should not focus on Anthropocene technologies, or even that they receive too much focus, but rather that these technologies should not be the only ones that environmental ethics and philosophy investigate. Further, I have argued that maintenance asks for a thinking through of technologies, time, the construction of the environment, and who or what is at work in such constructions that current approaches overlook. My suggestion is not that maintenance is applicable to all topics or areas in environmental ethics or philosophy, but that there is great potential to use this lens, especially to think about technologies and the built environment *through* time, to connect environmental ethics and philosophy with adjacent fields already engaged in similar efforts, and to do so in ways that can bolster underrecognized work done by marginalized groups. At a time when great damage has been done and when major transitions in ways of doing things are necessary, maintenance offers a lens through which environmental ethics and philosophy might give more careful attention to technological and environmental relations, questions of what these relations should be, and how to sustain them over time.

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Notes

1. See Denis and Pontille (2019) and the introduction to Young and Coeckelbergh's edited volume, *Maintenance: Keeping Things Going*, (2024) for overviews of this emerging literature.
2. Or ruination—see DeSilvey and Edensor (2013).
3. See David M. Kaplan's introduction to his edited volume, *Philosophy, Technology, and the Environment* (2017). Kaplan points to repeated attempts to bring these fields into conversation, including a special issue in what is now the journal *Techné* from 1999, edited by Maria Banchetti. She stated the aversion existing between these fields in 1999 in this way: "Environmental ethics overemphasizes wilderness and views human technological activity negatively," and on the other side, "Philosophy of technology displays a "naïve anthropocentrism" by focusing the role of devices and machines on social, political, and economic affairs to the exclusion of ecological concerns" (2, cited in Kaplan 2017). Marion Hourdequin's more recent paper, "Environmental Ethics: The State of the Question," (2021) which provides a representative overview to the main questions and issues in environmental ethics, also illustrates the non-technological orientation of the field, as technology or technologies are scarcely mentioned.
4. These distinctions are frequently contested with some environmental philosophers rejecting outright the categorization of the 'natural,' or its ontological priority. Most significantly, see Vogel 2015; but also Plumwood 2002; Murdock 2019.
5. In other fields, management might also include people, although for reasons described above this is less the case in environmental ethics and adjacent fields.
6. See Gammon 2018 for a discussion of these themes.
7. One way to demonstrate the thematic absence of a topic, like maintenance, in environmental ethics and philosophy, as compared to management, is to look for these topics in a journal representative of the field. *Environmental Ethics*, the oldest environmental ethics journal, has published countless papers related to the management of nature, resources, lands, wildlife, etc. since its inception in 1979: too many to overview or cite, and only two papers (to my knowledge) that deal squarely with maintenance:

Michael Mackenzie's "A note on Motivation and Future Generations" (1985), and Eric Katz's "Geoengineering, Restoration, and the Construction of Nature" (2015). MacKenzie argues that the maintenance of hydraulic systems in agriculture formed a common project over which communities bonded, intra- and inter-generationally, and suggested on this basis that technologies, and their ongoing maintenance, offer promising ways of relating over time. Katz picks up on maintenance needed in climate engineering technologies as evidence for human dominating intervention in nature, in ways that echo the concerns of Preston and Lee described below.

8. I follow Lee's use of nature in this section.

9. Although Preston himself is ambivalent about this term. He coins and develops the idea of 'Anthropocene Technologies' in the Hastings Center Report, "De-extinction and Taking Control of Earth's "Metabolism" (2017) but doesn't use it in his monograph about these technologies, *The Synthetic Age* (2018). This has also been noted in Boersma 2022, footnote 11.

10. A sample of this extensive literature in environmental ethics can be found in Preston 2016, and in adjacent fields see (e.g.,) Buck 2012; Stilgoe 2015; Chakrabarty 2021.

11. Reynolds names examples of Earth systems interventions, where human intervention shaped environments, sometimes unintentionally (e.g., agriculture, landscape burning, intentional species extinction). But intentionality is a central feature of the Anthropocene technologies (largely overlapping with Preston's) that he surveys.

12. For detailed examinations of Anthropocene interventions into nature in the case of gene drive technologies, see Boersma (2022) and Boersma, Bovenkerk, and Ludwig (2023).

13. There are, of course, exceptions to this, but I'm attempting to describe the main trend. For instance, Vogel 2015; Hale and McAllister 2020; Kaplan 2017; Epting 2016; Scott 2018. One notable exception of an alternative avenue is recent work on biomimicry in philosophy of technology: see van der Hout 2016; Holy-Luczaj and Blok 2019; Blok 2022; Gerola, Robaey and Blok 2023.

14. While also allowing for much greater nuance and particularity than the monolithic and false 'we' implied as devising 'Anthropocene technologies.'

15. This point, or a very similar one, has been made before: Cronon 1996; Light 2001; Vogel 2015; Murdock 2019.

16. See e.g., McLaren et al. 2020 for maintenance and repair's connections with more technical fields.

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