we will draw on and highlight how and where we feel the criteria have been met for considering computing as ecocide. Through our analysis, we highlight how certain aspects of computing, such as distribution of responsibility, anthropocentric vs geological timescales, and the pervasive ideology of techno-solutionism, minimise the attribution of and distract from the responsibility of computing for ecological harms. We discuss how we might use ecocide, and the turn towards ecological harms, as a means to re-evaluate computing and its relation to the environment.

2 BACKGROUND

Globally we are facing multiple crises, where we are overstepping several fundamental planetary boundaries undermining the possibilities for flourishing life on earth [77]. Humanity has changed the planet with repercussions on a geological scale, coining the name of this time period as Anthropocene [76]. Perhaps most urgent is the current ongoing sixth mass extinction of species, where we have lost 69% of species populations since 1970 [82] and climate change [45]. While the biodiversity loss so far for the most part have been fueled by land and sea use change, it will soon be more affected by climate change, linking these two planetary boundaries in feedback loops [18]. But the contribution to this global crisis is unequal, where the global north have a significantly larger impact in terms of ecological footprint [82], and in terms of carbon emissions, the 10% richest in the world have contributed with 52% of the cumulative carbon emissions between 1990 and 2015 [35]. In what follows, we set out the concept of ecocide and its production and how it has been considered in computing research to date.

2.1 Defining Ecocide

As awareness of humanity's impact on the environment has grown, there has been increased need and desire for regulation for environmental protection. As Andrews [4] argues, although environmental protection law only became prominent in the 1970s - in the USA in 1970 and in the EU in 1972 - governments around the world have used policy to manage, exploit, colonise, and protect natural resources, including land itself, for much longer. While a review of all such policy is well beyond the scope of this paper, we want to highlight that despite this long history of regulation and policy to manage the environment, it is currently only considered a crime at any international level to cause mass destruction or loss of ecosystems during wartime [40]. Here *'mass destruction'* is understood to occur "where the spatial size affected exceeds 200 km in length or where impact on ecosystems exceeds 3 months, causing severity of impact to human, natural or economic resources". To put this into perspective, 200km is somewhere between one and five days of the current estimated rate of deforestation in the Amazon rain forest. Hence there is a growing movement arguing for including a fifth crime to be tried by the International Criminal Court (ICC); ecocide. If ecocide was added as a crime in the ICC it would stand alongside genocide, crimes against humanity, crimes of aggression, and war crimes, allowing the ICC to prosecute individuals for crimes regardless of the jurisdiction in which they occur. The existing international crimes all propose prosecution of harms to human-beings, while the proposed ecocide law suggests the environment is also due the same rights. Not only is this a non-human centered approach to rights, it is also proposed as a protection for populations vulnerable to consequences of environmental destruction, including through the propagation of resource scarcity leading to genocide [22, 33]. The proposal to sit alongside other international crimes is both an issue of awareness raising, and an attempt to transform the legal protections of the environment - namely to create a legal duty of care.

Ecocide is not a new concept and has been around since the 1970s. As late as 1996 it was on the table to be included in the Rome Statute that created the ICC, but was removed without a vote [40]. There have been extensive campaigns to recognise ecocide as a crime, including several draft texts of the law being proposed. Notably, several countries have adopted versions of ecocide as a crime, though often explicitly in the context of war and without due processes to evaluate the criteria, such as intentional [60]. In 2021 a panel of experts working with the End Ecocide Foundation drafted a text for the crime of ecocide [1] and renewed calls for the recognition of ecocide within international law. That draft text is the basis of the analysis in this paper. We draw on the second paragraph of the proposed text, which provides further definition of the characteristics of ecocide.

> For the purpose of paragraph 1:
> "Wanton" means with reckless disregard for damage which would be clearly excessive in relation to the social and economic benefits anticipated;
> "Severe" means damage which involves very serious adverse changes, disruption or harm to any element of the environment, including grave impacts on human life or natural, cultural or economic resources;
> "Widespread" means damage which extends beyond a limited geographic area, crosses state boundaries, or is suffered by an entire ecosystem or species or a large number of human beings;
> "Long-term" means damage which is irreversible or which cannot be redressed through natural recovery within a reasonable period of time;
> "Environment" means the earth, its biosphere, cryosphere, lithosphere, hydrosphere and atmosphere, as well as outer space.

The proposed characteristics are intended to support evaluation of crimes and to create processes for that evaluation. They are not without critique - Minkova [60] provides analysis of the limitations in the potential of the proposed law when consider its qualification against 'social and economic benefits anticipated' and with relation to ambiguity on the intentionality implied in requirement for 'knowledge' of environmental harms. She argues that, on the first hand, that the justification of ecocidal crimes on the basis of their anticipated benefits perpetuates an anthropocentric perspectives on environmental harm. On the other hand, the ambiguity on whether a 'wanton' act requires knowledge of the consequences of those harms, also creates a loophole in the application of the law. Specifically, the question of knowledge is one where differing proposals of ecocide law have set different standards for what constitutes knowledge and therefore how it can be assessed in a definitive manner. In our analysis, we therefore pay particular attention to these

[1] https://www.stopecocide.earth/legal-definition

two questions of benefits and knowledge. To start, in the following section we explore prior research in computing on ecocide.

2.2 Ecocide in Computing Research so Far

In this paper we have adopted a broad definition of computing, with the aim of conceptually discuss the implications of an ecocide law. Environmental concern has a long but perhaps not prominent history within the field of computing in general, with a focus primarily in the beginning of using computational power to model sustainability problems, like the models that laid the basis of the book Limits to Growth [59]. Computing and sustainability has been covered in many different subfields, such as Sustainable HCI, Green IT, Sustainable Software Engineering etc, but have an interdisciplinary nexus in the area of ICT for Sustainability (ICT4S) with its inaugural conference in 2013 [41]. The work within this field can broadly be divided into Sustainability in ICT and sustainability by ICT, the latter using the power of ICT to enabling more sustainable production and consumption patterns [41]. Sustainability in ICT, as defined in Hilty and Aebischer, is "Making ICT goods and services more sustainable over their whole life cycle, mainly by reducing the energy and material flows they invoke" [41, p. 18]. With this focus, there are numerous efforts in assessing the environmental impact of ICT and computing. However, there is less to be found on ecocide.

When in January 2023 searching the ACM Digital Library and IEEE Xplore (the two main publications venues for computing related research) with the search word ecocide we received in total 33 results that somewhere in the fulltext or metadata mentioned ecocide. After going through the results, and excluding texts that were not peer-reviewed (13 - books and book chapters, magazine articles, talks, full proceeding), and results that were not even remotely connected to computing (1) and one that did not use the word ecocide in the fulltext (1), we ended up with a corpus of 18 journal or conference articles. While this shows that the concept of ecocide have been used, it is striking is that for these 18 instances where the word ecocide is used in the fulltext, only one paper present a definition of the word - "they overuse and exhaust their vital resources" [70], and is as an argument why societies collapse. Furthermore, the term ecocide is used only once in 16 of the articles, and only twice in the remaining two articles. This shows a fairly superficial use of the term ecocide, and it is also a concept that has entered into the literature late, the first instance is from 2007 [84], with a majority of the papers after 2015. In most cases, ecocide is invoked to describe something that already occurs in our society [12, 23, 24, 46, 54, 65, 83, 84], or something that should be avoided [29, 30, 38]. In two cases the use of the word is from another source, in one case as a direct quote [66], in another as an enumeration of sustainaiblity dimensions [73] - but in neither case is the term picked up again or discussed. In three of the papers ecocide shows up as part of an empirical results, as a post-it note [68], as a social media post from the public concerned with an oil spill [47] and as a word that occurs in reader's vocabulary [53]. In neither of these three cases is the word ecocide elaborated on in the analysis or discussion. In only one case is ecocide connected to a computing system directly, in this case the authors argue that their app "help to bring the slow colonial ecocide to the surface" [11, p. 14]. Hence, we would argue that ecocide is not a concept well explored within computing in general.

3 EVALUATING COMPUTING AS ECOCIDE

In the following section we use the definition of ecocide, as quoted in the introduction, to assess the extent to which computing, as an industry and in particular cases, can be found to be culpable of ecocide. We will step through three ways in which computing appears to contribute to or commit ecocide. We first consider harms associated with computing's energy footprint - that is, the environmental harm of computation. The footprint of computing is most often the cause for concern for interventions in ICT4S and when targeting individuals' sustainability behaviours. Second, we will assess the extent to which the computing industries draws out other resources to support its continued growth. In particular we will examine water as a eco-system supporting resource and its use in data centre cooling and lithium extraction. Third, we will look at the consequences of the accumulation of computing technologies on local ecosystems - namely, ewaste. Finally, we will briefly consider computing as a facilitator of ecocide. While we consider such harms to be a significant proportion of the risk of computing, it is clear that the likelihood that such actions would be consider crimes is extremely low.

3.1 Computation as Ecocide

When it comes to the environmental impact of computing we are most often concerned with its carbon emissions and with that its energy footprint. We need look no further than the highly publicised cases of Bitcoin's excessive energy consumption relative to its benefit to society to find fuel for such an argument [17, 49]. Bitcoin is a cryptocurrency built on blockchain technology that, by design, requires significant computation to verify transactions. While it has long been suggested that more energy efficient blockchain technologies are possible and imminent, those energy efficiencies have often been offset by greater demand and mining [17]. Driven by a frenzy of media hype the number and scale of Bitcoin miners has risen rapidly. With this, the computational intensity, energy consumption, and carbon emissions have soared and can be argued to be *severe*. Estimating how much environmental harm Bitcoin has made is almost a sport in itself. Köhler and Pizzol [48] nicely summarise the many estimations:

> "For example, claiming that Bitcoin mining uses more energy than mining gold, is equal to Switzerland's energy consumption, was to use all the world's energy by 2020, and be alone responsible for not reaching the Paris Agreement."

Given the widespread coverage of Bitcoin, it is reasonable to assume that the vast majority of people mining Bitcoin are aware of its environmental harm to some extent, implying it is to some extent *wanton* environmental harm. Yet, much like computing itself [37], putting an exact number on the energy consumption or carbon emissions of Bitcoin is hard. Even then estimates for how much renewable energy Bitcoin consumes range from 28-77.6% [48], and so we have a wide margin of error when trying to argue for its harm. It is perhaps therefore even harder to argue that Bitcoin should be considered in terms of ecocide, falling into the category of complex and distributed moral and practical responsibility [34]. Arguably that responsibility does not lie with the end-users [7]. No one individual is currently mining all Bitcoin nor using all the energy required to do so. Although it is computationally intensive by design, it seems unlikely that the designers of Bitcoin could be at fault for its energy use or prosecuted as such - the designer's identity is not known and while the design itself is more energy intensive than other protocols, it does not consume any energy if it is not used. Moreover, Bitcoin's relatively rapid rise and recent fall suggest it cannot be considered *'long-term'* – certainly not yet. The environmental damage done by Bitcoin mining is distributed across the globe, and therefore *widespread*, but is unequally distributed targeting areas with low-energy costs [49]. As Drumbl [20] has argued and [60] reiterates, damage to such areas might not be considered *'severe'* as those areas may be less valued by the international community than others.

Perhaps more clearly falling under the guise of ecocide are the recent cases of the development of Large Language Models (LLMs). As recently and publicly argued by Emily Bender, Timnit Gebru, Angelina McMillan-Major, and Shmargaret Shmitchell [9], building on arguments in the same vein from other authors [15, 16, 78], development and training LLMs come with significant computational and thereby environmental costs. What is noteworthy about this paper is that it highlights the specific knowledge that organisations have of their own environmental harm and the apparent efforts put in place to limit the academic and public discussion of it. Again, while estimates vary, the cost of training a single base model was found to be as high as a trans-American flight [78] and creating the models in the first place requires significantly more energy and iterations. These harms have been known and discussed in computing for some time and their production in pursuit of Machine Learning and Artificial Intelligence is now developing faster than in other areas of computing. They are already *severe* and are likely to continue to grow in *severity*. Unlike Bitcoin the costs of developing LLMs, in computing power, energy and infrastructure, has centred the responsibility for them among a few large corporations. Given both the popular and academic discourse on the harms of LLMs and algorithmic computation in general [9, 15], it is unlikely that these corporations lack knowledge or awareness of the potential environmental harms of this form of computing. These harms should be considered *wanton*. These models also perpetuate other harms [9, 25, 62], particularly to marginalised communities through biases and informational injustice, which may suggest their benefit to society is reduced. Yet, the weakness in the definition of ecocide in relation to economic benefits [60], may be a loophole for this case. The companies producing LLMs are some of the most valuable in the world. Even if that wealth is heavily centralised, the indirect economic value is both immeasurable and politically powerful. Like Bitcoin, we might not be able to argue that the harm from LLMs is *'long-term'* nor *'widespread'* in a strict sense - specific LLMs may only be a few months or even years old and their lifespan as particular technologies or techniques is incredibly and increasingly short. Although they are used globally and increasingly pervasive in interactions with computing devices, the environmental harms are likely to be localised to the datacenters required to train them. It is in this regard that we turn to the infrastructures of computing.

3.2 Computing Infrastructure as Ecocide

Not only is computing itself a bricolage of materials, processes, infrastructures, policies and more [63], its use is equally though unevenly [49] distributed across global processes of production, consumption, and waste in almost every part of human and many non-human lives. While in Section 3.2, we argued for the direct impact of computing on energy consumption, we here also recognise the broader impacts of supporting computing at the intersections of the water, energy, food and land nexus [56]. One growing area of scholarly concern is the overlap in the harms of colonialism and capitalism, as they relate to both human and other-than-human lives and their extinction. For instance, Galligan [33] has argued that ecocide leads to resource scarcity, which in turn leads to various factors leading to conflict, in turn leading to increased possibility for genocide. Thus it is vital that we pay particular attention to the relationships between computing and the ecologies, of human and non-humans, that are implied and assumed in the production of computing.

This argument, that computing is infrastructured [63], implies both a material form of support, such as undersea cables [75], cleared land, hydropower dams [49], and so on, and a socio-political support, such as national policies supporting innovation and local policies supporting things like low energy costs, or the specific development of sites such as datacenters. Dunlap [21] argues that even where 'green' technologies are concerned, such as in the case study of wind energy in Oaxaca, the forces and technologies of their development are coercive, oppressive, and harmful. That environmental protection policy follows long after environmental management policy [4] is a core insight on the dynamics of protection and exploitation in regulating the environment. Vonderau [81] describes how a Swedish civil servant proudly establishing the Northern Swedish city of Luleå as a site for a Facebook data center as "selling the Nordic cold to the cloud industry". This socio-materiality of computing can itself have direct and indirect impacts on the environment and, as we will see, that impact can exceed reasonable limits of consumption of resources and cause short and long-term harms to environments. Perhaps even more so than the immediate impacts of computing, the infrastructural harms of computing are likely to be experienced mostly *severely* across generations [34]. While these works, including on the genocide-ecocide nexus, typically do not focus directly on computing as a tool of harm, the capacity to cause such harm is evidenced elsewhere.

While it has become familiar to state that 'data is the new coal' (whether ironically or not), much analysis of the environmental impact of computing and data also points to the fact that 'water is the new coal'. In the particular sites of datacenters, where data is collected, processed, and stored, the energy costs associated with cooling the multitude of computing devices has brought about demand for natural resources. Ristic and colleagues [71] estimate that each gigabyte of data output at a datacenter has the potential water footprint equivalent to a kilogram of tomatoes - up to 205 litres of water. Where Lally and colleagues [49] demonstrate a 'parasitic', and thereby non-deterministic, relationship between BitCoin miners and low electricity costs associated with hydropower in central Washington, other analysis shows a more directed set of policies and practices for the exploitation of land and water and the displacement or destruction of arable lands and agricultural practice. Mél Hogan [42] demonstrates how such material relations of computing create the infrastructure of such activities as the national and international surveillance of the United States National Security Agency (NSA). Situated in Utah, one NSA datacenter has been examined as a site of the mixed use of electrical, land and water resources. While Utah may have low energy costs and plenty of land, it is, as Hogan argues, one of the most draught prone states in the US. Estimates of the storage capacity and throughput of such a surveillance datacenter indicate water consumption upwards of 7.5 million litres of water every day. This is the equivalent daily water usage of over 10,000 people at the average level of water consumption in the USA. It is reasonable to argue that these harms are *severe*, though arguments that they are *wanton* might depend on the assumed societal benefit of the surveillance industry. Building such data centers will require some environmental assessment, so the knowledge of the harms should be available to decision-makers, so other factors are likely to outweigh the drain on and damage to the local water system. These harms are also likely to be heavily localised, and so the extent of the environmental harm might not be considered *widespread* [34], and perhaps only if the reproduction of datacenters across many geographic sites is considered together.

Yet, the impact of water use is also seen at distributed sites for the production of computing. While Hogan [42] points to the specific data security practices of datacenters, that is, backing up data on multiple sites, multiplies the environmental harm of the data that is 'in the cloud', many authors [6, 55] have shown the devastating and *long-term* impact of lithium mining on indigenous communities across Chile, Bolivia, and Argentina - the so-called 'lithium triangle'. One estimate, reported by [55], suggested a net loss at the water table of 1750-1950 liters *per second*. Liu and colleagues [52] highlight the significant and *severe* degradation over the past 20 years due to lithium mining, including, decreasing soil moisture, vegetation, and increased daytime temperature and drought conditions, including in nature reserves. Put bluntly "the fast expansion of lithium mining operations in the ASF (Atacama Salt Flats) is found to have a strong correlation with the ongoing environmental degradation in the study area" [52]. In these cases, computing, as an industry, relies on and assumes the consumption of nature as a resource. Many large computing corporations acknowledge the environmental harm of sourcing raw materials and any argument against this extraction as *wanton* relies again on the economic benefit to society. These economic benefits are not localised [55], but might be justified at the cost of marginalised communities [20] or lost in the geographic distribution of moral responsiblity [34]. Mirroring this concern, we turn our attention now to the residual impact of this infrastructuring to see the materiality of computing itself.

3.3 Materiality of Computing as Ecocide

Computing has a substantial materiality, with its consecutive environmental impact, which is classified as direct effects or first order effects [67]. The first order effects concerns the full life cycle of product; materials and energy used in manufacturing, energy use during its lifetime and disposal at end of life, and these environmental impacts are always negative [67] - that is, they are always environmental harms. While the benefits of using ICT in relation to solving environmental problems is often proclaimed [27] the negative effects are often forgotten or not taken into consideration [10, 14]. While there are considerable environmental and social sustainability issues upstream in sourcing materials and manufacturing, in this section the focus will be placed on the end of life of ICT products, when it becomes Waste Electrical and Electronic Equipment (WEEE) or e-waste. As Gupta and colleagues [37] show for the iPhone all attempts to reduce emissions-in-use are shadowed by the increased consumption of the devices themselves. Thus, while companies advertise more energy efficient products, they increase their hardware footprint, including datacenters with high turnover of hardware.

The dependence on electric and electronic equipment world wide has led to the waste stream from this usage to become the fastest growing waste stream, with an annual growth rate of 3-4% [72]. In 2019, there was a striking 53.6 Mt of e-waste generated globally, which equals an average of 7.3 kg per capita per year [28]. The same year only 17.4% of the global e-waste were properly documented to be collected and formally recycled [28]. It is unclear where the 82.6% undocumented e-waste ends up, but a large part of it is estimated to be exported for second-hand usage or as e-waste, predominantly from countries in the global north to countries in the global south, a so called transboundary movement [72]. This a global and *widespread* problem. These global e-waste flows are problematic because the legislation around e-waste management, and the infrastructure for properly handling e-waste, is weak in developing or less developed countries. Here the e-waste can be handled through informal sectors, with considerable environmental and social impact, which is not solved only by removing the informal sectors since they have become livelihoods for a considerable amount of people [80]. Even in relatively developed countries, technology innovation is pushing back the boundaries of regulation of waste management [13]. There is legislation that should hinder the transboundary movement of e-waste, for example the Basel Convention, and International Environmental Agreement to control the transboundary movement of toxic and hazardous waste, and the Bamako convention which has the same aim, but for hazardous waste entering Africa or being traded within Africa. However, both these conventions, while signed by many countries, are only advisory [72], and there is a need for more stringent legislation on e-waste management globally [79].

While there is valuable materials to recycle from e-waste, so called urban mining, there are also numerous toxic or hazardous substances, such as flame retardants or heavy metals. A recent systematic review on levels of Arsenic (As), Cadmium (Cd), Chromium (Cr), Mercury (Hg) and Lead (Pb) in soil, water or sediment samples from areas that recycle e-waste show that these levels were generally above international standards [44]. The study also noticed a gap in knowledge, since most studies had been done in China, whereas e-waste recycling is *widespread* and happens all over the world. While it could be difficult to argue that the environmental damage of informal e-waste handling would be widespread, since its effects can be local or regional, there are potential *long-term* damage with these higher than standard levels of heavy metals. Studies show that e-waste leachates and contaminated underground water affect eukaryotic cells (plant cells), for example that root growth was inhibited and that there was a genotoxicity at the chromosome level [8]. Not only plants cells are affected, there is also a DNA damaging effect on prokaryotic systems (bacteria) [2], as well as on animals [3]. In mice there were significant increase in sperm abnormalities when assessment of sperm shape was conducted, and there were also a significant decrease in sperm count [3]. These were not general studies on the toxicity of heavy metals, but were toxicity studies based on material collected from informal open dumpsites at the Alaba International market in Lagos, Nigeria.

Hence, while perhaps not widespread in the session of harm but widespread in terms of responsibility [34], the long term effects of not properly handling e-waste, could be considered a *severe* and long-term, including generational damage.

3.4 Computing as a facilitator of ecocide

Technology and computing are often invoked as part of the fundamentals of any 'green transition' [27]. Techno-utopianism, solutionism, and many other names have been applied as both critiques and celebrated labels for the visions driving eco-technology designs. However, in many other ways, computing is a direct facilitator of practices and processes that increase environmental harm. These harms are in-grained in our daily lives, but also pervasive in some of the most harmful industries in society, such as fossil fuel industries. In this section, we briefly examine the impact of computing as a mediator of environmental harm. We consider that such harms may be the most prevalent, *widespread* and *severe* of harms associated with computing, but which are least suitable to the definition of ecocide. For instance, a precision agricultural technology, incorporating computer vision and robotics, is apparently capable of killing up to 100,000 plants an hour [2]. Such developments of 'smart' plant and land management are contributing, whether locally or globally, to the decrease in biodiversity and the increase in 'productive' monocultures. These same techniques might equally be used for the preservation of habitats, such as algorithmic monitoring of legal and illegal deforestation, and as such, the technologies in themselves are less likely to be considered as causes of ecocide as much as the application industry, such as agriculture or forestry.

One further example is the exponential growth of computer-facilitated services, such as ecommerce. While production and consumption of goods entails environmental harms across various processes, and ecommerce may be less harmful than traditional brick-and-mortar stores for certain products [74], the overall impact of ecommerce is one of increased and globalised consumption [50]. Like previous examples, such as Bitcoin, it is unlikely than any individual ecommerce transaction is a form of ecocide. Whether large ecommerce providers, such as Amazon, are contributing to ecocide is more likely to rest on their infrastructuring, including land and water use, given that they do not produce materials and only facilitate its distribution. Here we might pay more attention to the potentially unethical practices of designing such services [36] as a site for improving computing's relation to the environmental impact of ecommerce. It is argued that computing can decrease emissions in other sectors, but it is as likely that it will lead to increase of emissions if not properly governed [32, 45, 50]. So while the harms of computing as a facilitator are indirect, they are likely severe and widespread, have supported a *long-term* shift in consumption in society, while bringing about both societal value and harm in information distribution that complicates the assessment as *wanton*.

[2]https://www.forbes.com/sites/johnkoetsier/2021/11/02/self-driving-farm-robot-uses-lasers-to-kill-100000-weeds-an-hour-saving-land-and-farmers-from-toxic-herbicides/

4 DISCUSSION

In this paper we have sought to position the environmental harms of computing alongside a standard for evaluating harm, specifically the proposed international crime of ecocide. Our intention has not been to provide definitive proof, one way or the other, but to raise the question of the extent to which we can consider, be accountable for, and take responsibility for the environmental harm we create as designers of computing technologies. While we, as a community, continue to strive to account for environmental harm through methods such as life cycle assessment and analysis (LCA), and to reduce harm through the multitude of optimisations, reductions, and withdrawals of harmful technologies, we must also realise that those existing and ongoing harms have now exceeded any reasonable level of reversible harm. As Pargman and colleagues argue [64] there is a need for computing to recognise and work with laws other than Moore's law. Naming environmental harm and seeing it as a crime against nature changes how we can and should think about the limits of computing. Across a number of cases, we have shown the environmental harm from specific computing practices, such as surveillance, and general computing engineering, such as e-waste, that contribute directly, knowingly, and irreversibly to harm across ecological systems, such as at the Atacama Salt Flats, to genetic and generational harm, such as in the case of heavy metals in e-waste leachate. These harms may be positioned as *associated* with computing, but the direct harm of computing through infrastructures and computational intensive practices, seem both more at the core of computing, while simultaneously, more evasive with regard to the definition of ecocide. Following our analysis we have found ourselves asking: "Why is this still allowed?" It is hard not to wonder if proposing that computing might be responsible for ecocide is a dangerous question, and a hypocritical one to ask while sitting at a computer typing out an argument for a computing research conference. In this Discussion we want to examine this question looking at the governance of computing and arguing for a shift in paradigm for commoning responsibility for environmental harm and care.

4.1 Is Computing Governable?

Across the definition of ecocide and our analysis of existing computing against it, we have not attempted to prove ecocide is happening with and through computing, though we suspect it is in certain contexts (see Table 1), but to find out how ecocide law might change how we think about the environmental harm of computing. The four variables defined in the law - wanton, severe, widespread, long-term - all problematise how we might assess computing as ecocide. While we can largely suggest that there is industry[3] and societal knowledge, and in some cases acknowledgement, of the

[3]See for instance https://sustainability.google/, https://sustainability.fb.com/, https://www.microsoft.com/en-us/sustainability, https://www.apple.com/environment/

		Wanton	Severe	Widespread	Long-term	Environment
Computation	Bitcoin	✓	✓	✓	?	CO_2e emissions
	LLMs	✓	✓	✓/ ?	?	CO_2e emissions
Infrastructure	Data centers	✓	✓	Localised	✓	Water and Land
	Lithium	✓	✓	Localised	✓	Water
Material	eWaste	✓	✓	✓	✓	Genotoxicity
Facilitator		?	✓	✓	✓	CO_2e emissions, biodiversity loss

Table 1: Computing's harms and assessment against the criteria for the crime of ecocide. While some examples fulfil all criteria, others are still to be determined or may depend on the definition of, for instance, what geographical region constitutes 'widespread'.

harm of computing (cf. [9]), and therefore argue that its continuation is wanton, we might struggle to show that such harms are severe, widespread, or in timescales beyond human-centric ones to be considered long-term. Consequently, the possibility to ignore or excuse the environmental harm caused by computing comes easily especially in to comparison to more obvious and immediate forms of environmental harm. As Gardiner [34] calls it, environmental harm is a triple crises of international, intergenerational, and theoretical contestation - a 'perfect moral storm'. As we have seen with many of the cases of environmental harm of computing analysed here, those harms are distributed such that no one single product or technology appears to be doing severe and long-term harm in the here and now. So how can we begin to take account for and rein in the environmental harms of computing?

Perhaps most fundamental to accounting for the environmental harm of computing is the distribution of computing within our society. To be considered a crime by the International Criminal Court, as is the intention with the proposed ecocide law, there must be an individual who is responsible, even if that individual is an organisation. For many of the cases we have explored, it might be difficult to establish such responsibility: Who is responsible for the energy costs of BitCoin? Is it that person who makes the code first available or those who use it? When a company launches a robot that kills thousands of living plants in seconds, is the developer responsible for their computer vision code? What if the computer vision code is open source and simply co-opted into the destruction of biodiversity? Is every bit of computing, including writing this paper on a laptop connected to a cloud service, contributing to the ecocidal effects of computing? There are ongoing and recent calls to regulate the development of AI systems [4], but the power to do so lies only with the labs developing such systems, whose commercial interests may well exceed their environmental concerns. At the same time, there are specific and local legal contexts in which environmental harm is and can be held up as a crime, but there are also those where the socio-political configuration of regulation mean that is not. In the case of the Atacama Salt Flats, the ownership of land confers the ownership and therefore right to exploitation of any water below it [52]. In Sweden, a technology company found to be operating outside the law was able to overturn a ban on its operation with favourable support from politicians [13]. As Minkova [60] has argued, the cost-benefit analysis implied in the proposed text of ecocide law does a lot of work to excuse environmental harms in the name of (human-centered) development and innovation. Would centralising responsibility for specific harms, just push companies to more diffuse harms? If the responsibility for computing's environmental harms is distributed, contested, and weighed against commercial and speculative interests, including for green transitions among other things, we will likely not succeed in protecting the environment from these harms.

As computing continues to develop and become entwined in green transitions new forms of governance may be needed [32, 45, 50]. A small corner of computing academia is unlikely to change land ownership law or national waste law, but we can attend to how we construct models of governance in computing and what is implied in them. Rather than accepting the international, intergenerational, and conceptual diffusion of responsibility for computing's harms [34], we can act directly to build new models for responsible computing. As Abede and colleagues [1] have argued there are positive roles for technology as a *diagnostic* for these imbalances, as a means to *formalise* issues such as diffusion and scale of harm, even as a mechanism to realise publics on matters of concern in new light - as might happen with a framing of computing as ecocide. David Franquesa and Leandro Navarro [31] have already demonstrated the impact of new models of commoning in ownership of computing devices. When we are supported in assessing the value of computing re-use, as in the case of commoning devices, we not only retain computing's value but diminish its harms. How would such valuing of resources and resource-use look like when the idea is to limit computing in the first place? What happens if we collectively decide who gets to compute today? We could look to and attempt to remedy the potential for devaluing and ignoring of marginalised human communities, where harms in areas deemed less valuable will not be considered severe [20], and ask who gets to compute at whose cost? Developing our sense of the legal alongside the political economic in computing[26, 61] is necessary to balance what we consider to be a benefit to society. Perhaps more radically, what would such commoning look like, as dos Santos and colleagues ask [19], if it took into account the non-human members of the ecologies of computing use? In legal and economic terms, how might we think about the costs and compensations to non-human ecologies of the massive environmental costs of computing? We do not have answers to these questions, but we urge computing researchers to engage deeply with a changing ecology of the value of computing. We suggest a need for a paradigm shift in computing to respond to and anticipate a coming duty of care for the environment.

[4]https://time.com/6280372/sam-altman-chatgpt-regulate-ai/

4.2 A Paradigm shift?

While the possible implementation of ecocide law, and the related rights of nature, are concepts that are possible to include in our current justice systems (we are already giving non-humans rights in the form of corporations legal rights, why should not plants, animals, or full ecosystems have the same possibilities), we argue that there is a possible larger impact with, and interpretation of these concepts, one that could also shift culture, both globally and within computing. This echoes the recent legal cases which have held large oil companies responsible for a failure in the legal duty of care [43] and the argument that climate harm can amount to homicide [5]. These legal cases and arguments have employed, as in the case of *Milieudefensie v Royal Dutch Shell*, human rights law to show that companies have a legal responsibility to protect life and this includes showing due diligence in avoiding harm. Turning to the work by Donella Meadows, she explores possible ways to change systems, so called leverage points [57]. The leverage points that are (perhaps) most difficult to change, but that can lead to the most impact within a system, is the level of paradigms. Meadows defines this as "The shared idea in the minds of society, the great big unstated assumptions, constitute that society's paradigm, or deepest set of beliefs about how the world works. These beliefs are unstated because it is unnecessary to state them–everyone already knows them" [58, p. 162]. In the current western modern worldview, nature is considered as something outside humans, a resource that can be extracted, without inherent value [39]. Ecocide law could here work as a Trojan horse, technically easy to incorporate in the legal system, but act as a probe that shift our understanding of nature; to something with inherent value and rights on its own. This is part of a much needed and larger shift within our culture, to change our relationship with ourselves, as part of nature, not apart from nature.

We want to propose two components of this shift: first, that we stop talking about environmental impacts or carbon emissions, and instead talk about environmental harms. Stating the carbon emissions or water consumption of a data center does little to show the actual cost of these computing activities, particularly where the current paradigm [69] suggests 'resources' are abundant and infinite. We *assume* nature is ours for the taking. As Max Liboiron [51] notes pollution was historically defined only as the excess contaminant from which a body of water or land could not recover. Similarly, we currently act and design our computing systems as though the environment can and should be able to tolerate *some* 'emissions'. Changing our mindset to see computing, and other activities, as harms brings into light how we thinking about and distribute such harm. We must therefore take care in how we decide to distribute the harms of computing in support of our and our planet's continued existence.

Second, as we make this re-accounting of computing's harm, it should be explicit that we consider our environment, nature, and local ecologies as equal partners in the decisions we make about the cost and benefit of computing [19]. No-one wants to find that in ten or twenty or a hundred years that we look back and rename this phase of earth's existence from Anthropocene to computocene in recognition of, for instance, the genotoxic legacy of the accumulation of e-waste. This requires that we think about the harms of computing, even when we see them as small or distributed, as collective and as, according to ecocide law, with the potential for it to be severe, widespread, and long-term. We must start to formalise how we can make decisions on the responsibility for the environmental costs and harms of computing. We, in the LIMITS and related research communities, already *know* this, and we must avoid the wanton continuation of the discourse and practices of computing without limits.

ACKNOWLEDGMENTS

A warm thank you to Pella Thiel for discussions on Ecocide.

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